OIL, GAS & CHEMICALS

Guide for designing, building and operating a digital facility

A digital facility significantly improves operational efficiency and safety while minimizing cost and risk.

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Why you should read this guide

This guide is aimed at decision-makers involved with the planning, designing, building and operating of a digital oil, gas & chemicals facility. It focuses on the most significant considerations offered by digitalization which might be overlooked with traditional methods of designing and building a new facility or upgrading an existing site to become a digital one.

The guide highlights specific technologies, processes and working practices with which decision-makers may not be familiar, as companies move to embrace the power of digitalization to improve profitability and minimize risk.

It is, in effect, a checklist outlining new practices and considerations while drawing attention to potential pitfalls that those unfamiliar with digitalization may experience.

We encourage feedback. If you have any queries or would like to discuss any part of the planning, designing, building and operating of a digital facility, please refer to back page for contact details.

What is a digital facility?

We opt for the term “facility” to be synonymous with a variety of sites including plants and processes across the entire hydrocarbon industry. Other terms used widely throughout industry include digital plant or smart plant.

The one common line running through each definition is the concept of connecting machines to work faster, more efficiently and in collaboration with one another. It is all about connectivity. Now, more than ever, the facilities have become heavily reliant upon the connectivity possibilities between equipment and the automation that it can provide.

Industrial Internet of Things
At the heart of the digital facility are a host of terms including the Industrial Internet of Things (IIoT) and Industry 4.0 which can be defined as how physical components are connected and networked together using an Internet connection. Software written for these products can then be used to optimize performance.

Collaboration the key to improved productivity
Digital facilities use collaboration within, and across, sites as well as between operators and suppliers to optimize performance throughout the lifecycle.

These digital facilities do away with disjointed silos of excellence and instead ensure best practices are deployed throughout.

As a result, digital facilities are safer and more reliable along with being more agile and more profitable. They are also more environmentally sound.

Planning, designing, building and operating a digital facility
This guide focuses on the planning & designing, the building and the operating of a digital facility, as considered in Figure 1.

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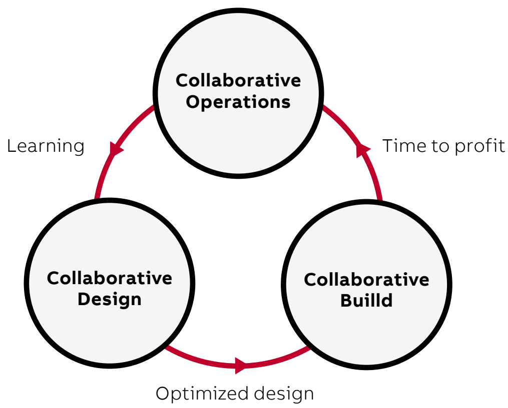
Figure 1.



Design

- EICT integration planned from the start, leveraging well-proven design specifications
- Better balance between project and operational objectives
- Cloud engineering where appropriate, automated data management and digital twins

Build

- Decoupling software and hardware build to permit late changes and digital marshalling for more efficient commissioning
- Digital twin for training to further accelerate start-up

Operations

- Insights from Big Data and digital twins to guide decision-making for process and yield optimization, cost minimization and safe performance
- Automating wherever possible and using predictive maintenance
- Remote support from headquarters and supplier organizations

The 5 things that really matter

Here we highlight 5 key areas that need to be considered throughout the planning & designing, building and operating phases of a digital facility. While there are other considerations, generally if any of the following is overlooked then a digital facility will be sub-optimal.

Standardization
Standardizing wherever possible lowers initial costs by simplifying designs and enabling onsite integration to eliminate factory acceptance testing and cut deployment time. It also makes facilities easy to maintain going forward. Where customization is absolutely needed, companies should build a prototype, test it and then mass produce it.

Open platforms
The use of open, but secure, systems also lowers initial and ongoing costs. More importantly, however, it helps maximize the use of any data collected as it can be more easily and effectively shared throughout the digital ecosystem created.

Automated data management (ADM)
ADM simplifies and standardizes design processes by using proven technological packages, accessible by all relevant parties in a real-time basis, to track changes, eliminate costly manual steps and reduce human error, even auto-generating application software and associated documents where appropriate. Once facilities move into operations, ADM ensures that information remains up to date and accessible whenever and wherever it is required.

Duplication minimization
Proven best practices should be used and shared to avoid reinventing the wheel and technology should be deployed to eliminate unnecessary duplicative work.

System integration
Comprehensive informational and operational technology (IT and OT) system integration is required for a digital facility to deliver efficient and profit-maximizing actions. First, there must be efficient data extraction and consolidation from different sub-systems (e.g. SCADA, MES, ERP) to one common repository where data is stored. Second, where necessary and appropriate, there must be a way of securely moving that data to the cloud in order to provide an integrated, and as close to real-time, overview and performance visualization of one or more facilities as possible.

Why invest in a digital facility?

A digital facility is a good way to future proof an investment. Such a facility collates data and turns it into information and knowledge that ensures maximum output at minimum operating costs.

Digital facilities not only cut costs, schedule and risk in the design and build phases but, longer term, they deliver greater profits through optimized operational costs and performance with increased productivity and safety.

As indicated in Figure 2 which is derived from various industry studies and ABB experience, digitalization can improve recovery rates and start-ups while decreasing maintenance and lost production hours.

And, as seen in Table 1 which highlights ABB's real-world achievements for oil, gas & chemicals companies, digitalization offers significant capital and operational expenditure benefits.

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Figure 2.

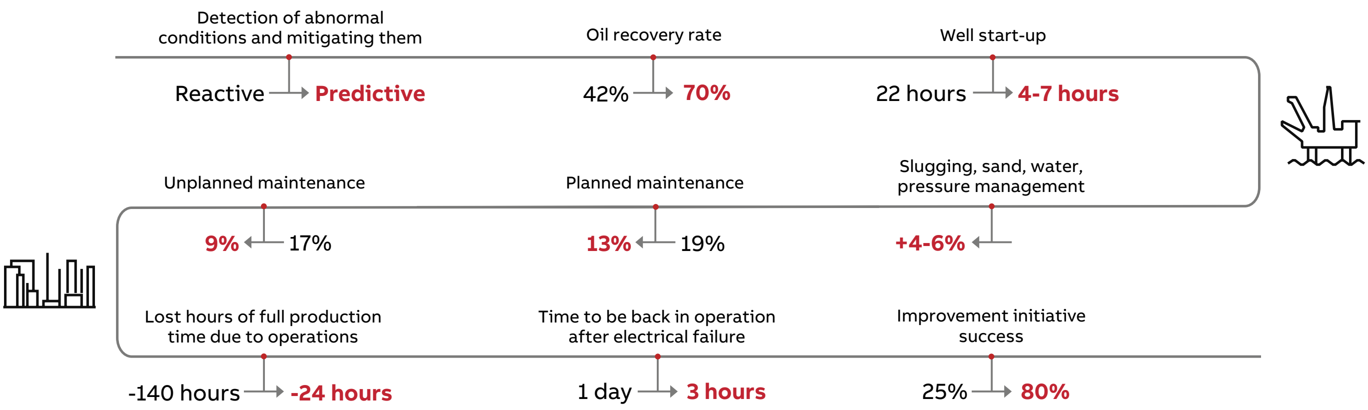

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Table 1.

	CAPEX benefit	OPEX benefit
New project execution	• 20–30% reduction potential in greenfield CAPEX • Up to 25% quicker schedule completion and 40% fewer start-up and installation hours	• The more operational considerations are factored into the project execution phase, the greater the benefits during operations
Automation and productivity	• Brownfield capital projects have similar savings as above if using digitally-enabled approach and single-source integration • Up to 60% space savings through flexible automation • Minimized weight and accommodation requirements	• 20-30% OPEX reduction potential and up to 20% improved uptime along with extended TAR intervals via simplification from integration and predictive analytics • Up to 20 year extension of facility lifetimes along with 5-10% increase in production and field recovery • Optimized number of people on board and minimized human error
Connectivity	• Up to 20% IT infrastructure cost reduction if designed into the project from the start	• Reduced retrofit cost for cabling and IT along with up to 10% cost reductions from reliable and scalable infrastructure • Efficiency from automated data transfer with minimal risk by being cyber secure by design
Maintenance	• Priority monitoring list optimizes budgets: knowing what to maintain or replace, when and how	• Up to 50% cost reduction through predictive, instead of time-based or reactive, maintenance
Workforce management	• Reduced commissioning costs by 20-30%	• Improved productivity of smaller operating and maintenance crews, supported remotely by internal or external experts • Greater safety using technology to monitor people working on assets and up to 50% alarm reduction through intelligent applications which reduce unnecessary costs and hazards

Planning and designing a digital facility
5 critical steps to take

A significant portion of project-specific documents are generated during the design phase. These include functional design specifications, detailed design specifications and test specifications. The design phase is also when standard designs, types and templates are selected, produced, agreed and fully tested with the end-user/customer.

The idea is to maximize re-use and produce as many deliverables as possible during the build phase. This approach minimizes the amount of project-specific design work required.

The following 5 steps are critical to planning and designing a digital facility that is cost-efficient, is built on time and is safe and reliable to operate.

1. Plan for greater system integration from the start

Challenges
For a digital facility to work in any capacity, the electrical, instrumentation, control and telecommunications (EICT) products and systems must be integrated from the start to ensure that each is using data from a consistent source.

More than ever before each of these disciplines are interdependent. This is reflected, for instance, in the use of fieldbus protocols such as ProfiBus/Net, FF, Hart, IEC61850. Such interdependency is needed to achieve one connected system, from edge to cloud or on-premise smart solution, that will support:

- Unmanned/autonomous operations
- Predictive maintenance
- Process safety management
- Process power management
- Collaborative operations

Actions
To achieve one connected system, a company needs to:
- Identify one company that is capable of designing, supplying and/or integrating the EICT infrastructures. This company is referred to as the EICT contractor throughout this document.
- Engage with that company at the earliest possible opportunity and ask relevant questions about infrastructure to start planning integration efforts.

Benefits
The benefits include:
- Achieving greater cost and time savings compared to integrating just one of the component elements
- Minimizing integration risks
- Maximizing efficient data flow

2. Select an EICT contractor during FEED

Challenges
For integration to be a success it is important to identify and engage with the EICT contractor early in the process. One concern is that by giving all EICT packages to one company, the overall cost will not be competitive.

Actions
Simulated tender: To test the competitiveness of the EICT contractors, end-users should prepare a simulated EICT package early in the FEED and ask the incumbents to tender.

Frame agreement detailing price structure: Once selected, the EICT contractor provides a frame agreement for hardware and software services comprising prices that are fixed, pro rata and unit price lists. During the EPC phase, the cost estimates produced by the EICT contractor are adjusted using this frame agreement and used by the EPC(s) to generate the purchase orders.

Engage operations staff earlier: Staff tasked with operating the digital facility should be engaged in the project much earlier than they are now. Without their input, digital facilities risk being designed in ways which optimize short-term build costs at the expense of long-term operational expenses.

Benefits

Engaging an EICT contractor early on can lead to significant capital cost savings. For instance, an EPC may lack detailed knowledge of one aspect of the EICT from a vendor. To compensate for this, the EPC may produce a design with excessive spare capacity and safety margins.

For example, in the electrical design, excessive short circuit capacity is often specified. Yet the EICT contractor can typically achieve a 20 percent cost and space saving by applying their know-how to generation and load impedances and creating a compact, balanced design.

3. Assign the right roles and responsibilities

Challenges

Avoiding duplication is vital and requires a clear understanding of roles and responsibilities for content verification.

EPCs should avoid over-specification and instead focus on orchestrating the project from a high level, leaving the granularity of each EICT discipline to the chosen contractor.

Actions

Early engagement of the EICT contractor (Step 2) and ensuring end-user, EPC, EICT contractor personnel are integrated from the start (Step 1) ensures clarity about each person's role and responsibility.

The division of responsibilities between the EICT contractor and EPCs for each phase of project execution should be defined in the project responsibility matrix developed during the FEED phase.

The EICT Project Manager, along with the client's project management team, will be involved with the development of these matrices.

For guidance, the flow chart in Figure 3 offers a proposed structure that helps identify each party's roles and responsibilities.

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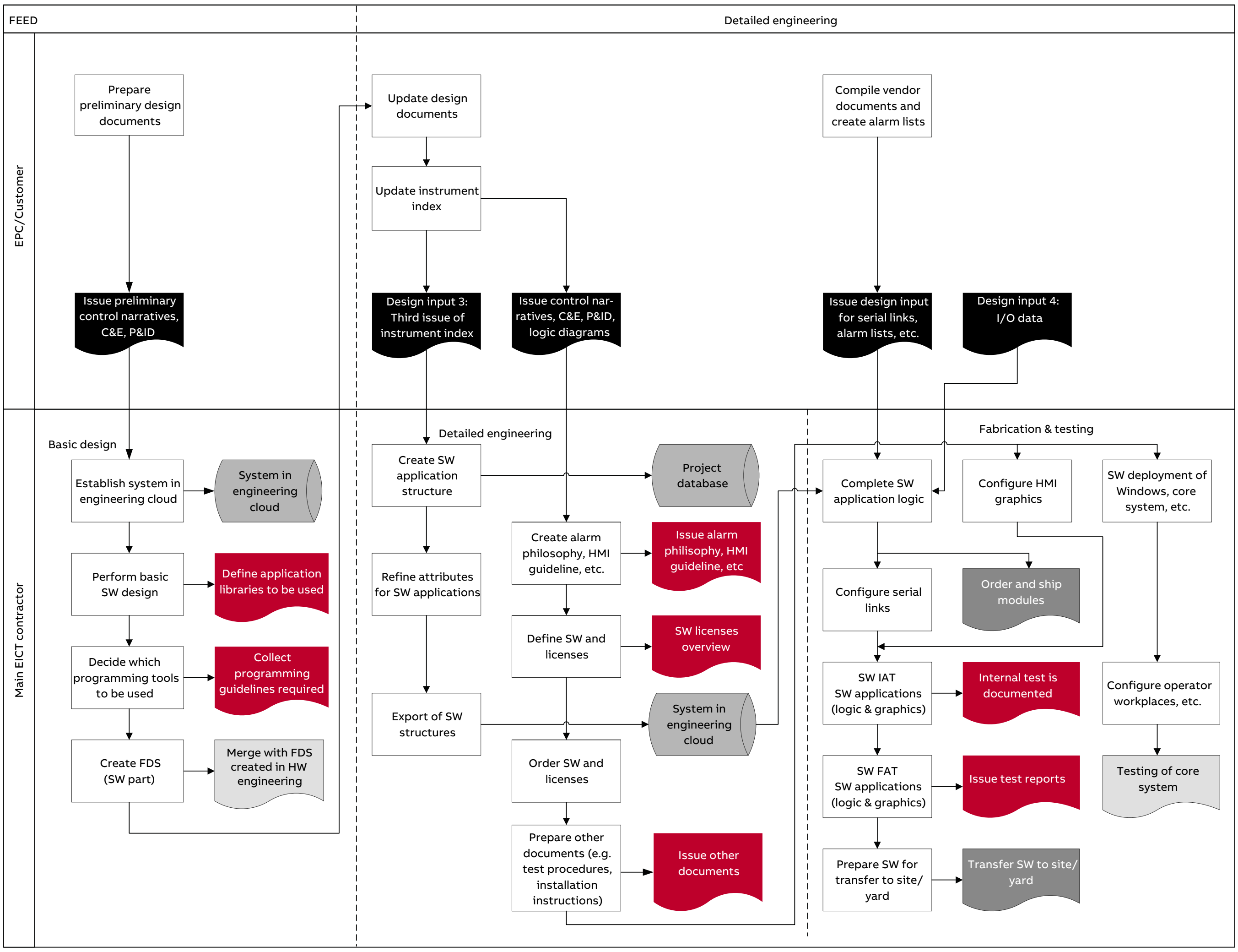
Figure 3. Engineering workflow in the planning and design phase. The specific division of responsibilities, as well as the further detailed content of the matrices, may change from one project to another based on the client and the contract scope.



C&E: Control & electrical; P&ID: Piping and instrumentation diagram; SW: Software; FDS: Functional design specification; HW: Hardware; HMI: Human machine interface; IAT: Internal acceptance test; FAT: Factory acceptance testing; I/O: Input/output.

Benefits
With correctly assigned roles and responsibilities the benefits include:
- Cost control, thereby improving profits for EPCs and end-users
- High levels of facility safety

4. Understand what digital technologies and innovations are available

Challenges
EICT technologies are becoming increasingly interdependent so it is even more critical to choose a supplier that implicitly understands integration.

Actions
Understand and embrace virtualization, emulation, simulation and cloud computing, where feasible, along with digital twins and digital marshalling.

Digital Twins – Here data from the common engineering database is used to create a virtual replica of the process, so that the control, safety and electrical software, operator interface etc. can be designed on this model. Other users may include a 3D model of the facility, document databases etc. in the digital twin, which would represent different aspects or layers of one common digital twin handled by a common data management system. A low- or high-fidelity simulator can use the process data to simulate the behavior of the facility in a cloud environment or appropriate on-premise environment if cloud computing is not an option. This allows companies to test the software, operator interface, safety logic and pre-tune the system, without requiring the hardware. This removes the cost and time associated with coupling up simulated I/O for functional testing of the application software.

Digital marshalling or using soft marshalling, flexible I/O and standardized cabinets means companies no longer have to specify detailed I/O configurations for the hardware. It also paves the way for virtual commissioning during the build phase where process models, or digital twins, can be used to significantly boost the value of functional testing. Such models provide highly realistic feedback thus reducing the frequency and likelihood of on-site changes.

With earlier generations of hardware, it was necessary to specify the different quantities of I/O (such as analog in, digital out 4.20 mA, 24 V, Hart etc.) before system fabrication. Now these systems use one type of I/O channel that can be individually assigned to a particular type after fabrication. Thus, controllers can be standardized on a handful of sizes e.g. 500, 700, 1000, 1500 I/O, eliminating the need for specific hardware design and for the traditional CPU-I/O-marshalling-field termination cabinet.

Standardization, open systems and automated data management (ADM) all play a role. Standardization, for instance, is one of the biggest elements in driving down the cost and reducing the time spent during the design phase, through increased familiarization and reducing the need for training with respect to bespoke project-specific designs.

ADM manages the overall project engineering workflow by allowing project managers to efficiently deal with inevitable change requests such as modifications to the customer supplied data.

Such tools electronically track project progress and use the current status to ensure that the right people in the engineering process are quickly informed of any changes and are immediately linked to the data that has changed.

The classic approach of document transmittal, document control has been known to cause repeated and time-consuming revision cycles.

Benefits
It is essential to apply innovative technologies to lower risk and cost, while shortening delivery times. The main benefit from shortening automation project delivery times is to move automation engineering off the project schedule's critical path. Lowering the risk leads to lowering the overall cost as seen by the end-user.

5. Deploy an enabling business model

Challenges
An expensive piece of equipment or technology might add cost in the project phase but more than pay for itself over the facility's lifetime. For example, investing in digital twins early on not only helps optimize the planning and design phase but it also sets the facility up for improved performance once operational.

Unfortunately, most project budgets do not allow for investments in such performance-enhancing technologies to be made so early on. Trying to fit them in at the operational phase is often costlier and more difficult.

Another barrier to realizing digital's full potential to streamline effort and cost lies in EPCs currently having the full responsibility along with legal liabilities for projects. There is little incentive therefore for EPCs to embrace an approach with a single EICT contractor overseeing the creation of a fully connected system, as opposed to themselves.

Additionally, proof of delivery often relies on outdated methods, such as wet signatures. Such practices limit the benefit potential of the ADM, mentioned earlier.

Actions

This disconnect between project and operational priorities needs to change, with funds and priorities realigned, or the full opportunity offered by digital will be missed. After all, by designing with a digital twin, we have the base from which to deploy predictive maintenance, digital safety management, remote and/or autonomous operations and so on. And, by doing this, companies can reduce both initial and ongoing CAPEX cost as well as OPEX.

If the issue preventing this concerns re-allocating upfront capital expenditures, an alternative being explored on the market today is to consider subscription-based contracts with suppliers instead. This moves the cost from CAPEX to OPEX.

Benefits

A truly successful digital facility improves short-term profits while at the same time facilitating a lower total cost of ownership across its full lifetime.

Changing commercial business models to reflect operational needs in the planning phase will enable the paradigm-shifting results outlined on page 6.

Building a digital facility
5 key priorities

Remote and parallel work practices are two significant milestones that define the speed and efficiency by which today's digital facilities are constructed.

Engaging early in the design process with an EICT contractor (see page 7) can help bring traditionally separate bid packages under one roof. This also ensures an integrated approach from the start, making sure that products and systems talk with each other and deliver the information needed at the right time.

This streamlines the build process while laying the foundations for a smoother operational life.

Building a digital facility is characterized by prioritizing five key elements.

1. Fully utilize the engineering skills offered by the EICT contractor

Challenges
Traditionally, the EPC oversees a wide assortment of sub-contractors, each of whom have their own engineering solutions, and then uses third-party system integrators for back-end support at commissioning and start-up. This can result in a mix of EICT packages that are somewhat disjointed, increasing risks of failure when integrating everything together.

Actions
A sole EICT contractor acts as the system integrator and manages the interfaces, delivering

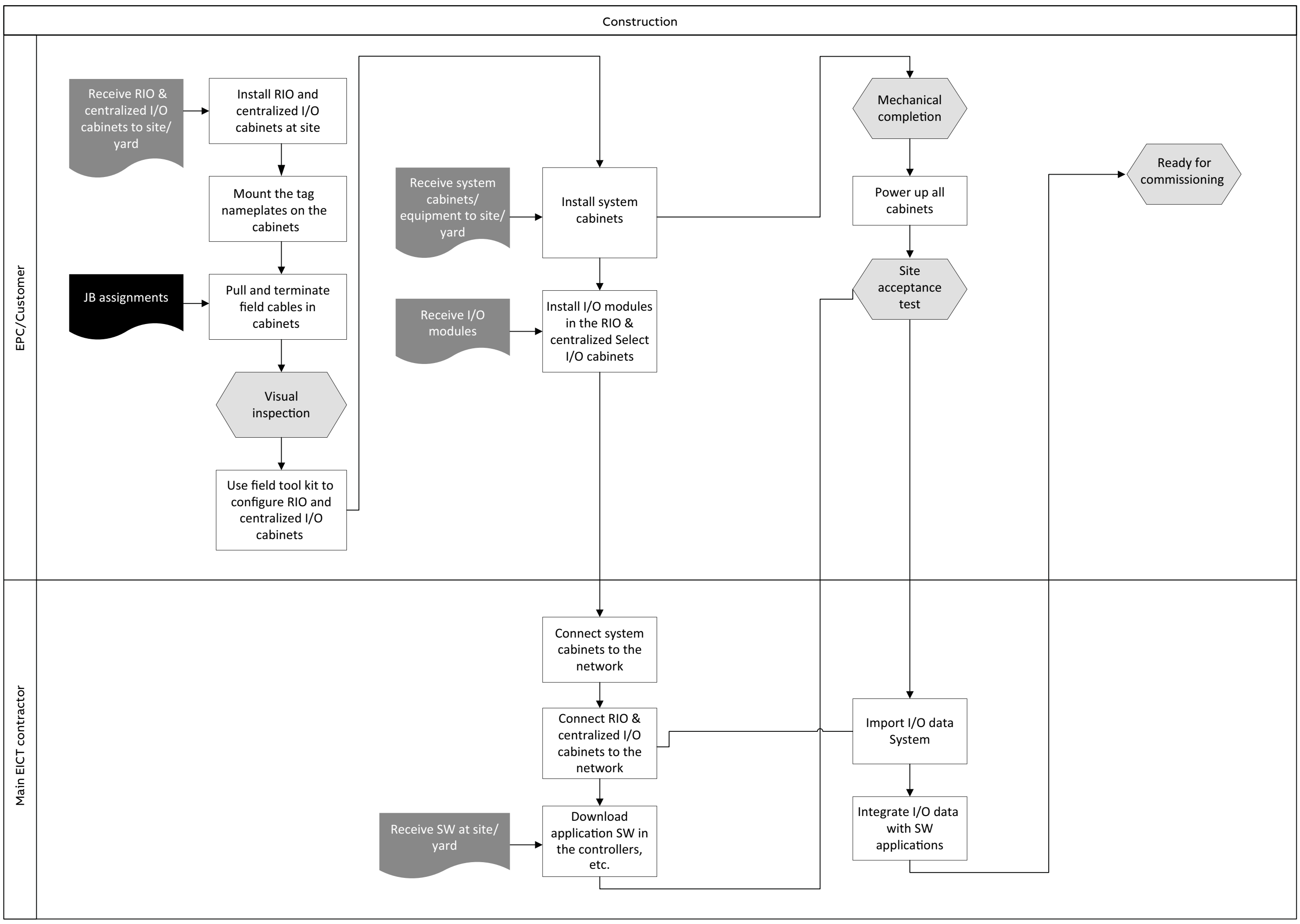


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Figure 4. Engineering workflow in the building phase. As with the a similar diagram shared in planning and design, the details will vary by project but the general principles hold true.

RIO: Remote IO; JB: Junction box

the back-end support at commissioning and startup – and beyond – along with providing single source of accountability for this entire scope of work. See Figure 4.

Included is the interface responsibility for mechanical and software packages connected to the EICT such as compressors, potable water, third-party data historians etc. This ensures consistency between these packages even if multiple EPCs are involved in the project.

Benefits
Using a single EICT contractor typically cuts time by:
- Avoiding a multi-vendor tendering approach for each of the major scope packages
- Having a more efficient start-up and commissioning process

2. Capitalize on digital marshalling

Challenges
In traditional facilities, the hardware engineering, such as field cabling design, and the software engineering, including I/O allocation, are inextricably linked and result in a serial workflow with numerous iterations. This entails the use of expensive junction boxes and cabinets to marshal the I/O signals in multi-core cables towards a particular programmable controller I/O system.

Actions
Decouple hardware from software engineering
By decoupling the hardware from the software engineering, (see page 9), the digital facility sees the hardware shipped to site and tested independently of the application software, which is now tested in the cloud where feasible. Traditional system staging and testing is reduced.

Digital marshalling
The software and hardware elements are plugged together much later in the project build using signal names (tags).

Benefits
Digital marshalling eliminates the need for:
- Project-specific junction boxes
- Armored multi-core field cables
- Marshalling cabinets

Meanwhile, additional signals and changes to signal types, such as from digital to analog, can be accommodated far more easily with less cost and schedule impact.

A digital facility sees the hardware go through a 100 percent electrical test at the factory and be shipped directly to site. Thus, the final selection of hardware can be much closer to delivery, reducing the impact of late changes. Such late changes have often reached 20-25 percent which is hugely expensive in terms of cost and quality.

> In a digital facility designed using digital marshalling, digital twins and cloud engineering, the amount of on-site commissioning can be reduced by up to 70 percent as many of the tests no longer require physical presence at the site.

3. Use flexible I/O wherever possible

Challenges
Conventional I/O can be costly and time-consuming to implement.

Actions
To significantly reduce cost and time implications, more use needs to be made of I/O interfaces that are based on fieldbus or industrial Ethernet.

Soft marshalling to multiple programmable controllers via an industrial Ethernet I/O network can be applied to:
- All the I/O signals coming from foundation fieldbus (FF) devices connected via FF HSE (High Speed Ethernet)
- Third-party process packages
- Low, medium and high voltage electrical equipment (LV, MV and HV)
- I/O signals coming from 0/4...20 mA analog and 24 VDC binary field devices

Benefits
Hardware is then significantly reduced and greatly simplified compared to using conventional I/O, as the I/O signals effectively become marshalled in software.

Standard junction boxes containing smart configurable I/O become smart junction boxes. These can be procured from stock and installed in any convenient location. Field devices are simply cabled to the nearest smart junction box.

The I/O loops are quickly and efficiently tested and verified by taking advantage of digital communication technologies such as HART.

4. Leverage the digital twin

Challenges
Changes decided within the building phase might have unanticipated consequences during actual operations.

Additionally, familiarizing staff on a new facility or process can be time-consuming and with varying results, depending on initial skill levels of the local staff. If the training is started too late or is not comprehensive enough, this can lead to delays or issues when beginning operations.

Actions
Using a digital twin early not only helps simulate the entire process control side of a plant enabling companies to better predict, plan and budget during the design phase, it also helps evaluate proposed changes during construction.

It is also useful in terms of application testing and training. Such training should occur 6 to 9 months before the actual facility start-up to allow for feedback and questions as well as to provide opportunities for improvement areas were identified.

Benefits
In this way, by the time the digital facility is ready for the purpose of start-up and commissioning, companies are a step ahead and are likely to experience fewer teething issues.

5. Set up a team dedicated to commissioning, start-up and transfer to operations

Challenges
Quite often, the smarter, digital solutions are not fully utilized in the early days of operations because they are never commissioned. This is usually the result of pressure in the later stages of projects to meet the start-up deadline, putting priority on only the systems critical to get the facility started.

Furthermore, because digital technologies evolve faster than traditional EICT solutions, the systems included in the design may no longer be relevant as other enterprise-level tools or improved solutions may have been introduced in the years since they were designed.

Actions
Be agile in terms of evolving technology and avoid locking down too early in the project lifecycle to benefit from technology advances later in the build and operate phases.

For instance, ensure that the intrusive sensors are included, but select the intelligence required later.

Design a flexible modular system that enables you to plug in the needed digital services and analytics when needed.

It is advisable to set up a dedicated commissioning team, familiar with the latest digital tools and services and who can work with the operational support and facility management teams to get the digital solutions commissioned and ready to deliver value from the start of the project.

Benefits
Setting up such a transfer team maximizes the chances that, up and running, the facility:
- Has most appropriate and up-to-date technology
- Actually uses the planned digital solutions thereby optimizing operations as intended

Operating a digital facility
9 strategic considerations

Early engagement with the EICT contractor will result in the selection of correct technologies and the application of new business models. Combining these elements in the plan and design phase will improve performance.

The result will be a facility that is using the right data from all the OT and IT products and systems and turning this into the right information for use by the right job function at the right time.

If certain elements have been missed, or you are trying to make an existing, traditional facility with various legacy systems smarter, then you will need a software and/or service pack which can unify complex industrial languages and serve the data.

There is an extensive range of innovations, technologies and services that ensure traditional facilities run safely and profitably. Here we highlight the key principles and a selection of technologies that carry the greatest impact in operationalizing your digital facility.

1. Optimize data routing through the most appropriate method

Challenges
Smart devices, IoT sensors and instrumentation with built-in intelligence and connectivity must be able to push data to both a control system and to the cloud where appropriate.

Actions
Ensure that there are connectivity solutions for safe and secure data collection to, and in some cases from (provided it is traceable), the cloud environment , where relevant, including IoT gateways, control systems and edge devices (closest to the data source). See Figure 5.

There should be edge analytics both inside and outside the control system as well as on and off premise cloud solutions, as best suits the individual situation.

Benefits
Appropriate data routing helps maximize speed, efficiency and security.

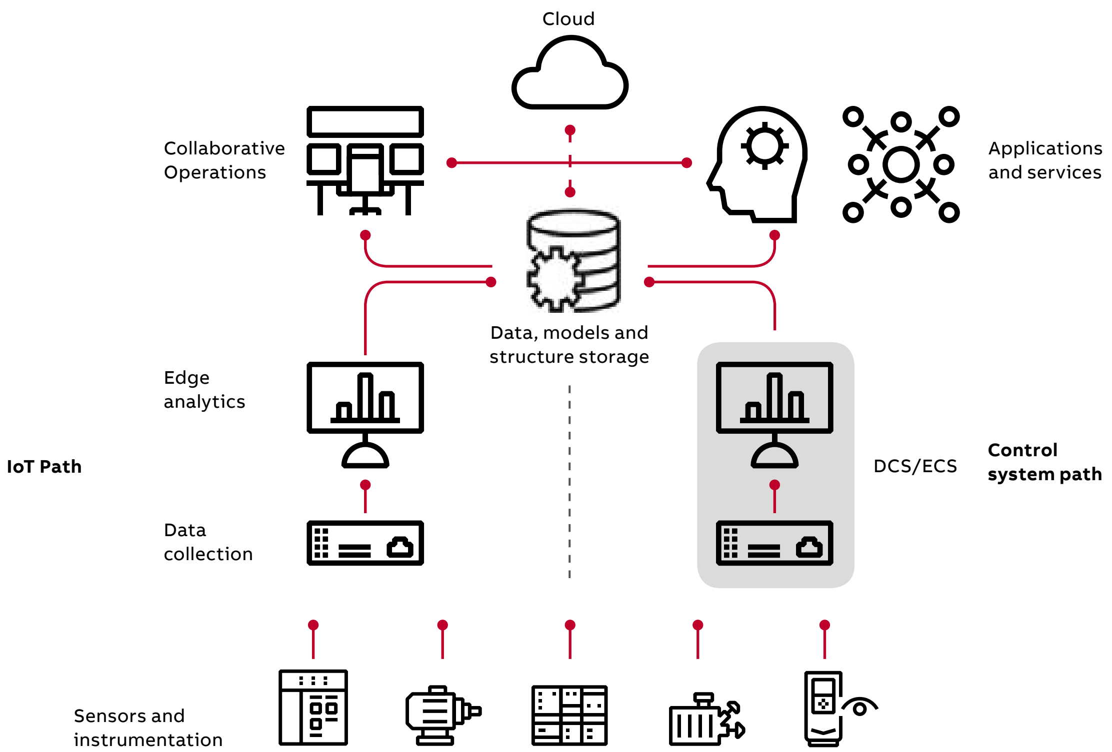

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Figure 5. Data routing in a digital facility

2. Maintain a high level of cyber security

Challenges
Weak passwords and poorly engineered computer security systems can malign a facility's access and/or process control systems, enabling intruders to gain access to sensitive areas.

Actions
At a minimum, companies must ensure they comply to IEC 62443 cybersecurity standards. Companies need to keep up to date with security patch and malware protection management.

Such security should have specific requirements and recommendations for implementing and deploying updates from third-parties as well as a robust network, including firewalls and controlled interfaces, to protect against outside intrusion.

There should also be a strategy development for recovery, including a backup system that can provide a system restore to ensure business continuity.

Additionally, continuous, remote monitoring with periodic security reviews – including alarm triggers - should be in place along with ongoing cyber security maintenance.

Benefits
The defense-in-depth method for cyber security offers a series of eight steps that build to make the system secure through cyber security consultation, hardening, monitoring, securing perimeters, white listing, host network detection, host intrusion detection and secure configuration and securing the interior.

3. Automate wherever possible and use remote expert assistance

Challenges
A digital facility will only operate at its optimum if every application that can be automated is implemented and only escalating deviations to experts – internal and external - for input.

Even when automation is fully implemented and fewer staff are then needed on site, it is important to ensure that remote access to the site is available for maintenance, security and safety purposes.

Actions
Machines can process routine information more quickly and more efficiently than human operators. Having a high level of automation thus means that processes will likely run more smoothly. They can also be run with fewer people on-site and/or via people in remote centers of excellence who can provide the best advice in a timely manner to individual facilities or fleet-wide. This provides less cost overall and improved safety.

These centers and internal experts are increasingly connecting to supplier remote centers and experts for 24/7 troubleshooting, best practice and proactive support.

ABB call these Collaborative Operations Centers. In this setup human operators are freed up for more value-adding activities.

Benefits
Digitization not only improves operational efficiency, but also the availability of resources. Asset and operational information is collected, correlated and analyzed around the clock in Collaborative Operations Centers to identify, categorize and prioritize performance improvement actions.

4. Deploy process optimization and production enhancing technologies

Challenges
Once up and running there is usually scope to improve operations e.g., through loop tuning. However, this is often overlooked due to time or other priorities. Out of sight - out of mind.

Also, sometimes it may not be clear which decision is the best one to take or the quality of the decision is dependent on the skill or alertness of the operator - something which is likely to vary by shift.

Actions
In operations, the digital twins mentioned earlier should continue to be used. They can assess changes and keep the facility perpetually optimized while also helping decision-makers decide between scenarios to improve production for example.

Additionally, a digital facility should use cloud-based or smart on-premise solutions for tracking key performance indicators to ensure processing and production excellence at an individual plant level and/or fleet-wide.

Dashboards, such as those provided in Figure 6, should also be utilized. They provide a common

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Figure 6. Dashboards, such as these ABB examples provided here, provide quick and easy visualization for operators to optimize performance.

view of key summary statistics and are effective in highlighting priority areas executives should look into further.

Benefits
Digitalization helps ensure that a plant is running at peak performance levels and that decisions taken are profit-maximizing while safe at the same time – regardless of operator experience or fatigue.

Additionally it makes it easier for best practices to be shared across a plant and the wider enterprise.

5. Adopt predictive maintenance where appropriate

Challenges
Traditional maintenance routines are based on service time, not actual requirements, despite the fact 70 to 90 percent of failures are unrelated to equipment age. The problem with such approaches is that considerable effort is devoted to devices that are working perfectly well. It also does not address the reality where 20 percent of the equipment tends to cause 80 percent of the issues.

Furthermore, up to 40 percent of production losses can be attributed to preventable operator errors where, in a typical facility, this could account for one to two percent of facility's total production capacity.

The result of excessive maintenance can be that facilities actually become less reliable due to increased human intervention.

Actions
Employing predictive maintenance throughout a digital facility means that failure modes are remotely monitored using sensors. Dedicated analyses are performed which assess the equipment itself and/or its environment for clues to drive maintenance programs.

Fleet analytics – from an operator's own fleet of sensors and devices, or even across external facilities and other industries via third-parties such as ABB – can also be used to estimate the likelihood or frequency of events.

When data is collected from a large amount of identical equipment operating under similar conditions, it becomes possible to build a precise model of that device's degradation process.

Benefits
With low sensor prices and the availability of wireless technology to transmit information, predictive maintenance regimes can be extended to include a much wider range of equipment such as rotating machinery.

With predictive maintenance, service teams are alerted to issues that need addressing based on actual need, not because a certain amount of time has elapsed. Equipment is serviced before a fault occurs.

However, where the timeframe to failure is very short or there are no methods or instruments for identifying developing failures, traditional time-based, preventative maintenance according to manufacturer guidelines is still recommended.

6. Use digitalization to identify and manage critical events

Challenges
Effective process safety management and safety barrier management generates vast amounts of data from IT and OT. All this data needs to be managed and given context to achieve comprehensive safety planning and performance.

Actions
Digital control room applications, such as alarm management, use analytics and artificial intelligence tools to highlight and prioritize critical events which need to be addressed, thereby preventing problems from escalating and helping to ensure safe operations.

The control rooms are designed with interactive lighting, sound showers and high-performance graphics which contribute to increasing operator engagement and improving their situational awareness.

Benefits
High-performance graphics used in today's control rooms, are proven to deliver a 500 percent improvement in detecting abnormal events, along with a 41 percent reduction in the time taken to handle them.

Operators can more easily optimize their functional safety effort throughout the entire process safety life cycle and not just in the risk assessment and design phases or in small pockets in an organization.

7. Optimize energy management

Challenges
Energy management in the oil, gas & chemicals sector is often not fully optimized. This not only leads to extra costs in terms of the price paid for energy but also, more importantly, to significant process disturbances if power supply is interrupted.

Actions
The digital twin advantages described earlier in terms of facility design, operator training and process optimization also apply to energy management.

Simulators exist to enable operator training and electrical control system training in a realistic, yet disconnected, environment. They can also help improve electrical consumption and lower electricity costs.

Big Data analytics can also be used to forecast energy import, load, and trading variables while measuring and analyzing energy efficiency performance patterns to keep operations running smoothly.

Benefits
The digital facility minimizes disruption and costs from downtime and blackouts - even when working with unreliable power supplies - as digitalization can help automate reactions to disturbances based on priority or criticality.

Digitalization makes it easier to optimize energy efficiency in real time and to purchase energy at a better price within a facility or even across sites which can now be compared due to the greater interconnectivity between them.

8. Enable safe and productive mobility

Challenges
Oil, gas & chemicals facilities tend to be highly complex and hazardous environments in which to work.

Actions

Wearable devices are used to help ensure operator safety while also giving workers the ability to access and view order information in ways which keep their hands free, e.g., using headsets, and with the ability to have a two-way interaction with remote experts when needed.

The digital facility delivers its data according to user requirements including smart phones and iPads.

Augmented reality and virtual assistants will be heavily used by engineers and technicians in a digital facility to help employees perform their tasks more effectively.

Benefits
Worker safety and productivity are significantly enhanced since they receive better advice to guide their activities.

9. Move towards unmanned, autonomous operation

Challenges

In the much longer term, the digital facility will likely be one that does not need human operators on-site. Instead, operations will be controlled from afar.

For every human engaged in operating a facility, there are many more needed behind the scenes to cover everything from staff illness and vacation time along with handling offsite accommodation and travel needs. All of which is expensive to run and exposes people to potentially hazardous working environments.

Actions

Achieving the goal of zero manning requires the full and proper application of the technologies described earlier. Here are four guiding questions:

1. Are operations safe?
   - Companies must ensure operations are safe through process safety management.

2. Can the facility be operated without a physical presence?
   - They must also be able to run operations with no physical presence via automatic state-based controls for startup, change and shutdown.

3. Can the facility be inspected and maintained without a physical presence?
   - Maintenance and inspection must also be done with no-one there, using facility-wide condition monitoring and predictive analytics, as opposed to only tracking critical equipment as the latter is insufficient in processes with so many interdependencies.

4. What are the opportunities for using robots/ drones?
   - Robots and drones must also be used for activities like pig handling, inspection, gas detection etc.

To answer these questions, a digital facility will need:

- Internet of Things sensors and devices to measure and control what is needed to make things happen
- Intelligent projects to drive consistency
- Connectivity to bring information to the right decision-makers (ie from edge devices, to the lake -groups of edge devices- and, where appropriate to the cloud)
- Analytics to process it; the more autonomous we want to be, the more we go toward predictive and artificial intelligence
- Dashboards to bring it to the remote operator, domain expert, cooperative vendor

Digital technologies must be used to sense, measure and control operations with the requisite connectivity to share the information in a timely manner and the analytics to process it – with a significant reliance on artificial intelligence – and appropriate dashboards to bring the information to the remote operator, domain expert or vendor partner.

Benefits

Autonomous facilities not only reduce labor costs, they also improve productivity by leveraging real time analytics to take process optimizing decisions. And, perhaps most importantly, they can increase worker morale and safety by drastically limiting the amount of time personnel need to spend in dangerous environments.

Summary overview of differences

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Table 2.

	Traditional Facility	Digital Facility
New project execution	• Engineering database at EPC with document control by ABB and revisions every 2 weeks • Commissioning on site with large team and many costly, last minute changes • Hardwired marshalling, local cabinets and infrastructure to test	• Automated data management to streamline shared development activities • Decoupling software from hardware build via cloud engineering, digital twins and flexible I/O to make late changes less disruptive and costly • Digital marshalling and standardized cabinets to enable remote commissioning
Automation and productivity	• Integrated electrical and control • Performance degrades due to lack of control loop optimization • Alarm flooding from false positives and incorrect limits	• Integrated EICT and digital twins to test changes and keep plant optimized, always • Autonomous normal operations with deviations by experts • Automated alarms on critical events only
Connectivity	• High retrofit costs and only critical assets are connected • Limited data transferred due to bandwidth and cost • Asset health monitoring not integrated with DCS • Facilities potentially vulnerable to cyber attack	• Onsite maintenance and operations teams fully connected and adequately informed, able to be supported remotely by remote experts thus optimizing cost and performance • Automated, cyber secure data transfer conforming to industry standards
Maintenance	• Periodic, time-based inspections for preventive maintenance to manufacturer specifications • Alarms or failures trigger troubleshooting • Personnel traveling to potentially dangerous sites	• Strategic asset management of all equipment with minimal ad hoc troubleshooting as predictive maintenance anticipates and pre-emptively addresses issues on critical equipment and rotating machinery • Drones and remote monitoring to support field inspections and operations
Workforce management	• Control, maintenance, and optimization is onsite which is costly and exposes staff to risky situations • Reliance on manuals which may be hard to find or out of date • Manning of control room and shift patterns based on plan, not actual needs	• Minimum of control and maintenance onsite with a greater reliance on remote support from centers of excellence • Augmented / virtual reality - decision assistance • Virtualized control systems allow workers to connect from anywhere in the field

Conclusion
Digitalization is driving a truly disruptive transformation within the oil, gas & chemical industries. The benefits in terms of improved profitability and enhanced safety are significant.

Digital can cut CAPEX and OPEX by 20 to 30 percent while increasing uptime by up to 20 percent and extending facility lifetimes by up to 20 years. In fact, predictive maintenance can also be used to cut related costs by up to 50 percent.

Furthermore, intelligent applications can reduce unnecessary costs and hazards by monitoring people and assets more effectively. They also make it easier for workers to focus on priority issues as digitalization can be used to reduce the number of alarms they currently face.

However, as is the case with all revolutions, such change is never easy.

This guide, drawing from ABB's many years of implementing digital solutions across the hydrocarbon chain, has outlined some key steps and considerations. Discussed are 5 key elements to consider regardless of whether you are designing, building or operating a greenfield or brownfield facility. And, within each phase there are factors which will enhance digital results.

A general theme is the need to change ways of working in order to leverage digital's full benefit. For example, companies will need greater system integration from the start and to determinedly eliminate redundant processes by embracing standardization, open platforms and automated data management.

A shift towards total cost of ownership, instead of cost minimization by project phase, will also be required. Incorporating digital technology, such as simulators, early into planning and design may add cost, but will more than pay for itself over the facility's lifetime.

We hope you find the recommendations useful and would be happy to discuss how these are best customized to your individual situation.

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