

The Path to Perfect Project Performance

Digital Transformation of Projects



Introduction to Digital Transformation

Digital transformation is at the top of the agenda for all executives across all industries and is considered a prerequisite to drive step changes in efficiency and ensure the survival of companies. This imperative also applies to the process industries; digital transformation in projects is being driven by lower CAPEX expenditure and the need to deliver projects on schedule and to budget.

In capital intensive industries, 98 percent of mega-projects incur cost overruns or delays, with average cost increases of 80 percent over budget and average slippage of 20 months from the original schedule¹. The adoption of digital technologies can lower the costs and risks for construction and commissioning, eliminate many of the costs and delays associated with handover. 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.² 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 Hexagon PPM and our customers. For over 40 years, we have provided 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 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 (figure 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.

What is new is the maturing and convergence of key digital technologies such as artificial intelligence (AI), 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. Hexagon PPM leverages the experience of other Hexagon divisions and our corporate R&D center and already has several initiatives looking at the application of AI. 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 Hexagon PPM remains at the forefront of digital transformation of project execution in coming years.

1 McKinsey & Company

2 How Digitalisation May Drive A New Golden Decade for Majors, MORGAN STANLEY & CO. INTERNATIONAL PLC 28 March, 2018

ARC Emphasizes the Importance of Digital Twins with PPM Solutions

Dick Slansky, ARC Senior Analyst for Engineering Design Tools comments:

“As all industries move forward with a digital transformation specific to their engineering and process, nowhere is it more important to get this right than with major capital asset projects that involve very large budgets and an expansive scope of work. A digital transformation for large CAPEX projects must involve a comprehensive and complete digital

thread and digital twin that will connect and provide access to all project stakeholders across the design/procure/construct lifecycle. This digital thread must connect all engineering design, construction data, and project data and information for the EPC and all suppliers and contractors. Hexagon PPM provides a complete set of solutions that delivers on the digital twin and digital transformation needed in today’s CAPEX environment.”

Let’s look in more detail at what we are delivering to ensure project success today.

Project Selection and Front-End Engineering Design or Loading (FEED/FEL)

Owners have resource constraints. A critical decision which impacts the efficient operation of the facility and ultimately the financial health of the business is the proper selection, funding, and monitoring of projects and portfolios.

Ideation can have genesis from any number of sources, from operations, maintenance, asset management, regulatory requirements, safety, and others. Eventually, these ideas need to be collected and evaluated in the context of on-going projects and resource capacity. Prioritization for authorization and funding typically relies on financial metrics such as ROI, NPV, and IRR as well as scoring of qualitative factors such as safety, strategic alignment, and risk.

As ideas are collected and evaluated, they enter a stage gate process which allows for a controlled approach to project progress and provides opportunities for re-evaluation, adjustment, or off ramps as project assumptions are clarified or business and market conditions change. Our portfolio management solution provides a platform and tools for idea collection, evaluation, authorization, and funding sanction, as well as

for evaluating resource capacity and managing risks and the stage gate process. The stage gate process over arches the project lifecycle. It begins with project selection and leads into FEED/FEL as an early stage.

FEED/FEL is the most critical part of an asset’s lifecycle and where most of the project costs are determined. In this stage, the process technology and facility configuration are planned and the efficient construction and operation are determined. To implement these plans properly and to assist the owner in deciding to invest in a plant, expansion, or modification, it is critical to ensure all pieces of the puzzle are properly accounted for and configured, with safety being the top priority. Beginning with a proper design basis is a critical step in creating a solid conceptual design and enabling management to make an informed investment decision. Digitization initiatives represent a paradigm shift in that Project and Operational Excellence parameters are taken into consideration at the conceptual design stage.

Capturing and Verifying the Digital Twin for Brownfield Projects

Most existing brownfield facilities have little digital information available, but all is not lost. There are technologies and techniques available today that allow us to gather and consolidate data from existing sources to reconstruct the engineering design base and build a partial digital twin. Brownfield projects such as extensions and turnarounds are often a catalyst to initiate the reconstruction of a facility digital twin. This phase is crucial as it provides the basis and foundation for all that is to come at later stages and becomes a “single trusted source of truth” and to some extent displacing the older systems of record in Digital Transformation initiatives.

Laser scanning can capture the geometry of a facility to provide an accurate geometric basis for 3D modelling, the DCS system can be used to establish instrumentation data, P&IDs can

be converted from unintelligent 2D CAD files to intelligent P&IDs. The Asset Lifecycle Information Management (ALIM) backbone is used to capture legacy data for brownfield projects including information from unstructured documentation such as scanned images, Excel data sheets, and legacy point solution databases then extracting, validating and consolidating this data and documentation. We cover capture of brownfield legacy data to re-create the digital twin in more detail in our companion whitepaper “Digital Transformation of Facility Operations”.

Once the engineering design basis for the facility or part of the facility involved in the project is captured, it can be made available to engineers, contractors, and suppliers to perform efficient project engineering development.

Contractors and Materials Vendors

Projects rely on contractors and strategic suppliers. Partnerships with these vendors is put in place early in the project lifecycle and often even prior to the project. The contracts with these strategic partners establish the legal agreements between the parties that allow for business relationships and the delivery of services. These agreements include specifications how data will be exchanged

and establish the contractual framework for collaboration enabled by our tools. In addition to the contract side, the work progress and vendor deliverables must be managed, typically by someone who understands the work products provided by the vendors, as well as payment certifications. These operational processes are foundational to enabling vendor contributions to the projects such as FEED/FEL.

Integrated Design Development

Data-centric design tools have been a prime focus of Hexagon PPM and today we have a comprehensive suite of tools that take the input from process simulation tools and use this to perform FEED design to produce PFDs and pass this data through basic and detail design with the creation of P&ID data, instrument and electrical design, and 3D modelling. Traditional drawings and documents (P&IDs, loop diagrams, instrument data sheets, single line diagrams, arrangements, plot plans, isometrics, etc.) are replaced by reports generated on demand from the underlying engineering database. For brownfield facilities where no 3D model exists, a laser scan point cloud can be imported into the 3D model and used as a basis to model against.

Data is exchanged between design tools via a negotiated process such that data is not overwritten in discipline tools without express decision of the responsible design engineer. In this way changes such as changing the type of instrument on a P&ID for example will ripple through to instrumentation and the 3D model in a controlled fashion. The quality of the engineering design is ensured by using standard catalogs containing piping standards and other common bulk item definitions as well as design integrity rules that are available out of the box but can be supplemented by additional rules created by subject matter experts. These catalogs reduce errors in design, reduce variability in design, and the cost of MRO materials.

Our integrated design tools ensure a high quality, consistent design, reduce risk of errors, promote design reuse, and typically reduce design effort by 30 percent on projects.

Design tools exchange data and published documents through a central ALIM backbone where data is consolidated and made generally available to all authorized project stakeholders. Precedence rules determine which data from which design tool will be shown.

In the case of brownfield projects, we have the unique capability to manage data-centric, concurrent engineering. This offers the benefit that the “as operated” data is undisturbed for normal users while data is worked on in separate projects within the system by project personnel.

Projects vary hugely in size, duration, and responsibility. Once a project is complete, data and documents can be merged back into the “as operated” area and be available to all users. This is a highly complex process as items can be impacted by several changes in parallel and the data in the “as operated” area can change during the many months a project can take. Our data-centric concurrent engineering process provides visibility across projects, inconsistency reports to resolve conflicts and ensures that projects are notified when changes occur to the “as operated” engineering design basis that impacts them. These innovations ensure projects are not executed in a “silo” but take account of other ongoing projects and the evolving “as operated” digital twin reducing the need for costly rework and delays.

Asset Lifecycle Information Management (ALIM) and the Digital Twin

In addition to captured legacy information and data and documents published from Hexagon PPM design tools, project data and documentation are typically submitted from contractors and vendors. Our project collaboration solution (see text box) supports the planning, submission, validation, and review of information deliverables on projects. It supports both data-centric deliverables such as tag registers, cross references, 3D models, etc., as well as document deliverables such as vendor and contractor documents and drawings from a wide variety of third party tools. The digital twin of the facility is incrementally built up from information submitted from contractors and vendors as the project evolves. Complex relationships defining the digital twin configuration including those between design intent (tags), supplier models and physical equipment and facility breakdown by geography, system, discipline, and supply (PO/Contract) are managed in the ALIM backbone.

3D models from a wide range of suppliers can be converted and loaded into the system with the intelligence needed to support intelligent navigation with other data and 2D hot-spotted drawings and documents. Data can also be extracted from information deliverables submitted as unstructured documents and

drawings and consolidated into the digital twin using the same processes as for legacy information.

All project stakeholders: contractors, vendors, authorities, etc., can submit, view/navigate and mark-up information, create or update information and process workflows according to their access rights using a zero-footprint web client that just needs access to a web browser. Incoming data is held and validated in a staging area using the built-in validation engine prior to being released to the digital twin.

The review of project deliverables is automated by workflows, a patented process can use tag metadata to determine the appropriate discipline specialists to review each deliverable. All responses, actions and queries between project stakeholders are managed within the collaboration solution.

Our collaboration solution improves the efficiency of project deliverable review by 12 percent, reduces the cycle time by 50 percent, and helps reduce change orders by 10 percent by providing early visibility of issues that need resolution. These improvements result in savings estimated at \$53 million per \$1 billion CAPEX.

Project Collaboration at a Major USA Oil and Gas Company

A major oil and gas company based in the United States recognized it needed to improve its processes for reviewing deliverables and communicating with contractors on projects. The company wanted a system to help identify which documents were most important, based on design characteristics of equipment instead of document meta-data. When comments were sent back to the contractor, the company wanted to track progress instead of waiting until the next revision of the document to see if they were integrated. It wanted to be more consistent from project to project. It was important to

get the most from subject matter experts by providing them with a tool that works across projects and simplifies communication with the contractors. After trying multiple products that were already available, the company decided that working with Hexagon to develop something new was the only way to meet the objectives. After two years of hard work and refinement, the company deployed our collaboration solution on a very large project involving several contractors and thousands of documents. HxGN SDx™ Projects was born for collaboration out of collaboration between Hexagon and a major oil and gas company.

Materials, Procurement, and Logistic Management

Materials management is an important bridge between engineering, procurement, and construction (EPC). Starting with being a collector for all types of bill of materials as developed by our integrated design tools, a good materials management system can handle large amounts of data and integrate with various ERP systems such as SAP or Oracle EBS.

Automated, rule-based requisitioning from engineering BOMs is used to identify changes and transform engineering data into procurement data in the shape of a requisition. After requisitions are approved, procurement manages and typically bundles or splits multiple requisitions into one or more inquiries to get supplier quotations.

A web portal provides access to suppliers, subcontractors and freight forwarders so that they can respond digitally to requests for quotation and download/upload documents and provide information regarding prices and delivery schedules. The portal simplifies and accelerates communication between all parties. Based on incoming bids, the buyer will award one or more supplier and cut a purchase order or release.

Once the purchase order or subcontract is placed, progress is followed up by expediting and inspection visits are planned and coordinated.

Suppliers provide packing information for approval by the traffic department. Freight forwarders provide shipment details.

Once materials arrive at the construction site, a mobile application (barcode, RFID) is used to register receipt, transfer of goods, locate material, create picklists and inventory management.

The materials management solution provides information for construction management on the material status for construction planning and execution. Materials costs must be monitored and controlled as this is 50 percent of TIC. Integration between the materials management system, projects performance, and the ERP financial accounting system allows cost accounts, requisitions, purchases orders, and actual payments to be linked so commitment values can be monitored closely against planned budget values and quantities.

Our materials management solution helps to lower greenfield and brownfield project costs, compress schedules, improve risk management, and enable companies to act globally to maintain advantage in a highly complex, international, and competitive market.

Fabrication Tools

Our fabrication tools include a unique bottom-up approach to control the complete production process within yards and fabricators, based on Industry 4.0 concepts. This proven solution contains all functionality for the work preparation, part nesting, and numerical control (NC) generation with load balancing for material and resources in a single integrated solution.

Our solution integrates with 2D/3D design, schedule, material management, and the robotic machines on the shop floor. The solution considerably increases material and resource utilization, manages remnants, improves

schedule and material flow, and significantly reduces the man-hours required in the work preparation process. Significant material optimization can be achieved. Real-time feedback from shop floor machines and workstations to provide valuable insights on work progress at any given time.

During fabrication, increased use is being made of laser scanning to capture the state of fabricated modules and verify these against the design intent in the 3D model to ensure that assembly will proceed smoothly and identify any issues as early as possible.

Construction and Contractor Management

Using current information from 3D models, 2D engineering tools, materials management, project controls, and scheduling systems, our construction solution ensures that accurate and timely decisions can be made on the most up-to-date information needed for optimized construction planning and execution. During design, even before mobilization is considered, advanced work packaging (AWP) can begin. AWP can be used to align the entire EPC process to ensure efficient construction sequencing with minimized risk and maximum productivity. Users can view and filter 3D models and drawings with enhanced 4D animation to verify the construction sequence with powerful new pre-configured filters and selection rules for a 3D model.

Rule-based early construction planning and management of the construction work package (CWP) schedule and supportive documentation is provided. Subsequent breakdown of CWP and constructability of installation support work packages (IWP) includes 4D animation and links to drawings and documents as well as constraints in the IWP. Ability to provide the planner with information regarding an IWP's constructability before issuance to the field to ensure the sequence of the IWPs are conflict free and make logical sense and to check availability of material.

Installation work packages can be downloaded to a mobile app for offline usage. The mobile app makes it easier for field crews to connect with

the home office and allows users to view, update, and monitor the work package from the field in real time. This delivers significant efficiency and improvements in executing a work package with less paper, along with cost and time savings. Carryover work can be delivered into completions management.

These simple construction tools can typically help save 10 percent of construction costs on projects.

Contract management, contract change management, and project budget change management are just as important during construction and installation as they are during the design and procurement phases. The projects performance solution provides the ability to compare actual installation quantities and hours with total scope planned values. Productivity and performance can be monitored and rolled up for management-level views. Progress can be aggregated and combined with progress from other departments for a total project perspective. When change occurs, as it inevitably does, projects performance provides the tools to manage the change with separate but integrated functionality for project change and contract change and integrations with to the procurement and contracts solution.

Completions Management, Digital Twin Handover and Project Closeout

Our cloud-based, completions management solution can work in a stand-alone environment or integrated with the larger engineering and project eco-system. It provides visibility of completions throughout the full lifecycle of industrial projects, both large and small. It creates a foundation of information with traceability and accountability for care, custody, and control by managing the turnover requirements and ensuring a seamless transition to operations and maintenance. It focuses on the collection and re-use of best practices to eliminate (or greatly reduce) the “re-creating the wheel” from project to project, while providing consistent planning, execution, and completions reporting.

The solution consolidates asset information and verifies installation, testing, and performance of all equipment, instruments, piping and control system IO points. Using advanced “work packaging” utility, companies are empowered to develop all disciplinary work packages at a fraction of time and cost from the traditional approach. The combination of cloud and mobile applications (online/offline), Smart Forms technology (digital forms), along with modelling techniques, will enable a company to deliver higher quality reporting with reduced effort. The flexible platform will ensure system integrity while delivering the end-product that meets ISO specifications or higher standards.

The digital twin built up during the project is automatically available for both the project and operations and provides a platform for maintaining the digital twin during the operations phase of the asset lifecycle. This means that the digital twin is carried forward intelligently through each stage of the project avoiding the need to transfer or recreate information and eliminates the need for final project handover to operations. This uninterrupted digital thread eliminates the typical 1-4 percent total investment cost associated with handover and the source of many potential delays in project execution and operations start-up.

Once the project is complete, it must be closed out financially. This includes closing contracts and purchase orders and settling claims through the procurement solution. The project may continue to accumulate costs. When all costs are finalized, the projects performance solution can aid in identifying the asset account book transfer value and the asset transfer work process as well as the management of the overall project closeout work process. Finally, project costs can be consolidated and archived or fed back into the estimating historical database to close the cost cycle and be leveraged for future estimates.

Our digital twin 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

It details the final destination for all data and documents to be handed over from contractors. This also details the form and format of load files required to keep operational software systems evergreen.

Conclusion and Digital Roadmap for Project Transformation

Hexagon PPM offers today an extensive suite of solutions that manage project performance, integrated design, materials management, procurement, logistics, collaboration, fabrication, construction, and completions to optimize efficient project delivery and incrementally build the digital twin for effective, safe operations.

From the initial stages of ideation through to project closeout, a digital thread is continuously maintained through all processes. The digital twin is incrementally built up during the project and then handed over “in situ” saving the cost and delays commonly encountered in final handover to operations.

Operations can continue to maintain the digital twin in the ALIM system with fit-for-purpose operations management of change and other processes.

Hexagon PPM experts are available to assist your organization explore the “art of the possible” to digitally transform your projects for optimized project execution and prepare for digitally transforming your operations.

Our R&D efforts continue to further explore digital technologies to improve project effectiveness, including:

- Object-based integration through ODATA4 restful APIs where tags automatically flow between design disciplines based on design maturity rules
- Object rather than file-based graphics to further improve visualization performance and graphical reporting
- Airborne drones to monitor and measure construction progress against reported progress and plans
- Artificial intelligence to optimize, standardize, and ensure the integrity of design across areas within a facility and across projects.
- Enterprise workforce mobility, provided via low code/zero code platform that can offer cross platform mobile apps and cross-application orchestration, enabling project stakeholders greater access to the digital twin during the project and to capture information and respond to work processes in the field.





Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's PPM division empowers its clients to transform unstructured information into a smart digital asset to visualize, build and manage structures and facilities of all complexities, ensuring safe and efficient operation throughout the entire lifecycle.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 20,000 employees in 50 countries and net sales of approximately 3.9bn EUR. Learn more at [hexagon.com](https://www.hexagon.com) and follow us @HexagonAB.