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Drilling Systems Automation [DSA] is Here

Propagation, Pitfalls, Profits & Production

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Upstream Global Consultant: DE WARDT AND COMPANY

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Upstream Global Consultant

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Here are some questions I will answer:

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- 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?

Today's world of drilling automation

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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

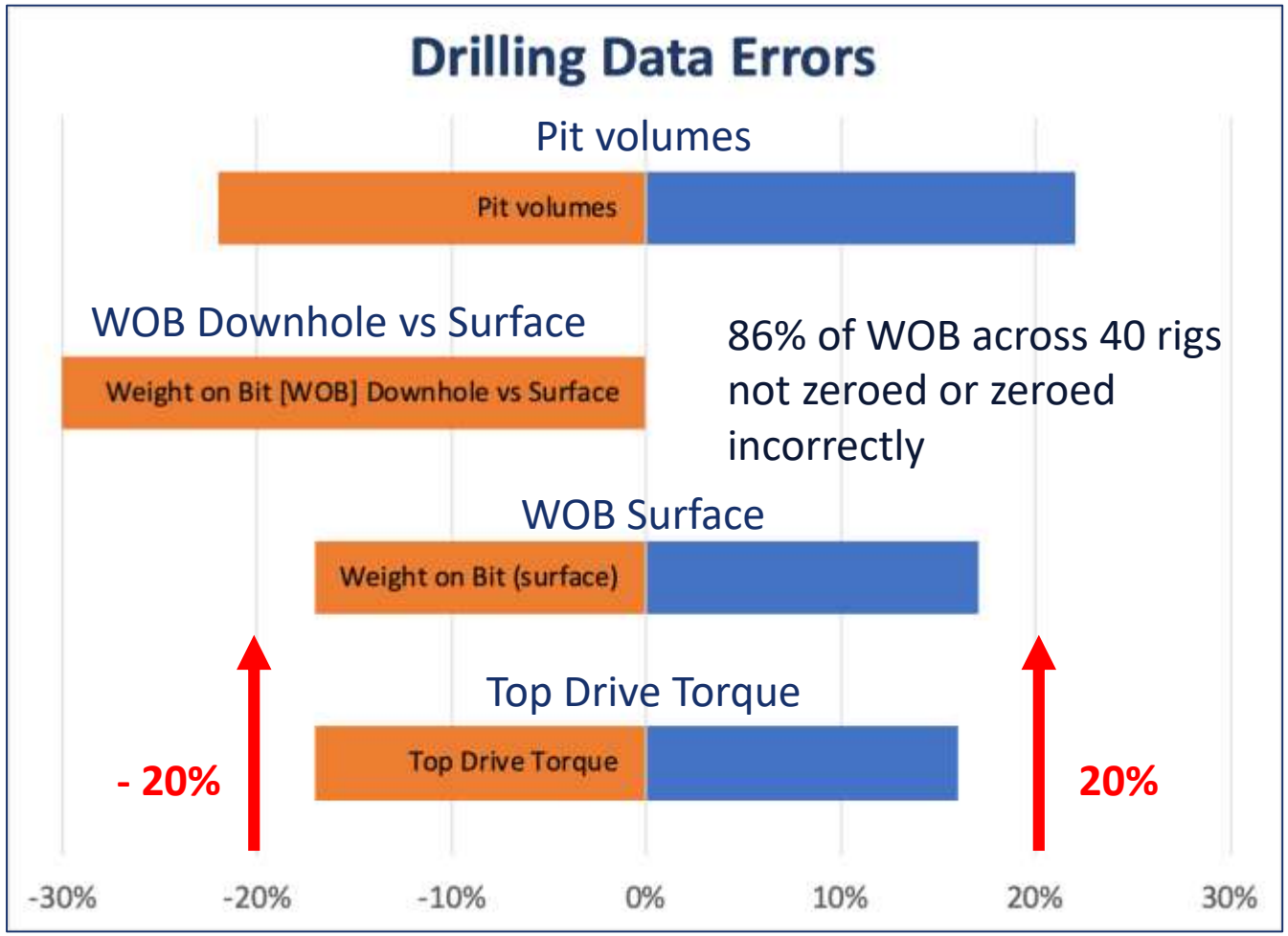
- Dynamic positioning is fully automated and robust

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
- **<u>Who knows the true quality of their drilling data?</u>**



SPE 184741; SPE 189626; SPE 189636; SPE 139848

WOB = Weight on Bit

Data attributes require upgrades
for effective analytics and automation

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Complete
Determine state of system

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

Drilling Systems Automation (DSA) Decision Making and Control Framework

- 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)

Level 4 - Enterprise Well Construction Management

Business-related activities needed to manage an operational organization

- Well Proposal
- Cost Estimation and Control
- Scheduling
- Supply Chain Management

Level 3 – Well Construction Operations Management.

Activities of work flow to produce the desired end products

- Well Design
- Drilling Process Management
- Risk / Uncertainty Management

Level 2 – Well Construction Execution Management

Activities monitoring & controlling

- Drilling Process Physics / Models
- Operation & Equipment States

Level 1 – Well Construction Machine Control

Activities involved in sensing and manipulating

- Machine Control – Machine Sensors

Level 0 – Well Construction

Actual physical processes

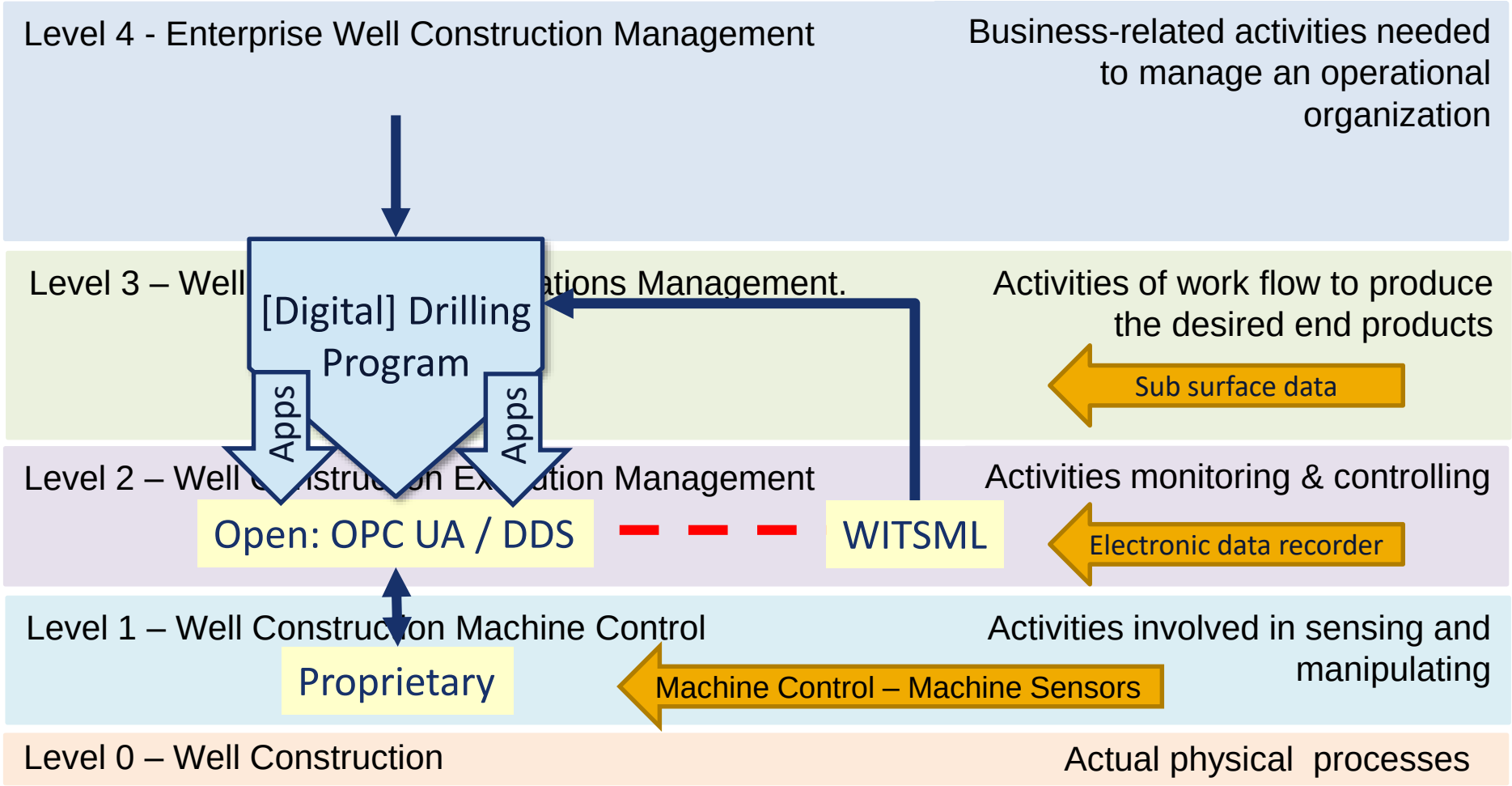
DSA Roadmap

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



Automation is not all or nothing

Humans will remain in the loop to various degrees

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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]

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Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D

Key issues transitioning to higher levels of automation

Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
Done by Humans	Manually		ory analysis		uman decision		al control	D0
	Supported by artifact		orted by art		upported by artifact		orted by artifact	D1
Supported by Automation	Low level automation support		evel automa ort		utomated decision upport		y-step action support	D2
	Medium leve support		au		gid automation deci upport		evel support action tion	D3
	High level automatio support		evel autom port				evel support action tion	D4
	Full automation support		Full automation s					
Done by Automation					w level automatic king		evel action sequence nation	D5
					el auto ion making		el action automation	D6
					ull automatic decision making		evel action sequence tomation	D7
							Full automation of action sequence	D8

Requires Decreasing Data Attribute Risk

Revised Human Competency Models

Requires Decreasing Operation Uncertainty

Advisory directional drilling

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Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
Done by Humans	Manually	A0	Memory analysis	B0	Human decision	C0	Manual control	D0
	Supported by artifact	A1	Supported by artifact	B1	Supported by artifact	C1	Supported by artifact	D1
Supported by Automation	Low level automation support	A2	Low level automation support	B2	Automated decision support	C2	Step-by-step action support	D2
	Medium level automation support	A3	Medium level automation support	B3	Rigid automation decision support	C3	Low-level support action execution	D3
	High level automation support	A4	High level automation support	B4			High-level support action execution	D4
	Full automation support	A5	Full automation support	B5				
Done by Automation					Low level automatic decision making	C4	Low-level action sequence automation	D5
					High level automatic decision making	C5	Medium-level action sequence automation	D6
					Full automatic decision making	C6	High-level action sequence automation	D7
							Full automation of action sequence	D8

Automated directional drilling

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Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
Done by Humans	Manually	A0	Memory analysis	B0	Human decision	C0	Manual control	D0
	Supported by artifact	A1	Supported by artifact	B1	Supported by artifact	C1	Supported by artifact	D1
Supported by Automation	Low level automation support	A2	Low level automation support	B2	Automated decision support	C2	Step-by-step action support	D2
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Mapping typical Managed Pressure Drilling

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Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
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Drilling is a complex, poorly organized collection of systems and sub systems

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- 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

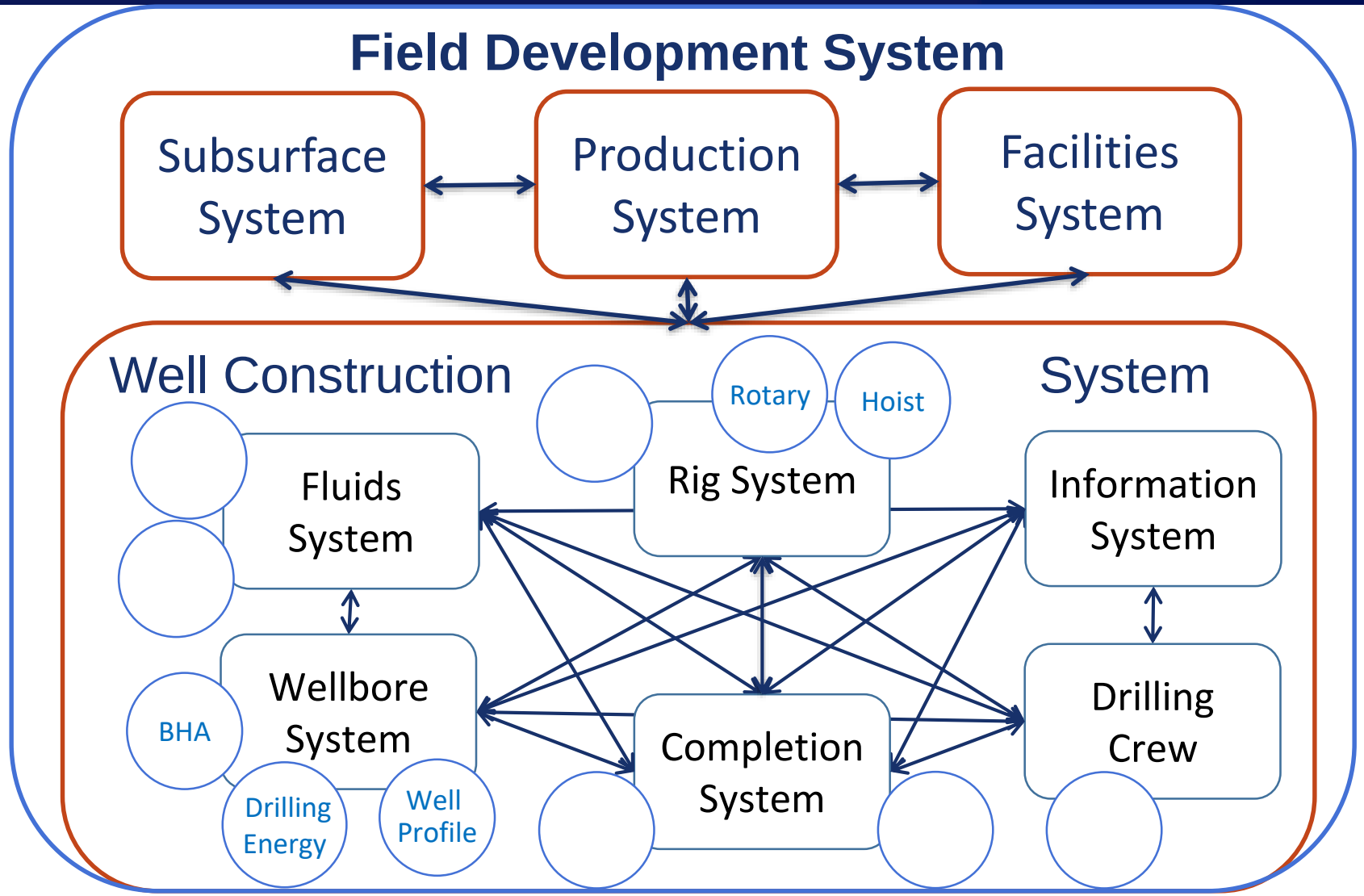
Systems of Systems view of well construction inside Field Development

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

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- 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

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- 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

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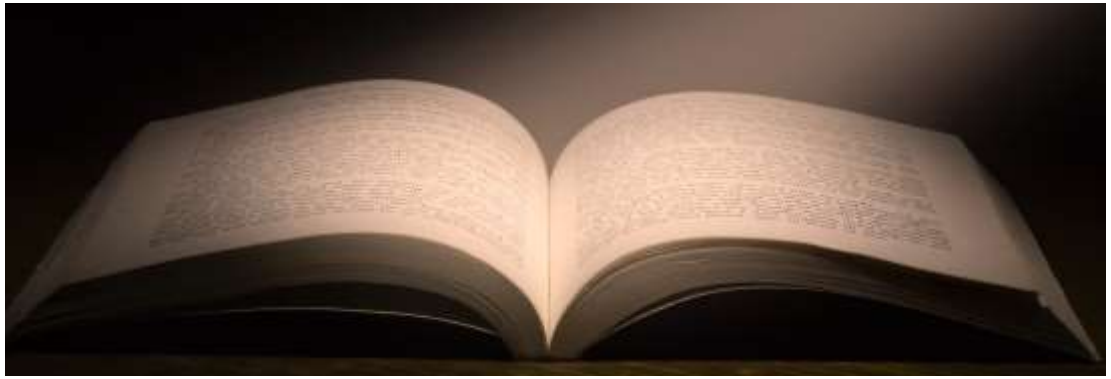
- DSA is being implemented across many systems in drilling
- Data improvement initiatives are underway
- Drilling is being digitized – personnel must transition
- Humans will move to supervisory control
- Mapping drilling systems available – subsurface linkage opportunity
- Risks / rewards not balanced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

Drilling systems automation is advancing rapidly

Integral with digitization of upstream oil and gas

Understand what is happening through industry resources:

www.DSARoadmap.org



DSA Roadmap Report

www.DSABOK.org

Portal to DSA Sources

Also visit SPE Drilling Systems Automation Technical Section

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