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FIELD OF THE FUTURE Digital Infrastructure and IT Architecture

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Abstract

In order to successfully generate benefits from programmes such as BP's FIELD OF THE FUTURE, the supporting IT architecture and connectivity must meet the specific needs and challenges of the digital oil field. Developing IT architecture that can be efficiently deployable at scale across a global and dynamic organization is fundamental. BP has extensive experience in researching and deploying large scale IT architecture for the digital oil field.

This paper will discuss, and illustrate with examples:

- BP's approach to Field Digital Infrastructure and respective implementation, focused on high bandwidth connectivity, low latency and high availability, in order to address the increasing data requirements of programmes such as BP's Advance Collaborative Environments (ACE).
- BP’s experience in deploying over 1,800km of fibre in regions around the world, including Azerbaijan, North Sea, Gulf of Mexico, Alaska and with additional hydrocarbon basins being actively planned.
- How standardization is playing a key role in BP’s deployment activity and allowing the FIELD OF THE FUTURE programme to happen at scale and at pace.
- Digital security challenges that need to be overcome as process control and the corporate network meet to allow free data flow
- The important role Service Orientated Architecture plays in BP.
- BP’s active commitment to promote and support the development of industry standards such as PRODML and WITSML
- How IT disciplines and technology developers have worked together during the creation, design, implementation and operation of BP’s FIELD OF THE FUTURE programme

Introduction

Over the past five years BP’s IT group and technology developers have been collaborating on the FIELD OF THE FUTURE programme. The close interaction between these two areas has delivered significant benefits and is now considered a key success factor to successful implementation, both specifically to BP or any similar programme.

The challenges that need to be overcome in order to deliver successful digital oil field technology are numerous, varied and extend far beyond turning a good idea into a one-off prototype. In BP, the challenge is not to just create innovative ideas, but a foundation on which to take technology to operating assets at both scale and pace in a sustainable manner. To do this it has been essential to consider the ‘end game’ from the outset.

At an early stage, this led us to consider:

- IT infrastructure necessary to support the deployed technology.
- Common IT architecture to allow component integration.
- The methodology in which technology is developed and, once installed, how to support globally deployed solutions.

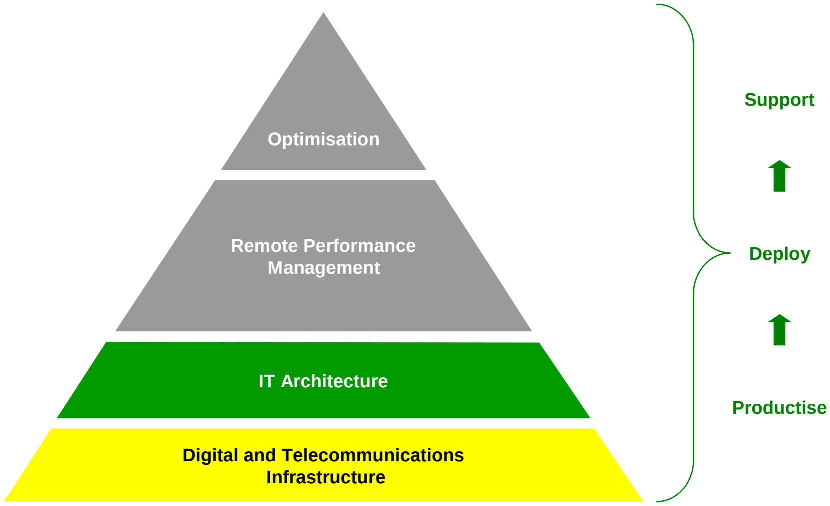


Figure 1 – The Field of the Future Framework

The FIELD OF THE FUTURE framework (figure 1) illustrates the points above, demonstrating how each element builds upon the foundation for robust and sustainable technology solutions. Having the necessary IT infrastructure helps to ensure the required performance and reliability will be achieved. As these can be long lead time items, careful analysis and planning is essential to get this aspect right. With a holistic and planned IT architecture, technology; which might initially be prototyped as a discrete item, can be integrated to create higher valued solutions. With this in mind BP has adopted a Service Orientated Architecture (SOA) approach to achieve this. Prior to deployment all technology is 'productized' to ensure it is robust and can be deployed repeatedly. While this is not a new idea, it is frequently overlooked and may frustrate later attempts to scale up deployments of any solution. Finally, it is essential that the solutions are sustainable and supported in a manner that will allow value maximization. This is particularly true at a worldwide deployment level, where synergy at a global level is required. The paper will now consider each of these areas.

Digital Infrastructure

Digital infrastructure encompasses many different IT technologies including servers, desktop computers, local area networks and wide area networks, as well as user systems such as telephones, video conferencing, surveillance video, security and safety systems. Within these systems connectivity, or specifically the transport layer of the wide area network, is one of the most critical systems to properly engineer and construct, given the difficulty to make large capital changes in later stages of a facilities' lifecycle. In addition, connectivity provides services to every digital system, including the FIELD OF THE FUTURE programme, safety, enterprise backbone and document management, all of which must cross from the field to some other location. All of these systems have performance needs that can be expressed in terms of bandwidth, latency and reliability.

Limited bandwidth has always been viewed as a constraint in developing and deploying new digital systems within BP. While everyone agreed high bandwidth, low latency, reliability and security were required, consistent definition was lacking. As a result, projects made individual decisions based on their own interpretations of current and future requirements.

In 2004, BP's Field Digital Infrastructure team defined a blueprint to use when selecting connectivity solutions for major production assets interested in FIELD OF THE FUTURE technologies. The purpose of this blueprint was to define minimum connectivity needs for BP, based on experience, speculation and additional research, including human factors. Further analysis revealed that the blueprint needed to address the needs of all digital systems and not just one area of interest. The blueprint's scope was expanded from FIELD OF THE FUTURE technologies to also meet the needs of enterprise traffic, voice and video services, morale systems and operational safety requirements.

Table 1 below was created on the back of this review of performance requirements, which for the first time began to define high bandwidth to BP. In developing this table additional observations were made. Firstly, low level application usage was analysed versus end user processes. This is because it was determined that users would develop new ways of working which would integrate various traffic types, such as web browsing with webcam video. How applications were used defined actual requirements, rather than just a list of those applications.

The next step discussed how peak performance was more critical then long term average utilization. In order for ACE to be successful, remote and local personnel need to see the same data. This required real-time data transfer, rather than synchronization in batch uploads every 15-30 minutes. As a result, a key component of table 1 was to describe the expected performance level.

Traffic Type and Possible Use	**Fully Used Today**	Future Capacity/ Session	Future Qty. of Sessions	Performance Description/Benefit	Capacity Range
Telephone Call	Yes	32kbps	24	Higher fidelity and better data/fax capability	0.75Mbps
Standard Room Based Video	Limited	600kbps	3	Clearer motion and greater detail	1.2Mbps
High Quality Video Conference – Collaboration Room	No	3Mbps	1	Near HDTV quality	3Mbps
Personal Video – Wearable video	No	300kbps	4	Ability to support at low frame rate.	1.2Mbps
Video Surveillance (scan mode) – CCTV for security/process	No	300kbps	10	Capable of identifying motion or patter detection	3Mbps
Video Surveillance (Monitoring)	No	2Mbps	3	Fine detail analysis	6Mbps
Email per 20 users	Limited	2Mbps	2	Near LAN like access with onshore servers	4Mbps
Thick Client Applications for 20 users – e.g. Work/Document/Safety	Limited	10Mbps	2	Download a 1Mbyte file in 3-5 seconds from onshore	20Mbps
150,000 data points moved to Historian	Limited	2Mbps	1	Synchronize points within 1-2 seconds of acquisition	2.0Mbps
Offline server synchronization and backup	Limited	2Mbps	2	Move 2 Gigabytes in 4 hour window	4.0Mbps
Web Based Applications/15 users5	Limited	2Mbps	2	Web page (100k) raised in 1-2 seconds	4Mbps
Remote Control	No	1Mbps	1	Ensures adequate capacity to move change commands	1Mbps
Distributed Temperature Sensors (DTS)	No	1Mbps	5	5 minutes samplings synchronized within 10 seconds. Multiple samples can work within same capacity due to sampling delays.	5Mbps
Life of Field Seismic	No	50Mbpss	1	Not included in analysis	n/a
Nominal Bandwidth Requirement					~50Mbps

Table 1 – What is High Bandwidth

Finally, as shown in Figure 2, video based traffic, whether it be used for meeting room collaboration, surveillance or field assistance, was identified as the largest area of growth in bandwidth utilization. This growth would be seen in the number of parallel sessions occurring, as video conferencing and webcams become predominant, Furthermore a the desire for higher quality such as high definition would push the video streams from 500k to 3,000kbps or a 6x increase.

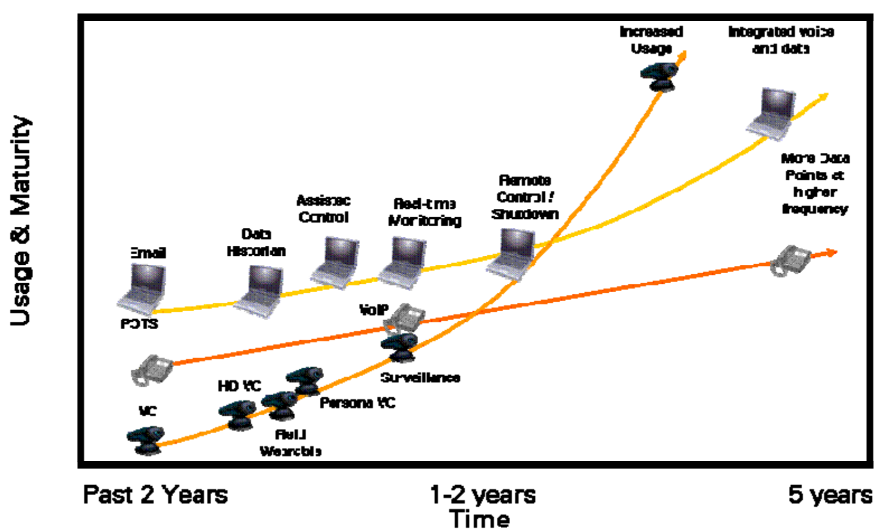


Figure 2 – Demand for Bandwidth

In addition, latency requirements were examined, given that application performance is highly driven by latency or round trip propagation of data signals. By looking at technologies such as VoIP and lightly examining human factor requirements around frustration and error rates, a basis for latency showed it needed to be sub 200 milliseconds (ms) with a preference for much less then 100 ms. To minimize the impact on specific collaboration events and highly sensitive data flows, consistent quality of service was required.

Through all of this, BP has summarized the definition of high bandwidth, low latency and reliability as follows:

- Bandwidth of 50 mbps with long term needs exceeding 155 mbps.
- Round trip delay of less then 200 milliseconds (ms) with a preference for 50 ms or less.
- Prioritization of data based on application and criticality.
- No Single Point of Failure and an alternate channel in case of a catastrophic failure.
- Segregation of data as defined by BP Digital Security Standards.

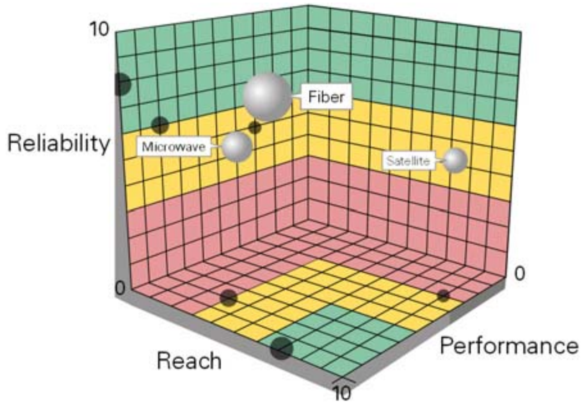
Given this technical definition for connectivity it became time to identify a technology strategy. BP looked at several different aspects of the environments where production occurs and may occur. The evaluation revealed there was no single solution capable of meeting needs as well as being financially responsible. While fibre could meet the needs and could reach anywhere, it would be difficult to deploy in some very remote areas or in onshore environments with hundred or thousands of points of presence, such as North America Gas.

BP's experience with communications technology focused around using satellite in offshore, microwave, fibre and trials with other newer technologies such as Wimax or equivalent. Table 2 demonstrates some of these experiences.

Technology	Experience Based on	Limitations
Satellite	Nearly every potential situation both onshore and offshore	Low bandwidth and high latency
Microwave	Offshore: • Gulf of Mexico continental shelf • Trinidad • North Sea tail circuits on fibre • West Java Onshore: • North America Gas • North Slope • Pakistan	Offshore often requires multiple hops (~40km's) across platforms to reach the more distant platforms.
Fibre	BP Owned: • North Sea - UK • Caspian BP Leased • North Sea – Norway • Onshore locations around the world	High capital cost Systems were all subsea passive (non repeatered) Limited oil and gas industry experience with large fibre Limited telecomm industry experience with Oil & Gas fibre

Table 2 – Comparison of communications technology

Figure 3 summarizes how these technologies compare against each other and demonstrate the basis for the preference for fibre where feasibly possible. However, just saying fibre was not enough; there was a need to understand how to best engineer, acquire and deploy this same fibre. Based on this, a strategy was developed and continuously evolves from learnings in each project. This strategy is underpinned by the following principles:



- Fibre is operational in a timeline consistent with the business.
- Deliver day to day reliability and user confidence.
- Long term access to unlimited capacity at decreasing unit rates.
- Global approach to ensure functional excellence.
- Implementation of basin wide solutions flexible to change.

Figure 3

Following the selection of fibre as preferred technology, BP has evolved the way fibre is deployed within different basins. The original 200km North Sea system (6 platforms connected) was done as a trial. New installations in Gulf of Mexico (1,300km consists of five existing platforms and two under construction), the Caspian Sea (400 km loop with six platforms) and North Sea West of Shetlands (twp new platforms) are viewed as strategic implementations.

Each time a system is deployed, new lessons are learned and best practices are being logged into BP's Engineering Technical Practices for the engineering and construction of subsea fibre systems. Some of the more predominant practices being used on future systems include:

- Use of subsea repeatered cables to eliminate inter-platform dependencies for power.
- Use of a loop with dual landings and significant separation to prevent a single weather event (e.g. Hurricane) from taking out the entire system.
- Dark fibre access, so electronics can be upgraded at a later date to give higher capacity or multiple wavelengths, can be used to give 10 gaps of capacity to each platform.
- Complete desktop studies and cable protection studies to determine ideal routes and burial methodology to minimize cable damage risk.
- Use telecom companies as primary contractor and supplement with oil and gas subcontractors as required.
- Lease backhaul circuits from established carriers and tie into local data centres
- Use multi-function umbilical with fibre and wet mate connectors when possible versus dedicated fibre risers.
- Minimize the running of fibre parallel to pipelines.
- Heavy involvement from Sup's marine and subsea teams for planning, safety and engineering reviews.

Where there are established providers with established solutions, BP will consider purchasing capacity off these systems, as being done in the North Sea. In the event that no such providers are available, BP will directly take on the capital project to build and operate the system.

Once systems are implemented, BP is typically working with subsea telecom cable maintenance organizations to do the "wet plant" maintenance. Dry plant and electronics are being supported through standard field telecomm support organizations.

In areas such as Gulf of Mexico, where there are different operators distributed across a large basin, additional complexities during construction and long term maintenance include:

- Maintaining adequate documentation with marine authorities and survey companies to assist in educating other seabed users of congestion.
- Ensuring the cables are protected properly as new pipelines are installed and cross the fibre cable.
- Developing and maintaining a large repository of repair and change procedures to deal with the multitude of future maintenance scenarios.

To manage this, BP is developing internal expertise to act as a marine authority. In addition, this authority will be key in future developments of Engineering Technical Practices and peer assist to other SPU's as them embark on similar projects.

Service Orientated Architecture (SOA)

The FIELD OF THE FUTURE programme requires an IT Architecture of the Future (AotF). The AotF will enable the required business agility through the use of process based services. Service Oriented Architecture (SOA) is the AotF.

In BP’s view, SOA is a transformational approach to the design, implementation, and management of business solutions and technical infrastructure. SOA is more than technology. It’s an architectural style that creates new business applications through the intelligent ‘orchestration’ of discrete, reusable business functions called ‘services’(Figure 4), each of which performs a single, well-defined task (such as delivering real-time operating data or a well test).

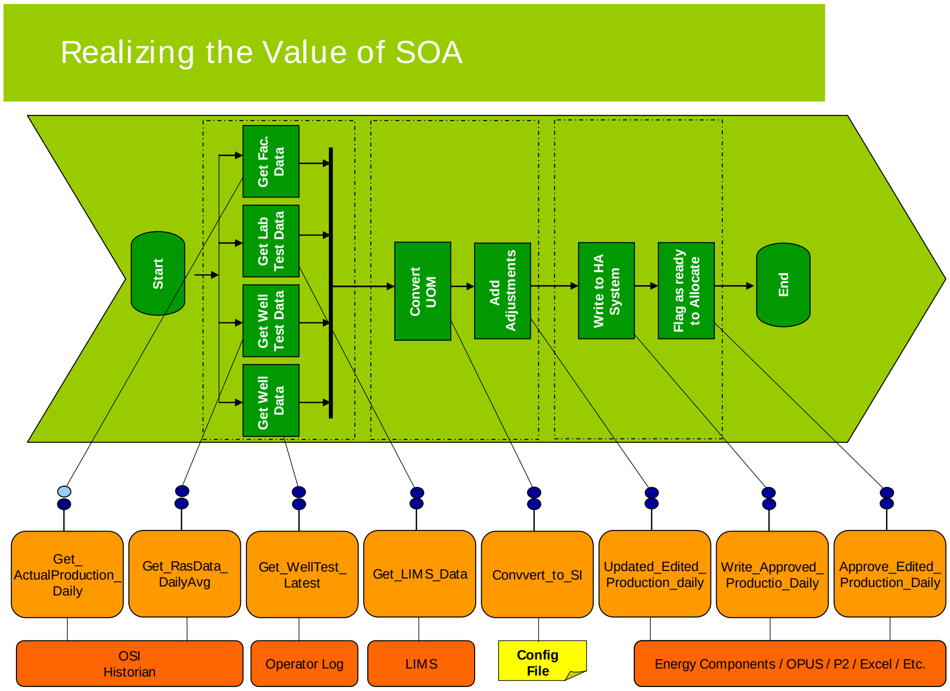


Figure 4 – Orchestrated Services example

Business solutions, in this new paradigm, are ‘composite applications’ consisting of standard services linked together with business logic and standard web service connections. Unlike traditional software applications, which reflect current (often outdated) processes, a suite of component services can be rapidly rearranged and-or extended to reflect new business strategies and evolving market conditions. Ultimately, an SOA environment will abstract the application engineering process to a higher level, requiring little or no programming, to adapt to changing business requirements.

In a conceptual model of SOA (Figure five), users of a composite business application leverage a common interface layer. This provides access to standard business process modelling and orchestration tools, a common set of generic SOA functions (including security, management, and governance of services) and a repository of specific business services they can work with. This includes component services provided by external vendors, and legacy internal applications “wrapped” with a standard interface to look and act like any other service.

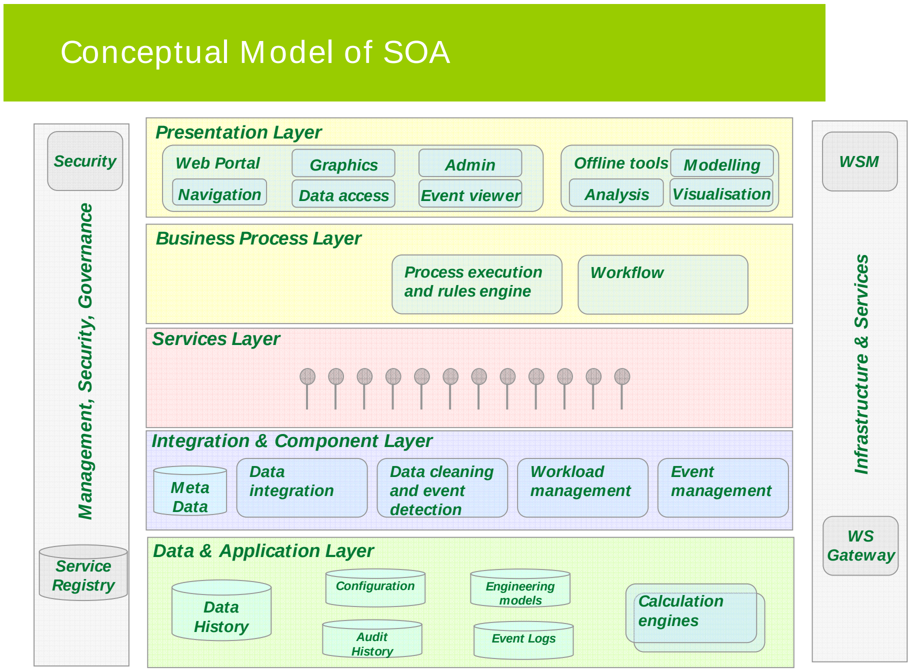


Figure 5 – Conceptual Model

Unlike the project-centric approach of simple web services and conventional application solutions, a successful SOA strategy requires corporate investment in common infrastructure components and the definition and operation of relevant governance processes to encourage and reward both the development and reuse of services and processes across the organization.

Global web interface standards are used, where possible, to address interoperability between services and maximize options for changing out products. The applicable standards come primarily from the World Wide Web Consortium (W3C) and Oasis. Where IT standards are incomplete or immature, we must choose to develop proprietary solutions or work to develop and promote a standard within the upstream oil & gas industry. Examples of industry interoperability efforts BP has chosen to take a lead role include PRODML, WITSML, and web service interoperability.

A major point worth underscoring is that SOA will eventually alter the historical relationship between IT and the operating units, making the implementation of solutions more of a partnership between business and IT rather than the traditional model where requirements are 'thrown over the fence' to be implemented by the technologists. With this approach, business users who are not programmers can sit down with IT staff and collaboratively develop the composite applications they need to run their business more efficiently and competitively. SOA methodology requires that the business users take ownership for the business process and the change management of that process, thereby maintaining direct control of their IT spend. The IT organization, in turn, provides the common services and the relevant infrastructure necessary to increasingly automate the business process. IT, therefore, becomes more of an accelerator of business change, rather than a supplier or, as is often seen, an impediment.

SOA changes the fundamental relationship between the business and IT and, if that relationship is not addressed, much of the true value of SOA will not be realized. Therefore, a comprehensive engagement and education effort, supporting a governance process that fits with the organization's culture, is a key to the success of an enterprise-level SOA programme.

Within BP's FIELD OF THE FUTURE ™ programme the opportunities provided by SOA were identified as a good fit to support the level of flexibility and requirements necessary to integrate and reuse components. BP's Digital and Communications Technology function has been proactively engaged with technology development teams to ensure a consistent and scaleable architecture across the whole programme. The FIELD OF THE FUTURE programme now has a defined architecture, based on SOA principles, that is at the centre of current and future developments. Technology programmes are being defined in terms of services to integrate specific workflows. This process not only provides design clarity and future flexibility, it is also leading to efficiencies as common services are identified. The architecture has also contributed to establishing the use of a common set of IT components at the presentation layer as well as the data and application layer. This standardization supports another FIELD OF THE FUTURE programme goal of productization.

Productization

All FIELD OF THE FUTURE technologies are developed to make them deployable at scale and at pace and an approach known as productization has been adopted to achieve this. Having established common infrastructure and standards for IT architecture, the logical approach is to extend the same underlying philosophy to the way each technology is developed. The concepts supporting this are straightforward and would be the same as those seen in any commercial software package. The key objective is to avoid individual deployment customization, placing emphasis on 'configurable' deployable technology solutions. Once the technology research and trial phase has been successfully completed, the required solution is re-engineered to meet the broader requirements of global deployment. This not only means addressing configurability and quality, but ensuring the delivery of other aspects, such as installation and training material, as part of 'the package'. In this way each technology can be correctly deployed onto the common infrastructure, as well as the data and applications physical architecture. By there being no customization, there is minimal risk of technology not working with other FIELD OF THE FUTURE components when deployed in each specific Asset..

Deployment and Support

The principle goal of programmes like the FIELD OF THE FUTURE programme is to maximise benefits, by ensuring technology is delivered to multiple operational assets in an efficient and timely manner. Standardization is one key route to achieving this. The process by which technology is then deployed is described in more detail in the paper 'Pace and Scale Deployment of a Real‑Time Information System' (SPE 112118).

Successfully deploying technology is not the end of the road. Ensuring technology, and resulting sustainable benefits, is a necessary part of the process. The approach to standardization also applies here. This paper's focus is on the Digital Infrastructure and IT architecture, although the same approach has been adopted in BP for other aspects of support including technology products. For Digital Infrastructure, IT architecture, and second line product support, a global support model has been implemented, based on a globally linked team following the same process, and thereby providing support to all deployed solutions. This delivers a number of advantages such as the standardization achieved at deployment being maintained in operation. This not only makes support much easier but also allows the role out of problem fixes and enhancements at scale and pace. A second advantage, specifically for end users and translating into real value, is that knowledge sharing and best practice is positively facilitated as end users use identical and commonly deployed solutions.

Conclusion

Having a holistic approach to Digital Infrastructure and IT Architecture has enabled the FIELD OF THE FUTURE programme to achieve an integrated solution and go beyond what would otherwise be a set of smart but isolated point answers. Our experience of applying SOA has been proven to deliver the additional benefits of service reusability across individual technology projects and future flexibility from having transformed processes into services. Whilst this is at present still happening bottom up, the benefits are already resulting in a more top down approach, exemplified in the close working relationship between technology and IT disciplines within the FIELD OF THE FUTURE programme. The productization principle builds on standards developed for Digital Infrastructure and IT Architecture, further facilitating deployment at scale and pace. The theme of standardization then continues into when systems are operational, allowing more effective delivery of support and a more prompt roll out of enhancements, without site specific changes and users to exploit knowledge sharing and best practices. The timely and close involvement of IT and technology disciplines working together has been fundamental in realizing these achievements.

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