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Adapting Wells Automation Efforts to a Low Oil-Price Environment

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Houston, Texas

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Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.
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Outline

- Automation Principles
- Automation Examples
  - Focus on e.g. Drilling Automation, Pipe Handling
- Summary – Thoughts & Learnings

AUTOMATION PRINCIPLES

Why automate…?

Don't exceed maximum weight on the bit

Don't exceed make-up torque of the drill string

Don't exceed the maximum RPM of the bit

Stay on target

Drill faster

Drill efficiently

Avoid lateral vibrations

Clean the hole

Drill this section without tripping; i.e. with one bit

Don't stall the top drive

Time is money

Don't exceed the maximum RPM of the top drive

Safety first

Condition the hole

Avoid stick-slip vibrations

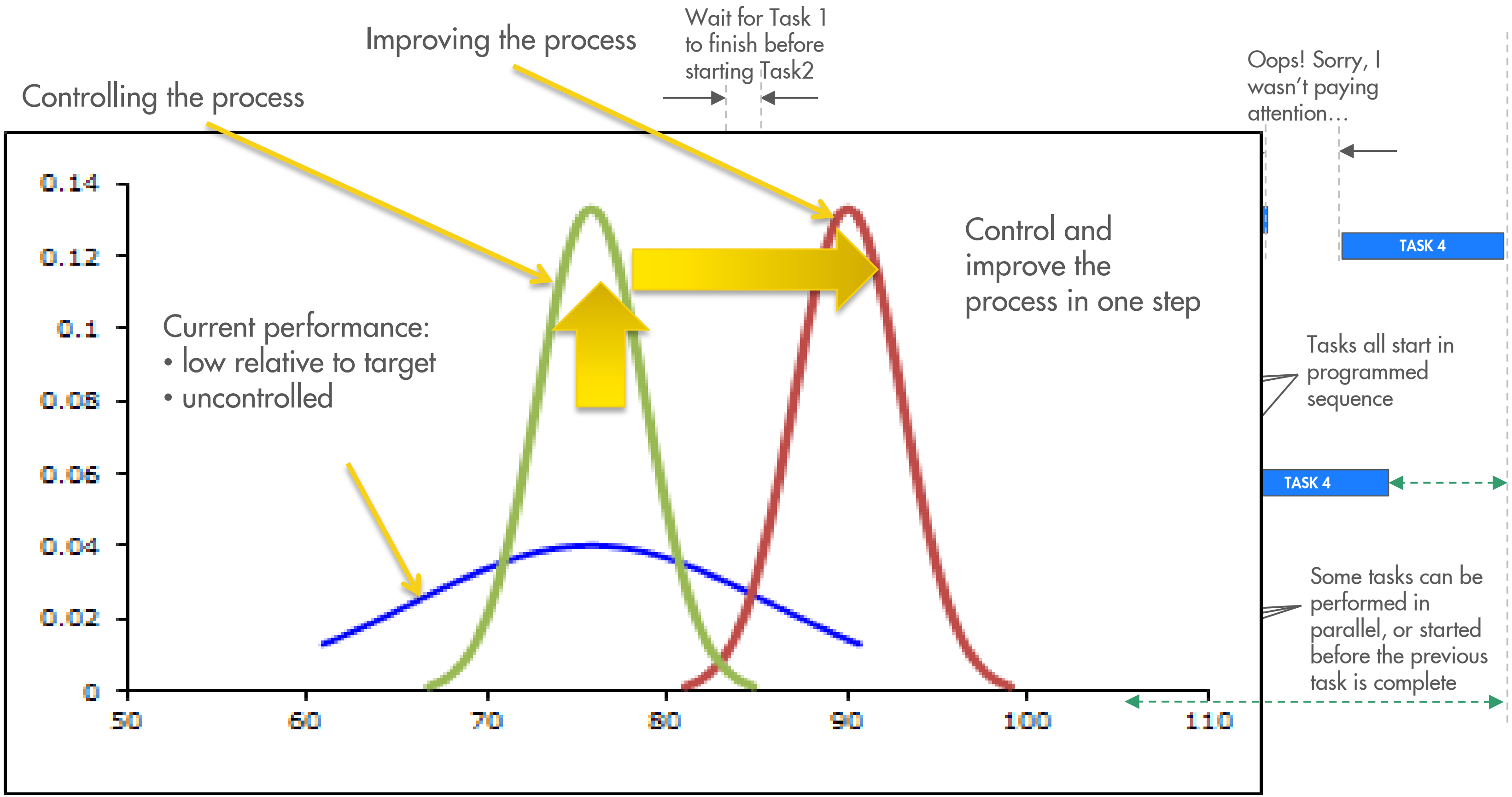
Don't buckle the pipe

Don't stall the downhole motor

Go back to bottom fast and safely

Connect a new pipe fast and safely

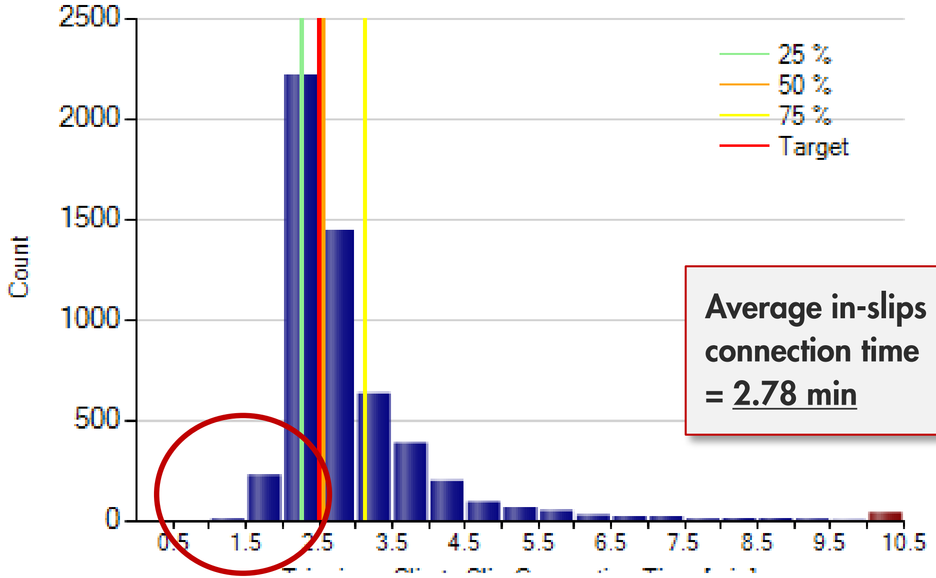
Automation and Optimization



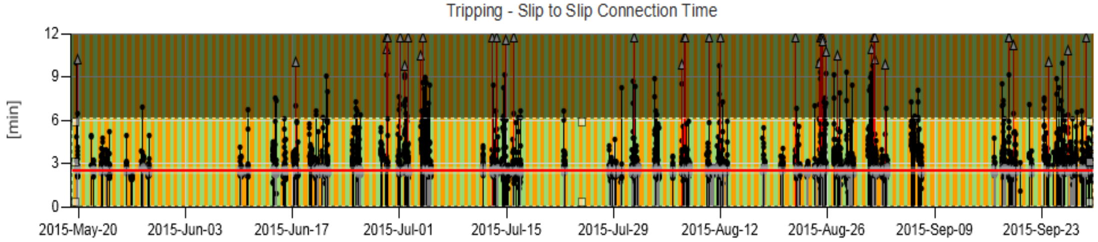
Pipe Handling Example – Make Up Connection

Manual operations show distribution of performance

- Some instances reflect issues not related to consistency of the process
- But a number of instances are more efficient than the others
- This is the BiC performance we want to replicate



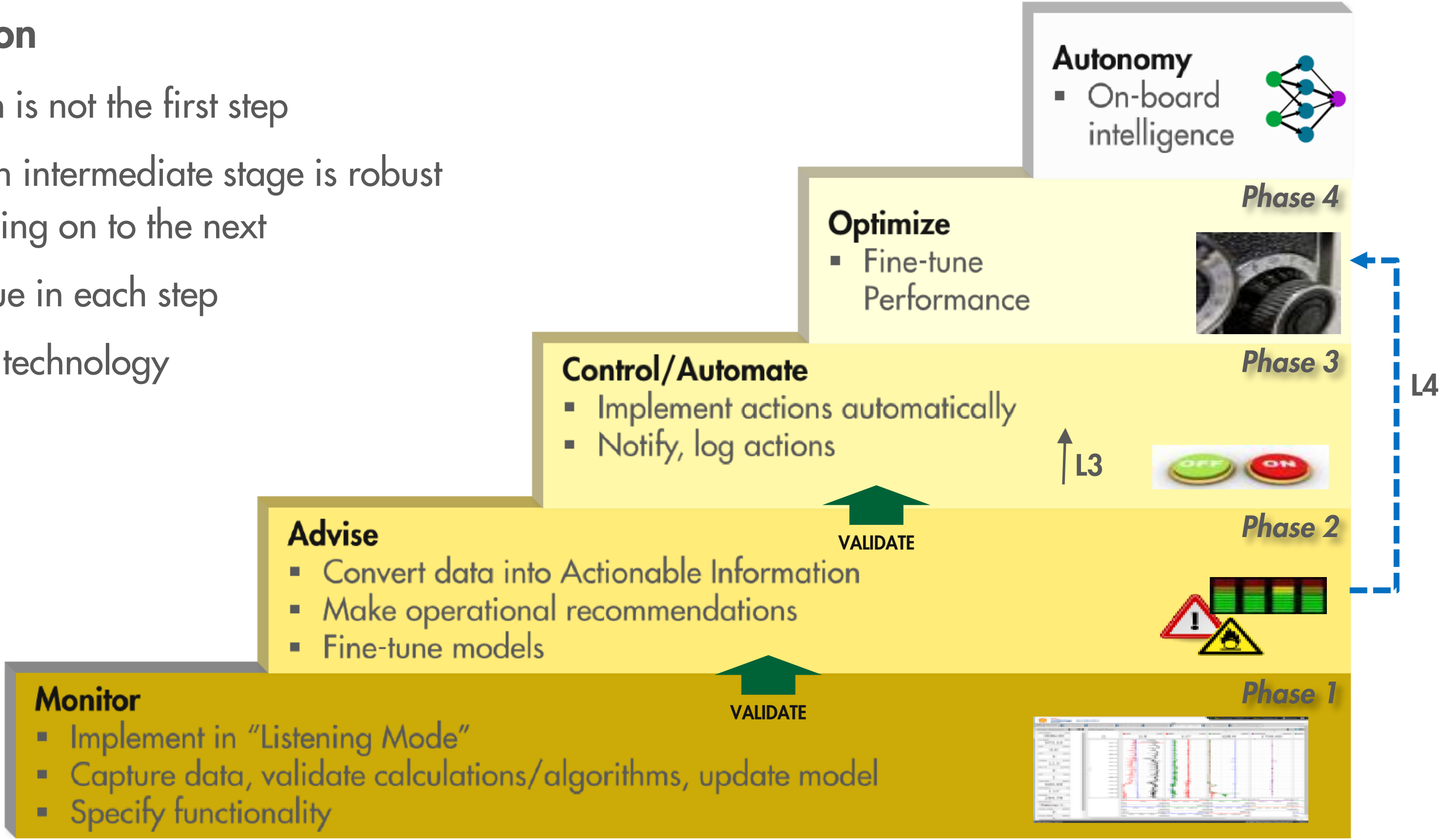
Average in-slips connection time = 2.78 min



Typical Automation Maturation Staircase

Risk Mitigation

- Automation is not the first step
- Ensure each intermediate stage is robust before moving on to the next
- Deliver value in each step
- Mature the technology

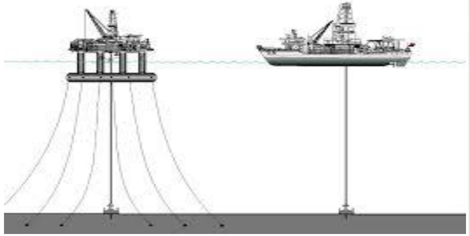


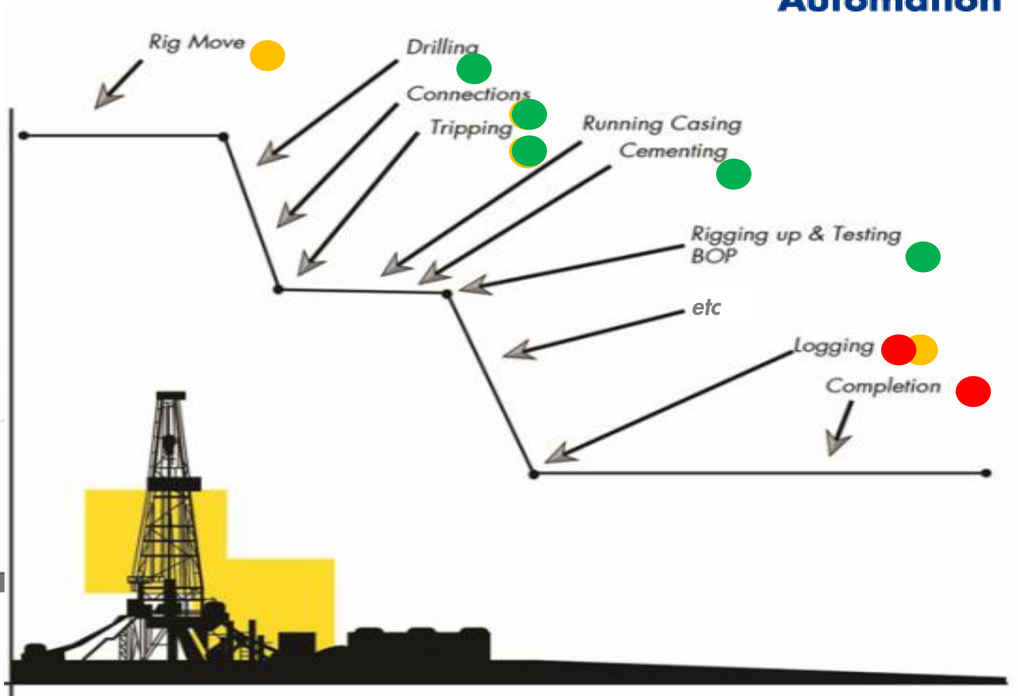
Automation

Shell WellVantage Automation

Value Proposition: Deliver better, safer, more cost-effective wells

- Performance ≥ Best in Class
- Consistency
- [Enhanced Safety/Well Integrity]
- Minimize costly problems
- Avert Train Wrecks





- Now
- Ongoing
- Later

'Any routine task can potentially be automated in the drilling and completion process'

Safety and Automated Systems

One of the primary HSE goals of automation is to get people out of harm's way. But every solution brings its own new challenges:

- Guard against equipment moving when it may cause injury or harm
  - e.g. crushing, collisions, equipment damage, create unsafe conditions
- Interlocks
- Hold points
- Build in safety at design stage
  - e.g. IEC 61508: Functional Safety of Programmable Safety-Related Systems
- Implement safeguards appropriate to the severity of risk/consequences

What if the automated system is an integral component of process safety?

- Consequences of failure
- Process assurance

Example

While tripping out drill pipe, a floor hand was struck by the iron roughneck.

The iron roughneck was engaged to extend while the worker was in its path.

Attempts to warn the person and stop the iron roughneck failed.

Safety Alert

From the International Association of Drilling Contractors

ALERT 13 – 21

IRON ROUGHNECK "STRUCK BY" INCIDENT RESULTS IN FATALITY

WHAT HAPPENED:

While the rig crew was tripping drill pipe out of the well, a floorhand was struck by an iron roughneck and suffered fatal injuries. At the time of the incident the floorhand was fitting a collar clamp around a drill collar. Witnesses state that a remotely operated iron roughneck was engaged to extend while the worker was in its path. Attempts to warn the person and stop the iron roughneck failed. Even though this incident is subject to an ongoing investigation, this alert provides guidance for the industry on the risk factors and hazards identified during the preliminary investigation.

Photo of an Iron Roughneck

WHAT CAUSED IT:

Key issues:

- Initial design HAZOP (Hazardous Operation) may be inadequate and must be reviewed.
- Ensure safety controls exist that enable workers and drillers to confirm that the path of the iron roughneck is clear of personnel.
- The sound of equipment moving such as an iron roughneck may be muffled by other noises on the equipment or the work site.
- Layout or design of the drill rig and doghouse may impede a clear visual line of sight of workers in the danger zones.
- Emergency stop controls must be nearby, identifiable, and readily accessible.
- Safety controls on remotely operated devices must be reviewed regularly to ensure that they are adequate in controlling any risk of injury or harm.

CORRECTIVE ACTIONS: To address this incident, this company did the following:

Recommendations:

- Rig Managers are to assess all operational risks relating to the use and maintenance of iron roughnecks.
- Supervisors are to take all necessary and reasonable actions to ensure that no person or property is exposed to more than an acceptable level of risk relating to the use and maintenance of iron roughnecks.

The Corrective Actions stated in this alert are one company's attempts to address the incident, and do not necessarily reflect the position of IADC or the IADC HSE Committee.

Issued September 2013

Safety Alert

From the International Association of Drilling Contractors

- Engineering personnel should re-examine iron roughneck design and interaction with control systems to eliminate risk or implement controls to ensure any risk associated with the use and maintenance of iron roughnecks is within acceptable safety limits, having regard to each relevant safety requirement, and is as low as reasonably practicable.
- Engineering controls should consider mechanical barriers, audio-visual warnings and rig platform authorization controls that ensures people are in a safe area before iron roughnecks can be operated.
- Engineering personnel should ensure that engineering inspections have validated that the safety critical elements of iron roughneck operation, including all safety-related software and hardware functions to verify the suitability of the safety measures, are implemented.
- Maintenance and engineering personnel are to ensure test reports detailing all validations are recorded and managed as part of the SMP (Safety Management Plan) and can be presented for inspection if requested.
- Ensure that the provisions of Section 696 and Section 697 of the Petroleum and Gas (Production and Safety) Act 2004 are met.

Credit to: State of Queensland, Department of Natural Resources and Mines, 2013
Petroleum and Gas Safety Alert 58

The Corrective Actions stated in this alert are one company's attempts to address the incident, and do not necessarily reflect the position of IADC or the IADC HSE Committee.

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Issued September 2013

AUTOMATION EXAMPLES

IDAPS - Influx Detection At Pumps Stopped

CHALLENGE

- High probability of formation influx occurring when pumps are stopped to make a connection.
- Current finger printing methods for influx detection rely on subjective observations by third party Mud Loggers.

SOLUTION

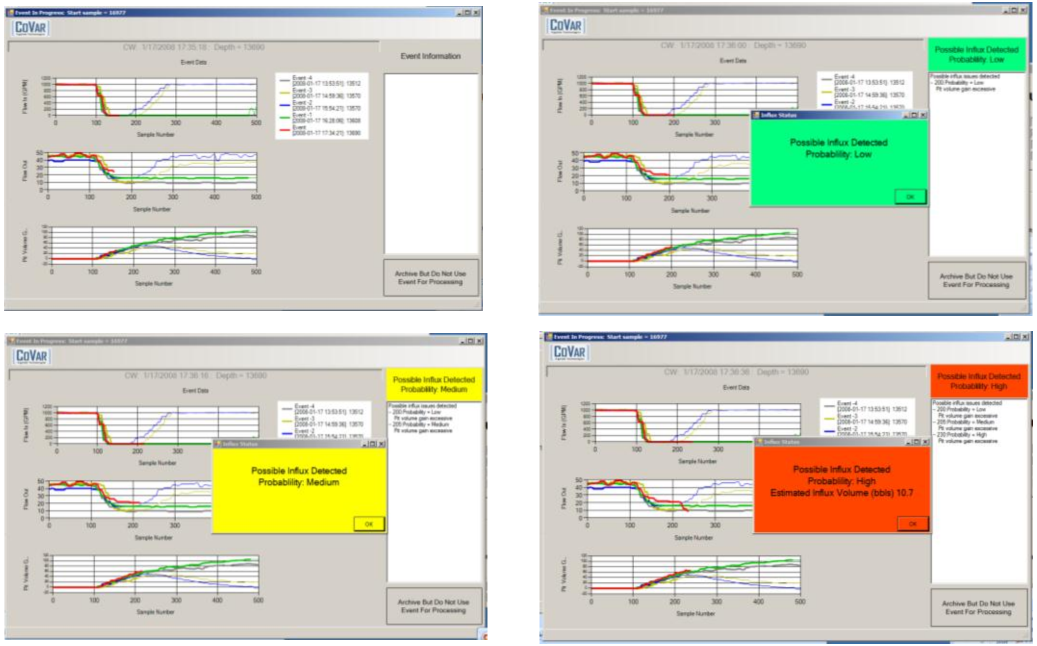
- IDAPS has been developed to provides a rigorous, automated, method for influx detection when making a connection.
- Machine learning can reliably spot influx (or losses) when comparing the current “pumps stopped” signature to the last few signatures.

IMPACT

- At least 25% of all influx events on exploration wells occur while making connections
- Most rigs don’t have kick detection alarms to alert the driller during connections.
- IDAPS fills this gap and provides early warning of abnormal flow back signatures.

APPLICABILITY

- Now incorporated into WellVantage, IDAPS is available for every well operation globally where WellVantage real-time services are employed.
- IDAPS is being licensed to selected partners for availability on a commercial basis.



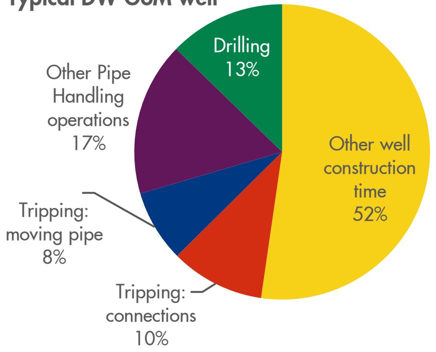
- Data for pumps-off occurrences are detected, aligned, and saved as unique “events”
- Recent event data patterns are used to calculate acceptable limits for next expected “normal” events
- Statistically meaningful deviations from “normal” limits result in influx alarms (low probability, medium probability & confirmed)
- Advanced signal processing minimizes false alarms and maximizes detection performance

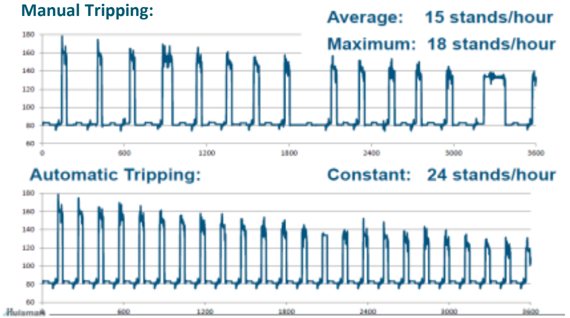
Deep Water Automation – Pipe Handling

Tripping

- For DW, tripping occupies more time than drilling
- A number of automated tripping technologies are under development
- Some are integral to drilling systems, others can be retrofitted
- Continuous motion of pipe/Continuous Circulation can minimize borehole stress as well as trip time

**Time Breakdown:
Typical DW GoM well**





Drill Floor Logistics

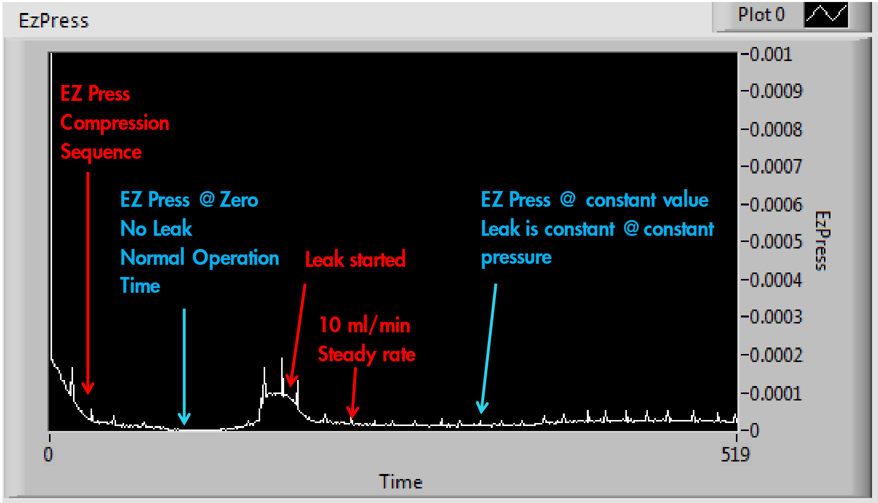
- Efficiencies save on flat time as well as drilling time (the "other 75%")
- Positions cannot be eliminated unless all pipe handling operations can be automated
- Robotics can eliminate the need for people on the floor

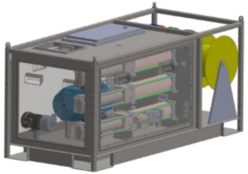
Potential savings: $2.5m - $25m per well

Image courtesy of Robotic Drilling Systems AS

BOPX – Automation Enables New Test Methodology

- **BOP Testing is performed on virtually every rig in the fleet.**
- **BOP Pressure testing processes have not radically changed in decades.**
- **Primary Areas of BOPX improvement focus**
  - Pressurizing sequence & accuracy – shock/overshoot & safety
  - Pressure decay testing methodology - major time impact
  - Pass/fail criteria & methods – subjective vs. objective
  - Leak location detection – acoustic & accelerometer designs
  - Test design – troubleshooting optimization
  - Valve positioning - accuracy & control
  - Automated BOP Testing





The BOPX EzPress system can:

- Reduce BOP testing time
- Reduce HSSE risks associated with testing
- Quantify a leak rate
- Objectively output a pass/fail analysis
- Automatically generate a report
- Interface with existing data historians to allow remote monitoring

Through use of a **Constant-Pressure Variable-Volume** methodology, the system can mitigate:

- Temperature effects
- Air Volume effects
- Mechanical effects

Constant Pressure implies the fluid injected matches the fluid leak rate

- Precise pressure and flow measurement required

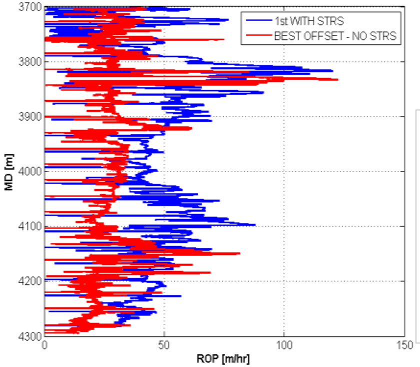
SoftTorque – Mitigating Stick-Slip

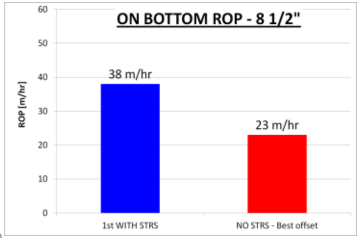
What is Stick-Slip?

- Torsional vibration resulting in cyclic stopping (sticking) and releasing (slipping) of the bit during drilling operations
- 3-10 second period (dependent on drill string length)
- Detected at surface as a fluctuation in torque
- Causes bit damage and reduced ROP

Soft Torque mitigates stick slip vibration in a drill string:

- Allows faster penetration rate (Magnolia)
- Reducing bit wear, less bit trips (Oman)
- Improving down hole tool performance and life (SRAK)
- Improving core recovery (Qatar)
- Reducing rig superstructure vibrations (Gabon)





Multi-vendor commercialization strategy; competition reduces cost and improves product functionality.

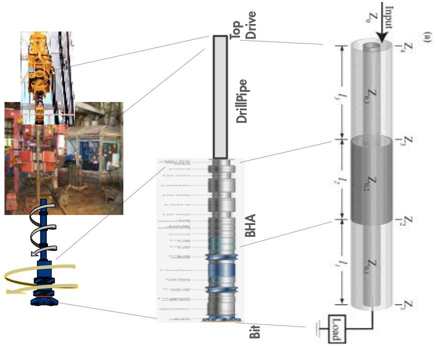
Each STRS licensee has an approved commissioning protocol to “guarantee” quality.

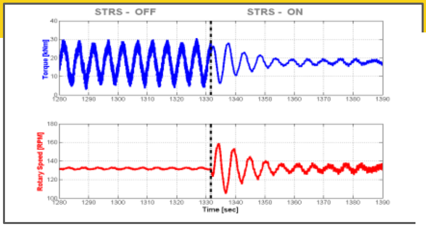
>115 deployments to date for Shell & partners alone

Consider the drill string as a transmission line for torsional vibration.

Ztorque applies a transform via digital control of the top drive rotation to eliminate reflections of the transmitted vibrational signal from the top drive. This stops torsional vibration in the drill string, and extends the operating envelope of the STRS technique.

Ztorque features auto-tuning; matching of STRS to the current system (drill pipe and BHA, etc.) is done automatically, eliminating the need for detailed expertise on the part of the operator.





Example of smoothed surface torque when Soft Torque switched on

Without STRS

With STRS

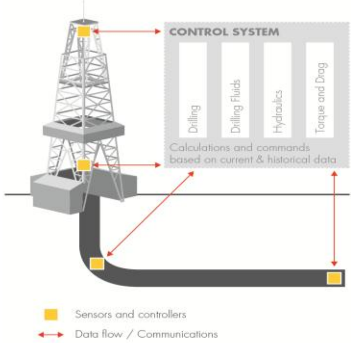
EXAMPLE: DRILLING AUTOMATION

Automation Example: Drilling Automation

Shell WellVantage*
Automation

Context

- Shell WellVantage Automation uses real-time data technologies and control systems to optimize drilling efficiency. The system incorporates functionality such as ROP optimization and closed-loop trajectory control



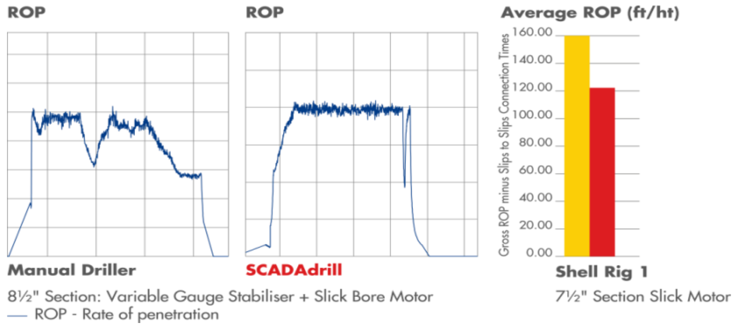
- Interface with existing rig controls
- Computer-based coordination of mud pumps, top drive and hoisting/lowering functions
- Using hole condition monitoring data

Action

- Deployed in Australia, Canada, China, the Netherlands and the US

Business impact

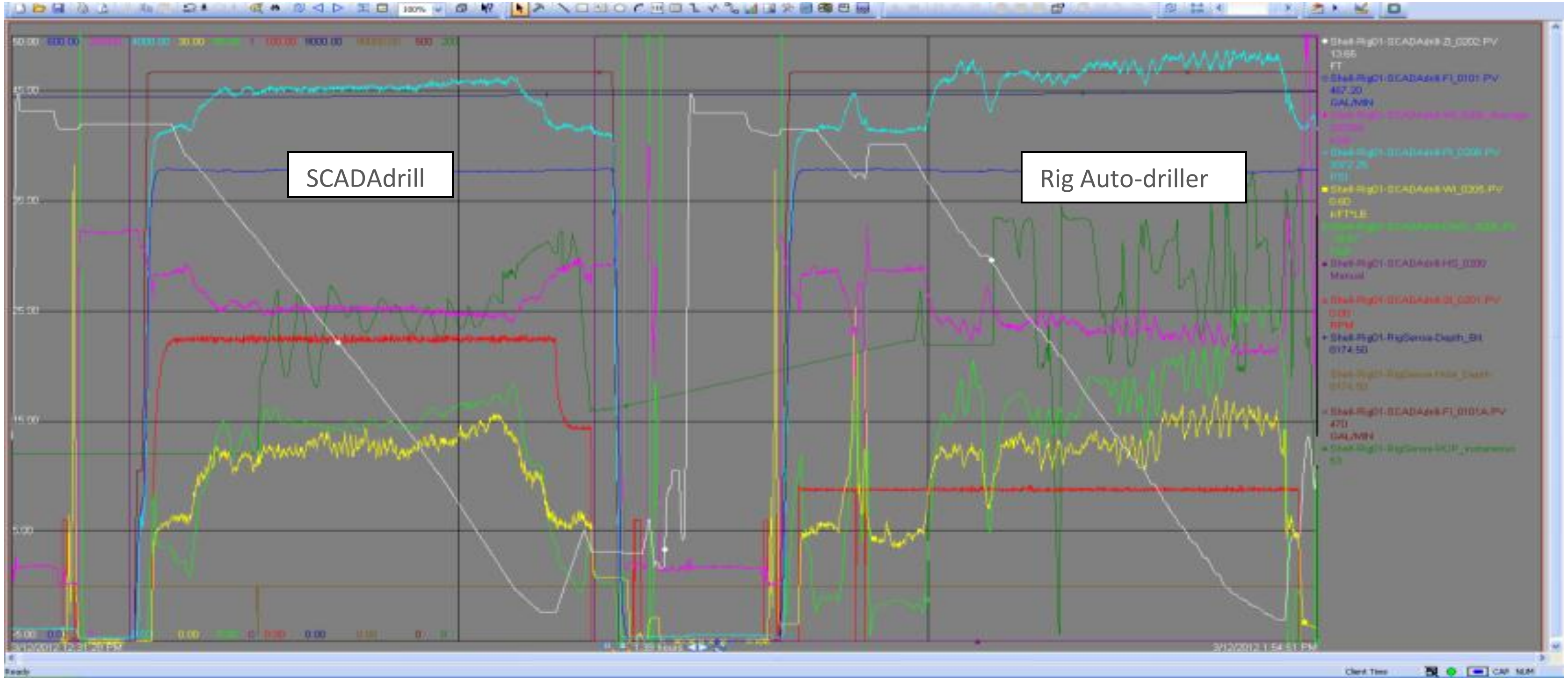
- **Enhances safety** by reducing the number of people needed on-site
- **Reduces cost** of personnel, travel, tools & maintenance
- **Increases efficiency** through delivery of more consistent and repeatable drilling operations



*Registered trademark of the Shell Group of Companies

SCADAdrill Performance: example

Automation gives us refined control of drilling variables via a rapidly responding system and unique control algorithms, which are flexible enough to respond to variability in drilling conditions



Automated Drilling System (WellVantage / Automation)

Technology Highlight

- Novel automated drilling system allows direct application of Shell best drilling practices, improving drilling performance, consistency and safety

Impact

Automated Drilling system

- Faster/lower cost
- More accurate directional drilling
- Reduced safety incidents due to poor drilling practices

Real Time & Remote Operations

- Integrates directional driller, MWD, geosteering & delivery teams
- Reduces decision time

Results

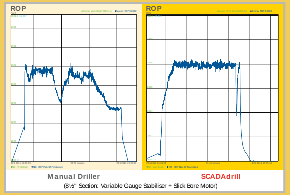
- **SCADAdrill Performance :**
- **Overall ROP 47% faster than manual driller**
- **92% of the well was drilled by SCADAdrill**
- **96% of sliding done through SCADAdrill**

Shell WellVantage Real-Time

Shell WellVantage Remote Operations

Shell WellVantage Automation

Manual Driller



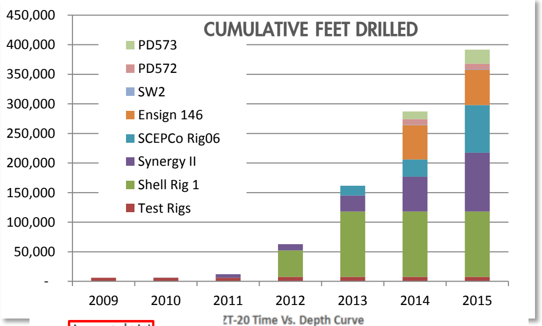
…automated = smoother!

From: "Technology & Best Practices Application in Fushun Shale Gas Project"
(Joann Chu, Steve Glover, Unconventionals Technology Conference 2015)

WellVantage Automation – Current Status

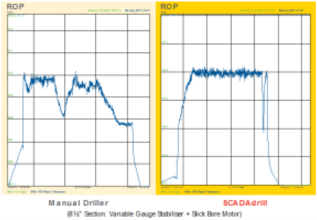
WellVantage Automation as delivered is a technical success

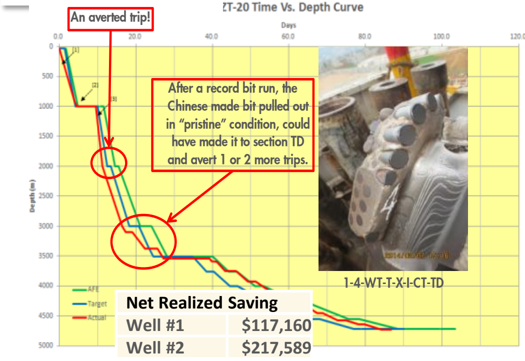
- Core product consistently performs as well as (or out-performs) the best manual drillers
- Has been deployed in US, China, Australia, Canada, Netherlands
- Advanced software kernels currently being applied to drilling automation (WellHydraulics, Torque & Drag, ROPtimizer); applications for Deep Water
- WellVantage DD: Closed Loop Directional Drilling



But: the target market has shifted

- Challenge to achieve economies of scale vs. “one off”
- Factory Drilling with inexperienced crews is not our current challenge
- Rig fleet has contracted, we have high-graded drillers and rig crews
- Focus on Performance: benchmark has been raised



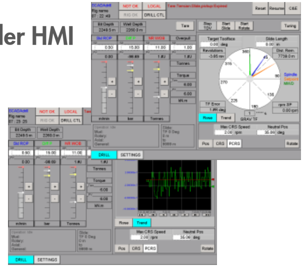


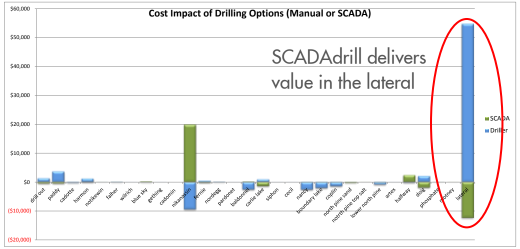
WellVantage Automation has had to adapt to the new environment

- Focus on <u>value</u> delivered
  - ➔ Loadable configurations
  - ➔ Improved sliding
  - ➔ Driller HMI
  - ➔ Time-based Continuous Rotation System (TCRS; hot-fix)
  - ➔ Enhanced directional capabilities
  - ➔ ROPtimizer (hot-fix)
  - ➔ Auto Downlink for RSS tools

(hot-fixes where practical; SAT costs are a hurdle)

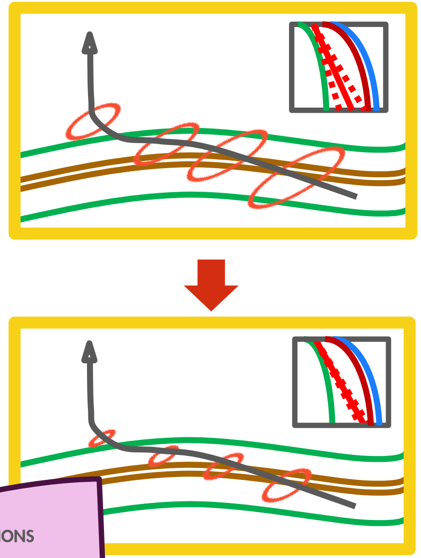
Driller HMI

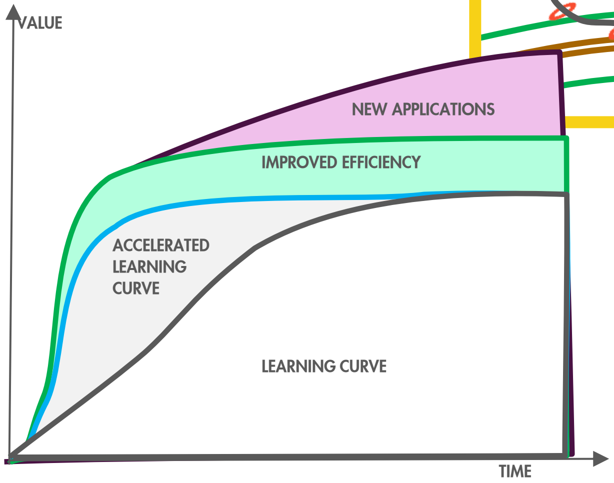




Drilling Automation: What Comes Next?

- Reduced footprint to reduce cost and complexity
  - Both Hardware and Support Infrastructure: I/O, comms, security, data historian, etc
- Standards and Interoperability
  - Required for the technology to achieve broad adoption; otherwise incompatibilities will constrain usage
- Use of high-speed downhole data
  - Learn lessons much faster
  - Enhance performance based on actual downhole conditions
  - Distributed sensing while drilling
- Mature the Applications
  - Reduce setup/configuration time and effort
  - Increase confidence in the technology
  - Learn how to derive greater value from the data and capabilities
- New applications:
  - e.g. those enabled by high-speed downhole data
  - Downhole actuators (electrical power to downhole devices)
  - Intelligent/autonomous downhole devices
  - Machine learning
  - Reduce uncertainties; safely operate closer to constraints
  - Drilling fluids management
  - Auto geo-steering
  - etc…





SUMMARY

Learnings and Thoughts on Automation…

- Focus needs to be on value delivered, not on automation
  - Economies of scale can help defray implementation costs
  - New applications enabled by technology
- Often, value is not in time savings (but not always):
  - Safety – get people out of harm's way
  - Consequences of failure – implications of automating safety processes
  - Can we improve productivity? e.g. minimize formation damage, add another frac stage
- Human issues:
  - Replace the human? Eliminate people cost (e.g. 1 offshore position in Norway requires 6 people)
  - Fear: "will I be replaced?"
  - Or provide a tool for the human to improve performance?
  - Trust in the automated system
  - Perceptions, e.g. "automation will slow things down.."
  - Retain operator engagement in the process
  - Hawthorne effect
- Automation in many wells applications is not yet mature
  - It takes time to refine an Automation application, i.e. to deliver full value
  - Need sufficient numbers of operations to achieve maturity
  - Automate the existing process? or use automation to enable a new process?

THANK YOU

QUESTIONS & COMMENTS

Adapting Wells Automation Efforts to a Low Oil-Price Environment