REPRINTED FROM

OIL & GAS MONITOR

AUGUST, 2014 WWW.OILGASMONITOR.COM

LET YOUR DATA DO THE TALKING

By: Moray Laing & Keith Holdaway, SAS

I: THE GENERATION Y OPPORTUNITY: LEVERAGING YOUR DATA TO TAKE ADVANTAGE OF THE BIG CREW CHANGE

Introduction

One of the greatest challenges facing our industry today is managing the 'Big Crew Change'. Anticipating the impending shortage of technically proficient personnel as they exit stage right, we are faced with not only an experience gap, but also a fundamental difference in the way that the next generation thinks. What cannot be quantified is the extent of the impact of this demographic shift. What type of changes in efficiency and performance might we anticipate if about 20 percent of the business has fewer than 5 years of pertinent experience?

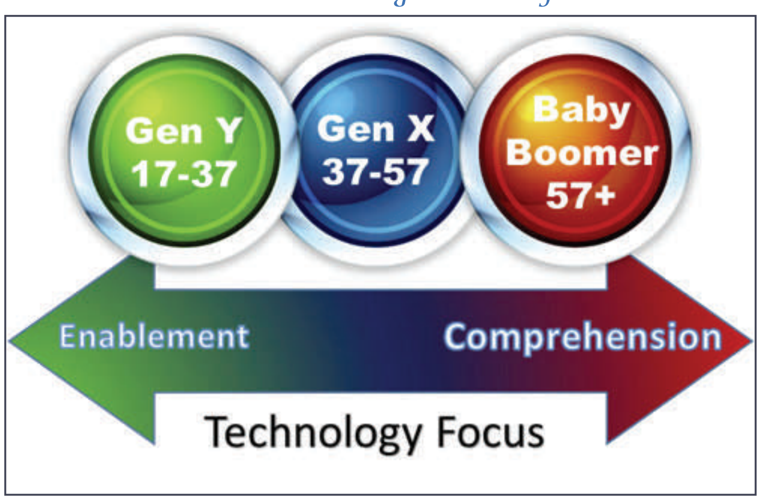
As the old school retire from the petroleum industry and the new generation of geoscientists graduate with an advanced appreciation of statistics and soft computing methodologies, we shall evolve even greater application across the upstream by coupling expert knowledge that is readily retiring from the petroleum industry with data-driven models to explore and predict events resulting in negative impacts on CAPEX and OPEX.

The question we should be considering is: "How can Information Technology not only bridge the experience gap, but also enable the next generation to carry the torch of oilfield innovation to new and greater heights?"

Generation Y vs. Generation X and Baby Boomers

Before we begin to consider what the answer may be, let us first understand the underlying principal differences between the various generations within our workforce, Figure 1.

Figure 1: Workforce Generations



The key to any IT strategy allowing the new generation is to comprehend and quantify some significant and fundamental tenets. The Baby Boomers were great innovators of electronic technologies, and Generation X that followed had to understand the fundamentals inherent in these technologies so that they could develop and evolve the plethora of software solutions that have dynamically changed the world we live in today. This resulted in both generations being labeled as Technology Savvy. However,

LET YOUR DATA DO THE TALKING

Generation Y has generally not been exposed to the underlying technology solutions, but rather have been technology enabled. In short, their focus is not on how things work, but on what they can achieve with technology. Their focus is on the enablement rather than the comprehension. Just ask your children to plug in that new games console and you'll see what we mean. Yet once it is up and running there is only one winner.

Enabling Generation Y to Utilize Data

So what does this mean as regards managing the crew change in Oil and Gas? The answer is relatively simple. If we consider the innovation of electronic technologies in terms of an oil and gas reservoir, Generation X and the baby boomers have achieved some pretty amazing numerical solutions such as reservoir simulators. However, these solutions have been created and evolved around first principles and empirically acceptable mathematics and physics. What is unknown and uncertain are managed by assumptions and estimates. As Generation Y enters the work force they are less likely to discuss the underlying principles and more likely to consider these assumptions and estimates in greater detail. Generation Y embark upon a new way of thinking and a new paradigm for problem solving. So Generation X's prevailing intuition on how things work, for example in reservoir simulation and modeling, may not necessarily apply when Generation Y adopt an enablement strategy to resolve the complexity inherent in reservoir modeling. They are wondering how they can enable themselves to better understand the life-cycle of a reservoir based on technology enablement. Put simply, can we use the volumes of information that have been collected to quantify these uncertainties without getting into the weeds of traditional empiricism that furnish the physics based numerical models?

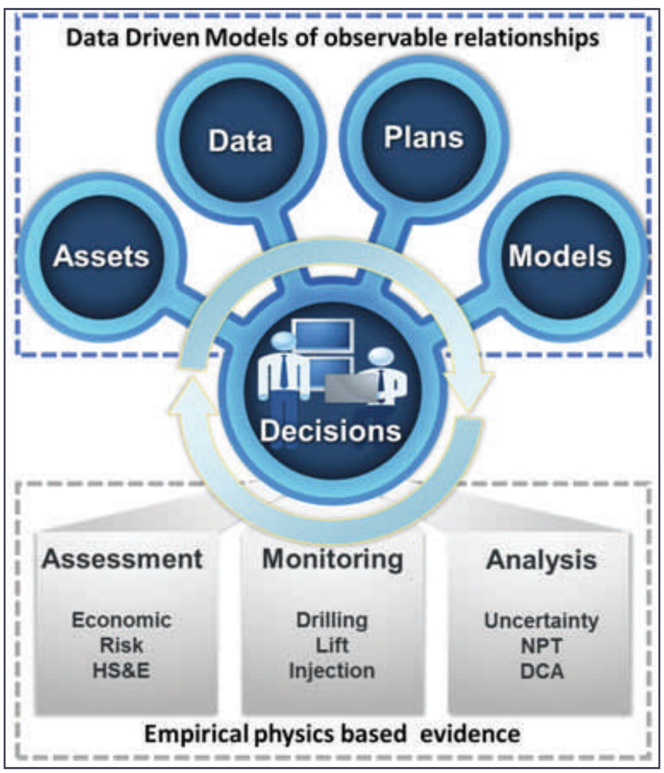


Figure 2: Generation Y Strategic Use of Information

Figure 2 illustrates how Generation Y places itself at the center of the relationship between information and ordinary activities such that they have a more strategic approach to problem solving that leverages data-driven models bounded by engineering constraints inherent in physics based models.

Let us illustrate the Generation Y stance with an example in E&P, ocusing on Artificial Intelligence (AI) in reservoir simulation and odeling. It is generally accepted that AI represents the capability of machines to imitate or even eclipse human intelligence in routine engineering and scientific tasks that are centered on perception, reason and action. AI like human intelligence is by nature multifaceted, attaining goals that range from knowledge epresentation and reasoning, to comprehension as well as visual perception. Generation X has a history of misusing and ultimately squandering such soft computing technology, consequently adopting a stance to misjudge and prematurely dismiss the perceived benefits of AI when applied to reservoir simulation and modeling, preferring to fall back on conventional and well established workflows and technology that invariably succeeds in the hands of an experienced team of engineers and geoscientists.

Generation Y's timely position in the technology evolution married with a strategic perspective enables the adoption of the data-driven technologies and machine learning such that reservoir models are built on the observed phenomena. These observations are represented in the form of data. Let the data do the talking. This refreshing approach has witnessed the birth over the past decade of top-down intelligent reservoir modeling and simulation methodologies based on surrogate reservoir models where the manacles of empirical algorithms are loosened if not entirely discarded.

Conclusion | The Generation Y Opportunity

The current status of the Oil and Gas industry's demographics already paints a doomsday scenario necessitating a large influx of new hires over a condensed timespan. One factor that positions this crew change in a different light is the drive for new hires is mandated by demographics, and thus the industry will have serious staffing issues in spite of the level of hiring activity. There is nothing to hinder an influx of inexperienced new hires. The difficulty will be to train them to be fully able and competent very quickly without the traditional indulgence of having them learn the hard way through on the job training, exposing them to a period of trial and error. The most critical question is: Are we really exposed to have a substantial loss in performance?

In the next section, we shall discuss in more detail how data-driven models are changing the world. We shall enumerate what the Oil and Gas industry can garner from other businesses as regards improving not only workplace efficiency and collaboration threaded by IT and data-driven methodologies, but also enabling Generation Y to take Innovation in Oil and Gas to another level.

II: DATA DRIVEN MODELS...THE TIDE OF OPPORTUNITY

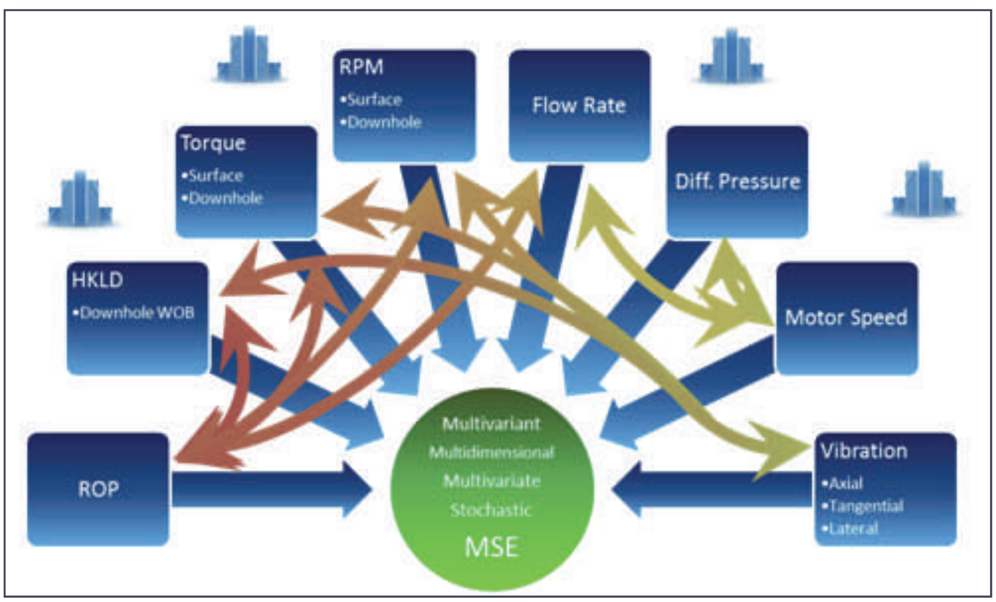
It's hard to escape the chatter about "big data". Evangelists talk of volume, velocity and variety of data across business verticals and the impact that big data will have on traditional analytics. Certainly, surfacing trends and identifying relationships and correlations in a multivariate, multivariant and multidimensional system provides food for thought. But does big data without business context provide any knowledge that enriches upstream decision-making?

The technique to bring context to analysis is to develop data-driven models (DDM). As part of a series, this section will examine the development and deployment of DDM in the oil and gas industry. In the next section, we shall discuss in more detail how data-driven models are changing the world. Oil and gas companies have much to learn from other industries. Not only are data-driven models making the workplace more efficient, they are enabling Generation Y to take innovation to another level.

Navigating Murky Waters

So the upstream O&G industry generates big data. Great! But running analytical workflows across these data to garner information requires engineers across all disciplines to step into a reality not dictated by ingrained postulates and axioms dressed as first principles. Mother Nature is fickle. No matter how hard theoretical physicists and geoscientists strive to explain the fundamentals that drive our observations, the actual always deviates from the plan. We must consider how our engineering principles relate to the complex systems and different environments of the global oil and gas reservoirs.

Engineers have nurtured a familiarity with the upstream environment to a degree that emboldens definitive strategies to recover hydrocarbons from some of the most complex reservoirs; and with an historical success that enables them to fill the gaps in their knowledge. But they cannot know the reservoir, the contextual wrapper. Thus it is impossible to determine cause and effect unless observed in a laboratory where an artificial environment controls the context. To attain that contextual understanding, we must apply data-driven models (DDM), marrying interpretation with the non-determinism of soft computing methodologies.



Drilling System Subsurface Complexity

What is a DDM?

Let's start with a definition of data-driven models. Computational intelligence has matured over the past decades, primarily in the area of machine learning. This has greatly enhanced the competences behind empirical modeling. The school of thought that embraces these new approaches is coined Data Driven Modeling (DDM). It is focused on analyzing the total data within a system. One of the central tenets in DDM is to surface connections between the system state variables (input and output) without definitive knowledge of the physical behavior of the system. This methodology advances the horizons beyond conventional empirical modeling to entertain contributions from super-imposed spheres of study. Thus we have evolved through history from a time when empirical models underpinned science to a few centuries ago when the scientific landscape was populated by purely theoretical bastions of thought.

Moving on from computational branches of science, we now stand at the crossroads of a data intensive exploratory analysis that is ideal for DDM. In the oil and gas industry, we are generating numerical simulations of a reservoir without fully appreciating the contextual wrapper that permeates in the subsurface and reflects the dynamic behavior of fluids in a porous medium. The principle of a DDM is that unquantified behaviors in neighboring systems can be observed in the data.

There is a fundamental difference between a discrete data point and how we choose to analyze the specific measurement. Do we consider the value on its own? Or within the context of how a process or equipment performs? Or as an observation point within a system that is responding to various inputs and producing desired outputs?

The first principles of any system are important, but in order to create valuable analytical models we must also understand that there are relationships within the data that can be observed from a systematic viewpoint and can be further developed to define models that describe and allow control over desired outcomes. We would suggest that the solution lies somewhere in the middle. A hybrid model that is constrained by First Principles but defined by data observations can provide an analytically sound model of the system that can be operationalized within the real-world. Consider the complexity of a subsurface process like drilling.

The point is not to replace fundamental scientific observations but to enhance our knowledge by using a DDM in conjunction with them to enhance the information and put the big data into that real world contextual wrapper.

Example of DDMs Outside of O&G

Data-driven models offer incredible value, both economic and social, owing to their inherent knowledge impact that potentially transforms the way we communicate, understand our environment, perform our jobs and basically run our lives. There is an extensive array of previously incomprehensible applications of DDMs currently being implemented that have an innovative influence on people’s lives. Let us touch upon one such example in the fraud detection space.

Insurance companies are exposed to the slings and arrows of criminals focused on fraudulent activity. In fact, it can cost the insurance industry in the realm of $80 billion each year. CNA is one of the country’s largest commercial lines carriers that combats and invariably witnesses fraud in 1 of every 10 claims they process. Implementing predictive models across each line of their business CNA are able to score all the claims and identify those that can be deemed as high alerts based on historical signatures in the submitted data, be it structured or unstructured.

This case study illustrates the benefits of developing data-driven models built on historical events garnered from big data. In real-time as new claims are being processed, the data is fed into the DDMs enabling CNA to observe the ratio of cases flagged for possible fraud increase by some 8%, only 2 years after implementation. This resulted in recovered or prevented fraudulent activity that totaled $6.4 million.

Example of DDMs Inside of O&G

The oil and gas industry tends to lag behind other industries in advanced technology adoption. But the full gamut of possible DDM applications in E&P are only limited by an engineer's imagination. One example that underlines the advantages of implementing a DDM in the unconventional assets is found in the Pinedale anticlinal structure in Wyoming, as detailed in SPE paper 135523.

Faced with the analysis of disparate subsurface data generated from over 50 fluvial sand packages in a single wellbore drilled in 5000 feet of vertical section, the operator wanted to comprehend well performance potential and variability across the geologic structure. Such knowledge is imperative to optimize reservoir development and well completion strategies, with an emphasis on evaluating an optimized hydraulic fracture package.

A neural network was chosen among many soft-computing techniques to evaluate both reservoir parameters as well as variables that are controlled by the operator such as proppant volume and flowback methods. Input data included general information from 211 wells and 2399 stages, PLT data, stimulation treatment data, petrophysical data for formations and sands, flowback data, proppant type, proppant volume, and well production data. The purpose of the analysis was to identify patterns among the poor and exceptional wells and thus appreciate the decreasing trend of stage production performance over time, identifying those factors that have most impact on production. The disparate data systems had to be aggregated to produce a managed robust data set conducive to effective exploratory data analysis. These two important steps are essential to identify plausible and efficient hypotheses worth testing and steer the decision makers towards sound modeling techniques.

Data clustering was used to create different models and assess different parameters. Models were able to identify the relative impact of the most significant variables affecting stage production performance, and develop probability distributions for potential outcomes at different categories of production. The probability distributions provided a basis for completion optimization. Findings included identification of the impact of flowback procedures in total well performance, and the probable sensitivity to key geologic and petrophysical parameters that most affected performance.

Evaluation was conducted on 195 stages with 49 stages identified for increase in proppant volume. Through this process, the operator identified a need to update the DDM to include the impact of pressure depletion from down-spacing. Even in the absence of accounting for pressure depletion, the operator experienced excellent results. The analysis resulted in identifying a "very favorable" economic return at a gas price of $3.00 per Mscf/d, and break even at $2.60. The team has also identified seven stages that, if eliminated, can improve the economics significantly.

Thus E&P engineers can complement the traditional interpretation of their data with DDMs, implementing a suite of soft-computing techniques such as Artificial Neural Networks to garner insight through pattern matching. The data must be put into context and DDMs enable that context to be defined since the data tells the story.

So Where Does Generation Y Fit In This Equation?

Put simply, the very essence of a data-driven approach is to place the focus on the outcome and allow the mathematical complexity to remain fluid within the model. This aligns with Generation Y's "technology as enabler" persona. The focus shifts from a depth of understanding behind the algorithms, towards consideration of how to enrich and enable the process with the insight that the DDM provides. As the bard himself would suggest, data-driven models are our tide of opportunity. If we enable Generation Y to use them, we can expect a flood of good fortune.

III: WHAT'S NEXT FOR ADVANCED ANALYTICS?

It would be difficult to argue with the success that upstream exploration companies have enjoyed in the past century. But is that an argument against change? After all, given that success, why should companies continue to innovate and adapt? The business models in practice years ago are rapidly shifting due to the influx of new technology and data. In a way, the past has set the stage for the next act, as a prologue does in a play.

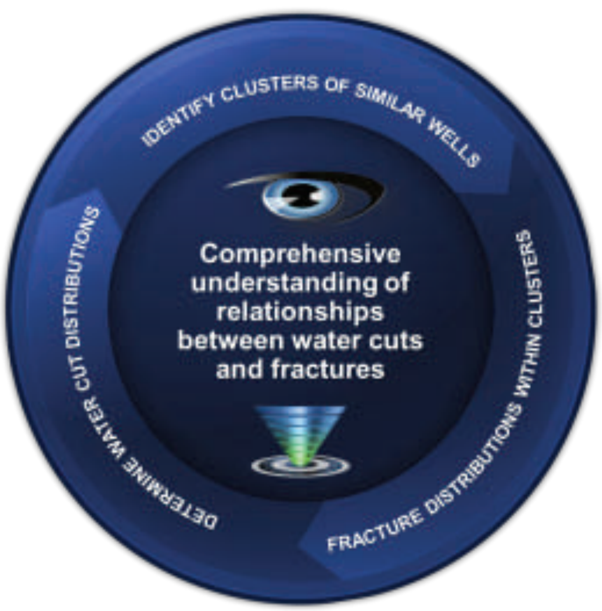
We have moved effortlessly from empirical models that embraced our thinking centuries ago to a theoretical manipulation of data, designing models that incorporate qualified generalizations. Such luminaries as Sir Isaac Newton, Johannes Kepler and James Clerk Maxwell made enormous contributions to our understanding of Mother Nature that, by extension, enabled the geoscientific community to grasp fundamentals that underpin physics and mathematics. These fundamentals reflect the heterogeneous complexity inherent in hydrocarbon reservoirs.

Only a few decades have passed since we strolled through the computational branch of science that witnessed the simulation of complex systems, edging towards the current landscape sculpted by a data intensive exploratory analysis, building models that are data-driven. Let the data relate the story and let history influence the context for the present as we combat data overload, marrying first principles and stochastic modeling methodologies to ask more questions and harvest more insight.

Moving forward, advanced analytics uses more data in near-real time, enabling rapid decision making at the point of operations. Oil and gas business models continue to change and capitalize on the next evolution of analytics. Three areas of the upstream business are ripe for this transformation: subsurface dynamics, drilling automation, and reservoir management.

• Subsurface Mechanical and Fluid Dynamics

In subsurface fluid mechanics, there exists a dichotomy as to the description of forces driving subsurface fluids. On one hand, there is the application of velocity potentials [energy/unit volume] within engineering hydraulics, including reservoir engineering. On the other hand, A. Scheidegger stated unequivocally: "It is a force potential and *not* a velocity potential which governs flow-through porous media." As a result, the industry has adopted a number of simplifications in geometry and assumptions regarding the properties of oil, gas and water, as well as simplifications of Darcy's equation, to find reasonable answers to practical problems by making use of analytical equations. But time and again, seasoned professionals are challenged by the complexities inherent in reservoir modeling. Data-driven methodologies are gaining momentum as a complement to first principles equations. This is largely due to the accelerated increase in data sources and data volumes that surface hidden knowledge if mined by advanced analytical workflows.



LET YOUR DATA DO THE TALKING

Reservoir simulation and modeling is ostensibly a bottom-up methodology initiated by the development of a geo-cellular reservoir model. Implementing deterministic modeling and geo-statistical data manipulation enhances the geo-cellular model by integrating the most optimal and most current petrophysical and geophysical knowledge. Then, adding engineering fluid flow first principles is an attempt to resolve numerically a dynamic reservoir model.

Shahab Mohaghegh et al have proposed a Top-Down Intelligent Reservoir Modeling (TDIRM) methodology that starts with gathering intelligence from field measurements such as production data enhanced and calibrated by core, well logs and seismic data. This approach is not intended as a substitute for the conventional reservoir modeling workflows but as a rich, complementary data-driven perspective. TDIRM embraces artificial intelligence and data mining workflows such as neural networks and fuzzy pattern recognition. It offers an ease of usage that predicates short development cycles and minimum data sets to shed light and supplement traditional reservoir management techniques.

• Drilling Automation

This same approach can be applied to the process of drilling a wellbore. Current initiatives in this field are based on the development of automated drilling solutions that manage the efficiency of the process while mitigating risks to rig personnel, the environment, and the assets. To date, much of the effort has focused on developing solutions to control drilling equipment. However, drilling is a complex operation that aggregates information from both surface and down-hole sensors to optimize performance and mitigate risk. Additionally, many of the rig's physical elements – such as the hoisting systems – are stochastic in nature. There is no guarantee that control parameters will match exactly with system output.

In order to develop prescriptive solutions, these various levels of complexity need to be integrated within an intelligent analytics platform that provides advisory output and associated levels of confidence in the outcome. High speed, low-latency event stream processing solutions can deploy complex analytical models in the sub-second environment required by drilling control systems. Imagine a future where autonomous drilling rigs are able to drill efficiently and safely, and also act as conduits to a higher logic of execution. The focus then shifts from managing tactical situations to exploiting strategies across a portfolio of assets.

• Reservoir Management

Controlling operations to maximize both short- and long-term production requires lifecycle optimization. This optimization considers reservoir model uncertainties as well as production measurements, time-lapse seismic, and other available data. How can we use that huge amount of information in an efficient way and ensure that the reservoir models are kept current and consistent?

In reservoir management, arbitrarily complex and multivariant models can be produced by a data-driven methodology while parametric models tend to be limited by human comprehension. Do reservoir managers depend too much on empirical observations? As the industry generates more data variety and deals with the avalanche of real-time data streaming in from intelligent well sensors, it evolves into an "Internet of Things" environment that necessitates a data-driven suite of soft computing techniques.

Still the industry pursues an abstraction of reservoir management. In response to the plethora of real-time data from sensors deployed in intelligent wells, a reservoir management solution embraces advanced technical tools as well as automated analytical workflows. Remote work practices promote collaborative centers of excellence.

The Path Forward

In each of these cases, the best practice is a hybrid solution that marries a data-driven suite of advanced analytical methodologies with the wisdom of experienced engineers to constrain modeling across the E&P. This hybrid solution is gaining rapid acceptance by the engineering silos as a means to provide the vast pool of knowledge as deductive information in the upstream models. In the future we anticipate situationally and contextually aware analytics with the ability to automatically determine the different phases of operation and adjust or alter modes for a real-time system optimization.

William Shakespeare noted in "Measure for Measure:" "*Our doubts are traitors and make us lose the good we oft might win by fearing to attempt*." Where do these doubts come from, and how can we overcome them? The answers may lie in the generations discussed at the beginning of this series. As Generation X, we inherently wish to understand the "how" of any solution with our expectation of the output being linear and complete. Generation Y seems to have reversed this notion. Their focus is on the strategic use of solutions focused toward a multitude of possibilities. Let the data do the talking, and witness what the next generation is able to achieve.

ABOUT THE AUTHORS

MORAY LAING
PRINCIPAL CONSULTANT

Moray Laing joined the SAS Energy team as a Principal Consultant for Oil and Gas in 2013. He started his career at Baker Hughes where he spent the first eight years working as an engineer in the SLS and MWD product Lines. In 1996, Moray moved into the software development team at Baker Hughes where he was responsible for development of leading edge, real-time and remote (drilling, completions and production) and visualization solutions. After 2007, Moray held a variety of positions in business development, marketing and innovation management where he was responsible for delivering over $100mm in new product revenues.

Moray holds a Post Graduate Diploma in Computer Aided Engineering from Robert Gordon's University. He is also in the process of completing his Executive MBA from Texas A&M University.

KEITH HOLDAWAY
UPSTREAM DOMAIN EXPERT

Keith Holdaway, upstream domain expert for the SAS Global Oil & Gas business unit, provides SAS customers and prospects with consulting expertise based on 15 years of experience as a geophysicist in the geological and geophysical (G&G) space.

His work with the Ministry of Petroleum in Saudi Arabia, British Petroleum in the United Arab Emirates and Shell Oil in Oman has provided Holdaway with a wealth of experience processing and interpreting seismic and reservoir data.

When he joined SAS in 1997 as a principal software developer, Holdaway designed architectures for customers across the mid-tier Java space.

In 2008, Holdaway joined the SAS Global Oil & Gas business unit as a domain expert focused on mapping SAS technology to the geological and geophysical space to provide significant value to SAS customers. Holdaway is also an active member of the Society of Exploration Geophysicists, the European Association of Geoscientists and Engineers and the Society of Petroleum Engineers. Holdaway is also a Fellow of the Geological Society of London. He graduated with degrees in geology and geophysics from Durham University in United Kingdom.