## Title:

Independent Verification and Validation of Sensors and Systems in Drilling – Development of an Agreed / Consistent Industry Methodology (Recommended Practice)
Phase I: Identification and prioritization of sensors / systems benefitting from IV&V, one proof of concept of IV&V application
SwRI Budgetary Estimate B10/2018/0102

## Submitted by:

Maria Araujo, Southwest Research Institute®
6220 Culebra, San Antonio TX 78238
Contact info: e-mail maria.araujo@swri.org ; phone: 210-522-3730

## Principal Investigators:

Maria Araujo and Paul Wood will undertake the primary workload, leadership, and direction of Southwest Research Institute (SwRI®) internal resources and coordination of other resources necessary for the development of a competent set of standards and practices for independently verifying and validating sensors and systems associated with drilling data, drilling operations, and various degrees of automation of drilling.
Expert participants on a volunteer basis include: drilling industry experts in the domains of the systems and sensors being verified and validated and others TBD based on technical needs identified by the core team.

## Leadership

- Program Manager: Maria Araujo (Manager R&D, SwRI). Manage the program using SwRI knowledge of the process.
- Deputy Program Manager: John de Wardt, (Program Manager Drilling Systems Automation (DSA) Roadmap Industry Initiative, President DE WARDT AND COMPANY). Provide the primary link between SwRI to the relevant drilling industry experts as well as be the primary advisor to SwRI on the plan and implementation of this program.
- Deputy Program Manager: Paul Wood, (Staff Analyst, SwRI). Co-manage the program along with Maria using SwRI knowledge of the process.

## Steering Committee

Selected drilling industry leaders from various organizations whose purpose is to steer this initiative in the best interests of the industry and JIP Funders and to identify the right industry experts to advise technical aspects of drilling, drilling sensors, and drilling systems. The anticipated make-up of this steering Committee is:

- IADC Drilling Engineering Committee (DEC):
  - To be advised by IADC DEC
- Drilling Systems Automation Technical Section (DSATS) of the Society of Petroleum Engineers (SPE)
    - Mark Anderson, Shell (DSATS)
    - Tony Beebe, Northern Offshore (DSATS)

- International Association of Drilling Contractors (IADC) Advanced Rig Technology (ART) Committee
    - To Be Advised (TBA)
    - TBA

- Operators Group on Data Quality (OGDQ):
    - Proposed: Matt Isbell - HESS
    - Proposed: Michael Behounek - Apache

- Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA) / Society of Petroleum Engineers (SPE) / Wellbore Positioning Technical Section (WBPTS)
    - TBD

- Energistics
    - TBD

- Industry Segment Representative cross check:
    - Drilling Contractor:
    - Original Equipment Manufacturer (OEM):
    - Electronic Data Recording:
    - Mud Logging:
    - Data Processor:
    - End user (operator)

- JIP Funders:
    - One person per funder

## Advisors

Some important, knowledgeable people who are too busy to be involved but are invested in giving their guidance/feedback (intermittently).

## Experts

Drilling industry experts from across the chain of sensors through to end users who are identified by the steering committee to provide the technical input to SwRI for formulating the proposed solution. These experts will also review and verify the planned solutions together with the steering committee to ensure suitability in the drilling industry.
Standards experts from organizations who provide certification and testing to the drilling industry.

### Business Impact:

Some critical sensors employed in drilling are inadequate in a number of ways (Ref 1: Zenero 2014 and Ref 2: Zenero et al 2016); for example, some sensors are neither regularly calibrated nor maintained, some sensors measure properties in the wrong location invalidating the value

they purport to represent, and some sensors are not adequately designed for the function(s) they are intended to provide. Additionally, the communication channels transferring the data from point of acquisition to an end operator or analyst are susceptible to reliability problems such as noise, latency, and data drops. The Operators Group on Data Quality have identified multiple drilling sensors in use today that exhibit output errors greater than the accuracy needed for current drilling operation and analysis, thus leading to the need to establish a methodology to ensure consistent and continuous data quality (Ref 3: Behounek et al 2018). The growing application of drilling automation to various aspects of drilling operations (steering, tagging bottom, drilling-a-stand, etc.) increases requirements on sensor data quality as well as evidence that systems function as intended (Ref 4: Cayeux et al 2013). The DSA Roadmap Instrumentation and Measurement Systems (IMS) team developed classifications of sensors for various purposes; this classification can assist in defining tiers of sensor and system requirements from simple data through full automation and detailed analytics.

Time stamping of data from various sources in any drilling operation has proven to be inadequate for proper correlation of data (Ref 5: Isbell, M). Time stamping in other industries is covered by various industry/international standards. SwRI is familiar with these standards and applications in other industries enabling this project to determine if improvements in time stamping data could fall within the independent verification and validation (IV&V) program in drilling. Data telemetry from downhole to surface and vice versa is a particular challenge due to latencies, mud characteristics, electrical transmission and the like; therefore, it may fall outside any valued application of IV&V.

Multiple systems are emerging as panaceas to mapping missing data, analyzing large amounts of data (big data and predictive analytics), and modeling various drilling processes (Ref 6: Wigh, E.) many of these systems have not been verified in terms of capability, reliability, and validity. Often, each client (operator/drilling contractor) tries to validate these systems as black boxes, with various methods and varied results. DSA has brought to the forefront a need for formal verification and validation certification to ensure reliability and safety of interconnected drilling automation systems.

The PMBOK guide (Ref 7: IEEE), a standard adopted by IEEE, defines verification and validation as follows in its 4th edition:

- "Verification. The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process. Contrast with *validation*."
- "Validation. The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers. Contrast with *verification*."

The formal verification and validation of sensors, equipment, and systems will benefit both suppliers and customers. Suppliers will have an expert-defined program through which to verify their sensors and system, and customers will have defined attributes without having to each invent and test on their own each offering. Suppliers will accelerate delivery to market through a single formal test rather than attempt to satisfy each customer individually over an extended

sequence of tests; similarly, customers will have faster access to certified sensors and systems. Conversely, poor sensors and inadequate systems will become transparent, thus avoiding safety, risks, and costly consequences.

The value in aviation, transportation, and space from verification and validation programs for sensors and systems is millions of dollars. The cost of poor quality data from sensors and systems can range from performance reduction through to catastrophic events; the former amounts to at least $100,000's for the lower cost operations while the latter can eventually ruin a company.

## References:


Ref 1: Zenero. N. 2014. The Role of Data in Drilling; presented at the SPE Implementation of Drilling Systems Automation Workshop, Halifax, Nova Scotia, Canada, 24 September.

Ref 2: Zenero, N., Koneti, S., and Schnieder, W., Iron Roughneck Make up Torque – It's Not What You Think! SPE 178776, IADC / SPE Drilling Conference Ft. Worth, Texas, USA, March 2016.

Ref 3: Behounek, M., Nguyen, D., Halloran, S., Isbell, M., Mandava, N., Vinay, N., McMullen, J., and Hoefling, C.,; Operators Group, Rig Contractors and OEM / Service Company Work to Solve Rig Data Quality Issues. SPE 189626, IADC / SPE Drilling Conference Ft. Worth, Texas, USA, March 2018.

Ref 4: Cayeux, E., Daireaux, B., Dvergsnes, E., Florence, F.; Toward Drilling Automation: On the Necessity of Using Sensors That relate to Physical Models. SPE 163440, SPE / IADC Drilling Conference, Amsterdam, The Netherlands, March 2013.

Ref 5: Isbell, M., Unsynced time measurements can lead to data aggregation challenges; IADC Drilling Contractor, November 2017 http://www.drillingcontractor.org/unsynced-time-measurements-can-lead-to-data-aggregation-challenges-44767.

Ref 6: Vigh, E., Digital solutions guide path to better accuracy in directional drilling, IADC Drilling Contractor, March 2018. http://www.drillingcontractor.org/digital-solutions-guide-path-to-better-accuracy-in-directional-drilling-45982.

Ref 7: IEEE (2011), IEEE Guide--Adoption of the *Project Management Institute (PMI®) Standard A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*--Fourth Edition.


## Technical Objectives:

The development of a Recommended Practice(RP), potentially evolving into a standard at a later date after application experience based on industry desire, for the verification and validation of critical sensors and systems in drilling will be led by SwRI experts in the process of IV&V and will include input from a carefully thought out selection of recognized experts in oil and gas drilling from across the spectrum of sensor manufacturers, OEMs, rig builders, drilling contractors, service companies, and operators. The scope excludes marine systems and other system that support drilling assets outside the drilling (completion) process.

While individual operators have conducted verification and validation activities, there has been no consistent set of defined requirements for the sensors and systems and thus there has been no consistent verification standards or standards for validation of sensor and systems functionality. This estimate will facilitate the development and implementation of standardized verification and validation activities that can provide common and standardized results that can be used by oil industry players to ensure that the sensors and systems used in drilling displays,

drilling controls, data analytics, and automating drilling activities provide the capabilities and accuracies needed. The results from the program will be the publication of an agreed industry methodology which can be implemented by any recognized and competent independent organization including, but not limited to, SwRI.

IV&V applied to drilling sensors and systems will require a tiered approach that recognizes the various different uses of the data. The specific levels will be developed by the Steering Committee; however, an indication is given below based on the various uses of sensor data on drilling rigs and drilling operations:

- Display onsite real time: to the operator (driller, directional driller, etc.) for action implementation by that person and for alarms.
- Display remote: to the remote engineers and analysts.
- Detailed analysis: suited for real time use in models and simulations.
- Control: of equipment and machines under human supervision.
- Autonomous: fully autonomous acquisition, analysis, decision and action implementation.

## Methodology:

IV&V is a well-developed and defined (e.g. IEEE Std. 1012-1998) practice based upon systems engineering. IV&V processes determine if products (sensors and systems) of a given activity conform to the requirements of that activity, and if the sensor/software satisfies the intended use and user needs. As defined in the IEEE standards, IV&V processes include activities such as assessment, analysis, evaluation, review, inspection, and testing of software products and processes. The extent to which IV&V is applied is defined by the user requirements combined with expert opinion on minimizing interventions to those sufficient for assurance. Realistic, fit for purpose, and effective IV&V programs are driven by industry experts to which the IV&V program will apply.

SwRI has significant experience in a number of areas relevant to the development of a set of standards for the verification and validation of sensors and systems used in Drilling. SwRI has been involved in the development and implementation of IV&V in advanced industries that rely on data for analysis, control, and automation, namely commercial aviation, transport and aerospace for decades. SwRI has also conducted verification and validation of a variety of sensors and systems, both as a part of the development of the sensors and systems and on behalf of a variety of clients. As an independent, not-for-profit organization, SwRI is uniquely positioned to lead the working group in developing common standards for sensors and systems, including standards for the verification and validation of the equipment.

### Work Scope

The first step in developing a set of verification and validation standards is to classify the sets of sensors and systems for which standards should be developed. This will be based on the DSA Roadmap Systems of Systems/Systems of Interest to classify all data sources throughout the drilling operation. The second step is to prioritize the classes of sensors and systems so that the standards that will have the most immediate impact can be prioritized. While the development of standards for the verification and validation of various classes of sensors and systems can be carried out in parallel, prioritizing the classes will allow the working group to focus on those that need to be developed soonest. Once the classes of sensors and systems have been identified and

prioritized, sub groups of the overall working group can be formed to develop standards for each class of sensors and system.
For each class of sensors or system, a set of minimum characteristics must be identified. In addition, other relevant measures of the characteristics of the class of sensors or systems will be identified. Once minimum requirements for a class of equipment or systems have been identified, tests should be defined to measure the characteristics of the sensors or system that determine whether the sensors or system meets the identified minimum requirements. Once minimum set of tests have been defined, they should be implemented. Once implemented, they can be used to determine whether candidate items meet the minimum requirements for the class of sensors or systems.
In addition to the definition of a minimum set of requirements, the working group will define and lead the implementation of verification and validation tests that further define the characteristics of the sensors or systems in terms of its capabilities, accuracies, interoperability, and other suitable parameters. The availability of these additional tests will allow operators to determine whether specific items have the characteristics needed for specific tasks within drilling, data analytics, modeling/simulation, and the automation of drilling.

### Deliverables:

The Verification and Validation Working Group will develop a series of deliverables that begin with general planning documents and proceed through identification of working group members, classes of sensors and systems to be evaluated, prioritization of the classes, plans for the development of class specific requirements and resulting verification and validation tests, and eventually of operational verification and validation tests for various classes of sensors and systems.
The deliverables will be phased such that successful completion of a phase opens the door to funding and implementation of the next phase. The initial phase is designed to develop the scope of application and to develop one application with immediate benefit in order to demonstrate the validity of this approach to drilling sensors and systems.

### Phase I: 10 months from JIP approval

The initial deliverable from the Working Group will be a fully fleshed out plan for the development of a Recommended Practice (RP) for the verification and validation of sensors and systems used in drilling operations and drilling analytics including the automation of drilling. An initial set of working group members will be identified and tasks will be assigned to those members. Phase 1 deliverables will include an initial set of classes of sensors and systems and a structured prioritization of those classes (cost, impact, value). One of the high priority applications will be developed into a RP as proof of concept (application of IV&V to drilling).
The end of Phase I will be a Stage Gate review by the Steering Committee, JIP Funders and IADC DEC to approve or disapprove (with recommendations) to commence Phase II. Regular updates will be presented to the Steering Committee, the Funders and the IADC DEC.

### Phase II:

In Phase II, the Working Group's efforts will be prioritized by sensors and system class according structured prioritization made in Phase I addressing the highest ranked. This prioritization will define the scope of this Phase II through the application of an agreed cutoff in the ranking. Sub-work groups will be created and will focus on the identification of the minimum requirements for each class of sensors and system followed by the identification of the various characteristics that further identify the capabilities and attributes of the members of that class of sensors and systems. Phase II will end with the identification of test strategies and tests to characterize the members of the various classes described in a draft RP covering installation through continuous operation. The end of Phase II will be a Stage Gate review by the Steering Committee, JIP Funders and IADC DEC to approve or disapprove (with recommendations) to commence Phase III.

Phase III:

In Phase III, the subgroups formed in Phase II will focus on the creation of the tests that illuminate the characteristics of the members of a class of sensors or systems. The tests will not only determine whether an item meets the minimum requirements for that class, but will also illuminate the other characteristics deemed important by the subgroup so that operators can determine if a specific item is appropriate for a given task. The deliverable form Phase III will be a descriptive RP for IV&V of drilling sensors and systems from installation through operation.

### Start-up Date:

Start-up date for the initial phase can occur within 30 days of the confirmation of funding for the program.

### Project Duration:

The duration of the first phase of the effort is estimated at nine (9) months. Additional phases will occur for specific classes of sensors and systems and their start dates and durations will be determined by the sub-working groups formed for those classes of equipment and systems.

### Project Cost:

The quoted estimate for Phase I of the effort includes:

- Costs of SwRI leadership and implementation.
- Costs for DE WARDT AND COMPANY (John de Wardt) project advise and steering.

The budget for Phase I is $100,000.

The budget for Phase II will be developed at the end of Phase I (the Stage Gate) and is dependent on the scope of sensors and systems that rank high enough to warrant an IV&V RP.

Please note that this preproposal estimate is submitted as a guide and merely represents our estimated time and/or price to perform the services based upon our general understanding of the program and your needs at this time. The estimated time and price as set forth herein are subject to change. This preproposal estimate shall not constitute an offer for services and is intended for discussion purposes only. Should you decide to have SwRI conduct this program,

SwRI will prepare a formal proposal that will include a statement of work and contract for services.

### Cost per participant:

The funding for Phase I is proposed as $10,000 from ten (10) companies.
The funding for Phase II will be developed from an agreed / approved budget and an estimate of the number of participating companies.