“DIGITAL TRANSFORMATION OF FACILITY OPERATIONS – CHANGING CORPORATE CULTURE AND ORGANIZATIONS TO INTRODUCE NEW WAYS OF WORKING”

ABSTRACT

Digital transformation and implementation of digital twins have been led by discrete manufacturing, such as the automotive industry and aerospace. While the process industries may not be leaders in the adoption of digital technologies and digital transformation, the trend has certainly now taken hold.

Digital transformation is at the top of the agenda for all executives across all industries - specially mining, oil & gas, energy and infrastructure, e.g.- and is considered a prerequisite to drive step changes in efficiency and ensure the survival of companies.

KEY WORDS

Digital Twin, Digital Transformation, Project Management, Operations, Maintenance.

INTRODUCTION

This imperative -Digital Transformation- also applies to the process industries; digital transformation in projects, operations and maintenance is being driven by lower CAPEX/OPEX expenditure and the need to deliver projects on schedule and to budget.

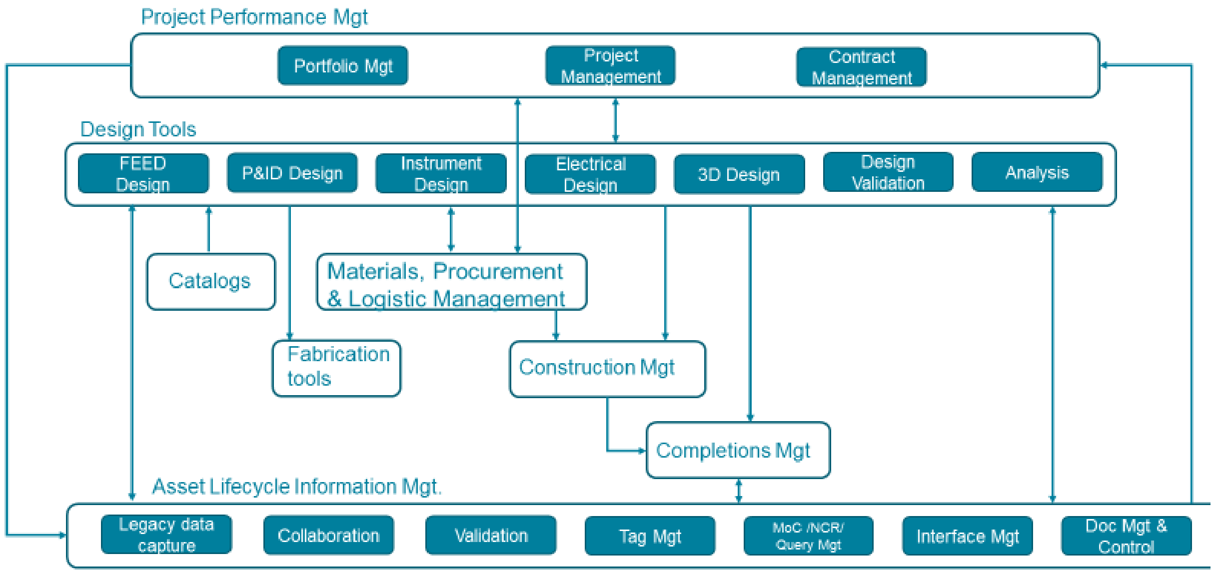
In capital intensive industries, for instance:

- 98% of mega-projects incur cost overruns or delays.
- With average cost increases of 80% over budget.
- Average slippage of 20 months from the original schedule.

The adoption of digital technologies can lower the costs and risks for construction, commissioning, hand-over and transfer to operations eliminate many of the costs and delays associated with handovers and ensure fit for operations deliverables. In oil and gas, future projects could have 50/30 percent less CAPEX/OPEX due to unmanned platforms, remote operations centers, and automated data collection lowering headcount. Additionally, these strategic investments can ultimately become profit centers beyond the traditional ROI paradigm, resulting in a greater return to shareholders/stakeholders for our customer organizations.

The digital transformation of projects is nothing new to us and our customers. During these 40 years, the technology -specially the Digital Transformation- has increased its participation and currently the industries -step by step- are being implemented with concepts/systems such as: data-centric design tools, rule-based design verification, and management of the end-to-end flow of data between tools. Solutions have been introduced to manage design, procurement, materials, construction, completions, hand-over, operations and maintenance, and portfolio, and project and contract performance.

The concept of providing a central, standards-based, consolidated repository for data and documents with workflow to manage project change, technical queries, and other work processes is now well established. Together, these technologies provide a continual chain or digital thread through the project from initiation to final handover, incrementally building a virtual representation or digital twin of a facility (exhibit 1). These innovations ensure that the correct information can be provided to end users in context of the work being undertaken to support making better decisions earlier and to avoid project delays and unnecessary additional costs.



(Exhibit 1 – Overview of digital solutions for project execution)

What is new is the maturing and convergence of key digital technologies such as artificial intelligence (AI), IoT, VR, AR, deep learning, big data, etc., that have already been successfully applied in other industries such as finance, automotive, and aerospace. Now these can be applied in the digital transformation of the process industries. The experiences of other industries have generated several initiatives looking at the application of AI and the other ones. One initiative is the automated resource planning/re-planning to fully optimize construction sequences daily. By analyzing millions of construction scenarios, there is potential to reduce construction costs by approximately 10 percent. Another example is the optimized, automated, 3D pipe routing with an AI system. This will replace rote 3D routing work after the logical connections (P&ID) and layout are defined. The benefits of this approach include project schedule acceleration through faster creation of the bill of materials for procurement and faster creation of detail drawings needed for construction work packages, more accurate bids and estimates, reduced 3D modelling effort, and quality assurance costs. It is through industry leadership in areas such as these that will ensure customer remains at the forefront of digital transformation of project execution in coming years.

The main drivers for facility operators are the need to improve operational efficiency and safety, as well as reducing costs to survive in an increasingly competitive environment while complying with an ever more stringent regulatory environment. At the same time, the technologies needed have become more available, mature, and proven in use.

In a recent survey of process industry executives, the top three challenges identified as facing their business are:

- Managing / reducing costs (67 %)
- New technologies forcing business reorganization / transformation (52 %)
- Managing people, systems, and processes (44 %)

These highly interrelated issues are seen as both opportunities and challenges; this can be illustrated in more results of the same survey, which show that 60% of respondents state that their company doesn't have a clearly defined roadmap for digital transformation.

This white paper will guide executives responsible for operating facilities through the process of how existing and emerging technologies can be adopted to digitally transform operations, improve efficiency, and reduce risk.

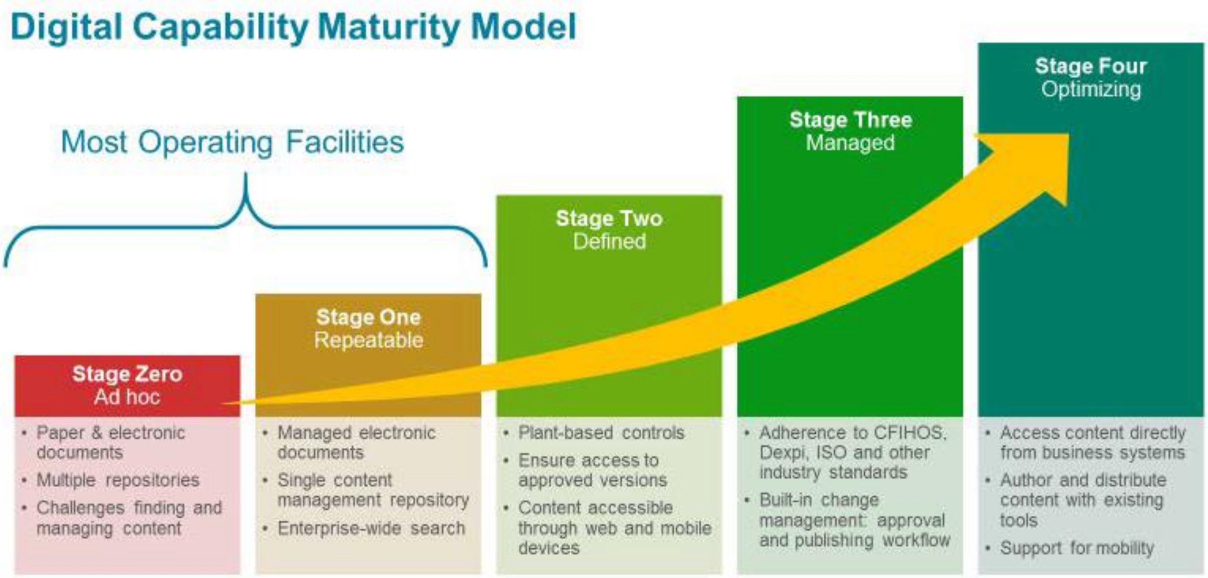
1. CAPTURING THE DIGITAL TWIN

The digital twin of a facility is a virtual representation of the physical asset. This digital replica describes how components are configured topologically and geographically, what chemicals and materials are involved, and how systems function. The digital twin can include both data and documents, but ideally documents are parametrically generated on demand from the underlying engineering databases, as our schematics tools today provide for loop, cross-wing diagrams, data sheets, single line diagrams, and 3D models for isometrics, arrangements, and layout drawings. Documents may come from a wide variety of tools - both PPM and third party - but be consolidated into a single, seamless digital twin with intelligent navigation between hotspots and all accessed through a simple web browser, with no need to install local software.

An ideal digital twin will include incoming real-time and historical sensor information, while using artificial intelligence (AI) and machine learning can create models that can accurately simulate the behavior of the physical facility. Advanced analytics can also be used with the digital twin to identify patterns not clearly visible by manual inspection to identify possible root causes of problems and support processes, such as predictive and prescriptive maintenance. A digital twin enables faster, better, more-informed decision making by providing access to accurate, up-to-date information in context. Maintenance of information in centric tools reduces the administrative burden and costs of maintaining large volumes of documents such as loop diagrams, single line diagrams, plot plans, arrangements, and isomeric drawings.

The digital twin can be leveraged by value-added work processes such as management of change, isolation of equipment for repair and maintenance and leak detection and repair (LDAR). A digital twin is a prerequisite to support remote operations and reduces the need to physically walk the facility, thereby reducing costs, risks, and safety concerns. The enrichment of the digital twin with real-time sensor data from DCS and data historians, maintenance management, and other operational systems provides an additional dimension not possible previously with asset information management systems. For example, the digital twin can be used to perform “what if” analyses to evaluate alternative facility modifications and optimization of turnarounds.

A digital twin describing the configuration of a facility is a prerequisite for digital transformation and the introduction of new, efficient, data-centric ways of working. Ideally in a greenfield project, a digital twin including all the information needed to operate, maintain, and modify a facility in a safe, efficient manner would be built up incrementally during the development project as part of the digital thread running through the lifecycle of a facility and handed over at the end of the project. This approach is the same when we talk about "Digital Transformation of Projects", as part of investment life cycle. However, most facilities today were built decades ago and have a very low degree of maturity regarding digital capability in operations.



(Exhibit 2: Digital Capability Maturity Model)

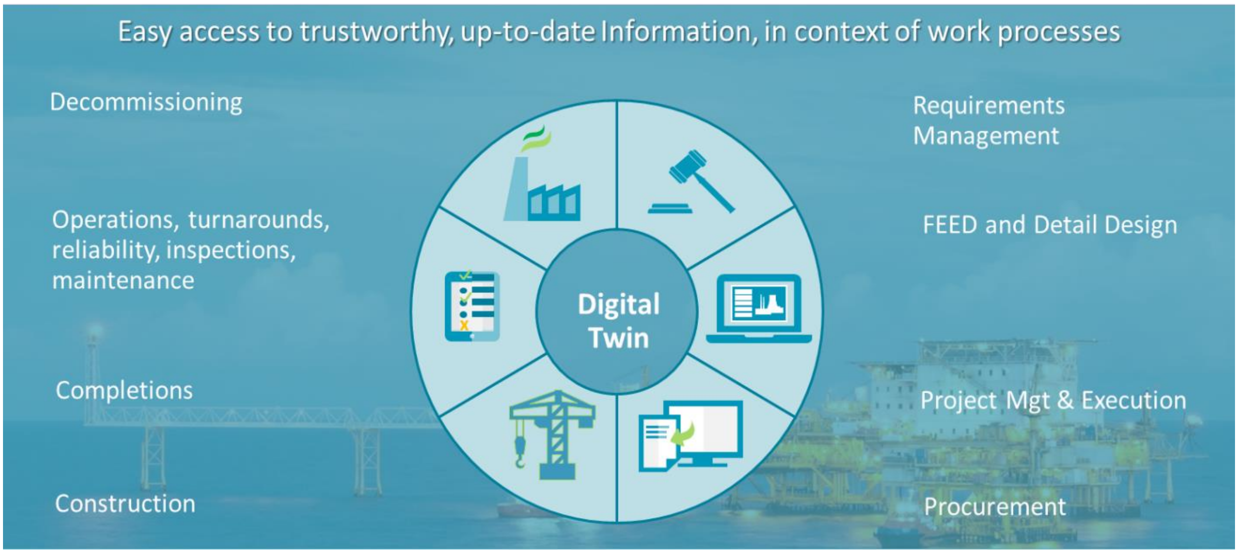
For these low maturity brownfield facilities, there is still the opportunity to create a digital twin, with technologies that can reconstruct in the following ways:

- Existing documentation in many different third-party formats can be scraped to capture tags and document relationships
- The geometry of the physical plant can be captured by laser scanning.
- Buried pipes and cables mapped using ground penetrating radar and data can be extracted from existing databases and spreadsheets.

Tag and document references in documents and drawings can be hot spotted and provide for simple end-user navigation between the different information within the digital twin. Once set up, the capture process is automated and requires minimal manual intervention. Where information is unavailable or likely to be outdated, data gathering can be done in the field using mobile devices, for example: name plate data and serial numbers can be collected, photographs can be taken, and drawings can be annotated in the field for update. Once the data and documents have been captured, they are placed in a staging area, consolidated to create an integrated digital twin, and validated against a range of predefined business rules prior to being loaded. Validation can also include verification of available documentation to check for missing identified tags and potential orphan tags in the digital twin. Data can be consolidated and enriched from legacy spread sheets or ad hoc databases.

The identities for tags and documents are often inconsistent; to address this, alias rule names can be established. For example, 21-PA-001 can have aliases of 21PA001, 21/PA/001 and 21-PA001. Processing documents will typically identify copies from multiple locations; semi-automated processes can help identify duplicates and help identify the best document to be used as the master in the digital twin.

P&IDs represent the single most critical document type for an operating facility, and accurate P&IDs are essential for safe and effective operations. Hot-spot navigation between tags on the P&ID and other data and documents provides an important navigation capability to key operations information and is available for both unintelligent pdfs, 2D CAD, or intelligent (data-centric) P&IDs. Many customers choose to invest in converting unintelligent 2D CAD or PDF P&IDs to fully intelligent, data-centric P&IDs that can be validated and provide intelligent data on the topology and systemization of a facility. Unintelligent 2D CAD P&IDs can be recreated in PPM's intelligent P&ID tool or can be converted gradually through hybrid or automated processes. The best option is to have fully intelligent P&IDs that can be verified against the 3D model to ensure consistency in topology between the two.



(Exhibit 3: Digital Twin Environment)

While most facilities do not have a current 3D model, the laser point cloud can be imported into our 3D modelling tool, and changes can be rapidly created in a hybrid laser cloud/3D environment for modifications, turnaround, and facility extensions. In this way, the 3D model can be gradually built up over time.

These various sources of information can be consolidated into an integrated digital twin in our asset lifecycle information management system (ALIM) and provide the end user with a simple web-based experience for seamless navigation.

Once the digital twin for a facility has been established, it must be maintained. The continual evolution of the design base from modifications, turnarounds, etc., needs to be reflected by managing the update of the digital twin. The ALIM backbone maintains the digital twin, including both data-centric metadata and documents through a zero-footprint web client that allows users to access and maintain data from anywhere through a simple web browser. Laser scanning using traditional, tripod-mounted devices or drones can be used to recapture the evolving state of a facility and compare it against the data in the digital twin 3D model.

2. INTEROPERABILITY

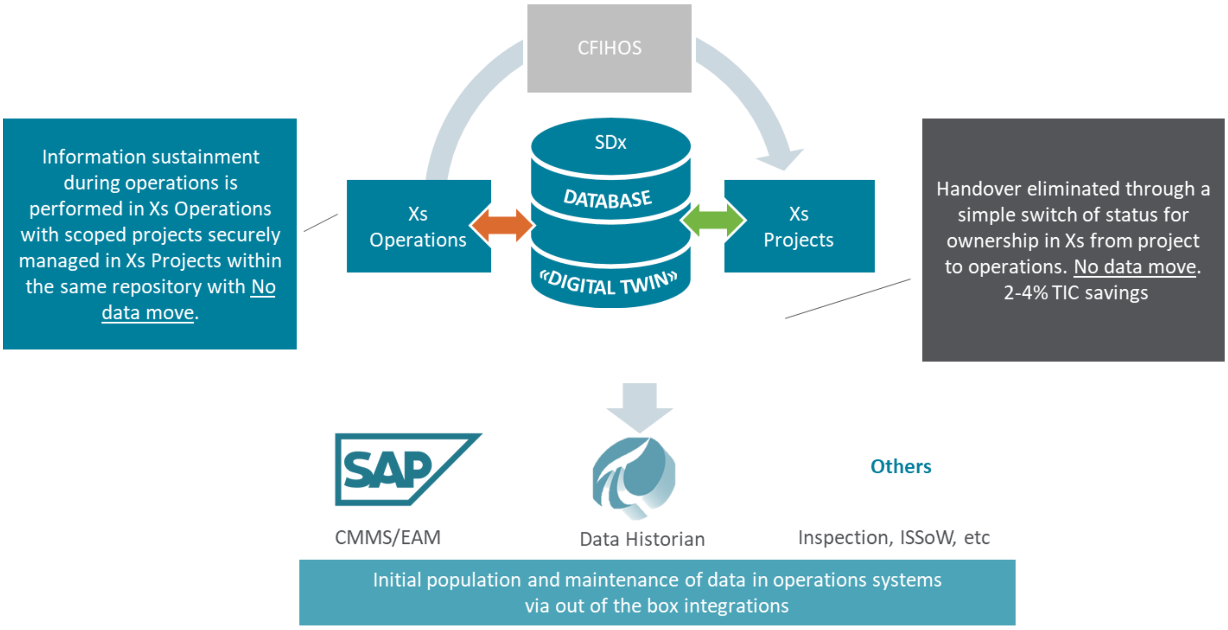
The digital twin needs to be open to both access information from other systems and to provide access to other systems. It cannot be an isolated silo of information; it should act as a bridge to other systems in the operations landscape. This should include:

- CMMS/EAM such as SAP® PM for maintenance history
- Data historians such as OSIsoft® PI System™ for real-time information, analytics, and trends
- Asset performance management systems for reliability
- Inspection systems for inspection history, edge computing for sensor data

The ALIM system that manages the digital twin provides access to third party systems through ODATA4 RESTful web service APIs. These provide highly performant, secure, and simple read/write access to the digital twin.

PPM's out-of-the-box interfaces currently include bi-directional data exchange with SAP PM that ensures master data synchronization between the digital twin and SAP PM. In SAP PM, the ALIM system tag registers are the master for Functional Locations (FLOC). The FLOC hierarchy in SAP PM and the installation/dismantling of equipment in SAP PM updates the equipment records in the digital twin. In addition, documents from the digital twin are displayed directly in the SAP PM interface to allow simple access to SAP PM users to the digital twin in context with a single click.

Integrations can be built to data sources external to the owner operator e.g. to external catalog equipment data sources such as SAP AIN (Asset Intelligence Network). For example, in the case of the abnormal flow from a pump, an alternate pump model with a higher capacity may be found and a plant change request created linking to the new pump type.



(Exhibit 4: Interaction and Interoperability)

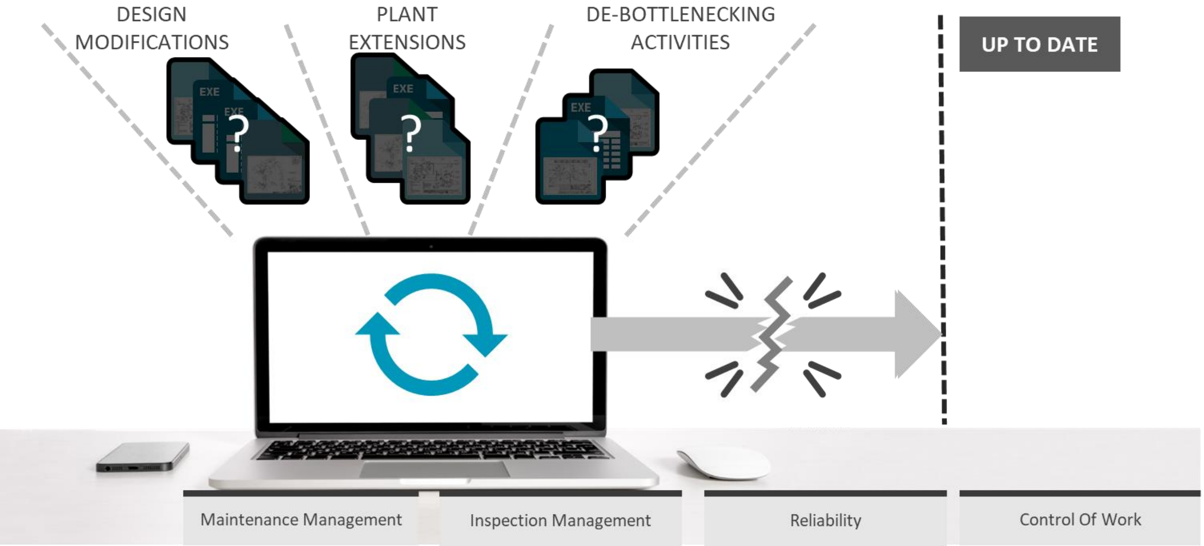
A similar bidirectional master data management interface is under development with OSIsoft to its data historian to maintain the asset hierarchy of the historian. This interface also allows for direct access to real-time and historic trend data from the digital twin without the need to unnecessarily duplicate data within the twin.

Interoperability with and master data management across other operations systems can be quickly established with other operations systems on an as-needed basis.

3. AUGMENTATION WITH ARTIFICIAL INTELLIGENCE AND ASSOCIATED TECHNOLOGIES

The augmentation of the digital twin with data from other sources such as data historians, CMMS, and inspection systems, coupled with advanced analytics (Artificial Intelligence, Deep Learning, etc.) provide the basis for identifying issues before they become a problem. This will allow proactive intervention. For example, abnormal vibrations from a motor or abnormal flow from a pump that is impacting production or will potentially impact production. Alerts can be sent to operations center workers and enable timely intervention in advance of an issue becoming a lost production opportunity or incident. The impact of a modification on the facility and equipment can be determined in advance of physical change avoiding costly mistakes.

Making the link between that data from the assets - such as a compressor, the live process data from the control system, the design data and the business data in enterprise asset management (EAM) systems (such as SAP), and leveraging that in an analytics tool to make decisions on maintenance, safety, and production - will make a real difference to facility operations.



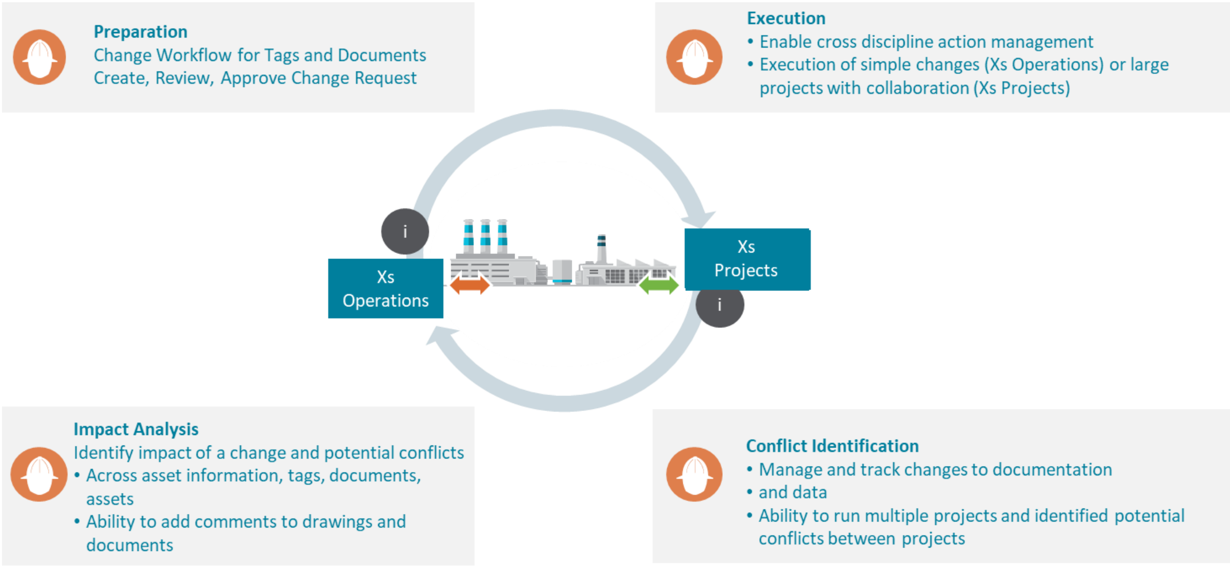
(Exhibit 5: AI and Operation Challenges)

4. LEVERAGING THE DIGITAL TWIN

The digital twin has an intrinsic value in that it provides a single point of reference for trusted information and enables better and faster decision making, but further value can be obtained by leveraging the digital twin in the context of work processes such as management of change, lock out, tag out (LOTO), permit to work, LDAR, process safety information management, etc. Intelligent 2D and 3D models and laser scans can be used to provide graphical reports that can be used together with data from other operations systems such as SAP PM, OSIsoft PI System, etc., where items in a maintenance package are located to determine the need for scaffolding, where motor tags are located are showing abnormal vibration to guide a technician, critical equipment items where maintenance has been delayed.

5. MANAGING CHANGE

Managing change to an operating facility is a critical and highly complex process for operating facilities. Changes need to be tracked through the review, approval, and implementation cycle to ensure that appropriate scrutiny of change proposal consequences has been made including health, safety, environment, quality (HSEQ) consequences. This is managed in the system by an automated workflow to ensure complete records are maintained, including who has been involved in each change and that consistent work processes are followed for the electronic management of change process. The digital thread identifying the chain of events impacting all objects in the digital twin is established for operations as described for projects when we talk about "Digital Transformation of Projects", as part of investment life cycle."



(Exhibit 6: Plant Operations Change Management)

Change on an operating facility is complicated in that changes do not occur in isolation. Multiple, simultaneous changes with partially overlapping scopes is the norm. Changes can vary greatly in size and duration, and responsibility for execution can vary. Our ALIM system manages this complexity and provides change impact analysis with graphical scoping and graphical reporting of changes. Changes are securely executed in separate areas of the system leaving the "as operated" digital twin undisturbed until it is complete and ready to be merged into the "as operated" digital twin. The concurrent engineering process is a process involved in detail into "Digital Transformation of Projects."

All changes to the digital twin are time stamped and no data is deleted, just soft terminated. This allows for complete auditable traceability of all changes to the digital twin and the unique capability to "turn the clock back" to any point in history to show the state of the facility as it was at that time.

The electronic management of change system reduces the administrative burden of managing change, reduces cycle time, provides improved visibility, and eliminates rework from change conflicts.

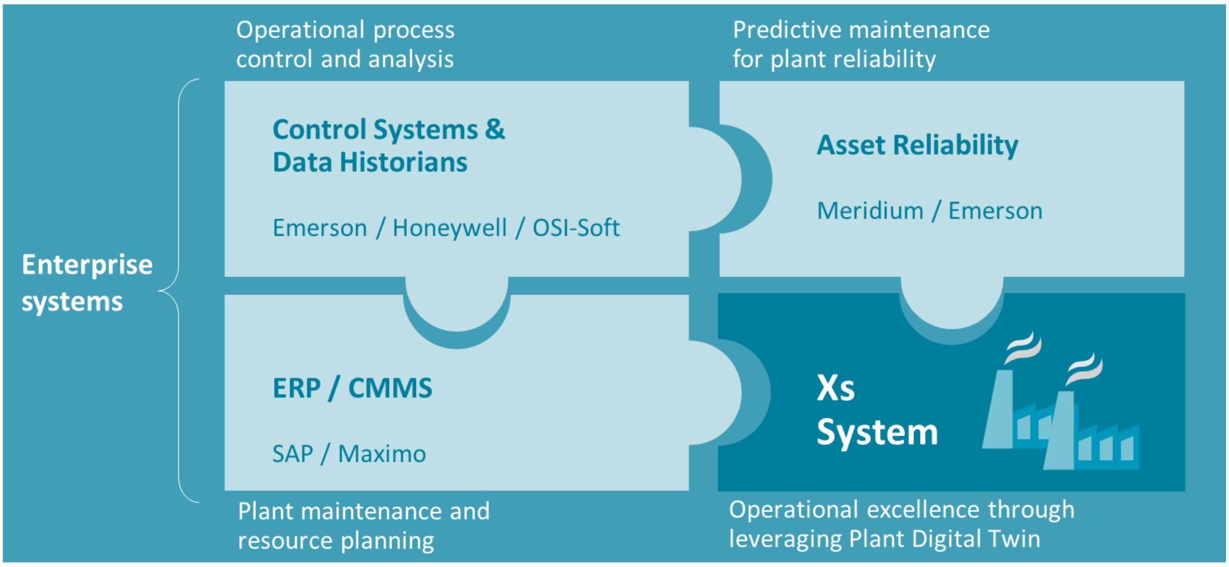
The electronic management of change solution workflow they chose to implement represented a major cultural change in the organization but resulted in significant benefits. The new data-centric process ensures a faster, more consistent change review, approval, and implementation cycle across all facilities. Reminders and alerts avoid delays and bottlenecks. Full auditable traceability of all changes is available. The linking of changes to tags, documents, projects, and other elements in the digital twin enables improved change impact analysis and visibility of other changes with overlapping or conflicting scope.

6. HANDOVER AND THE CFIHOS STANDARD

The digital twin system is based on the CFIHOS (Capital Facilities Information Handover Specification) for information handover which defines the data and documents required by owner operators including:

- Data required to populate operational software systems (maintenance, reliability, inspection systems, etc.)
- Data and documents required for specific work processes (operational readiness, lock-out/tag-out, leak detection and repair, inspection isometrics, etc.)
- Data and documents required for process safety management compliance
- The documents previously stored in multiple silos are now integrated and linked
- Information formerly locked within the documents is now accessible and searchable
- Plant documentation can now be viewed and accessed via a photorealistic laser scanned image of the plant

We have designed our solution so that additions necessary for specific customer, facility, or CFIHOS requirements can be quickly and simply included into our asset lifecycle information management system where the digital twin is managed.



(Exhibit 6: Handover Integral Managing System)

The optimal strategy on projects is to incrementally build the digital twin on a project from day one, validating data submissions from contractors and suppliers and only changing ownership at the end of the project. This approach avoids the typical 1 to 4 percent total investment cost associated with projects and is discussed in more detail when we talk about, “Digital transformation of Projects.”

7. ENTERPRISE WORKFORCE MOBILITY AND DIGITAL TRANSFORMATION

Mobile devices and apps have enabled digitalization like no other single invention. Being able to access any piece of data from anywhere has changed our lives, and now we can use that power to change our businesses and transform work processes. Digital transformation is only as powerful as the ability to get information to the user, wherever they might be, and it is critical that work process changes start with mobile in mind, not as an afterthought.

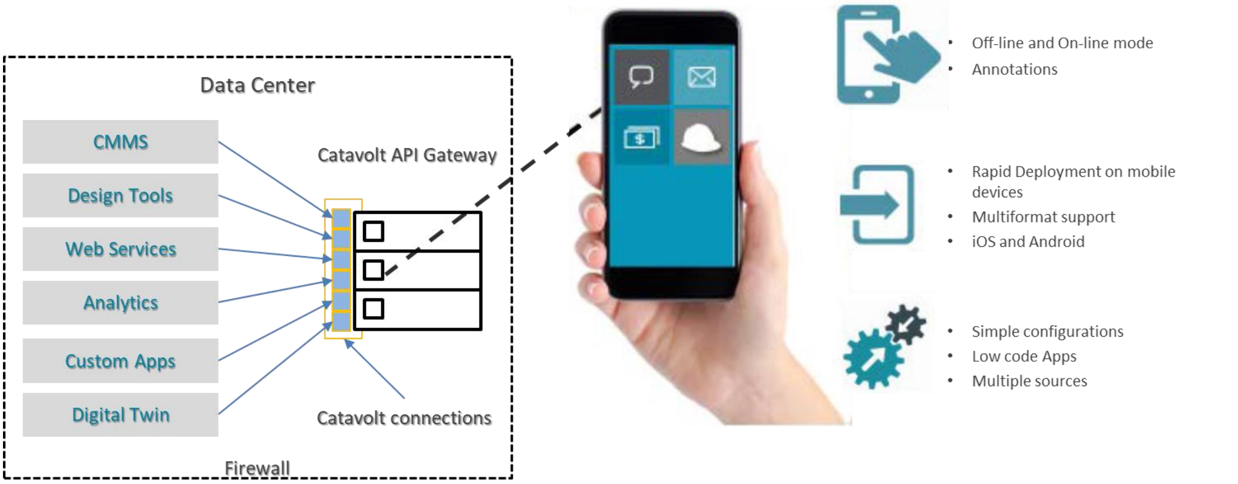
The availability of Class I Division I enclosures now allows us to use consumer mobile devices in the most hazardous environments and extend the edge of data to wherever the user is. Mobile is no longer restricted to just phones and tablets; wearables such as goggles (HoloLens), helmets (DAQRI), gloves, and vests are extending the ways in which data can be delivered to the end user. Safety on a job site can be enhanced by combining wearables with the digital twin and Industrial Internet of Things (IIoT) so that employees on a job site can be mapped against dangers and real-time observations; for example, users can be alerted as they enter areas where work is ongoing or where they are not authorized to work. During incidents, the locational capabilities of mobile devices can be used to identify where workers are and guide them to safe muster zones or guide rescue teams to incapacitated workers.

Mobile solutions can be used when building the digital twins for capturing name plate data for equipment, verifying P&ID topology in the field, or geotagging the laser point cloud. Once the digital twin is established, it can be leveraged by developing electronic work processes that serve workers with relevant data in the context of the work they are performing on mobile devices.

The spatial relationship of mobile is powerful. Combining real-time images and maps with 2D and 3D models or laser scans creates immersive experiences that are important for designing, training, construction, and safety. Mobile apps can guide a user to a work location, by providing 3D model or laser scan information, field workers can make the right decisions such as which valves to close or open in an isolation sequence. Quality can be enhanced by accessing visual instructions, taking pictures and videos, and performing visual verification.

With enterprise mobility, it is important to recognize that the needs of a user sitting at a desktop are different than those of a mobile user. What might be reasonable on a desktop seems long or cumbersome on a phone or tablet. While quantities of data might be manageable on a desktop platform, the need for quality data is greater on the smaller platform. The design of mobile apps needs to be designed closely to meet the exact context of the work to be performed in the field. Digital transformation creates a volume of data not available before; the temptation might be to throw that data at the end users. However, it’s important to not overwhelm the process with unnecessary data. “Less is more” in the design of mobile apps.

For each work process, specific apps are needed, and this requires a mobility platform that can quickly create and modify mobile apps based on user feedback. Digital transformation is not a once-time process but a process of continual improvement. The mobile platform provides a zero/low code capability to develop cross-platform mobile apps using subject matter experts without the need for IT specialists. Apps can be adjusted quickly, and changes are immediately available to end users.



(Exhibit 7: Mobil Platform for Enterprise Apps)

Mobile apps typically require combining information from the digital twin with information from other systems - such as CMMS systems - to provide the right, contextual data to the field worker. The mobile platform is capable of easily creating compound apps where, for example, a 3D model or laser scan from the digital twin can be combined with a maintenance work package from SAP PM. Data can be viewed together and data updated in the separate systems. This cloud-based orchestration capability through readymade connectors to systems in the operations application landscape support rapid deployment and digital transformation of traditional work processes.

These mobile apps can typically significantly improve wrench time and avoid delays while workers locate the right information, capture work done accurately to avoid sending crews to do work already done and improve the quality of work undertaken.

8. CONCLUSIONS

Digital transformation is both a great opportunity and challenge to owner operators. Those who build a robust strategy and move quickly to take advantage of the digital twin and new ways of working will achieve a competitive advantage. Digital transformation is not restricted to new greenfield facilities; brownfield facilities can also retrospectively build a digital twin that is a prerequisite to undertake digital transformation. While there are costs associated with establishing the digital twin and undertaking digital transformation, the rewards for faster and better decision making, improved efficiency, and reduced risk are far much greater with a ROI typically under two years. While primarily a technology provider and partners can assist owner operators in developing their digital transformation strategy, developing ROI cases and determining the impact on existing working processes and organizations.

Enterprise workforce mobility is a critical element of digital transformation. Operational performance can be enhanced by providing real-time data on a device with the ability to gather better, more accurate data that will be used to increase wrench time and long-term up time.

The maturing and convergence of many key technologies such as artificial intelligence (including machine learning, data mining and digital neural networks), augmented connectivity, sensor and data fusion, image and video analytics, visualization, robotics and drones, edge computing, blockchain, and many more open unlimited opportunities. Robotic inspection, drone-based spectroscopic LDAR, and remote operations are all available or will become mainstream in the next few years.

While required technologies are available, the challenge of changing entrenched culture and working practices should not be underestimated. All these technologies rely on and leverage a high-quality digital twin to enable improved automated identification of anomalies and recommendations to be made to operations' control centers and reduce the need for manual walking of the facility.

Digital transformation is far more than providing faster access to existing information and documentation. There is a point at which there is no further advantage; it is as fast as it can be. The human is the slowing factor here. It is time we let the plant "think" for itself. The goal for owners must be a self-operating plant. That is still futuristic, but with the new technology, we can put you on the path of that ultimate vison, if your goal is to maximize the value of your assets and increase your margins.

Digital transformation demands continual improvement and evolving cultural and procedural change. While it is important to start by having a strategic end goal in mind, it is possible to start small by making limited improvements. Operators can digitize part of a facility in relation to a turnaround and then scale up as experience is gained and benefits can be demonstrated. Or use existing OPEX budget to gradually, year by year, create the digital twin of offshore assets. Whichever approach is chosen, now is the time to embark on your digital transformation journey.

In a typical CAPEX/OPEX lifecycle, the capital project (CAPEX) part is usually short term compared to the much longer lifecycle of the plant/facility operations and can incur significant costs over the operational life of the plant. Applying the concept of the digital twin to operations represents a major change and optimization of operations, for instance:

- 10% to 30% reduction in engineering hours, therefore, Avoiding Design Errors, Improved Control of the Performance of EPCs and their Deliverables
- 5% to 10% reduction in build costs, so that, Avoid Errors in Materials, Increase Traceability and Eliminates Incoordination in Purchases due to Changes in Engineering
- 20% to 50% reduction in hand-over hours, minimizing, Avoid Errors in the Construction Process Sequence, Improves Re-planning in Detail, Facilitates Construction Change Management, Avoid Rework in Start-up, Avoid Cost Overruns and Delays and Anticipate Handover Errors

- 3% to 5% in maintenance hours, Avoiding Mistakes and Lack of Information and Minimizing Cost Overruns in OP/M Change Management

The concept of digital twin will change the business model for operators where advanced analytics based on technologies like machine learning and AI can predict, prescribe, and optimize the operation of the equipment and processes and connect the virtual with the physical. Hexagon PPM's digital twin solutions can provide their operations customers with a completely managed and optimized environment based on merging virtual engineering with physical facilities and the intelligent edge.

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