Vision and Needs

This section of the DSA Roadmap report describes the vision created in an SPE DSATS workshop in Vail 2012 adopted in this report, uncertainties related to achieving this vison and the needs for both drilling systems automation and this roadmap.

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Vision

In 2012, one hundred and twenty participants at the SPE Applied Technology Workshop in Vail, Colorado, drafted a Drilling Systems Automation (DSA) vision. The published vision stated: "In 2025, well plans are uploaded into an interoperable drilling system that automatically delivers a quality wellbore into the best geological location, installs the casing and zonal isolation according to plan, installs the completion system according to the program and updates remote operators and experts in real time to changes in the situation, and identifies potential paths for success for the experts to input control. Deep, complex wells will rely more heavily on centers of excellence onsite and remote to provide real time and near real time updates. Routine multiple wells will rely on remote operations centers to monitor progress and react to alarms."[1] This is the vision adopted by the DSA Roadmap.

Six years later and after overcoming many challenges, the oil and gas drilling industry continues to move toward realization of this vision, which remains highly relevant as the target for DSA.

Uncertainties that can determine DSA outcome

A number of technology and business issues exist, the resolution of which will significantly influence the outcome for DSA. These potential 'forks in the road' are industry choices that will directly impact the development path forward.

Future downhole-to-surface telemetry data rate

Questions about the future of data rates, bandwidth, and latency:

- Will high data rates (bits per second (bps)) with low latency hardwire systems become commodity items or remain a special option?
- Will these hardwire systems have some power-down capability?
- Will mud pulse telemetry increase the bps rate these systems can deliver?
- Will EM, combined with mud pulse, increase capability?
- Will an alternative telemetry technology deliver higher bps rates than mud pulse?

The potential of downhole telemetry futures and their impact on DSA development are discussed under Section 5: Communications. Some specific developments occurring today indicate that greater availability of hardwire systems is underway, bringing benefits by delivering data to surface and downlinks with both high data rates and low latency. Furthermore, the potential exists to offer power down capability for conductive systems.

The bps rate of mud pulse telemetry has and will continue to advance. And although mud pulse has proven to be a robust form of data transmission from downhole and has proven to deliver higher capabilities than originally envisioned, these successes are limited to ideal conditions and the system continues to suffer from high latency caused by the physics of the transmission system. An alternative telemetry system that exceeds mud pulse–EM capacities but still falls far short of hardwire systems will probably be developed in the future. This gap is simply a result of physics of each system's technology.

The impact of telemetry system capability and adoption (economics) of DSA progression drives the placement of processors and automated systems. In a low data rate–high latency system, the controls and automation must close the loop down hole. In a high data rate–low latency system, processing can be undertaken at surface.

The development of the processing center downhole or at the surface is also impacted by the cost and availability of sensors and computation power that can be installed downhole. Development is also impacted by the need to provide control input to the three key surface machines—drawworks, top drive and mud pumps. This interaction will evolve as competing interests, technologies, and new developments in the world of sensors and processors play out.

Advancement of interoperability in drilling

Within the industry, there appears to be great reluctance to share data from current machine and equipment control systems. This sentiment is caused by a perceived loss of proprietary insight and Potential embarrassment over the actual level of data quality, in terms of accuracy and frequency, compared with the perceived quality.

Open communications systems such as OPC UA can provide access to all the data and the machine directives but has not been widely adopted. Work has been undertaken to provide a companion specification connecting OPC UA to WITSML, which enables OPC UA to build a bridge from the sensors to the data users and to provide control applications back to the machines. In addition, in association with the SPE DSATS 'Drill a Stand' initiative, work has been undertaken on the design of a Rig Information Model (RIM) that can enable auto detection of sensors and machines with their corresponding data.

IRIS, now part of the Norwegian NORCE research group, launched an initiative called Drilling Data Hub (DD-Hub) to develop a semantic language for the transfer of data in a standard format for consumption and processing by any end user. The signal semantical data model is a means by which to precisely define the meaning of every signal, such that a consumer application can discover the significance of each signal and make inferences with which to choose between signals of similar nature based on usage in the application.

Recently, initial operator reluctance to open systems for interoperability appears to have shifted toward cooperation as suppliers see customer demand for interoperable systems. Although progress is still to be made, this development will impact the eventual outcome of DSA.

SPE DSATS has launched an initiative, that includes Energistics, the data standards organization for the industry standard WITS–WITSML, to characterize and develop an understanding of the issues that can create interoperability. The first step in this undertaking is to define its current and future state and thus expose the gaps industry solutions must cross to reach full interoperability.

Adoption of redesigned rigs

The impact on DSA of rigs specifically built for automation will be greater than will the application of automation to rigs already in operation because the former are more suited to take advantage of advanced mechanization systems and rig layout designs.

On land, where new-design rigs can easily replace current rigs, such a program is being pursued by one integrated service company. By designing in continuous tripping mechanisms and by preparing (making up) drill pipe offline, newer rig designs are enhancing mechanization of pipe handling to reduce critical path activity time. This mechanization will be automated to ensure consistent operations and reduce the footprint required by humans. BOP handling systems can similarly be automated to enable fast and consistent rig up times and automation of BOP testing is being pursued.

Offshore, facility cost is a barrier to replacing current rigs with new-design rigs. However, a new technology opportunity is being offered to the industry that may offset the cost of asset obsolesce. This new system employs 180-ft stands that are made up on one side of the drilling tower before being handed over to the operations side of the drilling tower. Offshore continuous tripping systems have been designed; one prototype utilizes opposing top drives while another incorporates a vertically moving rotary table incorporating an iron roughneck.

Intelligent equipment

The Internet of Things (IOT), is rapidly advancing the industry's ability to add sensors to intelligent equipment, and to transmit these sensor-generated data as an autonomous body. Advances in surface equipment will readily be realized along with industrial development; advances in making downhole more intelligent will include sensor-equipped bits able to provide an array of data that automation systems can process to improve both drilling performance and reservoir production. As IOT advances and cost of application is reduced, there will be a flood of new data that can be managed and acted upon only by automated systems.

Human Interaction with Automation

Humans will remain intertwined with automated drilling systems. The future of this twinning of humans with automation and the transition to move from current state to future state is not easy. It will require mapped transitions containing well thought out and applied competency and training activities. Because this skill set is new to the drilling industry, the effectiveness of application and impact will have direct consequences on the uptake of DSA. This is discussed under Section 11: Human Systems Integration.
The transition from humans to automation will occur in levels across the four cognitive functions—acquire information, analyze and display information, decide action, and implement action.
Initially, drilling industry projects of human-to-automation transition only addressed the last cognitive function—implement action. Recent, successful applications include the first three stages that occur in both human control and automation, which has led to advisory systems in which the human implements the action. After confidence in the algorithms is gained by both the developers and the humans executing the action, the loop can be closed for data input to the machines. The cognitive functions will be automated at different rates to different degrees creating a complex matrix of opportunity.

The frequency and accuracy of sensor data

Data frequency and accuracy is a major issue that can block implementation of DSA. Essentially, the industry has split into two areas: high frequency and high accuracy sensors in systems that are controlled by suppliers who require these sensors to deliver control level input, such as rotary steerable systems (RST), and low frequency inaccurate sensors that are bought and installed for a client who is not the end user of the data, such as the deadline anchor drill string weight sensor.
The many insufficiently accurate sensors in use must be replaced for DSA implementation to occur. When such replacement is technologically, or economically impossible, solutions lie with modelling parameters. The economic impact of upgrading many rig site sensors has been a challenge to address as the value from such upgrades is often underestimated or is additive to the customer not the owner/investor.

The economic value of such upgrades can be split between improved data quality with which the driller (and engineers) are able to take good decisions, the value from data analytics, and the further impact of enabling automation that assists the driller to achieve performance targets. A proof of concept joint industry project (JIP), for the application of systems engineer independent verification and validation of sensors and systems, was launched in 2018. This JIP can realize a recommended practice (RP) that brings commercial aviation- and aerospace-applied methodologies to sensors and systems validation in oil and gas drilling, which can solve numerous data issues.

Needs for Drilling System Automation.

Communicating the business value that it can deliver is a key hurdle to DSA implementation. Currently, automation drilling results have shown a 40% improvement in rate of penetration over human driller rotary drilling in open hole sections, an 80% improvement while slide drilling in building/steering wells, and mile-a-day wells drilled through the buildup into the horizontal section.

However, the overall value proposition is larger. A recent offset industry example has demonstrated that when port container handling lift equipment was automated with supervisory remote control, the whole wharf system became autonomous. The impact was an 18% increase in productivity, a 27% reduction in maintenance and a 22% reduction in fuel consumption and emissions. By applying a comprehensive DSA, similar system value can benefit operators, drilling contractors and service companies.

Summary

The oil and gas drilling industry has multiple needs that can be addressed through the increased adoption of automation, which will occur only if the adoption of automation brings financial rewards to those who invest in it. Addressing them will ensure that those immediate needs do not become barriers to or delay the adoption of automation and its numerous advantages in controlling manual operations in drilling.

Automation enhances responsiveness in drilling operations through high-speed interpretation and action on sensor data that exceeds human capability in terms of quantity of data input and frequency and speed of reaction. It also allows operators to close the loop in locations where humans cannot operate or when the system may operate with delays and latency that create unacceptable noise in the system, such as rotary steerable systems.

Repetition is challenge common to many manually controlled repetitive industrial processes. That is because humans often become bored undertaking these processes, which can lead to inconsistent performance. Automation ensures consistency, which provides the base point from which to improve performance during repetitive actions, such as pickup and laydown of drill pipe. In drilling, flat time operations performed offline by robotics and automation will be more deterministic than those carried out manually reducing risk of time overruns affecting critical path drilling durations.

Similarly, because repetitive operations, such as making drill pipe connections, are more consistent when automated than those performed by humans, they can achieve greater performance compared to the average time over multiple crews. Additionally, predetermined responses for specific inputs from sensors create a deterministic outcome, such as the impact on borehole stability from drill string acceleration and deceleration during tripping, compared to inconsistent (non-deterministic) responses from humans. Increasing consistency of multiple operations through automation enables more predictable drilling durations and costs.

For at least the past 20 years, other industries have applied automation to successfully achieve the goal of removing humans from safety critical areas, such as spray painting and steel mill operations. During drilling rig operations, automation can remove humans from high-risk areas and activities, such as heavy load paths, chemicals addition, pinch points, and dropped object zones.

By adopting programmed algorithms for deterministic operations such as connections while drilling or tripping pipe, friction tests, drill off tests, and bedding bits, automation can also help offset the knowledge and skill loss caused by high drilling crew personnel turnover. Automation allows the industry to incorporate knowledge from retiring older generation experts into automated systems that a new wave of young experts can use to decide action prior to implementation.

Likewise, in place of human interpretation, these automated systems allow engineers to input the details of a digitized well plan, such as trip speeds and pump ramp up, directly into machines that deliver the plan.

Automated drilling systems will reduce well costs by reducing non-productive time (NPT) through control systems that manage the operating envelopes of downhole tools and boreholes. These automated systems are able limit shocks, manage tripping envelopes, maintain borehole condition, and efficiently controlling numerous other operating events. Rate of penetration is increased and bit run duration is maximized when best drilling practices, such as initiating drilling, friction tests, continuous ROP maximization, and continuous application of MSE management, are automated.

Drilling costs are reduced in the long term by replacing human operators and reducing the number of on-site personnel. Especially offshore, automated mud systems, automated pipe handling and BHA make up, and replacement of travel with remote specialist input, all result in significant cost savings. Further savings can be realized by reducing flat time through automation of mechanized parallel activities and by increasing borehole quality through automated continuous application of best practices for swab and surge control, hole cleaning, and tortuosity minimization. Increased consistency of drilling practices that lead to reduced NPT and invisible lost time (ILT) result in more predictable well construction duration and costs.

In land drilling applications, automation can offset potential shortages of competent personnel by minimizing crew count. This is of particular importance in the current and foreseeable labor market as was recently explained by Jay Minmier, president of Nomac Drilling, in his role as 2013 IADC vice chairman. “Speaking for US land, there are currently roughly 40,000 people employed on the rigs for drilling contractors. Historical attrition rates have been 30% to 40%, so we are talking about 10,000 to 12,000 new-hires per year just to sustain, not including growth. It’s safe to say that we are looking at needing 20,000 to 25,000 people to come into the industry in the next two years. And if you include the worldwide offshore market, it may be double that amount.”

The huge reduction in rig count during the last oil price fall was followed by rising rig activity level. The reduction in manpower caused by the former resulted in permanent experience loss. Typically, the industry has addressed this labor shortage through the addition of personnel and aggressive training.

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DSA offers an alternative by automating many processes, which reduces the rig personnel head count during drilling operations. As automation replaces some entry level positions, remaining personnel will be placed in supervisory positions that require higher education and more training. As a result, operations will be conducted with fewer personnel having higher skills.

In deepwater operations, DSA reduces loss of well control incidents through consistent procedural responses to sensor signals and the opportunity to more readily accommodate uncertainty in subsurface models through fast, continuous automated data acquisition, data analysis and decision (option) presentation.

Well Complexity	• More difficult profiles, tighter bottomhole pressure margins • Automation mitigates risk and controls costs on complex wells
Data Overload	• More real-time measurements, more parallel complex operations • Automation can manage, interpret and act on large volumes of data
NPT Significant	• NPT accounts for 35 to 40% of deep-water drilling costs • Automation minimizes NPT by responding predictably to events
Well Manufacturing	• Will drill many similar profile wells per field • Automation will repetitively drill to plan with minimal risk and cost
Expert Resources	• Operations starved for expertize – increasing NPT, risk and cost • Automation will make available scarce expert resources
Knowledge Transfer	• Skilled employees will exit the drilling industry in the near future • Automation can transfer knowledge from skilled to new employees
Health, Safety, Environment	• Driver is to make the work environment a safer place • Automation will reduce the number of people in "red zones."

Table 1: Drivers for drilling automation. Table 1 lists operational concerns (*left*) and specific automation drivers and the effect of automation on those concerns (*right*).[2]

Needs for a DSA roadmap.

The key reason the drilling industry lags other industries in applying automation is that while many see it as inevitable, no consensus exists as to how to achieve DSA. The underlying goal of this roadmap document is to serve as a drilling automation value proposition. More specifically, this roadmap provides a mechanism to forecast technology developments, provide a framework to help plan and coordinate technology developments among disparate players, and to enable contributions from different industries.

The need for an industry roadmap is compelling. The well drilling and completion industry is highly fragmented and will require structure to enable the interoperability necessary to deliver functioning automated and autonomous systems. The roadmap will provide definition of supplier opportunities so that they can develop applicable products and services. A transformation of this scale across our industry requires consensus on how DSA will develop and must attract the requisite levels of investment. Entry of non-oil and gas industry players will enable the industry to access alternative skills and advanced technologies that are necessary for accelerating successful adoption. Fear of technology and personnel change is significant but can be overcome through a clearly communicated comprehensive way forward.

References

[1] De Wardt et al, 2012: "Well Construction Automation - Preparing for the Big Jump," paper SPE 163146, presented SPE Applied Technical Workshop, Vail, Colorado, USA, July 16–18, 2012.

[2] Macpherson, JD, de Wardt JP, Florence F, Chapman CD, Zamora M, Laing ML and Iversen FP: Drilling Systems Automation: Current State, Initiatives and Potential Impact," paper SPE 166263, presented at the SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, September 30–October 2, 2013.

