Oil & Natural Gas Projects
Exploration & Production Technologies

Very High-Speed Drill String Communications Network - Intellipipe(TM)

DE-FC26-01NT41229

Goal:
The goal is to lower the cost and improve the efficiency of drilling by increasing the speed and enhancing the reliability of data transmission between the bottom of the drill string and the surface. The objective is to further develop, refine, and commercialize a very high-speed method for transmitting data between the bottom of a drill string and the surface. This utilizes a unique method for transmitting data across a threaded tool joint.

Background:
The quest for high-speed data transmission has been a holy grail in the exploration and drilling disciplines since its inception. High-speed transmission is essential to evaluate the down-hole drilling environment, accurately characterize the formation being drilled, and precisely navigate well bores to targeted reservoirs in real time. Since 1939, technology has been proposed to provide data from down-hole to the surface. The technical barrier has been the couplings between the discrete pipe sections comprising the drill string.

For more than 60 years, the oil and gas industry has struggled with the problem of a drill pipe connection, or "tool joint", that would stand up to the wear and tear of hostile drilling conditions and operations, yet provide a reliable and rapid data transmission connection. Largely because of this stumbling block, in the mid 1970s developers turned to a technology called "mud pulse telemetry".

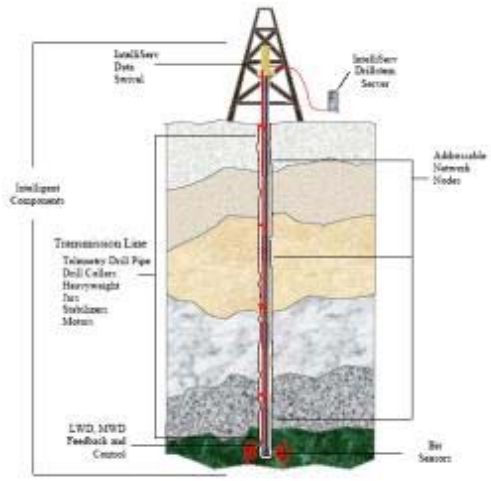
Data Link assembly which collects data from the rotating pipe during drilling operations

Mud pulse telemetry eliminates the need to hard wire pipe and electrical connections and transmits data as pressure pulses through fluid circulated to clean the cuttings out of the well bore. But the excruciatingly slow pace of mud pulse telemetry — 3 to 10 bits per second — often means that data resolution and tool reliability is so poor that the driller cannot make crucial decisions in real time. Often, time-consuming operations are required to retrieve the down-hole data, or drilling would have to stop while other procedures were employed to confirm the low-resolution data pulsed to the surface.

Additionally, underbalanced drilling (UBD) operations utilizing foams and gases cannot be used with the current mud pulsed system.

High-speed data transmission during drilling is a key enabling technology that has eluded the industry for years. The barrier has been bridging the tool joints connecting segments of drill pipe. The unreliability of electrical

connections at hundreds of these joints has prevented commercialization of data transmission systems. In 1997, Novatek, Inc. began development of a high-speed data system that can be used with segmented drill pipe (now called IntelliPipe®). Grant Prideco, a major drill pipe manufacturer, began working with Novatek on the data system in early 2000. This project is designed to accelerate development of this system and its demonstration in field tests, so that it can be offered commercially at the earliest possible date.



Schematic of IntelliServ Network

This project incorporated three phases, with go/no-go decision points between each phase. Phase I moved the system from a working bench model to a system ready for field-testing. Phase II extended the technology to full-length drill pipe systems and extended it from an unidirectional to a bidirectional communications system. Phase III involves an effort to commercialize the system.

The essential component of the IntelliPipe® system is the “milli-hop” telemetry system, where electrical conductors inside neighboring pipe segments are coupled electrically by a high efficiency, low power transmitter that sends data across each threaded drill pipe connection to the next segment. Electrical coupling is automatic as each tool joint is made up and the rig floor process is conserved since the wired pipe requires no special handling procedures.

Coupler with embedded electronics capable of data transfer of over one million bits per second

The milli-hop transmitter utilizes close-coupled inductive coils and magnetic field containment strategies to send the signal passively across a very small gap at high efficiency and low power. This design allows the inductive couplers to be sealed and protected against the non-ideal drilling environment. The couplers are embedded in the steel of the tool joint, in a protective groove machined in the secondary shoulder (in the case of Grant Prideco, in the eXtreme Torque® or double shouldered GPDS™ tool joint designs). This approach is simple, couples low power requirements with high bandwidth, and is transparent to conventional drilling operations.

The entire system (called the IntelliServ® network) includes: 1) the IntelliPipe®, powered addressable nodes placed in the system periodically (e.g., every 1,000-5,000 feet) to boost the signal, and if desired, to collect or process additional data, 2) a “data swivel” deployed just below the top drive (or above the kelly), which collects data from the rotating pipe during drilling operations, and 3) data collection tools (existing and new applications) and network hardware and software to control data flow.

The primary challenges facing this system include:

- developing a means of attaching and protecting a data cable within a variety of drill string elements, including elements that have dynamic geometrical features (such as drilling jars),
- optimizing the efficiency and robustness of the milli-hop connector,
- developing adequate electronic and software support to reliably drive the data network,
- developing interfaces between proprietary data collection tools, surface systems, and the network, and
- developing adequate manufacturing methods and tooling.

System design goals include operation of all components at 25 ksi total pressure and 200°C, as well as robustness of all components during normal pipe handling operations. Product optimization efforts have focused on robustness, developing cost effective manufacturing processes and minimizing downhole power requirements. Collaboration among system designers, the drill pipe manufacturer, and third party tool manufacturers has been essential.

Performers:
Novatek Engineering, Inc. – Project management and all research products
Grant Prideco – Industry commercialization partner

Location:
Provo, Utah 84606
Houston, Texas 77056
Woodlands, Texas 77380

Project Impacts:
Intelliserv is a company partnership between NOVETEK and Grant Prideco. Originally there were only five people working on this project at NOVETEK to develop a high speed network for drilling pipe to be used for increasing the efficiency of oil and gas drilling and exploration. A little more than four years after awarding the financial assistance to NOVATEK, Intelliserv employs over 115 people. IntelliServ expects to become a service company that services the entire oil and gas industry, with over $1billion in sales within 10 years, and employ thousands of people. The long term results of this success will be to more than double the proven reserves of oil and gas in the United States and world wide. No private or public oil and gas initiative has or will have this effect on our ability to increase the supplies of oil and gas in the U.S. and world wide. The oil and gas industry has needed this system for many years, but has yet to produce one because of fluctuations in the industry which prevented any long term technology effort from succeeding. Because of the large swings in the economics of the industry, the oil and gas industry has a very poor track record in bringing advanced technology to practice.

Accomplishments:

- Developed the basic elements necessary for a high-speed, drill string communication network capable of transmitting high-bandwidth downhole data through the use of a novel technology for sending data across tool joints,
- Manufactured several thousand feet of pipe incorporating these novel couplings and a high-speed data cable that runs the internal length of each joint, for testing and demonstration purposes,
- Developed a drilling jar capable of operating within the new system,
- Successfully demonstrated pipe and connection robustness and system data transfer capability in shallow wells,
- Successfully demonstrated system's bi-directional data rate of 2 Mbit/sec during drilling, reaming and cementing in 3000-ft and 4500-ft well field tests,
- Formed a company to serve as the sales and service entity to support commercialization of the technology, and
- Initiated testing in first of three commercial wells.

To date, the basic drill string elements necessary for a top-to-bottom high-speed network have been developed, including data swivels, drill pipe, heavyweight drill pipe, drill collars, a jar, and various electronics modules required for simple data collection functions and communication with existing tools. At present, work with five different tool manufacturers is ongoing to develop interfaces with measurement-while-drilling (MWD), logging-

while-drilling (LWD), and bit dynamics tools. Board-level (benchtop) testing and/or some shallow well testing of prototypes have been completed with three such interfaces. Hardware development to date has focused on two string sizes: 5 7/8-inch drill pipe, primarily used for premium offshore and extended reach drilling (ERD) applications, and five-inch drill pipe for a wider variety of applications. Approximately 9,000 feet of 5 7/8-inch pipe and 8,000 feet of five-inch pipe has been manufactured for laboratory and field-testing and demonstration. In addition 6 1/2-inch and eight-inch wired collars are available.

Lab testing of short strings of IntelliPipe® has been conducted in 100-feet and 1,000-feet test wells to determine the effectiveness and robustness of electronics modules, data cable, and data couplings under a variety of test conditions. Full-scale IntelliPipe® joints have been demonstrated in these tests to successfully transmit digital data error-free or at low bit error rates (without error correction) at raw data rates of two Mbit/sec. Coupling designs were successfully tested for make-up/break-out robustness over 100 full-torque cycles. Also, electronics modules left in the well for more than a month demonstrated that performance is only a function of battery life.

In addition to demonstration of robustness, laboratory testing of full-scale wired pipe has also served to quantify the transmission range of the system. A passive transmission range of up to one mile is projected with the latest transmission line design and with improvements to the dynamic range of present prototype electronic modules.

Novatek worked with a major jar manufacturer to develop a design that accommodates stroking of the jar, while maintaining a high speed data linkage. This design was successfully tested with 110 jar cycles, yielding no discernible change in transmission line characteristics before and after jarring.

More than 100 full-scale joints of 5 7/8-inch IntelliPipe® were successfully tested in a 4,500-foot well at the Rocky Mountain Oilfield Testing Center near Casper, Wyoming. This test included 10 joints of heavyweight drill pipe, 106 joints of normal weight drill pipe, and five IntelliLinks™ spaced in the string at approximately 1,000-foot intervals. Communication with the drillstring was established during drilling and reaming operations, totaling approximately 400 and 600 feet respectively. During this test, a simple bi-directional high-speed IntelliServ® network was demonstrated, with five IntelliLinks communicating at two Mbit/s raw data rate.

In a second major field test in a shallow directional well in Oklahoma, approximately 80 joints of IntelliPipe®, with two IntelliLinks positioned 1,500 feet apart in the string, were successfully used during drilling and cementing operations. A data rate of two Mbit/sec was achieved without any data errors for the duration of the two-day observation period.

Novatek and Grant Prideco have formed a company (IntelliServ, Inc.) to serve as the sales and service entity for the new system and its components. A primary function of IntelliServ will be to modify and assemble existing commercial drill pipe and other drillstem elements. In preparation for this function, specialized machinery capable of production-volume pipe modification has been built. Facilities have been acquired with sufficient laboratory and warehouse space to handle the remaining development work, as well as initial commercialization efforts.

Field testing in deep (>14,000 feet) Oklahoma gas wells are ongoing.

Current Status and Remaining Tasks:
Development efforts to improve the flexibility and capabilities of the IntelliServ drilling network software and hardware are continuing. A key area of focus is integration of several existing down-hole measurement and logging devices with the IntelliPipe hardware and network system.

Efforts remain underway to improve the passive transmission range of the system. The present system has demonstrated transmission over 1500 feet prior to needing a boost in signal level. Improvements to electronic module sensitivity are expected to bring as much as a three-fold increase in this range. Work is also underway to increase the high pressure and high temperature capabilities of IntelliPipe components and network electronics.

Intellipipe was deployed in a major operator's well during June 2004. Total footage of IntelliPipe and IntelliLinks was approximately 7,100 feet. Non wired drill pipe was deployed at the bottom of the well with the IntelliPipe at the top (total planned depth requires more drill pipe than is available in the wired IntelliPipe configuration).

This test is the first of a three-well test series. IntelliPipe and IntelliHeavyweight™ pipe will continue to be added to the string to increase total depth capability. A major service company is planning to deploy an MWD tool at the second well. This tool will be capable of transmitting real time data over the IntelliPipe string during drilling. Temperature limitations of the present electronics will limit the potential top to bottom communications depth to somewhere between 8000 and 11,000 ft. A higher-temperature (350°F) electronics package has been deployed in the fourth well. Commercialization is planned the second quarter of 2005.

Project Start: September 30, 2001
Project End: December 31, 2004

DOE Contribution: $4,200,000
Performer Contribution: $7,908,548

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Additional Information:
Revolutionary 'Smart' Drill Pipe Creates Downhole Internet - A U.S. Department of Energy-funded technology that establishes a "downhole Internet" for drilling oil and natural gas wells is now available for commercial use. - Techline May 16, 2006

Final Report [PDF-4765KB]

Program Factsheet - July 2005 - Smart Drill Pipe - Revolutionizing the Industry [PDF-792KB]

DOE-Funded "Smart" Drilling Prototype on Track for Commercialization - Techline Sept. 13, 2004

Intellipipe(TM) Technology: Wired for Speed & Durability (field test) - Techline June 5, 2003

Topical Report - Testing at RMOTC 2003 [PDF-362KB]

Pertinent Publications:
Nickle's Daily Oil Bulletin - Smart Drilling Prototype Reaches Milestone

Michael Jellison - Intelligent Drill Pipe Improves Drilling Efficiency, Enhances Well Safety and Provides Added Value

Drilling Contractor Magazine - IntelliPipe moving closer to commercial reality

American Oil and Gas Reporter - Telemetry Drill Pipe Opens New Possibilities in Drilling, Field Development

World Oil - Real real-time drill pipe telemetry: A step-change in drilling

GasTIPS - Very High-Speed Drill String Communications Network: An Enabling Technology SPE 80454 Intelligent Drill Pipe Creates the Drilling Network

Wired Magazine - Wiring the Wells

IADC/SPE 79885 Telemetry Drill Pipe: Enabling Technology for the Downhole Internet

Michael Jellison - Tubular Innovations Designed To Meet Demands of Deep, Challenging Applications

Oil and Gas Investor - Smarter Wells, Greater Rewards

SPE 74536 Telemetry Drill Pipe: Enabling Technology for the Downhole Internet

Offshore Magazine - New Drilling Data Transmission Technology

Oil & Gas Journal Online - SPE: Government, industry unveil new drill pipe telemetry test results