drilling
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Drilling Systems Automation Roadmap

The Means to Accelerate Adoption

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Affiliated with: SPE / IADC / AUVSI

DSA Roadmap

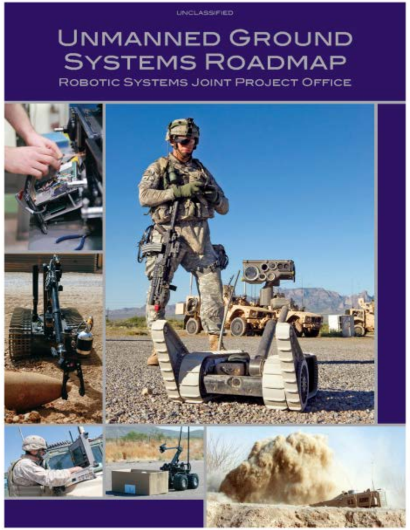
IADC
SPE International
Society of Petroleum Engineers

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



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.

Well Proposal

Well Design
- Basis of Design
- Detailed Design

Cost Estimation and Control
- Budget
- AFE
- Cost Approval

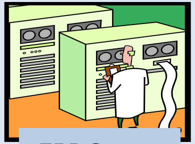
Risk / Uncertainty Management

Scheduling
- Wells
- Locations
- Hook up

Supply Chain Management
- Procurement
- Contracts
- Logistics

Data Mining

Data Analytics



ERP System

Level 3 – Well Construction Operations Management.

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

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

Remote Excellence Center

Remote Operations Center

Operations States
- Well State,
- Drilling Completion State
- Automation State
- Environmental State
- Equipment State

Models & Simulations

Subsurface Wellbore Predictions

Level 2 – Well Construction Execution Management

Activities of monitoring & controlling physical processes.

Drilling Process Physics
- ROP Optimization, Tripping, Steering

On Site Interp. Center

On Site Control center

Swab Surge ROP Equipment

Level 1 – Well Construction Machine Control

Activities involved in sensing and manipulating physical processes.

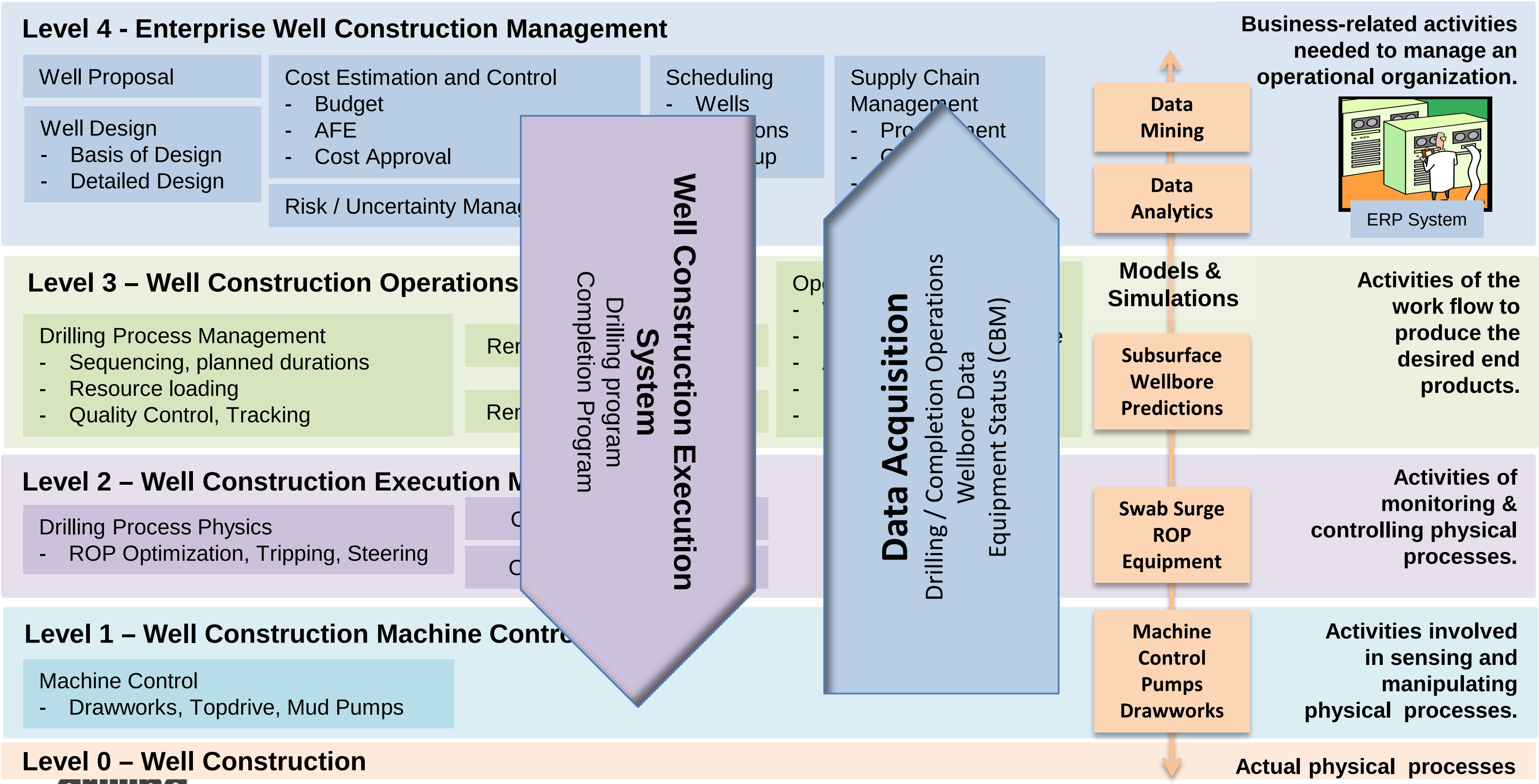
Machine Control
- Drawworks, Topdrive, Mud Pumps

Machine Control Pumps Drawworks

Level 0 – Well Construction

Actual physical processes

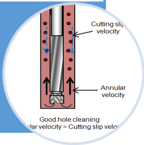
DSA Decision Making and Control Framework – from ISA 95 and MES



Operations States
known state is a requirement for success

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

Well State



- Specific process underway
- Fundamental to both automated and human controlled interactions
- ……………..

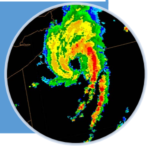
Drilling or Completion State

- Systems individually in control
- Systems combined
- Systems hierarchy
- ……………………..

Automation State

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

Other States



Equipment State

- Functionality
- Efficiency
- Condition
- ………………

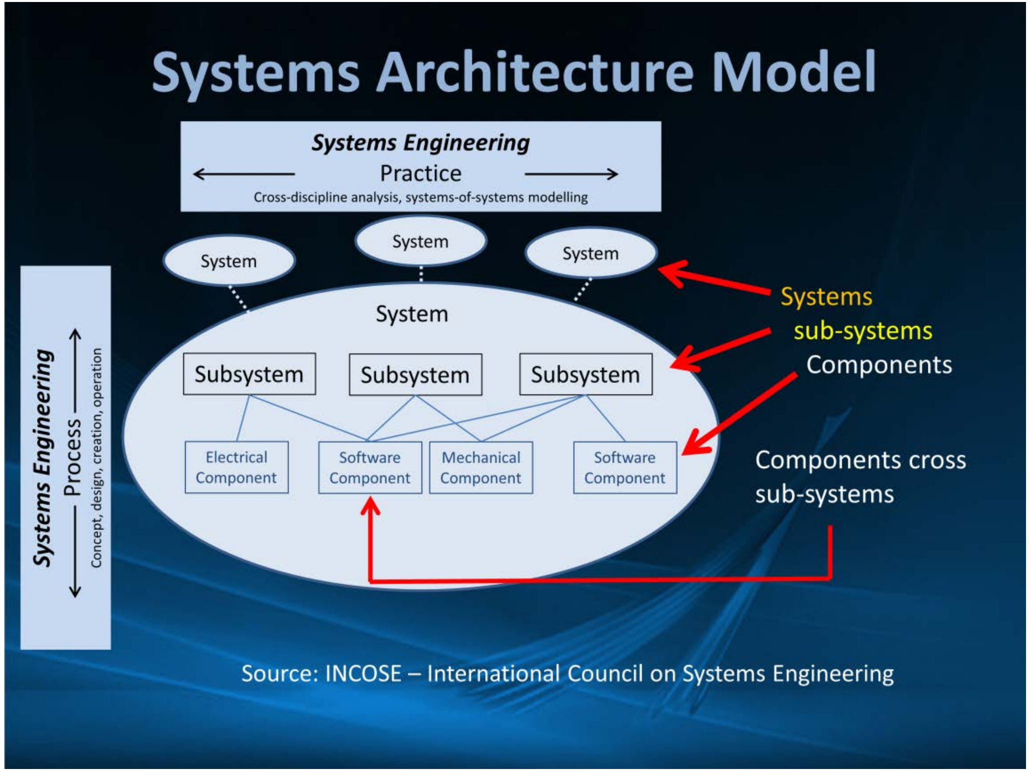
Eight challenge areas address the roadmap spectrum
50 volunteer professionals are engaged

- 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

Systems Architecture

- ✓ 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

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

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

Accuracy
Calibration method and frequency

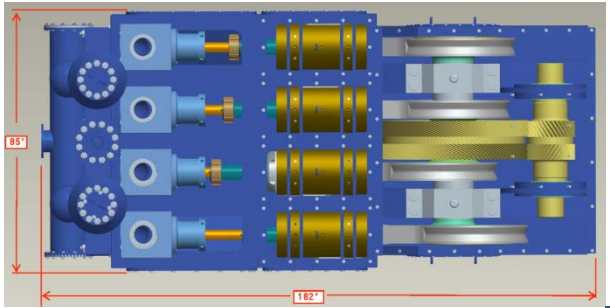
Conversion
Information for correction

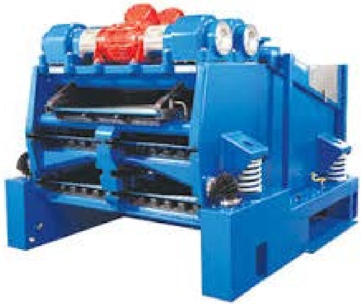
Criticality
Redundancy – not duplication

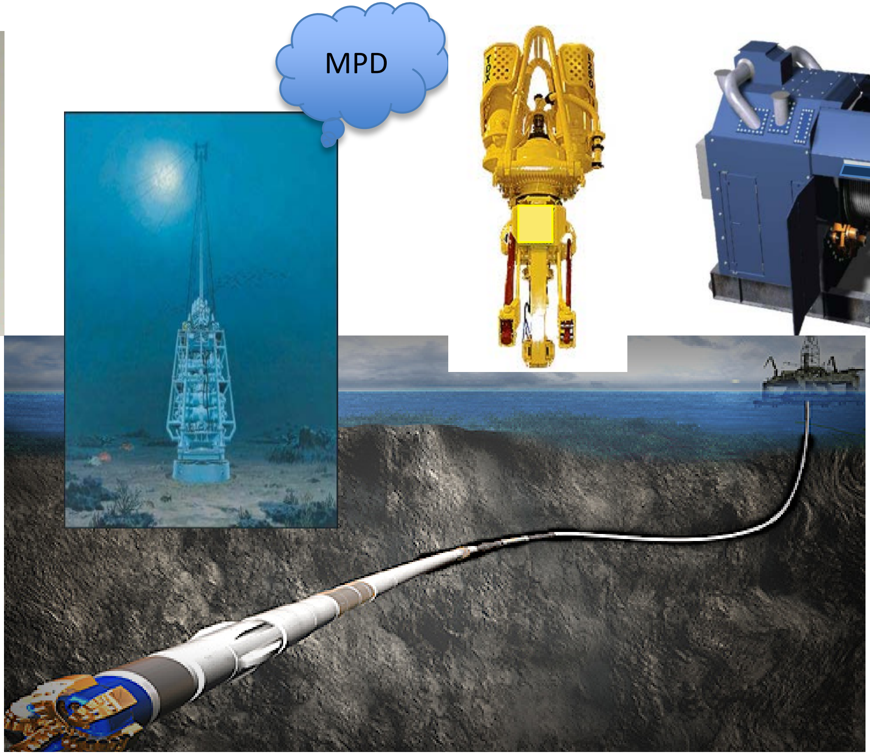
Availability
Probability of outage and duration

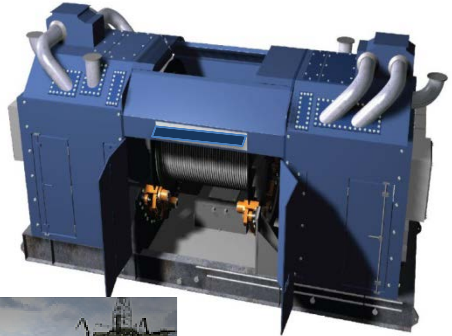
Known quality: requirement for input to control
Access: all providers same validated measurements

Drilling Machines and Equipment





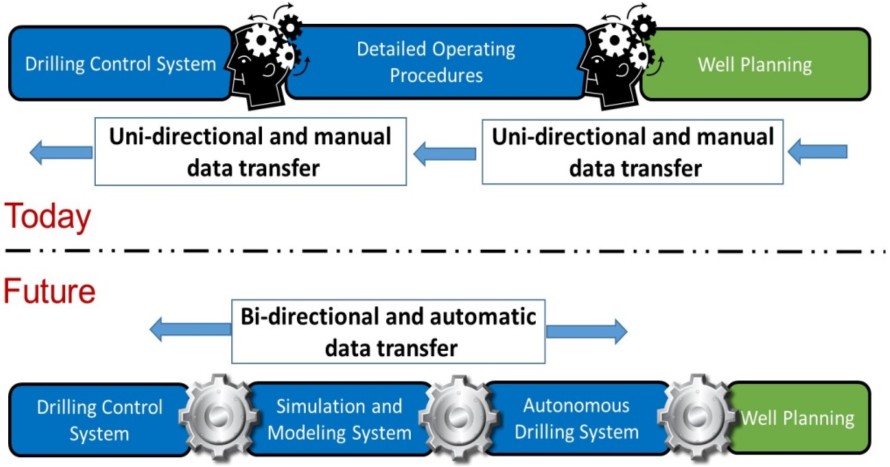




- **Machines and Equipment can adopt automation: expect designs to change to leverage the value of automation**

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

ISA
IEEE
OPC FOUNDATION

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

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Thank You / Questions

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