EDITORIAL NOTE

Digital Transformation for Oil & Gas Production Operations: Voice of the Oilfield™ Technology

How O&G production operations can benefit

Digital Transformation for Oil & Gas Production Operations: Voice of the Oilfield™ Technology

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INTRODUCTION

During the last 20 years, there has been a paradigm shift with the development of digital technology that is changing not only the way we access information, but also the foundational business models previously used by multiple industries. This "Digital Transformation" has truly come of age, as every level of the corporation has come to rely on accurate, real-time data for making top-level market decisions down to performing individual processes. It is characterized by the rapid creation of new, innovative, digitally-driven technologies, which can be easily combined to generate powerful capabilities in the capture and processing of data.

The Oil and Gas industry has commenced its own Digital Transformation, with the increasing use of emerging digital technologies, such as the Industrial Internet of Things (IIoT) and Big Data Analytics, to enhance the Exploration and Production lifecycle.

In this white paper, we will define Digital Transformation, highlight how it can benefit Oil & Gas companies, and present Halliburton's specific approach for introducing digital technologies into the realm of Production, with what we call the "Voice of the Oilfield™ Technology."

WHAT IS DIGITAL TRANSFORMATION?

Digital Transformation can be defined as: *the profound and accelerated transformation of business activities, processes, competencies and models to fully leverage the changes and opportunities of digital technologies and their impact across society in a strategic and prioritized way, with present and future shifts in mind (i-Scoop, 2016).*

> "Digital Transformation has truly come of age…"
>
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There are several reasons why Digital Transformation is happening on a global scale and across so many types of industries:

» The advancement in digital technology over the past two decades has made it possible to gather and access quantities of information never seen before.

» The increase in computing capacity and the sustained lowering of costs for computing hardware, along with the transformation in infrastructure provision enabled by Cloud Computing, allows vast amounts of data to be processed efficiently and effectively.

» The increased coverage and capacity of new telecommunication networks, both in commercial and industrial environments, is making it possible to transmit data to and from millions of devices and data centers.

» New advanced tools for storing big volumes of data have been emerging during the last few years, facilitating Big Data Analysis, deep machine learning and identifying and correlating patterns that were impossible to detect before.

Digital Transformation in E&P

The Oil and Gas industry has never been an early adopter of technology, preferring to wait for new technological advancements to reach maturity before applying them to their business and operational processes. Now, after the successful Digital Transformation in other industries (Schwab, 2016), major Oil and Gas companies are starting to deploy Digital Transformation programs to take advantage of IIOT, the Cloud, Big Data Analytics and many other digital technologies to improve hydrocarbon exploration and production processes.

Aside from the advances in mainstream digital technologies, the prolonged Oil and Gas market conditions and lower prices have driven industry-specific innovation, as companies seek to optimize their operational processes by leveraging operational data. After a 70% price drop in the cost per barrel of oil at the end of 2014, the oil price has been oscillating in a band of 40 to 60$/bbl (see Figure 1). EIA forecasts Brent crude oil prices to average $55/b in 2017 and $57/b in 2018 (US Energy Information Administration, 2017). This "new normal" for oil prices is pushing the industry to look beyond cost cuts and reduction in personnel for efficiencies in production processes, especially in mature and unconventional fields where production costs are higher. The application of new and innovative technologies is necessary in order to achieve a more efficient and cost-effective recovery. In this context, digital technology is key for the Oil and Gas industry and more critical than ever before, as it allows a better understanding of the dynamics of production operations and, as a result, helps to identify areas for improvement.

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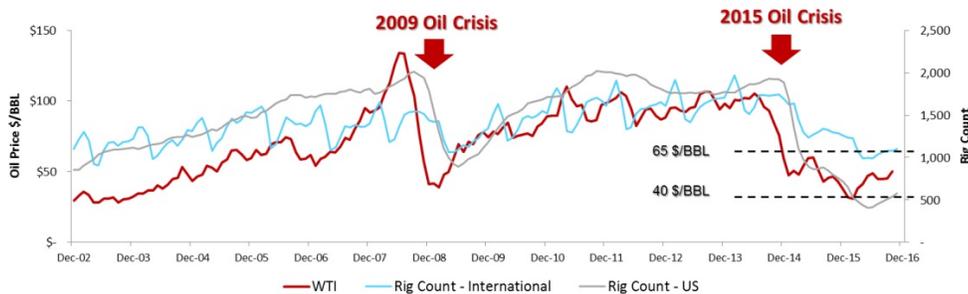
During the last 15 to 20 years, there have been some attempts to use digital technologies to automate and optimize production operations. For example, there was the Digital Oil Field (DOF), which aimed to integrate all data from production operations and enable automatic workflows for monitoring, analysis and optimization purposes. Many DOF programs were implemented by a wide variety of companies from 2000 to 2010, creating big value (Saputelli, et al., 2013). However, the value of the DOF was limited for two reasons:

- » DOF only focused on operational data, with very limited integration with data from other important areas like finance, maintenance and sales.
- » The available technology to run the DOF was very limited in comparison with the trends of Digital Transformation.

In recent years, several operators and services companies have launched Digital Transformation programs, hoping to realize the benefits shown in other industries. This has been especially useful for transforming field operations and bringing efficiencies to the production process, via IIOT devices, Edge Analytics, mobile technology, integration platforms and Big Data Analytics.

E&P DIGITAL TRANSFORMATION STRATEGY

The E&P Digital Transformation starts with an open end-to-end platform for E&P data integration and processing that enables multi-domain workflows designed for a deeper and better analysis of the available data. Also, this transformation must include digital technology drivers that have been successfully used in multiple industries, such as Edge Analytics, Cloud Computing, Augmented Reality and Big Data Analytics, in order to achieve better and safer operations.

The Voice of the Oilfield™ Technology

The Voice of the Oilfield is a comprehensive approach for achieving Digital Transformation in Oil and Gas production operations. The reservoir management process involves a great degree of uncertainty, with subsurface fluid dynamics estimated using simulation models fed with data collected at the exploration, drilling and production stages of the asset lifecycle. Getting enough information about the reservoir dynamics and the production wells and facilities network is required to better

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understand how to safely and profitably maximize hydrocarbon recovery. For this purpose, a vast amount of data is generated, collected and processed. This data includes seismic records, core samples, fluid tests, subsurface and surface real-time signals, simulations models, maintenance records, financial and commercial data, etc. Having more and better information from the reservoir, production wells and facilities results in more accurate models with less uncertainty, which in turn facilitates better decisions regarding field development planning and operation. But, the reality is that more than 60% of the data generated during the production process is not used for analysis and process improvement. The data is typically stored in silos, in different formats and with disparate levels of quality, preventing comprehensive analysis of the reservoir production system.

Digital Transformation is enabling new possibilities for maximizing the value that can be obtained from all the data generated across the reservoir and throughout the production lifecycle. New and sophisticated technologies for data capture, integration and analysis are available, creating an exciting frontier in the digital management of hydrocarbon reservoirs.

The Voice of the Oilfield solution is comprised of technologies that are seamlessly integrated to create a digital representation of the field (see Figure 2). These technologies include:

- » Field automation
- » Intelligent field control devices
- » Advanced telecommunication
- » Specialized petro-technical applications and simulation models
- » A Cloud-based integration platform for data management, workflow orchestration, Big Data Analytics execution and powerful visualization

The Voice of the Oilfield also integrates recent, state-of-the-art digital technologies that have been successfully used in other industries to provide additional capabilities to the solution. Examples of these technologies are IOT devices, wearables, drones and Augmented Reality.

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Components of the Voice of the Oilfield
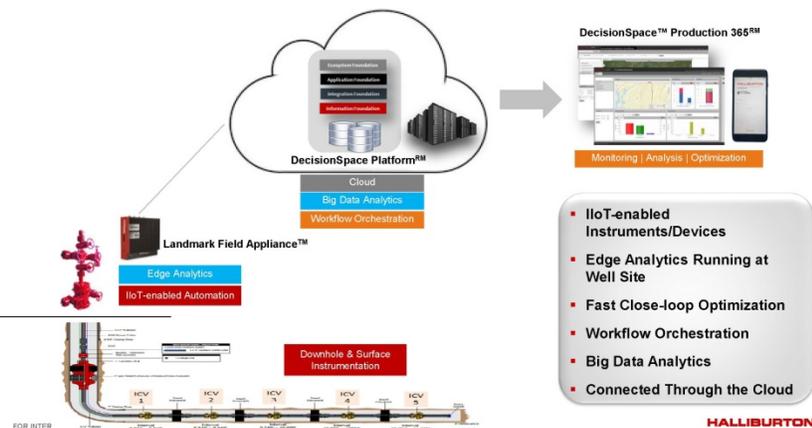
Figure 2 *Voice of the Oilfield High-Level Architecture*

DOF versus Voice of the Oilfield™ Technology

The Voice of the Oilfield differs significantly from the DOF programs implemented during the last twenty years. New technologies like IIOT, Edge and Big Data Analytics and Cloud Computing make it possible to collect and transmit more data in real-time and to run faster and more accurate simulation models. Unlike the DOF, which focuses on operational data, the Voice of the Oilfield integrates all data related to the complete value chain of production operations, including maintenance, finance, human resources, logistics and security. This opens up the possibility to execute multi-domain analysis and apply Big Data Analytics to identify patterns that would not have been possible in the past. Furthermore, using advanced data acquisition and transmission technologies and taking advantage of the increased computing power, the Voice of the Oilfield is able to accelerate the monitoring, analysis and optimization loops of production operations.

In traditional DOF implementations, the production operations include three loops at three different speeds:

Fast Loop: includes well and facility monitoring and control. It is focused on keeping operations within the operational envelope, performing event detection and executing reactive actions to address operational failures or unexpected performance. The timeframe is between minutes and hours, and the main source of information is the real-time field data capturing and transmission infrastructure.

Medium Loop: focused on well and surface network optimization. Real-time data is combined with well and surface network models and well test information to execute optimization algorithms for maximizing production and reducing operational costs. This leads to changes in the well choke position and the injection rates, as well as scheduling well interventions. This loop is executed in days to weeks and depends on the execution of new well tests and the update of well and surface models.

Slow Loop: combines well and surface models with the dynamic reservoir model to optimize reservoir recovery, while maximizing production. Information obtained from real-time systems and steady state models is used to update the reservoir model, reducing uncertainty in the simulation. Once the reservoir model is updated, scenario analysis can be performed to find the optimal field configuration, according to the asset team's objectives and restrictions. This leads to changes in injection patterns, drilling new wells, modifications in artificial lift strategies, etc. The timeframe is on a monthly to yearly basis.

The Voice of the Oilfield helps to accelerate the production operation loops, continuously integrating production information and updating subsurface and surface models, thus enabling real-time reservoir optimization. With the implementation of data-driven proxy models and Edge Analytics, the Voice of the Oilfield is able to implement intelligent closed-loop optimization at the field level, thereby helping in increasing efficiency of wells and equipment in the context of complete field optimization.

The digital field representation provided by the Voice of the Oilfield has the following characteristics (also depicted in Figure 3):

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Completeness: captures all required data about the reservoir dynamics and production process, leveraging digital technology like 4D seismic, micro-seismic and field automation, including IIOT devices, subsurface instrumentation, Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS).

Consistency: provides an integrated digital representation of the field by using integrated subsurface and surface simulation models on a single platform. It also enables cross-discipline collaboration and data sharing that leverages "out-of-the-box" workflows.

Intelligence: delivers scientific depth of analysis for precise recommendations by using sophisticated first principle and data-driven models to capture the complexity of the reservoir management processes.

Speed: enables critical "reflex" at the field level through proxy models and Edge Analytics that run at the well location for real-time production optimization, giving the well self-monitoring, self-control and self-healing capabilities. It also creates a connection between field operations and integrated analysis conducted in the Cloud that can translate recommendations into actions for production process improvement.

> "The opportunities… automation at the well, advisory services from operations, optimized future decisions. Truly untapped value for our customers."
>
> Dale McMullin
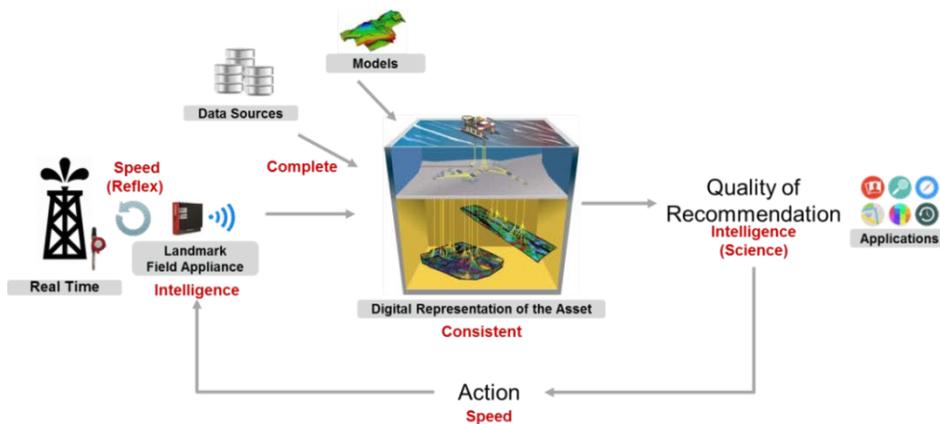
Figure 3 Voice of the Oilfield characteristics

TECHNOLOGY ENABLERS FOR THE VOICE OF THE OILFIELD™ Technology

The Voice of the Oilfield uses digital technologies that have been successfully applied in other industries as enablers for the digital representation of the oil field. These enablers are described as follows.

Industrial Internet of Things (IIOT)

The Voice of the Oilfield includes seamless integration with IIoT devices installed in the field to get real-time data from wells and equipment. These devices include sensors and actuators installed in wells and facilities, providing instantaneous information about production process dynamics and equipment performance.

Unlike traditional instrumentation commonly used at oil and gas production facilities, the IIoT sensing devices have much more functionality than capturing a signal and transmitting it to a remote location; they have the ability to connect automatically to a control network, using self-discovery capabilities. This means that once the device is turned on, it is immediately recognized by the network and starts to share information. IIoT devices can also perform data cleansing and pre-processing, adjust different measurement units and provide information about the health of the devices. It also includes mobile and wearable devices used by field operational personnel that provide valuable information about safety and logistics.

With the integration of IIoT devices, the Voice of the Oilfield is able to capture a wide variety of signals and data, such as pressure and temperature levels, flow rates, pump speed and amperage, video, motion, personnel location and routes, etc.

Edge Analytics Devices

One of the most important and innovative components of the Voice of the Oilfield is the Edge Analytics device. This is an intelligent device that executes real-time analytic algorithms at the field level to facilitate production monitoring, event detection, alarming and closed-loop production optimization for wells and facilities (see Figure 4).

The Edge Analytics device provides field data capture and transmission, real-time data analysis and control capabilities. It allows the implementation of Edge Analytics algorithms, such as data aggregation and filtering, smart alarming, sucker rod pump failure pattern recognition, electro submersible pumps tripping and failure detection, gas lift optimization, chemical injection management, etc.

With the Edge Analytics device, it is possible to analyze real-time operational data close to the operation, providing a "reflex" capability to the well and giving it a greater degree of autonomy. The device enables self-monitoring, self-control and self-healing features for the individual well, as part of an integrated system that incorporates field analysis and simulation systems.

Open Platform

All the progress in digital transformation in the retail, telecommunications and automotive industries is due to the implementation of open platforms that provide the required services and infrastructure to enable quick and simple integration of specialized solutions and applications. These platforms have the following common characteristics: they are accepted as standard across the industry, they are scalable and secure and, more importantly, they are open.

One of the main elements of the Voice of the Oilfield is an end-to-end open platform that provides access to information from any domain in the exploration and production lifecycles. It also offers advanced analysis, workflow orchestration and visualization capabilities. This open platform is the backbone for the implementation of specialized production operation solutions.

Big Data Analytics

With the application of Big Data Analytics, we can measure and, therefore, manage information more precisely than ever before. We can make better predictions and smarter decisions. We can target more effective interventions, and can do so in areas that so far has been dominated by gut and intuition, rather than by data and rigor (McAfee & Brynjolfsson, 2012). Taking advantage of the ability to integrate data from multiple domains in multiple timeframes, the Voice of the Oilfield applies a comprehensive infrastructure of Big Data Analytics that comprise not only the systems and libraries used for the implementation of analytics, but specialized algorithms designed to address the specific challenges of the Oil and Gas industry.

By integrating digital applications, companies have been able to increase their reservoir limits significantly, resulting in a decrease of up to 20% in upstream and downstream capital expenditures, in addition to ancillary benefits. Some companies have begun using 4-D seismic imaging to add a time-lapse dimension to traditional 3-D imaging, enabling them to measure and predict fluid changes in reservoirs. This enhanced view of reservoirs typically increases the recovery rate by as much as 40%, boosting upstream revenue by up to 5% (Martinotti, Nolten, & Arne Steinsbo, 2014).

Figure 4 Edge Analytics Device

Cloud Computing

Another important characteristic of the Voice of the Oilfield is that the integration platform and the specialized applications and simulation models are implemented in the Cloud. Cloud Computing is the on-demand delivery of compute power, database storage, applications and other IT resources through a Cloud services platform via the internet with pay-as-you-go pricing (Amazon Web Services, 2017). The flexibility of the Cloud enables users to size their infrastructure for the production management they require and provides immediate adaptability if more or less capacity is needed.

SPECIALIZED PRODUCTION WORKFLOWS

The digital representation of production operations comprises not only the integration of the data acquired during the production process and the execution of simulation models, but the reflection and automation of the business processes executed by the asset team on the digital platform. The Voice of the Oilfield includes a collection of automated workflows that orchestrate data, simulation models and petro-technical applications, which significantly reduces the processing and analysis time to help with optimization of the decision-making process. The workflows executed during the production lifecycle can be categorized into three types, as described below.

Production Operations Support

These workflows automate tasks that are executed by field personnel in daily operations, including field data capture and validation; production allocation and the generation of reports to regulatory agencies and partners; managing the schedule of routine operations, such as chemical injection, preventative maintenance, well tests and report production; and estimating costs and reserves.
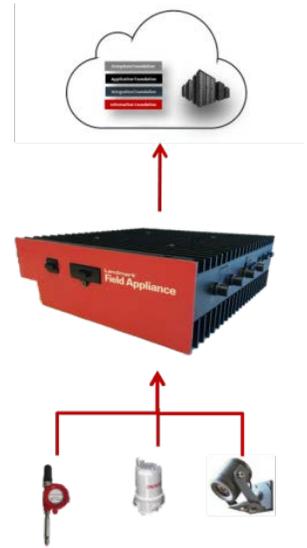
Production Surveillance and Loss Remediation

These workflows monitor and analyze well and facility performance, detect current and predict future failures or operational events and forecast production rates. They automatically identify requirements to test or adjust wells and facilities via re-configuration of chokes or artificial lift equipment, intervention and/or flow remediation. The implementation of surveillance and loss remediation workflows have reported a 5- to 10-fold time execution reduction in the detection of operational events, resulting in a decrease of downtime and deferred production (Al-Jasmi, et al., 2013).

Production Optimization

These workflows use first principle and data-driven models to optimize the production of individual wells, the field production network or the entire reservoir. The workflows include:

» Efficiency analysis of wells, production equipment and plants Scenario analysis based on operational and economic objectives and constraints, considering risk, costs and return on investment for making changes to the field

» Integrated production optimization based on both reservoir dynamics and well and facility capacity

» Assessment of current economic viability of the field

» Update and optimization of the field development plan, including the design of secondary or tertiary recovery

Several case studies demonstrate that the implementation of production optimization workflows has generated a 5 to 8% production increase (Al-Jasmi, et al., 2013) and a 20% operating cost reduction in operating fields (Sankaran, Olise, Meinert, & Awasthi, 2011) .

THE VOICE OF THE OILFIELD™ Technology SAMPLE IMPLEMENTATIONS

The Digital Well Pad

The operation of well pads in shale operations faces multiple challenges, including high well and artificial lift equipment downtime, high incidence of spills and emissions, irregular production rates, oil hauling and gas transportation restrictions, etc. These challenges are mostly related to the high degree of manual tasks performed around the well pad operations.

The Voice of the Oilfield provides the necessary technology and processes to provide an integrated digital environment for the well pad operation that fosters faster, better decision-making. The solution includes IIoT devices for field data capture (pressure, temperature, level, rate, video, and motion), high-speed connection to field devices and a Cloud-based integrated production environment. This provides access to all the

relevant data and comprises simulation models and specialized applications for performance analysis and production optimization. The solution may also incorporate an Edge Analytics device at the well pad to enable well pad event monitoring, well health diagnostics and closed-loop control and optimization capabilities.

Intelligent Completions

An Intelligent Completion is a high-cost and complex production technology that requires thoughtful design and optimized operation to provide maximum value. Using the advanced digital technology provided by the Voice of the Oilfield, it is possible to implement an Intelligent Completion Optimization solution that combines advanced simulation and workflow automation for improving completion designs and optimizing downhole valve settings to help maximize production per zone, while delaying water breakthrough in operating wells.

The subsurface and surface instrumentation installed at the Intelligent Completion site are integrated with the Edge Analytics device, in which proxy models and Edge Analytics algorithms optimize the downhole valve configuration in response to operational events in real time. Integrated near-wellbore and reservoir simulations that are continuously updated with real-time data allow the analysis of fluid patterns in the reservoir to optimize the intelligent well's ICV/ICD configuration to help maximize recovery. This proactive approach to field configuration can also help maximize the value of Intelligent Completions.

Artificial Lift Optimization

The integration of real-time data, well test information and well and surface network models makes it possible to analyze the performance of artificially lifted wells for optimization of the configuration of the pumps or other artificial lift equipment. This can help optimize the efficiency and run time of the equipment, for maximizing production. The artificial lift optimization solution provides operation monitoring, well performance evaluation and artificial lift efficiency optimization. The solution includes Edge Analytics designed to run on an Edge Analytics device at the field level, and to execute smart alarming, pump failure and tripping detection, pattern recognition and intelligent control.

This solution helps to minimize artificial lift equipment downtime, and can help identify opportunities to maximize equipment efficiency for increasing production.

SUMMARY

The Voice of the Oilfield represents a Digital Transformation for Oil and Gas production operations since it integrates advanced technologies like IIoT, Edge Analytics devices, the Cloud and specialized applications to create a digital representation of the field, continuously integrating production information and updating subsurface and surface models to achieve real-time reservoir optimization.

Now more than ever there is a need for new cost-effective opportunities to make production smarter and more connected. The Voice of the Oilfield is such an

"So much asset history is waiting…now with our scientific depth and data analytic capabilities, we can finally maximize their value."

Dale McMullin

opportunity, providing your field with a voice that is connected to the office and the board room in real-time, allowing top-level market decisions to be made efficiently and effectively.

If you have any questions around this topic, please join us in the Production and Economics Community Forum on iEnergy® to continue the dialogue.

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