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# Bentley's and Siemens' Vision for Cloud-based Distributed Engineering and Operations

# Executive Overview

Bentley and Siemens recently briefed ARC Advisory Group about their vision for an open, cloud-based solution for engineering and operations. The cloud solution – a portal accessed through a browser – will federate data sources, provide functionalities and facilitate the management of the digital twin of the asset, throughout its life cycle. It would overcome the current challenge of engineering tools that are poorly connected to asset information during operation and vice versa, as well as the disconnect between functional (1D and 2D) and spatial (3D) information. The solution would also provide compliance management in a single environment.

> Bentley and Siemens developed a vision for an open, cloud-based solution that will deliver a collection of microservices including process and plant engineering, physical layout modeling, project and construction planning, maintenance, and asset performance modeling. It will also support federating data from underlying services and related applications, so that each data point is stored only once. The solution will provide means to access traditionally inaccessible data, through intelligent scanning and interpretation. Services to validate data and link it to other information, combined with traceability of changes will improve the degree of accuracy, completeness and trustworthiness of asset data and documentation, improve compliance and the quality of decision making. The solution is scalable, secure, extendable and will reduce IT footprint and cost.

The solution would facilitate the construction of digital twins as a federation of data from many on-line and off-line sources and require very little IT integration. It would help incorporate data from digitally inaccessible sources, sometimes referred to as "dark data", and mobile sources used in the field.

An accurate, up-to-date accessible digital twin reduces time to operational readiness and can influence time to market. The ease with which this twin can be updated during operation or modified during projects, supports the need for increased flexibility and adaptability. The seamless and on-going integration of process engineering, maintenance, 3D representation and operational performance information, speeds up and supports continuous improvement and thereby efficiency, sustainability and return on assets. Owner-operators can combine the solution with asset management best practices to improve useful life and asset value. The digital twin makes it easier to engineer for safety and compliance and verify compliance of the as-built and as-maintained facility.

Different types of cloud services, including on-premise and hybrid, will be possible. Pure cloud and hybrid implementations allow easy scalability and reduce bottlenecks that potentially occur when users simultaneously access a database. The solution will be implemented as microservices, a suite of independently deployable modular services that can be complemented and the roadmap of which can be adapted based on client needs.



**3D Plant Model with Operational and Functional Context Information**

# Challenges in Capital Projects in the Process Industries

The financial crisis of 2007-2008 and the recent drop in oil prices that led to significant reductions in demand and asset utilization, has created the aware-ness that large-scale and single-purpose assets can have important drawbacks when markets are highly volatile. The resulting pressure to in-crease efficiency and return on assets requires shorter times to operational readiness and greater flexibility in operating and modifying assets to follow market demand. In practical terms:

- For plants under construction by engineering procurement and construc-tion firms (EPC's), owner-operators (OO's) require tighter collaboration

than before. Examples of these requirements are electronic design reviews and tracking of construction and commissioning progress against electronic documents and 3D surveys.

- The asset information built up during engineering and construction is often incomplete or outdated at the moment of transfer. NIST estimates the cost of information losses during handover to be 1.8% of capital expenditures. There is a huge opportunity to enhance the process by improving change management to ensure the data is accurate and information is reused.

- When engineering or maintenance trouble shoot an operational issue or need to start a modification project, they lose precious time when trying to determine the current status and performance of the asset before starting their actual work because often, the asset information is missing or inaccurate. Functional, operational and 3D spatial information – for the plant, building, or both - are often not available side by side and are often inconsistent. Furthermore, time is often lost due to inaccurate information on spare parts. NIST estimates the cost of information losses in the operate-maintain phases of the asset to be 2.4% of the capital expenditure cost. Complete, accessible, and accurate asset information has the potential to shorten project duration and "mean time to repair" (MTTR), and to lower operational and capital expenditures.

- High reliability is required for the best return on assets and process safety. Reliability-centered maintenance methodologies are well advanced and remote equipment monitoring is available. To be efficient, reliability engineers need seamless access to all asset information.

- As regulatory requirements tighten, compliance costs increase. In some cases, compliance becomes impossible as accurate information cannot be produced at any point in time. The efficiency of compliance processes must be improved using electronic design and requirement documentation, with electronic sign-offs.

- In the foreseeable future, modular production plants will be built that are easier to modify and use more energy and material efficient process technologies. Initial use in pilot installations will gradually be extended to industrial production. This will further increase the pressure on flexibility and efficiency for fast-track engineering as well as on operation and requirements for a digital twin.

Todays' tools are often specialized for a certain type of task but lack the connectivity that would enable the easy comparison and cross-referencing of asset information. Engineering tools are well suited for design and build phases but may be less suited for use in operations and maintenance. In most instances, the functional information in those tools is disconnected from 3D designs, even though the designs could provide excellent context for operations training, maintenance task planning, trouble shooting, and decision making under abnormal conditions. In turn, 3D designs for project planning lack access to engineering design or information, and/or maintenance records, thus narrowing the user's view. In fact, 3D models are rarely updated after plant changes, and are typically not reused for operator training. One of the reasons for the disconnect between simulations and asset information is the lack of support for keeping them in synch. The tools used are often demanding on skills, license costs, computing and network resources, and this demand fluctuates wildly. When a project is executed, the bottlenecks appear.

> **Asset Management Challenges for the Process Industry**
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> - Unused and inconsistent data in drawings, PDFs and legacy tools
> - Information accessed by several stakeholders
> - Requirement for long term asset and operational efficiency
> - Regular modernization and/or adaptation of plants
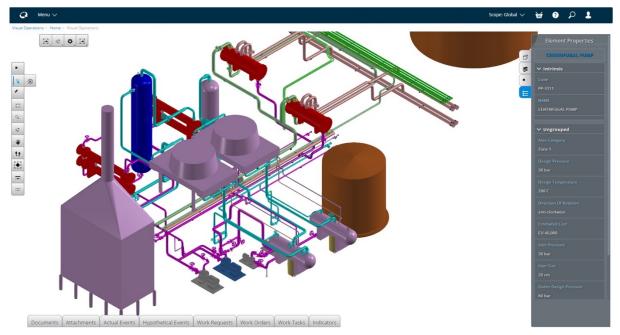> - Regulatory pressures, sustainability, security, and safety

As most plants in areas with advanced economies are brownfield plants which were built decades ago, asset documentation is a real challenge. While there is a business case for up-to-date asset information, ARC estimates that the average percentage of assets with current asset information is most likely below 50 percent and rarely exceeds 70 percent. It is troublesome that most owner-operators are not able to identify their out-of-date information, let alone show a progression of improvement over time. When users are aware that some available data is incomplete, inaccurate, or outdated, they understandably begin to question the validity of all accessible data.

# Technology Trends and Vision

Todays' cloud and virtualization technologies enable an easy and instantaneous on-demand availability of computational resources and services. On-premise clouds would limit a company to their own infrastructure, but hybrid private/public cloud solutions enable the on-demand extension of cloud-based resources. This flexibility enables responsive, collaborative engineering and asset management with its highly variable demand on

resources. Cloud platforms can be configured for high availability and provide close to real-time updates of information upon entry by the user. Security risks of cloud solutions are a concern but can be managed to a level of acceptable residual risk with appropriate measures.

Cloud platforms and software as a service (PaaS and SaaS) have introduced the concept of services, such as analytics, that the user can apply to his or her data, to study correlations or cause-and-effect relationships, thereby providing a significant improvement in productivity.

**3D Plant Model with Visible Context and Further Accessible Information**

The industrial IoT provides the possibility to monitor plant or equipment performance remotely. This domain is advancing in great strides, with secure and standardized connectivity lowering the cost and effort of developing applications and providing process and maintenance engineers with more opportunities for analytics.

## The Vision

Combining these technology trends with deep domain knowledge and the existing challenges discussed above, Bentley and Siemens developed a vision for an open, cloud-based solution for engineering and operations. The cloud solution – accessed through a browser – will federate data sources, provide functionalities in the form of microservices, and facilitate the management of the digital twin of the asset, throughout its life cycle. The solution will use

state-of-the-art cyber security, information segmentation related to user roles and role-based access, management of change, and data traceability and visualization.

## Data Sources and Data Access

The solution would facilitate the construction of the digital twin as a federation of data from many sources. This can include engineering databases, maintenance repositories, stored 3D models, 3D surveys, and photogrammetric information. Access to schedule, cost and other information accessible through ERP, recipe databases, project and portfolio management systems, LIMS and more would be provided via connectors. This approach of distributed data management, where every data point is interconnected, avoids replication, while providing consistency and accessibility. The data will be distributed through cloud services, as hybrid or on-premise instances, and utilize the users' local storage. The process would require very little IT integration.

In addition to information accessible on-line, there is a category of inaccessible sources, such as PDF documents, drawings or paper documents, and electronic data in legacy systems that can benefit a broader set of users, when made available. The portal would include intelligent services to help incorporate, analyze and connect data from these sources, also called "dark data." Functionalities to access this data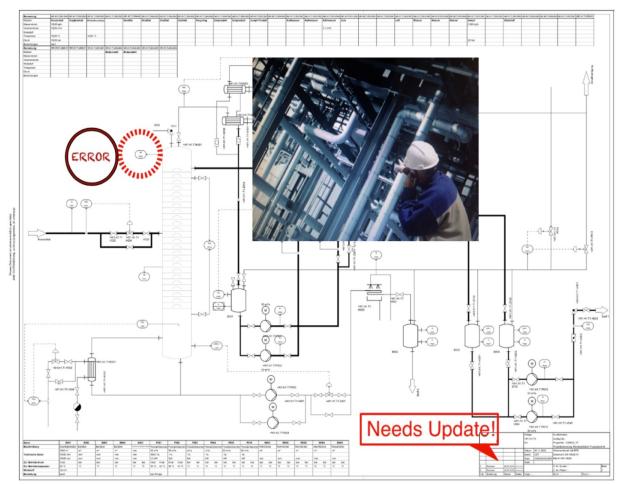 would include smart scanning to interpret schematics and drawings, reading from instrumentation and equipment lists, and linking diagrams with data objects describing the physical objects. Other software components would help extract locked data and making it available to those who may need it. As the data quality may be inconsistent, validation steps will allow the differentiation of useful data from poor data. Upon validation, the data can be linked to plant and data objects. In addition, the solution provides the possibility to add untagged plant information on field on his or her mobile device.

### Bentley Systems

Bentley serves infrastructure, cities, process industries, power, utilities and mining with digital engineering modeling capabilities throughout the lifecycle of the assets.

Digital engineering models can be used for design, structural analysis, construction planning, or asset information, integrity and performance modeling. Beyond engineering technology (ET) these models are also linked to information and processes in information and operational technology (IT and OT).

Bentley systems provides a range of products for the process industries such as OpenPlant, PlantWise, ContextCapture, AssetWise and ProjectWise.

These functionalities add context to "dumb data" and can considerably reduce the effort of building the digital twin and increase the percentage of documented asset information.

The solution will also provide separate views and environments to manage a plant in operation and projects on brownfield operations. It will separate data related to the project from characteristics, history, and records related to the operating asset.

The solution will provide capabilities for users to work off-line based on snapshots of asset information recorded at any point in time, with the possibility of subsequent updates synchronized on demand.

As a digital twin of the physical plant, asset information changes over time, and it can be important to compare the asset states at different points in time



**Intelligent P&ID in Context with Markups**

or to analyze its evolution. Therefore, the solution will provide the capability

to "travel" through the digital asset history.  The solution will help users maintain process simulations throughout the asset lifecycle, by providing the capability to associate a simulation with an asset information snapshot, for example at handover (as-built), and at every major plant modification.

### An Ecosystem of Applications and Services

The solution will be built as a set of microservices including collaborative process engineering and functional asset information management (that is, 1D information such as specifications and data sheets and 2D schematics), and 3D design and physical asset modeling (such as physical layout, positions and location). Furthermore, it will contain information management from asset and project management perspectives including maintenance history, reliability data and failure mode analyses, plus analytics services, and the capability to trace back versions. Many functionalities draw on software that both companies market today and their accumulated know-how and experience. The user will be able use pre-existing 3D plant models or projects authored in most available 3D design tools and mix and match those with models based on photogrammetry or 3D pointclouds to create a "reality mesh."

> **Siemens Digital Enterprise Software**
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> Siemens' software for industry covers the domains ideation, realization, and utilization. This includes project and portfolio management (Teamcenter), product data management, product lifecycle management, (NX, Tecnomatix, Simcenter, Mentor), Engineering and Asset Management System (COMOS), immersive operator training (COMOS Walkinside), manufacturing operations management (MOM or MES), programming and management of automation and field devices (TIA Portal), recently complemented by MindSphere, a cloud platform focused on industrial manufacturing.

The portal will accommodate the need for an up-to-date version of accurate asset data, critical to make correct maintenance-related and operational decisions quickly, as well as the requirement for historical snapshots, essential to engineering purposes and project progress reviews.

The solution will support project engineering for modernization, maintenance and overhaul in existing and operating plants. Multiple disciplines can simultaneously work on projects, each with their role-based views of the data and with appropriate workflows for reconciliation and conflict resolution. Reconciling the data in scenarios involving turnarounds as well as maintenance during operations are on the roadmap. The portal will support electronic workflows for collaboration with engineering, construction, and service providers, and allow reviews, red-lining and markups, and full authoring.

Services will provide analytics on the available information to monitor asset information quality and completeness, or to compare plant performance changes related to asset characteristics or plant modifications.

### Changing Business Processes and Digital Workflows in Ecosystems

Digitalization enables a tighter collaboration in increasingly complex ecosystems. The benefits of digitalization can only be realized when business and electronic work processes are adapted, and users are prepared for and supported during change. Supporting the industry in realizing the vision and the workflow changes needed, Bentley and Siemens are establishing a joint Process Industries Academy.

# Advantages and Benefits

Combining 1D, 2D, and 3D in a single environment provides functional context to physical representations and vice versa. The more "dark data" can be made visible, tagged, validated and linked to other available information, the more valuable and context-rich information will become. Access to operational, business and project, portfolio or product data management software will provide even more context.
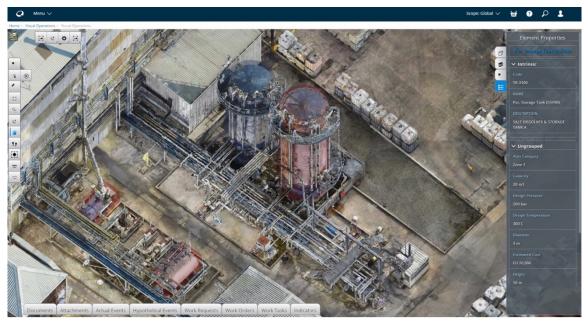
Context is critical for understanding the meaning of information and for acting appropriately upon it. The easier it is to update and complement asset information, the higher the degree of documentation of the asset and the more accessible the information will be. It is therefore reasonable to assume that the solution will speed up decision making because context is at one's fingertips and will improve the quality of decision making, and because more accurate information becomes available.

Making good and informed decisions can make the difference between a potential disaster and a smoothly operating plant. Consider all of the major industrial accidents over the past twenty years and how the lack of accurate contextual information may have played a part.

## Summary of Potential Benefits

There are many advantages associated with the use of software that correspond to the vision described:

The cost of owning and maintaining IT infrastructure to host demanding tools is reduced. The load volatility is handled in a cost-effective manner and can adapt to the users' needs without restrictions. With state-of-the-art security, cyber risks can be reduced to an acceptable level.



**A Reality Mesh Model with Functional Context: Highlighted Areas Are Identified Process Units with Properties (Image Courtesy of Bentley Systems)**

Operational and project-related information can be used side by side. All disciplines have direct access to information changed by colleagues in other disciplines and the time to find information is reduced substantially. Collaboration between engineering, operations and maintenance is facilitated. Configured workflows enable compliant, quality-controlled processes, projects, and document generation. Overall, this leads to productivity improvements.

The time and effort to federate and complete asset information, especially for brownfield installations, would be significantly reduced, plant documentation kept up-to-date to a larger degree, its quality improved, and this could help to better meet regulatory obligations. The traceability of information changes and data validations recorded over time will enrich context and enable objective assessment of the quality of the data. This, together with metrics on completeness of the data, informs users and authorities about the trustworthiness of the information.

By having higher quality information and more time to analyze it, maintenance and operational decisions and activities become more accurate and

improve reliability while reducing cost. Operational readiness can be predicted more reliably and be reached sooner. In addition, adequacy of actions in emergencies is improved.

The items listed above are mechanisms, each of which impact several bottom line benefits. For example, the reduction in time and effort to complete asset information reduces labor costs, or improves quality of work (or both), which could result in reduced operational risk, and improved asset utilization. If developing a business case, ARC would expect to find at least the following bottom line benefits with contributions from the items listed above:

- Improved operational and asset performance
- Improved engineering and maintenance efficiency
- Increased quality time for engineering and less time spent on data and IT tasks
- Reduced downtime, less equipment damage, and most likely a reduction in information-related incidents and accidents
- Reduced operational and IT risks

## Outlook

The vision described here is only the start of a journey. Gradually, more applications will be converted to cloud platforms in the form of microservices, enhancing the solution. One can think of the integration of operational data, operational intelligence dashboards, immersive operator training simulation and links with applications such as process screening and simulation, asset strategy and reliability applications, and more. The benefits of the environment will increase with the number of microservices.

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| **3D** | Three dimensional | **MOM** | Manufacturing Operations Management |
| **ERP** | Enterprise Resource Planning | | |
| **IoT** | Internet of Things | **MTTR** | Mean Time To Repair |
| **IT** | Information Technology | **NIST** | National Institute for Standards and Technology |
| **LIMS** | Laboratory Information Management System | | |
| | | **PDF** | Portable Document Format |
| **MES** | Manufacturing Execution System | **PLM** | Product Lifecycle Management |
| | | **ROA** | Return on Assets |