

# A Snapshot of Integration in Upstream Oil & Gas Operations

A Research Report By  
Advertas and *Upstream CIO* Newsletter

A white paper

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## Introduction

During the month of June 2006, producers of various sizes, plus an industry standards group were interviewed at length about the current state of their plans regarding integration between business and production systems. *Upstream CIO* newsletter and Advertas, a marketing research and consulting firm specializing in technology and energy clients, sought to determine how production data and corresponding technical applications are integrated into business systems. In addition, the interviewers also asked how business data and applications were being made available to field operations personnel for improved decision-making. The results reflect the comments of six companies, which varied from super-majors to independents, as well as the Petrotechnical Open Standards Consortium (POSC). In addition, the head of a governmental agency and an IT leader at an oilfield service company were also surveyed for their input to provide a broader perspective.

This reports details the results of the study, which was financed by Information Builders, a technology company that has successfully implemented integration initiatives in other industries and seeks to better understand specific challenges in the oil and gas sector. Interviewers used a common set of ten diagnostic questions, which enabled comparisons to be made. The results reported below are a snapshot of the state of production data and application integration today, and point out the current technology gaps, as well as the requirements and business value for implementing next-generation integration solutions.

## Executive Summary

### **Where do producers stand today?**

The major producers surveyed all have digital oilfield initiatives that involve integrating technical data with business processes. Their initial focus varies from subsurface to drilling to production and reservoir management. The small and mid-size companies are focusing more on standardization initiatives, although the majors have completed such projects as well.

The majors share a similar workflow process, where production data are stored in a data historian, then applications pull data from that historian for production accounting and allocation purposes, sending the results to the enterprise resource planning (ERP) systems for business reporting. The mid-sized and smaller companies are just now beginning to implement new technology to streamline their workflow processes. However, spreadsheets remain the engineers' preferred tool for analyzing data.

## What are the main integration challenges?

With few exceptions, respondents agreed on a common set of challenges facing integration solutions, including:

- Lack of standards and naming conventions;
- “Silos” of information;
- Quality and gaps in data;
- Large quantities of data;
- Lack of experienced people to interpret the data; and
- Lack of a common integration framework.

Today’s challenges, gaps, inefficiencies and obstacles to successful integration have both technical and cultural aspects. There is an increasing need for standard naming conventions for the growing mass of data, much of which may be stored in multiple locations. Search tools should enable the desired data to be located, used by multiple functions, updated with added value and then placed back for future use. In addition, the industry would benefit from improved methods of finding and cleansing data faster, eliminating workflow bottlenecks. Cultural “silos” are prevalent, but are beginning to be addressed through the establishment of cross-functional teams with the support of upper management.

*What is apparently lacking is a scaleable integration framework that would enable the “plug – and play” of best-of-breed applications.*

## What benefits would the right solution bring?

The producers sampled are generally in alignment on the sources of value from integrating data from the field with production and business systems. Four main sources were cited:

### 1. Improve Reservoir Drainage

*Understanding the state of the well/field by monitoring changes in the mix of products over time (composition of oil, gas and water) will result in improved hydrocarbon recovery and discovery of additional reserves.*

### 2. Efficiency and Productivity

*Better management of assets as information on reserves replacement, operating efficiency and well productivity is made available.*

### 3. Equipment Condition Monitoring and Reliability

*Condition monitoring of critical equipment to reduce 'trouble' cost and improve effectiveness of maintenance, the combination of which will result in less downtime or increased asset-utilization.*

*"When an apples-to-apples comparison of fields can be made in "right-time," normative analysis can be performed and variances against targets reported, allowing for process changes and aiding capital expenditure decisions."*

### 4. Supply Chain Integration

*Improved forecasting and supply- demand balance by providing production information to all stakeholders, particularly those in supply chain functions.*

When an apples-to-apples comparison of fields can be made in "right-time", normative analysis can be performed and variances against targets reported, allowing for process changes and aiding capital expenditure decisions. Most importantly, integration across functions provides the automation of technical and business processes. Information on reserves replacement, operating efficiency, and well productivity are key. Without these, management operates under a handicap when it comes to field management. Large scale developments, such the Mars platform having a design capacity of 220,000 bopd and 220 mmcf/d, can easily realize value from the aforementioned integration solutions. The four sources of value listed above can be expected to result in at least marginal improvements on the order of 3% to 5%. Given the present price of oil and gas, even this level of improvement would mean over \$1 million per day in added value for a large platform.

## Detailed Findings

### Integration in the upstream – three domains

One of the super-majors divided the oil & gas enterprise into three principal areas that shared common information interest and therefore a need to exchange information. Those three domains included:

- Administration: Accounting, regulatory compliance, management reporting – Using production information to effect tactical and long-term strategic business decisions.
- Production: Process control, production accounting/allocation, asset management – Using real-time information to improve production, schedule well workovers (maintenance) and better manage assets.
- Subsurface activities: Seismic, modeling, well analysis – Focused on geophysical and geological (G&G) information.

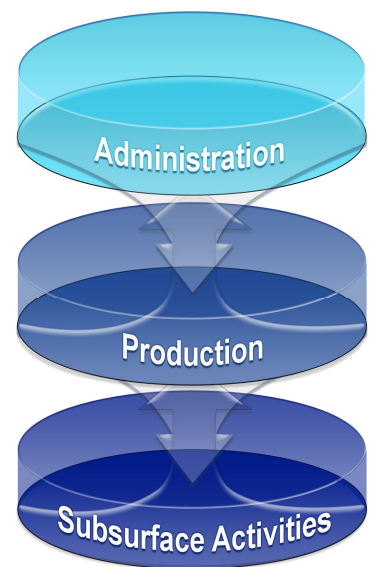


Figure 1 - Three Domains

There are sources of value in exposing production information to stakeholders across these three functions, for a variety of good reasons.

## Sources of Value from Integration

### Figure 2: Principal Sources of Value from Integration

There were four main areas where the companies interviewed saw significant business value in integrating production and operations data with back-office business systems:

- Improved Reservoir Drainage;
- Efficiency and Productivity of Staff;
- Equipment Monitoring and Reliability;
- Supply Chain Integration.

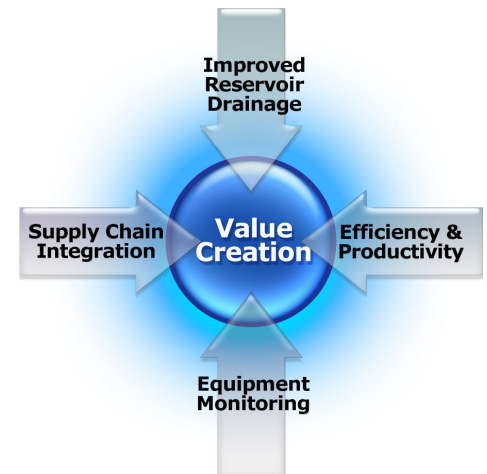


Figure 2 - Value Creation

### Improved Reservoir Drainage

Not surprising, this study found the most significant source of value to be from improved reservoir drainage. Integrating operations data with subsurface models enables operations to see and interpret subsurface conditions, increasing reservoir life and accessible reserves.

A mid-tier participant concluded that extending the integration of operations data into business data yielded more accurate analysis for past performance evaluations, as well as enabled future forecasts, resulting in better projects. Undoubtedly, having information about reserves replacement, operating efficiency and well productivity is a major key to competitiveness for any producer.

Including maintenance in the production data flow enables better management of mature fields that are in decline by helping engineers manage and schedule well workovers and other field maintenance. In addition, better integration of technical applications facilitates the evaluation of reserves in current fields as well as finding new reserves in old fields. The opportunities are clear: improved hydrocarbon recovery, better decision-making at the right time, and optimization of worldwide assets are now possible through integration.

### **Efficiency and Productivity**

One mid-size operator saw efficiency as the number one reason to integrate business with production data. Reliable information in a consistent format saves both time and energy. A major operator saw some value from integrating operations with business systems for improved efficiencies, decision-making and data quality, but this was seen as being of significantly less value than integrating subsurface applications with operations data.

Another major company said that having accurate and timely production information has a profound impact on the agility of the supply chain. A third large company also said that standardized systems, along with integration, have also enabled better procurement processes.

The standards body representative said that for integration initiatives to work, they must improve individual productivity, which is key to buy-in. He suggested compensating employees based on individual productivity. That way, employees will support integration because information they need from disparate systems can be acquired and disseminated much faster – to their personal benefit.

### **Equipment Condition Monitoring and Reliability**

Reliability is one of the specific aims of one super-major's digital oilfield initiative. There is a company-wide initiative to measure lost opportunities, such as equipment downtime, that require the capture of information from the field from a variety of sources. Other companies have seen marked benefits from connecting production information with limited business information to enable field personnel to set alarms and tweak production in marginal wells. Stakeholders across the industry are beginning to be able to see their company's production anywhere, on a well-by-well basis, along with a variety of analog data, which allows quick comparisons to targets and key performance indicators (KPIs).

Another operator cited the "reduction of trouble cost" as a business driver for integrating systems. Integration also affords more ways to forecast and anticipate potential problems, thereby reducing cost, risk and disturbances throughout their business processes.

Even a smaller offshore operator conceded that integrating business and operational data could enable problem trends to be recognized earlier. His company, specifically, has a project underway charged with moving production accounting to the field, where operators enter the data into a commercial production accounting system, as opposed to spreadsheets. The expected benefits from this level of automation include fewer staff, exception reporting, highlighting variances between meters and identifying day-to-day changes. All of these types of data are important to managing the life of the field.

For smaller and mid-size operators in particular, the business case is much more manageable. It's relatively straightforward to show the value of implementing integration technologies. "We're simple guys," a mid-tier respondent said. "Just prove the business case." A separate operator remarked that it boils down to this: "Will it impact the bottom line by increasing revenues or decreasing expenses?" Indeed, it seems others have found strategic integration to decrease the expenses related to equipment maintenance and increasing revenues related to reliability.

### **Supply Chain Integration**

Capturing timely production information is seen as enabling greater supply chain visibility and market responsiveness (agility). Knowing what is being produced by platform and field will allow planners to better respond to changes in demand.

## Framing the Problem – Integration Challenges

The individuals interviewed revealed many challenges, the span of which included:

- Silos of information;
- Staff skills and capability limitations;
- Unmanageable volumes of data now, with more expected in the future;
- Data flow bottlenecks in quality control and validation;
- Delays in searching for and finding required data; and
- Pervasive use of personal Excel spreadsheets and datasets rather than “systems of record.”

Certainly, the incoming data stream is large, and the volume is expected to increase as new fields come on stream and mature fields are retrofitted with automation technologies. Study participants indicated some

topology or hierarchy of information is needed to qualify and make good inferences from massive amounts of data. One super-major commented “We are somewhat suffering from information overload. The question is now how we make the best use of all the information being acquired from the field.”

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Exacerbating the volume problem may be the bottleneck in data quality control, which includes cleansing it of noise and stray values and filling in any gaps. For example, at one mid-sized company, rapid changes in field configuration require human process owners to validate production accounting, implement new standards, and perform “reasonability” checks on information, and these important steps have been slowing the integration process.

Once the data is validated and stored, being able to find it again poses a challenge. Some estimates have engineers spending as much as 70% of their time searching for the right data within the enterprise. “We don’t really know how many people have touched a given set of data, nor do users often have confidence in its usefulness,” one interviewee said.

Often quality-controlled data is pulled out of the data historian and put into Excel spreadsheets or other solitary applications for analysis and processing, and afterward neither the improved dataset nor the knowledge value added to it are captured back into the historian as the Golden Dataset. Others may benefit from this added value, along with annotations of who used it when and what was done. Often “systems of record” are not used because these systems are not integrated with various technical and business applications.

Another area of major challenge is the human and cultural aspects of integration. In addition to the widely talked-about silos of information and terminology differences, there are skills and capabilities limitations in the staff. Field and operations people lack information technology knowledge and skills, while engineers in the office may lack field experience. While digital oilfield initiatives make more information available to all, some employees do not possess sufficient experience to interpret the acquired data. Production optimization is a complex task, requiring high-end technology, advanced concepts and geophysical models. Therefore, training, job rotation and working closely with the educational institutions in the human resources supply chain are required.

*To find items of interest quickly, a "Google-like" search capability would be a significant value-add to these standardization efforts.*

Both super-majors and independents have launched cross-functional initiatives to develop standard naming conventions, which also begins to address silos of information. A key determinant in the success of these initiatives is, of course, executive management support. One independent described their development of a company-specific "master list" of naming conventions, standard nomenclature and data standards. This, however, only partially speaks to the need to access and analyze the large volume of data. To find items of interest quickly, a "Google-like" search capability would be a significant value-add to these standardization efforts. Producers may find search engine tools could make individual documents and pieces of information appear as one central repository, which could go a long way towards addressing both gaps in and the sheer volume of data from the field.

All producers were looking to leverage their existing staffs and do more with fewer resources. Some of those interviewed reported launching standardization initiatives to drive down lifecycle cost of their IT infrastructure and increase staff productivity. With a common operating model and standard infrastructure and applications, employees could be more productive from any location worldwide.

Most participants reported deploying a standard, scalable set of applications to new assets. While standard applications and IT infrastructure enabled sharing of information, the connections between applications is still largely done

*What is apparently lacking is a scalable integration framework that would enable the "plug and play" of best-of-breed applications.*

point-to-point. Some study participants expressed disappointment that even limiting applications to a single vendor did not ensure seamless integration. What is apparently lacking is a comprehensive integration framework that would enable the "plug -and play" of best-of-breed applications.

## Notable Initiatives

The current high price of oil is making digital oilfield projects economically practical, and several of the larger companies interviewed have such projects well underway. These projects have several aims, among which are:

- Implementing standards for improved communication;
- Equipping managers for better asset management; and
- Tools for improving workflow efficiency.

### Implementing Standards for Improved Communication

Standardization spans not only data format, but also extends to toolsets and, where possible, workflows to accelerate integration.

There are several data standards consortia whose goal is to advance communication standards for exploration, drilling and production. Randy Clark, President of POSC, was interviewed to gain an overview perspective of how data standards will figure into the industry's integration efforts. Clark said there is currently a "big chasm" between data standards and business processes. In addition, the Society of Exploration Geophysicists (SEG) was mentioned as having established a common data standard for geophysical data, which is used globally. Efforts are primarily focused on using production data to improve reservoir management and increase production.

*"There is currently a big chasm between data standards and business processes."*  
– Randy Clark,  
POSC

The organizations that have pursued integration efforts most proactively have also created a standard set of tools deployed to all new fields. The tools in this set may include built-in "adaptors" to production accounting systems, procurement and maintenance. The interfacing of applications is largely point-to-point, with some limited use of commercial middleware tools. This common toolset enables near real-time views of production, rolled up to field, region or even global views. While there has been substantial progress, challenges still remain. Some of the most significant challenges include the disparate sources and nature of data. Examples given by study participants include the difficulties in correlating time-based data with event-based data. Complex workflows and disparate toolsets were referenced as typical challenges, as well as the need to "clean" the data of gaps and holes.

*One independent has made efforts enterprise-wide to standardize operational and financial information on wells globally in order to "compare apples to apples" for business decisions.*

One independent has made efforts enterprise-wide to standardize operational and financial information on wells globally in order to "compare apples to apples" for business decisions. A mid-tier producer that has grown significantly through acquisition now has a variety of systems and processes that do not communicate. Those systems are being replaced with a standard set of operational tools as part of a worldwide

project to standardize the company's production IT infrastructure. This standardization initiative, which has senior management's "extreme" and "adamant" support, is now about 70% complete. The person interviewed felt that a mid-sized company is the right size to tackle such a standardization challenge because it has the resources to implement the right IT tools but is not so large as to make the problem intractable.

As one might guess, the super-majors have a more structured approach to standardization, as in one instance deploying a "suitcase of standard applications" in all new "greenfield" operations. In addition to providing the ability to compare "apples to apples", these implementations simplify integration by drastically reducing the number of databases people can access by a factor of 10.

Another major producer has also been focusing on standardization during the last 4 years, developing a common set of applications and IT infrastructure. The result has been lower lifecycle IT cost and increased staff productivity, particularly as people move about internationally. Operating in more than 30 countries, this major operator enjoys a single operating model, enabled by standardization of data and applications. This company consolidated data centers and reduced the number of SAP instances from 137 to only a few.

One participant reported changing the corporate integration strategy to reflect a growing standardization of the IT infrastructure. After reducing the core set of applications to the tens rather than the previous thousands, it was found that even more could be done using integration tools.

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## **Equipping Managers for Better Asset Management**

The technical ability to gather and store data has resulted in “more bits per barrel,” according to one participant. Because companies have realized that these data can be leveraged to provide real value, there is a marked trend towards enabling colleagues and managers in the office to view field and well-site conditions, as well as to empower people in the field with current business information.

Most of the mature fields owned by one major company have automated means of capturing production data, but a mix of products is used for this. Fluid volumes data are needed daily for most wells, but for high-volume (30,000 b/d) offshore wells, capturing production data every 15 minutes would be better. The company has numerous custom solutions and advanced process control tools, but most of the data analysis is still done with spreadsheets.

One independent has tested real-time drilling systems, but found little value added from these efforts. The detailed, to-the-minute level of granularity in real-time information was found to only be significant in subsurface-to-operations integration. The value of real-time business information as it relates to the well is the end-of-day data, tightly integrated with business applications for operational statistics.

Strong local control of operations was reported to be most effective in decision-making. Typically, production managers have P&L responsibility for their assets and are therefore provided a handful of key performance indicators (KPI's) accordingly. However, information has primarily flowed up within the organization. Some initiatives have been launched to provide additional information back to field personnel via Web portals. Additional examples in this area include automation of invoicing and providing access, via handhelds, to purchase order status, suppliers, bill of materials (BoM's), delivery commitments and gas nominations, along with planned downtime.

In terms of oilfield service providers, participants identified the transfer of data from field suppliers to the owner as a barrier to integration and faster decision-making. Efforts are underway to facilitate faster review and approval, “synchronizing” the field service data with the owner's model.

For example, there has been a recent push to provide electronic field tickets to integrate with invoicing applications in the back office. Someone in the field may need to know whether a given piece of drilling equipment is in inventory, on order, or in repair, and what the bill of material (BoM) is for a particular piece of equipment. This type of integration is being done through hand-held personal computing devices, and the data are often transmitted from the field PC to the office network via satellite. Similarly, there is also movement toward online equipment condition monitoring.

## Tools for Improving Workforce Efficiency

One of the super-majors shared their aim to have fewer people in the field, which means more of the analysis of wells is to be done by engineers, technicians and accountants in the office, aided by various IT tools. There is a good deal of decision analysis that occurs to determine which wells to schedule for workovers, owing to the large quantities of wells and the number of mature fields. For this purpose, engineers particularly need production information at least daily.

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It was reported that some engineers have responsibility for as many as 1,500 wells. Therefore, having information from the field frequently is essential to focus resources most effectively. Another of the independents interviewed had put in place tools for pattern recognition across multiple wells, as well as automating the data analysis using Web-based tools.

Even smaller companies are starting to address integration of production and business systems. One small operator, whose producing assets are mainly offshore, has just started taking steps to capture production information through automated means. Historically, that company depended on e-mail and spreadsheets, but today data are collected from the field twice daily for a variety of purposes, including accounting and operations. Culturally, the company has been cautious in making investments in automation due to the uncertainty in achieving a positive return on investment (ROI) for such projects. Every investment is considered carefully in terms of both ROI and immediate impact on profits.

## Implementing Step Changes

While these standardization and integration efforts are yet to be fully realized, an important factor is the significance of the asset. With more complex assets such as offshore production platforms, higher levels of integrating more detailed data through to sales become more important. Most important, however, is getting well production information transmitted to the office, including trends in well decline, water separation, production equipment monitoring and overall well health.

One super-major anticipates a high degree of structural change in the industry coming over the next 10-15 years as mature fields decline and oil gets more expensive to extract. Like other producers, the company is looking at technology to reduce the cost of extracting deep gas, heavy oil, tar sands and other unconventional reserves and expects to leverage multiple technologies to do more – economically – with fewer human resources.

## Current Workflows and Processes

All major producers surveyed shared similar workflow process for sending production data to the office (see Figure 2). In addition, one operator cited a set of standardized infrastructure and applications that are aligned with expected workflows to capture and feed production data into enterprise systems like SAP or JD Edwards. Their goal is to “maximize automation” to remove time and labor costs from their work processes while having timely production information from the field.

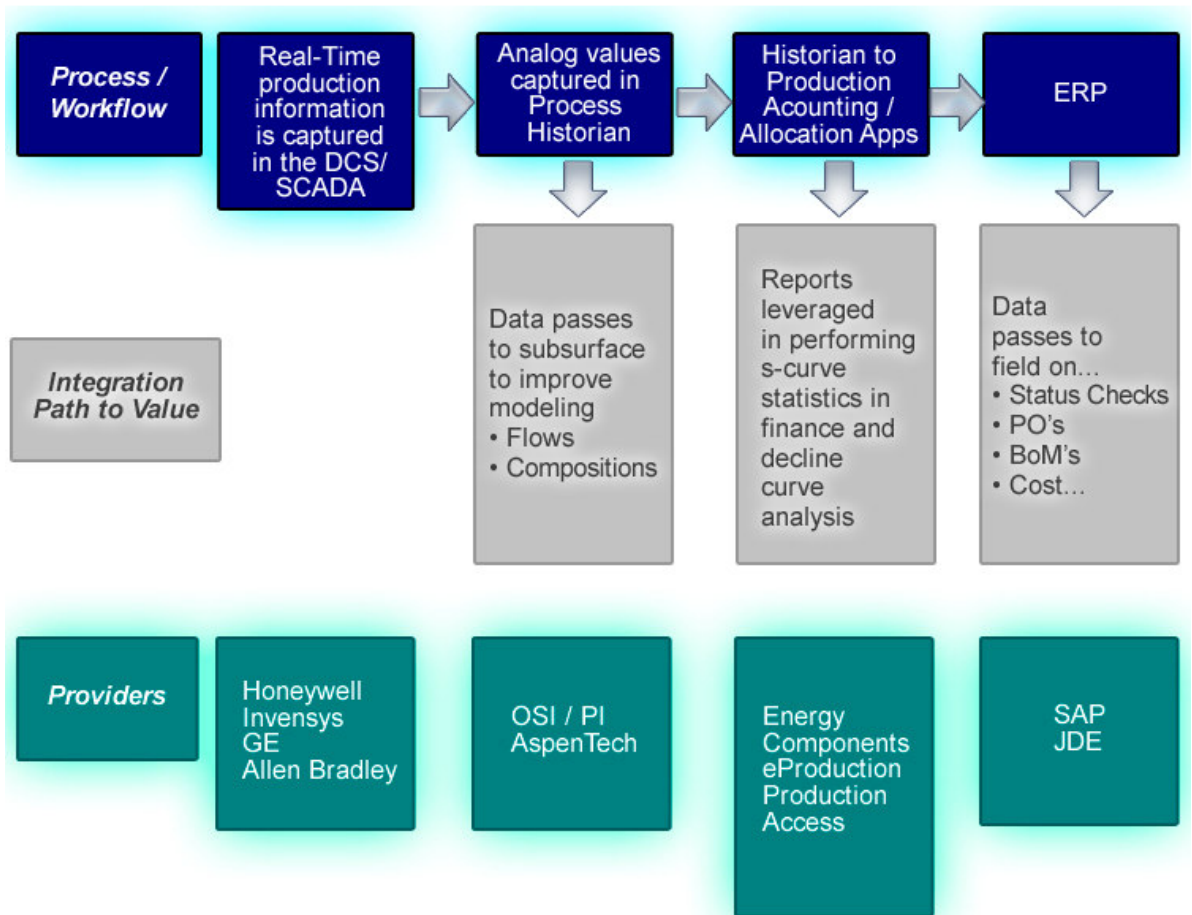


Figure 3 – Production Data Capture Overview

Another major operator has a fairly clear division of responsibility, segmenting allocations by barrels and dollars. Real-time systems like SCADA and DCS are the purview of production operations, and these are maintained locally. The quantities of oil, gas and water produced by each well go to engineers, who use this information to manage and schedule well workovers. Accountants, on the other hand, do not need water production data, so they use a separate workflow.

Respondents reported that proper consideration of processes is foundational in successful integration projects. In hindsight, one operator found it had not done enough mapping and aligning of workflows before launching its integration efforts. However, with consistent models, another mid-tier company is capturing data at the source for use in end-of-month reports, which are used for both financial statistics and decline curve analysis.

*In hindsight, one operator found it had not done enough mapping and aligning of workflows before launching its integration efforts.*

Given that companies are still working toward consistent internal workflows, it is not surprising that this study found an even greater lack of work process consistency between companies. POSC is working with Accenture, HP, Wellogix and OpenWire to develop the Energy Ideas Exchange (EIX) specifically for the oil and gas industry workflows. Companies will be able to see well and equipment status, as well as purchase order status, well logs, temperatures and pressures, on an executive dashboard.

## Gaps in Integration

After the general challenges to integration are addressed (the volume and quantity of data, silos of information, etc.), there are also business process and technical gaps in current integration solutions. When survey participants were asked what the current gaps and inefficiencies were at their company in providing the right data to the field and the back office, three specific technical difficulties were brought to light:

1. Too many point-to-point solutions;
2. Supply Chain technology – service company to producer; and
3. Gas imbalances between production and revenue data.

Study participants consistently reported the pervasiveness of point-to-point integration solutions, creating delays and issues in software updates. For example, while a maintenance person may need to access only a few systems, Petroleum Engineers and Geoscientists who are evaluating and optimizing fields require information from far more numerous and disparate systems, so the problem is compounded for these groups. Static and dynamic models of geographical and geophysical information are especially labor- and time-intensive. “These projects are more difficult than they have to be,” one interviewee said, and the time to build and run the model often precludes doing a number of “what-if” scenarios, which can yield important risk distribution information on the field in question. While financial data is handled linearly, there is a very complex workflow for reservoir management.

Another point of breakdown in the integration process is the flow of information between companies. Specifically, better integration technology along the products and services supply chain is needed. Service companies are frequently on site to capture information, and even before the service company truck leaves the site the service employee has completed paperwork on the job and/or loaded it into his PC. From there information may be sent via satellite to the service company’s home office. However, it is often weeks before the field operator will see this information or the invoice for the work. Service companies could share important operational information with the operator digitally upon job completion while still on the work site.

And finally, there is a “huge” integration gap when trying to align production and revenue figures when it comes to gas imbalances. Although SAP does this function well, it is not economical for smaller producers. Produced gas is sold as specified by customers’ monthly nominations; however, actual allocations don’t always match up. In fact, there is commonly an imbalance. For example, one customer may nominate 50 MMcf of gas but receives only 48 MMcf. This imbalance rolls over to the following month. This process is further

*There is a “huge” integration gap when trying to align production and revenue figures when it comes to gas imbalances.*

complicated when the number of gas customers is eight or ten or more, which is not unusual. Joint operating agreements will typically stipulate how imbalances are to be addressed, but this is only a legal/commercial solution to what is really a technical problem of measurements and accounting. Further downstream, processes involving natural gas liquids make the accounting problem even more complex. There is currently no economical way to address these problems through automation and integration.

## Use of Interoperability Technologies

Interviewers asked study participants which of the five main interoperability technologies are currently being employed at their companies. They were asked to rate the extent of the usage of each on a scale from one to five, five being the most extensively used and one being hardly used at all. The averaged results are as follows:

Technology	Usage Factor
Java	3.3
.Net	2.8
Standards	2.3
Web Services	1.9
SOA	1.2

**Figure 4 - Relative Usage of Interoperability Technologies**

While .Net scored somewhat lower than Java, respondents agreed that their organizations are increasingly migrating to .Net in a systematic way. Further, the use of Java is concentrated in G&G technical computing applications, whereas .Net and XML technologies appear to be gaining strength across all business functions.

WITSML is used extensively in Norway and by some of the super-majors and to some extent in service companies, but not yet within the independents, according to Randy Clark of POSC. One of the super-majors using WITSML remarked that demand for it is not urgent, but it will eventually be adopted as a broad standard. Several of the study participants are helping to develop the PRODML data standards that will facilitate integration of production applications with other business processes.

Web Services have been billed in the industry as the answer to many integration needs, however one participant felt that security is extremely difficult due to many partners being outside the corporate intranet. Web Services have not permeated much of the oil and gas industry yet, however, the application integration potential is "huge," according to Clark.

It is also interesting to note that Service-Oriented Architecture (SOA) had the lowest utilization of all the technologies represented. This is likely due to SOA being a nascent technology that many producers are still evaluating. Some participants commented that SOA works well within the enterprise but not between companies, which makes it difficult to implement with vendors and partners.

## Intelligent Integration Framework

Integration is the key to realizing the vision of the digital oilfield. The integrated set of applications and data between subsurface, operations, and enterprise systems should be thought of as a vital nervous system. Producers are now realizing increased value from vertical integration from subsurface through enterprise systems.

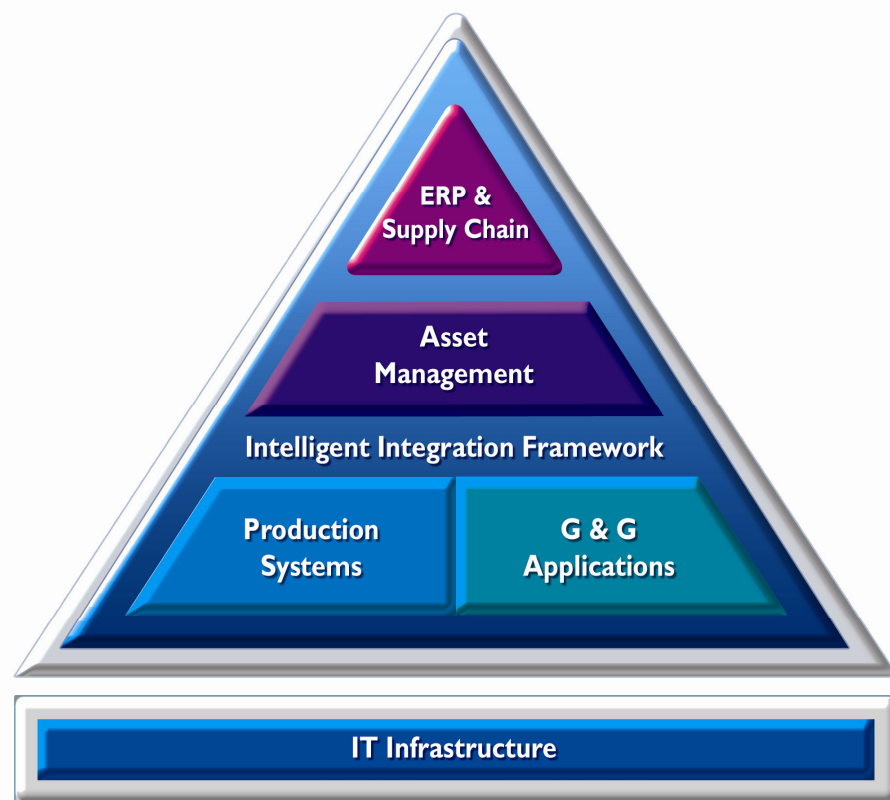
*The integrated set of applications and data between subsurface, operations, and enterprise systems should be thought of as a vital nervous system.*

Creating a global common set of both processes and toolsets facilitates comparison and analysis across fields, as well as allowing increased productivity. With a shortage of resources, including both talent and time, integration between functions allows automating data flow, improving data quality and freeing managers to concentrate on their areas of expertise.

It is clear that integration necessarily means communication between diverse, often proprietary, systems supplied by different vendors. Wholesale replacement of existing systems may not be financially or logistically feasible. Some producers have been effective in creating a set of global standard applications and IT infrastructure, appropriate for the size and operations of the asset. However, prevalent point-to-point integration increases lifecycle costs. In addition to globally standard applications, a robust, intelligent, integration architecture is needed, along the lines of a service-oriented architecture. This framework would enable the “plug-and-play” of best-of-breed applications, and possess four fundamental characteristics:

- *Scalable* – An integration platform must be scalable to the needs of individual assets, large and small, as well as the organization as a whole.
- *Support standards* – Owing to the extraordinary value from integration between subsurface and operations, any integration platform that extends to the rest of the enterprise must necessarily support the communication standards prevalent in geoscience and production data. WITSML, pioneered by POSC, and the standards set forward by the Society of Exploration Geophysicists (SEG) are prime examples.
- *Reduce project timelines, lifecycle costs and risk* – Based on the size of the integration problems in the oilfield, and the limited staff available to deploy and maintain these complex systems, the integration framework must be easy to implement and offer low lifecycle costs.
- *Support security policies* – With increased visibility of data comes increased security risks. An appropriate integration framework will support the secure transfer of information from one function to another and provide a higher assurance level of data integrity.

As illustrated in the example of Figure 5, a specialized digital oilfield integration framework would also increase productivity by organizing and making available pertinent information across the enterprise. The framework would be able to model complex workflows that differ between assets. John Knabe, Houston Branch Manager of Information Builders, says "A robust, adaptive framework, such as iWay, creates a scalable, secure infrastructure. This infrastructure, combined with an enterprise search engine capability, like WebFocus, is a powerful information-delivery capability."



**Figure 5 - Example Integration Framework in Upstream**

Once this framework is in place, a variety of reporting, analysis and search engine tools could be used to organize information and gain insight from the many applications and data connected by the framework.

## Future Developments

This research surveyed only producers and standards organizations like POSC, however, realizing the vision of the digital oilfield will require integration with oilfield service companies, manufacturers and other suppliers across the upstream oil and gas sector. A few brief examples of these have been cited above, however, a separate study would be justified to examine integration with oilfield service companies, for example. While the number of interviews represented here is relatively small, the responses are significant in that they represent the views of foremost thought leaders in within the community of producers. The next installment of this investigation is likely to focus on oilfield service companies and their information relationship to producers.

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