Adapting Wells Automation Efforts to a Low Oil-Price Environment

David Blacklaw, Shell
Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

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.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Shales: Our use of the term “shales” refers to tight, shale and coal bed methane oil and gas acreage.

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this document “Shell”, “Shell group” and “Royal Dutch Shell” are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words “we”, “us” and “our” are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies.”Subsidiaries”, “Shell subsidiaries” and “Shell companies” as used in this document refer to companies over which Shell has joint control are generally referred to as “joint ventures” and companies over which Shell has significant influence but neither control nor joint control are referred to as “associates”. The term “Shell interest” is used for convenience to indicate the direct and/or indirect ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management’s current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management’s expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as “anticipate”, “believe”, “could”, “estimate”, “expect”, “intend”, “may”, “plan”, “objectives”, “outlook”, “probably”, “project”, “will”, “seek”, “target”, “risks”, “goals”, “should” and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell’s products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including potential litigation and regulatory measures as a result of climate changes; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional factors that may affect future results are contained in Royal Dutch Shell’s 20-F for the year ended 31 December, 2015 (available at www.shell.com/investor and www.sec.gov). These factors also should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, April 14th, 2016. Neither Royal Dutch Shell nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation. There can be no assurance that dividend payments will match or exceed those set out in this presentation in the future, or that they will be made at all.

We use certain terms in this presentation, such as discovery potential, that the United States Securities and Exchange Commission (SEC) guidelines strictly prohibit us from including in filings with the SEC.

U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain this form from the SEC by calling 1-800-SEC-0330.

April 2016
Outline

- Automation Principles
- Automation Examples
  - Focus on e.g. Drilling Automation, Pipe Handling
- Summary – Thoughts & Learnings
AUTOMATION PRINCIPLES
Why automate...?

- Don’t exceed the maximum RPM of the bit
- Avoid lateral vibrations
- Don’t exceed maximum weight on the bit
- Drill faster
- Stay on target
- Don’t exceed make-up torque of the drill string
- Drill efficiently
- Drill this section without tripping; i.e. with one bit
- Time is money
- Safety first
- Condition the hole
- Don’t stall the top drive
- Don’t exceed the maximum RPM of the top drive
- 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
- Clean the hole
- Drill efficiently
Automation and Optimization

Controlling the process

Improving the process

Wait for Task 1 to finish before starting Task 2

Oops! Sorry, I wasn’t paying attention...

Automated Process

Tasks all start in programmed sequence

Optimized Process

Some tasks can be performed in parallel, or started before the previous task is complete

Current performance:
- low relative to target
- uncontrolled

Control and improve the process in one step

Control and improve the process in one step

Improving the process

Current performance:
- low relative to target
- uncontrolled

Controlling the process

April 2016
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-slip connection time = 2.78 min
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

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

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

‘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
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.
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 provide 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.

April 2016
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

**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
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

April 2016
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: 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.

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

April 2016
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

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 value 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)

An averted trip!
After a record bit run, the Chinese made bit pulled out in “pristine” condition, could have made it to section TD and avert 1 or 2 more trips.

An averted trip!
After a record bit run, the Chinese made bit pulled out in “pristine” condition, could have made it to section TD and avert 1 or 2 more trips.

Well Realized Saving
Well #1 $117,160
Well #2 $217,589

SCADA delivers value in the lateral
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