SPE/IADC-173010  
Drilling Systems Automation Roadmap  
The Means to Accelerate Adoption  

John de Wardt, DE WARDT AND COMPANY  
Program Manager: DSA Roadmap Industry Initiative  
Affiliated with: SPE / IADC / AUVSI
Drilling Systems Automation is growing

- Drilling industry needs a roadmap for automation
- Decision and control framework interrelates levels of control
- Operations states are a required distinction
- Systems architecture is fundamental and leads to use cases
- Eight challenges cover DSA spectrum
Drilling Systems Automation Roadmap (DSA-R)  
a designed process from Sandia National Laboratories

- Launched June 2013
  - Committee with broad expertise
- Needs for DSA-R
  - Lag other industries in automation application
  - Lack consensus on how to implement / fragmented
- Vision
  - Plans uploaded into interoperable drilling system
    - Multiple wells / Complex wells
    - Remote control centers / centers of excellence
- Boundaries
  - Business Model / Equipment design
<table>
<thead>
<tr>
<th>Level 0 – Well Construction</th>
<th>Actual physical processes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1 – Well Construction Machine Control</strong></td>
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<td>- Drawworks, Topdrive, Mud Pumps</td>
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<td><strong>Level 4 - Enterprise Well Construction Management</strong></td>
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<td>Well Proposal</td>
<td></td>
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<tr>
<td>Well Design</td>
<td>- Basis of Design</td>
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<tr>
<td>- Detailed Design</td>
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<td>Risk / Uncertainty Management</td>
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<td>Cost Estimation and Control</td>
<td>- Budget</td>
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<td>- AFE</td>
<td>- Cost Approval</td>
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<tr>
<td>Scheduling</td>
<td>- Wells</td>
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<tr>
<td>- Locations</td>
<td>- Hook up</td>
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<td>Supply Chain Management</td>
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**Machine Control**
- Drawworks, Topdrive, Mud Pumps

**Drilling Process Physics**
- ROP Optimization, Tripping, Steering

**Drilling Process Management**
- Sequencing, planned durations
- Resource loading
- Quality Control, Tracking

**Remote Operations Center**

**Remote Excellence Center**

**ERP System**

**Data Mining**

**Data Analytics**

**Models & Simulations**

**Subsurface Wellbore Predictions**

**Swab Surge ROP Equipment**

**Machine Control**
- Pumps
- Drawworks

**Models & Simulations**

**Data Mining**

**Remote Operations Center**

**Remote Excellence Center**

**On Site Interp. Center**

**On Site Control Center**

**Business-related activities needed to manage an operational organization.**

**Activities of the work flow to produce the desired end products.**

**Activities involved in sensing and manipulating physical processes.**

**SPE/IADC 173010 – Drilling Systems Automation Roadmap – John de Wardt**
DSA Decision Making and Control Framework – from ISA 95 and MES

Level 4 - Enterprise Well Construction Management
- Business-related activities needed to manage an operational organization.
  - Cost Estimation and Control
    - Budget
    - AFE
    - Cost Approval
  - Scheduling
    - Wells
  - Supply Chain Management
    - Procurement
    - Contracting
    - Logistics
  - ERP System

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- Activities of the work flow to produce the desired end products.
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    - Contracting
    - Logistics
  - ERP System

Well Construction System
- Drilling program
- Completion Program
- Data Acquisition
  - Drilling / Completion Operations
  - Wellbore Data
  - Equipment Status (CBM)

Remote Operations Center
  - Remote Excellence Center
  - Remote Interp. Center

On Site Control center
  - On Site Interp. Center

DSA Decision Making and Control Framework – from ISA 95 and MES

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Operations States
known state is a requirement for success

Well State
- Wellbore stability
- Wellbore cleanliness
- Wellbore pressures
- Pore and frac gradient
- Tortuosity
- Subsurface model

Drilling or Completion State
- Specific process underway
- Fundamental to both automated and human controlled interactions

Automation State
- Systems individually in control
- Systems combined
- Systems hierarchy

Other States
- Common states that can influence the decisions process
- Weather
- Sea conditions

Equipment State
- Functionality
- Efficiency
- Condition
Eight challenge areas address the roadmap spectrum
50 volunteer professionals are engaged

• Systems Architecture – John de Wardt, Slim Hbaib
• Communications – Moray Laing
• Instrumentation and Measurements Systems – John Macpherson
• Drilling Machines and Equipment – Robin Macmillan
• Control Systems – Calvin Inabinett
• Simulation Systems and Modeling – Blaine Dow
• Human Systems Integration – Amanda DiFiore, Mario Zamora
• Industry Standards and Certification – Mark Anderson
Top down description of how connected elements deliver value
Correct interconnectivity to deliver customer value
Solves relationships for automation / control loops created by fragmented industry
Leads to Use Cases
## Communications

<table>
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<tr>
<th>Consumers</th>
<th>Needs</th>
<th>Framework</th>
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<tr>
<td>Surface Controls</td>
<td>Rig versus Office</td>
<td>(4) Enterprise Zone</td>
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<tr>
<td>Sub Surface Controls</td>
<td>Device to Device</td>
<td>DMZ Information Sharing</td>
</tr>
<tr>
<td>Surface Acquisition Systems</td>
<td>Process to Process</td>
<td>(3) Manufacturing Zone</td>
</tr>
<tr>
<td>Downhole Tools</td>
<td>Device to Process</td>
<td>(0,1,2) Cell Area Zone</td>
</tr>
<tr>
<td>Remote Control and Advisory Centers</td>
<td>Interoperability</td>
<td>Media</td>
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<td>Contextual Awareness</td>
<td>Latency</td>
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</table>

**Trends will affect communication solutions:**
- The Internet of Things
- Future communication media
- In-stream advanced analytics
- Cyber defenses

Protocol standards / physical media enable disparate solutions interoperate and interconnect common objective
Instrumentation and Measurement Systems requirements beyond current state

- Complete Measurements and estimations
- Logical Correct sensor for operations state
- Proximity Direct measurement – close as possible
- Conversion Information for correction
- Criticality Redundancy – not duplication
- Accuracy Calibration method and frequency
- Availability Probability of outage and duration

Known quality: requirement for input to control
Access: all providers same validated measurements
Machines and Equipment can adopt automation:
expect designs to change to leverage the value of automation
Control Systems

- Control systems - prevalent at the machine level (Level 1) / the Execution level (Level 2).
- Zone management - power limiting and tool health management occur at Level 3.
- A rigorous systems engineering approach – seamlessly integrate across various systems
- Interdependency of controls systems - simulation and modelling raise the machine intelligence level
- Control systems will become multi variant and bi-directional with automatic data transfer
Simulation Systems and Modelling

- Simulations
  - replicate the drilling process
- Depend on knowns and unknowns
- Multiple simulations
  - simultaneously
  - output from one = input to another
- Well State
  - defines priority for control
- Objective: agnostic ecosystem – ability to adopt simulations with ease

Simulations and Modelling Examples (incomplete)

- Torque and Drag
- Seismic (1D – 4D)
- Shock and Vibration
- Wellbore Survey
- Anti-collision model
- Drill bit cutting model
- Cement displacement model
- Hydraulics models (fluid properties, ECD prediction, hole cleaning)
- Drilling Hazards

- Rate of Penetration
- Mechanical Earth Model
- Pore Pressure
- Casing load model
- BHA prediction model
- Well control simulation
- Well Placement
Human Systems Integration (HSI)

• Manages transfer of tasks from Human Domain to Automated Environment
  - manpower, personnel, training, safety & occupational health, and Human Factors Engineering

• Human Factors Engineering
  - designing products, systems or processes to account for interaction between them and the people that use them
  - reduces the potential for human error

• Interface design
  - simplify operator decision and response time
  - promote situational awareness and communicate intent

• Plans to overcome organizational barriers

Humans will interact with automation
Role of humans at the well site will change dramatically
Industry Standards and Certification

- Protocols
- Interchangeability
- Lower Investment

STANDARDS BOOST BUSINESS

ISA, IEEE, OPC Foundation logos
Conclusions and Recommendations

- Application of advanced control systems deliver value
  - surface and downhole
- Systems architecture in conjunction with use cases
  - define a holistic automated system environment
- Operations states enable required definition
- Decision making and control framework maps hierarchy and interactions
- Advances will occur in sensors, communications and simulations / modelling
- Industry standards are available to benefit adoption
- Human Systems Integration is critical to successful application
Acknowledgements

Multiple co-authors, their team members and their companies

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Thank You / Questions

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