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# Real-Time Asset Management: From Vision to Engagement—An Operator's Experience

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## Abstract

The Digital Oil Field is rapidly gaining attention within the oil and gas industry. Several oil and gas operators are working to develop their vision for an oil field of the future, testing new technologies, setting up programs and participating in industry events. The vision is an integrated approach allowing more real-time control of asset management. Many different names are used in the upstream industry to describe this trend; Smart Fields, Digital Oil Field, Next Generation Oilfield, Field of the Future, e-field, Instrumented Field and Intelligent Energy. However, there is still uncertainty as to what needs to be done and what value it will actually bring to the industry. Several operators and service companies are transitioning from the initial envisioning and abstract phase to projects creating measurable value for the company. In this paper, Chevron's efforts within the Digital Oil Field domain, including concept, business case, corporate governance, technology development, partnerships, deployment and field experience are presented.

## Introduction

The vision of a digital oil field is that of real-time monitoring, analysis and control for optimum field management. Recent technology developments have started to provide data to enable this change. In recent years, there has been a revolution in the degree and sophistication of available surface and bottomhole sensors, automated wells and process instrumentation. The vision moves a step nearer reality when the hardware and the data gathered are connected to field performance models, where the information is continually analyzed and reactions optimized in line with a given strategy, e.g. maximize oil production. However, the emerging shift from episodic to continuous data use in the upstream oil and gas industry is a significant challenge. As the concept of the Digital Oil Field has matured over the last few years, several examples of single discipline, point solutions have been published. These include success stories with data validation, smart wells, advanced monitoring, rapid update of numerical models, optimization and visualization technology. However, the historical approach has been too fragmented to make a significant business impact. A few papers have been published describing an integrated approach bringing several of these technologies together toward real-time asset management <sup>1-5</sup>. However, none of these address establishing, nurturing and governing a corporate program and associated challenges. Moving from initial corporate awareness to measurable projects in the field organization is new terrain for our industry. This includes creating a compelling business case, measuring value, developing technology and creating partnerships between operators, vendors and academia.

For several years, Chevron has pursued opportunities that could significantly shift our mode of managing upstream assets. A new effort, *i-field*, was launched in 2002 to achieve widespread integration of processes and associated technologies across all related assets. The vision is to transform how we operate, with real-time instrumentation delivering real-time information, allowing real-time implementation of decisions, with processes coordinated to bring innovative solutions to our assets' needs - hence, *i-field*. The key aspect for the *i-field* program is <u>integration</u>. This includes designing new work-processes, integrating existing technology and developing new technology where needed. The goal is improved decision-making and asset reliability. Chevron's effort is well-established and has created value, but it remains to fully harvest the potential of the Digital Oil Field. In this paper, the Digital Oil Field is used as the generic term, and *i-field* as the term for Chevron's efforts.

## **Current Asset Management Challenges**

Despite continuous efforts in the upstream industry, there is still room for substantial improvement in asset performance. With the development of new downhole and surface sensors, our ability to measure is ahead of our ability to utilize the data. Many assets are inundated with data hardly used for surveillance, analysis or optimization, and reservoir management elements may not be systematically integrated, i.e. the data is not merged and managed consistently. The tools most frequently used for surveillance and analysis are often widely available spreadsheet programs never designed to accommodate continuous data. Other challenges include the facts that management of facilities is frequently separate from management of the subsurface work-processes, and that there is usually no direct link between real-time data and numerical or geological models. Consequently, many professionals spend 60-80% of their time finding and preparing data instead of focusing on improving the quality of the decisions. This current state often prevents significant work-process enhancements through integration and optimization.

#### Concept – What is an *i-field*?

The objective of *i-field* is to **continuously** optimize the production of hydrocarbons from the reservoir to the sales point. To realize this vision, new technologies, processes and ways of working must be integrated and delivered across the asset base. There is a need to develop and integrate new optimization processes and technologies to facilitate faster and better decisions. Improved decision-making will in turn improve upstream operational excellence, reliability and efficiency. We need to better utilize existing and emerging technologies, and to use available data more effectively. Recent technological development of sensors and instrumentation increasingly allows use of technologies primarily used downstream such as alarms, discrepancy management, temporal data visualization, control rooms and optimization.

*i-field* was defined in a JPT article<sup>6</sup>, where the Chevron CTO, Don Paul, states "the basic idea of *i-field* is to have an instrumented, integrated, information-intensive environment for operating oil fields. As you increase the number of sensors and controls, it allows you to connect the reservoir down the value chain and, in a sense, make the oil field look more like a factory than it has historically been viewed. In the downstream, sensors, measures, controls, and efficiency are the drivers. Those are important in the upstream too, but historically we have not had the level of instrumentation, and the practice of optimization. From a technology point of view, that will be the driver, particularly in old fields where you are trying to squeeze out the last percent of recovery, as well as in expensive capital projects, such as deep water".

Oil and gas asset activities span a range of time scales, as illustrated in **Figure 1.** Many assets have in place SCADA or DCS systems to acquire surface facility data. Some have subsurface well instrumentation data, as well as field actuator equipment such as chokes. SCADA data supports real-time operational activities including quick detection of failed equipment and remote equipment start-up and shut down. These activities are referred to as *Operator Optimization*, and occur at a time scale of minutes to once per day.





analyze its behavior and optimize its performance. These activities are referred to in the figure as *Production Optimization*. At a much slower time scale of months to years, assets integrate field data to construct, calibrate and run numerical subsurface and surface simulators to optimize field development scenarios. These activities are referred to in the figure as *Field Optimization*. Finally, *Reservoir Recovery Optimization* is the slowest loop where decisions are made concerning secondary recovery, or to tie in marginal fields.

Within each of these four time scales, the aim is to create value by reducing the decision cycle time and improving decision quality. Additionally, there is a need to tear down the work-process fences between disciplines. Combining continuous data with analytical tools and models will allow a more real-time approach to asset management. In some cases, the link between continuous data and models has been available for decades for the fastest time scale, Operator Optimization. As illustrated in Figure 2, such links remain to be established between continuous data and control for the production engineering domain and at the field level, as well as manage the interfaces between the loops. The term realtime is sometimes confusing, as it does not necessarily refer to making decisions on a second by second basis, but rather making faster and better decisions. The decision time loop can be as fast as seconds for a well with artificial lift, but can be up to three months or more for a continuous seismic monitoring project. Consequently, terms such as relevant-time and *right-time* are sometimes used instead of real-time.



Figure 2: Illustration of Existing Process Loop for the Operator Optimization Domain, and future Process Loops for the Production and Field Optimization Domains

The key concept behind an *i-field* project is to consider the requirements of end-to-end work-processes, and examine the potential benefits of changes. Thus, in short, an *i-field* project is about change. Change is achieved and managed by integrating technologies and work-processes across disciplines, and realized through people. There is, however, no simple recipe defining exactly what an *i-field* project is or will be for an asset. Clearly, it is not about applying a single set of predefined technologies in a specific manner, but rather

continuously creating value through a process methodology for implementing technologies and managing change.

## How to Measure Value of the Digital Oil Field

Asset teams often struggle to create a convincing business case to establish Digital Oil Field efforts, including deploying new technology solutions. Better tools to measure the Value of Information (VOI) are clearly needed to create compelling business cases to drive a broader implementation of the Digital Oil Field <sup>2, 3</sup>. There are several ways of assessing the provided value. The first is to address the value from a company portfolio point of view, and arrive at aggregated, high-level values as an indication of possible benefits. For the Chevron portfolio, this approach resulted in an estimated net yearly added value of several hundred million dollars (USD).

An alternative approach is to look at benefits on an industry level, suggesting categories and development types for which added value can be expected. CERA recently conducted such a *Digital Oil Field of the Future* study (DOFF)<sup>7</sup> looking at possible benefit areas. The study included a series of interviews with key industry players, and collected their opinions within different value categories (lower operational costs, increased production rates and lower facility capital costs). They arrived at a breakdown of relative benefits suggesting significant benefits exist for all cases considered, such as deep-water oil fields and onshore gas fields.

The third approach is to look at opportunities at the asset level, and build a business case for each asset. Using this approach, more than 20 interviews were conducted in a number of Chevron assets, ranging from mature brown field onshore to offshore green fields. The five identified Workflow Value Metrics for this study were:

(1) Efficiency. Savings related to performing the same task or arriving at the same decisions, but with lower operating expense, improved capital efficiency and well/facility utilization.

(2) Minimize lost or deferred production. A variety of factors may cause wellbore and overall field production to fall below the planned production decline, including gradual effects such as premature skin increase and episodic effects such as equipment failure. There is value associated with workflows minimizing or eliminating these factors pulling production below planned decline.

(3) Accelerated Production. Certain workflow activities can cause production to exceed the original production targets, e.g. proactive optimization.

(4) **Penalty Avoidance.** Certain well and field events can have large impulsive or instantaneous cost, e.g. spill, leak, noncompliance, or loss of capital equipment. Workflows to reduce the risk of such occurrences add value.

(5) Increased Recovery. Any workflow improving recoverable field reserves has very large potential value. Although traditional subsurface engineering workflows may improve field recovery significantly, production optimization

activities may extend field life by changing the economic limits for field abandonment.

The results of this analysis suggest that the values indicated in the CERA study are somewhat conservative, as illustrated in **Table 1**. The identified values indicate a substantial potential in pursuing the Digital Oil Field on a corporate basis.

Category	CERA Estimata	CVX interviews
OPEX		
Improve ultimate recovery	1% - 7%	Reduce decline 3.5% - 12%
Accelerate production	1%-6%	4% - 18%
Reduction in downtime	1%-4%	5% - 10% reduction in well downtime 8% - 10% reduction in steam system downtime 30% reduction in well workower frequency 33% increase in facility uptime (sand reduction) 225% - 3.4% improvement in ensine availability
Efficiency	3% - 25%	25% fuel savings for engines
Reduction in regulatory events	Not recorded	50% reduction of some emissions
CAPEX		
Drilling cost reduction	5% - 15%	Saved cost of back track and kick-off \$500MM event, typically 1 in 10 event

Table 1- Estimated Value by Managing Assets in Real-Time – a Comparison of CERA and Chevron Results

To assist its assets in developing a business case, Chevron has teamed with Schlumberger to develop tools to quantify the Value of Information. These tools provide a basis for improving current work-processes and have the potential to justify investment in new and emerging technology. These tools, the Flow of Information Tool (FIT) and the Screening Economics Tool (SET), have increasingly helped the assets develop business cases to establish local *i-field* projects.

It is important to recognize that the value for an *i-field* project is realized at the asset level, and thus the main drivers will have to be identified within each asset. Each project needs to develop its own business case demonstrating how value will be created. Many Chevron assets focus on how *i-field* can improve their operational excellence and reliability. To achieve this, an informal classification system was needed to differentiate between activities in the Digital Oil Field domain.

The *i-field* levels – an informal classification system As the Chevron *i-field* program matured, different views became evident as to what the effort is covering. Some imagine it as a control room with futuristic technology currently at the research stage. Others associate *i-field* with SCADA technology available for decades. Clearly, there is a need for a nomenclature distinguishing between what is available now and what is to be developed, and also between work-processes within surveillance, analysis and optimization. Consequently, an informal classification system was developed for clarification. Four levels were identified as a staircase toward the real-time asset management system, as illustrated in **Figure 3**.

The first level, **surveillance**, is about installing the right sensors, systems and instruments to collect sufficient real or near real-time data to support decisions from reservoir to sales. A lower layer, *level zero*, is sometimes added to represent the underlying data and communications infrastructure needed to support the surveillance; some assets have a good set of

sensors in place, but lack infrastructure to get the data from those sensors back to key decision makers. Having the underlying infrastructure in place also enables leveraging solutions across assets.



## Fig. 3- The *i-field* Staircase

Once the foundation is in place, a layer of software tools can be used to translate this data into meaningful information, by integrating it with existing models and providing real-time analysis. Use of intelligent tools to manage, visualize and analyze data is another key aspect of implementation, and is the second level, **analysis**. This *data-to-information* step can deliver significant benefits across a range of processes<sup>8</sup>. At this level, we begin to use the information developed to improve work-processes and decision-making. Several papers have presented improved well monitoring and reservoir description using continuous downhole data.<sup>8-12</sup>. However, a challenge at this level is preparing the data for continuous analysis by including data and processing validation algorithms. Recent advances in the use of Wavelet algorithms have started to address this challenge.<sup>13-15</sup>

The third level, **optimization**, can be thought of in two stages – single process optimization, and multiple process or full asset optimization. Most optimization efforts in the oil field today target a single process (gas lift optimization, water injection optimization). Recent advances in this area use novel methodology such as genetic algorithms<sup>16</sup> and neural networks<sup>17-18</sup>. Future optimization capabilities, in the form of integrated work-processes and decision support tools, will allow optimization across several processes. This is achieved when decisions are made in real-time responding to real-time events, and when subsurface and surface controls are linked, with automatic event detection and handling.

The final level of the *i-field* staircase, **transformation**, is achieved when the organization is fully capable of utilizing the potential created in level three. This involves changes to work-processes, virtual teams, and the use of global centers of excellence and centralized control rooms. Optimization across assets is the goal, with advanced automation, analysis and optimization tools supporting multi-functional teams.

Within an asset, various activities may occur at different levels at any one time. Activities at *i-field* levels one to three exist within Chevron and the industry, spanning offshore and onshore oil and gas fields. However, to date, there is no instance of a level four, and this represents the aspiration or the vision of *i-field* in the future.

At each level, benefits are realized through (a) reduced time spent finding and manipulating data, (b) increased time available for analyzing data, (c) faster and better decisionmaking and (d) the ability to make proactive decisions based on predictions rather than reacting to events after they happen. This informal classification system has proven very useful as a communication tool when consistently used across the company. Similar conclusions were reached in other efforts to create classification systems for the Digital Oil Field <sup>1-3.</sup>

Installing sensor hardware to get to the first level, surveillance may require substantial investments, particularly downhole. Although the value created at this level often justifies the investment<sup>8</sup>, more value is created by advancing to subsequent levels. In the *i-field* program, the main focus has therefore been elevating the assets beyond the basic surveillance level, where continuous data is often available, but not fully used.

#### Establishing a Corporate Digital Oil Field Program

A corporate program was established in 2002 to govern our activities in the Digital Oil Field domain. The *i-field* team consists of members from the Technology Company and Operational Units. Its objectives are assisting assets in identifying opportunities and providing resources and guidance for new, integrated asset-led projects. The team links available process and technology solutions to asset needs, and, together with key collaboration partners, develops technology components were gaps exist. As projects are completed, the team documents value and cross-pollinate successful solutions between assets, including lessons learned. The implementation design had to address integrated asset management and improved organizational capability. To enable the process enhancements and as part of technology development, a total of nine technology projects are governed by the *i-field* program:

1. Real-Time Production and Reservoir Optimization. In 2003, the joint Chevron-Schlumberger RTPRO project (Real-Time Production and Reservoir Optimization) was initiated. The scope was to create prototypes of a web-based system for production surveillance, analysis and optimization with access to real-time data systems. Beginning with a list of eighty oil and gas workflow activities, the RTPRO team worked with assets and stakeholders to prioritize and filter the list to arrive at eight workflows for future feasibility study. Synergies amongst the workflows were identified; an implementation plan and team organization was defined. Efforts are focusing on the analytical enhancements and optimization opportunities for the identified workflows. The project team is developing applied solutions for (1) Model-Based Voidage Management, (2) Advanced Sand Management and (3) Production Management including Well-Deliverability Analysis.

**2.** Center for Interactive Smart Oilfield Technologies. In 2004, the Center for Interactive Smart Oilfield Technologies (CiSoft) was established by Chevron and the University of

Southern California. This is a unique collaboration between a major energy company and university, and is a center of excellence for research, development, demonstration and deployment of technology solutions. The intent is to match Chevron's worldwide business needs with the research and development capabilities at the USC School of Engineering and its associated Information Sciences Institute (ISI), Integrated Media Systems Center (IMSC) and Petroleum Engineering (PTE) programs. The collaboration includes (1) contributions to advances in science and technologies associated with design, (2) implementation and operation of intelligent, integrated fields, (3) design, demonstration, development and deployment of prototype systems and (4) development of training modules for specific field systems developed by the CiSoft.

CiSoft is also establishing, in the graduate curriculum, an innovative M.S. degree program combining petroleum engineering and information technology, communication and visualization expertise. Chevron's sponsored graduate students from across the globe participate in the CiSoft's education and training program, allowing access to the latest advances in reservoir monitoring and asset management. The CiSoft's contributions benefit the Chevron *i-field* initiatives through developing technologies for (1) oilfield instrumentation, (2) real-time data acquisition, (3) real-time data management and analysis, and (4) real-time decision-making processes. Additional benefits include developing employee expertise and educating a new breed of engineers equipped with skills necessary to utilize these technologies. Successful implementation will help build organizational capability for implementing instrumented fields. It will create a platform for the cultural change needed by upstream decision-makers facing massive data volume.

**3.** Integrated Modeling and Simulation. This project builds upon the current efforts to couple asset management modeling and simulation. It has a strong link to the reservoir simulation workflows and new modeling functionality covered in one of the CiSoft projects. It will identify use case workflows for reservoir management and production operations (Ensemble Kalman Filter, Production-Injection allocation, integrated optimization, etc.). The near-term intent is to assess and leverage developing industry solutions, and implement for improved decision-making. From a technical perspective, this project plays a key role integrating with other *i-field* projects. The objective is to demonstrate a system of new workflows including uncertainty and scenario planning.

**4. New and Emerging Well Technologies**. In this project, focus is on accelerating the development of Intelligent Well Completions technologies. This is accomplished by forming collaborative groups, and target assets where the business environment permits the investment. Both deepwater and non-deepwater opportunities are being evaluated. Recent papers have covered optimization of Intelligent Wells, and link to distributed fiber optic sensor technology.<sup>19-22</sup> The project also addresses such new developments in downhole sensor applications, enabling the data acquisition to link subsurface and surface facilities workflows. A new alliance relating to

**5. Real-Time Operations Optimization.** The objective of this program is to develop or apply new workflows for field operations. The project scope is to (1) identify automation and optimization work-processes and technologies, integrating these with other related projects; and (2) accelerate consistent use of field-ready automation and optimization technologies. There are close ties with new data management tools being developed in CiSoft, and the surface facility integration required for the coupling of models and simulation. Efforts cover areas such as (1) gas lift optimization, (2) advanced alarms and automation and (3) facility processing optimization.

6. Artificial Intelligence. Soft computing and artificial intelligence methods can improve upstream profitability in a variety of ways, ranging from business portfolio optimization to increased production reliability and efficiency. The effort is focusing on new applications that can enable *i-field* asset projects, including propagating the tools developed for one asset to others. Some areas of interest include exception reporting tools, a signpost tool, steam injection scheduler, and a voidage predictor and model. A key element is working with the impacted groups with the change management required for broad implementation and sustained usage. The project also explores the use of robotics and other AI approaches in the next generation asset decision environment.

7. Applied Visualization. In a joint effort with Accenture, key visualization tools and user interface applications are assessed and incorporated into workflows where the human interactions can be enhanced. The term visualization is commonly used in the oil and gas industry to describe techniques for displaying and viewing complex geologic structures in 3D. Within the *ifield* project, the term visualization is used to describe new ways of displaying oilfield operations data traditionally viewed using spreadsheets, line graphs or maintenance manuals. The objective of this project is to quickly turn this data into meaningful information for the user. These tools could range in complexity from enhanced 2D displays to augmented and virtual reality. Areas of focus are: 1) visualization of operations data in the Asset Decision Environment (ADE), a key component is the incorporation of well designed user interfaces enabling engineers and operators to "see" the right data at the right time during the decisionmaking process; 2) user interfaces for mobile/handheld devices, application and data interfaces designed for the smaller PDA device sized screens; and 3) wearable computers for operations personnel, in conjunction with CiSoft.

8. Wireless Applications. This project was established to identify and deploy a more systematic approach within wireless technologies, as a key enabler for fast decisions and improving business performance. Program objectives include (1) identify wireless technologies for use in production operations, (2) accelerate use of field ready wireless technologies, and (3) develop and pilot applications for wireless technologies used in field surveillance. MEMS

(Micro Electro Mechanical Systems) technology is also monitored for potential upstream applications. The program targets advances in operational excellence and efficiency by providing information to operations and engineering (level one - *Surveillance*) that has historically been cost prohibitive. Wireless technologies provide access to new information, reduce manual data collection, and capture the data used in level two - *Analysis*.

9. Asset Decision Environment. In 2004, a joint venture was established between Chevron and SAIC called Asset Decision Environment (ADE). ADE in the production domain is defined as an environment where field data can be consolidated, where decisions regarding field and asset management processes can be made, and from which decisions can be communicated back to the field location, or elsewhere. The first stepping-stone for this environment may be a Decision Support Center (DSC). An illustration of a floor plan for a DSC is given in Figure 4. Such an environment requires the integration of a number of different data sources, systems and technologies to present the information required to make improved decisions. An ADE can be the environment where tools and processes developed in other technology projects can be integrated and delivered to the asset.



Figure 4: Example Floor Plan for an Asset Decision Environment (ADE)

In such an integrated real-time operating environment, people can manage and execute business processes via collaborative decision-making across the asset. One of the key properties of an ADE is its ability to deliver value through the implementation of new integrated work-processes. This is a key enabler for assets to reach *i-field* levels three and four. An ADE may be a physical operations room, a virtual environment, or a hybrid. The industry is changing with respect to the perceived need of Operations Centers. These are currently being built to optimize business processes within several disciplines, including drilling operations, production optimization and operations maintenance. Currently there seems to be a solid business case for building centers within the drilling domain<sup>23</sup>, but limited experience has been published for other domains.

One of the largest challenges associated with ADE is likely to be managing the change. This area is probably the least understood for any asset engaging in an *i-field* project. Moving to a more real-time, cross-functional way of working with collaboration across assets will expose deficiencies, not only in current organizational arrangements, but in performance metrics, incentive programs and accepted modes of behavior. The change-management element of the ADE project will highlight these challenges early and develop development appropriate measures during and implementation. Chevron is planning building three ADE, the first one in Bakersfield, California,

**Other Key Enablers.** In addition to these nine technology projects, strong linkage and alignment have been established with two other efforts; (1) a corporate initiative to address the IT & IM architecture and (2) an initiative in the operating companies to standardize applications and work-processes for surveillance and analysis. These are not governed by the *i*-*field* program, but are critical to a successful implementation. By bringing all these components together, we aim to accelerate the lessons learned and business impact across the Chevron portfolio. Without the central focus of the *i*-*field* program, we would be destined to the normal functional silos optimizing only within single workflows. Through project integration, normal organizational boundaries are crossed by utilizing skills from the technology companies, the operating companies and our partners.

## **Engaging the Operating Organization**

A critical component of our approach is establishing a collaborative relationship with the operating organization. This engagement has the following steps:

(1) Initially, it is important to simply have educational dialog exploring the interest in assets that may benefit from a higher degree of workflow optimization. This dialog takes place with key stakeholders and needs to be reinforced by local management.

(2) Once a decision is made by the operating unit to explore value-adding opportunities, an Asset Assessment is scheduled. This is a joint, usually week-long, process exploring and prioritizing opportunities. It is important for the asset to take ownership of the results and recommendations.

(3) Based upon the recommendations and high-level business case, the asset or operating unit decides whether they want to pursue a dedicated project, which we call an "*i-field* Project". A structured project management approach is available to assist the project team through the phases – which is called the "*i-field* Project Design Process". The actual project team is usually staffed with a dedicated project manager from the operating unit, key functional experts from the asset and complimentary experts from the *i-field* central team. The *i-field* central team members may come from our internal technology company or our strategic partners.

Throughout this entire process, the pace and priority are driven by the operating unit's business environment and desire to resource a project. In this way, business ownership is evident. Key elements of solidifying this ownership are existing relationships between asset and *i-field* personnel, the visionary sponsorship of local decision-makers and the full involvement of asset personnel both in the office and the field.

## **Progress to Date**

Within Chevron, there have been several areas of early adoption of the Digital Oil Field. It is in these areas where we will establish successful work-process change, technology deployment and behavioral change, all of which are required to deliver sustainable measurable benefit. Operating areas of early adopters are:

**San Joaquin Valley, CA.** This business unit has embraced the *i-field* methodology as a strategic priority across their assets. The initial project leading the way is a green-field steam-drive development at the San Ardo field. Since this is a new capital project, a fresh view can be taken when designing workflows. Key areas of focus include the integration of heat management (both surface and subsurface), data architecture and asset decision processes. Other areas of the operating unit are deploying components of solutions providing needed learnings for the San Ardo design - as well as provide some near-term business impact. Plans are also underway to establish a Decision Support Center (as part of the ADE project). The implementations are being phased in as fields are ready and the San Ardo project begins its construction.

Chevron Europe, UK. Also incorporating the *i*-field approach as part of their operational transformation, Europe has embarked on an enabling IT & IM Data Model and Infrastructure solution enabling business unit-wide deployment of a number of key initiatives. Partnering with Microsoft and others, an accelerated deployment of a new IT architecture (level zero) will establish a new foundation across the entirety of any operating unit. At the same time, an *i-field* project is being designed for the Captain Field in the North Sea, a shallow water operation. The project covers reservoir optimization and voidage management, facilities availability optimization, supply chain management, new workforce competencies and a step-change mode of operating via the Asset Decision Environment project. Closely attached to the European deployment is a test facility as part of an Operating Center JIP sponsored by Epsis, a partner company based in Bergen, Norway.

**Carthage Field, TX.** The first *i-field* project was launched at the Carthage field in East Texas, a major onshore gas field. Many process learnings have come from this initial thrust for what an *i-field* project actually does regarding process change and integration. The scope of the first phase of this project is Production Operations, with field personnel demonstrating opportunities in reducing data collection and handling, well work prioritization, automating reports and visualization tools, and artificial lift optimization. Early indicators are validating the expected production increases and operator time savings assumed when the project began.

**Tahiti Field, Gulf of Mexico Deepwater.** At the other end of the spectrum, one of Chevron's major new capital projects in the Deepwater GOM is incorporating the *i-field* methodology in its operational design. This mega-project is due for first oil

production in 2007. Concurrently, a joint team is working on key integration processes. These include real-time reservoir management, process control and optimization, an asset decision environment and integrated asset modeling. As learnings occur from the design, they are communicated to other key deepwater projects in development.

**South Timbalier 52 Field, Gulf of Mexico.** Just underway in the GOM is an *i-field* project designed to build upon an already high-performing asset by today's standards, South Timbalier 52. This is a significant shallow water asset, with a substantial degree of level one and level two processes in place, and plans to pursue levels three and four. The primary areas of focus are automated system optimization, enhanced reservoir management, creating an asset decision environment and new collaborative team competencies.

**El Trapial Field, Argentina and Frade Field, Brazil.** In South America, two very different assets are designing an integrated project using *i-field* processes. At El Trapial, an onshore waterflood, the first phase focus on the more foundational elements allowing a higher-level *i-field* project to be assembled at a later date. Initial deployment of automation and surveillance solutions across most facilities and wells solidifies an opportunity to replace a significant amount of manual efforts – thereby identifying improved operational actions. Alarm management, SCADA, water injection data collection and submersible pump performance enhancements will enable many base business practices to be implemented. A subsequent *i-field* project would cover areas such as voidage management, injection optimization and well productivity.

Offshore Brazil, the deepwater Frade project is currently evaluating an *i-field* approach as part of their overall operational design. Components that might be addressed include real-time reservoir management, gas lift optimization, subsea system optimization, alarm management and advanced process control capabilities.

**Quick Hits**. Based on the asset engagement processes, opportunities are identified that can be quickly implemented, often referred to as *Quick Hits*. These efforts, if successful, pave the way for more integrated *i-field* efforts by gaining attention and confidence in the organization. Generally, existing technology is deployed without any need for technology development. These can also be feasibility tests of new technology as part of a technology development program. Prototypes are developed to address specific asset requirements, and pilot tested with the asset(s) to validate the technical feasibility and to allow the users to assess value. Some specific examples are:

<u>Cyclic Steam Candidate Selection at San Joaquin Valley, CA.</u> Artificial intelligence in the form of neural networks was used to optimize steam injection<sup>16</sup>. This enhanced approach has increased the successful performance by as much as 30% over what performed manually.

<u>Neural Networks and Data Mining at Strathspey, UK</u>. Use of neural networks and simplified data models was combined with routine reservoir surveillance to cleanse and aggregate data, deliver comparisons of performance against prediction and provide alarms and triggers. This has resulted in significant decrease of time spent on aggregating and analyzing data, and has significantly accelerated decisionmaking processes within reservoir management <sup>17, 18</sup>.

<u>Spill Prevention Technology, Texas.</u> Low-cost technology installed to significantly reduce all oil and saltwater spills from a 70-year old field. A pilot installation helped to avoid a major spill in 2003, after two significant spills had occurred in 2002 before the new technology was installed. Additional units are currently being installed across the field.

<u>Wireless Deployment at MP41, Gulf of Mexico Shelf.</u> Three categories of opportunity were identified: SCADA, forms and communications. The deployment is testing the feasibility of a wireless network on the main structure in the field.

The challenge is using the lessons learned from these examples of successful implementations to greater effect.

## **Rethinking Partnership Models**

Over the last ten years, the oil and gas industry has seen a significant reduction in R&D efforts among operators. Increasingly, the vendors have taken responsibility for continuing to push the technology envelope. Given the complexity of developing and deploying a Digital Oil Field, a redefined partnership between operators, vendors and academia is needed. This includes moving away from the traditional approach based on direct financial support and recruiting, to a multi-faceted program involving expanded and shared opportunities in research, education, and employment. Chevron has established several new partnerships within the *i*field domain, aimed at joint R&D and technology development. The essence of these new partnerships is a formal, stable affiliation built upon past experiences with complementary strengths, intersecting R&D interests and shared vision and values.

**Operator-Vendor Relationship.** We have established several large R&D efforts with key vendors. This includes a 25 manyear team effort to develop the next generation reservoir simulation model, a 10 man-year team developing tools for real-time production and reservoir optimization, and a six man-year team developing new systems integration and process change in decision-making environments. The funding model is generally a 50-50 joint venture. The experience with such partnerships is very good, and it is an excellent way of accelerating technology development by bringing together the best knowledge from two companies.

**Operator-Academia Relationship**. Another relationship requiring rethinking is between universities and industry, where there is a need to create a new form of partnership built on complementary strengths. This includes building a new type of research entity, combining the capabilities of faculty, students, and Chevron employees. An example of such a partnership is the Chevron-USC Center for Interactive Smart Oilfield Technologies (CiSoft) described above. Partnerships have also been built with Los Alamos National Laboratory (Alliance for Advanced Energy Solutions) and the University of Bergen, Norway (Center of Integration Petroleum Research). Ideally, all three entities (operators, vendors and academia) should work together to accelerate the R&D and deployment needed for the Digital Oil Field. Chevron has a strong record in establishing partnerships, including vendors supplying commercially available technology in key areas. This concept of collaboration in all phases of technology development is illustrated in **Figure 5**.





## **Lessons Learned**

The road from a corporate vision of the Digital Oil Field to actual deployment projects in oil and gas assets can provide considerable challenges. Lessons experienced in Chevron as our efforts matured were as follows:

**Focus on Work-processes, not Technology.** For a Digital Oil Field deployment to be a success, one must focus on improving the work-processes and decision-making. A common risk is that the concept can be used to promote particular pet technologies as opposed to the integration of technology pieces. By concentrating on workflows, the focus will be on asset decision-making and how decisions can be improved, as opposed to maintaining a technology focus (technology looking for a problem). Technology in turn, can assist in enabling, automating and improving workflow efficiency. In short, the Digital Oil Field is <u>not</u> a technology project, but a substantial element of technology is needed to achieve operational transformation.

**Secure Management Support.** Any project requiring change in asset work-processes must be solidly anchored with management support. As a corporate effort is created, necessary management support must be available, both in the technology companies and the operational assets. It is imperative to seek the key, innovative leaders in the business units to be champions. However, one must be aware that strategic thinkers are rare. In Chevron, the *i-field* project has a Decision Review Board with executive members from the Technology Company, Chevron North America and Chevron International Exploration & Production.

**Create Pull for the Digital Oil Field in a Decentralized Company** As many oil and gas operators are organized in a decentralized way, launching new corporate efforts is challenging. The traditional top-down process does usually not work well in companies with relatively autonomous assets and strong focus on short-term value creation. The alternative is to create a bottom up approach, as the local assets get engaged, and *want* to deploy *i-field*. A major part of a corporate effort is to create such a pull, by visiting assets and creating traction and enthusiasm. In Chevron, only willing assets are engaged, and the experience gained is shared across other assets.

**Don't Underestimate Resistance to Change.** A key factor in engaging an asset is understanding the existing resistance to change. Part of the purpose of a central Digital Oil Field program is to explain to the asset engineers how they can benefit from the change (*What's in it for me?*). These Change-Management issues are often overlooked when deploying new technology. Managing the work-processes and the change aspects of implementation of *i-field* technology is a critical success factor, often underestimated by engineering professionals.

Be Aware of Short Term Value Drivers vs. New Technology. The oil and gas industry is generally slow to adopt new technology due to the need to focus on short-term value drivers. For most assets, the success metrics are measured monthly or annually. Sole focus on cost reduction or production can reduce the level of innovation an organization is willing to assume. New technology may provide substantial potential value, but its accompanied by a risk and perceived negative impact on the asset success metrics. A corporate governance program must be aware of all these factors, and plan for risk mitigation.

**Create an Asset Assessment Process.** In order to achieve the elevation of assets to *i-field* levels two to four, a series of different technology components may need to be integrated and deployed. As a result, we created an Asset Assessment process in order to identify:

- Potential implementation opportunities for *i-field*
- Cross-asset learning opportunities
- Potential new technology development opportunities
- *Low hanging fruit*; opportunities that the asset can quickly implement as part of their daily business
- Implementation opportunities for utilizing existing technology in solving asset specific problems

#### Integrate R&D Efforts Where Technology Gaps Exist

Although the integration and deployment of existing technology could create substantial value, there is still a need for R&D within the Digital Oil Field domain. A common problem is that R&D resides in different departments or research units. Often, little or no coordination between R&D

efforts in different disciplines exists. A way of mitigating this is to create a common platform where the components constituting *i-field* solutions reside. In Chevron, the creation of *Technology Focus Areas* has helped to bring related technology development together coherently, with prioritization of R&D funding administered by the *i-field* Focus Area team.

**Don't Wait for the "Oil Field of the Future"** A risk with the Digital Oil Field is that the concept is perceived as futuristic. Although R&D is an important aspect, a substantial improvement in asset performance is possible through integration and deployment of technology available <u>today</u>. Any corporate efforts should have R&D elements, but not necessarily owned by the R&D organization. In Chevron, R&D is governed in the *i-field* project, but the main focus is on assisting our assets deploy solutions improving their asset management.

**Share Early Success Stories.** Given that the concept of the Digital Oil Field is still in an early phase, there is a need for success stories documenting the value. This will increase opportunities for a broader implementation among the operators. As part of this effort, a natural path is to launch feasibility and pilot studies, and to develop tools to determine the value. Willingness to share such success stories across companies is an important factor in getting faster deployment. As an example, the recently established SPE Real-Time Optimization (RTO) Technical Interest Group (TIG) promotes and encourages the development of hardware and software tools including associated standards and work-processes for real-time optimization of hydrocarbon production systems<sup>1,2</sup>.

#### Conclusions

- 1. The upstream industry is moving towards real-time asset management allowing quick identification and capitalization on opportunities to optimize the field's productivity, efficiency and recovery. Development and integration of new asset monitoring and optimization technologies is needed for asset teams to make faster and better decisions.
- 2. Better tools to measure the Value of Information (VOI) were established to create compelling business cases, which in turn will drive a broader uptake of the Digital Oil Field.
- 3. An informal classification system was developed with four levels as a staircase toward the real-time asset management system; surveillance, analysis, optimization and transformation.
- 4. *i-field* is well established in Chevron as a corporate effort with a core team, nine technology projects and six assetbased *i-field* implementation projects.
- 5. Strong alignment is needed with corporate initiatives addressing IT architecture, and initiatives in the operating companies to standardize applications and work-processes for surveillance and analysis.

- 6. A critical component of our approach is establishing collaborative relationships with the operating organization. Chevron has successfully implemented elements of the *i-field* concept worldwide. It remains to take a more integrated approach to create a step change in performance.
- 7. Within Chevron, there have been several areas of early adoption of the Digital Oil Field. We have increasing interest from our assets to initiate integrated, local *i-field* projects.
- 8. In order to accelerate the deployment of the Digital Oil Field, new partnership models have been developed, and value created through new partnerships with vendors and academia.
- 9. The road from a corporate vision of the Digital Oil Field to actual deployment projects in oil and gas assets can provide considerable challenges. Lessons experienced in Chevron have been presented in this paper.

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