How to integrate 3rd party software into a drilling control system – The future is here!

Authors: Kim Andre Evensen, Omer Zec, Snorre Aasen-Hodnemyr & Randi Reber

Background

Two decades ago, when the first PLC based control systems for our drilling equipment were made, no one could anticipate what possibilities the future would hold. Back then, all control systems were made to control drilling equipment as individual machines as good as possible and the idea of having additional smart functionality and using data models and historical data as a way of improving performance was at best in the distant future. Today, this future is here. The drilling industry has seen an increase in companies providing solutions to enhance drillers' efficiency, safety, and situational awareness, driven by the growing demand for safer and more effective drilling operations and technological advancements. In addition, the entire process of keeping a drilling rig in operation with regards to logistics, personnel, energy consumption and more, benefits from all the development and possibilities made in the digital industry the last years. Smart digital solutions in the consumer market also creates an expectation from employees in the oil industry that digital development and technology should be introduced also in their work environment for added value. For HMH as a manufacturer and innovator in the oil service market it is important to be open and seek new technology and partners to collaborate with.

On a drilling rig, the drilling control system (DCS) is a fundamental part of the overall well bore construction process. But a drilling rig is a large ecosystem of companies, people, and different types of actors that all work together to perform a task: Well bore construction in the most efficient and safe way. Enabling digital solutions, collaborations, and integrations, without doubt, will add value. The sensor data retrieved by the HMH topside equipment can be used as an input to software models provided by other companies or be presented to the driller to provide situational awareness. It can also support software modules that handle logistics (eTally™) and planning of operations to further boost the efficiency on the rig. In HMH we see many benefits of opening our drilling control system for both sharing and receiving information from 3rd party partners to help increase the efficiency for our customers and create new business opportunities.

In 2016, HMH launched its open interface platform called DEAL™, which streamlines the way to add smart functions to the drilling control system. The main purpose of DEAL is to be able to, in a systematic way, install software modules that add smart functionality across different types of drilling equipment and minimize the time needed for re-testing and commissioning when deploying new software to the rig. DEAL is a platform where it is possible to deploy software modules with as little impact in the equipment controllers as possible and it enables the possibility of adding software modules that can speed up, monitor, and assist different processes on the rig. A typical example of this is CADS™ that can run automated sequences for trip in/out, stand building or drilling connections. Or Drillers Assist™ that can apply operational limits to the drilling equipment to protect the well or perform automated hole cleaning or mud pump start up to assist the driller. These software modules both use DEAL to get access to the drilling equipment as opposed to connect directly to the drilling equipment controllers.

While this concept has been tested and is in use for several other industries like cars and mobile phones there are some unique challenges when introducing this method of deploying software to the oil industry that are important when considering creating “a drilling rig app”.

Market

The market is nowhere nearly as large in terms of number of users as in the private consumer market. The margin of error when developing a software for a drilling rig is small and compared to the effort and resources put into development, the expected success must almost be guaranteed for the first installation. At least to such a degree that it is possible to optimize and further upgrade the system quickly after installation so that the end-product start to add value quickly. The return of investment is very important both for the isolated product and for the possibility of other products in the future. One success opens for many more possibilities. One failure can do the opposite.

Figure 1

Retrofitting

The control system on a drilling rig that has been in operation for a long time was not originally made with automation and digital solutions in mind. It was made assuming the driller is the main source of know-how by enabling him or her to control the drilling equipment and monitor that things are done in a safe way. In addition, neither controllers nor communication networks were made to serve the additional load added by future software modules. Even the technology available at the time of the original delivery might have been insufficient to serve this kind of use. Because of this, retrofitting might be challenging but not impossible.

Risk assessment can require a human to supervise the equipment and manually go to a safe state in case of a sensor failure or unwanted situation. Removing this need might be costly in terms of added sensors, control system and network changes. Even if the control system was to be completely changed and equipment upgraded, it would require a lot of rig time during installation making the business case for such an upgrade difficult to accept.

Therefore, any integration of 3rd party software or even HMH's own software modules need to keep in mind that since drilling equipment requires human supervision due to risk assessment and well integrity, the fallback solution in case of failure in automation solutions must be normal manual operation by the driller. Of course, with the condition that completely upgrading equipment and network is not an option.

The Bigger Picture

Each party on a drilling rig has expert knowledge within their own domain. Few have expert knowledge of other parties' domains. This may lead to assumptions and misunderstandings. HMH has done several projects where we have collaborated with other companies for integrating operational windows and well control. Often the focus from our collaboration partners is on controlling equipment working in the well. More specific the hoisting for ROP and WOB, the Top Drive for controlling the drill bit rotation speed and the Mud Pumps for controlling the mud flow. Understandably, these are control parameters that for many companies are the core parameters. However, for the driller, while obviously important, they are a subset of all the information and parameters he/she needs to supervise and control during operation. The driller is also responsible for making sure there are no critical alarms active, that everything is performing as intended and to prepare the equipment for operation, just to mention a few tasks. Hence, for HMH when doing an integration with a 3rd party product, we have the responsibility to make sure that the products integrated fits into the bigger picture. For a company that has spent resources creating their own user interface it might seem redundant to also create new HMI for the integrated products. But from a drillers perspective it makes much more sense because if we keep adding new user interfaces each time it makes it impossible to maintain focus on the operation and reduces the situational awareness.

Although the challenges outlined here are undoubtedly genuine, they can be managed, and the advantages of allowing other companies to incorporate their software products into the drilling control system are significant.

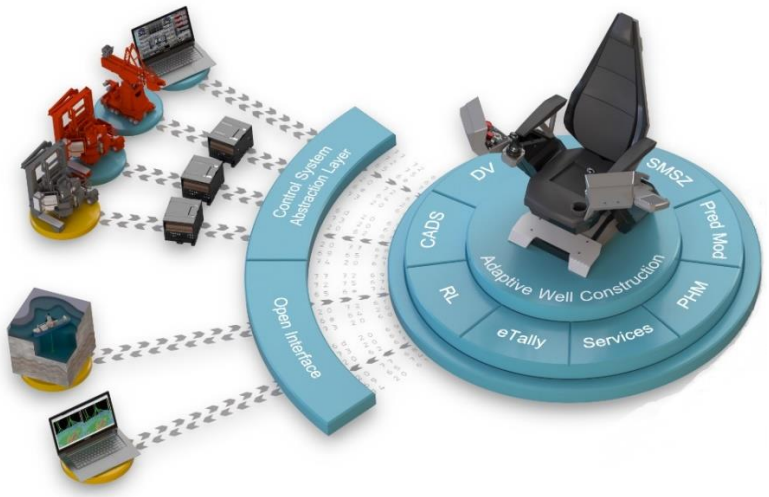

Figure 2

Figure 3

Integration Best Practice

During the seven years where HMH has delivered automation products and installed DEAL and smart software modules in several rigs, we have gained a lot of experience. Both from developing and installing our own smart software for the drilling industry and from working with collaboration partners and integration projects. We have done integration projects with all the main Integrated Drilling Services (IDS) providers as well as smaller companies that offer automation products. This experience has taught us how things should be done, both technically and with regards to work processes to achieve success. Based on this experience we have created a model of how to do integration projects that acts as our best practice when setting up projects during development and testing, and for commissioning/deployment and follow up. It should be noted that the best practice and the way we do integration projects might change over time as the maturity and technology changes both internally in our company and with our partners and customers.

Work Process

One of the key success criteria to a successful project and deployment of any integration between a drilling control system and software partners is a structured and good work process. For HMH this work process starts before the project is initiated, during what is called the pre project phase. In this phase two things are done.

- Concept definition
- Business case evaluation

A good business case is of course important to our customers, but also important for us as a company and the 3rd party company that we are collaborating with. A poor business case is more difficult to sell later and could be a waste of resources. The concept briefly describes what we try to achieve without any details on how to solve it beyond a feasibility evaluation – is this doable?

If the business case is good and the project initiated, we move into the next stage which is the main project phase. For this phase it is important to communicate with partners and customers about the work process and clarify expectations from all parties. In this paper we will only describe a typical development project, which is more demanding compared to selling products that are implemented already and can be delivered as “off the shelf” products.

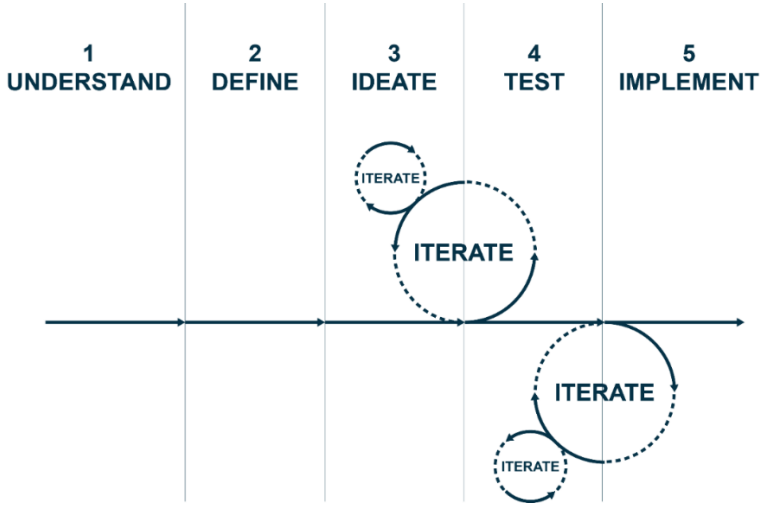

Figure 4

Early in the project phase we look at the use cases. Who will use the product and how is it intended to work? Each *function* the system wants to integrate should be described in detail so that all involved understands the functionality and product we are trying to implement and to make sure the product supports the business case as intended. Both measured by performance and by supporting existing work processes or creating more efficient ones. During this phase it is critical that end users are involved. Involving them early helps introduce domain knowledge and knowledge about the work processes they use that is important for how the product fits in with the rest of the operation. Typically, in this phase the use cases and functionality will be evaluated and discussed, and several mockups of the user experience together with the work processes will serve as an input to workshops where the concept is analyzed and corrected until it satisfies all involved parties. Normally this would be the end users, the 3rd party software company, HMH and other relevant partners.

When the concept is approved the development starts looking into the details and define a proper interface between the involved parties. The development follows typical agile methods with short implementation phases, testing and corrections in several iterations. For most of the integrations projects it is a big advantage to have a simulator of rig system to test at. At HMH, the simulated environment is designed to closely resemble the real control equipment used on the rig, rather than relying on animations or mockup rigs. By utilizing the authentic control software, the potential for unexpected surprises during the final installation on the rig is reduced.

During development it is also important to do regular check ins with the collaboration partner or the company who is responsible for the software module to be integrated. This helps build understanding and makes sure that the development on both sides is verified and adjustments can be made if anything should come up during development. Doing a separate run without meeting regularly introduces risk in the project and may lead to faults and problems at a later stage.

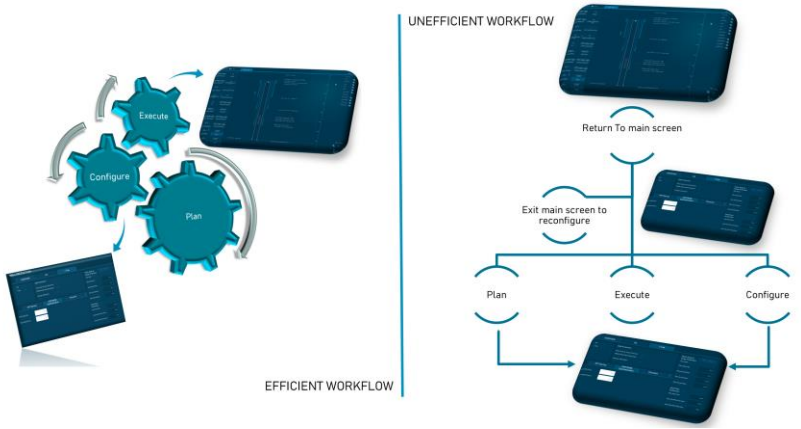

Figure 5

The project should naturally lead up to a demonstration or FAT depending on if the project has the intention of being deployed on a rig or if the goal is to demonstrate technology. For projects where the goal is an installation on a rig, an FAT is done. After the FAT the product will be deployed on the rig for a piloting phase. During this pilot phase it is essential that all involved companies are working together to give the new product the best start possible. Installation needs to be carefully planned so that nonproductive time on the rig is as little as possible and HMH and the 3rd party need to be standby, preferably available near the end users to assist if needed or swiftly correct unwanted behaviors or bugs during startup. End users, for example drillers, need to be guided when first starting to use a new product by training onshore and offshore. Normally HMH will create a training package along with the product development so that training can be done before deploying the software on rig. Keeping end users involved from the start of the project also helps create ownership in the product that makes the startup phase on the rig easier and more efficient.

After installation it is important that both HMH and the 3rd party software supplier communicates whenever a change is made in either system that might affect the other. For example, a machine is upgraded, or the software needs to updated.

Last, an important part of the work process is what is being done after installation by analyzing performance of the installed product and working to further optimize the effect. This is done by a separate team in HMH called DRILLPerform, that makes sure any performance issue is detected as early as possible and corrected. Logging the rig's performance together with information about how newly installed software is being used is helpful. By doing this it is possible to identify small optimizations in the software integration or work process that can further boost the performance.

Technical Solution

Based on all the integration projects HMH has joined over the last 7 years we have gained a lot of experience. The work process described earlier is based on this. In addition, we have streamlined the technical solution for how we do integrations by creating infrastructure in terms of hardware and software to support integration with 3rd party software applications. The DEAL platform is possible to utilize for any software developing company, but it might be too complex for partners without detail knowledge of drilling equipment to get the most out of the platform within reasonable time.

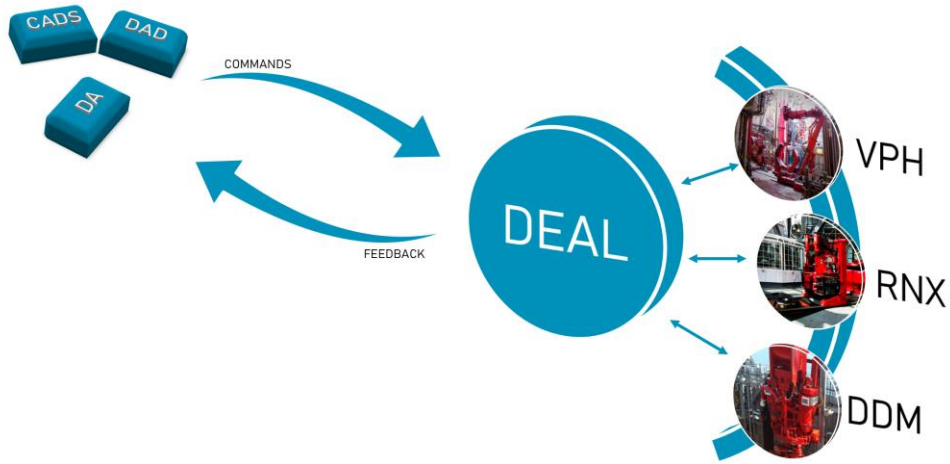

Figure 6

Also, layout and equipment configurations might differ between rigs, increasing complexity and the consequence of creating a standard interface could in many cases mean that compromises had to be made that would not enable the full potential of the integration. In HMH we have created the Smart Adapter™ to assist this. The Smart Adapter can further abstract the process to be integrated making it easier for companies without our domain knowledge to connect to the drilling control system. In most cases where an integration is done there is a "standard" package of functionality to be implemented. Most of these revolves around controlling what is happening in the well by working with the hoisting system, top drive shaft, and mud flow. In addition, a lot of sensor data is being transmitted out of the drilling control system, but the ones mentioned are the control parameters we are most often asked to integrate. We also need a way of interfacing the 3rd party application. The preferred technology for this is using an OPC UA server. OPC UA is known technology in the business and has many properties that makes it ideal for an integration project like this. Figure 7 shows a typical architecture on a general level for how HMH integrates 3rd party software applications.

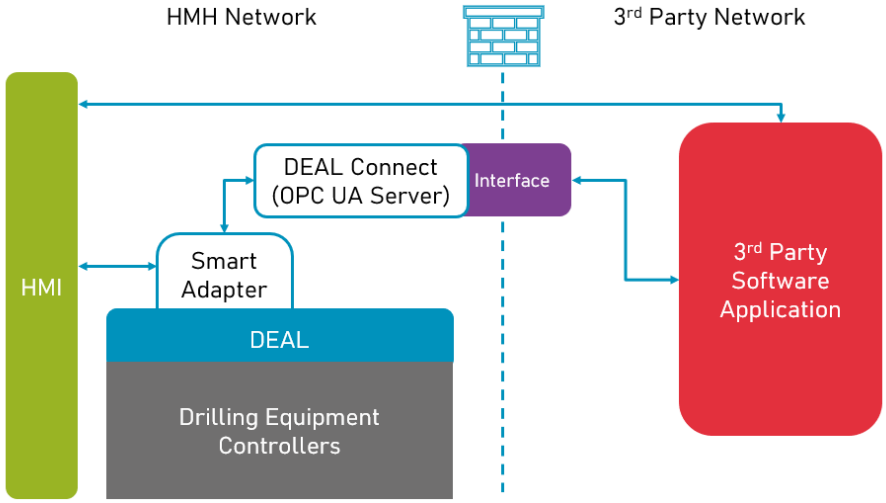

Figure 7

On the left side is HMH control system applications represented by boxes with drilling equipment controllers, the automation layer DEAL and Smart Adapter. In addition, the HMI is represented in green. The interface towards the 3rd party application is represented in purple and hosted by DEAL Connect™ on an OPC UA server. The blue arrows indicate data flowing between the components. To properly understand why this architecture is preferred, let's look at the different components.

Figure 8

DEAL Connect - OPC UA Server

DEAL Connect is HMH's platform for collecting and sharing data on the drilling rig and to the cloud. It has the capabilities to set up OPC UA servers to be used for several purposes on the rig when connecting to the HMH control system network. As mentioned, OPC UA is known to most software developers in the oil industry and is a cross platform standard that enables data exchange in typical industrial networks. The standard has many features that makes it suitable for integration on a drilling rig.

- Easy to exchange data models using XML format
- Security features like authentication, encryption, authorization, and checksums
- Client-Server or subscription method of exchanging data
- Cross platform

There are numerous features in the OPC UA standard, but from an industrial network perspective the ones mentioned above are some of the most valuable properties. The drilling control system is considered critical on a drilling rig. If there is a cyber security breach in this network the consequences could be serious. Security measures need to be taken when integrating with 3rd party software and OPC UA enables this in a simple and good way. By utilizing client-server communication, it is possible to place the OPC UA Server in a segregated network outside the crucial HMH equipment networks and act as an interface. The Smart Adapter is a client initiating connection out of the strongly regulated and protected networks to the server, performing read and write operations in a safe manner. The 3rd party application can do the same on its side towards the OPC UA server. This way there is no writing of data directly from the 3rd party application into the drilling control system. In addition, security measures like firewalls and encryption/authentication and authorization further reduces the vulnerability in terms of cyber security.

Having the possibility of quickly sharing entire data models and being able to communicate and adapt to changes fast this way, also speeds up the process of setting up an interface both parties can work with and minimizes the risk of faults in interface definitions.

The performance of a typical OPC UA Server is also more than sufficient to be able to serve large amounts of data going between the two systems with low latency and high throughput. The performance is most often limited by the surrounding systems not being able to handle the required throughput or latency required.

Human-Machine Interface

The human machine interface (HMI) is important when doing an integration project with a 3rd party. Based on our experience, successful integration of the required operational information into the HMH HMI is crucial. While 3rd party software developers devote considerable effort to designing their own HMI for product operation, adding a new screen in the driller's cabin is usually not an ideal solution. As mentioned earlier, the driller has a lot of information to consume that is always considered important. Well integrity information is certainly one of the most important ones but also information about equipment integrity and paying attention to what is happening on the drill floor is the driller's responsibility. Moreover, communication among various roles on the rig also competes for the driller's attention. While adding screens to this environment may be the easiest solution, it's important to remember that if every software product added to the drilling control system includes its own screen with information, it would become unmanageable. Therefore, HMH insists on integrating functionality from 3rd party services into the HMH HMI. This means that all functionalities should be possible to handle in the HMH HMI already installed by integrating information there. This ensures that new alarms, messages, and alerts are handled in a consistent way across products and vendors and makes it easier for the driller to handle the system. Note that we also talk about functionality and not vendor in this case. Instead of granting control of general control parameters like ROP, WOB, Top Drive Speed, and mud flow, HMH integrates the specified functionality. Like ROP optimization, mud pump start-up, vibration mitigation or operational limitations. From our experience releasing control in a general way without the driller being in control of what is happening creates uncertainty and reluctance towards the integrated systems. The driller needs to always have situational awareness and be able to activate or de-activate functionality as he/she sees fit.

So, what about the HMI that was made by the 3rd party company. Is it redundant? The answer is no. There are most likely very good reasons why that HMI was made and looking at Figure 7 there is a link between the 3rd party and the HMH HMI. This link indicates the possibility of viewing 3rd party HMI screens in the established HMH displays by communication through the firewall, but only as a detailed view. In other words, the driller should not rely on this window to operate the system, but it should be there in case a more detailed view is required.

Figure 9

Smart Adapter

The Smart Adapter is a software module that works in conjunction with DEAL to further abstract the equipment controllers, making them suitable for typical 3rd party software developers on the drilling rig. The Smart Adapter is also connected to the HMI and will handle the integration of information from and to the 3rd party from the user. In the case of retrofit installations, this feature allows for seamless adaptation to any existing HMI system, if required.

In addition, it should be mentioned that the Smart Adapter will be able to connect functionality from a 3rd party with similar functionality already existing in the control system. For example, if there is already installed a Drillers Assist with a mud pump startup that is manually set up by the driller, this start up function has dedicated start buttons and setup screens showing what is active and so on. It will also have a predefined behavior when starting the pumps. If a 3rd party software also has a mud pump start up but instead of being set up manually this is set up by a well model or other system automatically, the Smart Adapter can connect these two functions both in the control system towards the mud pumps and in the HMI. Meaning that for the driller, running one or the other function is a matter of selecting which is to be used. The start button and information will be located at the same place and give similar response to make it recognizable for the driller regardless of what system is active. This way he or she will always have a fallback solution in case one system fails and can operate the function in the same way. The same goes for operational limits and other functionality.

Another benefit of having a Smart Adapter is that it can make functionality available to other software modules installed on the rig. For example, if CADS is installed which handles the automation of repetitive tasks on the rig like tripping, drilling connections and stand building, the Smart Adapter can offer the possibility of automatically triggering smart functionality from a 3rd party vendor like mud pump start up or tripping speed limits as part of a CADS sequence.

Additionally, the Smart Adapter's versatility extends to accommodating changes in the integration partners used on the rig. In the event of replacing a 3rd party company with a new one, the Smart Adapter can seamlessly adapt to the new integration partner. This means that adding a new software to the rig can be done without requiring significant downtime or updates in the equipment controllers, assuming an integration development project has already been completed for the new integration.

Figure 10

Summary

The oil and gas industry has been undergoing a digital transformation, with many companies implementing digital solutions on their installations. However, integrating these solutions can be a complex process that requires collaboration between different partners. It is not uncommon for frustrating situations to arise where one partner does not understand the other's systems or the reasoning behind certain solutions. To achieve successful integration, it is essential to understand each partner's perspective and engage in mutual exchange. Identifying where compromises are needed as well as managing them in a way that all parties are comfortable with is crucial. All while keeping in mind that the experience of the end user is a very important factor to determine if the integration was a success or not.

Furthermore, it's vital to recognize that the integration model requires periodic review to maintain its status as a best practice. The oil industry is evolving rapidly, and new technologies are emerging frequently. As a result, it's important to remain open to changes and receptive to input from collaboration partners while also leveraging our experience.

In conclusion, integrating digital solutions into the oil industry is a complex process that requires collaboration, compromise, and open-mindedness. By understanding each partners perspective, giving, and taking where necessary, and revising the integration model regularly, we can ensure successful integration and keep up with the ever-evolving industry.

Smart Module Overview

Drillers Assist - Assist driller by enabling the possibility of applying static limitations/operational windows for tripping operations (Hoist, mud pumps, rotation)

Functionality for hole cleaning, friction test and more

CADS - Enables the drilling control system to operate using a preconfigured sequence to automatically perform a sequence

- Tripping
- Drilling connections
- Stand building
- Etc

DA Drilling - Enable the possibility of automating the drilling process.

- Improved ROP Control
- Off bottom operations
- Tag and pull off bottom
- Integration with 3rd party drilling automation
- ++

EKD - Easy to use software module that detects kick (influx) or loss during various drilling operations

optiCasing - Smart Module for handling casing connections. Possible to integrate with casing running tools and casing tongs. Analysis and evaluation of torque/turn curves can be integrated into the drilling control system

Soft Torque Z - Stick slip mitigation

optiWOB - Minimize WOB variations and boost the performance of the drillstring compensator system

Smart Adapter - Adapt and tailor make integration with 3rd party applications while maintaining DEAL and the abstraction layer already in place. Is able to support different HMI systems as well as any 3rd party vendor for operational windows, ROP/WOB control and other functions.