Digital Oilfield Ten Years On

Progress and Pain

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Table of Contents

1 Introduction

1.1 A Salutary Lesson

Back in the early 2000s, my company was working for one of the large oil and gas service providers. They were interested in developing technology that would facilitate collaboration among disciplinary teams, and reduce the friction and errors caused by the overly-formalised interchange of data between the groups. The facilities engineers, for example, were given a defined set of information from the reservoir engineers, but this often omitted information that later proved to be vital. It wasn't sufficient to simply extend the dataset that was exchanged, because where would that stop? Also, what was important for one asset might not be significant for another, and one group didn't understand clearly what the other might need.

We all believed that technology was the answer, and we set about investigating ways to link data together. My view was, and still is, that trying to create a single database to store all data was impractical and unnecessary, and what we needed to do was create an information bus that would allow us to aggregate information from heterogeneous data stores. By providing a shared information bus and knowledge repository, and discipline-specific tools, the information could be accessed as required, and updates would be shared seamlessly with the whole team.

As it turned out, the impact of these technology advances was limited, and the change that had the greatest impact was the accidental creation of a physical meeting space which could be used by people from different disciplines to discuss and share their ideas and challenges. In short, the greatest benefit accrued from people and communication rather than technology and process. Looking back, it was probably not important that the meeting space was physical, and web conferencing would have been equally valuable: the key point was the discussion that ensued.

This was a salutary lesson, and it is evident that it has been learned and re-learned by others before and since. A study of six major oil companies (Quaadgras & Edwards, 2013) highlights that organisational change, team working and coaching are as important, if not more, than technology. Whatever else this review might discuss, we believe people can deliver astonishing results with the most basic of tools, given the right motivation.

1.2 Context

In a 2012 survey carried out by Vodafone (Vodafone Group, 2013), 33 per cent of respondents reported they had no experience of a digital oilfield trial or pilot within their company. Further, the same study reported that 66 per cent of companies believed that they were not culturally prepared to adapt to the needs of the digital oilfield, and that the same percentage felt that a lack of knowledge or awareness of the digital oilfield was hindering cross-industry adoption. In the 2015 Digital Oil Outlook Report (JuneWarren-Nickle's Energy Group, 2015), 46% of respondents stated that they had insufficient subject matter expertise to comment on the value of the suggested digital oilfield use case scenarios.

This data is extremely disappointing, given that Digital Oilfield was one of the most promising initiatives of the last decade and a half, offering improvements in automation and integration that would deliver real value in cost savings and increased production. Unfortunately, it does not appear that much of this early promise has been realised across the industry, and the focus has sometimes been on technical innovation that is often disconnected from business benefit. Indeed, while the industry is ripe for transformation, Digital Oilfield has not been associated with a clear and unequivocal set of goals that could produce real and dramatic performance improvement. Further, despite substantial investment, the positive results that have been achieved have not been translated into a set of accessible best practices. In an entertaining presentation of the current situation, Crompton provides an overview of business process and technology transformation, and suggests that progress has stalled (Crompton, 2015). He even maps key digital oilfield technologies to the Gartner hype curve.

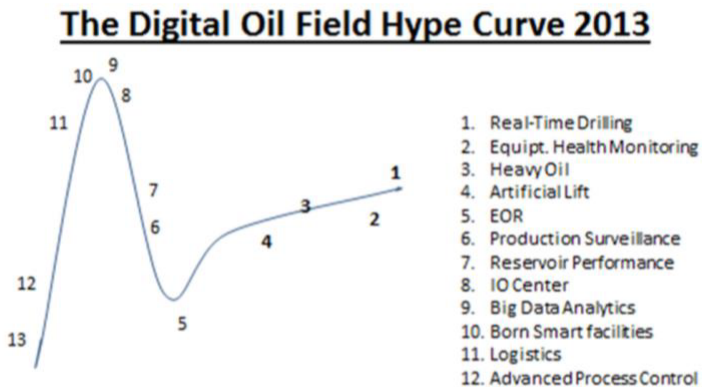


Figure 1 From (Crompton, 2015)

In this paper, we will review a selection of the published works on Digital Oilfield in the last decade, and considers progress in a number of fields. This includes the application areas, the benefits claimed, and any broader lessons. We will use the available data to attempt to identify areas where best practices can be identified, alongside the delivery of clearly defined benefits. In doing this work we have benefitted from a previous review of lessons learned and best practices, authored by representatives from service companies, operators, and academia (Saputelli , et al., 2013).

Based on this data, we attempt to identify the areas that should be the focus for the future, and where the greatest benefits will accrue, given the current context. We will also make recommendations regarding the changes required to ensure that progress is steady and that every company benefits.

1.3 What is Digital Oilfield?

Given the obvious confusion in the industry, it's worth beginning with a definition. Unfortunately, the digital oilfield is “a somewhat ill-defined, misunderstood and abstract concept.” (Cramer, et al., 2012) Further, it has been pointed out that “understanding the actual state of digital oil field implementation across a portfolio of projects and assets in a single operator, or across operators today, is almost impossible due to the lack of consistent definitions of what constitutes a digital oilfield.” (Feineman, 2014) A significant proportion of the literature is vendor-generated and tends to consider the problem in the context of that company's solutions. As an example, an exploration of the needs of the digital oilfield (Vodafone Group, 2013) places an emphasis on wireless technology, which is perhaps unsurprising given its authorship.

Petropedia (Petropedia Inc, 2016) defines it in terms of the use of advanced software and data analysis, and claims it is “the focusing of IT on improving the business drivers, which includes improving safety, optimizing production rate of hydrocarbons, environmental protection, finding reserves and exploiting them to the fullest."

Petrowiki (Petrowiki, 2015) concurs with the view that the core technologies are advanced software and data analysis, but astutely observes that the term "has been used to describe a wide variety of activities, and its definitions have encompassed an equally wide variety of tools, tasks, and disciplines." The article identifies six frequently recurring themes:

- Operational efficiency
- Production optimization
- Collaboration
- Decision support
- Data integration
- Workflow automation

However, they note that this is not a complete list. Most interestingly, they define the problem to be solved as one of responding to a higher cost, higher complexity environment with a workforce that is smaller and has less experience. We will return to this topic later in the paper.

In a similar vein, Cramer, et al., suggest that digital oilfield is likely to have an impact on four aspects of the business: personnel safety, environmental, productivity and financial (Cramer, et al., 2012). The authors provide examples of, and KPIs for, digital oilfield practices in these areas.

1.4 The Perceived Benefits

A majority of the publications reviewed for this paper highlighted the increased cost of production, the complexity of field development, and the so-called "great crew change" as drivers for digital oilfield. The chart below (Dutto, et al., 2015), demonstrates the level of challenge associated with the demographic profile of petrotechnical professionals (PTP).

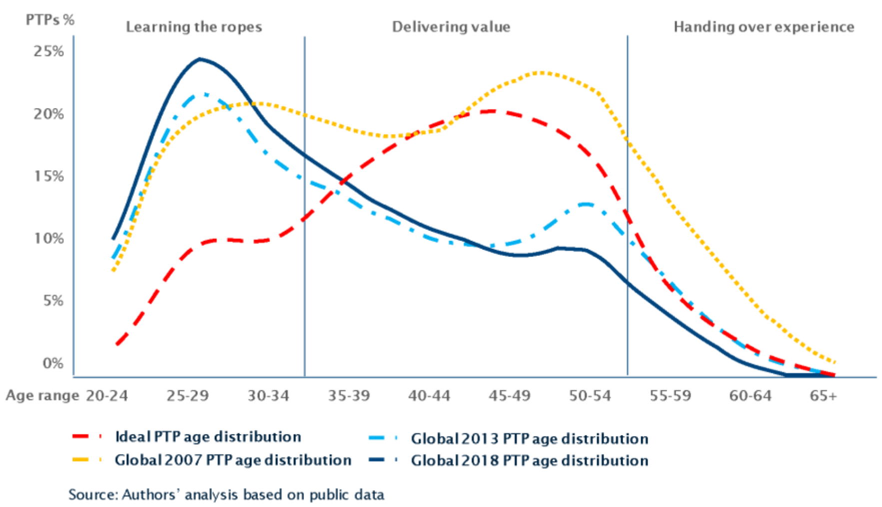
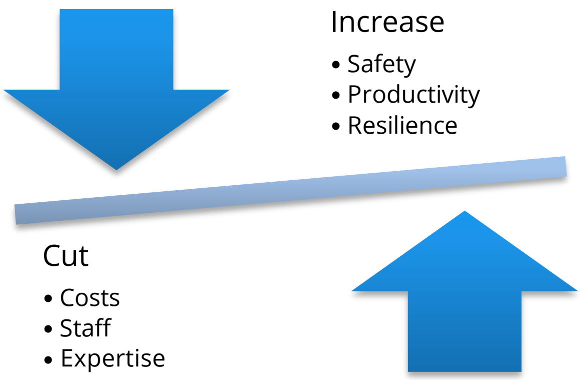


Figure 2 (Dutto, et al., 2015)

It might be argued that the current environment, with significant reductions in new development efforts, has mitigated those concerns. However, there is evidence (Control Engineering, 2015) that,

companies are actually dispensing with the services of their most expensive, and most experienced, staff. Whether these individuals will exit the industry, or potentially fill a skills gap reported by Middle East operators (Dutto, et al., 2015), is open for debate.



The key question is whether digital oilfield really does offer the tools to address this issue and, even if it does, whether it's possible for companies to understand and take advantage of the benefits? As we'll see, the larger operators are the source of the majority of publications, and the smaller independents are poorly represented. It may be that this reflects a different set of priorities, or an unwillingness to invest. It might also be that smaller companies are simply too busy to report their innovative solutions.

1.5 Barriers to Adoption

Among many reported issues, culture and resistance to change are most frequently cited as key barriers to adoption (Saputelli , et al., 2013). Indeed, it has been suggested that "the pace of change in the oil and gas industry is on the order of 15 to 20 years or more" (Davidson & Lochmann, 2012). Change management is key (Berger & Crompton, 2015; Ruvalcaba Velarde, 2015), but there is limited evidence that the industry is investing in the soft skills that would be required for any significant shift.

The need for organisational change to support implementations is described in several references, and it is argued that "the formation of a small, central empowered team is the most effective means of achieving the adoption of iE [intelligent energy] practices, principles and associated technologies in a multi-asset organisation." (Edwards, et al., 2013)

It is reasonable to assert that many companies find it difficult to be certain of the expected benefits of digital oilfield. This is compounded by uncertainties over ROI and aggregate value at the business portfolio or corporate strategy levels (Al-Mulhim, et al., 2013). The suggestion that digital oilfield programmes progress in five-year phases (Dickens, et al., 2012) implies a longer-term view than many might feel they can afford right now. Others have pointed out that it could be concluded that digital oilfield projects "move too slowly for the type of organisation that is delivering them, or alternatively, that there is too rapid a rotation cycle in the organisation for the type of change delivered by a typical [digital oilfield] project" (Gilman & Nordtvedt, 2014).

In addition, while a pilot might be considered a success, it is demonstrably difficult to scale this to a whole organisation (Davidson & Lochmann, 2012). Thus, claims of value delivery of over 70 mboed net production (Dickens, et al., 2012) are obviously appealing, but it is simply one data point. The challenges are broadly based, encompassing people, process and technology. Chevron have attempted to address this challenge by leveraging a central development approach that looks for common solutions across business units (Bourgeois, et al., 2015)

If programmes of the kind advanced by ADCO (Akoum & Mahjoub, 2013) are to find general applicability, the techniques and tools must be standardised and, to some degree, commoditised. In their paper, they lay out an architectural framework for business intelligence and data management based on Gartner's Business Analytics Framework. Much of what is presented appears to have been developed specifically to meet the needs of ADCO, and the extent to which the tools discussed could be applied elsewhere is unclear. Many companies do not have the skills that these authors suggest is required for success, at least for their application.

Finally, despite an assertion that "the number of cases history [sic] continue to rise exponentially" (Saputelli , et al., 2013), it is also noted that "many achieved benefits have become diluted in businessas-usual performance as digital automation becomes a normal way of business and is embedded in the asset."

2 Areas of Progress

2.1 Scope of This Review

As may be apparent from the definitions, the scope of digital oilfield solutions appears to be extremely broad. This makes it difficult to achieve a clear view of the rate of progress or of the current status of the industry. For example, to what extent should the efforts of an individual vendor to enhance the capabilities of their product be regarded as evidence of progress of digital oilfield? More fundamentally, is digital oilfield an industry initiative, with metrics for success based on overall industry performance, or should we celebrate one or two individual company success stories? And, if improvements are reported, can we be confident that they have been measured against an established baseline?

Some work has been done in this area (Reid, et al., 2012), and the authors emphasise that the "practice of measureable and subjective benchmarking is critical in defining the traditional baseline and in providing demonstrable proof of the performance gains" derived from digital oilfield initiatives. Undoubtedly, this exercise provides an estimate of the relative improvement in the performance of an asset or business, but it is more difficult to unequivocally attribute this change to the introduction of digital oilfield technologies. It is always best to be wary of the Hawthorne effect (Wikipedia, 2016).

Work on a maturity model for digital oilfield has also been reported (Feineman, 2014), despite the difficulties with comparisons described above. As with so many other areas of digital oilfield, this is an interesting discussion of the challenges associated with generating such a model, as much as a description of best practice. Nonetheless, the paper proposes the maturity assessment concept below.

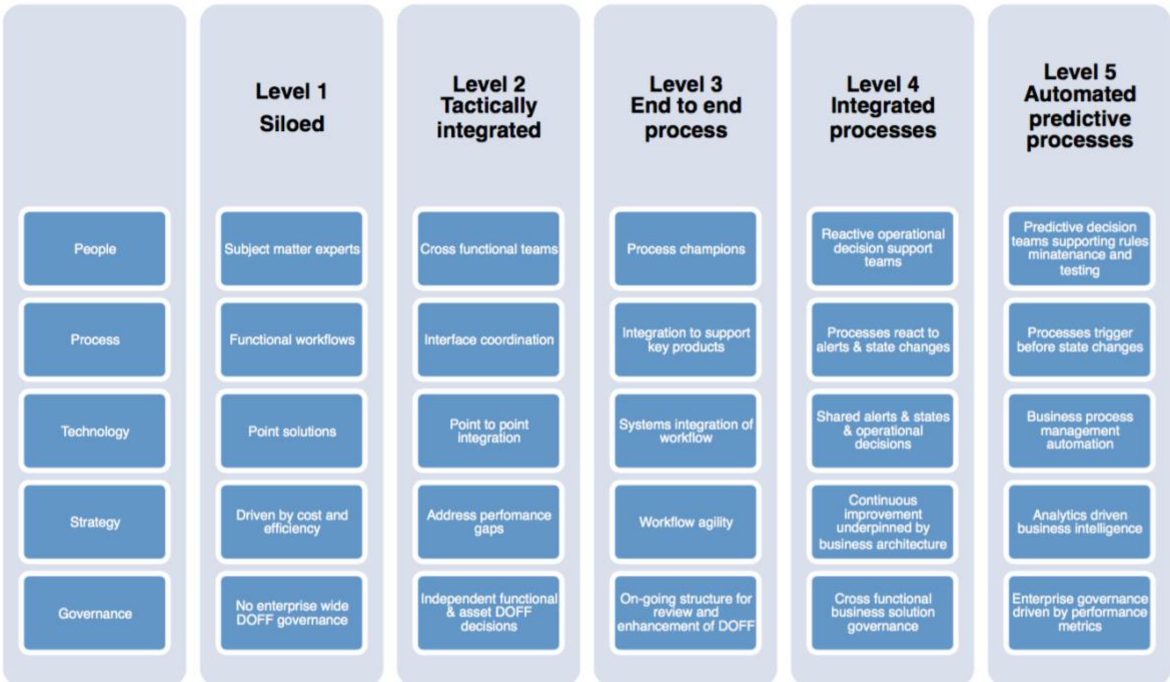


Figure 3 From (Feineman, 2014)

2.2 Artificial Intelligence and Predictive Analytics

The use of artificial intelligence and predictive analytics (AIPA) has been the subject of a comprehensive review (Bravo, et al., 2014). The authors believe in the particular value of AIPA in the context of the digital oilfield. However, while the automated processing and analysis of data to support decision making is perceived to be increasing within oil and gas, it is still immature compared with other industries. Circumstantial evidence for this is provided by comparing the occurrences of relevant search terms in industry-specific publications versus the entire web, as shown in their graphic below.

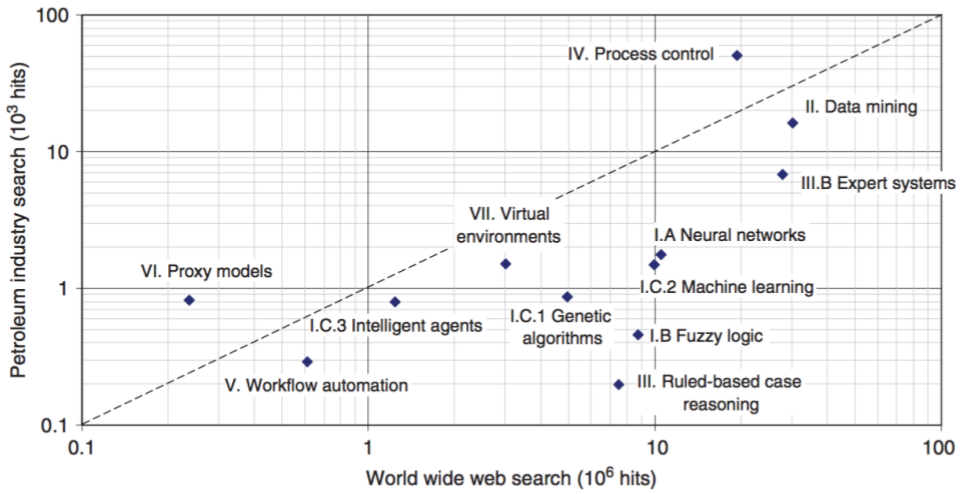


Figure 4 (Bravo, et al., 2014)

AIPA awareness and adoption in the industry is reported based on the results of a survey of SPE members carried out in 2011. Unfortunately, respondents were self-selecting, only 612 surveys were completed from an initial sample size of 10,000, and the questions were somewhat generic. As a result, the conclusions of the paper that AIPA technologies “have penetrated the industry in many ways” seems open to doubt.

Notwithstanding this, there are some extremely impressive reports of success with analytics (Turk, et al., 2013). Devon established a dedicated analytics team and, working with external consultants and software vendor, created a proof of concept and several pilot projects. They believe that they were able to deliver decisions faster and more cost-effectively over traditional domain analysis. In order to ensure clarity internally, the team developed their own definition of analytics: “the discovery and communication of meaningful patterns in data.” One of the most vital conclusions concerned the importance of identifying good questions, the resolution of which would drive an evidence-based decision. As might be expected, dataset quality issues were a significant problem, spanning accessibility, consistency and relevance.

The importance of subject matter experts (SMEs) is emphasised, as they are critical in ensuring the success of analytics projects. This underlines the fact that these techniques might improve efficiency, and potentially uncover interesting new results, but they are not a complete replacement for discipline experts.

2.3 Asset Monitoring

In general, this review has avoided discussions of well monitoring and directional drilling. Many of the references cited contain information on these aspects, but the technology is well-established and proven and it is relatively straightforward to determine if there is a return on investment.

Linn Energy appear to be one of the few examples of small companies investing in digital oilfield, specifically around reservoir surveillance. (Eldred, et al., 2015). The company built a platform for data integration, surveillance and optimisation, primarily to support inter-disciplinary teams with access to a common set of data. The work is interesting, but while it may indeed have been inspired by the digital oilfield initiative, it is hard not to see this as an individual company seeking to use automation and data integration to improve its current processes. The distinction is subtle, and ultimately may not matter, but it relates to the extent to which new initiatives can directly leverage tools and technology developed under the same banner. The paper provides no quantifiable data on cost savings or efficiency gains, but the company undoubtedly values the tools that have been built.

2.4 Integrated Asset Modelling

There is evidence of ongoing substantial debate over the nature of integrated asset modelling, without considering what benefits it can bring. Wadsley argues that there is an optimum level of detail that balances accuracy of forecasts versus speed of execution (Wadsley, 2015). His goal is a “factory” model, in which the models for each stage in the hydrocarbon lifecycle are coupled together. As an aside, his suggestion that this is a parallel with Volkswagen’s factory does not bear scrutiny.

On the other hand, some operators have particular problems, like hydrate formation and chemical inhibitor tracking, that impose a specific set of constraints (Al-Jasmi, et al., 2015). In this context, PVT calculations are considered to be key to calibrating the well models. For Qatargas, what is important is a “robust flow modelling system, supported by physical laws that can offer all information relevant to well and reservoir performance, accurate to the highest degree” (Bian & Abuagela, 2015). In both these examples, the technical solution is designed to meet a specific problem, and it is hard to see this as a digital initiative in and of itself.

Overall, it is not obvious that there is a single approach that is appropriate for all assets. At best, we might be looking for a small set of solutions. At worst, there may be a unique implementation for each asset.

2.5 Standards

There is very little explicit reference to data standards in the literature on digital oilfield, beyond passing references to PPDM and OPC (Akoum & Mahjoub, 2013). This is possibly because the bulk of the reported implementations are specific to, and developed by, individual companies. Anecdotal evidence suggests that there is a perception that broadly-based, industry standards are too generic and complex, and that it is better to implement a simpler problem-specific solution. Whether this is a correct observation or not, there are industry bodies, like Energistics and others, attempting to build standards, create awareness and drive adoption (Hollingsworth, 2015). This includes PRODML, developed with the goal of establishing an industry standard for data exchange to support production processes (Ormerod, et al., 2013).

These authors suggest that the lack of data exchange standards causes increased complexity and reduces the ability to generate automated workflows. However, as the Ormerod, et al., paper identifies, the standard is still underused. While there might be significant benefits to the use of standards, they seem peripheral to current and historic digital oilfield initiatives. As has been pointed out (Black, 2014), adoption is key, and this has not historically been a focus for oil and gas standards bodies.

In contrast, there is even a suggestion that it might be necessary to eschew the idea of a standard deployed everywhere and, for speed and adoption purposes, allow local innovation and diversity. (Gilman & Nordtvedt, 2014)

2.6 Ontologies

There is limited information on the application of ontological frameworks, though some background is available (Saputelli , et al., 2013). In a discussion of approaches for ontological frameworks applied to the information interchange between production applications, the authors highlight the Integrated Operation for the High North (IOHN) project, developed by the Norway Scientific Council and Statoil in association with several services companies. Other projects identified as interesting in this context include Shell's Smart Fields® initiative, the Field of the Future® from BP, the i-Field® from Chevron, and Saudi Aramco's Intelligent Field Program, among others. It is striking that the list does not include any smaller operators, and that many of the actual implementations are regarded as company proprietary.

2.7 Cloud Computing

Following the NIST definition, cloud computing is "a model for enabling ubiquitous, convenient, ondemand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction". As has been pointed out (Perrons & Hems, 2013), cloud computing is attractive as a way to reduce costs, and increase deployment flexibility and speed of implementation.

Very broadly, the oil and gas industry makes two arguments against cloud (Feblowitz, 2011): security and data set sizes. Both of these concerns can be mitigated, not least by envisaging a near future in which a hybrid model is enacted with end-to-end data encryption and secure storage of keys. (Bello, et al., 2014; Pickering, et al., 2015)

Unfortunately, as Perrons & Hems point out, software vendors in the industry have been slow to move to the cloud computing model of "apps" and interoperability. Rather, the trend has been to move existing monolithic applications to shared data centres with access via remote terminals, thereby eliminating many of the benefits of cloud and adding very little value for the customer.

2.8 Big Data

It is still relatively early days for big data in oil and gas, and adoption is likely to be slow. IBM have made a case for the use of big data techniques in areas such as closed-loop reservoir management and production optimisation, and integrated operations (Brulé, 2013). They argue that it is more effective to consider data-in-motion combined with data-at-rest. Thus, they recommend combining stream computing for analysing high-frequency data, such as sensor data, with large volumes of structured or unstructured data in Hadoop or massively parallel processing relational data warehouses (MPP DW).

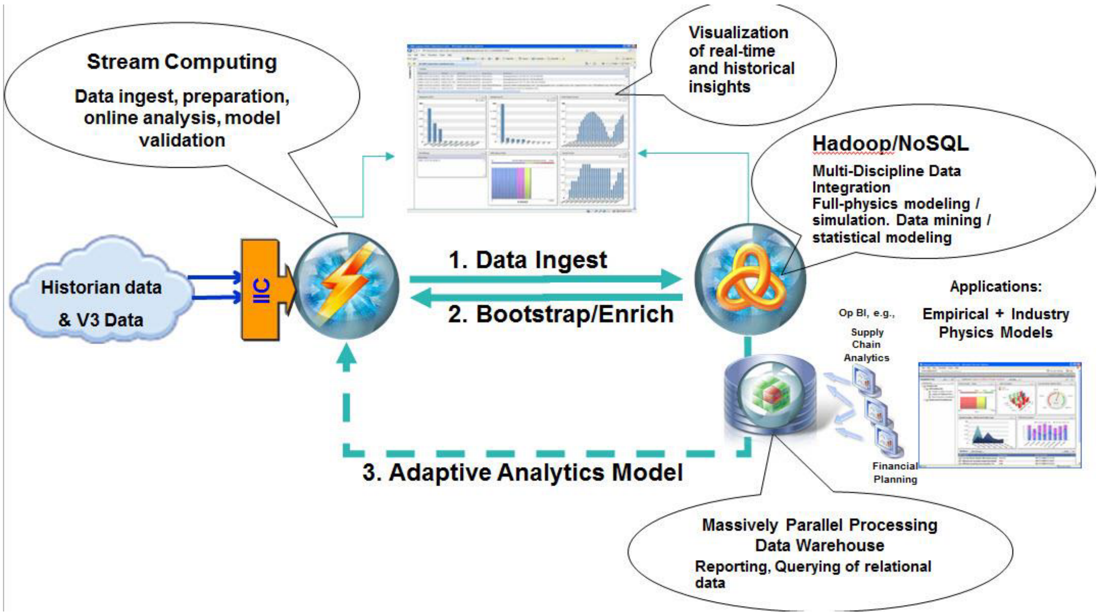


Figure 5 (Brulé, 2013)

While the technology described is undoubtedly interesting, it is necessary to carefully consider where it can add value. The work at Devon (Turk, et al., 2013) seems entirely relevant and illuminating in this context: they emphasis that without good questions we cannot have good answers.

2.9 Industrial Internet of Things

In his paper from 2015, Crompton included a digital oil field hype curve for 2013 that did not include the Internet of Things (IoT). It is still not clear that the technology trigger, in Gartner terms, has been pulled. The OMG is active in this area, developing standards in anticipation of wide adoption (OMG, 2016). Some papers have begun to appear, but they address IoT only in a superficial manner (DeVries, 2016).

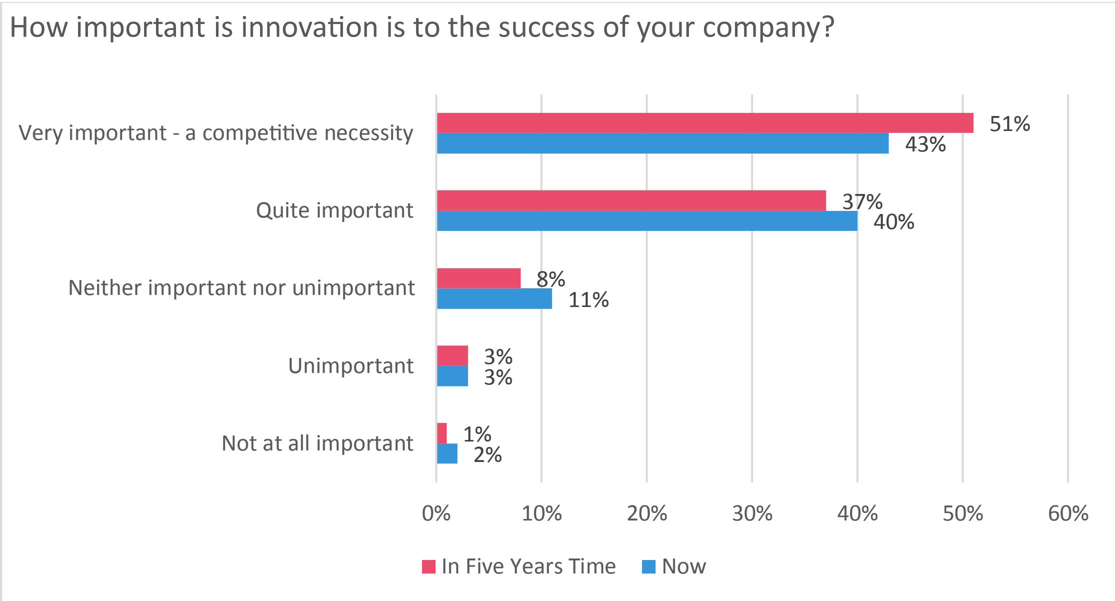
One of the most interesting ideas has been to use very low cost, disposable devices that can record (or capture) data and transmit it to the cloud. No control function would be included, so the security issues are minimal, but it might allow enhanced monitoring of a facility without expensive infrastructure.

As with so many other technologies, this has the feel of a solution looking for a problem.

3 Conclusions

3.1 The nature of Innovation

Many of the initiatives discussed in the context of digital oilfield are innovations, and in this regard it is essential to consider the capacity of the industry to accept innovation. In a survey of oil and gas executives (PwC, 2013), innovation was reported to be important both in the short and medium term. Indeed, the chart below taken from that paper shows that just over 40% consider it to be "a competitive necessity" now, and that figure rises to over 50% when asked to look out five years. However, the same survey reports that less than half of oil and gas executives say that they have a well-defined innovation strategy, compared with 79% of the top innovators across industries.



When the executives were asked to think about the following three years, and say whether they had plans in place to collaborate to deliver innovative products and services, the vast majority said they did. Indeed, 94% said that they were intending to collaborate with strategic partners, and 85% and 70% intended to collaborate with customers and suppliers respectively. While this is an interesting response, it is hard to see how this would work in the absence of a well-defined innovation strategy. In truth, while many consider that innovation in the upstream sector is increasing, a minority of companies consider themselves to be "early adopters", and the majority are "fast followers" who wait for technology to be proven (Donnelly, 2014). In part, this fact alone may be the reason for the relative slow pace of adoption of digital oilfield.

A recent paper on innovation networks explains some of the challenges that digital oilfield has encountered (Lyytinen, et al., 2015). The authors identify four distinct innovation networks:

- Project innovation form, which takes place in the context of a centralised and hierarchical control.
- Clan innovation network, which involves relatively homogenous participants who share a single discipline or closely related disciplines

- A federated innovation network, having members who operate under centralized control, often within a single organizational hierarchy (or within an alliance).
- An anarchic innovation network, in which control and decision-making is distributed through the network, and the knowledge resources are highly heterogeneous.

The last of these is the most complex, yet it best represents the way in which the cross-industry development of digital oilfield has been carried out. There are a wide range of participants who often have different and possibly conflicting interests with highly distinct knowledge bases. No one has control over the final product architecture, the digital infrastructure that supports the innovation, or the rules of engagement. It is unsurprising that the most success has been in a single company, such as BP, which generally resembles the project innovation network.
We argue that the recognition of these network models, and the existence of tools and mechanisms to address them, might enlighten future work in the area.

3.2 The Future: A Personal Perspective

Given the nature of this review, it seems appropriate to close with a personal view on some of the technologies currently in the early adopter phase.

First, if digital oilfield is not to simply be an expensive toy for the few, it must be accessible and relatively inexpensive to acquire. It is perhaps an oxymoron to advocate digital oilfield as a solution to the skills shortage if it requires a phalanx of PhDs to support its implementation.

Second, a dramatic increase in adoption of cloud computing seems inevitable. The mistake made by many companies is to ask what they can do internally, not what they should do. A significant part of the IT budget is regarded as commodity purchase, not an investment in competitive differentiation, and as such the move to cloud is in perfect alignment with the industry direction. It will also be the place where innovation happens. The current major players in oil and gas software think of innovation as the opportunity for third-parties to write add-ins for their platforms: the reality is that innovation will come from a wide range of completely new apps delivered in the cloud.

Secondly, big data will remain, like object databases before it, a niche interest without widespread adoption. For many, the definition of big data remains opaque, and the only one of the three Vs (velocity, variety, and volume) that is dominant in peoples' minds is volume. Concerns about industry adoption have already been raised (Perrons & Jensen, 2014).

The Internet of Things (IoT) will also likely remain a niche application, at least for the foreseeable future. While many are hard at work on the development of standards (OMG, 2016), past experience suggests that it will be challenging to get vendor buy-in in the face of likely customer apathy. A relatively simple problem, like home automation, is seeing slow progress despite the dominance of Apple and its efforts in this space.

Digital oilfield will fade as a distinct concept. While a number of companies have benefitted from its use as a driver for change, and vendors have created new solutions to address perceived needs in this space, it is questionable whether it continues to have value as an independent discipline. Just as banks have been forced to recognise that, at their core, they are digital businesses, so will oil and gas. However, unlike the efforts of the last ten years, which have seen major companies developing their own solutions, the broad industry will look to the market to supply the tools they need, just as other industries do.

Innovation within oil and gas companies will be focused on those areas that can really drive competitive advantage. Finally, the future really should be one in which individual users can choose a range of applications and bind them easily into workflows to meet their needs, without requiring programming skills and without interaction with any of the individual vendors. As examples of low-cost, powerful and easy tools for integration of disparate applications, consider Zapier (www.zapier.com) and IFTTT (www.ifttt.com).

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