Assess Digital Maturity to Set Digital Transformation Strategy in Oil and Gas

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Categoría: Marque con una "X"

- Artículo Técnico [x]
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Abstract

This paper presents a structured methodology for an oil company to embark on a digital transformation. It was implemented in several JVs with a NOC that includes three producing blocks with dozens of mature fields.

The methodology has several key unique strengths: One is the ability to isolate the core-money-making processes and build a digital strategy around them. This shows early gains and at the same time becomes a buy-in support for management. Another advantage is the simplicity to define the "desired" digital maturity level using direct input from the final stakeholders. This is achieved by using the process enhancement method, a SIPOC technique (Supplier, Input, Process, Output, Customer analysis). Also, an important strength is the methodology does not ignore the existing IT infrastructure, nor the field systems (i.e., SCADA) and re-uses them, as much as possible, giving enough time for a transition or an upgrade when needed.

Several tools are provided in this paper that makes the methodology consistent, auditable, and strong to support the designed digital strategy to any management level with high chance of approval. The methodology is flexible enough to be run on various types of contracts, hydrocarbon phase or operational environments.

As with any method, it relies on commitment from the top and base line in the organization, requiring open and honest evaluation of current inefficiencies and, equally important, resources (budget and people).

In summary, a digital transformation is not a sudden leap from a company's current analog status to an instantaneous digital state of being. Rather, it is a progressive, step-by-step transition of core processes and user-centric workflows that requires careful planning and a thoughtful methodology to find the most suitable scenario for each company.

Introduction

Even a well-conceived, digital strategy for a mature field will rarely show economic feasibility. Then it is difficult to obtain support from management as well as its final users. On the one hand, because it may require resources from OPEX budget, which is always limited and already committed; and on the other hand, it creates uncertainty with a new way of doing things using digital solutions. "Organizations are spending about a trillion dollars a year on digital transformation". However, "70% Of digital transformation effort fail". (Siebel and Rice 2019).

We are proposing a method that can layout a smart strategy showing early wins, stressing the outcome in terms of digital maturity status and that supports every solution on the benefits calculated out of actual measured shortfalls (i.e., losses, journey time, sustainability targets, others), in the particular asset.

This method clearly aligns the operating company's financial KPO and looks for improvement gains using digital enablers. To cope with the first, it starts by identifying the core-money making processes using a key processes map, and then assessing the shortfalls of those using SIPOC and Digital Maturity Index (DMI) tools. The combination of these outcomes provides a good understanding of how to leverage the automation of the specific workflow. Then the aggregation of several key processes' solutions become the basis to define the target DMI. Once the last is defined a proper solution assessment can be performed and along with it the budget estimate.

The deliverable of this method is an operating company's or field specific scenario to carry on with the digital transformation, that ensures wide acceptance and make the most of the digital technology available now. This would not prioritize the migration to cloud services rather than set a transition time to allow the Company to upgrade, train, and undergo the cultural changes that may be necessary.

The results obtained from several implementations proved that mature fields will hugely benefit from digital solutions (Bimani et al, 2019). An alignment to finance KPOs can be achieved by isolating shortfalls within key-core processes and overcome those with available digital solutions. Relevant improvements in uptime, loss reduction and in carbon dioxide (CO2t) emissions have been recorded.

Mature or aged fields will not be left behind in the digital transformation. They may be using out of date producing philosophies, aging technologies, excessive manpower, and experiencing significant shortfalls. Digital solutions would leverage their performance by automating routine tasks, either in the field or in their engineering practices. The first will be leveraged with the correct use of Industrial Internet of Things (IIoTs), and the second with the adoption of integrated application platforms. In this paper we propose a structured, step wise procedure to properly identify where and which digital technology to adopt.

Methodology

Digital Vision and Strategy

Digitalization or Digital Transformation must be focused on the company's business goals and objectives. It is not about technology; it is about strategy and a new way of thinking the way we do business (Rogers, 2016).

Digitalization, as with any other transformations, requires having the right strategy to achieve the outcomes and results that the business is expecting. Digitalization investments must be aimed to bring the expected return on investment (ROI), or now return on digital investment (RODI); an appropriate strategy to engage it must be properly laid down.

Implemented Methodology

A proper digitalization plan must be based on a list of activities and milestones that, together, are able to achieve the desired goals. Such list must respond to a methodology based on best practices and experience. It must be repeatable, so it can be tested, adapted, and corrected as it is used on digital transformation assessments.

The methodology described here is based on oil and gas operations and is mostly related to the technological aspects of the digital transformation. It provides a set of steps to guide the operating company through their digitalization journey. We propose a series of stages to enable them to view, envision, understand, define, and implement a solution system that allows digital enabler in operations; and is aligned with their performance and business objectives.

For a successful digital transformation, the following prerequisites must be fulfilled:

- Ownership: The corporate leadership must own and sponsor the digital transformation process. Without this commitment, the probability of failure is significantly multiplied. It is essential that the company's most senior management is committed to and see the business value of the transformation process.
- Workflows: the workflows are a set of activities that consolidates the way the operating company performs their business operations. As part of the digital transformation, the workflows must change. In other words, it is not simply a matter of applying digital technology to a workflow but determining how the outcome may best be achieved if/when this workflow is automated. Therefore, the actual workflows may be altered because of the digitalization process.
- People: The stakeholders, the people are the center of the digital transformation. This process must listen to and engage the people. Cultural change must be an integral part of the digital transformation journey.
- Processes: Transformation of workflows and processes using digital technologies must be carried out in observance of industry standards and best practices.

A methodology for a digital transformation journey is founded on the following major phases:

- High-level Assessment phase
- Solution Definition phase

The high-level assessment phase consists of the following steps:

- Discover of the KPOs that the operating company has for their operations.
- Identify all relevant workflows and processes that make up the company's operations.
- Determine the current DMI of each of the relevant workflows.
- Set target DMIs for each of the workflows.
- Valuate the gap between the current and target state of each workflow
- Estimate the impact that the target state of each workflow will bring up to the company's business operations

- Prioritize relevant workflows based on a ranking index. This will show what process should be digitalized initially to bring early benefits.

The solution definition phase starts from the information captured from all steps within the high-level assessment. The methodological actions of this phase are summarized below:

- Build the SIPOCs of the prioritized workflows at their current and target digital state.
- Craft a digital system architecture that fulfils the target functionality of the workflows.
- Develop a budgetary cost model and a phased schedule to build that system architecture.
- Produce an economical evaluation of the business impact. It is important to estimate the RODI that the proposed system architecture would bring to the operating company.

Both phases are further addressed on the following sections.

High Level Assessment

KPOs

A key performance objective (KPO) is a singular business goal that enables what the company expects to plan, organize, and execute to achieve a specific result on. In other words, the KPOs refer to the goals or objectives that a company or organization establishes to quantify its performance in a measured interval of time.

KPOs should be measurable and based on a timeline. Objectives should be attainable and realistic. Usually, KPOs are measured as a percentage of improvement (either increasing or decreasing) from an agreed base value.

Each industry has its own KPOs. Even within a specific industry, distinct companies may have different KPOs. For a specific organization, individual KPOs may change over time.

In the oil and gas industry, the organization may be a plant, an oil production field, a midstream facility, or the entire company. Each part of an organization may share KPOs or have different ones.

Workflow Identification

A workflow consists of an orchestrated and repeatable pattern of activities, enabled by the systematic arrangements of resources into processes that transform materials, provide services, or process information. It can be depicted as a sequence of operations, the work of a person or group, the work of an organization of staff, or one or more simple or complex mechanisms. In the case of oil and gas operations, a workflow is a set of steps and checking points to achieve a specific job as part of such operation. Usually, workflows are very well established, based on the organization’s best practices, and aligned with its business objectives (Reddicharla et al, 2019).

There is a clear relationship between KPOs and workflows. A way to reach a specific KPO is by:

- Improving current workflows.
- Creating new workflows to achieve specific KPOs.

It is very important to clearly identify the KPOs, the workflows, and to establish the relationship between them.

Digital Maturity Index

The corporate adoption of digital technologies in many of its operations began since their inception. Companies use digital tools in many areas: financial, business, management, and operations, among others. In the case of oil and gas operations, companies have heavily invested in automation and control systems for years.

Even before a company decides to undertake any digital transformation initiative, they may already have certain digital systems in many places. The DMI is a scalar indicator that reveals the level of digital technology adopted for a specific operation, plant, area asset or for the entire company. Establishing the DMI is essential for the digital transformation journey. Knowing where the company is, as well as the capabilities it has and requires, helps define a successful strategy. The DMI makes it possible to define objectives and initiatives and to measure the progress of digitalization in the company.

The DMI of a specific process is calculated out of the convergence of different digital technology aspects that the processes have. Each aspect quantitatively determines the level of advancement that such process has from the digital technological perspective. There are several views of maturity levels depending on the industry or academic group you look at. The one we consider here is an evolved and modified version of what one of the largest oil field service companies uses for its technologies (Agora, 2020). Those technology aspects that conform to the DMI value are:

- Level 1 – Connected, Data Gathering (DG): Data are gathered (part or whole) digitally and stored.
- Level 2 – Monitored (MO): Data are displayed for client to visualize or monitoring of current performance of assets.

- Level 3 – Insight (IN): Data are used to create insights generated by analytics algorithms. Predictions about future performance created.
- Level 4 – Controlled (CT): Data are used to actuate oilfield equipment in order to take action in the field. Human intervention in the field is reduced.
- Level 5 – Remote field operations (RFO): Use of data in conjunction with other technologies such as augmented reality (AR) and virtual reality (VR), to provide support and guidance for personnel to expand controlled systems.
- Level 6 – Autonomous (AT): Data and generated insights are used to actuate and control multiple oilfield assets in a coordinated faction with minimal human intervention.

The relationship among the different components of DMI is presented in **¡Error! No se encuentra el origen de la referencia.**.
During the evaluation of a specific workflow, each of the levels receives a metric based on the digital state of the workflow for that specific level. **¡Error! No se encuentra el origen de la referencia.** shows a five-score metric for each of the six levels based on the technical characteristic of the level itself. The six-level system is taken from the definition of a digital oil field (DOF), in the literature (World Economic Forum, 2017; Porter and Heppelmann, 2014).

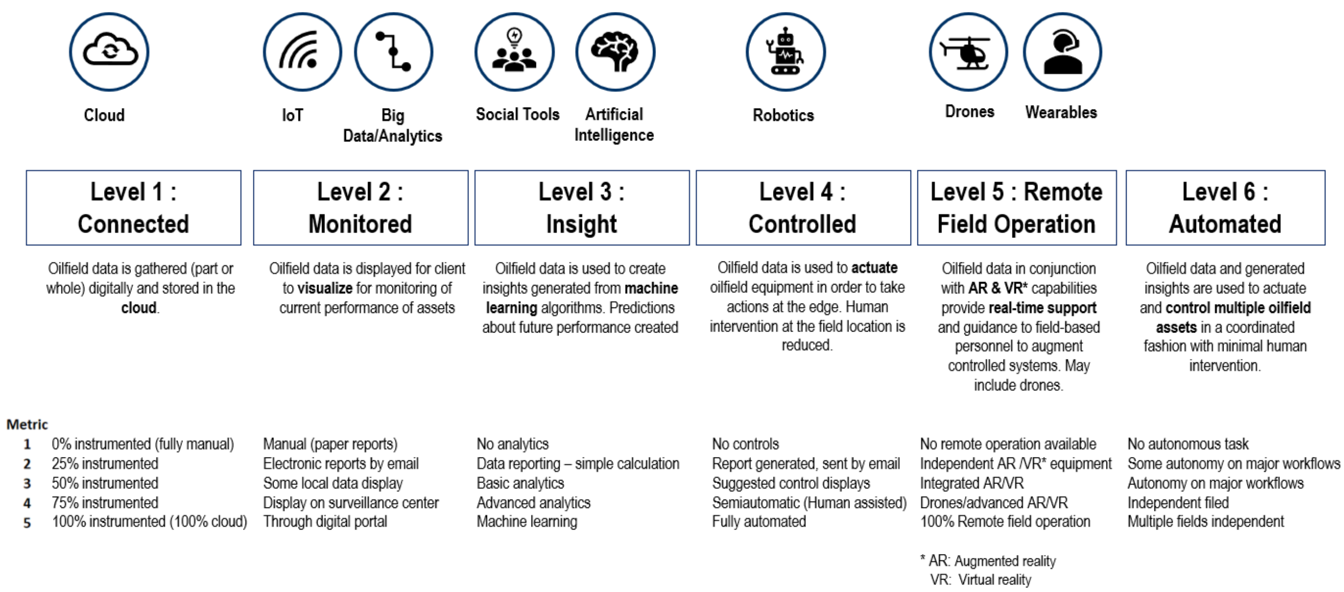

Fig. 1—Components of the DMI

The DMI for a process is evaluated by estimating the metric level on each of the components that forms the DMI. This estimation is conducted with the user in workshop sessions or interviews held with stakeholders (domain owners, clients, users, etc.) of the process. Please note that metrics are real numbers, not integers. It is critical to keep the metric level unaltered to ensure consistency and comparability of the results across workflows, domains, and oilfields.
The resulting DMI out of the quantification of each level is determined by the Eq. (1).

$$DMI = \frac{DG+MO+IN+CT+RFO+AT}{6} \quad (1)$$

where DG, MO, IN, CT, RFO and AT are the metrics for each of the corresponding DMI levels.
The DMI may also be presented on a radar or web chart. Sometimes, and only for a specific purpose, the DMI is presented as a portion of the total area of the hexagon, as a percentage.
As shown in **¡Error! No se encuentra el origen de la referencia.**, the radar chart is a polygonal form, where every vertex corresponds to one of the six levels and the axes points out the metrics value gathered during the assessment. Each evaluated process, workflow, or system may have a different DMI. The shape of the polygon provides visual information on how this DMI is spread across the different levels of the process. Also, an awareness of the gap between current and target metrics, for each level, can be depicted when plotting both in the same radar chart.
The DMI provides a quantification on how digitalized a specific workflow is. As an example, a narrow envelop will suggest a low DMI; a skewed envelop suggest efforts made on few levels or in an isolating way. The radar DMI plot also helps the company to set

the maturity targets for the respective process. This can be done on second thought exercise and then consider the implications from technology, resources, and scheduling points of view. The radar plot is excellent tool to level-up expectations from different stakeholders.

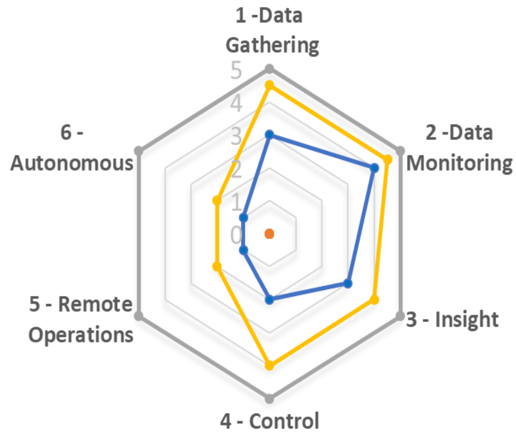

Fig. 2—Typical DMI representation on a radar chart. Current (blue) and target (yellow) status.

From our implementations, we observed a linear correlation from level 1 to level 4, meaning the previous level must mature before the next level can achieve maturity. Although, it might be a characteristic of the projects we deal with, we advise to leverage those early levels first. This relationship does not seem to apply from level 4 onwards.

When both DMI envelopes, actual and target, are presented in the same radar plot, the difference in the metric score will give an idea of the effort require to leverage each level (i.e., in Fig. 2, control level needs to go from 2 to 4). A digital solution needs to be adopted to achieve this, and similarly, for the other levels.

Another important insight from this analysis derives from what exactly the final user wants to accomplish. This is where benefits will be listed directly from the shortfalls of the current maturity level of the process. The numerical representation for such benefits is called business impact (BI).

Business Impact

The BI is a scalar number that measures the benefits that the business may obtain if the DMI of a specific workflow goes from its current digital state (measured by its current DMI) to a desired state (estimated as its target DMI). The goal is to digitalize (provide digital technology) in a way that the target DMI is achieved with the maximum BI. The BI is a real number between 0 and 100, representing a ratio or percentage of improvement obtained out of a specific business objective.

The BI must be aligned with the company KPOs. Each operating company may have different objectives regarding a true and quantifiable impact for the business. The specific KPOs that will constitute the BI must be defined and agreed upon with the stakeholders during interviews or workshops.

Typically, the performance objectives that are used to determine the BI for a specific oil and gas operational process or workflow are as follows:

- Material/equipment costs (MC) reduction: Estimated reduction of cost on material expenses, equipment rental, and expenses associated with major equipment's run-life extension that can be expected if the target digital state is achieved.
- Crew productivity (CPr): The effectiveness (achievement) of completion of tasks by a team (crew) within a specific metric, such as time, cost, etc.
- Production increase (PN): Approximate increment in production if the target DMI is achieved.
- Production loss (PL) reduction: Estimated percentage reduction of production losses, both planned and unplanned.
- Environmental impact (EI) reduction: Estimated percentage of improvement of safety and reduction of environmental incidents if the target DMI is reached.

Determining these performance objectives are high-level estimates, discussed and agreed upon among the stakeholders and the assessment team. Enumerating the objectives does not imply that such objectives will be achieved nor is there any commitment that the objectives will be reached if the digital strategy is implemented.

BI is quantified by summing the weighted index of the above variables. Each variable is assigned a specific weight, previously agreed upon among stakeholders and appraisers. The weight allocation is based on domain knowledge, understanding the company's key issues, and their relevance in their overall core business. Typical weight factors used in previous engagements are presented in Eq. (2); however, it could be defined in an expert-opinion type of exercise with the stakeholders.

$$BI = 0.1 \times MC + 0.2 \times CPr + 0.3 \times PN + 0.2 \times PL + 0.2 \times EI \tag{2}$$

Gap Identification

An investment is required to improve the DMI for a specific workflow to accomplish an expected BI. This investment is measured in time and money. Therefore, the gap evaluation between the current state and the desired state of the process is a measurement of the perceived effort to achieve the target status. This effort equates to the necessary resources (time, budget, and digital solutions).

If we consider that the desired digital state that fulfills the operating company's business objectives represents 100% (goal), then its current digital state is a fraction of that goal. The gap is calculated by the difference between 100% and the estimated percentage that the current digital state represents of that goal.

The gap evaluation enables companies to understand the current status of their digitalization and how much effort will be required on digitalization to achieve their business goals.

The gap is usually a bold estimate that results from discussions in workshops with the stakeholders.

Workflows Prioritization and Ranking

The estimation of DMI, BI and Gap for each identified workflow provides interesting metrics that allows us to determine which workflows must be transformed first. The general criteria favor those workflows that have high DMI, low Gap and large BI.

The prioritization index (PIdx) is a scalar value that details the workflows priority for digitization, relative to the other workflows. PIdx is a weighted average of the normalized values of DI, BI, and Gap. The weight factors are normally established and agreed with the stakeholders for that specific process. A typical PIdx calculation is shown in Eq. 3:

$$PIdx = 0.4 \times DMI_{norm} + 0.2 \times Gap_{norm} + 0.4 \times BI_{norm} \tag{3}$$

The resulting PIdx provides a metric to perform a fair mechanism to compare the digitalization efforts required for different workflows to select which workflows should be addressed first as part of the digital transformation effort.

This index allows us to establish a ranking of the identified workflows, so the digitalization journey must start with the workflows that were recognized to require the least investment, provide the most positive BI, and has the least gap between current and desired states. Therefore, this method isolates and prioritizes workflows that will bring early performance and financial gains.

Solution Identification

On this digitalization methodology, once the high-level assessment is completed, the next step is to craft a digital solution that aligns with the requirements and conditions previously discovered. Such a solution must be technology inclusive: the resulting architecture should be attached to any specific technology offer or products. The solution must be based on industry standards and best practices in the oil and gas industry and in the digitalization world. It is important to understand the digital offer of the moment because technology evolves rapidly and, on the other hand, the required specification may not be available at the time needed. As a practical rule considering only existing commercial technology could help in one instance but could harm in another. Existing technology may speed up early deployments, but it may delay critical solutions when heavy settings are needed for implementation. It is a compromised solution to have the correct mix of existing and bespoke technologies in the digital strategy.

It is important to stress that digital solutions can be adopted at all levels and processes in the company. The methodology here works at the operational and engineering levels. It has not been used for support or function domains (i.e., finance, talent management, HSE reporting, others) that we believe are a specific niche already covered by specialized providers.

Therefore, the solutions we seek are those digital offerings that can improve the efficiency for core field operation processes and core engineering workflows back in the office. The first is more related to IIoTs to cover the gaps left by any automation systems in place; and the second is about finding a multidomain ecosystem (platform) where core applications used by engineering teams will be available and fully integrated. This will save considerable amount of time currently spent on model updating, reporting, and dashboarding.

It is advisable to run domain-centric workshops at which domain owners and, relevant stakeholders can interact with digital solution providers and exchange needs (requirements, specifications, wishes) and available solutions on commercial and development stages. It is difficult to find a built-for-purpose solution; therefore, a compromised commitment must be from both parties to jointly take a rapid experimentation approach. In this way a bespoke (critical customized) solution can be delivered in the timeframe that suits both parties.

Workflows: Current and Target states

The workflows that have been identified as part of the high-level assessment and constitutes core of the company operations are those that must be transformed. As discussed previously, digital transformation is essentially about the change in the way business is conducted, a step change in the way operations are performed, using available digital technologies. In other words, the workflows to be digitalized are the core-money-making processes for the company.

To properly transform the identified workflows, it is important to know what the current state is (how it is applied today) and what is the foreseen target state of each of them. Each workflow will have a corresponding company' KPO to track its impact on the business. Workflows may be further sub-divided or merged as part of the transformation.

The methodology to determine, in detail, what is the current state of a workflow, is by creating its SIPOC diagram.

The SIPOC diagram is an excellent way to define and evaluate processes and workflow enhancements. In process improvement procedures, a SIPOC is a tool that summarizes the inputs and outputs of one or more processes in tabular or graphical form. It is used to define a business process from beginning to end. This tool also stresses what and where are the current loopholes of the process (i.e., redundancies, missing, unused outputs, and inefficiencies). Fig. 3 exhibits a typical SIPOC diagram.

The current SIPOC graphically describes how the workflow is currently implemented. The target SIPOC of a workflow is where the actual transformation will take the workflow to and should reflect the DMI after the digital transformation.

Establishing the target SIPOC for all identified workflows requires a true transformation mindset and the agreement of all company stakeholders, including operations, engineering, information technology, HSE, and even financial teams. Setting the target state of each workflow, in alignment with the target DMI and Company's KPOs, is the most critical and important step of the digitalization journey.

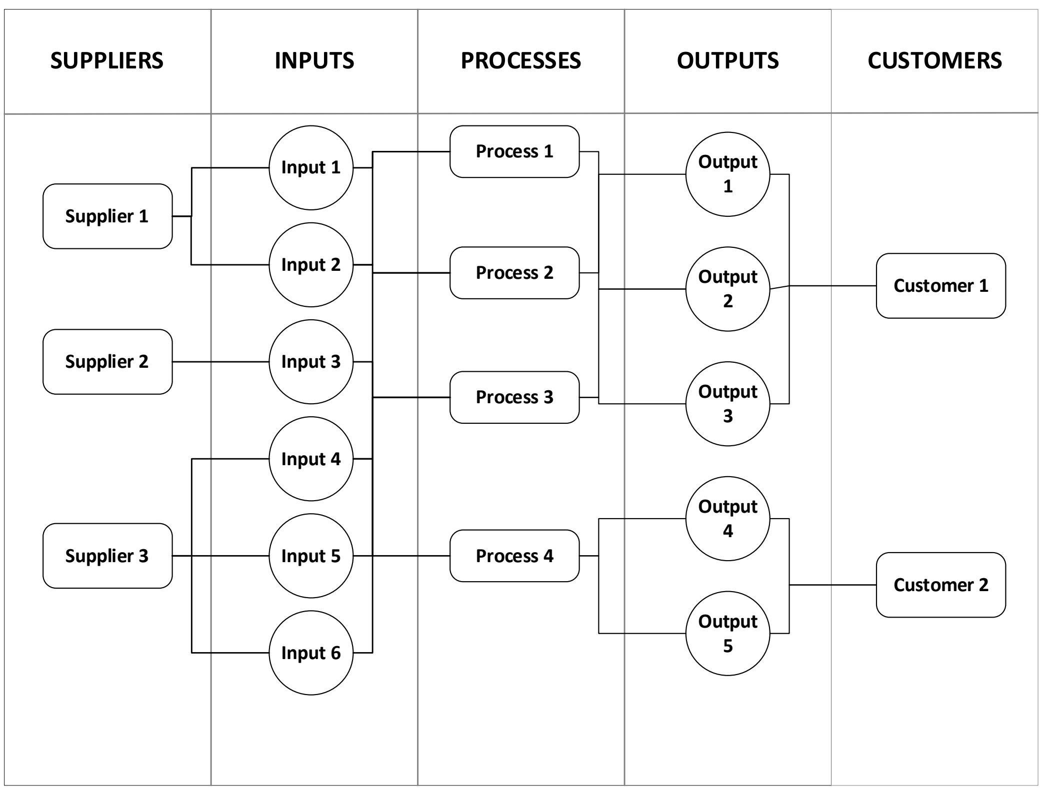

Fig. 3 -Typical SIPOC Diagram.

System Identification

Building the right solution architecture is the most challenging activity in a digital assessment. In general terms, it must comply with the following guidelines:

- Standard based: The proposed architecture must be based on standards and best practices.

- Vendor independent: Any incorporation of products or solutions coming only from specific vendors must be avoided.
- Proven: The proposed architecture must be aligned with commercial, tested, and proven architectures.
- Innovative: Although based on proven technologies, the proposed architecture should incorporate innovative and updated technologies and solutions where possible.
- Feasible: The resulting architecture design must be achievable within effort, time, and cost constraints.
- Cost effective: The solution must be cost effective and must achieve the expected ROI and RODI.
- Reusable: The solution should be generic enough to be partially or totally used on other operational activities with similar requirements.
- Available: The design must incorporate redundancy and fault-tolerance elements to assure high availability.
- Secure: Data are the most precious asset for the customer. The architecture must provide all mechanisms to assure data security and integrity.
- Modular, expandable: The architecture should be conceived to allow expansion (additional entities and data sources) and support modularity (easily add new functionalities with minimum effort).
- Use existing infrastructure when possible. The proposed solution design should consider the existing installed digital infrastructure and use it, where possible, without compromising the overall solution performance and be in compliance with the other guidelines listed above.

From the system design perspective, there are several architecture patterns that should be considered. There is no such thing as a "one-size-fits-all" nor "plug and play" approach in the digital application.

For example, the most common structural design pattern is the layered architecture, also known as the n-tier architecture pattern. This pattern aligns with the solution identification that has been presented above, making it one of the popular choices for most digitalization strategies. However, it must not be considered as the pattern to be used in all cases.

Components within the layered architecture pattern are organized into horizontal layers, with each layer performing a specific role within the solution. Although the layered architecture pattern does not specify the number and types of layers that must exist in the pattern, some layers may be defined based on the information collected during the evaluation of the current and target SIPOCs.

The basic layered architecture, in general, has the following:

- Data sources layer: Includes all sources of information (real time, timestamped, static, etc.) that feeds the upper layers.
- Data federation layer: Gathers or pushes back data from different sources (using dedicated connectors for each type of source), cleanses the data, and converts the data to a standard, unified, canonical data model (unified data model). Data can be consumed by upper layers in a standard way, regardless of where the data comes from.
- Business layer: Business processes, workflows, analytics, and reporting (both official and internal) applications are here, collecting data from the data federation layer.
- Presentation layer: This layer is responsible for handling all user interface and communication logic.

Fig. 4 shows a diagram that represents the above-mentioned layers. Please note that smaller solutions may have fewer layers whereas larger and more complex systems may contain more layers or interlayer components.

One of the most powerful features of the layered architecture pattern is the separation of concerns among components. Components within a specific layer deal only with logic that pertains to that layer. This type of component classification makes it easy to build effective roles and responsibility models into the architecture. It also makes it easy to develop, test, govern, and maintain applications using this architecture pattern because of well-defined component interfaces and limited component scope.

The layered architecture is presented here as an example. It does not mean that this approach should be used for every solution identification and design that may arise. The architecture selection must be carefully evaluated and discussed with the stakeholders.

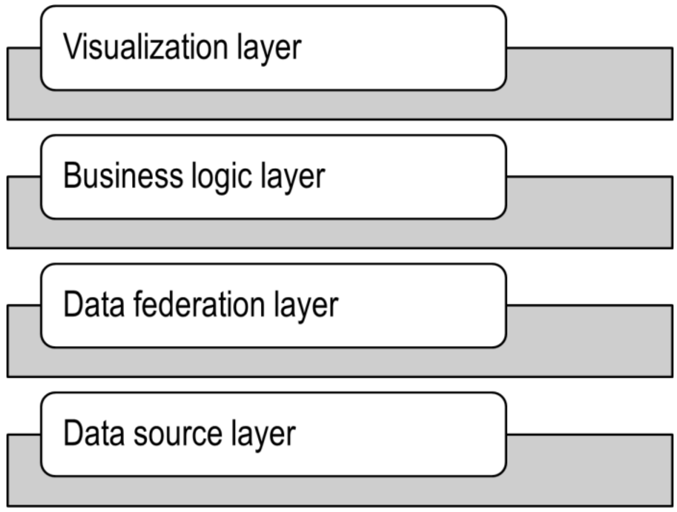

Fig. 4 -Layered Architecture Diagram.

Note that the layered architecture may bring some challenges to represent and clearly map out a multi-domain architecture solution and to integrate operation and engineering workflows.

Budgetary Model

After the high-level solution architecture is identified and established, the next step is to build an estimated cost budget.

A budget is a tool used to estimate the total cost of a project. It is not a specification document, and it cannot be submitted to suppliers or construction companies. The budget must include a phased approach or roadmap to target areas with the highest ROI, while minimizing investment risks. It provides to stakeholders a view of the expected budget for the project, along with several breakdown layers that allows grouping and isolation of workflows, fields, processes and others. Using this budget, companies can support allocating funds and resources for approved digital transformation projects.

A typical budget must consider the following aspects:

- Accuracy: Even though this is an estimate, it must have some accuracy. The estimate accuracy is a measure of how far the project cost estimate is from the real project cost. This accuracy is graded by “classes”. The budget class indicates the level of accuracy of an estimate (Jelen and Black, 1983). Class 5 applies to system definition and identification.
- Detailing: Although it is an estimate, the budget must provide enough detail to allow proper evaluation as to where the costs are and how they are distributed.
- Configurability: The budget must not be a static set of costs written in a report. It should be built in a dynamic, configurable way so it can be evaluated and analyzed under distinct scenarios. The budget must be built using the appropriate tools (i.e., spreadsheet program) to allow the consultant and the stakeholders to configure it and use it under different possible situations.
- Vendor independence: The budget, as the solution architecture, must be totally independent of technology or branding of any vendor.

The structure of a solution budget depends on the type and complexity of such a solution being envisioned.

The budget tool must allow grouping and aggregating costs in several ways:

- By components.
- By assets, fields, or subsystems (depending on the specific application).
- By business processes or workflows, as identified during the high-level assessments.
- By project phases if phases have been defined

The budget must be built from the high-level assessment and solution identification steps, presented earlier in this paper. Therefore, some details may not be available. Some assumptions must be made to build the budget. It is important to list all assumptions that were identified during the construction of the budget.

The budget must be disclosed and discussed with the stakeholders. It is important that it aligns with company’s expectations and financial constraints. The budget should take into consideration the project timeline.

Project Timeline

The project schedule must be fully aligned with all the components and activities listed in the budget and with the company's timeline expectations. In some cases, because of technical, operational, or financial constraints, the project schedule may be divided in phases.

There is no way to build a one-sizes-fits-all project schedule. Each company and each project are different. The schedule must be built and discussed with stakeholders, and, depending on the specific project, with possible suppliers or vendors.

It is not the intention of this paper to write a compendium of how to build a project schedule. It requires project management skills and experience. In very general terms, a project schedule must follow these basic guidelines:

- Identify schedule stakeholders: Clearly identify the people or teams that will review and approve the schedule.
- Determine the project activities: Create a list of tasks that must be completed to accomplish the project.
- Determine activities' dependencies: Determine how each task relies on others to be completed.
- Estimate resources: Determine and classify the resources required for each task.
- Sequence activities: Once the dependencies are established, some tasks must be sequenced to accommodate project time and resource constraints.
- Estimate durations: Adjust lead times for each task, based on the resources assigned and task complexity.
- Establish milestones and checkpoints: Pinpoint check points and goals so the project progress may be determined.

Based on different digital transformations, the schedule is often divided into early deployment activities and mid-to long- term solutions. Therefore, the digital transformation schedule is most likely a compilation of several sub-projects that inter-relates and which completion is necessary to ensure the final KPO target. In other words, digital transformation is a multiple-open-fronts project that requires strong project and stakeholder management.

Economical Evaluation

Budget model, project timeline, and KPOs provide the tools to build the economic model and estimates of ROI and RODI.

The KPOs are the business metrics upon which the digital transformation is constructed. These are the business objectives that the operating company is aiming to improve by digitalizing some, or all, of the business. The system identification and design, along with the budget and schedule, are created to achieve these business objectives.

The goal is to build an economic model. The economic model is theoretical, representing a relationship between variables and results. This model needs to consider different scenarios, the investment that every scenario requires, and the outcomes that the foreseen solution will yield for each scenario.

The economics may be illustrated by a three-dimensional relationship among scenarios, investments, and yields.

A scenario represents the investment required to execute a percentage (or the total) of the budget, according to some specific assumptions.

Investment is the actual financial funds needed to build the solution that covers a specific scenario. For instance, if only high-producing wells are addressed for digitalization, the required investment will be less than if the whole field or asset is fully digitalized.

Yields are the percentage of the KPOs that are reached if a scenario is implemented. They must be represented by revenue produced or the costs saved. For instance, a partial scenario will require less investment but will also produce less yield.

To simplify the economic evaluation, we are proposing a three-step approach:

1- Define scenarios. Although, this will be dictated by the company's or field situation, we advise to choose no more than three and set them based on the main drivers (i.e., architecture upgrade, remote operations, budget constrains).

2- Estimate budget and benefits. Budget was previously discussed. Benefits will be calculated using any existing downtime, losses records, efficiency metrics, and other relevant operational performance indicator. This is usually captured as part of the production excellence registers or even in the daily, production and operational, reports. The estimated benefits must be an improvement of the already identified shortfalls, inefficiencies or losses. The key task here is to assign the corresponding KPOs to the relevant workflow. This mapping exercise is not straight forward and requires domain expert to assist on. Fig. 5 shows an example of several field' workflows, and the associated KPO with quantified benefits.

	Workflow 1	Workflow 2	Workflow 3	Workflow 4	Workflow 5
Oil production BOPD		✓ Pattern balance ~2-5% production			✓ Activity risk reduction ~0.1% of incremental
Preproduction losses BOPD	✓ 2.2% losses due to ESP pump failure ✓ Reduction 5-9%	✓ Current losses ~4 KBWPD ✓ Ratio Oil/Water ~1/10 ✓ Reduction 5-9%	✓ Actual losses ~90-500 BOPD ✓ Reduction 5-9%	✓ Actual losses 120-700 BOPD ✓ Reduction 5-9%	
Crew productivity Man-hr-Yr	✓ Current workflow time ~21 h ✓ Reduction 10-13 h	✓ Current workflow time ~18 days ✓ Reduction 5-8 h		✓ Current WF time 2-7 days ✓ 4 People ✓ Reduction ~1-5 days	
Chemical efficiency USD/bbl	✓ Oil treatment optimization ~0.02$/bbl ✓ Impact on equipment run life and production losses	✓ Water treatment optimization ~0.01$/bbl ✓ Impact on equipment run life and production losses	✓ Water treatment optimization ~0.01$/bbl		
Equipment run life # of interventions	✓ Reduction of well intervention index ~0.03 intervention /well/ year				

Fig. 5 - Example of Benefit Estimation for Operation Workflows.

The benefits definition should be done in agreement with the relevant stakeholders. In the absence of a shortfall management system or any excellence program database, an expert opinion workshop should be led to define the base line and the improvements at the same time.

3- Assess the scenarios from the cost benefit and net present value (NPV) models. The first will provide a quick look at which workflows bring early gains and what is the time needed to pay them out. The second gives an overall impact on the free cash flow (FCF) of the oil field (when a field or asset wide strategy is proposed). One indicator that is gaining traction is the RODI, which is the classic ROI isolated for a digital budget. Fig. 6 presents an example of the RODI for four scenarios (S1, S2, S3, S4) for three different projects (P1, P2, P3).

Creating scenarios, calculating investments, and estimating yields on each case is a complex task. It requires a joint effort among the assessment team and, the operational and financial stakeholders. The budget should be built in a way that allows it to be easily configured for each possible scenario. The yields, derived from the company's achieved KPOs, requires insight information from customers, including capital and operational costs. Understanding the operating company's contractual conditions over the specific asset or field is also required.

Adjusting budgets to scenarios, calculating investments, and estimating yields takes time, effort, and experience. An early deployment scenario that tackles shortfalls and inefficiencies identified on core-money-making workflows will help to easy the finance stress on digital initiatives. Also, a clear performance gain of the KPO directly related to the corresponding digital solution and, in a wider view, to the scenarios, helps to overcome the finance stress.

Fig. 6 – RODI example for three projects and four scenarios.

To build economical models is vastly different among various companies and operations, and in most cases represents an important challenge. This is a critical task that should start as soon as possible for the base case and later it will be used to set scenarios. Note that this requires specific support from the economic team in the company.

Keep in mind that the economic evaluation of the digital transformation for a mature asset or field is conducted as an incremental assessment and must help to answer certain questions from management: "Is it worth it?" "Will it deteriorate the value of the asset?" and "How long will the implementation take?".

Results

A comprehensive methodology was applied to select critical field operation workflows to be improved by digital solutions based on immediate benefits, technology maturity and Return on Digital Investment. The most critical identified processes are: Artificial lift surveillance, well chemical treatment, annular gas handling, water disposal system and Gas Flare monitoring.

Producer wells, chemical treatment, water disposal systems and flares were instrumented and connected using Industrial Internet of Things (IIoT). Analysis of Real Time data was leveraged using AI/ML analytics on the edge. The outcomes provided insights for current field status (Alarms, triage) promoting seamless interaction between operational and engineering teams.

The edge technology provides connectivity, data delivery, remote control, and computing power at the location; that can be integrated into a current infrastructure. This approach enabled a low-cost and high-scalable solution for remote operations and smart surveillance using data contextualization to optimize production and uptime.

A rapid experimentation philosophy (pilot small, learn early, scale up fast) was used to materialize benefits since early stages of the implementation:

- The annular gas handling digital solution enabled incremental production between 7 to 20%.
- Smart Alarms for Artificial Lift Surveillance using AI/ML reduced time consuming and repetitive tasks in 20%, Uptime Increase by 19%, Production losses decreased in 9% and Events Notification Increase 94%.
- IP Cameras were connected for Gas Flare monitoring using AI/ML at the edge to reduce carbon monoxide production by 90% assuring the correct gas flaring to the atmosphere.
- Smart HPS surveillance increased operational availability to 100%, decreased operational maintenance cost per year to 10% and crew visits are reduced by 86%. The increase of reliability of the water disposal system eased water handling challenges for the process facilities.
- Field trips were reduced between 67 to 95% with the associated reduction of CO2 emissions in 30% on the identified critical processes.

Discusion

Due to high cost of hardware and infrastructure, mature fields find financial challenges to carry on with a full blast digital transformation in their field operations. This paper presents the approach taken in mature fields in South America to set a suitable Digital Transformation Strategy, materialize the benefits from the proposed digital solutions and improve field operation efficiency in a cost-effective fashion, while minimizing unnecessary employee exposure and reducing environmental footprint.

This paper can be used as reference to review practical examples of why and how to approach digital to gain performance on field operations. The examples presented may help to prove that Digital Transformation starts with a clear vision and strategy that will allow the deployment of digital solutions (EDGE computing, remote control, big data intelligence) on operational processes to enable a new way of operating not only to enhance production and people efficiency, but also to have a positive impact on the environmental footprint and employee's workplace

Conclusions

Mature or aging fields should not be left behind in the digital transformation. They may be using out-of-date producing philosophy, aging technology, excessive manpower and experiencing significant shortfalls. Digital solutions would leverage their performance by automating routine tasks, either in the field or in their engineering practices. In first case with the correct use of IIoTs and in the second case by adopting integrated application platforms.

The methodology presented here is an engineered mindset that aims to encourage oil and gas professionals to adopt the digital transformation by removing the common roadblocks of the unknown, fear of the cost, and knowing where to start with seemingly overwhelming digital technology offerings and potential pushback from internal and external stakeholders.

This methodology is not a cookie-cutter recipe for success, but rather a guideline that shares our experiences and stresses what it has worked for us in the several projects we have deployed so far

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Nomenclature

ARCH	Architecture
AT	Autonomous
AR	Augmented Reality
AWP	Annual Work Plan
BC	Base Case
BI	Business Impact
CO2t	Equivalent CO2 Emission in tons
CPr	Crew Productivity
CT	Controlled
DG	Data Gathering
DMI	Digital Maturity Index
DOF	Digital Oil Field
EI	Environmental Impact
FCF	Free Cash Flow
Gap	Gap
IIOT	Industrial Internet of Things
IN	Insight
JV	Joint Venture
KPO	Key Performance Objective
MC	Material Cost
MO	Monitored
NOC	National Oil Company
P	Project
PIdx	Prioritize Index
PL	Production Loss
PN	Production
RFO	Remote Field Operations
RODI	Return on Digital Investment
ROI	Return on Investment
ROMP	Emote Operations
S	Scenario
SCADA	Supervisory Control and Data Acquisition
SIPOC	Supply Input Process Output Client
UDM	Unified Data Model

VR	Virtual Reality