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BP's FIELD OF THE FUTURE Program: Delivering Success

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Abstract

This paper details the progress made with the implementation of BP's FIELD OF THE FUTURE program over the past four years. It first describes the approach taken by BP to install real time data infrastructure in many sectors of its operations. To date this infrastructure has included the installation of 1800km of fibre optic cable, the registration of nearly two million real time data tags within a common real time data backbone, and construction of more than twenty Advanced Collaborative Environments supporting production and drilling operations.

The paper then describes some of the activities underway in BP's operations, and the associated benefits, including:

- use of advanced well monitoring technology to manage sand production and other aspects of well performance in 20 fields (1-3% production benefit)
- examples of full field optimisation/visualisation and associated benefits (1-2% production benefit)
- the development of a new downhole flow control capability for high rate sand prone wells (resource/reserve benefit)
- early experience with the application of temperature profile monitoring and of life of field seismic (resource/reserve benefit)

Finally, the paper describes the people, process and organisation activity undertaken in several of BP's large operating areas which have directly impacted many of the operational staff working in these areas through an extensive set of change management workshops and similar activity.

The lessons learned from these activities over the past four years include the need to:

- define support and maintenance resources up front
- identify and standardize infrastructure requirements for new projects
- take a centralized global approach to planning deployment but a local approach to implementation
- fully resource change management activity

1. Background to BP's FIELD OF THE FUTURE Program

BP's FIELD OF THE FUTURE program (Ref 1) was established in 2003 with an initial focus on engagement and deployment, the objective being to deploy core technologies in a limited number of assets in order to build a track record, to re-affirm the prize and to build a technical and architectural foundation for subsequent 'bigger moves'.

These early deployments, conducted over the period from 2003 to 2005, confirmed the potential of the program to add significant value across a broad range of asset types.

Since that time the program has evolved to focus on the three areas, as described pictorially below in Figure 1. The common feature of most of the elements of the program is that they are related one way or another to real time data, and are aimed at high rate fields which form a significant part of BP’s current and future portfolios. BP is also working on high well count fields onshore in North America where cost effective solutions for optimization of gas well deliquification is the focus.

These and other technologies generally impact production, recovery or both. Over the next 10 years or so, it is expected that the program will contribute in excess of 1 billion barrels of recovery and 100 M/bd to BP’s E&P segment.

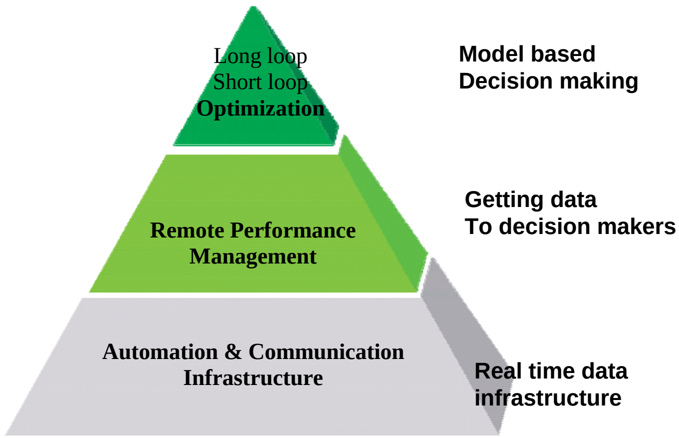

Figure 1

Automation and Communication Infrastructure

This area covers the entire infrastructure needed to equip a field to operate effectively with real time data, including telecommunications, the configuration of digital hardware and an integrated IT architecture including data storage standards. It also includes Advanced Collaborative Environments which are needed to connect decision makers to remote support teams. Requirements for each of these components have been defined in detail in order to provide for a standard approach in the new projects that BP is designing and bringing on stream in the near future. A major contributor to successful adoption has been the inclusion of these elements in BP’s Major Projects Common Process.

Remote Performance Management

This area covers the technology and workflows needed to get data to decision-makers in a form that enables rapid decision making

Optimisation

This area covers the technologies and workflows (usually model based) needed for optimisation of wells and facilities (short loop) and of reservoirs/wells and facilities (long loop).

2. Automation and Communication Infrastructure

2.1 Real time Digital and Telecommunications infrastructure

The approach taken has been to define a common Real Time Digital and Telecommunications Infrastructure for use by every technology project. The work to define the common infrastructure has taken place as a planned activity alongside the development of specific FIELD OF THE FUTURE Technologies. This work involved close co-operation between technology and IT disciplines and has been achieved through an integrated team spanning both organisations within BP.

A common Real Time Digital and Telecommunications Infrastructure also embodies a common IT architecture that informs design decisions for each of the technologies BP is bringing on stream today and in the near future. This means each technology is not just a point solution to a particular requirement, but forms part of an integrated solution that interfaces and builds on one another as depicted in Figure 1.

Systems based on standard real time architecture are now deployed in five of BP's major operating areas, accounting for approximately 75% of BP's operated production. Globally BP now has the ability to access nearly two million real time data items, and to facilitate access to these data BP has installed approximately 1800 km of fibre over the past four years. A key enabling area is the maintenance of the highest digital security standards, in particular where there are interfaces with process control networks. This has required careful definition and forms part of the common approach that has been implemented.

A common infrastructure has been enhanced through use of a common real time data management, storage and visualization capability. This has enabled a number of important advantages:

- access from all parts of BP to each deployment making it possible to support the operation of the system from central locations
- the easy installation and maintenance of new capabilities designed and built by BP
- improved remote operational and technical support to BP's operations, which has led to improved utilization of scarce skills
- easier transfer of learnings about real time management of operations from one area to another

The Real Time Digital and Telecommunications Infrastructure now forms part of BP's Major Projects Common Process and is integral to new asset builds.

2.2 Collaborative Environments

Effective use of Advanced Collaborative Environments (ACE's) across BP is an important element in making the best use of the real time data infrastructure. Guided by a central design and implementation team, to date some 30 assets across BP have embraced the ACE concept covering wells, production and drilling operations. These ACE enabled assets are currently supporting almost 2 million b/d of production globally, and drilling strings in places as far apart as the North Sea and Indonesia. With adaptation to local circumstances a common set of guidelines has been used across all assets for ACE design, and project implementation.

One of the common challenges in this program has been the need to engage with operations staff in the early design and operation of the ACE projects (Ref's 2, 7, 8). This has involved a half-dozen business transformation programs across BP, a major exercise impacting hundreds of staff directly and indirectly. One of the principal effects of greater connectivity has been the extension and support of team-working across multiple installations and from field to office, bringing a deeper level of expert support to field operations when required.

The following examples illustrate how BP is extracting value from the global ACE program:

Production Operations: During the summer of 2007, one of BP's key assets in the North Sea utilised their ACE for the day to day management of their annual Turnaround (TAR). By housing the core TAR team (e.g. the TAR planner, manager and 3rd party specialist suppliers) in the ACE, the asset were able to provide dynamic first line, real time support to the operation. This involved supporting operations, equipment and planning from onshore in a collaborative, high technology environment. Specifically, the ACE facilities allowed better real time decision making by acting as a focal point for daily meetings, issue resolution and shared planning. It is estimated by the Field Operations Manager that the ACE brought the asset 'online' one day earlier than would have happened without the facility, equating to circa $1.5m in saved production.

Drilling: one 2007 drilling program has saved up to five drilling days per well, thanks to faster and better informed collaborative decision making, another has reduced NPT by approximately 2% and saved up to 3% from base cost. Collaboration and access to expert advice has a direct positive impact on consistency of performance.

3. Remote Performance Management

3.1 Remote Performance Management - Wells

BP has deployed a common real time data management and visualisation system in the majority of its high rate fields. This system enables remote monitoring of bottom hole and surface conditions in individual wells in real time from any point on the BP network.

BP has also deployed a real time well performance management tool called ISIS (Integrated Surveillance Information System – Ref 5) on 20 of these fields,. This tool, developed by BP, is fully integrated with the real time data management system referred to above and has several unique capabilities including the ability to accurately estimate a well's production rate and phase in near real time using new modelling methods. This 'virtual flowmeter' is demonstrating the potential to improve well management efficiency (leading to higher production), surveillance (leading to improved recovery) and staff productivity.

The approximate % production and other benefits seen so far through the use of this tool, and the underlying real time monitoring capability, include:

- Better management of sand production in high rate production wells, specifically
  - Faster bean-up times achieved on start-up of sand prone wells (1%)
  - Faster turn around of sand prone wells following plant trips (1-2%)
  - Operating sand prone wells closer to their sanding limit (1%)
- Improved surveillance of individual wells, specifically
  - Production allocation errors reduced to < 3%
  - Watercut changes identified in near real time
  - Improved trending of reservoir pressures
- Streamlining of surveillance workflows, specifically
  - Uplift in staff productivity of up to 25%

3.2 Remote performance Management – Facilities

BP has also installed a companion system D2D (Data to Desktop), for monitoring surface facilities in these fields. This system benefits from a set of standard screens and product applications designed by BP to facilitate effective use of the real time data streams.

To date, documented benefits exceed 2% of asset production on average, and specific examples, along with % production benefit, include:

- Rapid identification of hydrate problems in a gas pipeline (1%)
- Troubleshooting water injection system performance (0.5%)
- Control loop tuning to optimise remote field tie-in (1-2%)

Further capabilities to support operational efficiency are being built and will be deployed in 2008/2009.

4. Optimisation

4.1 Optimisation – Short loop

BP has piloted a new approach to optimisation called which explores the full ranges of operational envelopes in order to identify optimal operating and accompanying control strategies, especially in subsea fields with complex gathering systems (Ref 3).

Results have been very encouraging with demonstrated benefits of 1-2% of base production in three fields, with a fourth field about to start intensively using advanced optimisation methods.

Specific examples of benefits in subsea fields include:

- Better management of riser stability (1-2%)
- Improved gaslift management (0.5%)

A very important enabler of this success has been the ability to couple the optimisation models with up to date , accurate estimates of well flow rate using the ISIS 'virtual flowmeter' referred to above.

4.2 Optimisation – Long loop

In this section of the paper we will cover technologies which mainly impact recovery.

4.2.1 Intelligent Wells

One of the technologies in this area is Intelligent Wells. The ultimate aim of this area of technology is to develop the capability to measure and manage flows in stacked reservoirs at the zonal level.

In the measurement area BP has actively applied Temperature Profile Monitoring technology. Here, temperature data are acquired along wellbores completed in multiple reservoirs and used to infer production/injection rates for improved voidage management both areally and zonally, and to inform improved well placement strategies. To date, installations in BP (which include the first deployment of a fibre based system in an open hole gravel pack completion) have monitored approximately 20 million barrels of production from stacked reservoir systems and more installations are planned. Inflow profiles from these installations have been verified with production logs and have given valuable information about zonal conformance and depletion mechanisms (Ref 9). During this program, significant challenges associated with the installation of these complex systems have been addressed and are being overcome.

An example of the application of Temperature Profile Monitoring for determining inflow distribution is given in Figure 2. The measured production temperature profile for the well was modelled to determine the best-fit production contribution from three reservoir intervals. In this case, the analysis shows the majority of production coming from the upper reservoir, with relatively little production coming from the middle reservoir. The measured DTS (Distributed Temperature Sensing) profile was used to determine the best-fit inflow distribution across three productive zones.

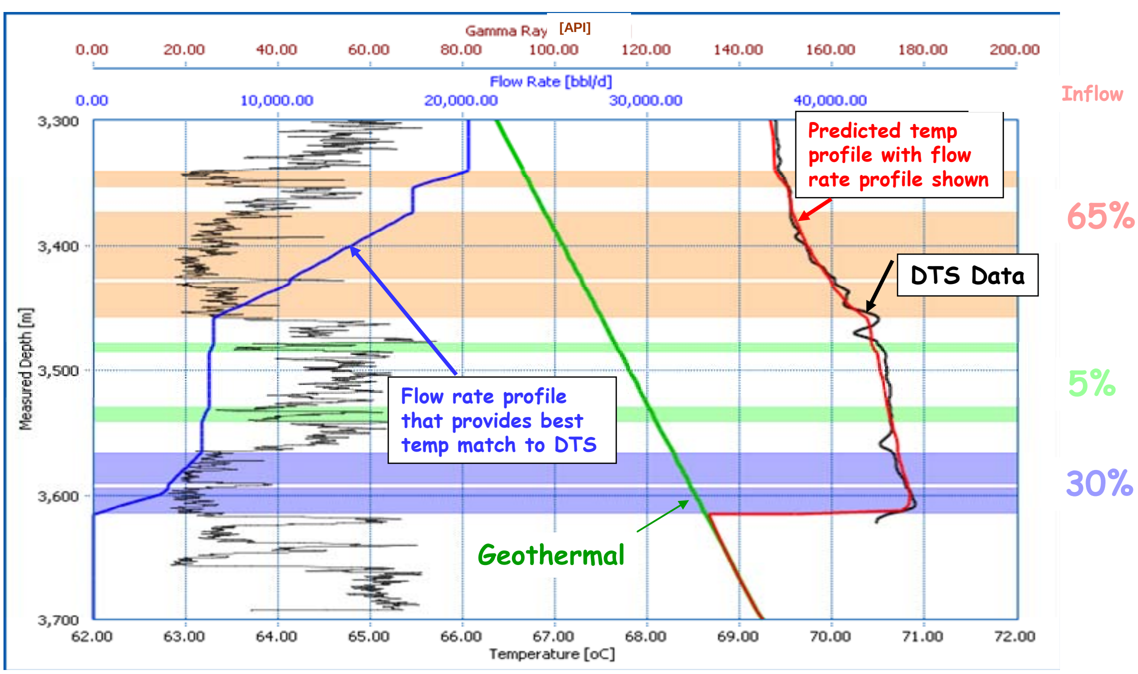

Figure 2. Application of Temperature Profile Monitoring.

Intelligent Wells also help manage flow via downhole control. BP currently has approximately 70 Mb/d of production and 40 Mb/d of injection through downhole flow control. Looking ahead to the future, BP has identified the need for a new capability for managing zonal injection in sand prone wells, and has worked with the market place to develop this capability. A prototype tool was successfully developed and tested and was installed recently in a high rate injection well. Its more widespread deployment is expected to impact recovery from stacked reservoirs under waterflood. In the next three years BP expects the injection volume to be controlled by this and other forms of downhole flow control to increase to nearly 1 million b/d, and the equivalent figure for production to grow to nearly 500 Mb/d.

4.2.2 Life of Field Seismic

A second area of focus for improving recovery is Life of Field Seismic (LoFS). Permanent seismic imaging and monitoring systems are an important and growing part of the seismic surveillance technology portfolio, and offer the opportunity for high quality, consistent and frequent "seismic-on-demand" 4-D images over the life of a field. BP has now deployed the world’s first three field-scale marine systems (Refs 6,10).

What LoFS has in common with the real time data systems discussed above is that it represents a step change in data acquisition frequency and volume. The combination of greatly enhanced capabilities for acquiring well and seismic data offers the possibility of significantly reducing reservoir uncertainty, particularly early in field life. However, the challenges of integrating these data streams and of using them to improve the quality of reservoir prediction are formidable . Some of the steps being taken by BP in this area are discussed in the next section of this paper.

The concept of permanent ocean bottom cable (OBC) monitoring, first tested with the successful Foinaven Active Reservoir Monitoring (FARM) hydrophone only seabed cable installation and shooting between 1995 and 1998, was extended to that of permanent 4C OBC monitoring.

Also, despite the overwhelming success of towed streamer 4-D surveys acquired every few years in many fields, it was apparent that some fields would require the step change in seismic imaging and/or repeatability of 4-D that permanent cables could potentially deliver in order to realise the same 4-D benefits that other fields had enjoyed.

These possibilities were first tested in full with the groundbreaking Valhall Life-of-Field-Seismic (LoFS) system installed in 2003, and acquiring between one and three surveys a year since. Following encouraging signs of success at Valhall, further initial pilot systems have now been deployed in 2006/07 over the North Sea Clair field (trenched OBC) and over the ACG complex in Azerbaijan (re-deployable OBC).

Valhall "Life-of-Field Seismic" permanent OBC system:

Installation and early use of the Valhall "Life-of-Field-Seismic" seismic system from 2003, as the world's first at-scale permanent OBC monitoring set-up is now well-known and well-documented.

Interpretation of the first few years of surveys, prior to commencement of water-flood, show clear and highly usable images that map out the effect of primary depletion around production wells. The high quality and consistent 3-D and 4-D images lead to higher confidence in anomaly interpretation. Reservoir changes on a ~3-6mth timeframe are clearly visible and overall the data is having a significant impact on field management and development including optimising well-work, new well planning and longer term reservoir management

ACG re-deployable OBC system:

Also in 2006 and into 2007, a novel OBC system with re-deployable cables was installed over the Azeri and Chirag fields, and initial surveys are being acquired. This initial installation, although still considered a pilot for this world-class set of oilfields under early production and expected future water-flood and gas injection, is in fact the largest re-deployable OBC system in the world, using 120km of cable. Analysis of the data quality and impact of early surveys will be used to determine ongoing deployment tactics and timing.

Clair "Life-of-Field Seismic" permanent OBC system:

In 2006 a small permanent trenched seabed receiver array of 40km cable covering ~13km2 was installed over the core Clair development area, and an initial survey acquired. Ongoing surveys are expected to deliver high-quality 3-D and 4-D OBC images of this complex, moderate porosity, fractured Devono-Carboniferous reservoir under early production and water-flood. Experience with conventional ocean-bottom cable acquisition on the Clair field has already shown significant improvements in 3D imaging and that azimuthal seismic attributes are useful in fracture characterization. Other benefits to the Clair field of the permanent system include improved 3-D resolution as a result of having the cables buried in the seabed and passive monitoring of micro-seismicity in the reservoir caused by production depletion and water injection.

4.2.3 Reservoir Modelling

BP is working to leverage its Top Down Reservoir Modelling capability through coupling it with real time surveillance data. Areas of focus include:

- Reduced model cycle time through automation of data handling and manipulation steps in the preparation of simulator input. Pilot work in one field has demonstrated the possibility of improving staff efficiency in this area by eliminating 2-3 days of reservoir engineering time from each modeling cycle, enabling models to be updated with actual production data on a 6-week basis.

- Improved reservoir characterization through adoption of data analytic techniques to mine the wealth of real-time surveillance data for inter-well reservoir insight

- Automation of traditional reservoir performance analysis techniques such as pressure build up analysis

Each of these areas is strongly enabled by the near real time ‘virtual flowmeter’ provided by ISIS referred to earlier.

Activities to streamline the integration of other forms of data, such as the LoFS data described above, are also underway.

5. Business Transformation Activity

Most of the technologies described above seek to move real time and other operations data to remote sites for analysis, enabling informed and faster intervention decisions. Such changes can be very profound for the asset teams impacted. Realizing the value from such technology investments is not automatic, and requires an integrated approach to technology insertion that holistically addresses diverse issues of technology installation, stakeholder engagement and alignment, business process change, roles and skills as a managed project. We refer to this type of integrated approach applied to digital oil field developments as business transformation, which was described in outline in Ref 4.

Within the FIELD OF THE FUTURE business transformation program, adoption success is based on the consistent application of tools to assure:

- stakeholder identification and engagement
- clarity of expectations of staff during and after the implementation project
- deep understanding of how work will change through process walkthroughs to clarify roles and their interactions
- identification of risks to adoption, and potential mitigations
- understanding between concurrent initiatives that will impact the same team members
- clarity of a specific team’s readiness for change

Our approach was initially refined and validated on a successful project related to value realization from ISIS in a single asset, which delivered significant financial benefits and surveillance staff efficiency gains of up to 25% through enabling the sustainable uptake and use of the technology.

Subsequently, the approach has been applied to several more assets, where projects are currently running. These include a major regional multi-asset project in the North Sea, a new field start up in West Africa, and application to a different technology in the Caspian region.

6. Deployment Activity

To address the challenges of deployment, BP has developed and resourced a deployment model which specifically addresses the following key success factors (Ref 11):

- Productization
- Deployment project integration
- Engagement and communications
- Technical systems integration, global standards application, and designing into new projects
- Applications and Technical User Support
- Business Transformation

Productization: An important first step in the process, which has received particular attention, is to do with the productisation of new products. This refers to the process by which they need to be demonstrated to be fully tested, and the support systems associated with them fully developed, prior to deployment.

Deployment project integration: BP has created an integrated FIELD OF THE FUTURE delivery team including most of the elements of technology development and deployment associated with the concerned technical, digital and supply chain disciplines, with a single point of accountability for delivery. This team has undertaken the deployment of all the digital related aspects of BP's Field of the Future program.

Engagement and communications: this has to take place effectively throughout the project. Such a complex activity means that many stakeholders need to be kept appropriately informed and involved for projects to stay on track.

Another key success factor has been the establishment of the post of FIELD OF THE FUTURE manager in most of the targeted BP operating areas. These individuals, who report through the line of the operating units, have played a key role in delivering the programs into the operating areas. In particular they have developed strategies for implementing Field of the Future in each of the operating areas, ensured consistent application of the each of the technologies in these areas and secured local management support for this activity.

Technical systems integration and global standards application: without a consistent and controlled underlying infrastructure, global deployment of technology becomes very difficult to manage. Initially, FIELD OF THE FUTURE technologies have been deployed to existing assets. As the success has been established, BP has moved on to implement the technologies on assets that are just coming into production and there have been some notable successes where new fields have come on stream with well surveillance and other features of FIELD OF THE FUTURE from first oil or gas. However, because these new assets have been in the project phase for a number of years, the implementation of FIELD OF THE FUTURE technology has in some cases been been retro-fitted rather than being an inherent part of the design.

However, with the clear benefits now visible at a segment level, there is a drive to ensure that all new major projects include provision for FIELD OF THE FUTURE technology in the scope and design of the project from the outset. BP's Major Project Common Process has been recently revised and now includes clear expectations on the project teams to ensure that they have identified the appropriate FIELD OF THE FUTURE technologies and included them in the project scope.

To assist Major Projects, the FIELD OF THE FUTURE team has developed a series of blueprints which document best practice guidance on design and implementation, and applicable IT and other system standards, particularly in relation to the infrastructure requirements. Guidance has also been produced to support the Major Project assurance process during various reviews in the Front End Loading stage. With these processes and guidance in place, it becomes much easier for Major Project teams and their contractors to build assets that fully exploit the FIELD OF THE FUTURE technologies from first oil or gas and throughout their entire lifecycle. Existing assets undergoing refitting can also utilise this information to ensure compliance with standards and bst practice.

Applications and Technical User Support: BP has established a global applications support team for FIELD OF THE FUTURE applications, and also resources the technical user support centrally through the early stages of uptake, until the user communities become self sustaining.

Business Transformation: The final key activity is to ensure focus on and support for ultimate value delivery, by enabling assets to adopt the necessary changes to their key business processes, as described in Section 5.

7. Conclusions

BP's FIELD OF THE FUTURE program has evolved from a collection of related activities to a fully integrated program that is delivering real results in terms of production and recovery benefits.

Along the way, the program has had to overcome a number of challenges - around the intent of the program, its value, and how this value will be delivered.

The enduring theme of the program is one of integration of activities that relate to real time data, whether reservoir or wells, operations or facilities, technical or digital, development or deployment, central team or asset team.

The journey is a long one and has only just begun. It is expected that the program will continue to make a contribution to BP's E&P business for years to come.

Some of the lessons already learned include the need to:

- Define support and maintenance resources for new products well ahead of deployment, so that users are fully supported from the time they take them
- Identify and standardize infrastructure requirements for new projects. This has been a key factor in enabling successful application of new real time products from the moment of first oil/gas.
- Take a centralized approach to planning deployment but a local approach to implementation – this in turn relies on excellent connectivity between central teams and asset teams. This has generally been achieved through extensive dialogue, generous listening and careful planning.
- Fully resource change management activity. This cannot be underestimated. Approximately 30% of the central team's resources have been assdociated with this activity.

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