DOTs ®

TRAC ID SYSTEMS AS

WHITE PAPER

An Integrated System for Drill Pipe Tracking and Fatigue Life Prediction
Drilling Operations Tracking System

Abstract
Drillpipe is subject to high loads and heavy wear under harsh conditions. Analysis show that significant costs are related to drillpipe failures in drilling operations, thus there is a great cost saving potential through proactive maintenance, optimized operations and improved logistics. A shift from traditional linear mindset to Integrated Operations (IO) with a "cradle to grave" approach is required to obtain full drillpipe life cycle management.

By combining RFID technology, cutting-edge information technology and advanced scientific software, the Drilling Operations Tracking System (DOTS®) enables automatic tracking and quality control of drill pipes through the whole value chain.

This paper presents a commercial available drillpipe tracking system utilizing new technologies and results from research, laboratory experiments, and offshore demonstrations.

Introduction
Drillpipe failures, as shown in figure 1, can represent a significant cost in drilling operations. One operator has performed analysis of 187 incidents, suggesting direct economical losses exceeding 150 million USD. Furthermore, challenges related to tubular identification, tracking and quality control appears in all parts of the lifecycle through:

- Expensive and hazardous drill pipe failures
- Expensive and inefficient inspection
- Poor supply chain management
- Inaccurate depth control in drilling operation
- Lack of global drill pipe identification
- Poor data quality and low level of data integration
- New challenges related to Extended Reach Drilling and drilling in remote areas

The potential benefits from electronic tubular tracking apply to all players in the industry, such as operator companies, drilling contractors, rental companies, inspection companies, maintenance companies and shipping.

Figure 1 Examples of drill pipe failures. Washout in 5" drill pipe (left) and twist-off in 3 ½" drill pipe (right). If a wash-out is not detected through monitoring drilling parameters the result is normally a parted string down hole.

Some of the potential benefits from the Drilling Operations Tracking System are listed below:

DOTS benefits in drilling operations
Reduced drill string failures (Twist-off and wash-out)
- Reduced NPT and loss of equipment
- Reduced recovery operations
    - Safer operations

Inspection advisory
- Optimized drillstring design
- Reduced, focused & improved inspection
    - Reduced maintenance cost
    - Increased drill pipe quality & life

Automatic tally & improved depth control

- More correct operations (Casing setting, TD tagging etc.)
- More efficient tripping and drilling operation
- Improved depth-log
- Simplified and improved tally management
- Better documentation
- Real-time data provider to analysis tools (Eg. E-Drilling)
- Enabler for automation

Operational error alerts

- Prevent incorrect use of drill pipes and mix of threaded connections
- Prevent use of drill pipes in quarantine

Reduced manual handling

- Improved HSE (Eg. Pinch injuries).

DOTS benefits in the supply chain

Electronic identification in drill pipe handling

- Eliminate manual errors in identification of drill pipes. (Typical 11.000 potential error sources for each inspection cycle for a drill string).
- Tracking of drill pipes in supply
  - Improved receiving and dispatch
  - Improved planning & supply
- Improved equipment utilization
  - Reduced stock and loss
- More efficient inspection & maintenance
  - Improved drill pipe handling
  - Electronic linking of inspection data
  - Improved inspection quality
  - Update of length in inspection report at re-cut of tubular

Equipment history availability

- Easier failure cause analysis
- Improved drill pipe design
- Contract compliance verification

Electronic integration (Customer / Supplier)

- Improved interaction between parties in the supply chain
- Better contract compliance

Tubular lifecycle

The tubular supply chain is complex and a number of industry players are involved. Tubular life can typically be 5 - 15 years and onshore to offshore cycle time typically 6 months. Information is produced in each business step, and global electronic identification together with standardized information sharing is required to obtain full tubular tracking and quality assurance. Figure 2 shows an illustration of tubular lifecycles and information generated in the different business steps.

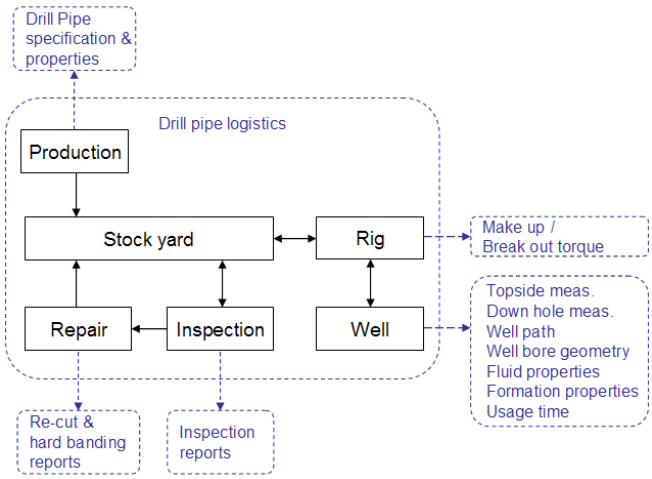

Figure 2 Tubular lifecycle

Tracking technology

Radio-frequency identification (RFID) is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves.

RFID has existed for more than 60 years, but it is in the recent decade that the use of RFID has become widespread in a range of applications. RFID is currently being implemented in different industries, such as farming, libraries, safety, food, postal, passenger transport, medicals, payment, etc. The Oil and Gas industry is lagging in the utilization of the RFID technology due to the harsh environment, challenges related to mounting techniques, metal shielding of signals, and smaller production volumes.

From the late 1980's several early attempts have been made to develop and commercialize a reliable technology for drillpipe tracking and quality assurance. Strassner and Chang [1], Sampaio et al. [2], and Ranashinghe et al. [3] describe an implementation of RFID in drill pipes. The motivation in these works was to improve the reliability, as well as extending the safe service life of drillpipes. Vincké et al. [4] describes a supervision system based on RFID tracking technology.

The technology is maturing, and robust solutions are now available enabling improved efficiency and cost reductions in the drilling segment. Improved technology, together with new packaging and mounting techniques, enable a functional and reliable tracking technology for downhole applications that meets the requirements of the most challenging wells.

The awareness of RFID in the Oil & Gas industry has increased during the last years, resulting in focus on standardization. Trac ID Systems AS has been an important contributor in this process, and provides

products in line with the prevailing guidelines and standards.

The Drilling Operations Tracking System

The Drilling Operations Tracking System (DOTS) enables Life Cycle Management through proactive maintenance, optimized operations and improved logistics for drill pipes.

DOTS utilize RFID technology, cutting-edge information technology, and advanced scientific software to achieve automatic tracking and quality control of drill pipes through the whole value chain.

The system is developed through a joint industry research program, supported by StatoilHydro, Eni, ConocoPhillips and the Norwegian Research Council and is now commercially available.

DOTS RFID Tag

Downhole application are challenging due to restricted RFID tag size and mounting technique, high temperature, pressure, shock and vibrations, and exposure of aggressive gasses and fluids. Furthermore, optimal reading performance in steel environment and through fluid, with electromagnetic interference at high velocity is required.

Comprehensive studies, laboratory experiments and industrial testing have been performed to develop a reliable tracking technology meeting the requirements of the Oil and Gas industry.

The DOTS RFID tag is designed to withstand downhole conditions and is optimized for automatic reading in the well centre. All tags are ATEX Zone 1 certified and is currently rated to 177°C / 350°F at 1 050 bars / 15 000 PSI, covering most of the HPHT drilling operations. Guarantied automatic reading in the well centre is obtained up to velocity at 2 m/s. All tags can be read with stationary and mobile readers onshore and offshore.

By mounting the tag in the pin tool joint API slot, optimal reading condition and protection is obtained. The threaded mounting slot is produced by the tubular manufacturer for new drill pipes and can be retrofitted, on site, for existing tubular.

The Fearnley Proctor Group has performed a comprehensive FEA (finite element analysis) for drillpipe integrity to qualify the method for incorporation of the RFID transponder. The optimum placement and mounting method, reducing the risk of fatigue failure, has been developed and verified. The figure below shows the DOTS RFID tag mounted in the tubular API slot. However similar mounting locations will apply to other equipment, such as bottom hole assembly components.

Figure 3 DOTS HPHT tubular tag, mounted in the pin tooljoint

DOTS Well centre Reader System

The DOTS well centre reader system identifies all RFID equipped items entering the well, at velocity up to 2 m/s. The data is sent to the TRAC Rig server for generation of electronic tally and calculation of usage parameters and fatigue development.

The system is easy to install, does not interfere with the ongoing drilling operation and requires low level of maintenance. All adjustments and tuning can be done electronically through remote onshore support.

The well centre antenna is placed below the rotary table and can be customized to fit in to the specific rig configuration.

The reading performance is not affected by steel, mud, temperature or other challenges in the well centre environment. The figure below shows a DOTS well centre antenna.

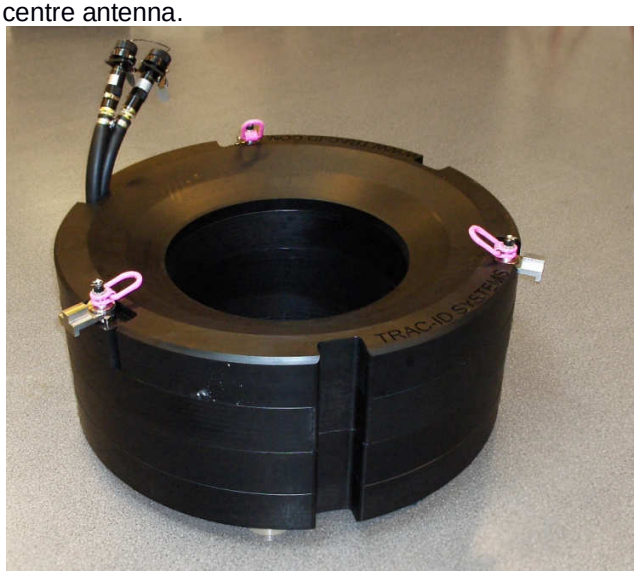

Figure 4 Well centre RFID antenna placed below drillfloor

Mobile solutions

The Trac Mobile Solution provides required industrial and ATEX certified hardware and software to enable identification and tracking of tubular onshore and offshore. Synchronization through wireless network, GSM or docking together with enterprise integration ensures real-time back office decision support.

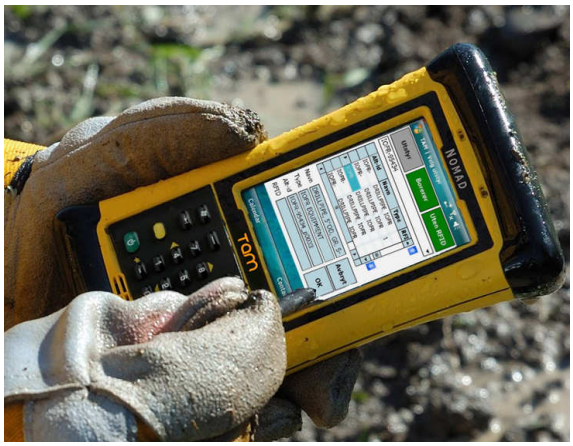

Figure 5 Ruggedized handheld computer with RFID reader. (Also available in ATEX zone 1).

Tubular Tally

The Tubular Tally module provides real-time automatic tally based on well centre RFID readings and rig measurements. Robust algorithms ensure correct tally even if tubular without tag should appear or if RFID reading should fail. The Tally can be monitored through an intuitive web interface, offshore as well as onshore, or in a 3rd party system through tally data exchange. All tally information can be exported to excel, word and pdf formats. The figure below shows the Tally user interface.

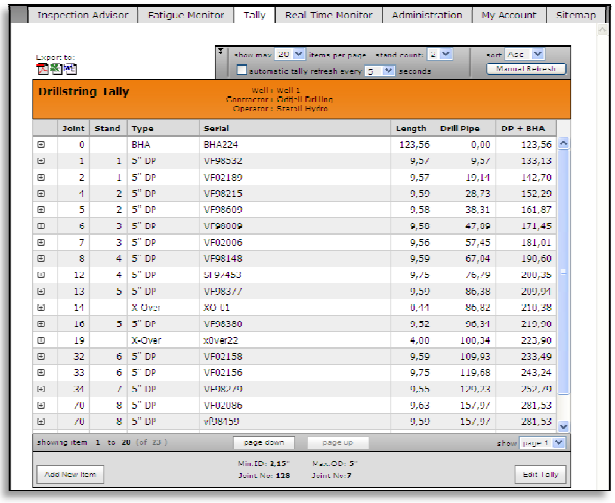

Figure 6Tubular Tally

Tubular Inspection Advisor

Based on time since last inspection, number of hours in well, number of rotations and estimated fatigue, the Tubular Inspection Advisor gives the operator valuable information for inspection management. All inspection information can be exported to excel, word and pdf. The figure below shows the Inspection Advisor user interface.

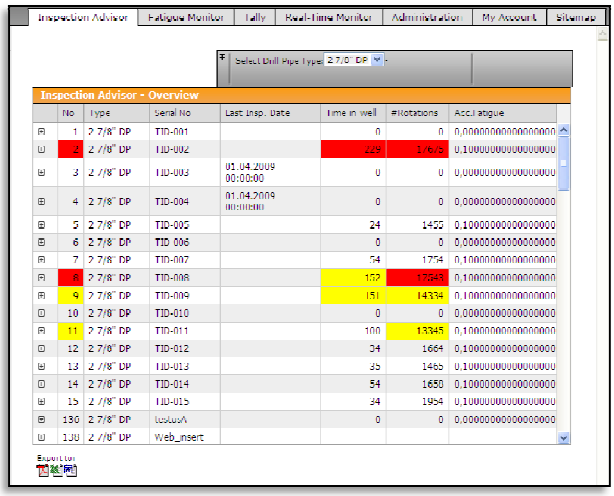

Figure 7 Tubular Inspection Advisor

The basic version includes advisory based on automatic accumulations of time since last inspection, number of hours in well and number of rotations. The advanced version includes advisory based on fatigue estimates and overload history.

Based on downhole logistics, well trajectory and geometry, and real-time rig measurements, bending forces for each individual drill pipe is estimated. Fatigue development is estimated and overload situations are detected. The models used are developed in collaboration with SINTEF, being a world leading competence centre in this area.

Tubular Logistics

The system provides real-time tracking of assets based on electronic identification. The figure below shows the graphical user interface for the logistics module.

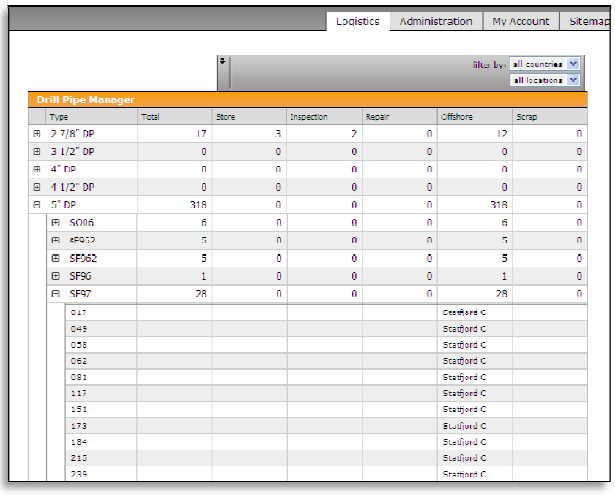

Figure 8Tubular Logistics

System integration
The DOTS system provides interfaces for process data as well as for enterprise systems integration. All DOTS logistics and quality information can be delivered to 3rd party systems.

A new standard for exchange of inspection data is proposed, including:

- Semantics based on the ISO15926 standard
- Syntax based on the WITSML standard
- Web service API

The DOTS system is capable of exchanging inspection data on the proposed format, enabling closer integration between the drill pipe owner, operator company and inspection provider.

Field Trials

The RFID technology has 10 years track record in downhole applications. Full scale onshore and offshore pilots has been executed the later years, demonstrating the potential of this technology. The figure below shows a tubular connection passing the rotary table, where the well centre reader antenna is located below.

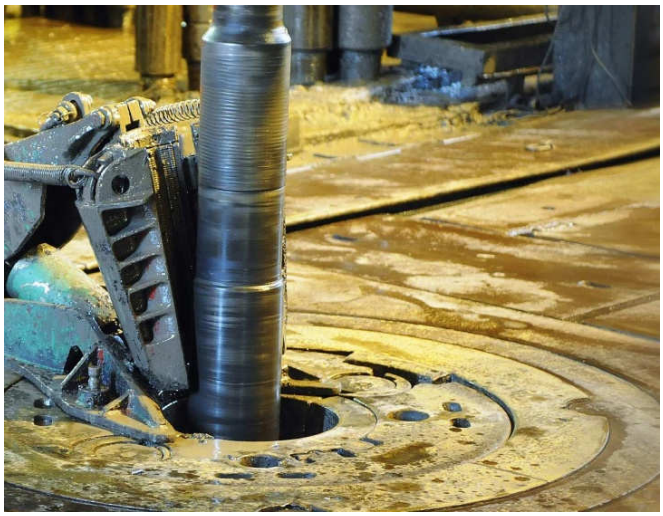

Figure 9 Drill pipe tooljoint passing through rotary table

Snorre B offshore pilot
The first full-scale offshore DOTS pilot was running at Snorre B on the Norwegian continental shelf in May 2008. 90 drill pipes were equipped with RFID tags and a well centre reader system installed on the drilling rig. The Trac server communicated with the Schlumberger Interact server by use of the WITSML protocol, generated automatic pipe tally and presented the tally offshore and onshore through internet.

The DOTS installation had minimal influence on the drilling operation and had 100% up-time. The system test was running for one month through 7 bit runs and the tag qualification programme lasted for 1 ½ year. All passages of drill pipes were read in the well centre reader system and no tags failed during 1 ½ year in operation.

Snorre B is now extending the pilot to cover a full drillstring and including both onshore and offshore tubular tracking.

Statfjord C offshore pilot
An "Automated Drilling Pilot" was running at Statfjord C in the Norwegian continental shelf for 4 months. StatoilHydro managed the pilot project, integrating 3 independent systems.

- DOTS – Trac ID Systems
- DRILLTRONICS – IRIS / National Oilwell Varco
- CMPF – Geo Services

The DOTS system produced an automatic drill pipe tally that was used in the DRILLTRONICS system for automation purpose. 307 drill pipes were equipped with RFID tags and a well centre reader system installed on the drilling rig. The Trac server communicated with the National Oilwell WITSML server and generated automatic pipe tally that was sent to the DRILLTRONICS system.

The installation had minimal influence on the drilling operation and the DOTS system had near 100% up-time. The system test was running for 4 months through several well sections. The system had excellent regularity in automatic tally generation and no reported tag failures.

Onshore warehousing – Independent Oil Tools
Independent Oil Tools, being a frontier in utilization of RFID technology in Oil & Gas, has tagged approx 6000 drill pipes and 2000 items of surface equipment. Their 10 years technology track record shows excellent tag reliability.

In 2006 Independent Oil Tools installed the Trac Asset Management system for onshore warehousing of Downhole and surface drilling equipment. The system included industrial handheld computers with RFID reader, wireless network on the yard, Trac warehousing server and integration to the existing enterprise logistics and maintenance system.

The system has been in daily use for two years, given access to ERP data on the yard, eliminated errors and given significant time savings during asset picking. Independent Oiltools is now extending the system to cover more of their processes.

Future extensions

The DOTS product line is now commercially available. However, Trac is continuously refining the system and extending the functionality within following areas:

- RFID tag for UHPUHT operations
- Extended reading distance enabling automatic identification in new locations. (Eg. Offshore pipe handling).
- Calibration and improvements of fatigue algorithms

Conclusions

Reports show that large costs are related to drillpipe failure caused by fatigue, wear and corrosion, and thus there is a great cost savings potential through (1) condition based maintenance, (2) reduction of operational errors and (3) closer integration between the players in the industry. Operators, drilling contractors, rental companies and inspection companies all share the benefits.

The industry's current focus on Integrated Operations, together with new technology and global standards for identification and data integration, enables full life cycle tracking and quality assurance for drillpipe and other downhole components.

Through extensive analysis, laboratory experiments, offshore verifications and stock yard implementation, the RFID technology has proven as a reliable tracking technology for drillpipe and other downhole components.

Drillpipe damage and fatigue life prediction are complicated issues and not fully understood. However, qualitative analysis is expected to give valuable information, and a Drilling Operations Tracking System will give an opportunity to extend the understanding of these phenomena.

Introduction of electronic identification may introduce new products and services beyond today's imagination, within planning, tracking, quality assurance and automation of the drilling process.

References

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[2] J Sampaio, J. Placido, and S Ferreira. Using radio frequency identification electronic chips to effectively control the elements of the drillstring. In *SPE Drilling and Completion*, New Orleans, 1998.

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