Analytic Innovations Address New Challenges in the Oil and Gas Industry
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Introduction

The world’s energy industry is at a crossroads. New challenges emerge almost daily – yet there’s a tendency to address them using techniques and technologies of the past. It’s time for a new approach.

Consider just a few of the new challenges. There’s burgeoning demand in emerging economies; increasing competition for leasing rights, financial and intellectual capital; increasing public scrutiny; and regulatory demands for transparency.

Some think that the supply of oil and gas has peaked and will be increasingly difficult and expensive to find. But others believe that new types of hydrocarbon structures are already increasingly available to advanced, but costly, extraction techniques. New transcontinental pipelines are being considered between nearly every oil producing and refining region around the world, and the construction of necessary storage facilities is booming. The world of downstream activity is also rapidly changing, as consumer demands adjust to worldwide economic conditions.

In this sort of environment, companies participating in the exploration and production, transportation and storage, refining and processing, and distribution of hydrocarbons need every competitive advantage that’s available.

Truly, companies participating in the upstream, downstream and retail sectors using old business techniques have an uncertain future – but there is good news. All the new and improved measuring and monitoring devices – and all the new information technology systems companies have invested in over the last 20 years – are capable of providing the data that can create new vistas of business acumen and operational effectiveness. With the strategic use of analytics, oil and gas companies can achieve the high degrees of confidence needed to make groundbreaking, profitable decisions.

Upstream Analytics

Upstream oil and gas operators continue to add new measurement and monitoring devices along the entire exploration and production chain, from reservoirs to primary storage and processing facilities. Each new device compounds the quantity of new data that can be harnessed to influence and improve exploration and production (E&P) operators’ decision making. By connecting the data from those field devices, companies are creating digital oilfields and new data-driven operators who are ready for analytics to change their game.

Analytics can optimize the activities associated with exploration and production, including oilfield production forecasting, predictive asset maintenance, reservoir characterization and analytics for unconventional resource recovery. Supporting these activities through data-driven integrated planning is a proven way to deliver significant efficiency gains.
Figure 1: Analytic applications within exploration and production have optimized the return from traditional oilfield assets and newer unconventional resources.

Exploration and Production Optimization

E&P operators can maximize total recovery over the long term by gathering real-time surveillance data from across the oilfield and presenting it to experts skilled in engineering and geosciences. This approach will fulfill the promise of the “smart” oilfield – that all data-producing devices can be combined to produce additional insights into the most effective timing and recovery of various processes.

Optimizing exploration and production can enhance operational efficiency by:

- **Improving the quality of data the operator relies on for critical decisions.** By integrating relevant data from multiple monitoring and surveillance systems across all geology, geophysics and reservoir engineering (GGRE) disciplines into a unified view and automating all critical preprocessing tasks, operators gain confidence in the decisions they are encouraged to make.

- **Increasing the reliability of reserves information through advanced modeling.** Reliability comes from generating reservoir models that truly reflect the spatial relationships between geological elements and their petrophysical properties – whether anisotropic or isotropic in nature.

- **Optimizing shale gas and tight oil exploration by modeling and simulating well performance** before deploying assets or selecting fracking techniques. For insights into these unique reservoirs, companies are beginning to mine the data harvested from recent experience with unconventional resources.

- **Predicting unplanned events so that mitigation can occur.** Predictive analytics adapts to every situation based on workflow rules that the operator defines according to circumstances.
• **Enabling operators to make more accurate determinations of reservoir properties using spatial analytics.** Variograms, kriging and simulation can help identify properties like porosity and permeability.

• **Increasing decision support across disparate upstream disciplines** by using data mining to create accurate predictive and descriptive models based on enterprise data collected from geology, geophysics, petrology and reservoir engineering.

• **Presenting probabilistic results in a dashboard environment** using flexible reporting capabilities.

### Oilfield Production Forecasting

Providing shareholders with insight into the future performance and remaining reserves of each reservoir is the fiduciary responsibility of every upstream operator. But yesterday’s prediction techniques may not apply as accurately as they once did, particularly with new shale gas, tight oil and oil sand fields coming to the fore. Oilfield production forecasting sets the stage for all subsequent activities, like planning, financing and producing, because it enables producers to:

• **Access well and reservoir data quickly and easily.** With intuitive graphical user interfaces, it’s simpler to integrate and profile forecasting data, identify outliers and missing values, and select appropriate treatment strategies.

• **Apply analytical functions consistently across the organization.** You can use forecasting that automatically selects the best model but allows human intervention and benchmarking for repeatability.

• **Perform decline analysis quickly and flexibly** with a robust analytical engine that provides what-if scenarios to model estimated ultimate recovery (EUR) based on a predefined range of easily adjustable, industry-standard default values.

• **Estimate unconventional well production sources more accurately** using best-fit prediction that utilizes smaller data sets when large volumes of historical data are not available.

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**Figure 2:** Oilfield production forecasting estimates reserves, improves understanding of well integrity and evaluates forecasted production scenarios with advanced decline curve analyses.
Predicting Failure of Field Assets

Once the forecasting, planning and optimization techniques are in place, the oilfield machinery runs at full capacity. Old equipment that’s been in the field a long time can break down and ruin the best plans for maximized recovery. All too often, the only things that drive maintenance are actual failure and unproductive downtime – despite signals that other equipment might be on the verge of failure.

By minimizing disruptions to production, or eliminating them before they happen, operators can maximize maintenance resources and keep production on schedule to meet financial goals. Various sources and forms of data, including basic historical maintenance records and other information, can help operators detect and diagnose the root causes of poor performance and limit unplanned downtime. By evaluating the integrity and reliability of facilities, operators can:

• **Create a single, consistent information source.** Access, standardize and consolidate all relevant information regardless of location or format.

• **Reduce maintenance costs and work hours.** Optimize maintenance plans and schedules – taking into account priorities, skill sets, time and resource constraints, etc. – and track work orders and resource usage through a single, integrated system.

• **Gain a big-picture view of performance.** Develop, monitor and measure KPIs via a Web portal that shows how well maintenance plans are working at any point in time.

• **Proactively manage activities and control costs.** Prioritize assets for maintenance, make the most of planned shutdowns, and monitor costs and completions.

• **Ensure ongoing performance improvements.** Easily share knowledge – benchmark standards, best practices, maintenance history, regulatory guidelines, etc. – among those who need it, in a form that works best for them.

Reservoir Characterization

Soft computing methodologies that map seismic attributes to reservoir properties are incredibly important as a means to define more credible and reliable reservoir characterization definitions that underpin field (re)development. The process to characterize the reservoirs of a mature field requires analyzing large data sets collated from well tests, production history and core analysis results. This data is enhanced by high-resolution mapping of the reservoir’s seismic attributes. It is imperative to capture the more subtle observations inherent in these data sets to comprehend the structure of the reservoir.
Invariably, operators can implement geostatistical methods to accurately quantify heterogeneity, integrate scalable data and capture the scope of uncertainty. However, emerging best practices in the field of reservoir characterization complement geostatistical findings with results from advanced analytics and exploratory data analysis (EDA). These techniques provide:

- **More reliable data for analysis.** Consistent data integration, data aggregation and data management, underpinned by univariate, bivariate and multivariate analysis.

- **A comprehensive toolset with broader implications for reservoir analysis.** The reservoir engineer can now visualize and perform descriptive and inferential statistics in near-real time on millions or billions of rows of data – true big data analytics.

- **The ability to evaluate more complex data in granular detail.** The spatial integrity of large-area reservoirs requires high-resolution seismic data and a more in-depth understanding of seismic attributes that can identify both stratigraphic and structural reservoirs.

*Figure 3: Reservoir characterization including visualization of 3D seismic attributes.*
Analytics for Unconventional Resource Recovery

Innovative, advanced analytical capabilities combined with other statistical tools can decrease cost and reduce risk while maximizing production from unconventional resource recovery (URR), like shale and coal gas or tight oil sands. Such analytics combine to help operators attain a comprehensive understanding of reservoir heterogeneity so they can extract hidden predictive information, identify drivers and leading indicators of efficient well production, determine optimal drilling and completion programs, and recommend optimum stimulation processes and frequencies. But these sorts of analytics are mostly new to the industry and deserve further explanation, given the high-stakes drama surrounding the need for success in this new extraction paradigm.

These capabilities work together to match high-tech drilling processes to the subterranean landscapes, decreasing uncertainties about what is beneath the surface, and shifting the mindset to that of a manufacturer’s model. The value of analytics to URR may become the proverbial silver bullet, as there are so many opportunities to apply analytics to workflows, data and conventional processes. Consider the following two examples.

One example involves the use of clustering, a data mining tool that categorizes and analyzes group data dimensions that demonstrate similar attribute characteristics. This data helps in analyzing wells because the clustering methodology classifies wells by dividing fields into selected areas and then grouping the most similar wells as its first set of clusters. For example, the following well parameters can be used as the data to create groups with similar characteristics: cumulative liquid production; cumulative oil or gas production; water cut (percentage determined by water production/liquid production); B exponent (decline-type curve); initial rate of decline; initial rate of production; and average liquid production. The methodology then compares the clusters’ averages to the remaining wells to form a second set of clusters. Then the process is repeated until enough subsets exist to provide meaningful insights about the entire well portfolio.

The clustering technique is especially important to the selection and use of expensive proppants used for hydraulic fracturing, or fracking. The clusters and information sets are so immense that computation time requires grid computing to calculate capacities for thousands of wells.

Another example of how analytics can be applied to existing methods is that of SEMMA processes (sample, explore, modify, model and assess). This method generates information that can be used with advanced analytics to enable upstream oil and gas companies to make more robust forecasts based on a deeper understanding of future production under current and simulated business conditions. For example, adopting an advanced analysis of decline curves methodology provides important forecasting results for future production from single or multiple wells across reservoirs and fields.
Because it is a process and not a methodology, SEMMA encompasses a series of progressive and interdependent steps that ideally should work together to build analytics and inform various operating goals. The SEMMA process does this by creating models that deliver higher degrees of certainty for production methods, given the current conditions and the resulting rates of return.

**Integrated Planning Capabilities**

Predicting the flow of estimated oil is the first crucial step in planning. Developing an integrated plan that maximizes production without compromising safety is next. The goal of such planning is to create a unified view of the task at hand – accessing and consolidating data from multiple departments, contractors and subcontractors into a single version of the truth, regardless of the original source or format. The value of integrated planning is letting the right hand know what the left is doing, so that resource allocations are timed and ordered. The benefits of integrated planning include:

- **One integrated plan.** Data from various, sometimes disparate, planning systems combine into a single view for the purpose of identifying dependencies between the various activities and then finding ways to optimize their execution.

- **Vet the plan.** Through a process that integrates data from various planning systems, a producer can check for consistency and then flag potential conflicts. Listings of planned work in the same functional and physical areas might create an alert that the space is double-booked and not likely to be worthwhile for either user. Different plan baselines keep track of revisions along the way. Changes in the overall plan can be written back to the source planning systems. Finally, producers can create a wide range of reports to share the integrated plan with various stakeholders.

- **Optimized activities and projects.** It’s important to take the best possible route toward all the projects and subset activities that must be accomplished. Producers can select this route using analysis/optimization techniques that include customized decision criteria like resource allocation, capital limitations, time horizon and benefit realization.
Figure 4: Integrated planning and logistics allows operators to balance remote site hoteling availability with projected hoteling demand by type of work.

**Downstream Analytics**

Once hydrocarbons are extracted, processed and delivered, the downstream petroleum industry creates products that meet the consumer in the form of gasoline for cars and natural gas and oil for home heating. The processed hydrocarbons also create building block components for a wide range of wholesalers, commercial and industrial customers that convert the raw products into thousands of end products used in consumer households.

To be effective, downstream companies need to keep an eye on all the variables affecting demand and competition. Consumers chase the latest thing or the most economical offering, and their demand for goods might align with their disposable income and economic trends – even the weather and housing market. Organizations must stay attuned to these leading market and consumer needs indicators, with continuous attention to achieving operational excellence. To effectively deliver hydrocarbons to their final users, organizations need coordinated technology solutions for demand forecasting, facility integrity and reliability, and customer intelligence.
Demand Forecasting for Refining

Refining plants have certain capacities to produce a range of products in quantities required by buyers. Predicting the right run rates and run times to meet specific market demands can present opportunities to generate revenue, stabilize cash flow and earnings, and directly create bridges to markets and customers. This is the ideal – balancing refining supply with demand, and being adaptable to meet special highly profitable situations. At the same time, refiners must be able to shift their processes and minimize disruptions so that they will run in sync with their capabilities.

Unfortunately, legacy enterprise resource planning (ERP) and supply chain management (SCM) technology infrastructures are workflow-based, resource-intensive and time-consuming. Final judgments in forecasting future demand can be driven by biased decisions or by specific people with domain knowledge. Finding the right demand signals well in advance across domains is increasingly viewed as the proper response to economic variables and razor-thin profit margins.

To accommodate today’s requirements, refiners have been adding more science to their ability to look into the future by finding ways to forecast demand for their products. For example, they might forecast which regions need certain blends of gasoline or chemicals in response to new regulatory requirements. Or they might try to gain market share when a competitor is experiencing a hiccup in production capacities. Forecasting demand in these sorts of situations can help address the pressures on profit that come from kinks in the supply chain, and subsequently keep profit margins at acceptable levels. Using data, midstream companies can achieve better ROI on their existing technologies, whether they are information assets or production plants.
Refining companies can achieve better ROI on legacy IT investments by maximizing the use of data. With demand forecasting, refiners can:

- **Perform accurate, demand-driven forecasts at any hierarchical level.** By tailoring the forecasting model to the type of data available, refiners can gain a true picture of demand that relies not only on historical demand data, but also includes consumer signals, consumption data and market indicators such as price, promotions and weather.

- **Determine optimal demand-shaping options.** Test various scenarios and conduct what-if analyses to gauge the impact of changes in marketing strategies or product mix on demand and profitability.

- **Measure forecast performance against KPIs.** Interactive dashboards provide the ability to monitor, track, alert and report on forecast performance metrics.

- **Reduce inventories and stock-outs by planning future events and consumer needs.** Reduce backorders by producing the right products in correct quantities at the optimum time.

- **Generate consensus forecasts with gap analysis and strategy reporting across all business units.** Meeting financial goals can be coordinated across business units – if the right hand knows what the left is doing and downside surprises are minimized.

*Figure 6: Example of demand forecasting output – forecasted US refinery capacity.*
Facility Integrity and Reliability

Running your processing, refining or petrochemical plant at peak performance is a critical factor for success, but there are times when events or special unforeseen factors prevent operators from achieving this goal. The trick is to learn how to predict when outages may occur, using data that's available for the incredibly wide range of variables that affect these processes, like temperatures, chemical composition degradation, mechanical wear and tear, or the simple life expectancy of a valve seal. By integrating data from a variety of process sources with knowledge and experience databases, operations can boost uptime, performance and productivity while lowering maintenance costs and downtime. Use predictive asset maintenance techniques to help you:

- **Predict and prevent production disruptions** by accessing and analyzing all relevant data – historical and real-time – from key metering, monitoring and surveillance systems.
- **Achieve a single, integrated view of all relevant information** – including historical, right-time and real-time data – regardless of source or format.
- **Ensure the accuracy and reliability of that information** with embedded data-quality techniques that standardize and cleanse data so that it’s ready for analysis.
- **Detect hidden patterns and anomalies that identify particular events** using advanced data mining techniques to sift through streams of complex data.
- **Predict when unplanned events – such as equipment failures – will occur**, using sequence analysis to identify upcoming events based on workflow rules that you define.
- **Mitigate the impact of unplanned shutdowns** with automated, early-warning alerts that are routed to the appropriate operations engineer and escalated, if needed.
- **Enable knowledge sharing and collaboration** by tapping into a knowledge system that stores past responses to events and is continuously updated with best practices.

Figure 7: Integrated business intelligence provides easy access to standardized or customized reports for users across the entire organization.
Commodity Trading Risk Management

Price volatility is the new norm for worldwide commodity markets. Oil looks like it’s breaking out above $110 a barrel, and then four weeks later it is struggling to hold $80. Natural gas spikes to $15/Btu and five years later struggles to hold $2/Btu given new finds the world over. The best that oil and gas operators can hope to do is reduce pricing risks for each commodity they produce or, increasingly, each special fluid needed to extract oil and gas. And downstream producers need to continually manage their exposures to market prices for their building block commodities and align with their processes for building consumer goods. In addition, there are formidable risk management challenges in complying with new and existing laws and regulations such as the Dodd-Frank Act (US) and MiFID (EU) – and in avoiding penalties for breaking them.

Paying attention to external price signals and staying abreast of new regulations are difficult challenges themselves. But producers along the entire hydrocarbon value chain also need to know their ability to meet demand given the challenges of different applications used to manage various commodities, foreign exchange rates or operational activities. Trading organizations need real-time information, from external and internal sources, along with the analytic ability to make smart assumptions about all future transactions that will occur along the very long production chain.

Operators need commodity trading risk management (CTRM) solutions that proactively capture, analyze, model and simulate what-if market scenarios. These solutions can help minimize the worst effects of possible price volatility while maximizing the profitability of special situations when they arise. Use CTRM solutions to:

- **Centralize risk modeling and reporting functions** by consolidating exposures across business units and trading books – from a variety of disparate transaction and market data sources – into a common risk data store.

- **Comply more easily with external regulations** through internal CTRM policies that let you register critical proprietary algorithms previously stored in spreadsheets within a secure and auditable database. This approach gives you the flexibility inherent in spreadsheets without the business control issues.

- **Reduce your reliance on spreadsheets and increase risk modeling and reporting activities** by using powerful analytical and data management capabilities to conduct your operations holistically around commodity risk management.

- **Track current and potential risk exposures** using advanced analytics to quantify and run exposure analysis metrics, including value at risk (VaR), earnings at risk (EaR), cash flow at risk (CFaR), gross margin at risk (GMaR) and potential future exposure (PFE) on your portfolios.
Customer Intelligence

The first rule in most businesses is to know your customer. How are your customers’ businesses doing? What external forces are affecting them? How quickly will they react to changes in end-user preferences? How can you prompt them to buy your products given their circumstances – and at what price?

Customer-focused business strategies create opportunities that drive profitable revenue growth, if they are managed within an integrated marketing framework that takes a holistic approach to marketing development. The framework includes formulating strategy, gaining insight from data and analytics, optimizing customer interactions, and finally understanding the customer experience. With customer intelligence solutions, you can:

- **Find the most profitable growth opportunities** through greater understanding of customer and market behavior, sentiment and influences.
- **Take the best marketing actions** by determining which combination of activities will get the most value out of each customer interaction and generate the highest returns.
- **Maximize cross-business impact** by gaining insight into customer activity and aligning that with your business strategy to improve organizational performance, build stronger customer relationships and deliver exceptional customer value.

Conclusion

Oil and gas companies must provide an increasing quantity of their products to growing world economies and simultaneously deliver financial results in a capital-intensive, highly regulated, competitive industry. They must also meet stringent requirements for environmental transparency, maximize investments needed to meet demand growth, and maintain and upgrade aging infrastructure. And soon the industry will be forced to meet these challenges with an aging workforce that is likely to retire in large numbers, leaving skills gaps across the entire work chain.

In this environment, upstream oil and gas companies need integrated views of their production processes, all the way from the reservoir to the pipeline. They must optimize their processes and perform predictive analysis of production problems to minimize losses.

Every day, oil and gas leaders around the world rely on the power of SAS® to deliver the predictive maintenance, forecasting and analysis, and energy trading and risk management systems they need to effectively manage the world’s longest supply and process chains – from the wellhead to the retail gas pump. With more than three decades of experience delivering industry-leading capabilities in data integration, advanced analytics and business intelligence, SAS provides key solutions that enable oil and gas companies to create intelligence from new data sources and deliver information for effective decision making across the enterprise.

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