Collaborative Workflows Improve Decision-Making Processes in the Digital Oil Field
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Facing Industry Challenges
Oil and gas field operators face a number of significant challenges. They must meet increasing demand in sustainable, safe and environmentally responsible ways. At the same time, they have to minimize costs while maximizing the profitability of highly complex operations. To do so, they must successfully integrate the expertise of multiple disciplines to achieve a more comprehensive understanding of their assets in relevant time.

Oil and Gas Resources are Harder to Find and Produce
Production from increasingly complex fields has become more challenging, both technically and geographically. Many recently discovered resources are in unconventional plays—naturally fractured reservoirs, heavy oil, tight gas. Others are located in remote regions, such as deep water, the Arctic Circle, deserts and jungles. And, because most traditional reservoirs are mature, to maximize recovery they require improved or enhanced oil recovery (IOR/EOR) techniques, which significantly increase operational complexity.

A network of knowledge is required to navigate the complexity of today’s asset management challenges. Success requires asset management teams to apply advanced technologies and combine the knowledge of multiple disciplines to achieve greater understanding of reservoir dynamics and production operations. Members of operations and engineering, subject matter experts, and management must collaborate in teams, whether co-located or virtual, to develop the proper analyses and make informed decisions.

Data and Technology Both Help and Hinder
Engineering and operation teams are often overwhelmed by daily activities that sidetrack them from analyzing essential information and optimizing production. Engineers typically spend more than 70 percent of their time looking for data and just 30 percent conducting analysis and taking decisions. Production operations engineers face at least three common problems (Soma, Bakshi, Prasanna, DaSie, & Bourgeois, 2008):

- **Inefficient access to information.** No engineer has complete knowledge of all data in the system, and finding the information required to make a decision is challenging.

- **Fragmented views of information.** Every simulation model depicts only one facet of the oilfield in detail—reservoir, network, etc. Generally, no unified view of all related asset elements is available in one place or one application.

- **Insufficient knowledge management.** Models are constantly being calibrated, and decisions taken, but the rationale behind them is generally lost. Such knowledge is extremely useful in auditing decisions made and in training new engineers.
To obtain the information they need, operators, engineers and managers may have to access hundreds or thousands of data sources including real-time, historical, production, maintenance and economics databases, among others. Real-time systems provide huge amounts of high frequency data. Pressures, temperatures, rates and other process variables are available in seconds or minutes. Many other systems generate additional asset information: subsurface and surface models, facilities configurations, production plans and economics. Rarely, however, are data sources integrated, making the search for relevant production information both overwhelming and time-consuming, further complicating the decision-making process.

Psychologists have long known that short-term or working memory, located in the prefrontal cortex, has limited capacity. An individual can only manage three or four new pieces of information at a time in working memory (Sousa, 2012). When engineers are overloaded with too much information, their ability to solve problems and make good decisions can be negatively affected. Information overload or “infobesity” not only causes erroneous or untimely decisions, but can also negatively impact a person’s health (Pearrow, 2012).

To make matters worse, thousands of technical applications are in use today—spreadsheets, surface and subsurface models, production management software, enterprise resource planning (ERP) systems, and many more. Each has a unique structure and means of interacting with other applications. Managing manual connections among so many components is nearly impossible.

As a result, different groups within a single organization may take decisions based on incomplete views of the same asset. For example, different sets of data and applications could generate a well model and production test analysis that do not agree. Thus, different teams might recommend different solutions to the same production problem. Conflicting decisions jeopardize an operator’s ability to optimize the asset.

**Expertise is Dwindling and Regulations are Growing**

Another challenge many organizations face is the limited availability of expertise. Often, subject matter experts are geographically dispersed across numerous time zones and may not be able to travel easily to remote areas where assets are located. In addition, large numbers of experienced engineers are retiring or approaching retirement age. Companies are at risk of losing valuable knowledge about production processes that their senior engineers have acquired over time.

Finally, regulatory requirements continue to evolve. Local, national and international agencies regularly enact new, more demanding security and environmental regulations, further increasing the complexity of operations.
Moving Toward the Intelligent Digital Oilfield

Over the past decade, operators and service companies have launched a number of initiatives aimed at dealing with the increasing complexity of production operations. Such initiatives have been called smart fields™, intelligent operations of the future, i-fields™, e-fields™, integrated digital fields, or more generally as digital oil Fields (DOF). At Landmark, we call this approach Intelligent Operations (IO). Primary goals of an IO include:

- Sustainably maximizing production
- Minimizing operating and capital costs (OPEX/CAPEX), as well as environmental impact
- Protecting the safety of personnel
- Ensuring the integrity of equipment for the entire upstream production process from reservoir to point of sale (Cramer, Göbel, Mueller, & Tulalian, 2012)

The basic means of achieving these IO goals entails:

- Integrating rapidly advancing technologies (automation, communication and computing), work processes, and people (skills, motivation, collaboration)
- Acquiring and analyzing data to make decisions and take actions at sufficient frequency to achieve required gains (Cramer, Göbel, Mueller, & Tulalian, 2012)

Progress toward a more integrated operating approach has significant implications for how oil companies will need to position themselves to succeed. Dramatic changes in the way they currently operate will be necessary from both process behavioral and organizational standpoints.

The value of integration. To make timely and appropriate decisions, production operations and management require the systematic integration of multiple applications and data sources. Technical solutions for the IO should reduce the number of dimensions associated with asset management problems, enable more rapid acknowledgement of operational events, and enhance diagnosis and analysis capabilities. They should obtain the right data and transform it into valuable information that asset teams can use to better understand the state of the asset. IO solutions can improve decision-making a number of ways:

- **Focusing on relevant information.** The first step in making a good decision is identifying and gathering relevant information about the problem to be solved, and delivering it to appropriate decision makers.
- **Pre-screening information.** In complex production environments, it is critical to process and filter raw information, disregarding unimportant data that would distract decision makers from the task at hand.
- **Distributing unique information.** To avoid overloading any one member of the asset team, the solutions distributes information based on each discipline's unique view of the asset, and work together toward a final decision.
• **Combining related information.** When faced with too much information, the brain attempts to combine similar or related items. The asset team should try to relate information from different sources to find new patterns that improve decisions.

**The automation platform.** Adoption of a modern information technology (IT) integration and automation platform would enable more efficient gathering, pre-processing, and delivery of relevant asset information to each member of the operation and management team.

The value of investing in such a platform in an asset production environment would depend on its ability to substantially improve decision-making processes. “Having more terabytes of data stored on a server doesn’t help a bit. Rather, it adds cost. Likewise, storing production rates and pressures minute by minute doesn’t add any value at all. Faster communications, bigger computers and more gadgets don’t help at all—unless they lead directly to better and more timely decisions” (Hite, et al., 2006).

The challenge to end users will be to quickly analyze data, and leverage the full knowledge of multiple disciplines to make the right decisions. IO solutions enable this by:

• Freeing up engineers from low-value work
• Improving understanding of production processes
• Enabling collaboration among co-located or virtual teams

**Commitment to change.** Real-time production optimization demands a commitment from operating staff to maintain models, generate and execute recommendations in a timely manner, and achieve and sustain maximum value. More active engagement on the part of business unit management may be necessary to encourage such behavior. Transitioning to a process-oriented operating style may also expose skill and training deficiencies in the current workforce that must be addressed. Finally, integrated operations highlight potential synergies between business units that may justify changes to the traditional asset team model (Cambridge Energy Research Associates, 2005).

**Collaborative IO Workflows: Philosophy and Best Practices**

Comprehensive workflows and collaboration environments are key elements of any successful intelligent operation. They integrate a multitude of data sources and applications, capture the knowledge of production processes, and enable improved decisions. These workflows help overcome the complexity of today’s asset management operations. Below we describe the philosophy and best practices necessary for successful design and implementation of collaborative production management workflows.
Modeling the Decision-Making Process

To guarantee optimal asset performance, a decision-making process model for the intelligent operation should include the key phases described in Figure 1.

**Figure 1. Key phases in decision-making process**

**Visualize/Realize.** The first step of the process involves visualizing and acknowledging operational events that occur within the production environment. If engineers do not realize an operational event has occurred, they cannot take a decision that would maintain a particular production process or return it to the desired state. Smart surveillance solutions exist—including real-time systems and historical databases—that can gather, store and display timely information. However, it is also essential to accelerate the engineer’s acknowledgement of operational events. To this end, a number of support activities should be implemented, such as automated notification, data validation and cleansing, statistical data pre-processing, and integration of relevant information.

**Understand/Diagnose.** Once relevant operational information has been made available, engineers need to understand the causes and possible consequences of these events to accurately diagnose the situation. To facilitate proper diagnosis, they should have systems for abnormal situation management, failure analysis, and pattern recognition.

**Analyze/Recommend.** Based on the diagnosis, engineers will analyze potential alternatives and recommend interventions necessary to take the process to the desired state. Analyses include assessment of multiple scenarios and their consequences, selection of the best possible scenario, and identification of all required actions. Reliable and timely information is essential to effective analysis and decision making. Tools to support this process include process models, statistical analysis and data mining technology, expert systems and pattern recognition applications, artificial intelligence tools, as well as knowledge bases of best practices and lessons learned.

**Act/Learn.** The final step in an optimal IO decision-making process is to implement the actions required to move the operational process to the desired state. At this point, engineers benefit from the support of real-time systems and field operations teams. In addition, all aspects of the decision-making process—the diagnosis, analysis, actions taken, and consequences (positive and negative)—must be recorded. This enhances the asset knowledge base and supports continuous improvement of the asset production management process.
Designing and Delivering Collaborative Workflows

In IO programs, comprehensive production management workflows must not only facilitate the systematic integration of data sources and applications, but also enable collaboration among all members of the asset management team. Such workflows effectively orchestrate various facets of knowledge required to overcome the complexity of production operations. Benefits include:

- Faster, more efficient operational decision-making through web-enabled access to all technical data and applications in a unified environment
- Automated capture and retention of institutional production knowledge
- Greater process efficiency and technical, scientific rigor through enforceable, repeatable activities based on consistent rules

Foundations

Collaborative workflows in a successful IO program should be built on the following foundational premises:

Figure 2. Collaborative workflow foundation
Continuous improvement. Not only should collaborative workflows incorporate continuous improvements into operational and production management processes, they should also be able to generate improvements through analysis of workflow performance and identification of opportunities. Artificial intelligence systems can recognize patterns in operational variables and predict behaviors that result in continuous process improvements.

Multi-dimensional integration. Collaborative workflows can help overcome the complexity of operational problems by integrating all dimensions of the asset—reservoir, drilling, subsurface and surface facilities—into intelligible views that improve understanding and enable easier, more effective decision making. Thus, collaborative workflows must support cross-discipline synergy, information sharing, and knowledge integration.

IT infrastructure integration. Current IT infrastructures must evolve from scattered silos of applications and data sources to integrated IT infrastructures in which team members can access all information in standard ways. Two types of IT infrastructure integration are required:

- Data source integration. An integration platform should standardize the way information is obtained from multiple data sources. To do so, it should come with a collection of software adaptors that extract data from the original sources, and a federated data model that abstracts these data sources through the definition of business objects, such as wells, pipelines, and equipment. This will ensure that all process information reflects the actual production process rather than the limitations of the IT infrastructure.

- Synchronized application execution. Comprehensive production management workflows require synchronized execution of multiple applications including models, optimizers, and data analysis tools. In an IO environment, automating the flow of information between applications should be assured.

IT-agnostic solutions. Relevant data sources and applications for an asset management environment are diverse and continuously evolving. IO environments should support and even facilitate this evolution. Thus, collaborative IO solutions should not focus on specific technologies. Instead, they should be “IT agnostic.” This means that workflows should be defined independently of the applications and systems used to implement them. A well-defined IO program allows technology to change without significant impact to the structure or performance of the whole solution.

Knowledge capture. Collaborative workflows should also capture and store existing knowledge about the production process and ensure that best practices that improve asset performance can be standardized and are repeatable. Such knowledge capture provides a mechanism for training new team members by encapsulating the expertise of current engineers within new workflows. Workflows incorporating artificial intelligence can actually generate new knowledge from available information through pattern recognition, prediction and self-tuning.
Asset team engagement. The ultimate purpose of collaborative IO workflows is to provide a more effective working environment for asset teams, allowing better communication and analysis to solve operational and management problems. Therefore, if the asset team is not fully engaged and committed, the IO program will fail. Making sure that potential workflows meet asset team expectations and can be easily introduced into team members’ daily work are key factors for success. Since new workflows will inevitably change the way teams work, all team members must be engaged early in the program. Also, intentional change management strategies must accompany solution implementation to ensure long-term sustainability.

Building Blocks of Collaborative Workflows

Collaborative production workflows may consist of many different elements or building blocks—from instrumentation infrastructure to powerful visualization tools and integrated models. Figure 3 shows the fundamental elements to consider in developing and implementing collaborative production workflows.

Figure 3. The building blocks of collaborative production workflows
**Improved Process and Engineering Procedures**

Most asset teams currently use manual, time-consuming business processes. Therefore, in addition to identifying asset management requirements, the first building block for new collaborative workflows is analysis of existing workflows and identification of improvement opportunities. This involves thoroughly defining the current (as-is) state, the desired (to-be) state, and the transition path from one to the other.

Extensive domain engineering knowledge is required to design comprehensive IO workflows that enable more effective collaboration, because these workflows must incorporate many technical engineering processes, and the results of one process often feed into others. To achieve the necessary level of integration, two important teams of specialists and consultants must work together.

- **Domain engineering.** This team includes experts in reservoir, production, facilities and maintenance and other production domains, who must define the proper technical solutions.
- **Information technology.** This team includes experts in databases, infrastructure and software development, user interface design and other IT areas, who must transform technical solution definitions into practical technological tools and workflows for collaborative asset operation and management.

Both teams participate in design, implementation, testing and deployment of the ultimate solution. Merging the unique viewpoints of engineering and IT is critical to the success of any IO program. The IT team must understand the requirements of actual users from the domain engineering perspective, while the engineering team must understand the technological capabilities necessary to deliver a viable solution. Over time, as these two teams work together on IO projects, each professional group becomes more well-rounded in both domain and technological skills.

**Instrumentation and Infrastructure**

Gathering real-time process information is another key element in a collaborative workflow. Teams use this information for several purposes including operations surveillance, real-time production optimization, model updating, and calculation of key performance indicators (KPIs). A typical IO automation infrastructure for a comprehensive workflow might include:

- Multi-phase flow metering
- Gas and liquid metering
- Gas and water injection flow rate
- Smart completions
- Distributed temperature sensing (DTS)
- Surface choke settings, control, pressure
- Electro-submergible pump (ESP) monitoring and variable speed drives
- Gas lift measurement and control
• Remote Terminal Units (RTUs)
• SCADA \(^1\) system

**Integrated Production Models and Data Federation**

To continuously optimize asset performance, teams require a total understanding of reservoir, well and production network dynamics. For any one asset, they may create multiple production models to simulate various elements of the production environment. Typically, these models are not integrated. Thus, analyses of subsurface, well and surface network models are usually executed separately. Collaborative IO workflows must allow teams to automate the flow of information among all these models so they can be used as a single, integrated model of the asset.

Federated data models are part of the solution required to enable both access to and integration of multiple sources of production information in standardized workflows. Federated data models abstract original data sources by defining business objects that represent various process entities, such as wells, pipelines, and equipment. Business objects link to each data element associated with the process entities they represent. As such, access to information about variables associated with real process entities is made through reference to associated business objects, not to the original data sources. This approach provides the following benefits:

• Integration of business-oriented information
• Capture of business process knowledge
• Flexibility to change underlying data sources

Federated data models create “production semantics” that enhance the meaning of production information, facilitating better data analysis and decision-making.

**Artificial Intelligence Components**

The application of artificial intelligence into collaboration workflows in IO implementations is on the rise (Bravo, et al., 2012). Artificial intelligence components that have been used include the following:

• **Virtual sensors.** Commonly based on artificial neural networks, virtual sensors can calculate the value of a specific variable using real-time data from correlated process values. Virtual sensors are particularly useful for estimation of bottom hole variables.

• **Pattern recognition systems.** Histories of production variables are an important source of information for the understanding of the production process. Identifying patterns in specific behaviors of process variables can help to detect incipient failures, avoid downtime and optimize the performance of wells and facilities. Pattern recognition solutions are commonly based on artificial neural networks, data mining and genetic algorithms.

• **Predictive models.** The ability to predict the behavior of key variables such as rates, bottom hole and surface pressures is essential to better decision-making. Solutions based on time series, predictive control, artificial neural networks and genetic programming have proven very

\(^1\)SCADA: Supervisory Control and Data Acquisition
effective in forecasting production and reservoir variables. For example, a proxy model provides an approximate representation of a system inside a boundary of pre-defined conditions. Such a model is used when insufficient information exists to build a full model, or if the only model needed is a representation of the system around an operation point. Proxy models use real-time data, neural networks and other heuristic schemas to simulate the behavior of reservoirs, wells and/or surface production networks.

- **Expert systems.** Expert systems are widely used for oil and gas applications, including support for drilling and production operations, and management of abnormal situation and failures.

Artificial intelligence components provide collaborative workflows with intrinsic analysis capabilities that empower asset management teams to take better decisions.

**User Interfaces and Collaboration Systems**

To facilitate IO approaches, the user Interfaces must help engineers engage more intuitively in the interpretation and analysis of operational events. It is not sufficient merely to display relevant process information. Users need ways of performing analyses more easily. Trends, plots, tables, smart icons and many other elements can help achieve this objective.

Since certain members of the team—for example, subject matter experts—may be located at some geographical distance from the operational environment, IO user interfaces should enable them to access information from any point in the enterprise network, in accord with the company’s security policies. For this reason, web-based user interfaces with powerful visualization capabilities are usually the best way for users to access information.

Collaborative workflows should incorporate multiple user interfaces that iteratively guide engineers through the information required or generated by the workflows. Navigation should be natural, and the sequence in which the information is presented should make sense to users.

In addition to intelligent user interfaces, other elements may be required to enable more effective collaboration among asset operation and management team members, including:

- **Real-time visualization/collaboration centers.** These specialized rooms or buildings provide a complete environment in which operational and management teams work on a daily basis. They incorporate both technological and ergonomic elements that facilitate access to information and effective team decision-making.

- **Company-wide collaboration solutions.** Various groupware solutions that allow interaction and information sharing among co-located and virtual members of the team include: video-conferencing hardware/software, Microsoft Sharepoint® sites, chat clients, cloud services, and others.

- **Mobile collaboration technologies.** Today, more users demand mobile devices and applications that provide access to process information anywhere, at any time. These are increasingly becoming an expected part of modern IO implementations.
Methodology

The implementation of collaborative workflows requires a well-structured process that allows visualizing, designing, deploying and supporting the required solutions. A Smart Transform™ process is required to help ensure the success of an Intelligent Operations program. The Smart Transform approach is composed of three phases: Smart Vision™, Smart Deploy™ and Smart Sustain™.

**Smart Vision™**: In this phase, the current state and the real needs (at technological, process and organization levels) of the client’s operation are identified through structured procedures in order to set achievable objectives and clear expectations for the program. The Smart Vision phase supports a precise implementation plan, leveraging the current available resources.

**Smart Deploy™**: In this phase, the design, development, testing and implementation of the solution are developed using our best-of-breed project management and software engineering practices. The Smart Deploy phase helps ensure that all the components of the solution are delivered in a timely manner and with the highest quality.

**Smart Sustain™**: Once the solution is implemented, this phase of the project focuses on maintenance and sustained improvement for maximum value. The Smart Sustain phase is a collection of best practices that provide for the best support, updates and enhancement processes for the implemented solutions, as well as change management tools.

*Figure 4. Smart Transform™ methodology*
Working with Landmark’s Intelligent Operations Solutions

Landmark’s Intelligent Operations solutions focus exclusively on the analysis, design and implementation of automated workflows and collaborative work environments for asset teams engaged in oil and gas production management. Our professional service consultants combine domain knowledge in reservoir and production engineering with strong information technology expertise. The Intelligent Operations team has extensive experience in best practices associated with implementation of collaborative workflows in the upstream industry, including integration of real-time data with well, reservoir and surface models to define optimal production scenarios. We have delivered sophisticated intelligent digital oilfield solutions for both independent and national oil companies in North America, Latin America, North and West Africa, Asia and the Middle East.

Figure 5. Recent Intelligent Operations Solutions projects around the globe
Intelligent Operations Services

Our work methodology begins by gaining a thorough understanding of your current decision-making processes, the needs and motivations of your engineering professionals, and definition of the goals you want to reach. Depending on your challenges and objectives, one or both of our primary IOS teams may partner with you to design, develop and deploy highly efficient solutions.

Figure 6. Intelligent Op IOS Professional Consulting Services

Our Workflow Automation (WFA) team provides expert services that optimize your E&P operations through integration of data and applications into automated workflows. Solutions include:

- Workflow analysis, improvement and reengineering
- Implementation of a unique, vendor-neutral IT integration and automation platform designed specifically for production operation workflows
- Training, documentation and support services

Our Collaborative Working Environments (CWE) team provides a comprehensive set of tools and services to create and support new levels of collaboration. Solutions include:

- Real-time visualization and collaboration centers
- Enterprise-wide collaboration solutions
- Mobile collaboration technologies

To ensure rapid and thorough adoption and application of new workflows and collaborative working environments, we also offer critical change management services throughout the life span of your intelligent operations project. Landmark provides a structured approach to shifting/transitioning individuals, team, and organizations from a current state to a desired future state. To
ensure maximum value is achieved, sustainability must be incorporated into the project and be in place before the project closes. The overall goal is to minimize the change impacts on workers and produce behavior changes to help drive sustainability.

The benefits of IO solutions span the operational spectrum:

- Earlier detection of incipient operational problems and optimization opportunities
- Faster, more effective operational decision making through easier, more rapid, web-enabled access to multi-discipline data and applications in a unified team environment
- Capture and retention of organizational knowledge in automated production workflows
- Enhanced technical and scientific rigor and process efficiency through enforceable, repeatable activities based on consistent rules
- Cost savings, and increases in production rates and recovery factors

References


About Landmark Services

Landmark Services works with companies to improve business processes, optimize operations, deliver innovative solutions, and accelerate adoption of Landmark software. We are experts in E&P, engineering, technology, and learning, and have methodologies designed to help companies like yours succeed. Our consultants work worldwide, spanning five practice areas: Intelligent Operations, Information Management, Cloud Services, Technology Adoption, and Education. Our goal is to help you transform your business and maximize assets by enabling the safe, fast, and accurate decisions needed to find and recover every last drop of hydrocarbons.

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