Primary funding is provided by

The SPE Foundation through member donations and a contribution from Offshore Europe

The Society is grateful to those companies that allow their professionals to serve as lecturers

Additional support provided by AIME
Drilling Systems Automation [DSA] is Here

Propagation, Pitfalls, Profits & Production

**Presenter:** John de Wardt, CEng FIMechE Dist Member SPE

- Upstream Global Consultant: DE WARDT AND COMPANY
- Program Manager: DSA – R, DSABOK
- Board Member: SPE DSATS
- Lecturer / External PhD advisor: Colorado School of Mines

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl
Here are some questions I will answer:

• What is the state of the Industry today?
• Is data ‘good enough’ today and for the future?
• Is drilling ready for a digitized and automated industry?
• Where will humans perform as manual activities transfer to automated?
• Can we map a complex drilling operation?
  – also linking with sub-surface and production?
• Who takes what in terms of risk and income?
Drivers enabling drilling automation

- Electric drives and control systems
- Mechanization of rig operations
- Lower cost computations
- Higher date transfer from downhole
- Improved downhole hardware
- Modeling of processes with algorithms
- Repetitive well drilling
- Competition for rig activity

- Dynamic positioning is fully automated and robust

Applications becoming common

- Managed Pressure Drilling (MPD)
- Drilling rate of penetration
- Steering – motor and rotary steerable
  - Geosteering
- Drill a stand cycle
  - Bedding bits / Friction tests /.....
- Wellbore protection
  - Swab / surge management, pump start ups,.....
- High performance tripping
  - High rates / continuous potential
Unfortunately, drilling rigs exhibit some key data quality issues

- Errors stack up - sensor to data
  - Sensor / installation / compensation / signal conversion / calculation / transmission
- Significant lack of meta data (data giving information about data)
  - Measurements have unknown quality
- **Who knows the true quality of their drilling data?**

86% of WOB across 40 rigs not zeroed or zeroed incorrectly

WOB = Weight on Bit

SPE 184741; SPE 189626; SPE 189636; SPE 139848
Data attributes require upgrades for effective analytics and automation

Complete
Determine state of system

Logical
Correct sensor for operations state

Conversion
Information for correction

Proximity
Direct measurement – close as possible

Availability
Probability of outage and duration

Accuracy
Calibration method and frequency

Criticality
Redundancy – not duplication

DSA Roadmap
## Drilling Systems Automation (DSA) Decision Making and Control Framework

<table>
<thead>
<tr>
<th>Level 0 – Well Construction</th>
<th>Actual physical processes</th>
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<tbody>
<tr>
<td>Level 1 – Well Construction Machine Control</td>
<td>Activities involved in sensing and manipulating</td>
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<tr>
<td>Machine Control – Machine Sensors</td>
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<tr>
<td>Level 2 – Well Construction Execution Management</td>
<td>Activities monitoring &amp; controlling</td>
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<tr>
<td>Drilling Process Physics / Models</td>
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<td>Operation &amp; Equipment States</td>
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<td>Level 3 – Well Construction Operations Management</td>
<td>Activities of work flow to produce the desired end products</td>
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<td>Well Design</td>
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<td>Drilling Process Management</td>
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<td>Risk / Uncertainty Management</td>
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<tr>
<td>Level 4 - Enterprise Well Construction Management</td>
<td>Business-related activities needed to manage an operational organization</td>
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<td>Well Proposal</td>
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<td>Cost Estimation and Control</td>
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<td>Scheduling</td>
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<td>Supply Chain Management</td>
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</table>

### Key Points:
- **Purdue Reference Model for Computer Integrated Manufacturing (1989)**
- **International Society of Automation ISA 95 standard defined for industrial application**
- **Relevant for DSA**
- **Bottom up mapping overview (examples)**

**DSA Roadmap**
Data sourcing / communication is an issue

WITSML - Well-Site Information Transfer Standard Markup Language employed for transmitting technical data between organizations in the petroleum industry

OPC UA - Open Platforms Communication Unified Architecture machine to machine communication protocol for industrial automation

DDS – Data Distribution Service application connectivity standard

Level 4 - Enterprise Well Construction Management

Business-related activities needed to manage an operational organization

Level 3 – Well Construction Execution Management

Activities of work flow to produce the desired end products

Level 2 – Well Construction Execution Management

Activities monitoring & controlling

Level 1 – Well Construction Machine Control

Activities involved in sensing and manipulating

Level 0 – Well Construction

Actual physical processes

[Digital] Drilling Program

Open: OPC UA / DDS

WITSML

Sub surface data

Electronic data recorder

Machine Control – Machine Sensors

WITSML

Open Platforms Communication

Proprietary

Well Site Information Transfer

Well - Site Information Transfer Standard Markup Language employed for transmitting technical data between organizations in the petroleum industry

Open: OPC UA / DDS

WITSML

Machine Control – Machine Sensors

Actual physical processes
Automation is not all or nothing
Humans will remain in the loop to various degrees

Mapping transition from manual through augmented to automated built upon huge depth of expertise & experience:

1. Sheridan et al, 1978
   • 10 levels of automation from manual to autonomous

2. Parasuramen et al, 2000
   • 4 cognitive functions for humans and automation

3. Save et al, 2014
   • Application matrix in European aviation automation industry initiative with pilots and air traffic control

4. DSA Roadmap adopted with permission
# Levels of Automation Taxonomy [LOAT]

<table>
<thead>
<tr>
<th>Supported Function</th>
<th>Information Acquisition</th>
<th>A Information Analysis</th>
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</table>
Key issues transitioning to higher levels of automation

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# Advisory directional drilling

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<td>C0 Manual control</td>
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<td>D2 Full automation of action sequence</td>
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# Automated directional drilling

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## Mapping typical Managed Pressure Drilling

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</table>
Drilling is a complex, poorly organized collection of systems and sub systems

• Minimizing complexity impact requires an industry architecture
  • Currently a common architecture does not exist

• Interoperability is not natural
  • Proprietary is perceived as competitive advantage

• Improved interoperability will support uptake
  • Demonstrated in other industries (aerospace, automobiles, telecommunications, ..)

• Bottom up implementation is underway with sub systems
  • Miss opportunities unless fit into an industry architecture

• Top down approach provides holistic value delivery
  • Maximum value generation
Systems of Systems view of well construction inside Field Development

Now automating Systems of Interest:
Rotary / hoist / BHA / drilling energy / Well profile

Opportunity is to plan comprehensive top down automation

One company doing this as a major application

Derived from International Council on Systems Engineering
Published in DSA Roadmap
DSA & data analytics risks

• Cost sink with little or no immediate payback
  • Competitive advantage is investment driver
  • Business model compensation limiting reward

• Automating drilling is not plug and play
  • Multiple rig control systems require interfacing
  • Even same control system differ rig to rig

• Data quality is starting to be addressed
  • Lacking and needs improvement
  • Need a structure for meta data / semantics

• New human competency models
  • Roles changing; training and competency must follow

• Cyber security is an issue
  • IADC Cybersecurity Committee provides digital security guidelines for drilling assets
Drilling Systems Automation brings value initially to the operator

• Improving consistency over multiple cycles
  – tripping
• Reducing operational durations
  – drill a stand cycle time
  – improvement drilling rate of penetration
• Improving wellbore placement
  – automation higher frequency / lower latency than humans
  – connect to real time subsurface models for instantaneous geosteering
• Improving wellbore quality for lower production operating costs / downtime, increased production
  – lower tortuosity (e.g. Artificial Lift Systems)
  – reduced fluid drop out
Conclusion: DSA is a growing application

- DSA is being implemented across many systems in drilling
- Data improvement initiatives are underway
- Drilling is being digitized – personnel must transition
- Humans will move to supervisory control
- Mapping drilling systems available – subsurface linkage opportunity
- Risks / rewards not balanced – competitive advantage
Integral with digitization of upstream oil and gas

Understand what is happening through industry resources:

www.DSARoadmap.org

www.DSABOK.org

DSA Roadmap Report

Portal to DSA Sources

Also visit SPE Drilling Systems Automation Technical Section
Your Feedback is Important

Enter your section in the DL Evaluation Contest by completing the evaluation form for this presentation

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