I would like to thank the International Association of Drilling Contractors for giving me the opportunity to present this very exciting subject at their World Drilling Conference in Barcelona, Spain on June 13th, 2012.

**Introducing John de Wardt**
John de Wardt is an independent, global, oil and gas management consultant specializing in Strategic Planning, Lean Manufacturing and Value Delivery Systems.
John's 36 years of work experience in 28 countries includes operations, engineering, contracts and management roles with ICI, Shell, Forasol/Foramer and Halliburton. He founded his consulting practice in 1994 and has a client list of 61 companies. John has published 20 SPE / IADC papers and industry articles many of which describe leading edge innovations in drilling. He has been a committee member on the SPE / IADC Drilling Conference for over 18 years and is the Program Chairman of the SPE Drilling Systems Automation Technical Section.
Drilling systems automation is now underway as various companies develop applications. Barriers that were in place are steadily breaking down as proof of concept is demonstrated. Compelling drivers include less people in drilling operations and repetitive low cost wells from shale drilling. Automation is most effective when the machines are designed to incorporate it; some clients demand old rig designs which negate advantages from new automation technology. Industrial automation has consistently been ahead of the application in drilling systems and, through new research, is making further advancements.

In this presentation, I describe two dissimilar scenarios (stories) depicting how drilling systems automation could be implemented. Drilling systems automation progress will be driven by leaders, supported by followers and taken up by the others at a later date.

In many ways drilling rig automation is not new. The National Automated Drilling Machine (NADM) project commenced in the 1970's, was purchased by National Supply who then invested $40 million in R&D before termination in 1986. This drilling machine drilled some test wells for Mobil in Texas. It is not surprising that it was not able to become commercial when you consider that the computer contained vacuum tubes and the power systems was an early hydraulic application to movable land rigs.

There are some key terms that require definition in order to communicate clearly the intentions with regard to drilling systems automation. Automation is the use of a control system to reduce human work whereas autonomous is control that works without external intervention. A drilling rig is a machine that creates holes in the ground and installs casings and completions into those holes. Drilling Systems is the combination of all the tools and machinery that drills a borehole in the right location.

- Automation: Use of control systems to reduce need for human work
- Autonomous: Not subject to control from outside
- Drilling Rig: A machine which creates holes
- Drilling systems: The combined machines, tools and processes that place a bore hole efficiently in the right location and install the completion
In 1978, Sheridan and Verplank (Ref 1) defined 10 levels of automation:
1. The computer offers no assistance: human must take all decision and actions.
2. The computer offers a complete set of decision/action alternatives, or
3. narrows the selection down to a few, or
4. suggests one alternative, and
5. executes that suggestion if the human approves, or
6. allows the human a restricted time to veto before automatic execution, or
7. executes automatically, then necessarily informs humans, and
8. informs the human only if asked, or
9. informs the human only if it, the computer, decides to
10. The computer decides everything and acts autonomously, ignoring the human

In 2002, they reduced these to 8 levels. Other experts have created definitions that cover the same range of automation applications which provide another view on this spectrum. One such person is Endsley (Ref 2).

Essentially, the transition is from manual control through to a fully autonomous system that makes and implements its own decisions. Within this transition are various levels of operator interface. In the case of drilling, the operator would be the driller, directional driller or other operator who typically manually controls their respective equipment.

It is not yet well known that a number of modern applications of automated systems and autonomous systems have been applied to various aspects of drilling.
In 2009, an International Oil Company undertook a demonstration of proof by automating the drilling of two shallow laterals. A programmed process logic controller (PLC) was installed on a simple, singles rig. This controller took data from downhole MWD tools and surface sensors as input to a processor that gave command signals to the key rig equipment.
Over the past few years, a major service company has studied the mean time between failures (MTBF) for rotary steerable tools operating in the USA. The studies showed that the MTBF doubled on land drilling rigs that included advanced drilling control systems. The conclusion drawn is that these advanced control systems drill in more smoothly and consistently than a human and maintain the best parameters more consistently during drilling. These two attributes reduce downhole vibration which is very damaging to downhole tools. These rigs simultaneously delivered 33% lower well cost than standard rigs with a 20% higher day rate demonstrating that advanced rig designs with advanced control systems truly deliver lower well cost.
A rate of penetration optimizer has been
published through the SPE / IADC drilling conferences; the data show that this system increases ROP by 40% overall. It is not a traditional auto driller operating off a set point; it is a true optimizing system that analyses the data continuously and maps where the best performance can be achieved in terms of WOB and RPM. Essentially, it is a continuous drill off test undertaken by an automated process that neither gets tired nor ignores the smallest signal to change the drilling parameters, however often this signal changes.

A major rig manufacturer has recently launched a central control system for drilling that collects data from downhole and surface sources and communicates control signals to the surface drilling equipment. The system is designed for users to install their own apps (or applications) to control the drilling process.

Barriers

- Business models and contract structures
- Cultural mindset / Resistance to change
- Reliability (perception more than reality)

Barriers are always present, we can list many but there are a few key ones that affect the rate of adoption of drilling systems automation. Business models and contract structures in the drilling business have not been designed to drive alignment to customer goals; consequently application of new technology that makes sense in terms of customer value cannot be rewarded and therefore are reluctantly developed and implemented.

There are mindsets in the industry that prefer to trade and adapt current technology with which they are familiar rather than plunge into radically redesigned systems regardless of the value these redesigns can realize.

Reliability has been the bane of both new technology adoption and automated systems. Based on many discussions in workshops and forums, the perceived lack of reliability does not match the reality. Failures tend to be magnified rather than taken on board as a learning experience. There are methodologies to manage reliability for the implementation of a new product and more specifically, for adoption of automation.

The drivers to adopt drilling systems automation are compelling. This is an easy list to create and a challenging one to ratify. This list has been enunciated in many forums in similar formats. It is obvious that industrial automation has been adopted in manufacturing to great benefit and that their list of drivers is similar to those for the upstream drilling business. Unfortunately, the typical drilling industry outlook is over weighed by the negatives that the positives of adoption struggle to find their value in any evaluation.

It is possible to apply significant levels of automation to drilling operations, including autonomous control, deriving benefits that include increased efficiency through consistent performance, improved performance as previously described, reduction of risk through envelope protection and the application of knowledge.
Many automation systems founder because they deliver insufficient value as a result of automating current designs.

Drilling rigs suffer from a belief that new automated or semi-automated versions should look and behave like traditional manual rigs. This, unfortunately, reduces the efficacy of the application of automation.

Sensors are the driver of data quality and frequency; as an industry the drilling business lives in the past of current technology. The means we use to measure critical drilling factors was designed in the 1950’s. The data from these sensors is both inaccurate and infrequent meaning that control, either manual or automated, is not possible.

There are industries that utilize modern sensors and automation systems that outperform those used in drilling operations. These systems can be readily adopted by the drilling industry. Inhibition is the result of the contracting model that drives low cost solutions rather than higher investment in better results. The top drive is a unique example of a new technology that was effectively sold to the customer (the oil company) and then specified to the supplier (the drilling contractor). It seems that this model will have to apply to modern sensors for drilling systems until the commercial model is changed.
Drilling Systems Automation is Advancing: How Far and How Fast?

There are two significant opportunities to advance automation in Drilling operations:

1. Apply current practices from industrial automation – complimentary industries.
2. Apply results from advanced research into automation and autonomous systems.

Algorithms that learn – the ultimate apprentice!

This is a control technology application that has been demonstrated through the autonomous flight of a large, model helicopter that performs a complete aerobatics show. Not only do these algorithms learn the intended path of a helicopter performing the same maneuver repeatedly when operated by an expert but they also learn the dynamics of the system. This ability enables perfect autonomous flight regardless of varying weather conditions. It is easy to consider that this application can be readily assimilated into drilling especially in the realm of directional drilling.

Automation jumping ahead

- Accessing non oilfield expertise
  - More advanced than we are
  - DARPA “coming out”

There are some significant advances being made in automation and autonomous systems that utilize gaming technology to massively reduce cost, perform highly accurate operations without damage and apply robotics to extremely difficult and varying terrain.
Scenarios are stories that describe the potential future. They describe different outcomes that are possible from the current situation. They are used to generate thinking of what could be possible in an uncertain world. I offer two extreme scenarios of what is possible in the arena of drilling systems automation.

In **Great Expectations**, a broad scale, swift advance of drilling system automation occurs in land drilling operations particularly focused in unconventional reservoirs such as shales. These systems operate autonomously drilling wells to preprogrammed plans. Drilling machines in a similar field share information so that they learn in a cohesive manner. The operations of multiple drilling machines are monitored and supervised through a remote control center.
The culmination of the advancement in drilling systems automation is development and deployment of a drilling rig on the moon that employs many drilling industry innovations in automation and autonomous drilling systems.

In *Hold Your Horses*, the aspirations of automated drilling system proponents are dashed as prototypes encounter significant problems. In one case, a major incident becomes a major news item with much blame falling on the lack of onsite personnel to control the drilling operation.

Novel rig designs, created to accomplish improved drilling performance under automated conditions, encounter significant capital cost that, combined with low reliability, renders them uneconomic to operate. The development of automated drilling becomes one of incremental applications to traditional drilling rig designs. The “automated rigs” are operated by a driller who remains in control at all times.

Drilling Systems Automation will be developed and implemented quite rapidly because much of the technology is available for adoption from other industries that have advanced further in the application of automation. The rapid and significant adoption described in *Great Expectations* is very possible. There are individuals and companies leading this implementation, they are developing and investing in the systems to be first to market. There are those who are actively observing with the intention to be fast followers of the trend. There are those who are ignoring the development of drilling systems automation and will only become adopters when its application becomes standard in drilling operations.

**Hold Your Horses!**

- Automation prototypes encounter significant problems in terms of operations and reliability
- A major incident occurred on one of the rigs
- Novel rig designs incur high capex and have low reliability
- Incremental application of control systems on traditional designed rigs
- Driller remains in constant control

**Choices at this stage of the game:**

- Lead – invest and develop to be first to market
- Follow – observe actively and implement soon after
- Get out of the way – ignore the development until it becomes standard in industry
Footnote
Great Expectations, a famous novel by Charles Dickens, is built on a theme of great ambition.

Hold Your Horses is a saying that is typically used when someone is rushing into something. "Hold your horses" literally means to keep your horse (or horses) still, which would be used when horse riding, or driving a horse-drawn vehicle.
If someone tells you to hold your horses, you are doing something too fast and they would like you to slow down.
