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Drilling Systems Automation

a technology that is at a tipping point

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EXPLORING WHAT'S POSSIBLE

Drilling systems automation offers a huge opportunity

- **Safety**
 - remove people from harms way
- **Performance**
 - Maximizing through continuous optimization
 - Consistency reduces the natural spread in human controlled performance
- **Costs**
 - Reduce manning numbers and specialists
 - Automation is the expert
 - control of process
 - Leveraged experts through remote operations centers
 - update the scene

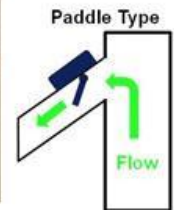
Drilling systems automation will become a significant factor in well construction

- Drilling operations measurements upgrade
- Automated and autonomous operations are here
- Automation is routine in other industries and in upstream oil and gas
- Lessons learnt provide leverage
- Barriers are overrated, drivers are strong
- Game changers await application

Current State



Barrels-In-Barrels-Out



Pump Strokes (In)

Flapper Meter (Out)

Poorly developed sensor systems,
intermittent measurements and manual
operations that lag behind other
industries

Measurements in drilling operations need improvement

- Rig hook load defines weight on bit
 - Deadline anchor – unresponsive and inaccurate
 - Strain gauge at pin – responsive with accuracy limits
 - Drillstring sub with wireless transmission – direct
- Mud flow into and out of the borehole
 - Pump stroke counter with pump efficiency factor
 - Deflection of a paddle – unresponsive with poor correlation to flow out

Mud systems are far behind other industries

- Manual addition of powders and liquids
 - Except high cost offshore
- Treatment equipment manually operated
 - Intermittent, not continuous measurement and control
- Unlike chemical, pharmaceutical and food industries



Reliability and performance has been demonstrated

- **Dynamic positioning system**
 - Highly automated, highly reliable in adverse conditions
- **Automated milling with coiled tubing drilling unit**
 - Time based machining – feed rate (lathe equivalent)
 - 50% increase ROP
 - Smoother window / more successful side track

Autonomous drilling has been achieved, MTBF is down due to automation

- IOC demonstration Canada 2009
 - MWD transmitted downhole data
 - Surface data – improved sensors
 - Autonomous drilling / steering shallow multilaterals
- USA land rigs, advanced automated drilling control
 - Double MTBF rotary steerable system
 - Cost per foot 33% lower than standard rigs

Autonomous = machine operates without human intervention

Industrial automation grew rapidly in the 1990's – Drilling has overlooked this opportunity

- Industrial processes improved measurement and control
- Increasing computing power – Moore's law
- Interoperability – best in class / plug and play
- Paradigm shift
 - Transformation of business model
 - Proprietary to standards based commodities
 - Differentiation in the control software

Beware of Mimicry!- Rethink



Observe the Process

Define the Objective



Copy



Take advantage
of Technology

Future State



Autonomous drilling of wells and
management of fluid systems

Drilling automation phases

- Closed loop drilling
 - Hole making is a structured process
 - Issues, symptoms, causes and preventive / mitigation actions can be defined
 - Decisions based on knowledge, best practice, offsets
- Autonomous drilling
 - Complete hole sections drilled automatically

Mud systems and cementing automation

- Automated transfer of bulks and liquids to mix fluid by recipe
 - Same as food processing
- Automated flow rate, mud weight and fluids properties control
 - Reactive to changing well conditions
- Both improve safety, efficiency and quality

Drivers and barriers define the landscape

Drivers shifting from deep offshore / major platforms to factory style drilling land wells

Barriers are NOT a lack of technology, standards, process automation domain knowledge, or the ability to implement any of these.

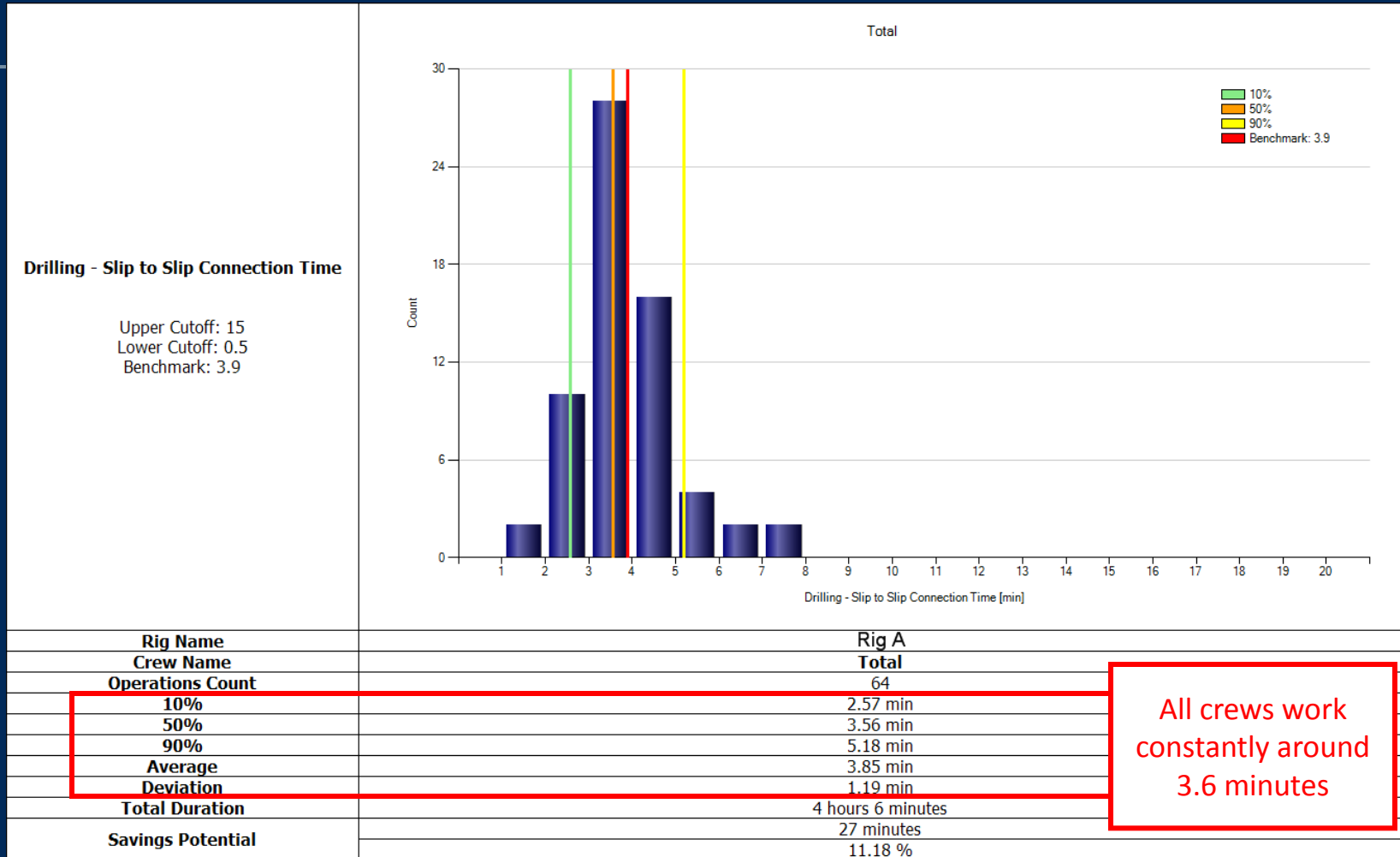
Drivers are becoming compelling

- **Safety**
 - Removing people from harms way
- **Increased efficiency**
 - Consistent performance repeatable operations, near best in class
- **Increased performance**
 - Continuous and automated drill off
- **Risk reduction**
 - Control operation within envelope – tripping swab / surge
- **Capture knowledge**
 - Big crew change

Consistency from Automation

Time savings from repeated
operations at same high performance
versus
distributed time of human operations

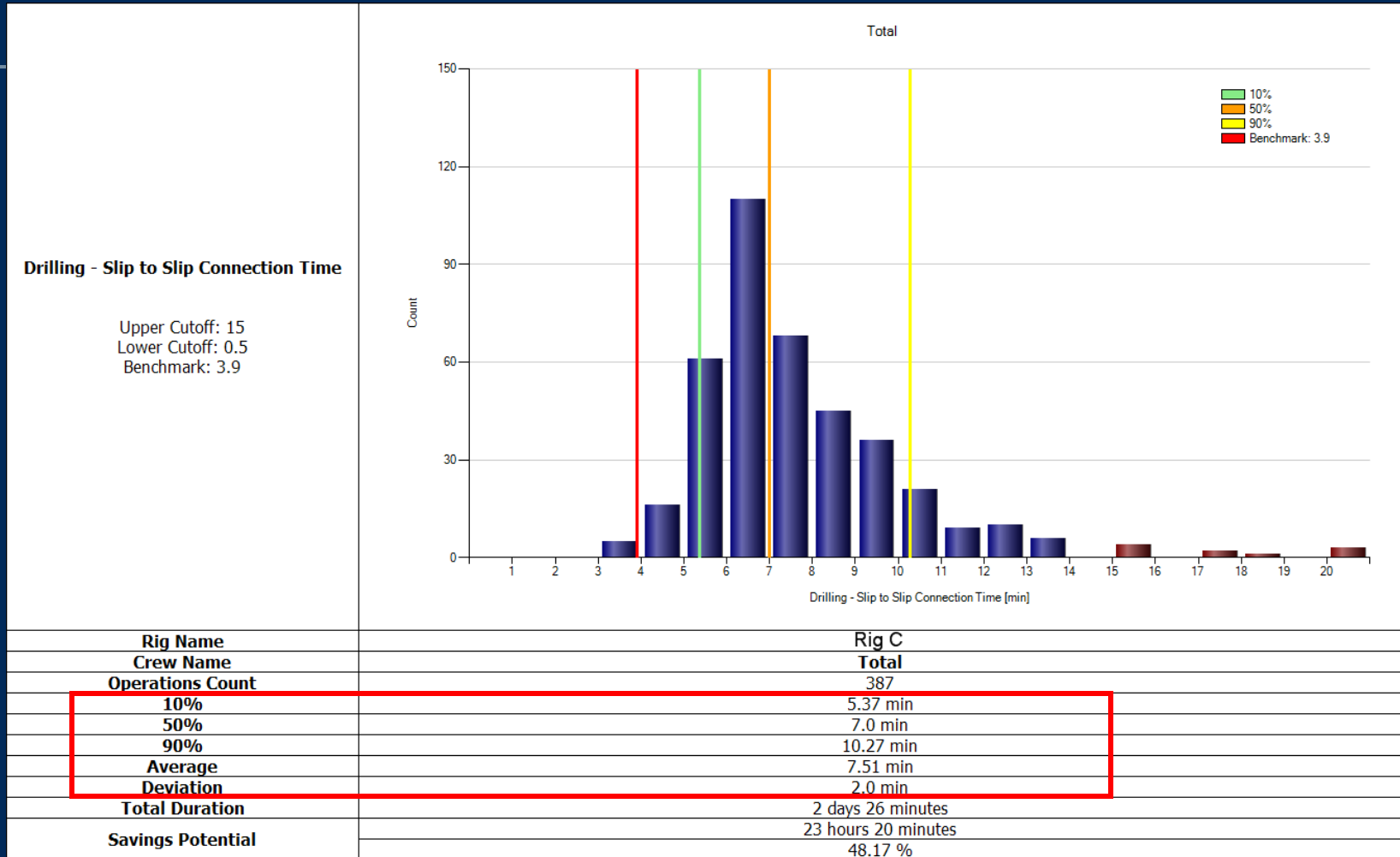
Slip to Slip Connection Time while Drilling Rig A



Rig A
Topdrive A
Iron Roughneck A

Source: ProNova with permission

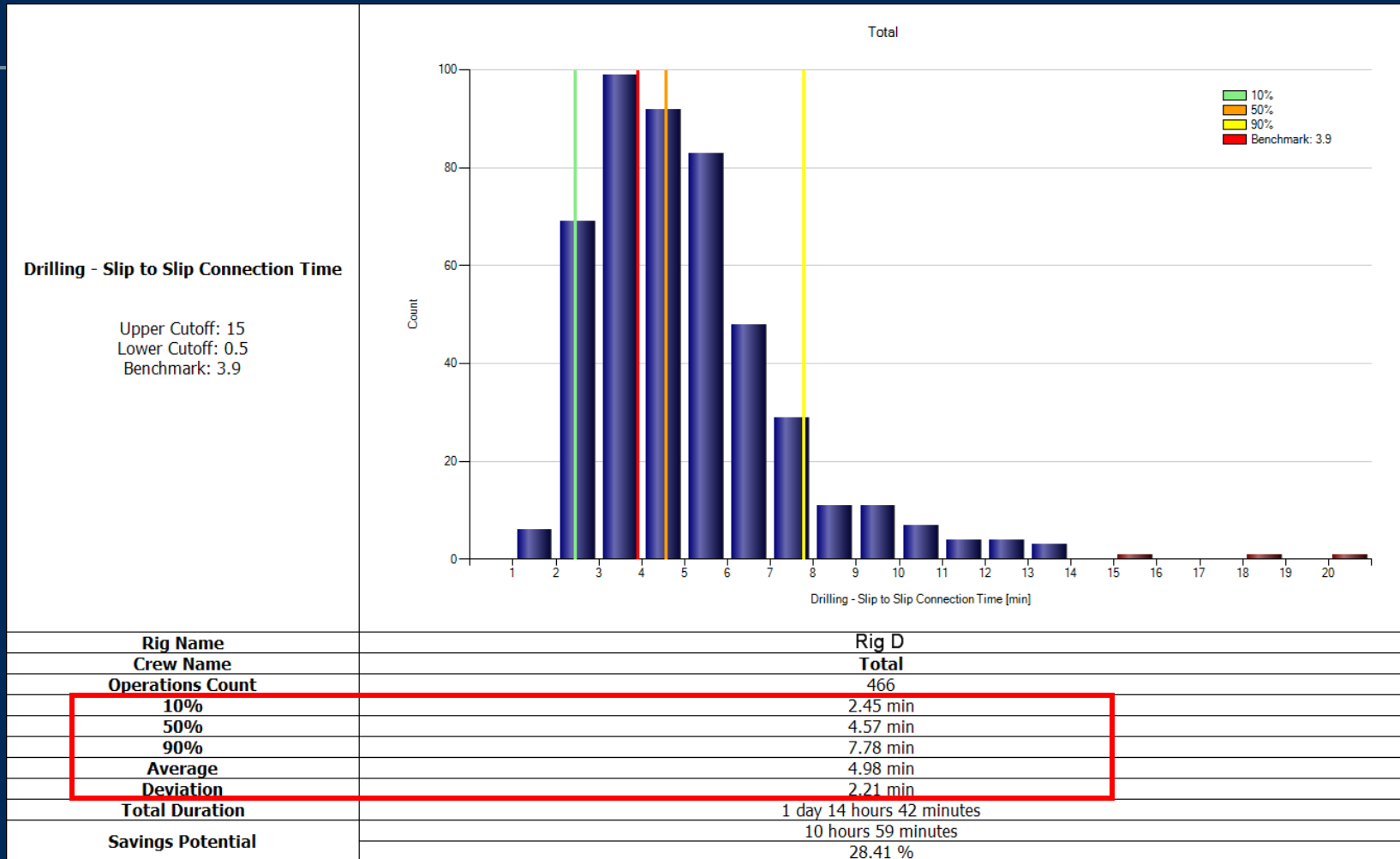
Slip to Slip Connection Time while Drilling Rig C



Rig C
Topdrive B
Iron Roughneck B

Source: ProNova with permission

Slip to Slip Connection Time while Drilling Rig D



Rig D
Topdrive C
Iron Roughneck C

Source: ProNova with permission

Attitude is a significant main barrier that is unrealistic

- Manual control is thought to be necessary
 - Suitable sensors are not installed
 - Automation can continuously perform at maximum performance level
 - It does not get distracted nor tired
- Automation is considered unreliable
 - DP systems are highly reliable
 - Refineries, production platforms and other industries rely on automation

Business models and contract structures throttle technology growth

- Day rate has limited reward
- Oil companies (Project Management companies) are the integrators and implementers who create the change
- Industry is unwilling to obsolete old assets

Game Changers

this big step is coming

Autonomous systems are able to
learn both the operators intentions
and the system dynamics

Automation with remote management

- Space flight offers the example
 - Autonomous operation of the craft
 - Re-direction of the autonomous operation when the “scene” changes
- Landing wells in the right location
 - Autonomous

Human centered automation

- Computers relieve humans of tasks that can be automated
 - They support the human brain
- Developing a language to define drilling states
 - 167 drilling states - basis of advanced automation
 - Artificial intelligence technique uses stochastic grammar allows organizing and interpreting data
 - The beginning of neurocomputation

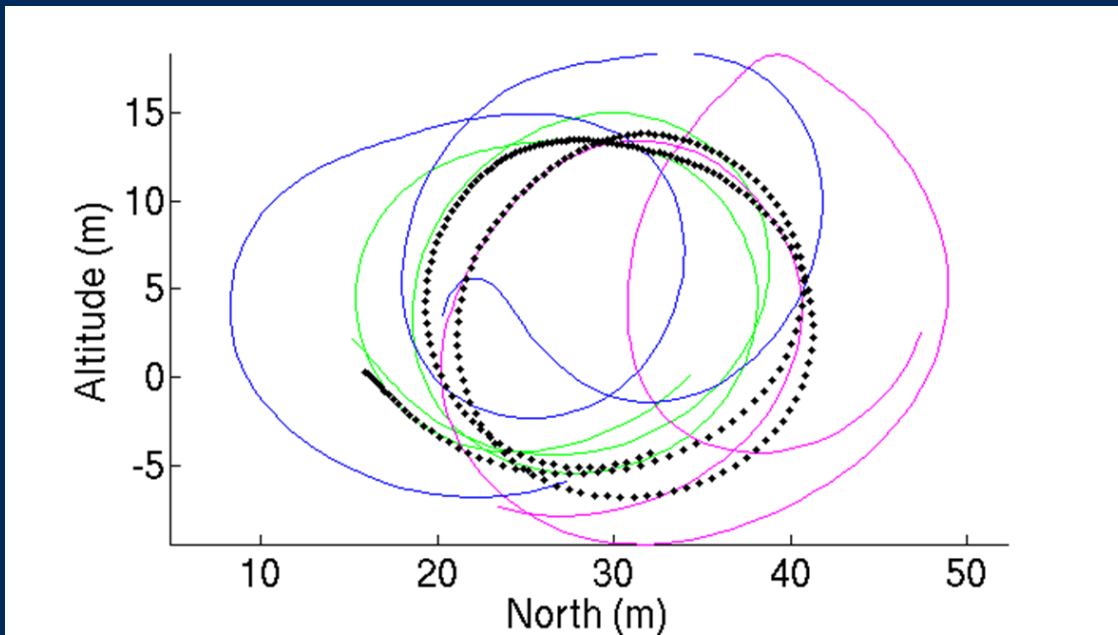
Source: du Castel

Commoditization

- **Consumer electronics**
 - Low purchase cost makes uneconomic to repair
 - Capability driven by processing power
- **Low cost tools available from Asian markets**
 - Automation can enable the requisite performance

Automation that learns like an apprentice

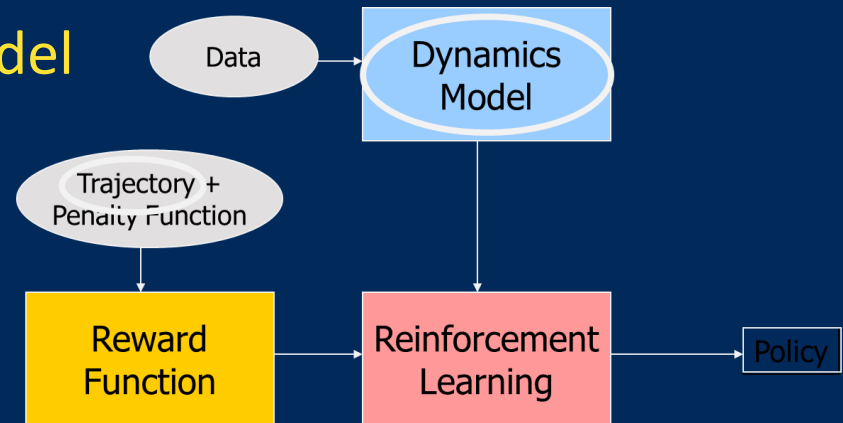
- Algorithms learn the maneuver and assimilate the perfect path of an expert operator



Source: Stanford University

Automation that learns like an apprentice

- Control system learns the dynamics of the system being modeled
 - Creates a dynamics model



- Autonomous machine becomes the perfect apprentice

Source: Stanford & Berkeley Universities

The perfect storm for drilling systems automation

- High volume of long reach wells, fast drilling requirement to reduce time and cost of shale gas and oil wells
- Technology transfer
 - Sensors then programming
- Leading edge
 - Advanced modeling / fast learning
 - Drilling equipment redesign
- Integration / implementation by oil companies
 - And Project Management companies for fixed well designs

Conclusions and Observations

- Limited use of automation at a tipping point
- Value from faster penetration and reduced NPT proven
- Availability of significant resources for automation is being accessed
- Factory style drilling is a new financial driver
- ROC's enable supervisory control over autonomous systems

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