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Making Our Mature Fields Smarter—An Industrywide Position Paper From the 2005 SPE Forum

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Abstract

This paper summarizes the findings of the SPE Forum held in September 2005 on "Making our Mature Fields Smarter". Participants in the Forum have granted permission to present this paper on the basis that the authors are neither representing the views of the SPE nor of the participants' companies.

We are delivering smarter fields in order to add value to our business – there are many facets to this value beyond reservoir, well, process and production management. What may not be so clear is how to apply these smart technologies to mature fields with a legacy infrastructure and long production history. Participants felt that maturity in itself made a challenge for deployment and enforces the need for effective Change Management. Deployment and Change Management are seen as the major challenges facing the creation of Smart Fields.

During the Forum it became apparent that companies do not have a common vision of what a truly Smart Field will look like and this contributes to the difficulty of assigning a value to "Smartness". There is a tendency to assign value to discrete technologies as opposed to the holistic full project value associated with the business process that has been improved by the application of that technology.

The essential foundations for a Smart Field are: People and Skills, effective Data Management and Industry Wide Standards, appropriate Hardware and Systems Architecture. High quality data is a fundamental building block of Smart Fields and it needs to be treated as an asset, managed effectively with staff assigned to ensure the integrity of the data management systems.

The key processes are built on this foundation and deliver the business result. These processes are supported by detailed workflows with corresponding enabling technologies. The business processes and workflows required to manage a mature field appear to be similar for many operators. The majority of the technologies that we require to create Smart Fields are already in place although we did identify seven specific areas where technology advances are recommended.

Collaboration and visualization technologies are enablers and are required in order to integrate across the core business processes and permit people working with these processes to assimilate the huge and diverse volumes of data and information.

Introduction and Context

During the past decade the concept of the Smart Field has developed from a twinkle in the eye of the visionaries in our industry to a position where several operators, notably BP, Chevron, Norsk Hydro, Saudi Aramco, Shell and Statoil, have flagship fields where many, but probably not all of the Smart Field Technologies have been deployed. The development and deployment of these technologies has normally been in Partnership between a major operator and one or more key suppliers.

Each of the major operators have their own terminology for "Smart Fields" as listed below. Throughout this paper the term Smart Field has been used based on its use at the SPE Forum and it is intended that any of the following terminology could be substituted by the readership.[1,2]

Operator	**Terminology**
BP	"Field of the Future"
Chevron	"*i-field*"
Shell	"Smart Fields"

Also, during the past decade there has been an increasing appreciation within the industry that much of the future lies with the effective management of existing production and the continued development of mature fields. What may not be so clear is how to apply smart technologies to mature fields with a legacy infrastructure and long production history. Participants felt that maturity in itself makes a challenge for deployment and enforces the need for effective Change Management.

Within Europe the SPE has been at the forefront of both of these trends – the advent of the Smart Field and the increasing importance of managing our mature fields effectively. There

have been a series of Applied Technology Workshops, which have been focused on the challenges of Mature Field production management and their continued development whilst in parallel there have been a series of Forums which have focused on the development and deployment of Smart Technologies as follows:

2001 Smart Wells
2002 Smart Fields
2003 Visualization

In 2005 the SPE in Europe decided to bring together these two trends in a Forum which was called "Making our Mature Fields Smarter". The focus was deployment as opposed to the technologies themselves and the Forum included topics such as understanding the value of deploying Smart Field technologies, legacy to real time data and Change Management.

This paper summarizes the findings from this Forum. Fifty people attended the Forum. Representation at the Forum covered 6 operators, all of the major suppliers, 8 specialist suppliers and 3 consultancies.

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Vision and Value

In spite of the development and deployment of Smart Technologies by major operators and suppliers to an increasing number of fields and some very well publicized meetings, conferences and forums it became apparent at an early stage in the Forum that companies do not have a common vision of what a truly Smart Field will look like and are unclear about the value which can be assigned to the deployment of Smart Technologies.

Further, there is a perception that the industry has been slow to take up many of the Smart Field Technologies. There are several potential drivers behind this reluctance. Some believe that "it is all about technology with little clear business benefit and consequently the full ramifications of the deployment are managed poorly". While others say that "everyone wants to do something different and consequently there is a failure to exploit the synergies between the deployments". Standardization of the basics and more sharing of experiences could help to break through a perception that Smart Fields are complex, high cost and unreliable.

The vision of success appears to vary between two extremes as follows:

- That over the next decade the way in which we understand our reservoir, identify development options, manage and optimize our wells, facilities and associated production will all change radically. Logically this leads to significant Change Management programmes for each field and a substantial impact on the people working on these fields.
- Alternatively, there is a view that the most successful companies during the forthcoming decade will be those which are most efficient at delivery of the current activity set and at the lowest cost.

There is some evidence that, irrespective of which scenario an individual or a company believes to be most accurate, the direction for deployment of Smart Field Technologies will be to deliver the easiest projects first. Ultimately, these deployments may well not be the highest value projects because there is a tendency to focus on metrics which are perceived to be easier to measure such as production efficiency and uptime.

One of the key decisions for an operator of a field on which it is deploying Smart Technologies is the point at which to move from a series of incremental steps to a major step change as occasionally happens when a field is redeveloped. An example of this is the decision to deploy fibre optic cable in order to increase bandwidth between field and centre. Examples of where this has been done demonstrate that this change provides an opportunity to make a step change in the way in which a field is managed when a whole raft of Smart Field technologies are deployed.

Both major operators and some suppliers see the potential for differentiation in the marketplace through the development and deployment of Smart Field Technologies. Consequently, although increasingly both groups are happy to publicize their successes, it is apparent that very few companies are ready to publish the real costs incurred and value generated through the deployment of Smart Field Technologies. This situation is likely to continue as long as the operators and suppliers who are developing and deploying these technologies continue to perceive competitive advantage.

At the Forum the only hard value numbers that were presented came from the multi – client study undertaken by Cambridge Energy Research Associates during 2003 and called Digital Oilfield of the Future: Enabling Next Generation Reservoir Performance[3]. These figures are reproduced below:

Category	**CERA Estimate**
Improve Ultimate Recovery	1 – 7%
Accelerate Production	1 – 6 %
Reduction in Downtime	1 – 4%
Operating Efficiency	3 – 25%
Drilling Cost Reduction	5 – 15%

Several companies explained that it has proven remarkably difficult to break out value retrospectively after a project involving Smart Technology has been deployed. Not only as an industry do we have a reluctance to undertake post- project reviews, but also the nature of Smart Field programmes makes it very difficult to assign value to the different projects within a programme which typically requires all of the diverse components and changes to work in order to gain the prize. This can hit hard the smaller vendors who struggle to derive a business value associated with their point solutions.

In addition to the conventional hard metrics which CERA have identified there are many much softer components of value associated with Smart Field Programmes. The Forum identified these additional components of value:

- Some of the increasing challenge associated with the demographics of the industry and the associated knowledge retention issues.

- Engaging the next generation of industry staff whose childhood has been in the digital age.
- The Safety of the workforce as more roles are moved to centres remote from the wells and process facilities and the travel exposure is reduced.
- Breaking down barriers between the disciplines.
- More effective use of very limited technical expertise.
- Improved quality of life for the Operational Staff.

During the Forum we asked whether our industry should be concerned about these divergent visions of the future and lack of clarity around the value. Whilst this situation continues there is an opportunity for those companies which embrace the digital future to place themselves in a very different position from the competition, and the Forum concluded that this will be a very much stronger position. However, the downside is that the adoption of this digital future by much of the industry will proceed at a slower pace. In addition there is a risk that the industry will fragment and the competition in the marketplace for products will be much reduced. Where there are multiple partners in a Joint Venture it could be harder to gain approval for Smart Field Programmes. The recommendation from the Forum is that not only successes, but also failures and practical experiences from the Early Adopter and Flagship Projects be publicized in order to align the Industry.

The Components of a Smart Field

During the course of the week the Forum converged on the critical components that are required in order to deliver a truly Smart Field (Figure 1). The key findings of the Forum about each of these components are summarized in the subsequent sections of this paper.

It became very apparent during the Forum that when deploying Smart Technologies by far the largest and most pervasive challenges, especially within mature fields, are associated with Change Management. At the highest level this requires getting clarity on improved business process which then leads to clear workflows and ultimately the potential automation of these workflows. These changes have a substantial impact on the role and working environment for the workforce.

There are some essential components, “the foundations”, without which it will be very difficult to make a business impact on the performance of a field through the deployment of Smart Technologies. These foundations include the following:

- Hardware and Systems
- Data and Standards
- People and Skills

Building upon the foundations are the major processes, which are supported by more detailed workflows and associated technologies. Smart Fields, irrespective of whether they are mature, will be working a minimum of one and potentially across several different major processes. Typical major processes could include production optimization, the drilling and completion of new wells and the optimized development of the reservoir. One of the challenges is to identify the boundaries of each business process and associated workflows and ensure that there is clarity on what is included and not included within each process. Clarity on business process is key to defining the impact on the organization and defining the required changes.

In order to deliver the business value from the deployment of Smart Field Technologies it is essential to have multiple disciplines working together with the same data, process and toolkit. This will only be achieved through much closer collaboration across the existing disciplines. This level of collaboration requires the use of high impact visualization in order to effectively communicate and disseminate large amounts of data and processed results in such a way that fellow workers with a different background can understand the importance and impact of what is happening in the field.

The Forum did identify several specific technical challenges which are incorporated within each section and summarized in the conclusions / recommendations.

The Foundations for a Smart Mature Field

Hardware and Systems

The underlying and critical enabler for the Smart Field is the relentless, rapid and massive increase in digital capability of the following:

- Data storage and rapid access to this data.
- Bandwidth for digital communication at an appropriate price.
- Compute Capacity.
- High Resolution Visualization of massive amounts of data.

However, the very rapid pace of change in these digital technologies also provides a huge challenge when attempting to maintain compatibility of the hardware and the underlying systems in the very complex environment of a producing field which probably already relies on several generations of hardware and systems.

Getting clarity on which hardware and systems should be updated and the knock on impact on both the remaining hardware and systems and on the implications for future changes is absolutely critical.

Data and Standards

In the Smart Field the volumes of data are increasing rapidly and often by several orders of magnitude above the data volumes which we are historically used to handling. In addition, in mature fields these large amounts of digital data are being added to what can be many years of legacy data in numerous formats and storage media. In order to exploit the full power of the Smart Field it is generally agreed that there is an increased requirement to improve data system interfaces in order to provide a digital link between the diverse data types and storage media.

During the Forum insights were provided into how the automotive industry manages large volumes of changing data, the impact that data standards have had and could continue to have on the upstream industry and an example of a relatively conventional, but massive data management project with large amounts of legacy data.

These insights demonstrated the sheer complexity of the existing Data Management Architecture which makes the typical user wonder why it has to be so complex – "Surely there must be easier ways to provide quality storage and access to our corporate and project databases"? and "Could we learn a great deal from what happens in other industries where there may be more flexibility in the data architecture, its associated interfaces and more use of standards"?

There was agreement at the Forum that data needs to be treated as a valuable asset. In the past this has not been the case, but due to the compliance requirements stemming from Sarbanes Oxley and SEC there is an increasing recognition within the industry that we have a legal and commercial duty to effectively manage much of our data. This transformation in the way in which we treat our data implies that we will be able to provide a compelling business case to support the cost of effective data management.

It became apparent that in order to truly treat data as an asset and to manage it effectively a substantial change will be required in the way in which we approach our data. The technical and commercial staff working a field will need to truly own, and be accountable for, their data and its integrity. It was agreed that they will need the support of professional data managers whose role is not to own all of the data but instead provide the infrastructure and work with the operational and field development teams to define the processes that are required for effective data management.

In the past the role of data manager has been devalued in our industry and in order to encourage people into these roles we will need to demonstrate that there are career paths which provide a future and are not just a fast way to exit from the industry.

In the sub-surface environment we have very few formal digital standards. Two of the few are the SEG-Y format for seismic data transfer and the WITSML protocol for transfer of well data between the rig site and the engineers.

A similar protocol is under development for the transfer of production data and is called PRODML. This Forum was the first public event at which PRODML was shown to an audience beyond those companies who are contributing to its development. The driver behind creating this protocol is both the rapid increase in digital production related data and a clear need in the industry to transfer that data from the field to the engineers who can make informed decisions based on this data. The commercial model behind PRODML works because of a common need and the desire by all parties to have a production data transfer capability which is accessible to all operators. This should lower costs and project risks and lead to more rapid deployment times.

There appears to be very strong similarities in the approaches and even the detailed work that the major operators are undertaking within their Smart Field programmes. In principle this should provide an opportunity for more collaboration on common standards. However as long as there is perceived to be a major commercial advantage in developing and deploying Smart Field technologies faster and more effectively than the competition there will be some resistance, in the short to medium term, to the adoption of industry wide standards.

People and Skills

A very strong theme throughout the Forum was that the success of deploying Smart Field technologies to our existing fields will be determined by our ability to manage the scale of change – technically, in business process and most importantly in the skills, culture and adaptability of the workforce. Change Management will permeate the delivery of truly Smart Fields.

When we consider the changes that the people currently managing and operating our existing fields are seeing as Smart Field Technologies are deployed it becomes apparent that the educational base, skill sets and competencies of the next generation of people operating and managing these assets will need to be enhanced. This enhancement will add an ability to be at home in a digital environment, maybe having different patterns of work and being able to collaborate more effectively across the disciplines whilst doing all of this remotely. Looking to the future it will be essential to retain the conventional skills such as having a good understanding of the fundamental principles of oil and gas field production and having specialist engineering and operating skills. We perceive that the need for high quality reservoir management, well engineering and well and facilities operations skills will not only remain, but become more tightly coupled as requirements for integrated problem solving become increasingly important.

Due to its importance the Forum spent some time exploring effective Change Management with examples being provided from both inside our industry and in the military and health services. Many books have been written on Change Management and the key components which are listed below were emphasized:

- Clear vision of what the end state will look like.
- Clear understanding of the prize associated with the change.
- Clear Roadmap of how to get to the end state.
- Visible commitment of the leadership to the vision and the process.
- Really effective communication and engagement with all involved in the change.
- A robust approach to delivery of the change with appropriate phasing of the change.
- Training and Support provided in support of the change.

The Forum explored the concept that the competence and potential of people may need to be matched to the level of technology that is applied to a field. Ultimately it is not apparent that everyone who is currently working on a field that is being taken through a change to a Smart Future will be able to transition to the new environment. Therefore, Smart Fields can be seen as a threat to some people.

Major Processes, Workflows and Technology

At the heart of an effective Smart Field is clarity around the business processes to which the technology is being applied. Smart Fields, irrespective of whether they are mature, will be working a minimum of one and potentially across several different major processes. Typical major processes could include production optimization, the drilling and completion of new wells and the optimized development of the reservoir.

One of the challenges is to identify the boundaries of each business process and associated workflows and ensure that there is clarity on what is included and not included within each process. Whilst making sure that the interfaces between processes are clearly understood (e.g. : the hand-off and receiving of information from other workflows).

The business process should focus on the rationale behind an activity and will be supported by one or potentially many workflows which focus on what physically will be done. Underpinning the business process and associated workflows is access to high quality data which is effectively managed. This requires that the link between the process, workflow and data is mapped and documented. The technology must then support the powerful and efficient delivery of the workflow.

Only once the business process is clear, the workflows mapped and the data is effectively managed can we achieve automation of one or more workflows. Automation is pervasive throughout many industries like pharmaceuticals, automotive and chemicals. There is a substantial process control industry that has grown to address the automation needs of many industries. Efficiencies born of the automation and control industry comprise an integral part of the commercial model for these industries. By comparison, the upstream oil & gas industry has been relatively a laggard in taking on board the commercial advantages of automation. It was commented that this could well be true because the oil & gas industry has not experienced a crisis of sufficient magnitude to force a step change from its current level of efficiency. Other drivers will precipitate the step change in our industry but we will be served by products developed for others and we will learn from their experiences.

At very high levels the business processes are company specific because they reflect how an organization actually manages its business of managing an oil or gas field. However, the fundamental principles of reservoir geology and oil and gas production have not changed and to a large extent we share the same toolkit. Consequently, when we move to a lower level workflow, as for instance would be the case with optimizing production from our wells, the vast majority of operators appear to be following the same approaches and workflows. On the face of it there is an opportunity here to share the workload associated with developing the automated workflows and associated toolkit.

The Forum concurred that the vast majority of challenges associated with deploying Smart Fields are not in the technology but instead in understanding our workflows and managing the associated change. The major exception to this statement is in delivering the vision of Real Time Reservoir Management.

At the Forum there was ample evidence that our industry is still trying to understand what we mean by the words Real Time Reservoir Management. Much of the problem is deeply rooted in our disciplines and our language. The Reservoir Development Teams tend to be focused on relatively long timeframes (more than one year) and understanding the uncertainties which are inherent within our knowledge of the reservoir and the associated development options. As such they are comfortable with probabilistic approaches to addressing and planning future reservoir management initiatives. On the other hand, Production and Petroleum engineers are much more focused on shorter timeframes, anything from minutes to maybe a year, and given those timeframes they find it more appropriate to consider fewer deterministic outcomes. It is apparent that the two disciplines are working on different business processes; Much confusion is created when both disciplines attempt to solve the same mid term problem (6 to 18 month timeframe) using their different approaches and toolkits, which at the limit lead to different outcomes.

In order to manage both the development of a field and the exploitation of the existing reserve base we need both approaches with all disciplines and workflows using a common set of well managed data. In addition there is probably a need to build a common understanding of the objectives that each business process is required to deliver and as consequence clarity on the best approach to use.

In the light of the need to map the workflows, data and technology needs and then understand the implications for the changing roles of the people developing and operating the fields, it becomes clear that Change Management lies at the heart of the Smart Field.

Integration through Collaboration and Visualization

In order to manage the future development and effective production of existing reserves it is essential to integrate across the core business processes. The integration is something which at present lies within the preserve of people. In the future this integration role will require people with an even broader discipline base and set of skills, who have also maintained their understanding of the fundamental principles behind oil and gas field development and production.

The Forum strongly advocated the use of visualization in order for the people to be able to assimilate the large volumes of data and information. Specifically visualization will be required in order to be able to understand the implications of the data and information which may be from outside of an individual's discipline.

A clear case was made for the use of collaboration environments with extensive visualization capabilities in which the people will be able to effectively view the real time data and information and in which highly informed, high quality and rapid decision making will be possible.

Evidence from other professions, including the military and medicine, shows that these environments must be designed around the people in order to function effectively and that ideally the people require appropriate information support systems.

Already, there is strong evidence from fields and suppliers which have implemented such centres that there are substantial savings and efficiency improvements from being able to focus specialist technical expertise on the operations and problems in multiple wells and fields.

Summary and Recommendations

As an industry, whether or not we can successfully deliver Smart Fields within our existing producing fields will be determined by our ability to manage the potentially substantial changes associated with our business processes, workflows and the implications for the roles of people both on site and in the centre. It is probable that grappling with this scale of

change is one of the major factors inhibiting the pace at which Smart Fields are deployed in our industry.

For our fields which are on production much of the activity associated with the deployment of Smart Field technologies is just about doing our business better by managing our base activity more effectively and making better decisions faster. This approach tends to focus on accessing the most obvious, but not necessarily the highest value, changes associated with a Smart Field – so for instance focusing on cost and efficiency savings as opposed to increasing recovery.

The business process should focus on the rationale behind an activity and will be supported by one or potentially many workflows which focus on what physically will be done. Underpinning the business process and associated workflows needs to be high quality data which is effectively managed.

Only once the business process is clear, the workflows mapped and the data is effectively managed can we achieve automation of one or more workflows. The technology is then required to support the powerful and efficient delivery of the workflow.

In the recent past our industry has tended to have a relatively cavalier attitude towards data. In the Smart Field this cavalier approach has the potential to lead to substantial problems as automated systems treat the data as valid and either guide us to inappropriate decisions or at the limit automatically and inappropriately control the wells and facilities. Consequently, high quality data is a fundamental building block of Smart Fields and it needs to be treated as an asset, managed effectively with staff assigned to ensure the integrity of the data management systems. The Forum recommends that as an industry we place a much greater emphasis on Data Management and that we work together on how best to transform our Data such that they are fit for the Smart Fields of the Future.

The Forum perceived that the majority of the technology required to create a Smart Field from an existing producing field already exists. Currently the biggest gap probably lies with the technologies associated with Real Time Reservoir Management. However, the Forum did identify seven areas where continued development of technology is either required or would be of benefit as follows:

- Automated Workflow Capture.
- Simplifying the Data Architecture.
- Real Time Reservoir Management - bringing together deterministic and probabilistic forecasting of reservoir and well performance.
- Development of Control Loops and associated Systems assigned to specific workflows.
- Development of Intelligent Agents for specific decisions within processes and workflow.
- Effective application of data mining technologies.
- Control Systems that do not overwhelm the operators in the event of an upset.

It became very apparent during the Forum that there is a high level of similarity in the work of the major operators and suppliers who appear to be at the forefront of developing and deploying Smart Fields. In principle there is the potential for substantial synergies by working together but it is probable that the perceived commercial benefits of being seen as an industry leader will inhibit this collaboration.

In order to align our industry behind a Smart Field future it is essential that we publicize our successes, failures and ideally also publish the value that is being generated through the development and deployment of these processes, workflows, toolkits and associated environments. Without this alignment the deployment will tend to be sporadic and the marketplace for the products which are at the core of the Smart Fields will develop more slowly.

Acknowledgements

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References

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Figure 1: SPE Smart Field Framework