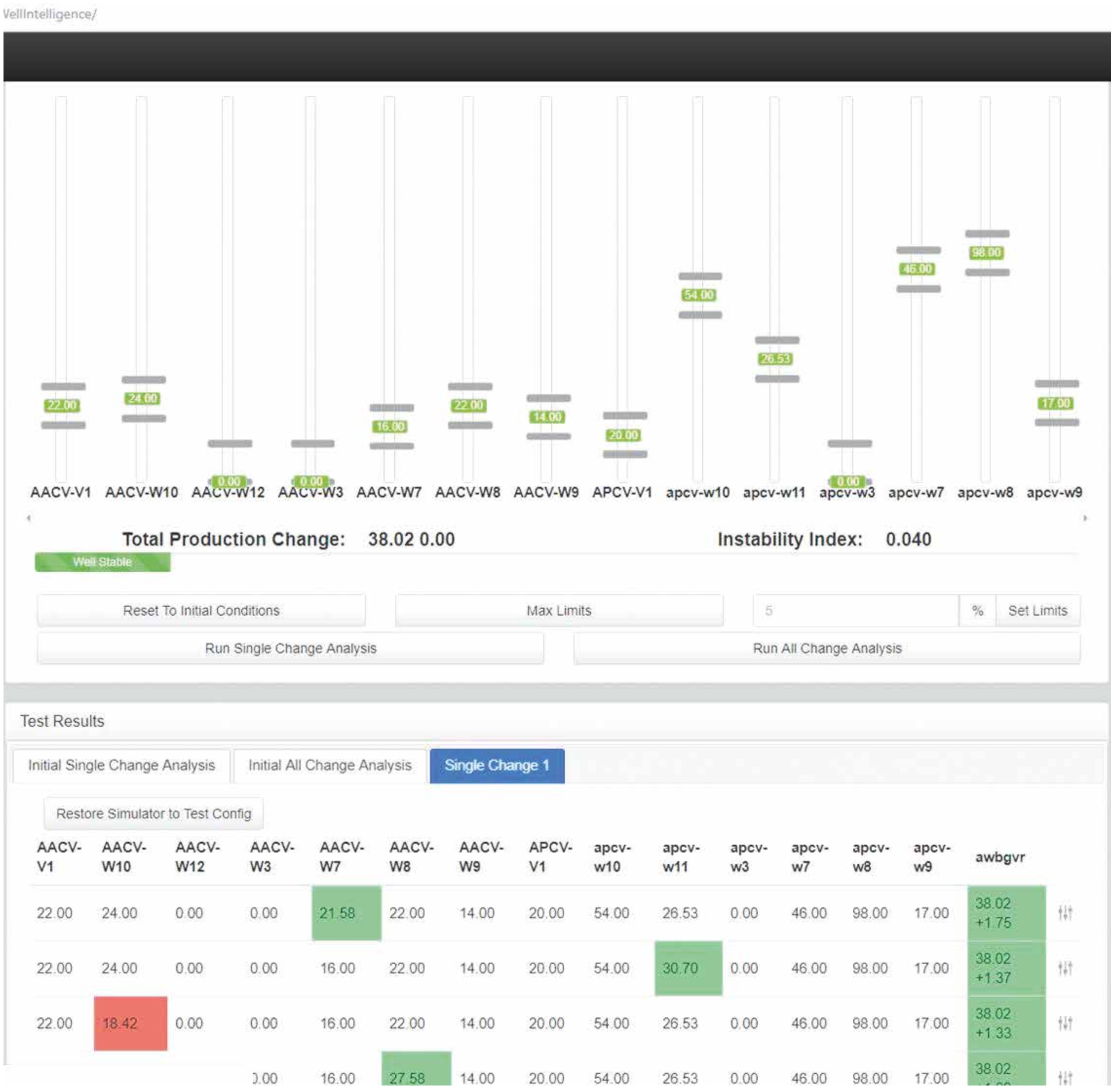
Petromall

INSIGHTS

NOVEMBER **2018**

Expert Centric Software

Modelling software around the needs of experts



Why an expert centric approach to software development may provide more value than the usual business process centric approach

SafeKick - better support for real time drilling operations

Maana - Better ways to connect disparate pieces of data together

Eigen - better understanding safety barriers

Intelligent Plant - online tools to better understand how different pieces of equipment operate

Think Tank Maths - better algorithms to help experts steer drill bits

Expert-centric software - modelling software around the needs of experts

Perhaps the oil and gas industry could achieve far more with digital technology if it could better model software around the needs of experts. This issue of Petromall Insights looks at what the benefits could be, specific areas more expert-centric software could help in oil and gas, why it isn't happening, how it could be done, and how to move forward

We'll present case studies including helping drillers better understand their risks of a kick, getting insights from a broad collection of upstream data, better understanding the condition of safety barriers, getting a better understanding of how equipment works, and better ways to steer drill bits.

Badly modelled software is not obvious as a problem which needs to be solved.

But we see the results of badly modelled software all the time – when we hear that people are not engaging easily with new software they have been given, they spend lots of time looking for the right data or putting it together, data is not stored in a way which is useful for others to work with, or software does not integrate easily with other software.

By "badly modelled," we mean software which is just not designed to make a close fit with the way that people work.

It doesn't help that the way that people actually work in our industry is not well understood by anyone, including, sometimes, people who do the work themselves. Most jobs, when it comes down to it, involve complex continuous judgements about a changing situation, assessing risks and making decisions. Yet most jobs to an outsider look like someone fulfilling a task, and their software is built as though that's all they do.

And if you look at the oil and gas industry from a university course, or a typical conference PowerPoint, it will usually be presented as though work continues through a predictable, linear series of steps towards a result. But the real world – and real jobs – are anything but.

Analogy to car driving software

The work of a car driver can be seen at two different levels – a linear task of moving the vehicle from A to B efficiently and without accidents, and the task of actually driving the car, which involves a complex situation awareness.

If we see the car driver as someone fulfilling a linear task, and are making software for managing it, it might just involving matching a list of jobs with a list of vehicles and creating a schedule for all of them. Software to do this has been around for many years and probably does not make a lucrative business.

But software to manage the driving itself might include complex algorithms to decide what to alert the driver about and why – from reducing in tyre pressure to a nearby object. It can include routing systems like Waze, which updates the advice about the best route to take, based on the time taken by other drivers in the area.

Building this sort of software could be a much more lucrative market.

Now, we can take a look again at the scheduler, and imagine what kind of software we would build, if was going to be modelled around what a scheduler is really doing.

Schedulers, whether in a mini-cab office or a drilling company, are not just matching assets to jobs. The scheduling role starts with trying to match supply of the asset to its demand. There are complex time considerations – how long the task will take and how long is necessary between tasks. The schedule itself will be developed in coarse grain and then fine grain. There will be interactions to manage between the asset and the customer. There will be goals to reach, such as reducing cost, increasing utilisation or reliability.

How much value could the software add

Petromall

Petromall is a unique oil and gas advisory service which prides itself on technical excellence in selected fields and supplementing business management and leadership; in the face of uncertainty.

We offer truthful, professional opinion and advice; no playback of what you already know, and no spin.

Petromall was founded by 4 senior industry and academic practitioners who consider the challenges faced by today's oil and gas environment are going to require herculean acts of leadership and technical skill in the high cost provinces of the world, in order to maintain an industry that is sustainable and even recognisable compared to recent history.

Similarly nations developing an oil and gas industry face related challenges as they seek to maximise the benefits of this new wealth-creating opportunity - in a responsible manner.

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Our presence reaches parts of the globe, such as: the UK, Malta, the USA, through partners in the Middle East, North Africa and Sub-Saharan Africa.

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Cover image: Production enhancements recommended by Intelligent Plant's "Well Intelligence" App

to the schedulers' task if it was modelled to help them do all that?

Case studies

This report includes a number of case studies of software companies and products which we see as being 'expert-centric', designed to support expert judgement, taking advantage of modern technology, such as analytics and AI in some cases.

We'll start with the story about SafeKick, a UK / US company which builds tools to support drillers, and shore based office staff, during real time drilling operations, providing a much more useful situation awareness than the standard approach with a multitude of different screens.

We'll present Maana, a Silicon Valley company with a CTO who previously helped develop the Microsoft Bing search engine, which is developing much more useful ways to connect different pieces of data together in a 'graph', creating a single view from multiple data sources very useful to an expert.

We'll discuss Eigen, a UK company which specialises in helping companies get a better understanding of their safety barriers. In the oil and gas industry, a safety barrier is not a physical barrier. It is a system where various management methods, sensors and alerts stop something bad happening. Monitoring the condition of a safety barrier requires multiple data sources brought together.

We'll present Intelligent Plant of Aberdeen, a company which operates an online 'Industrial App Store' with low configuration Apps helping experts understand how different pieces of equipment operate.

We'll present Think Tank Maths of Edinburgh, which develops algorithms for steering drill bits, helping assess the accuracy of data provided by gyroscopes and magnetometers within the drill bit, and doing it better than other standard methods.

More accurate steering of drill bits is critical to making sure the well ends up in the right place – and production from the reservoir is maximised.

The modelling approach

What all of these case studies have in common is that they run on models. Model is an abstract term, which can mean many different things. We define it here simply as a means of understanding how something works and sharing that understanding. We can use models to understand how a domain (such as drilling) works, how software can serve the domain experts, how the software should work, and how the software should be put together.

There have been many attempts over the years to develop standard means of modelling in the software industry (such as 'Universal Modelling Language'), or standard modelling software tools. But these should be seen as one of a number of means to achieve models, rather than the only way to do it.

Experts have always used models – even if they don't refer to them as the word 'model' – it means a method of understanding how something works in the real world, what affects what, or the story or scenario behind what is going on. If you hear two experts talking in a language incomprehensible to others, we could probably say they are updating each other's models about what is happening, and you would need to understand the model in order to understand what they are saying.

In the case studies above, SafeKick has a model about how drilling systems behave and what drillers need to know. Maana puts together different models about how oil and gas data relates together.

Eigen has a model about how safety related data fits together to provide an overall picture. Intelligent Plant sells apps, each with its own model about how equipment operates. Think Tank Maths makes an automatically updated model about how the data from the sensors in a drill bit relates to an understanding of the accuracy of that data.

Analytics, AI and expert centric software

Over the past few years, there has been a big boom in interest in analytics and artificial intelligence in the oil and gas industry.

Our discussion here about expert-centric software intersects with the analytics world – not the same thing but not an entirely different thing either.

There can be expert centric software with no analytics; there can be analytics which does nothing to help experts; and analytics which does help experts.

To give examples of all of these, the most useful software to an expert could be software which provides the right alert at the right time, not created using analytics, but created using business logic. "When this happens, tell the driver".

We have seen many efforts with analytics which have turned out not be much use to experts at all, perhaps spotting a trend which is obvious or which cannot possibly work. For example the story about when Google analysed internet searches in an effort to predict the spread of viruses and discovered a correlation between the number of people with colds with the outside temperature.

And analytics can serve experts for example if it can help understand trends in sensor data far better than an expert can, or analyse large amounts of data to spot if an investment made sense.

If we label something expert centric software, it should put the experts' needs at the forefront, modelling a system around that.

This picture gets more complex when the analytics or AI are actually developing their own models or understanding about how a system works. Here, the expert's role could become more choosing which computer generated model makes the most sense based on the expert's understanding of how the real world works.

Changing industry direction

With this Petromall Insights, we also hope to help shift the direction of the industry in how it looks at digital technology.

Digital technology discussions up to now have largely been around the technology and data itself, with themes such as big data, analytics, AI, data management, internet of things.

But the end goal of all of this technology is to support better expert decision making and judgement, unless we are living in a purely automated decision making world (and we are not).

And meanwhile, the oil and gas industry experts do not have software tools anywhere near as good as they could potentially be, with today's technology – and the main reason for this is that they are not designed around the experts' needs to begin with.

The oil and gas industry performs well when all of its various divisions perform well, from exploration to refining. And the performance of each of its divisions is largely down to the judgement and decision making of its experts.

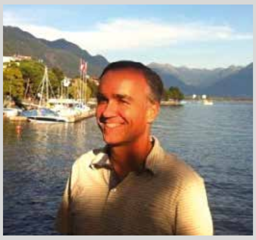
SafeKick – better drilling information for drillers

SafeKick has developed software tools which give drillers the situation awareness they need to monitor the changing risks of a "kick", and other critical factors

SafeKick, a company based in the UK and US, has developed software tools which give drillers the situation awareness they need to monitor the changing risks of a "kick", an uncontrolled flow of hydrocarbons into the well, and other critical factors.

A kick is the big hazard which drillers need to avoid, when a drillbit enters a reservoir, and high pressure oil and gas rushes into the well, and cannot be controlled, and so the fluids come up the well to the drilling rig and cause a major hazard. This is what happened with the Deepwater Horizon disaster.

The risk of kicks cannot be eliminated completely, since the very purpose of oil and gas drilling is to put a drill bit into oil and gas reservoirs (often at high pressure), and there are many unknowns.



Dr Helio Santos, president of Safekick

Conventionally, drillers monitor what is happening with a wide range of screens, which convey information directly from the sensors, but not necessarily in the most useful way to help a driller understand what is going on.

SafeKick's software is composed of different modules with the goal of helping drillers to understand what is going on inside the wellbore. For example, the "Kick Tolerance" module directly shows drillers how much high pressure subsurface gas they can allow into the well, and safely remove, in the circulating drilling mud. So they can manage their kick risk by being sure they are not drilling into gas at that pressure, or have drilled far enough into it to allow that volume of gas into the well.

There are many factors which make this calculation complex, including temperature effects, fluid compressibility, variable influx density, complex gas behaviour, wellbore weak points.

The software is based on both a deep understanding of the physics underlying the calculations, and also the way that understanding kick tolerance can constructively contribute to better management of the critical stages of the drilling process.

Understanding the risk of a kick involves a number of pieces of data. But rather than take a 'big data' approach, working with as much data as possible, SafeKick has identified just 20 data points, taken from various sensors, which together can give a very useful indication.

"20 variables give us everything we need to know," says Helio Santos, president of SafeKick. "If we have more variables that might help the process. But we are far from needing 100."

Dr Santos has observed that many of the data scientists working in big data do not have much understanding of drilling, taking the same approach as though they were understanding bank transactions or how to optimise a rocket launch.

Perhaps you can say that the more domain expertise you have involved in a software project, the less data variables you need to get useful insights, because the domain expert knows exactly what to look for.

If companies are collecting thousands of variables every second from equipment, as some companies are saying now in conferences, "That tells me – That they don't know their equipment very well," Mr Santos says. "They need to collect thousands of variables to find out if the equipment is in order or not."

In one example, a data scientist was trying to gather insights from drilling data, but did not have perhaps the most useful piece of information – what the drilling rig is actually doing at the time – it could have been drilling, reaming or circulating (sending mud around the well to clean out cuttings).

If they are not drilling, the data needed will be completely different from when they are circulating, for example. This applies to whether we are trying to detect a kick or finding out wear on any equipment.

Simulations

As well as making calculations, the SafeKick software makes simulations, of how it thinks the drilling should be proceeding based on the data available, if everything is within safe parameters. If the actual sensor readings different widely from the simulation, that can be an indication that something is going wrong.

In a similar way, aircraft pilots use simulators to model their flight, taking into account the route that the plane will take, weather conditions and other factors. The simulator will make a prediction of the flight time. If the actual flight time starts to diverge from the prediction, that can be a useful indication that something is not happening as expected.

Without such simulation, the various data points can be hard to get meaningful insight from. Consider a data point such as "standpipe pressure of 5000 psi" (standpipe pressure is pressure loss from drilling fluids in the entire drilling system). A driller can't know if this is low or high, without an understanding of what the standpipe pressure should be, Mr Santos says.

The company

SafeKick is built on solid drilling domain expertise. Company president Helio Santos formerly worked as a drilling engineer for Petrobras in Brazil, both onshore and offshore, and led several projects in Petrobras' research development centre. He also served as VP technology with Impact Engineering Solutions and president of Secure Drilling, a company acquired by Weatherford, and participated on the Editorial Committee of the Society of Petroleum Engineers' Journal of Petroleum Technology.

The software can either be installed on the rig computer, running on office PCs, or via the cloud. Some clients choose to only have it running on office PCs, rather than on the rig. It takes data from all the rig sensors.

The software is deployed on drilling operations of all sizes, including deepwater rigs, jack up rigs, onshore rigs. It is used by companies of all sizes.

Many customers wish to remain confidential, but the company cites Seadrill as a client it is able to name.

The company is looking for slow and steady growth, rather than looking for hundreds of deployments, to ensure it can maintain the quality, he says. Word of mouth marketing proves very effective.

Maana – what "model driven" means in oil and gas

Silicon Valley company Maana is working with Shell, Saudi Aramco, Chevron and more, with a 'model driven' approach to working with data. We asked the CTO Donald Thompson what he thinks 'model driven' means

Silicon Valley company Maana is working with Shell, Saudi Aramco, Chevron and more, with a 'model driven' approach to working with data.

"We're a model first company and always have been," says Donald Thompson, CTO of Maana. "This is core to our methodology."

"Model first" means that Maana starts a project by thinking about what model needs to be built to answer the business questions or solve the business problem. Then it thinks about what data and analytics it would need to get there.

This can be a better way to think about data than the idea of gathering data from multiple sensors and logs and storing it in a vast "data lake", and then trying to find value out of it, or use automated tools to build a model out of the data.

Knowledge and business performance

A discussion about models can begin with the idea that the overall performance of a business is driven by the decisions people in it make.

In order to make good decisions, people need the right answer to their questions. We can define knowledge as the ability to answer questions.

Our knowledge is built up from our processing of 'data' (which in the human world can mean all the raw sensory perceptions), which we distil into "information," and distil that into "knowledge."

And we can verify someone's knowledge by giving them a test, which requires something more than just reciting 'information' they have learned.

Similarly, in the digital world, we put together models based on data and information. You can verify how good a model is by seeing if it can answer questions about business problems. It is important to test models to make sure you are on the right track. "It is important that we are putting our best knowledge in a form that we can better measure, test, reason about, validate and improve," he says.

In a model driven business, all of the modelling, or updates to the model, should all happen continuously, not in a one-off analytics project, Mr Thompson says.

Building oil and gas digital models

Building digital models for our entire oil and gas operations won't happen overnight, but could be the long term "digital transformation" objective, Mr Thompson says. "If we're more deliberate about it, we can build the structures to achieve it.

Mr Thompson's company, Maana, is designed to achieve that overall goal, and organise the various pieces.

The approach needs to "start at the top and be embraced throughout the organisation," he said. "That's a big challenge with many impediments along the way."

There is no perfect vision about how to do it, it needs to be done one use case at a time (where each "use case" is a specific problem or question which needs to be solved).

Traders, shipping and refining

To illustrate how models could be developed for people in different roles, consider that in an oil company, every department operates under a set of local constraints, goals, strategies, and risks.

For example, the trading department has a budget, fulfillment demands, financial targets, Mr Thompson says. The shipping department operates a fleet of in-house and chartered vessels, and is concerned about issues such as fuel consumption, maintenance, piracy.

Also close to shipping and trading is refining, where the operators have another set of models to help them keep on top of the risks of processing different types of crudes.

Each of these departments can develop models that help make optimal decisions to maximize upside and minimize downside. But departments have impacts on one another and can benefit from models that have awareness across departmental boundaries and can consider the global efficiency.

Donald Thompson, CTO of Maana

Integrating models

The Maana software is designed to put together many different models together on one platform, making it easy for people across the company to access them, and share the same data.

There could be models for any of the problems in the oil and gas industry,

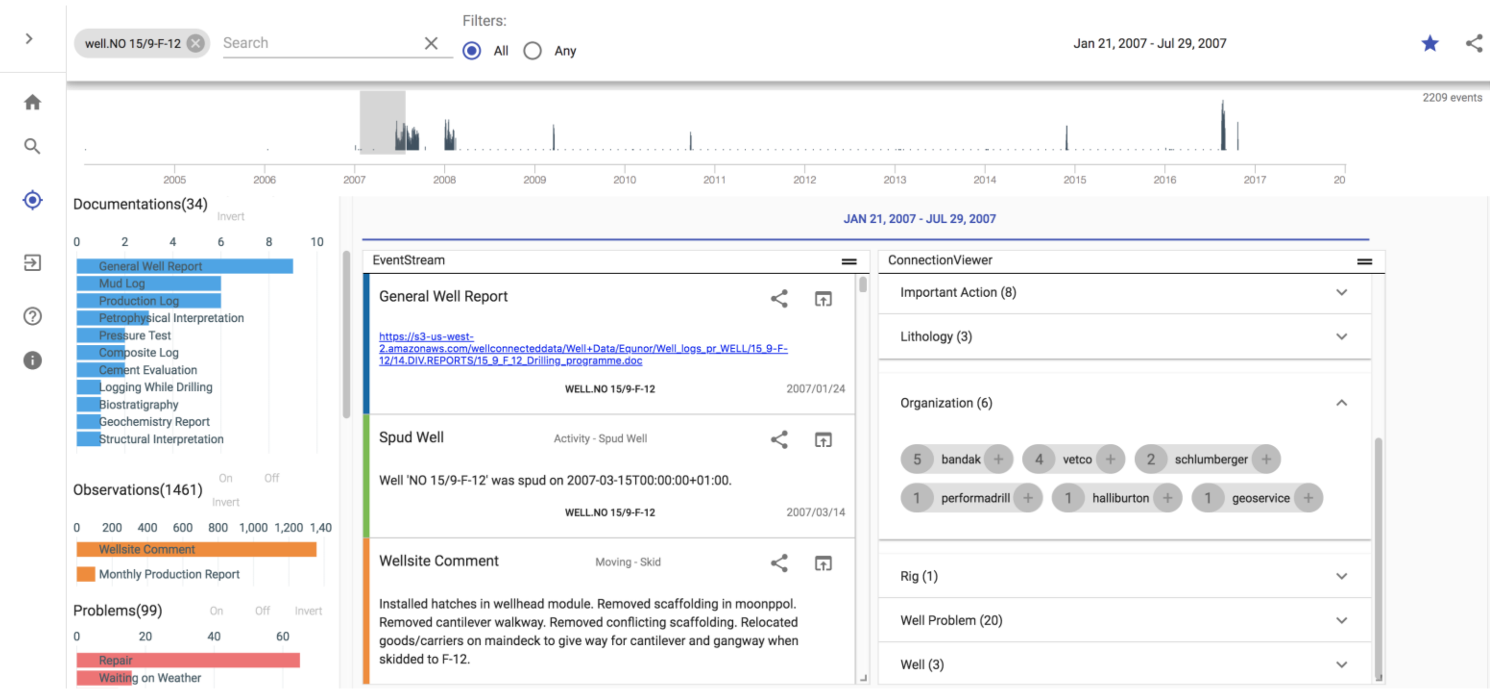
from handling complex seismic data to managing privacy of retail customer data. This involves a huge variety of data and data types.

There could be a commercial business model in this, where companies develop models which are then licensed to people to use, and a market where companies can compare them and just take the one which works the best.

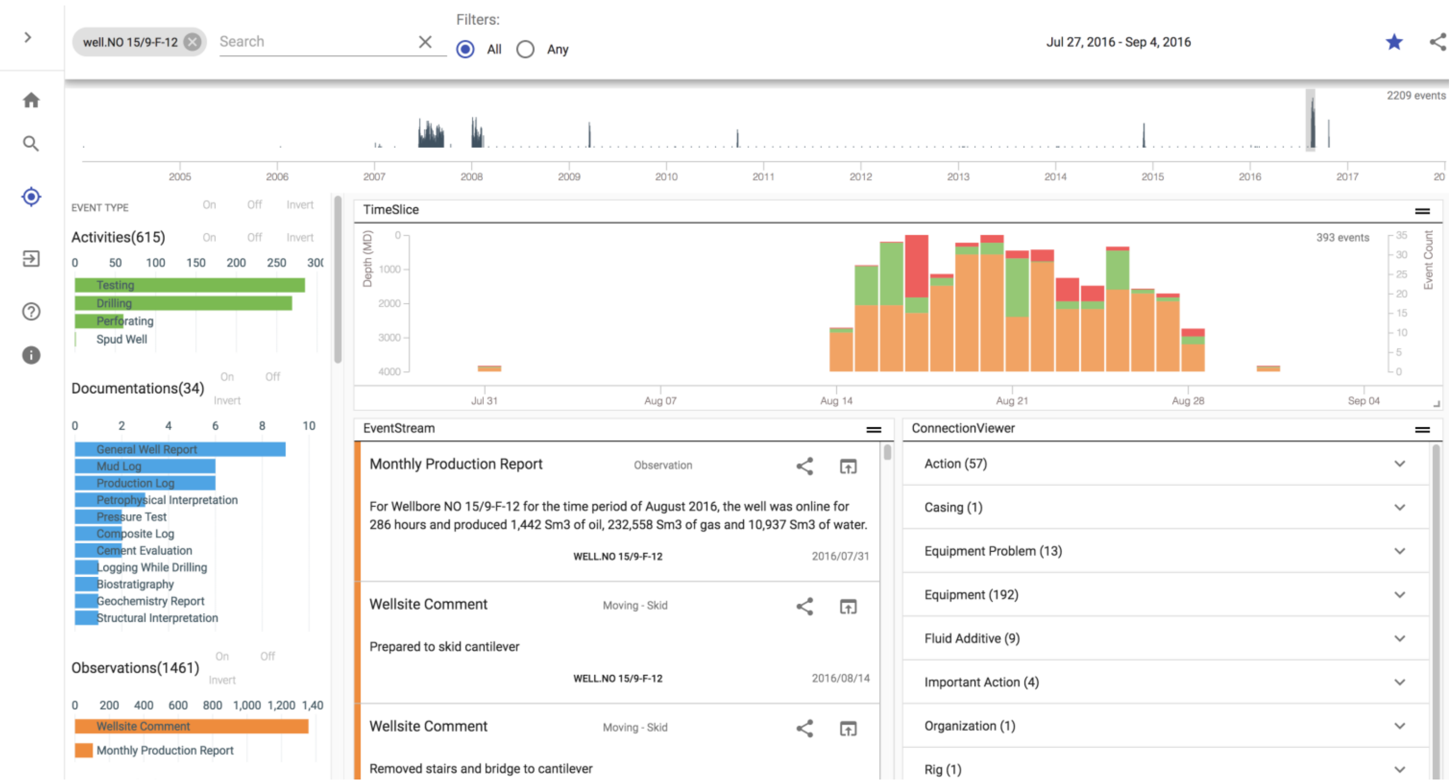
Maana can act as a kind of agency for companies like this, incorporating the best models as part of the software it provides to oil companies, Mr Thompson said.

For example if someone has come up with a way of making production from wells decline slower, by fracking or otherwise constructing them in a different way, that would be a very valuable model.

Screenshots from Maana software:



Documents and Wellsite Comments, with multiple extracted Organization entities



Monthly Product Reports and Wellsite Comments, with "zoomed in" TimeSlice view.

Eigen - modelling for safety data

UK company Eigen builds digital models of offshore asset data, particularly data relevant to safety, which enables large amounts of complex information to be brought together in a way that people can work with.

UK company Eigen builds digital models of data about offshore assets, putting data together in a way which makes it easier for people to work with, particularly for data about safety.

The company initially mainly worked with operators in the Norwegian sector of the North Sea, and now has a growing interest in the UK sector.

The software is in the 'operational risk space', giving clients a picture of their current risk in real time, which is updated when something changes, says CTO Murray Callander.

To understand how important it is to business to understand risk, consider that there is currently a large amount of sales going on in the North Sea, with old assets being sold by oil majors to new operators. The oil majors are less interested in the assets because they see them as high risk and low return.

The new operators still have the high risks and low returns, but they need to be better at managing and understanding the risks than the oil majors were.

Eigen's models

Eigen's models shows how all the information is related to other information. For example, you might have a sensor which monitors the pressure of a vessel, and will cause a shut down if the pressure rises above a dangerous level.

The philosophy is that any data without context is unhelpful – it is only useful within its broader context, so people can see what it relates to and where it is coming from. To put this in another way, data is only useful when it is part of a broader model.

To give an example of the importance of context of data, consider that you might have three pressure sensors on a vessel, and one sensor indicates a problem. The way you would react would be very different if you think there is only one sensor, or if you know there are three sensors and the other two are not indicating a problem.

When implementing a software tool like Eigen's, most of the work is on modelling – understanding what people need to see, when they need to see it, and what can be provided, bringing the data together in an "asset model".

But this is different to the typical "Big Data" approach that has been so hyped, which is to take a big mass of data, and try to work out what can be done with it, Mr Callander says.

The right view for different people

Once the data is modelled, it gets easier to present people with a view on the data specific to what they are looking for, he says.

An offshore asset will have many different people working on it, all looking for a different view of what is going on. Different people will group things together in different ways and hierarchies – for example one person is monitoring rotating equipment, another person wants to be sure a certain maintenance operation will go well, another person is concerned about safety of a certain area.

You can use a smart phone as an analogy for this – everybody configures their phone slightly differently for what they want to use it for, but all of the data comes together in a single model, Mr Callander says.

Monitoring safety barriers

Consider that a safety barrier is not a physical thing you can touch, it is a conceptual concept, or a grouping of objects, built up of physical or procedural things, such as safety data or control of work.

If people want to check the safety barriers are working and in good condition, they need to check a number of different sensors are operating, or procedures are being followed. The Eigen system can pull all the relevant data from the different systems and display it on a dashboard.

Safety barriers, as used in the offshore oil and gas industry, are not physical things you can touch, they are conceptual things, or a grouping of objects. But they still have meaning, Mr Callander says.

The idea is that you have a mixture of work controls, sensors and alerts which will enable any emerging problem to be identified and fixed before it gets uncontrollable.

The Eigen software takes data relevant to the safety barrier from various systems and puts it on a single screen or dashboard, so you can see any risks in a certain area, or risks of a certain hazard, or get a view from an entire offshore platform. Different people can view data from the data model in a way that is relevant to them.

Murray Callander, CTO of Eigen

You can see all the barriers marked as 'impaired' and find out more about why they are impaired, see the source data behind them, and then make a decision about what to do about it.

The safety barrier software can be linked to all the various elements, such as the sensors and work control systems, and provide information about how well the barrier is operating.

An additional benefit of modelling safety barriers is that it can help improve data quality, by acting as another layer of quality control over the data, making it more obvious when something is missing or wrong, Mr Callander says.

For example, you might discover that there is a missing sensor data stream, which means that your safety barrier is not a barrier at all.

Having the data modelled together also means people can find information they are looking for much faster, he says.

Abstracting objects

One important thing you can do with a model is see an object as something less than its full technical specification, Mr Callander says.

A model first approach can start by saying something is just a 'pump' or a 'compressor'. You can have lots of data available, but you only really need to know about the inlet flow, outlet flow, speed, inlet temperature.

A data-first approach, by comparison, starts with the technical data and then works with it, and can work with that specific piece of equipment.

If you are happy talking about equipment at a 'high level', just calling a pump a pump rather than by its code number, you can build software which can work with any compressor or pump.

This is important because when we are managing a safety system, we might just want to know whether a pump is working or not. All the extra technical information is unhelpful, Mr Callander says.

This is similar to how we see objects as humans – we refer to things by their general names like "do you have a pen?" We don't need to say "do you have a Papermate flexigrip medium blue rollerball?"

AI doesn't necessarily help management

Mr Callander observes that much of the industry discussions around artificial intelligence are often geared to trying to optimise something slightly, such as trying to predict a well slugging a bit better, or predict failure on a compressor a little better. It is a natural evolution of efforts which were happening before, but not much of a transformation.

But when people are managing safety barriers, their focus is not trying to optimise anything, but wanting to be sure all the safety systems are operating as they should be.

And all people involved in operating equipment have their own mental model about how it is working, or what is important to keep an eye on. Something which seems obvious to a person is also something an AI algorithm could never find.

Unless someone invents what might be called "wide AI", or AI which can look at a wide spectrum of operations at once, success in oil and gas operations will come from the right working combination of people with machines, lots of software models, and perhaps some 'narrow AI' which helps people do some things a little better.

Eigen's software contains models about how the various safety barriers on oil and gas platforms work, and the different pieces of data which must be available in order to ensure they are working.

The software does not store any data itself, it works connects with a company's existing data stores.

When it is being installed for a new client, the main focus is building the model for the specific implementation, because every offshore site is different, Mr Callander says.

"Every platform, every operator has some specific requirements on how they want to visualise it. The modelling is the major part – that's the key."

Intelligent Plant – an "Industrial App Store" for models

Intelligent Plant of Aberdeen runs an "Industrial App Store" for models which help equipment operators better understand how their equipment is functioning

Intelligent Plant, a company based in Aberdeen, is running an 'app store', selling Apps for different problems, such as Well Optimisation, Controller Monitoring, Wax detection.

The apps run on the cloud (usually Microsoft Azure), and work on data which is either cloud based or on local computers.

Each App in the Industrial App store can be considered to have a model. Some are created just from data, some have more engineering principles behind them, says Steve Aitken from Intelligent Plant.

Most of the apps on the store are developed by Intelligent Plant, but the company is keen to bring in apps from other companies.

Each App that contains a model could be considered a 'digital twin', or a digital representation of the actual asset, and how it functions. It can then be trained on live data, to make predictions about how the customer's actual asset functions.).

Many of the models are 'data driven', with algorithms calculating how cause and effect works on the asset, so they can give suggestions about the best settings to achieve a certain result, such as minimising 'trips' (when the equipment switches itself off).

To illustrate how this works, consider a computer that could calculate whether your room will warm up faster by shutting a window or switching on the heating.

Not such a useful algorithm to have in your house, probably, but something like this could be useful if you need to work out the best way to cool down an overheated offshore compressor.

Sometimes data driven models can be useful when their advice is wrong. In one example, Mr Aitken says, a model advised engineers to shut a valve. The engineers were certain that the advice was wrong, and shut the valve to prove their point. But nothing happened, because in fact the valve was faulty and the engineers were not aware of it.

The computer had made a wrong correlation between previous valve shutting and a certain outcome. But the insight – that the valve was faulty – was very useful to the engineers.

A data driven model can be maintained automatically, and update itself. In this way it can be better than human created digital models, which often do not get updated and fall into disrepair.

Store data where you like

One advantage of using Intelligent Plant's apps is that they can run on customers' data wherever it is stored.

In this way, the apps are different to tools from other large maintenance software companies, which will typically ask you to store the data within the software, Mr Aitken says.

If the customer has full control over which cloud system the app is run on, and where the data is stored, it means it is much easier to sell the data and software – they just provide the buyer with the login details.

Companies are increasingly willing to consider smaller technology and software companies, as they have seen that the mantra "bigger is safer" does not necessarily work, Mr Aitken says.

OGTC project

Intelligent Plant also develops models itself. It has a project with the Oil and Gas Technology Centre (OGTC), to develop new models about the reasons for trips (equipment shutdowns) on offshore equipment, based on analysis of sensor and alarm data.

As a result of the work, the App will build a model which shows how cause and effect works with the equipment – the factors which lead to trips happening, or the best/worst start-up sequence. This should in turn make it easier to predict failure of equipment and find ways to improve operations.

For example the analytics might be able to show that 15 per cent of trips are due to equipment not being serviced, 15 per cent due to equipment not being designed for the purpose it is being used for, and 50 per cent due to how it is being operated, what was happening around the compressor.

There is a common perception that a large amount of trips are caused by bad maintenance, leading to condition monitoring of equipment as opposed to improved operating practices.

Condition monitoring does not directly change operating practices, however, but analytic apps are designed to do just that, Mr Aitken says.

ThinkTank Maths –reducing uncertainty with drill string positioning

ThinkTank Maths of Edinburgh have developed a novel mathematics framework, the Trusted Reasoning Architecture, which is being applied to improve real time well positioning and drilling stability; providing also a sound basis for developing dynamic through-life subsurface management systems.

ThinkTank Maths of Edinburgh have developed a novel mathematics framework, the Trusted Reasoning Architecture, which is being applied to improve real time well positioning and drilling stability; providing also a sound basis for developing dynamic through-life subsurface management systems.

The Trusted Reasoning Architecture (TRA) enables autonomous systems to process large amounts of real-time data, provide immediate feedback, highlight subtle anomalies in sensor data, explain their reasoning and to continually update and learn.

ThinkTank Maths' TRA is delivering significant improvements to future flight and space debris positional awareness systems, a major contribution to next generation control systems.

The TRA has the potential to deliver improvements across the oil and gas sector in areas such as real-time remote site monitoring, through-life reservoir management and, by informing geological models and seismic interpretations, improved field appraisal and development.

One example of the TRA's application within the oil and gas sector is in improving real-time well positioning and drilling stability through its dynamic "Augmented Intelligence".

Through the utilization of novel mathematical approaches, in addition to development of advanced data analysis methods and bespoke machine learning algorithms, ThinkTank Maths' system provides a continually updating estimate of drill-bit position and its associated uncertainty using together data from directional and geological sensors.

Wellbore Steering

Steering a drill-bit accurately into its geological target is essential. The well's desired placement is selected after extensive analysis by reservoir engineers and if the drill bit is mis-placed, hitting an area of low hydrocarbon density or missing the reservoir entirely, the well will produce less than expected or not at all. If the well is designated as an injector poor positioning may impact on pressure support, sweep efficiency and ultimately reservoir oil recovery.

Accurate drilling becomes even much more important when targeting smaller oil pools, as becomes more common as a field matures, or in infill development where many pre-existing wells were drilled close together. The more uncertain the position of the pre-existing wells the more they must be spaced apart to reduce the risk of collision during drilling. Uncertainty in the position of a drill can also lead to poor coherence between the well and the geological models.

The orientation of a drill bit is determined by stopping the drill at regular intervals and gathered data from accelerometers and either a gyroscope or a magnetometer in the drilling bottom hole assembly ("measured while drilling" - MWD).

The gyroscope uses inertia to estimate the bearing of the drill-bit but can experience "drift". The magnetometer estimates the drill-bit's bearing by measuring the Earth's magnetic field and comparing it to detailed magnetic survey models but its measurement can be perturbed from the local geology, its own metal frame and magnetic debris in the drilling mud, as well as heavily relying on survey models.

At each successive MWD survey a mathematical method stipulated by the ISCWSA (Industry Steering Committee for Wellbore Survey Accuracy) is applied to estimate the position of the drill-bit and the uncertainty associated to that position estimate.

From these findings ThinkTank Maths (TTM) developed an alternative mathematical framework for handling magnetic data in order to estimate the borehole position and the associated uncertainty based both on the information from the regular surveys taken and from the more geologically orientated "logged while drilling" (LWD) data, measured hundreds of times more frequently than the MWD data.

ThinkTank Maths' system surpasses the conventional method in that uncertainties can actually decrease, when relevant, not just continually increase, as with the current standard methods. The TTM system can also operate without the need for any magnetic referencing data (data from a previous magnetic survey of the subsurface).

For this purpose the company has developed a suite of 'virtual sensors', with mathematical analysis of raw sensor data, both MWD and LWD. These virtual sensors can provide information which has never been previously available, such as assessment of drilling stability, extracting azimuthal drilling direction estimates and estimation of the quality of the magnetic environment around the drill-bit, all from LWD data.

By being able to estimate the quality of the magnetic environment from LWD readings TTM's system can also advise the driller when would be a good time to stop drilling to take a magnetometer reading. This is in contrast to current procedures which stop at regular intervals and can only assess the magnetic environment after the magnetic survey has been taken.

Making this decisioning process more informed means that drilling is never stopped for an unnecessary reading, or conversely, the drill-bit isn't operated for long periods of time under a poor understanding of its location.

The underlying mathematical algorithms associated with the TRA can continuously refine the virtual sensors, positioning methods and magnetic quality control methods. This is particularly useful when drilling in complex or very mature oilfields, where conventional algorithms might need frequent inputs from a domain expert to be updated.

The refinement of system alerts is useful and important for the driller in order to develop trust in a system. As a field matures or new sections are developed a non-adaptive rigid system will continually give alerts and warnings, not updating itself to the new environment. This can result in the driller dismissing alerts from the mis-trusted system out-of-hand, even when they are valid, potentially leading to problems.

Data output

The outputs of the TRA system, such as positional estimate and uncertainty or magnetic environment quality assessment, are displayed in an adaptable visual interface.

Magnetic quality control assessment is displayed using a convenient traffic light indicator system, numerical values such as the scale of uncertainty are plotted as a graph or displayed in a clear table, as required, with the positioning values and further information on particular surveys or warning indicators in a message panel. The tabulated data can also be exported into a text file to allow it to be transferred into other systems.

In order to avoid the driller being overwhelmed with all available data channels, both raw and processed, the system displays a streamlined set of indicators it passes to the driller.