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HOW DIGITAL WILL TRANSFORM THE UPSTREAM OIL ECOSYSTEM

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DESPITE ITS LONG-ESTABLISHED USE of technology, the upstream oil sector has been slower than others to embrace the digital solutions that have transformed many industries over the past decade.

That may be about to change. The dramatic decline in oil prices since mid-2014 has prompted much soul-searching among upstream companies as cash flows have dwindled and orders have dried up. As the industry seeks ways to return to profitability, digital is emerging as part of the answer, presenting the possibility of a radically more efficient new normal.

Upstream companies are beginning to innovate a new wave of technology solutions. At the same time, the current tough environment is creating a convergence of interests between oil companies and their suppliers and a willingness to consider new, digitally driven commercial relationships.

Together, these developments have the potential to transform the upstream industry's fortunes by substantially improving

capital efficiency, lowering production costs, and reducing time to first oil.

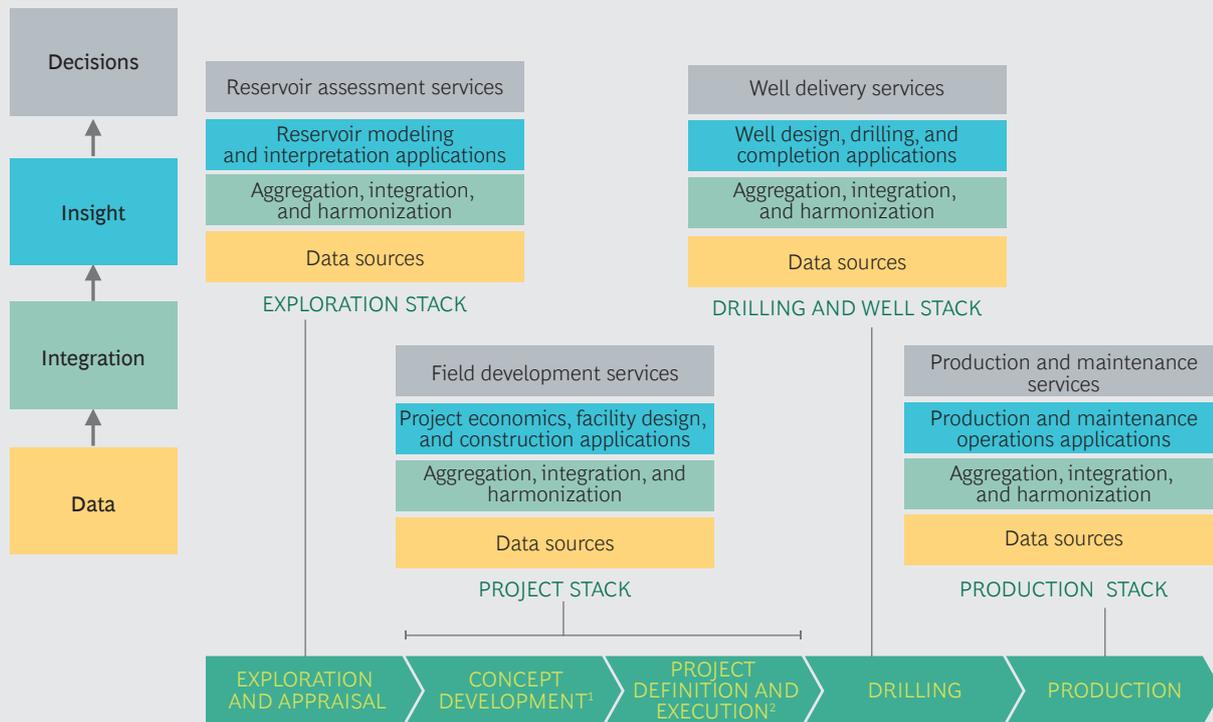
Through a Technology Stack Lens

Digitalization brings significant changes to an industry's ecosystem, disrupting traditional value chains and redefining roles: new business models empower some companies and make others obsolete. In our work with leading organizations, we find that companies often struggle with the complexity of these changes.

By using a structured approach to examine the potential impact of digitalization on their business, companies can understand digital transformation better and can more easily benefit from it.

We took a technology stack approach to explore how digitalization will alter the upstream oil ecosystem, examining all five steps in the upstream value chain: exploration and appraisal, concept development, project definition and execution, drilling,

EXHIBIT 1 | Digital Solutions for Upstream Oil Will Emerge Within Four Technology Stacks



Source: BCG analysis.

¹Selection of field architecture, platform, number, and type of wells.

²Construction of process equipment and facilities.

and production. (See Exhibit 1.) This approach provides the structure that company executives need in order to understand digitalization.

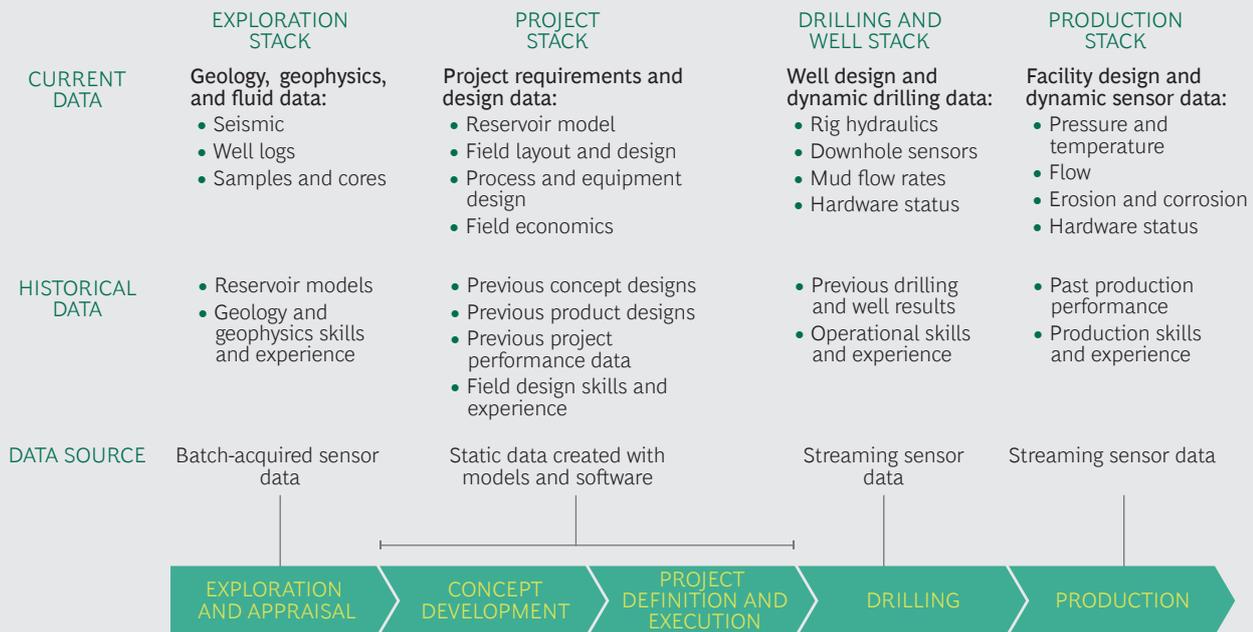
Put simply, digitalization is about converting data to insights and taking action based on those insights. How a company in the upstream ecosystem goes digital is different at each step in the value chain; each step involves different types of data, processing requirements, insight-generating techniques, and decisions. By following the data from its creation through the decisions made on the basis of that data, executives can gain a unique perspective of both the companies that contribute to each stack and the opportunities that are made possible by new digital technologies.

Our technology stack approach yields four distinct stacks: exploration, project, drilling, and production. We believe the process of digitalization will be unique to each stack, for two reasons. First, each stack is made up of a discrete ecosystem of companies,

with its own business arrangements, a distinct flow of data, and a particular set of technical challenges, and each stack has a different digital maturity. Second, the nature of the data generated and utilized in each stack differs from that of the others (see Exhibit 2):

- **Exploration and appraisal data**, which feeds the exploration stack, is collected from surveys and exploration and appraisal wells, typically acquired in batches, and processed together to derive insight into the reservoir.
- **Concept selection data and definition and execution data**, which support the project stack, are combinations of static and dynamic, or variable, data from reservoir models, field architecture, and equipment design information.
- **Drilling data and production data**, supporting the final two stacks, are streaming data, derived from drilling operations and production facilities.

EXHIBIT 2 | The Four Stacks Build Directly on the Underlying Data Types



Source: BCG analysis.

To Tap Transformational Benefits, Business Models Must Change

Within each stack ecosystem, companies stand to gain significant benefits because of digitalization. Many of the opportunities, however, will require greater collaboration across disciplines and companies and an agile response to digitally driven change. Investment throughout the upstream ecosystem will be necessary to support digitalization. The industry will also need to reconsider the business models it currently employs as operators and suppliers adapt to new roles.

By analyzing the companies, data flows, and potential technology developments inside each stack, we see the following value-creating opportunities and business model changes emerging.

THE EXPLORATION STACK

The application of machine-learning methods to reservoir modeling, based on large data sets and powered by scalable high-performance computers developed by global technology companies, will speed up and improve the interpretation of exploration data. Tapping this opportunity will require

substantial investment in the emerging field of machine learning, as well as closer cooperation between oil and gas, seismic-data-processing, and technology companies. Early implementations of machine-learning methods are already locating geological faults automatically from raw seismic data. Upstream companies—operators and oil-field service (OFS) companies—will need to adopt the following strategies.

Operators. Operators coordinate the value chain today and own most of the critical data along it. They should retain ownership of the subsurface data and models—which are key sources of competitive advantage. As more data interpretation tasks are automated, operators should aim to stay ahead of challengers by strengthening their high-performance-computing capabilities and investing in new capabilities such as advanced analytics and machine learning.

OFS Companies. OFS companies provide the majority of the data acquisition capabilities in exploration and offer data-processing software and solutions. However, their legacy positions could be threatened by a rapid shift toward cloud-based high-performance computing architecture and

the emergence of newcomers skilled in machine-learning technology. To avoid disruption, OFS contractors need to focus on migrating their legacy systems to the new computational architectures and accelerating their investment in analytics and machine-learning capabilities.

THE PROJECT STACK

A new generation of digital modeling and simulation tools will link reservoir data, field architecture, equipment design, and economics into a single digital framework. This will enable oil companies to quickly choose the most economical field design from a large number of options. Using historical design data, companies will also be able to develop a “digital twin” of the asset, which can then be used through the life of the well to model complex design, process, and equipment modifications in the virtual world before applying them in the real world. Digital twins are already being used by industrial companies such as aircraft engine makers.

We expect digital to significantly impact the development process at the project phase, between the field concept selection and commissioning steps. To unlock the potential brought by new technologies, companies involved in the project phase must take specific measures.

Operators. To develop an oilfield currently, operators manage a complex, sequential process; set standards; and contract with a large number of parties.

In the future, they should adopt a more iterative and integrated approach and construct new compensation models that account for the sharp reduction in work hours that is likely to become the norm at the project phase in the future. This will require increased collaboration and longer-term partnerships with engineering, procurement, and construction (EPC) companies. Such collaboration may resemble the risk-sharing partnerships in the aerospace industry, where preferred suppliers of key subsystems invest in a new aircraft program and share a portion of the revenue, with the aircraft manufacturer respon-

sible for integrating the completed subsystems into the overall project.

EPC Companies. These companies are likely to see a significant reduction in engineering hours as a result of digitalization. They will need to rethink their core business models. The winners will build skill sets to use, and potentially develop, their own design automation software and approaches. EPC companies will need to engage earlier in the process so that they can achieve low-cost design solutions that benefit both operators and themselves, minimize expensive changes, and partner with original equipment manufacturers (OEMs) to have predesigned solutions in place. To achieve this, EPC companies will need to work more collaboratively with both operators and OEMs. Reward arrangements will need to change to reflect this, with incentives for efficient, data-enabled delivery rather than hours spent.

THE DRILLING AND WELL STACK

Opportunities in the drilling and well stack will arise from the development of integrated drilling automation systems, which, coupled with better coordination and collaboration between rig owners, OFS companies, and OEMs, will result in closed-loop, autonomous drilling. Until now, discrete elements of the drilling process have been automated. However, companies are now working to link subsystems and thereby transform the entire drilling operation. Automated well design and drilling will substantially reduce costs and drilling times and improve companies’ ability to more consistently drill better-quality well bores. But shorter drilling times will call for new compensation arrangements.

By bringing greater transparency to the drilling process, digital technologies are already enabling companies to move away from a day rate compensation model to models that are based on outcomes and performance. These reward suppliers for successfully delivering on key performance factors, such as speed and quality.

Through this shift in models, drilling companies will be incentivized to invest in time-

saving technology and service models. Risk-reward arrangements will also support the transition to outcome-based models. We anticipate an increase in the number of alliances and greater cooperation between OFS contractors, key OEMs, and rig companies so that they can offer operators seamlessly integrated solutions with greater automation.

Operators. These companies should maintain control over the drilling plan and leverage learning across wells to automate and improve well-engineering design. They should also act as integrators and create commercial arrangements and incentives that will bring together rig owners, OFS companies, and OEMs to maximize the potential of automation. Getting the specific contractual terms right will be essential to ensure that collaboration is successful.

Suppliers. Rig owners will need to add value to the drilling process by exploiting the data generated from drilling to optimize rig performance so that both the operator and the OFS company benefit. Owners and OFS companies will also need to partner with makers of industrial control systems and sensors to improve the automation and integration of key rig processes. This will require a shift from day-rate-based to performance-based contracts that compensate suppliers for investing in new technologies.

THE PRODUCTION STACK

In production, new big data digital technologies will allow the capture and real-time processing of larger and more complex data sets. By automatically extracting insight from a combination of data derived from individual machines, system performance, and operator logs, these technologies will bolster operators' ability to improve operational performance. We envision two distinct types of benefits for companies operating in the production stack:

- Data from individual machines and their operating environment will enable predictive maintenance, improving the uptime and performance of critical production equipment.

- Overall system performance can be further optimized by combining data from reservoir models, well and process measurements, machine health data, and field economics in real time. Such a comprehensive data integration will enable continuous updates of reservoir models based on individual well behavior. This will lead not only to improved production rates but also to superior recovery.

Data and analytics technologies that are based on the Internet of Things could unlock optimization benefits that have been promised by suppliers but have remained hard to capture at scale. Incompatible or heterogeneous data formats have made it challenging to achieve these—until now. IoT technologies offer greater connectivity between sensors and production equipment and so improve data collection. To capture these benefits, the production software ecosystem will need to be opened up. This will reduce barriers to entry for startups and niche suppliers, threatening incumbents' established business models. Newcomers are already offering predictive maintenance solutions for equipment manufactured by traditional suppliers, stealing a valuable service business from the incumbents.

Operators. Operators have an important oversight role: to marshal data from different suppliers along the value chain and thereby enable optimization of the whole asset (reservoir, wells, and facilities). These companies should take a leadership role and collaborate with fellow operators and IoT technology suppliers to develop standards for the new data platforms. Operators can use these platforms to enable service-focused arrangements with their suppliers by sharing the data that suppliers need in order to offer such services. For example, suppliers of electrical submersible pumps are often compensated with performance bonuses that are paid if the equipment delivers an agreed-upon level of uptime, which is assessed using data monitoring.

Such changes are creating a profusion of choices for operators, which will need to

consider whether to shift from upfront purchases followed by maintenance contracts to as-a-service lease contracts.

While the performance of individual equipment can be left to suppliers or third parties, operators are best placed to drive the optimization of the production system. This will require oil and gas companies to acquire new capabilities, which, combined with their process experience, can deliver better uptime and more efficient production.

OEMs. To fend off challengers and benefit from digitalization, OEMs will need to undertake two significant changes: they must shift from a hardware sales mindset to one that is service oriented, and, in turn, they must develop the ability to produce, manage, support, and correctly price software-centric solutions.

This means that OEMs will need to provide more advanced analytics offerings that complement their superior equipment knowledge. They will need to adjust their products, leverage sensors differently, and convert from a sales to a service model. They must also make their equipment compatible with the data infrastructures and protocols that operators use.

The industry is already seeing examples of companies using data in smart, innovative ways and transforming it into profitable business decisions. For example, suppliers are offering products with as-a-service-, performance-, or uptime-based compensation models. Some are leasing equipment under new service agreements. These are similar to the “power by the hour” service agreements used by aircraft engine manufacturers: suppliers are paid based on the availability of the asset and take on the risk of downtime.

Under such arrangements, suppliers have access to the operator’s data and sensors and are incentivized to use these effectively to ensure that the equipment keeps running, rather than being paid when it fails. The information gathered also helps suppliers to improve future designs.

Benefiting from Digital Disruption

Oil companies and their suppliers need to take the following steps to capture the value of digitalization, navigate complexity and uncertainty, and take decisive actions:

- **Understand their current position** in the value chain, and the associated technology stack, and from there identify future roles. By mapping their current position within the digital ecosystem, companies can better understand the opportunities available as well as the potential disruptions. For example, the transition to outcome-based models will mean that a hardware manufacturer will need to acquire or develop data analytics capabilities that enable it to assess equipment performance, or it will face the threat of a rival stealing this new value-added and service-focused business area.
- **Identify potential partners.** Most companies will need partners to develop fresh capabilities. For example, operators may need to partner with software companies to access new technological capabilities and with traditional suppliers to develop new products and services and new commercial arrangements. We are already seeing examples emerging. Among suppliers, a large OFS contractor has partnered with one of the world’s leading technology companies to gain access to scalable high-performance data-processing capabilities, improving its ability to analyze subsurface data.
- **Establish the in-house development capabilities** needed for an agile response to new, rapidly changing digital opportunities. The right capabilities will enable companies to achieve a sustainable advantage over competitors. In today’s rapidly changing environment, the use of agile development methods is essential if companies are to adopt digital solutions quickly.

Digitalization is set to have a profound impact on both operators and suppliers in the

upstream oil and gas industry. A wave of digital solutions will bring greater technological innovation to the industry, but at the same time these solutions, and the new entrants offering them, are poised to challenge and disrupt the established practices and business models of the incumbents.

The potential for profitable transformation will be fully realized only if upstream companies embrace new models and greater collaboration.

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