Summary Report of the IADC organized
DSA Roadmap Workshop
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DRILLING SYSTEMS AUTOMATION ROADMAP & DSABOK™ 2013 – 2025

IADC WORKSHOP SUMMARY REPORT

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Automating the Future

DRILLING SYSTEMS AUTOMATION ROADMAP

&

DSABOK™

2013 – 2025

SUMMARY FROM IADC WORKSHOP

A more extensive workshop report including full descriptions of the flip charts produced by the workgroups with observations and comments on their feedback together with the full workshop presentation (including the missing sections due to the ice storm delay) will only be released to JIP Funder companies.

Those wishing to sign up as a JIP Funding Company to immediately access the full 247 page DSA Roadmap / DSABOK™ Report and the associated materials can contact john@dewardt.com for details.

Acknowledgements

We gratefully acknowledge the work, skills and knowledge impacted to the workshop by the steering committee, many of whom delivered presentations and facilitated work group sessions.

We are very grateful to IADC and their conference specialists for taking the initiative to administer the organization of this bespoke and first of a kind industry workshop.

Workshop Steering Committee

John de Wardt, DE WARDT AND CO, DSA Roadmap Program Manager, workshop moderator / reporter
Moray Laing, Halliburton, SPE DSATS Chairman, Communications
Marty Cavanaugh, Cavanaugh Consulting Ltd, Information Model
Mark Anderson, Shell, Standards & Certification
Robin Macmillan, NOV, IADC ART Chairman, Drilling Machines and Equipment
Hani Ibrahim, Quantico Energy Solutions, Support to Systems Architecture and HSI
John Macpherson, Baker Hughes, a GE company, Instrument Measurement Systems
Ben Facker, NOV, Controls
Jay Hollingsworth, Energistics
Paul Hunkar, DSInteroperability, OPC Foundation
Maria Araujo, SwRI, Verification & Validation
Amanda DiFiore, Charles River Analytics Inc, Human Systems Integration
Blaine Dow, Schlumberger, Modeling and Simulation
Mike Killalea, IADC

IADC Organization

Lori Gagula, IADC, Assistant Director Conferences - Western Hemisphere
Stephanie Carling, IADC, Director of Conferences - Western Hemisphere
Leesa Teel, IADC, VP Conferences

Workshop Sponsor Organizations

Rowan Companies
Cameron, a Schlumberger Company

Executive Summary

1. *Systems Architecture* provides a multi-faceted framework for the effective adoption of DSA. This includes four key aspects discussed in the workshop:
    a. Reference Architecture of Systems of Systems and Systems of Interest
    b. Epics, User Stories and Use Cases with States Definition
    c. Decision and Control, Framework derived from ISA 95 and MES
    d. Drilling (Rig) Information Model

2. *Communications* addresses links among the downhole, surface, remote operating centers, and distributed experts, in addition to standards for common protocols and interoperability, deterministic systems for hardware control, and secure data transport at all levels.

3. *Sensors Instrumentation and Measurement Systems* (IMS) defines the requirements for delivering comprehensive, reliable, quality measurements of the downhole, and surface operations in a timely manner for DSA.

4. *Drilling Machines and Equipment* includes a wide range of surface and downhole drilling equipment and robotics that are highly mechanized and partially automated through to almost autonomous.

5. *Control Systems* focuses on downhole, surface, and remote systems directed at creating the wellbore and delivering various levels of automation from monitoring through advisory control to autonomous systems.

6. *Simulation Systems and Modeling* covers planning, real-time, offline, remote and post-well modeling, and simulation tools and systems.

7. *Human Systems Integration* addresses the interaction of automation systems with humans and mode issues including human displays, human machine interfaces, role competencies, training, and distributed and decentralized control.

8. *Industry Standards and Certification* identifies available and required standards and regulations that define the operations of automation as well as current and future impacts that can define the ultimate future of DSA.

Work Group Sessions

The Drilling Systems Automation (DSA) Roadmap workshop included various work group sessions allowing participants the opportunity to give feedback and input to sections of the roadmap. The following sections include the work group descriptions and a summary of their key outputs. Details of the work groups outputs and their implications for the DSA Roadmap / DSABOK™ is reported in another, more extensive, document that is limited to JIP Funders at this time.

Systems of Systems / Systems of Interest including Industry Reference Architecture

Moderator: Hani Ibrahim, Quantico Energy Solutions

Fundamental to the correct functioning of complex interrelated systems, such as occur in drilling, is the need to properly organize these systems. Contractual relationships in drilling fail to achieve this. It is a must for adopting drilling systems automation, without it the best automation / control loops are not created and full value is not added. In developing the DSA Roadmap we developed a Systems of Systems and Systems of Interest map that can become the foundation for many attributes for successful adoption of automation into drilling as well as the ability for various discrete players to cooperate (interoperably). Industries have recognized value from cooperating on standards and competing on innovation. In this vein, we developed a high-level Reference Architecture for standardization in drilling automation cascading down through Pattern Architectures to Solutions Architectures where projects develop their innovation.

<u>Work Group Feedback</u>: This work group provided key endorsement of the Systems of Systems and Systems of Interest development. Many of the issues raised are addressed by the DSA Decisions and Control Framework Well Construction Execution System and will be further articulated to clarify their application. Sub surface (so called Earth Model) was assumed to be missing however it is mapped as a parallel System of Systems – logically as this continues through the life cycle of the well while Well Construction / Well Intervention / Well Abandonment is a periodic event. Linkage has been mapped via parallel Decision and Control Frameworks based on ISA 95.

Epics / User Stories / Use Cases and States Definitions

Moderator: Moray Laing, Halliburton

Incorporate a list of actions or event steps typically defining the interactions between a role (known as an actor) and a system to achieve a goal, they are building blocks for software and systems engineering. They are used to develop software programs for automation. In a complex operation, such as drilling, they can be organized in a hierarchy of Epics, User Stories and Use Cases. States definition defines the condition of an operation, historically in drilling this has been through manual reporting (drilling, tripping, cementing, ...). For improved activity definition, state engines have been developed and commercialized to define activities accurately from machine sensor output (rotating, pumping and slacking off draw-works is drilling). DSA requires that the current state and the future state is understood so that the system can complete the activities in one state and transition properly to the next state. The type of state expands as wellbore state, equipment state, automation state etc. are added for full automated comprehension.

Work Group Feedback: This work group listed multiple strong points for these definitions. Weaknesses were limited to a desire for more detailed definition, an effort that will require some form of industry initiative to achieve.

Decision Control Framework: ISA 95 and MES

Moderator: John Macpherson, BHGE

DSA applications experts have recognized that there exist models and standards applicable to DSA that can be readily adopted. One is the ISA 95 – the International Society of Automation standard for developing an automated interface between enterprise and control systems. This standard was developed to be applied in all industries, and in all sorts of processes, including batch processes, continuous and repetitive processes. We reviewed the history of this standard from the original Purdue Model to its current form and then developed a DSA model that shows the transition in exchange of information from current practice to remote control centers and cloud computing. We also mapped the expected future of data protocol standards needed to exchange information, especially the linkage between WITSML and OPC.

Work Group Feedback: This work group listed strong points as the application of this international standard which provides clear mapping of plan and data. Weaknesses and gaps centered on this being new to drilling with various requests to develop broader understanding.

Drilling (Rig) Information Model

Moderator: Marty Cavanaugh, Cavanaugh Consulting Ltd

There is a need to aggregate all the information concerned in planning and drilling a well and expose this information in a standard way. The Drilling (Rig) Information Model consists of a virtual device object that can be inherited and extended for use by each piece of equipment present on the rig. The Rig Information Model, originally developed as part of SPE DSATS Drill a Stand Team in 2011 (Marty Cavanaugh), has been realigned to the Systems of Interest in the Reference Architecture and expanded to be a Drilling Information Model. This provides a framework that can readily become a managed and maintained industry standard which will advance both data analytics and drilling systems automation.

Work Group Feedback: This work group included understanding of data sources and adaptability / extensibility among multiple strong points. Weaknesses and missing points were primarily related to *decisions to use it; WIIFM (manufacturers, service companies, contractors), costs, further development. SPE DSATS intends to address potential development of the Drilling Systems Information Model (DSIM) in conjunction with work on data semantics being undertaken by IRIS (Eric Cayeux).*

<u>Communications</u>

Moderator: Moray Laing, Halliburton

Communication is a complex process that requires full understanding from the sending of the message to the interpretation of the message in a correct and accurate manner. Aspects of communication that are critical for DSA include latency, bandwidth, uptime and cost. DSA communications arena covers downhole to surface (and back), surface systems and remote centers. The development of communications systems, particularly from and to downhole systems, will drive the rate and type of adopted automation systems. Communication is also a core element of interoperability between data and processes.

<u>Work Group Feedback</u>: This work group recognized the OPC UA / WITSML companion spec as a primary strength. Weak points included lack of awareness and engagement with associated adoption issues. Missing items were focused on actions to enable greater adoption of improved communications. Primary focus for solutions was identified as operator engagement.

<u>Instrumentation and Measurement Systems</u>

Moderator - John Macpherson, BHGE

Instrumentation and Measurements System (IMS) includes sensors – the source data. This section of the roadmap developed a comprehensive description and map of data requirements for automation. These requirements define targets for 7 characteristics of any measurement and further define 5 quality requirements. The transition from the current state for IMS to the future state needed for automation, and incidentally proper manual drilling operations, is a major jump requiring investment in sensors and maintenance, and a commitment to measurement transparency and interoperability. Progress towards systems automation is currently hindered by poor data quality, the result of a lack of standards and active ownership/responsibility for data.

<u>Work Group Feedback</u>: This work group quickly listed sensors and data as high value including data aggregators. Weak points were more extensive covering a range of topics including bad data, standards and prioritization. Similar missing points covered a large range from sensor availability to understanding effects of data quality.

Drilling Machines and Equipment

Moderator: - Robin Macmillan, NOV

Significant advances in drive systems and controls have created an environment in which drilling rig equipment and many of the associated machines are ready for automated control. The next stage in value realization is the redesign of equipment to take full advantage of automation, examples include offline stand building, continuous tripping..... Redesigned equipment has not been readily adopted as the barriers outweigh the advantages – cost of replacing current assets, speed of financial return from the business model. Drilling performance and well quality needs create an opportunity for the development of redesigned automated machines and equipment.

Work Group Feedback: This work group focused on rig equipment and fluids system. Highlights include work needed on pipe handling to enable full automation of this process resulting ultimately in removing humans from these heavy lift industrial activities. Day rate contracts and interoperability issues are prime barriers to progress. Fluids systems offer a huge opportunity for automation but have some key barriers: value proposition and integration of equipment from multiple parties.

Control Systems

Moderator: Ben Facker, NOV

Control systems have become prevalent at the machine level and have seen advances in the acquisition and analysis stages. The DSA Decision and Control Framework based on ISA 95 provides an important industry structure for the hierarchy over control systems up to enterprise management. Control systems offer both the direct value add of reducing human risks, faster response, reducing labor costs, offsetting labor shortages, ensuring reliability through complex envelope management and the indirect value of advancing equipment redesign for automated efficiency, effective parallel activities, etc. The future outlook depends on a number of aspects including accurate sensors, complete data, interdependency of systems, effective application. The challenge to describe the future is assessing the willingness of the industry to adopt effective solutions.

Work Group Feedback: Control systems remove human error in repeated operations offering a more consistent and repeatable performance. There are multiple industry challenges that include alarm management, interface inconsistency amongst other issues. There are a number of mission critical opportunities that the industry could choose to adopt.

Modeling and Simulation

Moderator: Mark Anderson, Shell

Modeling and simulation are key processes needed to fill gaps in impossible data acquisition and to test the outlook for future activities. The decision and control framework provides a map for the fit of modeling and simulation into the overall process. Models fall into domains described as industry accepted, proprietary for own use and proprietary available as a service. Model output accuracy and data quality available for the input are key factors determining the acceptability and usability of models. Models are needed as they fill gaps in the data acquisition spectrum that cannot otherwise be filled, but can they be trusted especially for automation.

Work Group Feedback: Physics based and standard models do exist, fortunately they do compensate for lack of some sensors. But there are many limitations resulting from lack of sufficient feedback loops, failure to choose the right model, boundary limitations and other effects. One major issue is gross validations, lack of transparency combined with lack of independent verification and validation of models; an issue the DSA Roadmap / DSABOK™ has launched an initiative to correct. Underlying this is the data quality. The missing points raised provide significant opportunities for the DSA Roadmap / DSABOK™ to articulate how the drilling industry can improve.

Human Systems Integration

Moderator: Hani Ibrahim, Quantico Energy Solutions

Drilling systems automation cannot advance safely and effectively without incorporating Human Systems Integration (HSI). There is a lot that DSA can incorporate from more advanced applications of HSI typically found in transport, aviation, aerospace and other technically advanced industries. The levels of automation from manual to autonomous through the 4 functions cycle is defined in a Levels of Automation Taxonomy (LOAT) matrix. The critical implementation areas of personnel competency, training, human factors engineering, etc. are described in terms of best practice.

Work Group Feedback: The LOAT developed within the DSA Roadmap / DSABOK™ initiative is regarded as a valid method for mapping levels of automation and communicating same. The industry wants more guidance on multiple issues regarding HSI during the transition to higher degrees of automation. The transition in terms of remote and local control must be developed with examples. This work group offered ideas for development that support the basis in the approach outlined in the DSA Roadmap / DSABOK™. More work is required to articulate them.

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