

# digital energy journal

Cybersecurity - time for a new approach?

Exploration – time to be optimistic in oil and gas

How data managers can learn scripting

AI - keep your objectives simple

Moving subsurface data between cloud software

Why digital isn't going as expected

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Cover image: some of the delegates at Digital Energy Journal's forum at ADAX, Kuala Lumpur, on October 10, "Opportunities for data scientists and architects in oil and gas"

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## Opening

# Are we doing cybersecurity wrong?

Most conference talks and articles about cybersecurity in the oil and gas industry focus on two issues, educating "users", and technological solutions. Perhaps we've got it all wrong.

Let's make a comparison with the physical security and policing world. Human mistakes and technology play a role here, but you hardly ever hear police officers and physical security people complain about their 'users' or ask for more technology.

Physical security people just get on with their job, with the understanding that there are always vulnerable people, sophisticated criminals, and stupidity on both sides, and technology can both help and hinder. They see their job as managing the situation the best they can, with the help of common sense and human judgement.

Maybe cybersecurity people should take a similar approach.

The oil and gas industry had another major cybersecurity hit in December 2018, when drilling services company Saipem was a victim of a version of the Shamoon virus, taking out between 300 and 400 servers, and up to 100 personal computers, out of a total of 4,000 machines, according to a Reuters report.

Shamoon is famous for the 2012 attack on Saudi Aramco, reportedly installed after an employee in the IT department clicked on a phishing e-mail. It can spread from one machine to another on the network. It e-mails your files to the attacker, erases the file and finally overwrites the master boot record of the infected computer making it unusable. Over 30,000 Windows systems were overwritten, and the company had to get new hard drives flown in on its private planes, reports say.

With this knowledge, how would someone from a physical security background tackle the risk in their company?

They probably would not blame users or look for high-tech solutions – phishing e-mails seem to be getting more and more sophisticated. High technology might come in the form of better virus scanners or network analytics systems, but would only work if they were pre-programmed to detect this kind of threat, and had authority and capability to stop a system spreading in milliseconds.

Probably a low-tech response would be more appropriate.

Just as a stranger cannot just walk into a highly secure facility, or land their aeroplane into a busy airport, it should not be possible for an e-mail from outside to go to an employee's desktop with a link which enables them to install software on a secure computer linked to a secure network. Whitelisting software applications and disconnecting computers accepting external e-mails from computers with access to internal networks is a hassle but surely worth it here.

How about more human watchkeeping in the cybersecurity world? The physical security world makes ample use of people.

The security guard makes manual, physical checks and keeps a mental record of the regular comings and goings in a facility, making it much easier to spot a rogue. In the cyber world, if you need to quickly identify a legitimate Windows update from a fake one, a task not needing enormous cybersecurity skills, you may be better with many junior staff rather than fewer more qualified ones, and may be better trying to do such work with people rather than machines.

And the physical security world places a premium on simplicity. An airport has a single, large secure area which you only enter once you have been checked. Computer systems by comparison are so complicated they are really easy for a hacker to hide in. But they could be made simple.

Do you need to use Windows when a simple logic controller would do the task?

Karl Jeffery, editor



*Note: we are planning to run cybersecurity forums in London, Aberdeen and Stavanger in 2019 exploring better approaches to cybersecurity taking lessons from the physical security world. If you have ideas, technology or business approaches you may be interested in sharing, please contact me.*



# Time to be optimistic in oil and gas?

## PETEX discussion

A panel discussion was held at the PETEX event in London in November “Time to be optimistic? Exploring the next 5 years of Oil and Gas”, with speakers from Crystol Energy, Heriot Watt, Shearwater, Seacrest Capital, Barclays, Geological Society, Shell

A panel discussion was held at the PETEX event in London in November “Time to be optimistic? Exploring the next 5 years of Oil and Gas”, with speakers from Crystol Energy, Heriot Watt, Shearwater, Seacrest Capital, Barclays, Geological Society and Shell.

Professor John Underhill, Heriot-Watt University said he thought there was a lot more optimism in PETEX in November 2018 than at the 2016 and 2014 events.

But he drew a comparison with geology in the early 70s and today. Then, “geologists were treated as heroes, exploring for energy in the background of the IMF crisis and strikes,” he said.

Geologists often do not feel like heroes today, partly because of there is so much disdain in society for the fossil fuel industry. This issue also impacts the supply of talent into our industry. “It is a challenge and not necessarily one to be optimistic about,” he said.

Geologists can be part of the solution to climate issues if they get involved in carbon capture and storage. “We don’t want to put CO2 in the wrong place,” he said.

The development of digital technology is also a “reason to be cheerful” in oil and gas exploration, so long as it compliments the development of skillsets geoscientists need, rather than working against it. “Good technical decisions have to be rooted in geoscience,” he said.

Carole Nakhle, CEO, Crystol Energy, chairing the event, observed that many university courses on oil and gas economics fail to attract enough students to run, while environmental

courses “are packed”.

### Shearwater – new species post extinction

Irene Waage Basili, CEO of seismic company Shearwater Geoservices (which acquired WesternGeco in August 2018) said that the oil price crash “was drastic, almost an extinction event,” with oil company exploration activity “completely stopped for quite a few years.”

But like an extinction of animals, it will be followed by “new species coming online and capturing new territory.” The new oil industry will be different to the last one.

Shearwater is one these new species, looking for ways to use the downturn to grow the company, she said.

The downturn of 2014 was different to other downturns. We had seen a big increase in the oil price on the back of China’s growth, and also shale changing oil supply, and proving hard for the offshore sector to compete with. Also there had been a “total lack of cost discipline in the entire value chain.”

Today, there are only a small number of companies in the seismic sector, with TGS and Spectrum doing multiclient surveys but not owning vessels, and WesternGeco, CGG, PGS with in-house fleets and in-house technology.

The asset light (non shipowning) companies may have been the most successful in getting through the downturn, she said. But this is not necessarily what oil companies want to see.

“Several companies in our space are moving

from asset heavy to asset light. CGG gave signals that it was going in a similar direction,” she said. “That gives great room for us, picking a different strategy, going for asset heavy, and trying to be complementary to these clients and former competitors.”

Seismic acquisition “is a market we know and believe in,” she said. But, “more specialisation focussing on cost is constantly what is required.”

### Phil Loader

Phil Loader, strategic advisor, Seacrest Capital Group (which invested in Azinor and OKEA, among others), and a former EVP global exploration with Woodside Energy in Perth, emphasised that change brings new opportunities for companies to differentiate themselves.

“If you like an environment which fosters innovation and creativity, you are in the right industry,” he said.

The oil industry’s critics haven’t presented any alternative to fossil fuels over the short term, he said. Renewables may eventually provide equivalent energy to fossil fuels, but we need more oil and gas exploration to “allow some time for renewables technology to catch up.”

One area where technology has brought big improvements over the past 15 years is in monetisation of stranded gas, as we see in Mozambique, he said. “15 years ago it was a gas province we didn’t know what to do [with],” he said. Today, “We can modularise LNG technology.”

Some companies are better than others in the support they offer for graduates or the culture to support exploration, he said. Supporting exploration means being able to support contrarian views, enabling people to gain experience, develop their intuition and continually learn.

The industry’s focus on lower risk plays in recent years is probably to blame for the low rate of discoveries. “The industry has shied away from basin opening, play opening wells. But a focus on lower risk plays will never deliver materiality,” he said.



Panel discussion at PETEX. From left to right: Lydia Rainforth, managing Director, European Energy Equity Research, Barclays; Valery Chow, Senior Energy Advisor within the Shell Scenarios Team; Phil Loader, strategic advisor, Seacrest Capital Group; Malcolm Brown, a former president of the Geological Society of London; Professor John Underhill, Heriot-Watt University. Not in picture: Irene Waage Basili, CEO of seismic company Shearwater Geoservices; Carole Nakhle, CEO, Crystol Energy (session chair)

But now, “companies want to replenish what’s in the cupboard. My hope is we’ll see more courage.”

The best time to invest in a basin is when hydrocarbons are proven but the basin is under-explored. On that basis, “Investors have got more choice than they’ve ever had, with many different types of organisations to invest in.”

For an investor, the full lifecycle value proposition of an unconventional well in North America is inferior to conventional exploration internationally, because companies ignore the amount of money invested in getting acreage, he said.

It can cost “\$250m to \$350m” just to find out if you are in the right place in an unconventional. “If you have a dividend policy, unconventional doesn’t deliver,” he said.

But if you have \$300m available, that’s good sum to spend in conventional projects, covering 3D seismic, conventional wells and some appraisal.”

Leadership can be more important than assets. “If you’ve got average assets and superb leadership and board, you’ll create value. Superb assets and average leadership will erode value.”

## Lydia Rainforth, Barclays

Lydia Rainforth, managing Director, European Energy Equity Research, Barclays, said she expects “AI to make the biggest and fastest difference to productivity” in the oil and gas industry.

Better use of digital technology, and letting it “fundamentally change methods of working”, is the way to make traditional oil and gas assets sustainable over the longer term, and compete with low carbon businesses, she said.

The oil industry could also look for ways to improve its ‘productivity’, which has fallen relative to the wider economy. “Each dollar generates 70 per cent less production than 10 years ago,” she said. “A mantra of capital discipline has been very much needed.”

However the downturn has brought in cost discipline, with companies planning projects to work at a \$50-\$60 oil price. If the oil price goes above that, then it generates excess cashflow which can go into reducing debt, increasing dividends or buying back shares.

Ms Rainforth’s role includes advising pension funds on which oil companies to invest in, based on an assessment of their relative competitiveness.

## Malcolm Brown, Geological Society of London

Malcolm Brown, a former president of the Geological Society of London (2016-2018) and former leader of exploration at BG Group, noted that oil and gas discoveries in 2016-2017 were the lowest in 7 decades.

On average, 40bn barrels of oil have been found every year since 1980. But there hasn’t been 40bn barrels found in any year since 2010. That is a period which includes the discoveries in Mozambique, Tanzania, Senegal, Guyana and Zohr.

“Almost all companies are finding less than their resources,” he said. Also, almost half of discoveries are less than P80 predictions. This means that if accurate predictions were available, management probably would not have authorised the spending to develop them.

Also the oil industry may be less competitive now than is commonly believed. The middle range of companies (like BG) have now disappeared, and the oil majors do not all chase the same prospects. For example, “Total drilled 26 gross wells in a period Chevron drilled 7.”

There are a smaller number of emerging plays, and “no-one is playing frontiers,” he said.

On the climate issue, “We have not told our story very well,” he said. Setting up the Oil and Gas Climate Initiative “is a good thing to do, but done on the back foot of an issue.”

The industry needs to better manage fugitive emissions of gas (leaks) because of the criticism that they are so large gas is just as bad as coal for the environment.

The industry is not as good as learning from its experiences as it could be. Technology could be helpful in this, he said. And perhaps more learning could make the workplace more enjoyable.

Mr Brown observes that while he thoroughly enjoyed his work in exploration, he does not believe that people of a similar generation today enjoy their work so much.

“Let’s get back to the fun stuff we call exploration and do it smarter and better,” he said.

## Valery Chow, Shell

Valery Chow, Senior Energy Advisor within the Shell Scenarios Team, said that the industry has been through a “perfect storm” over 2014 to 2017, with declining investment, a decline in

new funds, and new discoveries taking a long time to commercialise. “We have to go the 1950s to see numbers as low as these,” he said.

But on the positive side, we have seen the boom in unconventional in the US, and demand passing 100m barrels of oil per day this year, with growth coming from mainly non-OECD” countries in China, India and SE Asia.

The fundamental demand for oil in passenger transport and shipping is not seeing any slow-down, he said. China’s demand for LNG surged 45 per cent in a year, absorbing all the new LNG coming onto the market, he said.

Global energy demand dipped by 1.6 per cent in 2009 when the financial crash was at its peak, but grew by 1.7 per cent in every other year.

In order to keep temperature rise under 2 degrees, according to Mr Chow’s estimates, we would need oil demand to get much weaker by 2025, with almost half new vehicles to be electric by 2030, and continuous growth for gas, replacing coal, and providing a back-up for renewables.

A big question for the industry is whether the “systematic underinvestment in exploration” will lead to reductions in production and a rise in the oil price

After the crash “the industry has emerged tougher and more resilient – and searching for a new path forward. I think there’s some room for cautious optimism,” he said.

## Thanking students

One audience member, an exploration geoscientist with a UK oil and gas company, said that in a recent talk he gave to Aberdeen oil and MSc students, “I thanked them for having the courage.”

“Firstly they had made a lot of effort to do geology bachelor’s degree, then they have paid for the MSc themselves. They need to be in the top 10 per cent of the company to get a good job.

Then, “you go to a company full of old men, you can’t get a mortgage, your work has no impact on decision making. The alternative is to work at KPMG and have a nice life.”

The much feared ‘great crew change’, when experienced oil and gas people leave, could be welcomed by the younger generation, if it gives them scope to take on roles with more decision making, he said.

# Energistics demo – moving subsurface data between clouds

Oil and gas standards organisation Energistics ran a live demonstration at a SEG event of moving subsurface data between five different software applications on Amazon and Google Cloud, showing how RESQML makes it possible

Oil and gas standards organisation Energistics ran a live demonstration at a trade show showing how it was possible to move subsurface data easily from different cloud hosted software applications, with all of the data in Energistics' "RESQML" data exchange standard for reservoir data.

The demonstration was made at the Society of Exploration Geophysicists (SEG) 2018 Annual Meeting in Anaheim, California, in October 2018.

The presentation was made live at the exhibition stand of the Society of HPC Professionals.

Real data was used, for the Kepler field, jointly operated by Shell and BP, in the Gulf of Mexico. It followed a real geomodelling workflow.

The process began with a Kepler static model on Emerson software (Roxar RMS), which was updated with static software also owned by Emerson (Paradigm SKUA).

The data was then exported to IFP Beicip Open-Flow to generate additional properties. All of this time, the data was stored on AWS (Amazon) cloud.

Then the data was moved to Schlumberger's Petrel software, using Schlumberger's "DELFI" platform, which runs on Google Cloud.

Then the files were moved back to AWS for mapping new properties to the model on Paradigm's SKUA. Then a simulation was run using the "IMEX" software from Computer Modelling Group, running on AWS. Finally, time-lapse results were viewed on Dynamic Graphics' CoViz4D software on AWS.

At each step, the data in RESQML was read into the application, modifications were made on the model, and the resulting updated model was exported back in RESQML.

Metadata was also added at each stage, keeping track of what had been done to the data, who did it, and with which software application.

The only alternative to using the RESQML standard is to build one to one interfaces between each of the software applications used, which would mean extensive work, considering that the above workflow uses five data transfers from one company's software to another company's software. Developing one-on-one connections also needs someone to agree to pay for the work, either the software company or the operator.

Companies are increasingly looking to move data from one software package to another, because they are looking to analyse and develop data in many ways, and do not want to limit themselves to just software from one company,

Energistics says.

And typically, with one to one software connections, one company ends up being the "main" platform and the other one a kind of servant to it, with the company running the main platform having control over the data structures and what can be done. This gives them power to restrict what other software companies the client works with, which is something they may wish to do in order to keep the business for themselves.

There are also problems if data objects which aren't part of the main platform need archiving.

With RESQML, the data exchange is vendor neutral, the files can be read at any time in future with no dependencies, and metadata can be part of the standard.

Operators can make a mix of different applications, they can make partial data transfers if they want to, and the archive is not dependent on any vendor.

"This was a tremendous demo of the power of standards to facilitate collaboration, eliminate data friction and improve efficiency," says Ross Philo, CEO of Energistics. "As you can appreciate, it was something of a jaw-dropping moment for the audience."

## CGG / WoodMac's EV2 – evaluate basins around the world

The "EV2" service from CGG Robertson and Wood Mackenzie can be used to help you make decisions about which basins and plays to enter, and how your portfolio compares with competitors. It has data for 700 plays in 180 basins

The EV2 "exploration volume and valuation" online service, from CGG Robertson and Wood Mackenzie, can be used to help you make decisions about which basins and plays to enter, and how your portfolio compares with competitors.

It now has data for 700 plays in 180 basins.

It can be used by oil companies to help screen opportunities, make decisions about what to bid for in licensing rounds, assess and benchmark themselves against competitors, do geologic risk assessments, manage their acreage portfolios, and identify blocks they would like to request their governments make available.

It includes basins in Sub-Saharan Africa, Greater Caribbean, Australasia, South East Asia, Middle East & North Africa, Mediterranean, Caspian, Atlantic Margin, Northwest Europe, South America and the Arctic.

The service combines CGG Robertson's geological expertise with Wood Mackenzie's commercial insight.

Petroleum Edge Ltd is the name of the joint venture company, and EV2 is the name of their first product.

There are employees from both companies seconded to work for Petroleum Edge full time,

with support from Wood Mackenzie's regional analysts and CGG Robertson's geologists.

For unlicensed blocks / frontier acreage, the geologic analysis is based on analogue basins (basins which are similar geologically but where more is known about them).

The economic data is drawn from Wood Mackenzie data, including current fiscal terms, oil and gas price markers and tax components.

For each play, a minimum of 80 prospects are modelled, with five different field sizes, 5 water depth settings (for offshore fields) and five oil percentages (where applicable).



# LR – investment for offshore safety technology

Lloyd's Register Foundation is exploring ways that the venture capital technology investment model can develop new technology to improve offshore safety

Lloyd's Register Foundation, the charity arm of Lloyd's Register Group, is exploring ways to use the venture capital model to support the development of technology to improve offshore safety.

Its project involves finding offshore operating companies with challenges which advanced digital technology might be able to help with, and then sought technology companies which might be able to help. An event was held in London on November 28, bringing together the challenges with the possible solutions.

The four challenges, presented at the event, were to reduce the risk of falling objects on a drilling rig; to reduce the number of safety incidents on a vessel caused by bad decisions; to determine the mental health of the master of a vessel and the crew; and to detect errors made by mobile workers.

The challenges were presented by Per Lund, CTO, Odfjell Drilling; Fletcher Martins, Marine Operations Coordinator, Scorpio Group; Captain Chuxing Peng, Assistant GM, QSSD, Fleet Division, Pacific International Lines; and Inge Alme, Executive Vice President HSEQ and Development, Infratek.

The winners were promised support from both Lloyd's Register Foundation and Plug and Play, a Silicon Valley venture capital company, which claims to be the most active VC firm in Silicon Valley based on number of deals.

## Falling objects

Per Lund, CTO, Odfjell Drilling, presented the first challenge, reducing the risk of falling objects on a drilling rig. He said that drilling rigs are getting more and more complex, which can mean there are more different items with the potential to come loose. There are still people working on the rig floors, who can be hurt by something falling on them.

Potential solutions were presented by Cogniac, InstaDeep and SmartVid.io. All three companies offered software which can analyse images, and be trained to spot situations which might indicate a risk.

Cogniac claims to be able to train a system to identify images with just 50 images, so it can be trained faster to do specific visual inspection tasks. For example, if a common cause of dropped objects is floodlights with a damaged bolt, the software can be trained to examine photos of bolts to look for damage.

Cogniac can build an 'inspection workflow', where photos which might show a problem can be passed onto a person.

InstaDeep is developing tools to detect anomalous situations. The company suggests looking for problems with corrosion, vibration, extreme weather, or equipment installed in the wrong place, as potential causes of dropped objects. The system can identify these problems from analysing photographs, and also identify how long the problem has been in place, and how many people have been in the vicinity.

SmartVid.io, based in Cambridge, Massachusetts, is analyses video for construction and capital projects, aiming to give insights to safety managers. For example, it might spot that someone is not wearing a hard hat, or count the flow of people going onto the site. The photos can be gathered with mobile apps.

## Dangerous decisions

Scorpio Ship Management, an operator of tankers, bulk carriers, gas carriers and car carriers, is looking for ways to improve decision making made by seafarers, or more specifically, to reduce the number of accidents caused by poor decisions.

Investigations after accidents often end up by discovering that someone with a good track record made a bad decision – but nobody knows why that decision was made.

Potential solutions were presented by Contiamo, Hala Systems and fuseAware.

The Contiamo presenter noted that machine learning models are usually based on around 10,000 data points a day – so it would be hard to use machine learning in this case, for a company which has 15 accidents reports a year. However if safety reports could be gathered from many different shipping com-

panies it may be more possible.

Hala Systems makes software which can find correlations in data for safety purposes, used in aviation. One application is analysing aircraft flight data, to warn people in Syria of aircraft which might be headed in their direction carrying bombs, and give people much more notice of an impending attack.

## Mental health

Captain Chuxing Peng, Assistant GM, QSSD, Fleet Division, Pacific International Lines, a container shipping company based in Singapore with around 150 vessels, said that accident investigations often conclude that there is a factor affecting the mental health of the seafarer.

Or more specifically, the accident was due to a "lack of situation awareness by the person concerned," although the person was competent.

"If they were psychologically sound the problem could be avoided," he said.

For example, they may have received bad news from their family, which is taking their mind off their work, or just did not rest when they were supposed to be resting.

Understanding someone's psychological health should be more than just asking them "how are you," he said.

Potential solutions to the problem were presented by Emotion Research Lab, Senseye, Stroma Vision and Aveling.

Senseye of Austin, Texas, is researching ways our inner feelings might be reflected in changes in the 3,000 muscle fibres in our eyes, and this may be a pathway to a solution.

CEO David Zakaria said that the US Air Force has used the company's research, and as a result, managed to reduce training for pilots from 12-15 months to 6 months, by being able to detect how relaxed a pilot is with a certain task, or if they need further training.

So far the company has "biomarked" 5 per-

cent of the 3,000 iris muscles, he said. Factors that can be detected including people's stress, cognitive load (how hard they are thinking), hormones and memory. Perhaps it will be possible to detect a range of emotions, including anger, surprise, fear, disgust, sadness and happiness.

The relationship between mood and iris muscles is similar for just about everyone. The exceptions are for someone who is a "true psychopath", where the readings don't look the same, but you can use it to detect psychopathy. Also if someone is under the influence of alcohol or drugs, the iris muscle movements are more sporadic.

The system can work even on a blind person, because "the connection between iris muscle and brain is different to connection between iris muscle and visual cortex," he said.

Aveling is developing systems which can understand people's psychological and emotional health, but based on internal factors, not from scanning faces. For example someone's saliva could be examined for higher than usual Cortisol levels, indicating higher stress.

Jason Eden from Aveling, who also runs a company called Sleep and Fatigue Research

Ltd, notes the marine jobs "are some of the most stressful in the world." And one person's psychological health affects the safety of everyone else on board. "It is vital to know when someone is not fit for duty."

Mr Eden was formerly head of risk management and air safety with (UK) Royal Air Force Northolt, after serving for 6 years as a RAF pilot. He says that the idea for his work on sleep research grew from seeing how dangerous sleep deprived pilots can be.

His research shows that 96 per cent of people need at least 7.5 hours sleep, and "if you don't get that regularly you'll have a problem."

"Some people can get by on 5 hours – but you are more likely to get struck by lightning than to get that gene."

Stroma Vision of Chicago has developed facial monitoring technology designed for vehicle drivers, continually scanning the driver's face. The device costs \$199 plus a small monthly fee. It has sold \$120k worth of devices between May 18 and Nov 18. The service could prove particularly applicable to fleet operators, who want to see how their drivers compare.

## Errors by mobile workers

Infratek, a Norwegian company which provides services for critical infrastructure such as power grids, rail, lighting and heating systems, is looking for ways to quickly spot mistakes made by its mobile workers.

Mistakes can lead to safety hazards for future workers, and make maintenance more difficult, said Inge Alme, Executive Vice President HSEQ and Development, Infratek.

Potential solutions were presented by Numberboost, Cogniac and SmartVid.io.

Numberboost, from Cape Town, presented its image analysis system. It has built systems for the mining industry to detect trucks which are on the wrong road. It has also built a system for supporting vehicle inspection.

A photographer takes 9 photos of specific parts of the vehicle, including the license disks, which are then uploaded to a system. The software can choose photos to be further inspected by a manager in a central office. It has developed a system for reading the labelling on cables using a photograph.

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# WFS – a wireless computer network on the seabed

Subsea communications and computing company WFS is developing a "Subsea Internet of Things" (SIoT) system with modular devices which can be easily plugged in and plugged out, with no cables required

Subsea communications and computing company WFS is developing a Subsea Internet of Things" computing system with modular devices which can be easily plugged in and plugged out, with no cables required.

The company has SIoT devices deployed is currently running trials with two "tier 1" operators.

By making most systems wireless, WFS aims to resolve a problem usually faced when implementing subsea computer networks – that connecting and disconnecting devices using a remote operated vehicle (ROV) can get very tricky.

With the SIoT 'Hot-Swap' wireless system, connecting a device is just pushing a cylindrical container into a holder, something which can be done easily with a ROV, says Brendan Hyland, founder of WFS Technologies.

The next generation of SIoT devices will broadcast a position beacon, so that underwater vehicles can easily find them.

Data can be processed on seabed devices, or at the "edge", so reducing the amount of data communication to shore. Software can be installed on the devices to run algorithms, including predicting fatigue life and corrosion. So only "answers" need to be sent to the surface, not raw data.

The devices have a battery with a guaranteed life 30 years, made by French company SAFT (now owned by Total).

The system is designed so that any one component failure will not cause a knock-on effect to any others.

Altogether it should open up pathways for people to do more with subsea data, he says.

So far, WFS has made non-intrusive SIoT devices which can measure temperature, strain, vibration, corrosion, displacement, process flow and leaks. WFS has an intrusive SIoT device that measures pressure.

While most people can see the broad benefits, the critical thing is to develop "killer apps", where people get the value, Mr Hyland says. He draws a comparison with mobile phones, where take-up in the early 1990s did not accelerate until builders realised they could use them to avoid driving back to the office to get the next job.

WFS recently took on a new investor, described as "a multibillion dollar size US firm", but WFS is unable to reveal its name. The investment funds are being used to "scale up" the business. Also, Chet Mroz, formerly president and CEO of Yokogawa Electric Corporation has joined as an advisor.

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# Using digital technology to help with asset commissioning

Digital technology can make a big help with asset 'commissioning' - transferring the ownership of an asset from the contractor who built it to the operator who will operate it. But it needs to be thought through carefully. Josh Goolnik, Technology Manager with engineering contractor Wood, shares some advice

*By Josh Goolnik, Technology Manager, Wood*

Commissioning new assets is much more than flipping a switch. For greenfield and brown-field projects alike, it's a critical moment, the culmination of a significant investment in time, resource and materials.

And software and digitisation offer a more efficient, robust and visible way for operators to stay in control of commissioning.

Over recent years, the oil and gas industry has reaped the benefits of digitalisation. From the supermajors to smaller independent operators, digital approaches are being deployed right across operations in areas such as geological surveying, refining and drilling with significant gains seen in safety, efficiency and cost savings.

Different companies involved in the project can be given access, making it easier for parties to work together seamlessly in line with, for example, the mandate in the UKCS from the Oil and Gas Authority (OGA) for operators to 'collaborate' in order to achieve greater efficiency and help to grow the supply chain skill set.

But if software is going to be used to support the commissioning workflow, the transition to digital technology must be very carefully considered to be successful. There is a great deal at stake, and a high safety risk.

Also, with decades of experience most operators have well-established processes that are heavily embedded. A live commissioning project is not a good arena to introduce new ways of working for the first time. With the number of parties involved and a significant investment at risk, commissioning is the most critically collaborative point in an asset's life.

## New processes

Updating to digital hardware or introducing new systems is only part of the answer. In fact, the bigger issue is that old processes are no longer fit for purpose with an updated system. The real difference to commissioning comes when you optimise operational processes to suit new, digital technologies.

We have found that swapping to faster technology or digitising parts of a process only shifts



*Josh Goolnik, Technology Manager, Wood*

bottlenecks to a different point in the workflow. This is one of the most fundamental challenges facing the shift to digital, but there are opportunities to ease the pressure.

Best practice is based around early planning and that shouldn't change for the digital workflow. By involving commissioning teams at an early stage a lot can be done to improve the process. A key advantage if you are looking at digitising is the opportunity to start using the software well before commissioning begins.

During the asset design and construction stages data can be input to the software system in preparation for commissioning.

This provides teams the chance to familiarise themselves with the system and experiment with the connectivity. There will be site visits and queries throughout these stages providing many opportunities for teams to understand the new software or hardware – increasing efficiency when commissioning begins.

Partly digitising your commissioning process will have very little positive effect on efficiency. If you go from having everything on paper to only having some of it electronically, it means dealing with two systems and moving between hard copy and electronic. This can create inefficiencies and errors, and reduce any productivity gains as the user has to switch between systems. Digitising is a major change but at Wood, we would always recommend a complete switch over a partial one.

## Confidence in compatibility

Bespoke systems and tailored hardware might be desirable because they will be made for the individual asset or company but mainstream solutions have the advantage of familiarity.

Popular devices and software mean more

widespread use, which in turn means users are likely to learn faster and have a better network of support. Larger technology providers have made their devices and programs compatible across more systems so integration should be easier. If operators are going to adopt new software or hardware make sure it is deployed company-wide to get the most value from the change.

## Connectivity limitations

Real time operations are still limited by system connectivity. If you have a remote site or intermittent network access then the problem of synchronising data can arise.

Any digital process should account for potential data holes, transfer issues and blackouts. Many devices can continue to operate offline so work can continue without interruption, however it then becomes important to synchronise data, preferably at an agreed time, to ensure all parties are working from the same information.

Some inputs might be delayed causing either data black holes or forcing the system to rely on older information. A good system should be able to identify the status of all data and highlight any areas where new data is expected.

## Safety first

Handheld devices bring with them a new set of safety considerations to be aware of.

Most devices can be shielded so there is no ignition risk but additional risks are dropped object potential, the removal of at least one hand from use while operating a device, and the additional distraction of using the device in the workplace.

These should all be acknowledged and assessed within the operational processes.

## Wood's commissioning software

Wood's GoTechnology commissioning software suite is a solution for the whole process, combining consultancy and personnel support with a suite of robust processes, plans and procedures, and training.



# Bentley Systems – taking structural modelling further

Bentley Systems, a US software company specialising in tools for infrastructure, is pulling together a number of different software tools to make an integrated suite for modelling offshore structures and operations

Bentley Systems, a US software company specialising in tools for infrastructure, is pulling together a number of different software tools to make an integrated suite for modelling offshore structures and operations.

Bentley aims to provide a common data environment providing complete, accurate engineering information, from a range of different sources, including pdfs, drawings and unstructured spreadsheets.

Anne-Marie Walters, industry marketing director, Bentley Systems with responsibility for oil and gas, says that the company sees one of its strengths at being better at integrating different types of data together related to engineering and analysis.

“We’ve got really good at pulling data together - and providing one picture,” she said.

“We’ve got technology to extract data from different systems - to pull it together with other data. We’re known as the company that really solves the interoperability problem, especially for engineering information.”

The software is designed in a “very visual” way, Ms Walters says, showing engineers where the weak points in their design are, and how elements in the structure will weaken over the service life. This enables engineers to make easier decisions about how to alter the structure to improve its strength, such as with more piles or struts.

“Fundamentally the tooling combines modelling and analysis,” she says.

Bentley has a number of use cases on its files, where an offshore structure was subjected to actual extreme weather or a collision, and was filmed, showing it behaved exactly as predicted, she says.

## Acquisitions

Bentley has made a number of acquisitions over the past few years which have broadened its portfolio, growing from its initial development as a structural engineering software company.

In 2011, Bentley acquired a software package called Software for Offshore Structural Analysis (SACS), developed by a company

called Engineering Dynamics, which has been developing offshore software for structural engineering since 1971.

Nearly every offshore company is using either SACS to analyse its structures, to see if they might be likely to last another 10 years, or whether they can take more equipment such as injection pumps, Ms Walters says.

More recently the SACS product has been used for assets like FPSOs, to help extend life.

This year, the company launched SACS Connect Edition Version 12, where it can do finite element analysis for “extreme events” as part of the design work.

It also added more sophisticated engineering analysis, and better tools for analysing how offshore weather would affect structures, including extreme weather or a ship collision, and extending asset life.

In October 2013, Bentley built on the SACS acquisition with the purchase of a software package called MOSES, developed by a company called UltraMarine.

It is described as the “premier analysis and simulation software for complex projects involving the transportation and installation of offshore structures, including the launch of jackets and floating over of topsides.”

Another recent acquisition was a geotechnical (subsea) integrity analysis tool called (Plaxis), which will show how a building will affect the rock or soil beneath it.

Much of this software development comes out of university research in the Netherlands, looking at maintaining water protection from the sea, with much of the country on reclaimed land below sea level.

Using all the software tools together makes it possible to model both offshore structures and the seabed they sit upon, at the same time.

## AssetWise

In 2012, Bentley acquired a Canadian company called Ivara Corporation, which makes an asset performance software called

AssetWise.

By putting AssetWise together with the structural engineering software, it is possible to monitor structures over their lifecycle, as well as when they were constructed.

AssetWise also has tools for managing the various chemicals which are used to manage assets and inhibit corrosion. It can help make decisions about chemical usage, dosage rates and inventory. These capabilities will help reduce chemical costs by at least 10 percent and improve availability of inventory across the operation, Bentley says.

There are analytics tools which can automatically identifying rust in photographs, and being trained to understand the colour, extent and pattern, how much rust has been eaten away and so work out how bad it is.

## Working with photos

In 2015, Bentley acquired a company called Acute3D, which produces the Context-Capture software which can combine (2D) photos together to create a 3D model.

The software looks for common points in photographs, and then joins the points, creating a kind of mesh model - wire frame mesh model. The company calls it a “reality mesh”.

The 3D models can be provided to an engineer, to help her get a better sense of what she is looking at.

They can also be used to make measurements, or understand the condition of an asset better.

The engineer does not need to go back and take any more photos, all the information is there.

One company used this in the Gulf of Mexico, with unmanned platforms and wellheads close to shore which need decommissioning.

They were extensively photographed by sending out just a speedboat with a drone and a drone operator, capturing all the information necessarily within an hour.

# Teradata – getting data out of the applications

One of the biggest hurdles for oil and gas companies in their analytics projects is finding ways to release data which is 'locked' in software applications. Teradata's Jane McConnell explained why the problem exists and how to tackle it

One of the biggest hurdles for oil and gas companies in their analytics projects is finding ways to release data which is 'locked' in software applications.

The problem arguably exists because of the industry's preference for "buy" over "build" over recent years, preferring to purchase the software applications available on the market, rather than build their own, said Jane McConnell, practise partner oil and gas with Teradata, speaking at Digital Energy Journal's October forum in Kuala Lumpur.

For example, many companies have subsurface data locked in Petrel, business data locked in SAP, and operations / facilities data locked in engineering applications, she said. They also have a number of proprietary systems for storing data over the long term, including well data archives, borehole data archives, seismic data archives, operational data archives.

Companies bring data from these archives into their subsurface modelling projects, drilling projects and data science projects as needed, involving the development of 1:1 connections.

This all makes it harder for companies to get the benefits of analytics. They could find ways to produce oil faster, cheaper or more efficiently, or improve the success rate of exploration, produce a higher percentage of their reserves, improve safety, use less energy in the process. They might use analytics to see that drilling can be done safely in a part of the world which most drillers would not touch due to concerns they might be drilling into very high pressure areas.

Companies should aim to gradually migrate their data management into one integrated system, which the various apps would draw data from as they need it, to support the work people want to do, she said. In other words the mantra could be "data first, apps second".

## Integrated data strategy

This is something companies need to think strategically about. And when it comes to data strategy, a common problem is that companies bring in consultants who advise them to try to 'monetise' their data, doing extensive analytics on it and copying Uber and Netflix, she said.

But oil and gas companies are not like Uber and Netflix, who gain competitive advantage from

changing the way that products are sold. Oil companies are not looking to do this, but improve the way that they produce it.

A better data architecture for the oil and gas industry might have continuous flows of data going in, being checked, being analysed, and then being made available for the various software applications people work on, she said.

Where you have software applications, they are just 'consumers' of data, helping to do specific tasks or analytics on it, such as for subsurface interpretation, well planning, production forecasting and simulation. They would interact with the data architecture through an API.

This is a big change from the software applications of today like SAP, which handle all the tasks of data acquisition, organisation, storage, analysis and visualisation.

Ms McConnell suggests changing your structure gradually, first having an integrated company wide data acquisition system, then adding data storage and analysis to this integrated system, and removing these tasks from the software applications.

## Receiving data

A critical part of such an architecture is the way that new data is entered into the system.

The oil and gas industry has many sources of data, generated by business transactions, people, interactions and machines (sensors).

A good architecture would have a system for checking and integrating the data, and storing it in a "reference information architecture" in a standard format.

Data should be picked up automatically and automatically 'ingested' through predefined data pipelines built by data engineers, following a data flow defined by a data manager. The pipelines can determine where files need to be parsed or split, what to index, what to load into databases and what quality checks to run.

This replaces methods where data is manually 'imported' into the petrotechnical software with a fixed import procedure, and data must be in the right format, and loaded in the right way, otherwise it doesn't work or errors creep in.



Jane McConnell, practise partner oil and gas with Teradata

Data should also be freed from its historical file formats, such as tape, which are hard to interrogate.

Data should be standardised as much as possible, including

standardising master data, reference data, units of measure, geospatial data. You can add business and metadata, and data quality checks, along the way. So it all delivers data which is ready to use in analytics.

It might be useful to compare an oil and gas data architecture to the way water is provided to our homes, with data quality management being equivalent to processes to check water quality, and IT being equivalent to processes to manage the integrity of the plumbing systems, she suggested.

## Connecting different domains

This common digital architecture should also have data from all parts of the company, rather than having separate data stores for business, subsurface and operations, as is common today.

If the data stores are separate, it makes it much harder to do a business process which might involve data from two domains. For example if you want to analyse business performance but with data about actual production operations, not just data in the business systems.

The problem is made more difficult by the different working styles and language the different domains use.

In the 'business' departments, most companies use SAP heavily, and it stores a lot of transactional data. This is normally well known by the IT departments, but not necessarily data management people. There are also often data science people looking at SAP data drawing out business intelligence.

In the subsurface meanwhile, data management is often done "library style", receiving data on

tape or disk with a requirement to store it safely and make it available when needed. And a lot of the data is stored in software applications from companies like Halliburton and Schlumberger. “I don’t think I’ve ever seen an oil company where subsurface data has been managed by the same people who manage SAP and E-mail,” she said.

The facilities side has two main “chunks” of data, sensor / control system data, and documents such as CAD drawings and project plans. There are no models for linking data across multiple facilities, as you might need for making predictive maintenance models. Automation systems were built for controlling plant – no-one expected them to be used to generate data for predictive maintenance models, she said.

A common problem is understanding data from historians, where you don’t have a good way of identifying the tags (the piece of equipment which has the tag number in the historian data). Data analysts might want to connect performance with for example equipment installation date or its maintenance record. Sometimes the only record of a tag list is hanging on the wall in an office. “I’ve seen that way more than once,” she said.

The different departments run on different time-scales, with subsurface data valuable forever, business departments making management reports usually for the past few months.

To illustrate the differences, consider the way the word ‘model’ is used by different departments. Business IT people might expect to see a financial model, subsurface people would expect to see a subsurface model, facilities people might expect to see a CAD drawing, data scientists expect to see a regression model. So there can be communications difficulties.

The word ‘asset’ also has different definitions. To a business department it means money, to subsurface people it means an oilfield, to facilities people it means machinery or an offshore platform.

## Data management organisation

If companies are going to manage data themselves rather than just manage data within software applications, then they will need competent data management staff and governance systems, which can work in all company departments.

The oil and gas industry should see data management as a core skillset it needs, in the same way as it sees IT architecture as a core skill, even though some data managers specialise, such as in subsurface geotechnical data.

There should be a proper career path in it at oil companies.

Roles can include data archiving, security, ownership, metadata management, managing reference and master data (so the same well name is used in all computer systems).

The enterprise data management department should be responsible for setting rules for data quality and making sure they are implemented, leading to gradual improvement in data quality as it is measured.

They should be managing core tasks like standardising data models and metadata management. You could have a chief data engineer for specific areas, such as subsurface, facilities and business data.

Many companies manage their digital transformation by establishing a “digital office” established separate to the rest of the company. The digital office might manage a ‘data lake’ but not link directly to anyone’s day to day work.

But for this “digital office” to be sustainable, it needs to gradually become an integral part of the company, she said. For the same reason, outsourcing it is probably not a good idea.

Data ownership needs to be carefully thought through. In most oil companies, the subsurface data is owned by the exploration departments, because they had it first. But they are not the people who will need to use it over the lifecycle of the oilfield.

Data stewardship is always going to be important, checking that data is about what it is supposed to be, in the right standards, and properly managed. “Someone who cares about the data.”

## Why oil and gas is different

One question which often comes up in data management projects is how different the oil and gas is to other industries – or whether an approach which worked well in other industries should work here, too.

Ms McConnell has seen some of Teradata’s work doing similar tasks for other industries such as retail and e-commerce, and finds the oil industry isn’t as far behind as commonly thought.

“Sometimes they are getting stuck on stuff that’s pretty simple compared to what we deal with,” she said.

But many other industries moved away from storing data in software applications some years ago. “We’ve stayed trusting applications to do the work for us for quite a while. We’ve got quite a little bit of catch-up.”

The oil industry also has very complex technical terms to describe its data, something which is seen much less in banking data for example.

The types of data in oil and gas is always increasing, for example from new sensors being installed.

Another problem unique to oil and gas is the importance of measurement data. In banking, the only unit of measure is the currency. The oil and gas industry also has to deal with masses of data in old formats.

The oil and gas industry doesn’t need a large number of different technical solutions to improve, but it does need to do “a lot of work” simplifying and integrating the software structure it currently has, she said.

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Delegates at our Kuala Lumpur forum in October 2018



# How data managers can do scripting

Alvin Alexander, geo technician from JX Nippon, taught himself to do scripting with Python to automate common data management tasks. He explained how he does it at our KL conference

Alvin Alexander, geo technician from JX Nippon, taught himself to do scripting with Python to automate common data management tasks, and believes other data managers can do the same.

He shared his experiences and advice with a talk at the Digital Energy Journal forum in Kuala Lumpur in October.

It can be a lot more fun working by making scripts, rather than doing lots of manual work with a keyboard, such as making and copying folders, or copying data from one spreadsheet to another.



Alvin Alexander, geo technician from JX Nippon

Mr Alexander also has a bad wrist pain which emerges when he uses the mouse too much. So he writes scripts to automate as much as possible.

Mr Alexander has only been programming for 7 years, learning mainly from “a lot of online courses”. But he says the fastest way to learn is to encounter real problems and have to solve them.

And when you automate tasks, there are usually a lot less mistakes than from in manual work, such as from pressing the wrong key.

But the most important motivator for scripting can be that it is more fun finding a better way to do something.

“If you’re not having fun you’re not doing something right for you,” he said. But when you have fun, it increases your motivation, you are more productive, so it is better for the company too.

A starting point is to recognise that there is a very big difference between scripting and programming, Mr Alexander said. Programming is complicated work of building software. Scripts are something designed for a specific problem, such as “generate folders from a list”, or doing machine learning on log data. Data managers should focus on scripting, not programming.

When considering building an automated solution, a first question is how often you spend

doing a task. If it is a five second task, it probably doesn’t need to be automated. “If it takes three days, it probably needs to be automated.” If you have done something twice, maybe you will need to do it again, and it makes sense to automate it.

And if you have good skills in a programming language, particularly Python, maybe you will want to automate everything. Or there might be scripts available free online you can just copy.

## Examples of tasks

Mr Alexander gave some examples of common oil and gas data management tasks which could be done faster with scripts.

A “plain boring” task data managers might be asked to do is generate 200 folders from a list of folder names you want created. “It takes forever”, he said. “Copy one item, create a folder, rename, paste. In Python you can do it in 5 lines of code.”

A second example is to consolidate 5 Excel spreadsheets into one. Instead of doing this, you can convert the spreadsheet into code. “It doesn’t matter whether you have 5 or 5000 excel sheets, it is the same amount of code,” he said.

A third example is extracting data from a well log (LAS) file. For example, you want vertical permeability data at a certain depth. Usually this is done by opening the LAS file with a text editor, and copying the columns into Excel. You can buy software to do this, but it is probably not free.

Mr Alexander wrote his own “parser”, a software tool to break up well log data into useful elements.

You can make an automated solution with free code which will look for key words in the text. So it can copy pressure data only for a certain range of depths. A more involved question is to show how the permeability is varying by depth.

A fourth example is drawing curves. You can get Python code to draw perfect Sine waves, squares, perfect angle spiral, much better than drawing it by hand

In one project, Mr Alexander needed to trace a typical gamma ray curve. He tried doing it by hand using a mouse, or by looking for software which could do it digitally, but neither worked

well. So he wrote a script to trace the curve image.

A fifth example was a tool which can create a list of all of the data files on a CD, no matter what the folder structure is. This is very useful to a data manager who has been handed a CD with unknown contents and wants to understand what is on there.

## Using Python

“Python, among all programming language that I learned, is the most friendly, almost like talking to you, almost human language,” he said. “Not like Java or JavaScript.”

It can be amazing how little code you need to write with Python, because most of the code you might need is freely available. “The community is so nice, big, friendly, they provide almost everything for us. We almost never need to write any code from scratch.”

Mr Alexander recommends the Anaconda Distribution software for installing Python, with all its modules, and a store of tools to run on it, “like Google Play store for Android”.

You don’t need to use an IDE (Integrated Development Environment), as you do in computer programming.

There is an open source web application called Jupyter Notebook which can be used to run specific lines of code. “It’s very easy to use,” he said. “Since I learned this, I learned Python a million times faster. IDE is so confusing. There’s so many unnecessary things. In this it is only code. A lot of the scientific community really favour this.”

## Original work

Mr Alexander concluded with the Gustave Flaubert quote, “Be regular and orderly in your life, so that you may be violent and original in your work.” - this sums up the approach to data management, if you are orderly in how you go about managing data, it is possible to do much more with it.

In oil and gas, the people doing the “violent and original work” are the people who work with the data, such as the geologists, geophysicists, petrophysicist, reservoir engineers, other engineers – and many data managers are themselves also geologists so users of the data.

## “Simple objectives best” with ML

Machine learning projects can do better if you keep your objectives simple, said Manoj Goel at our KL forum – with a case study of automatically extracting valve data from a P&ID

It makes sense to keep your objectives simple when embarking on machine learning projects, taking one step at a time, said Manoj Goel, director of Reliable Business Technologies, a software systems Integrator in Kuala Lumpur, speaking at the Digital Energy Journal KL forum in October.

“We have to keep simple to succeed,” he said. “You have to take one baby step at a time and solve results. Nothing can be solved in one day. For a marketing perspective we like to sound complicated because we do not want others to do what we are doing.”

Computers are only capable of a fraction of what human intelligence can do, he said, but computers can do some of the drudge work which people do, perhaps the work which does not draw deeply on human intelligence but does take up a lot of time.

Mr Goel presented a case study of how his company developed a machine learning application to read valve data from piping and instrumentation (P&ID) diagrams, drawn on paper and scanned, on behalf of a major oil and gas engineering contractor.

These drawings can be large and complicated at times. The client was paying consultants to extract the data from the diagrams, a task which was proving expensive, slow, repetitive and error prone.

The main computer challenge was understanding the different symbols used on the charts, describing different types of valves and lines, and which can be drawn at different scales and orientations. Sometimes the labels are handwritten. Some of the scans of the paper diagrams were not very high resolution, made at a time when scanning technology was less advanced.

The project was split into two phases, with the first phase objective just to create a list of valves, including all the metadata, size and rotation in a spreadsheet. It is a computer vision problem – you get an engineering drawing as an input,” he said.

The project team decided to use the TensorFlow open source software developed by Google, which can build neural networks for image processing. It took 5000 lines of Python code on TensorFlow altogether. Most of the design work is working out what kind of model you



Manoj Goel, director of Reliable Business Technologies

want to build.

An alternative is Keras, which is also open source, written in Python, and can run on TensorFlow and other systems. It has a better user interface, it is easier to make

models,” he said. There are proprietary tools available, such as IBM Watson, but these are not necessarily the best tools for starting off with, he said.

The project team found that a 3 layer neural network model could get results 100 per cent correct, with P&IDs scanned at 200 dots per inch (dpi).

Where the computer was not sure what the symbol was, it could guess and assess the probability that it was correct.

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## Bain – organisational and capability aspect the hard part

While technical aspects of digitalisation are “relatively straightforward”, the organisational and capability part can be “something of a minefield,” said Peter Parry, partner and leader, oil and gas with consultancy Bain

While technical aspects of digitalisation are “relatively straightforward”, the organisational and capability part can be “something of a minefield,” said Peter Parry, partner and leader, oil and gas with consultancy Bain. But “the organisational components and the capability components of this are really fundamental to getting it kick started.

He was speaking at our London forum on November 19, “Solving E&P problems with digitisation”.

“It’s not a one-time decision, it’s a generational thing. We change the organisation slowly,” he said. “We build competence and capability over decades sometimes. But here is a subject where we need to build those capabilities pretty quickly.”

“The organisational components are going to be very fluid. We’re not going to end up with hard and fast structures, we’re going end up with very dynamic things. But we need to start to move forward without a hard and fast destination in mind.”

The big question is what is the right capability and organisational structure to deliver this. “The answer is rather difficult in practise, rather easy in theory,” he said.

It is commonly said that people overestimate the impact of digital in the short term (how quickly they will see good results). But they also underestimate the impact of digital over the long term, the sizes of the changes which will be possible.

Digital can be seen as a number of different ‘waves hitting our organisation, first with the technology, and then in how it affects people

and physical assets.

### Benefits

To see an example of what happens when you get digitalisation right, it might be helpful to look at the wind energy sector, where companies have improved the physical perform-

ance of their asset based on digitalisation of all aspects of operations, he said.

“Running a wind farm with outstanding digital capability to support and optimise it can add 30 per cent productivity to that asset,” he said. “It can improve return on capital of a renewable project from around 8-9 to 12-15 per cent. Some oil and gas companies are taking upstream people into their renewables business and say come and have a look at this,” he said.

Mr Parry shared similar ideas at a Rosneft technology conference in Moscow in November 2018, with an audience including an asset manager from each of their assets, and a representative from each of their service and supply companies, adding up to about 2000 people.

For an organisation the size of Rosneft to realise the potential of digital technology, getting the organisation to work together is key, he said.

### Agile

One new way of working is “agile,” which can be described as a way of working which means “putting things that are not working aside very quickly and focussing your time and attention on things that are working,” he said.

The Agile working method was developed in domains such as product creation, but can prove to be “fantastically differentiating” in oil and gas exploration. “You can squeeze projects that took 4-5 years into several months by working in that way,” he said.

Agile is “an entire way of working,” with people who can focus on ideas, get ideas to the business, and deliver as well.

There can be big resistance to agile ways of working, or people thinking it is nothing new. “It’s not how you will work, but about how teams will work, how quickly they will get negative outcomes off the table and positive outcomes moving forward,” he said.

It can be difficult managing procurement in an ‘agile’ world, because you don’t yet know exactly what you want. You need to structure the purchase as an ‘outcomes’ not physical assets. But companies are used to paying for specific machinery, or people-hours. An agile contract might say the outcome needs to be in a certain range, and the payment will vary de-

pending on what the outcome is. A contractor which proves unable to take the project forward needs to be quickly dropped.

People who work in technology organisations can often seem to do projects “for their own entertainment,” he said. “This process has to be pretty brutal in sorting the good from the bad.”

### Open platforms

Another good way of working is “open platforms”. This can mean a reverse of how the industry got competitive advantage over the past few decades, by having proprietary technology or insights, so it can close doors and have “things that we can do that you can’t.”

“Getting the best out of digital is about opening those doors, being the easiest to work with. About allowing others to build on your platform,” he said. Similar to how many software companies are making apps for mobile phone platforms.

“I just finished working with a very large company in their technology division. Getting that group of engineers to think open platform as opposed to proprietary technology is a massive change,” he said.

### Where do you start?

A simple list of projects oil and gas companies might want to be working on might include autonomous robots and vehicles, additive manufacturing (3D printing), internet of things / wearables / sensors, digital engineering and training, virtual and augmented reality, cloud and security, big data / advanced analytics, artificial intelligence, mobile and digital engagement, and robotic process automation.

“This is a typical portfolio of digital projects in E&P company. They are technically fascinating and can consume an enormous amount of time and resource,” he said.

But in terms of business results coming out of the back end, just about all are underperforming.

Of these 12 sectors above, the ones with the best results are autonomous robots and vehicles, digital engineering and training, and big data /advanced analytics. “These three areas you would expect to be furthest ahead in having deployed digital technology, in having seen re-



Peter Parry, partner and leader, oil and gas with consultancy Bain



sults, in terms of building new capabilities and sorting out organisations wrinkles, bottlenecks.”

Autonomous vehicles and robots are increasingly used onshore and increasingly offshore.

Digital engineering and training is proving to have fascinating potential. One idea for training could be for offshore workers flying by helicopter to start their shift having training via their headsets on the flight, getting an update on what has changed while they were away. “Training doesn’t mean just sitting in a room and listening,” he said.

Big data, advanced analytics and AI prove “easy to say, pretty hard to deploy at scale,” he said.

Ease of implementation of these technologies is usually a matter of capability, if you have a workforce able to use that technique, information, or changed way of working very quickly.

Meanwhile oil and gas companies are clear about what impacts they want to see, such as a big change in their HSE performance (which can be simply from taking people out of hazardous environments), and reduced capital costs of 20 per cent.

## One-off results

When oil companies cite specific results from digital technology, he said, they typically refer to one-off examples, rather than across their whole company. So they have reduced costs by 60 per cent but on just one project, or seen a 30 per cent production increase but on just one field.

This is equivalent to a bank saying that its customer satisfaction has improved by 60 per cent, but then saying “the customer who is more satisfied is that customer over there,” he said.

This focus on performance over just one project means that the organisational elements and capabilities get left behind.

## The entire organisation

The only way to get a big impact from digital is if the entire organisation does it. “I’m rarely going to get a big impact from a few folks doing something,” he said. One of the biggest struggles big oil companies have is with “speed and scale” – they have some results, but it isn’t being rolled out fast enough or having a big enough impact.

“It is only when you are investing heavily behind capabilities you’re going to get a good return on that investment, and maybe a significant competitive advantage. “If you don’t have these

things right you’re wasting your money, it’s a hobby, and it’s never going to have a substantial impact.”

Three organisational elements you need to make things work at scale are some kind of mission or strategy, some targets and governance, and operating models which include digital.

The strategy is needed to get the necessary resources committed to the digital initiatives.

The governance means there is clarity over who is in charge of the project and responsible for it. Sometimes this is shared between different parts of the organisation, such as the upstream business, regional technology centres or an asset manager.

The operating system needs to be updated to include digital. Many companies have operating manuals but have not updated them. “You cannot find, in a major oil and gas company management system, a description of how to manage drone operations,” he said. “It is somewhere under aviation.”

The capability isn’t necessarily all built internally, you can buy it in, for example by hiring data scientists.

Many people believe that the relevant business departments of oil companies, staffed full of engineers, must have the competence and capability to handle digital technology.

But while traditional oil and gas technology might change every 6 years, this sort of technology changes every 6 months. “So if you’re not focussing a lot of attention on how the outside world is adapting you are basically implementing yesterday’s solution.”

## How to deploy

It is often not the choice of technology which is most difficult, but the way to deploy it – and whether it should be pushed by the company centrally or by individual business units.

If technology does not have a particularly big impact, it might be better just to let the relevant business department decide whether or not to implement it.

If it only involves one business area, then again it should probably be implemented by that business unit.

If it does not have any disruptive or negative implication on anyone, then again the relevant business unit should be involved. And if the business unit has the capability to run the project then it probably should.

The company’s headquarters should get involved in other cases – for technology with a very large potential impact, which may involve multiple business areas, some negative impact or disruption to some people, and new capabilities.

Out of oil and gas 33 digital projects Bain considered, it turned out that only 7 of them should have been handled at a corporate / headquarters level.

## More data analytics people?

There is often a big shortage of data analytics people, if it is defined as people who use business information to try to improve the overall performance of the business. About 0.1 per cent of oil and gas employees are doing this. Engineers, geologists and geophysicists are all trying to get value from data, but with a different objective.

By comparison, about 1 per cent of employees in the automotive sector are working with data trying to improve business improvement, and about 7 per cent of employees of tech companies such as Amazon, Google and Netflix, and this number may be too low.

“I would argue, 0.1 per cent is not going to get you anywhere,” he said. “If you don’t change the way of working to realign with the way digital is going to provide capability, you won’t get anything out of it, it’s as simple as that.”

You also need the IT support functions able to work with the new software, and not always trying to catch up. One example is a company which bought a big piece of software, but their IT system could not enable it to be used in more than one location at once.

One oil and gas company, a “mid-sized European player”, was looking at the best way to set up an analytics team. Bain showed them what it would look like, taking best practise from other industries, and suggested there would be a customer or business function, a business analyst, data scientist, chief analytics / data officer, a data architect, data engineer, data analyst, data visualisation engineer, IT function support, service providers (e.g. cloud), platform service provider, digital ecosystem partners.

The analytics person is in this team, but sitting around a large infrastructure of people who can develop the system and take it forward. “You don’t have to hire all these people but you have to have access to them, have them plugged into your system,” he said.

## Using automated data clean-up techniques

With data being generated so quickly, organising data manually isn't feasible any more, you need a machine to help. Wacław Jakubowicz, managing director of Hampton Data Services, shared some tips

In the past, or up to the present day, it was possible to manage or clean data manually, as with physical libraries.

But now data is being generated so fast it is impossible to do it manually. So you need a machine assisted process, explained Wacław Jakubowicz, managing director of Hampton Data Services.

For example, machine learning tools can analyse documents to see which words occur most often, and try to classify it automatically. Another technique is to link data to objects, and then classifying the objects.

They can see which data appears to be related to other data, from looking at references in the headers / metadata.

You can get a sense of the general patterns of data about production, engineering, economics, and field development.

Once you have a sense of how data is created, you can see which data is missing, and then try to find it.

Machines can analyse data much more widely than people can – people typically just clean up the data they need to work with, Mr Jakubowicz said.

A challenge with any data clean-up project is that new data is being created all the time, which needs to be stored so the system understands which wells, assets or subject matter it relates to. Managing new data also requires active data management work. “You cannot rely on users to nicely file a file. They'll make 20 different versions,” he said.

Managing PowerPoint files as also part of today's data management work, since they are typically made at the end of a project to summarise everything, with investments made as a result of them.

### Case study - Reach Energy

Hampton Data had a data clean-up project with Reach Energy Bhd of Kuala Lumpur, which had bought a controlling interest in Emir Oil LLC in Kazakhstan. It came with a great deal of legacy data.

The database was multilingual, including with material from Beijing and research institutes in Kazakhstan, all poured together. Some data was

in Chinese, some in Cyrillic character set. The main dominant language and character set was English.

The data had many co-ordinate problems, and poor notation about what comes after what. A number of different data management companies had tried to improve it.

A first step for Hampton was to move the data to its own server in the UK. A separate copy of the data was kept in Aktau, Kazakhstan, synchronised with the data store in London. This means there is a complete backup in both locations. This covered both new data and legacy data.

Then it started a number of processes to rationalise and clean up the data.

An initial problem was understanding well and place names. Some wells were given multiple names (or aliases), or their names are spelt in different ways in Cyrillic. There can be files named in English, Russian and Chinese in the same folder. “You have to be multilingual to get your head around that, he said.

Hampton Data has developed its own translation tools through its work in different countries over the years, so it can auto translate file names from Russian and Chinese into Latin characters. The headers can also be auto translated – but with the formatting maintained.

Often the file name will itself indicate what the file is about, for example “core data from xyz well”, or “PVT analysis”. This means that English speaking engineers trawling through the data find it laid out for them nicely.

Hampton Data works with a company called XTM, which specialises in managing technical documentation, and also works with many large automotive companies. It gathers libraries and vocabularies specific to the industry, something Google Translate does not do. Documents can also be translated for other users, not necessarily into English.

### Nephtin Energy

Another client is Nephtin Energy, a start-up company based in Dublin, Ireland, which acquired a large gas field offshore Ireland, formerly operated by Shell UK. The investment funds came from a Canadian pension fund. Nephtin produces 60 per cent of Ireland's natural gas.

The data was very organised, as you might ex-



Wacław Jakubowicz, managing director of Hampton Data Services

pect from Shell. But the volumes were very large.

It would have taken a few months to do a data audit manually. Hampton was able to do it in a week with automated tools.

Nephtin runs with a very low number of employees, and is outsourcing as much work as possible to outside consultants. It uses Microsoft Azure for its IT infrastructure, and would like to have all of its data and applications on there.

One disadvantage of Azure is that “every time you look at data, move it about, you get an invoice hitting you,” he said. “It is an unpredictable beast, no-one knows what it will cost them at the end of the day.”

The company has moved data to the cloud in the same format as it was when they acquired the asset, they are not re-arranging any folders. Hampton provides a virtual “data custodian” system which runs semi autonomously, keeping the data organised.

It would be helpful if the applications and data could be stored on the same cloud infrastructure. But big subsurface software providers typically only want their software to run on their own cloud, which makes it tricky.

“If you want to bring your own bit of software like Hampton Russell or something else, it is not exactly encouraged,” he said.

There can be some flexibility, but it generally ends up that the larger the oil company, the more leverage they have to dictate which cloud will be used.

There are many smaller software companies who would like to run tools together with other software, including subsurface time depth conversion software, various simulators, petrophysics applications. But they can't, if they don't have access to the same cloud that the bigger software is running on, he said.

For example, one start-up company called Antaeus Technologies is looking at applications for wells, such as log interpretation and geomechanics. They have developed applications to work on the cloud.

# Teradata - why oil and gas struggles at digitalisation

If digitalisation is using data to drive your decision making, then perhaps that explains where companies are going about it the wrong way, if they start by trying to be like Uber, said Duncan Irving of Teradata

Duncan Irving, oil and gas practise partner with Teradata, defines digitalisation as when you can use data from your various operations and processes to drive your organisational decision making. With the right sort of data, it becomes a competitive capability.

But analytics can still provide plenty of value. For example, if we can standardise data for all the well plans we ever drilled, then we can analyse data and maybe relate it with data about the well's performance over its lifecycle, and understand why some well plans lead to better wells. The well planners have a better understanding of their process, and which aspects of the well planning process are most critical in terms of lifetime performance.

The oil and gas industry might be better off trying to understand the actual decision making and interactions which happen, he said. For example, people might be trying to understand whether one well is similar to another, and analytics might help with that. Or there might be better ways to gather data when multiple companies are involved in a project, for example multiple drilling contractors on one project, who could have a bigger and deeper data communication.

Another problem is how much the industry is motivated by hype in how it chooses technology. Today it is possible for an analytics company to get a meeting with an oil and gas company just by saying they are making 'machine learning', because people have basically been told to get a machine learning project by their management. "People are that shallow," he said.

Many software companies are just putting a 'machine learning' button on their software. "That's not serving either the organisation or the industry well in understanding how to use these new capabilities properly," he said.

Sometimes when companies say they want machine learning, they are really saying, can we have some cool stuff. What they really need might be "pretty simple stats."

For example, a desirable output could be a simple cross plot graph, showing how one piece of data varies with another one, which reveals the system works differently to how the experts have always believed.

Teradata did a successful project for Siemens with rail locomotives, combining sensor data from trains with operational data, and then being able to make predictions about when various

components would fail in future. The project could be considered more data management than data science, he said.

## Misunderstanding data science

There's a massive misunderstanding in the oil and gas industry about what data science and data engineering actually mean, he said. There's nothing fundamentally wrong with these disciplines, but you should not expect a data scientist to have the same understanding of drilling that a drilling engineer would. You have to sit a data scientist next to a drilling engineer with 20 years' experience and let them get on with it."

A data scientist is unlikely to be particularly good at preparing data and understanding data quality – and also knowing what a 'system of record' can do.

Data scientists are usually good at statistical analysis of data, which is something most engineers don't understand. But they are less likely to be good at vector calculus, which can be important for physics based simulation.

"We are expecting a lot from people with a PhD in maths – but not the right flavours of maths," he said. "I've seen that go very badly for them. They haven't been re-wired. But it's not their fault, it's our fault."

Sometimes recruitment consultants overpromise when selling candidates to industries, saying they are skilled in machine learning.

Machine learning can be considered part of artificial intelligence, which has been under development since the late 1950s. There is a lot to know about it. Data mining has been under development since the 1980s, looking for relationships and patterns in data which can provide some useful insight. So there is a lot to know about it.

If you have a big data clean-up task, you are probably better off giving it to one of the data management companies which specialise in it, rather than giving it to data scientists.

## Locked in software

Much of the technical data in the industry is locked in specialist software applications, provided by service companies.

This could be attributed to many years of oil and gas technical experts finding that they could not get what they needed from their in house IT de-



Duncan Irving of Teradata

partments, and so they asked a service company to provide their software and databases as "application suites", and a data management company to manage the data.

The IT departments "didn't understand what a workstation was for, or what those application silos did, or how to maintain them so the users could work with them wherever they were in the world," he said. This move led to data silos, "both physically and culturally".

We have got there because we preferred to "buy" rather than "build". "No-one got fired from buying a few more licenses from your favourite service company," he said.

It means that the only way to integrate software from different software packages is to export it into Excel.

One way out of this is for more data to be stored on the cloud, which means it can be accessed more easily by other systems.

## Data clean-up time

It is typical for data clean-up and integration time to take far longer than the actual analytics work, Dr Irving said. In one project, the geophysical and geological team took two months to integrate all the data they had about new acreage, then three days to use it to work out where the 'sweet spots' were for drilling.

In other project, to try to rank different options about how to plan and complete a group of wells, it took four months to standardise the data about past well plans, so they could be compared.

Another project team of five data scientists spent six months trying to integrate data from drilling operations and geological/geophysical departments. "And these data scientists are not cheap," he said.

"It makes data scientists feel a little bit sad to be doing something as mundane as this. They come into an industry, full of excitement, and you've got them effectively sweeping the digital floor, it's heart-breaking. Then they go off and work for a bank."



## Tessella – Putting the ‘data’ in data analytics

Oil and gas companies are excited about the potential of data analytics. However, they struggle to move from a promising idea to something useable in everyday operations. The problem, says Dr. Warrick Cooke, consultant with data science company Tessella, is the data being fed in to their models.

There is little doubt in oil and gas that data offers huge potential to improve efficiency and safety and save money. There is also little doubt that it is mostly failing to do so.

A major reason for failure, says Dr. Warrick Cooke, consultant with data science company Tessella, is a focus on data tools and models, at the expense of the actual data itself. Garbage in, garbage out, as the old computing adage goes.

There has recently been an explosion in easy-to-use data tools, such as Microsoft Azure, says Dr Cooke. These are extremely user-friendly, and push users to be hands-on and try things out, allowing quite powerful data and machine learning models to be built with relatively little experience.

Users can quickly come a long way with these tools. There are lots of simple tasks that they do well, and they are great for proof of concept models built on well understood test data.

“But they are quite formulaic, and they don’t encourage good practice in ensuring results are repeatable when models are applied to messy real-life production data”, Dr Cooke says. The result is models which work on test data, but are not fit to be released into the wild.

Dr Cooke makes an analogy to the early days of Visual Basic. “It opened up application development to a much broader audience, but many of these would then break once deployed. Eventually companies learned that making these applications a long-term success needed qualified software engineers.”

### Get the data right first

Tessella has a history of working with the oil

and gas industry to develop models and curate data. “We often find data is the biggest sticking point,” says Dr Cooke. “It can be fragmented, incorrectly labelled, missing information such as time or location, or not properly indexed.”

He gives an example of an oil company looking at drill readings to analyse drill team performance.

“Often data will not have consistent naming conventions, so two comparable pieces of data are recorded differently,” he says. “Equally, different data can be named identically. One company comparing asset performance was using the same Well ID across different regions. Our team needed to update the data before the model would work.”

The list goes on. Data is captured in different formats, sometimes even as scanned pieces of paper. Metric and imperial units are mixed. Data is missing; Dr Cooke tells of a project using sensor data, where one sensor was down for half an hour, creating a gap in the time series. Models built using ideal datasets can’t deal with these inconsistencies.

### If something’s worth doing

Models need good data to get good results. This means developing a system for naming things, and agreeing consistent data formats for wells, sensors and equipment. In most cases, it means considerable changes to existing data and data collection methods. This takes time and effort.

Where data is missing, domain experts should assess what it should look like. A data analyst may be able to tell you what they expect it to look like, based on the past patterns, but this is risky. What if the absence of data was caused



Dr. Warrick Cooke, consultant with Tessella (right)

by an unexpected event? It is often the gaps that represent the most important information for training models to recognise warning signs. Domain experts have the contextual knowledge to fill these in.

Even with good practice, real-life data is rarely perfect. Good models should be designed to cope with the unexpected. Problems such as inconsistent units or missing data can be overcome, but only if the problem has first been identified and the model trained to deal with it.

Just as critical is testing the model on less than perfect data – of the sort it will encounter in the real world – to see how it performs. This allows problems to be identified and modifications made, either to the model or the data – to ensure it delivers meaningful insights.

Testing should be ongoing. Expanding the model to new assets will bring new data problems which need to be factored in. This is true of any change, including when data sources such as new sensors are added to existing systems, or updates made to the model.

“Building a good model is important, and modelling tools can be a good starting point to test ideas,” concludes Dr Cooke. “But if you want a model that works on real-world data and scales across diverse assets, you need to ensure data is properly curated, and models are rigorously designed and tested.”

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## Doing more with a data lake

The idea of a data lake, a central depository for information, is popular in the industry, but many companies don’t get the value from them which they expect. Dave Camden, IM consultant with Flare Solutions, shared some experiences

The idea of a data lake, a central depository for information, is popular in the industry, but many companies don’t get the value from them which they expect, said Dave Camden, IM consultant with Flare Solutions.

Data lake is a technology which people get excited by, including a new generation of

people coming into the industry. But it is also basically just a file store, and getting value from it requires good data management systems.

These are problems which many people have decades of experience working with. “We’re still having to think about these things we’ve always had to think about,”

he said.

Data lakes can get very large, some as big as 3-5 petabytes (one petabyte = 1000 terabytes or 1m gigabytes). They are usually cloud hosted, and designed for fast data access. The data is usually in its original state (files or data objects). Some people have described them as “a place you put data



Dave Camden, IM consultant with Flare Solutions

until you decide what to do with it,” he said.

People usually start building them with an empty data store, then they put in folder systems, copy in their

files, and design data ‘feeds’ for new data to go in. “You are buying a bucket to put your stuff in, a file system,” he said.

A data lake can be a precursor to analytics, if you need to gather data together first. It is a way of taking data out of data ‘silos’, making the company data available to everyone in the organisation.

Putting data in the data lake is cheap to do, particularly as the data does not need to be converted. But if there is cleaning, formatting and structuring involved, it can take a lot of time, even if you use automated tools, he said.

It is similar to when people running a physical library ask for a hard copy of every document to keep in the library. It is easy to collect everything, but harder to get value from the documents once you have them. “A data lake is not for everybody,” he said.

Some applications may be better off using traditional data structures, such as the data warehouse. “They are still in their infancy, and part of a solution but not an entire solution.”

If the data is going to be brought into a software application for a certain task, it will probably need a rigid structure, so good data management is critical.

## Wood and trees

When managing data lakes, it can be helpful to recognise that some people want an overview picture, some people want a detailed picture. This is analogous to some people seeing a wood where others want to look at a single tree.

The “wood” approach, perhaps for senior managers, might include business intelli-

gence dashboards and information catalogues, looking at the entire data set.

The ‘trees’ approach, perhaps for technical specialists, might include doing a search for specific attributes, looking at the complexity of individual objects.

Meta data can help people who work at both levels, giving context around the data for people working at a higher level, and guiding people to the right information at the ‘trees’ level. The metadata should ideally tell you the source of the data and the processes it has been through.

## Exploration, development, production

A first phase of building a data lake could be considered ‘exploration’, trying to understand what value you have in your data.

This can be followed by a ‘development’ phase, developing techniques, workflows, thinking about how things work, understanding data flows (including from sensors), doing some data mapping, perhaps a little bit of governance, trying to move towards a “proper production environment”, getting a useful business output.

But hardly any oil and gas data lakes make it beyond that to the “production environment” stage, Mr Camden said.

## Varied data

All data lakes are different, with different amounts of structured and unstructured information, files in different original formats, different schemas.

There can be more structured information, such as data by time and depth series. There can be more traditional data stores.

Some companies have different data flows, for example you might have a stage before the data lake where you decide whether data might be useful, then clean and structure it, add metadata to it, before feeding into a data warehouse. There are a number of standard techniques for doing this.

## Knowledge model

You can make your data lake easier to run analytics on if you have a ‘knowledge model’ which shows how the various data relates to each other. For example, you already know that different assets have a rela-

tionship, or you have a taxonomy structure you use.

You might also want to use machine learning to enhance your knowledge model, if it can work out ways different information is related.

When figuring out how to get a machine to solve a problem with organising data, it can help to first ask yourself “how would I solve the problem.” If a person can’t solve it, it is “pretty tricky to teach a machine how to solve it,” he said.

But machine learning requires that the data is in good condition to begin with, which is usually not the case. If people have the wrong context when working with information, they make the wrong decisions, and machines are the same. “There’s nothing magical about the process,” he said.

## Data management

One hope is that the interest in analytics will drive a focus on data quality management and governance, a problem oil companies have had for decades.

Nearly all analytics projects eventually run up against a barrier, that poor data quality stops them going any further, he said.

To implement data management, you need clear strategies, not just developing them but making sure people are aware of them and understand them. “We’ve seen situations where strategies have been written and the people operating data lakes have no idea what they mean, so the thing turns to chaos,” he said. “Management and governance are about making sure things are defined, implemented and monitored.”

You might need senior management to support your efforts to improve data governance, and for that to happen, they will want to see that the project is providing benefits to the company.

You also need to think through the different security and access requirements for the different people who will use the data lake. You need standards for metadata and standards for the process for loading, stewardship and delivery of data.

The data lake may contain a copy of data stored in other places, in which case you need a process for managing the duplicates.



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