High Data Rate MWD Mud Pulse Telemetry

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Abstract

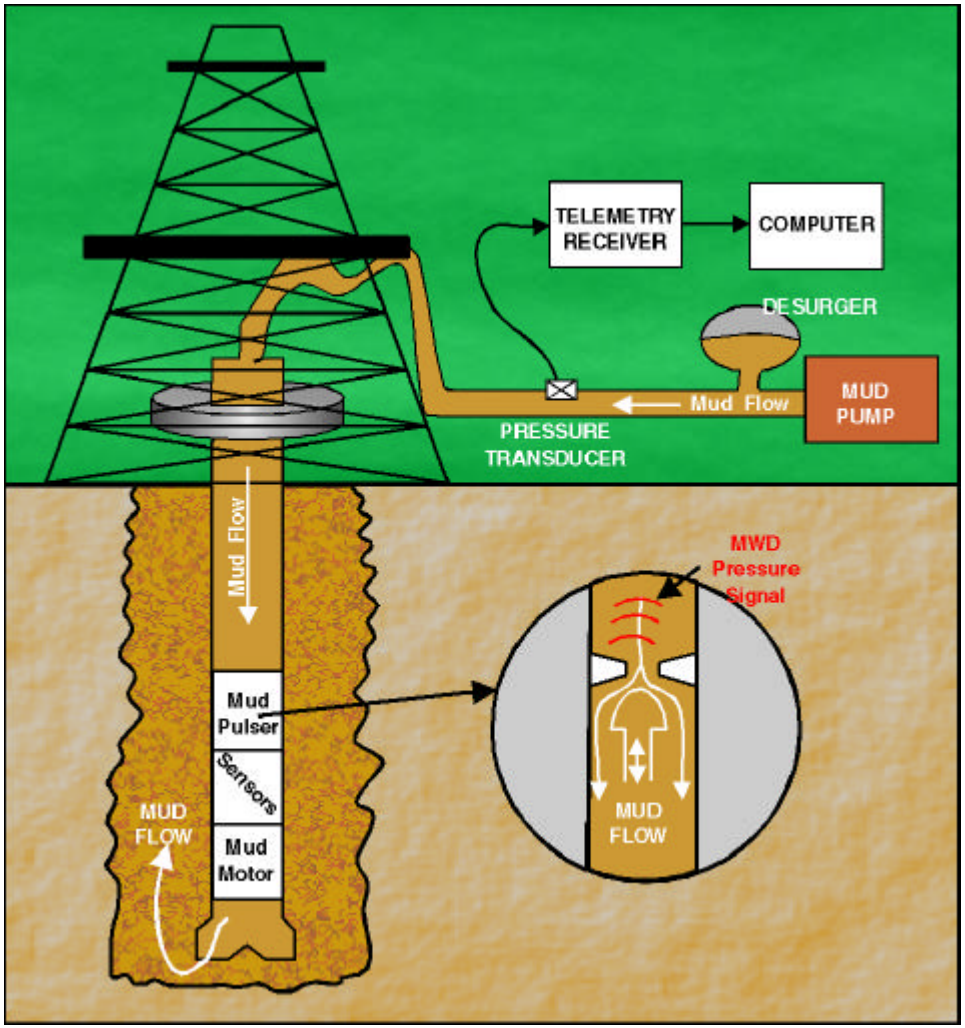
The objective of this project is to build and test a research prototype of a 20 to 30 bits/second MWD mud-pulse telemetry system. At current telemetry rates of 1 to 3 bits/second, the driller must be very selective about what drilling data is transmitted. This lack of information makes it more difficult to optimize the drilling of wells. Halliburton has demonstrated that a 30 bits/second mud-pulse can be recovered in a 10,000 foot flow loop.

HIGH DATA RATE MWD
MUD PULSE TELEMETRY

U.S. Department of Energy s
Natural Gas Conference
Houston, Texas
March 25, 1997

Wally Gardner
Halliburton Energy Services

MUD PULSE TELEMETRY SYSTEM



CURRENT MWD TELEMETRY

Mud Pulse (All Types)	**1-3 Bits/Sec**
Electromagnetic (in 1-5 ohm-m)	**1 Bits/Sec**
Acoustic	**Not Commercial**
Hard-Wired Drill Pipe	**Not Commercial**

Note: Data Compression, Not Included Above, Could Increase Data Rates an Additional 3x.

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PROJECT GOAL: 20-30 BITS/SEC

- Characterize Mud Pulse Transmission and Drilling Noise
- Develop Mud Pulsers for 20-30 Bits/Sec
- Develop Receivers and Advanced Signal Processing
- Demonstrate Working Pulser/Receiver System at 20-30 Bits/Sec

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WORK PLAN

Phase 0 **(Jun 94 - Jan 95)**

- Halliburton Research of Concepts
- Proved 30 bps is Possible

Phase 1 **(Jan 95 - July 97)**

- Present GRI/Halliburton Joint Project
- Build a Working 20-30 bps Pulser/Receiver

Phase 2 **(1998+)**

- Future GRI/Halliburton Joint Project
- Develop into a Commercial System

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PHASE 1: CURRENT PROJECT

- Major Tasks
  - Refine Pulser Concept Options
  - Collect and Analyze Drilling Noise Data
  - Develop Receiver and Signal Processing
  - Demonstrate 20-30 bps Transmission
- Enabling Technologies
  - Low-Power High-Rate Pulser
  - Knowledge of Mud Transmission Channel
  - Advanced Digital Signal Processing
  - Flow Loop for System Testing

WHERE WE ARE TODAY

- Two High-Rate, Low-Power Pulsers
- Acoustic Model of Mud Transmission Properties and Drilling Noise
- Tested Advanced Signal Processing Algorithms
- Transmitted and Received 30 bps in LSU and Houston Flow Loop, Processing Data from Memory
- Developing Real-Time Receiver & Algorithms
- Completed 11,000 ft Houston Flow Loop for System Testing
- Also Use 10,000 ft Flow Loop at LSU

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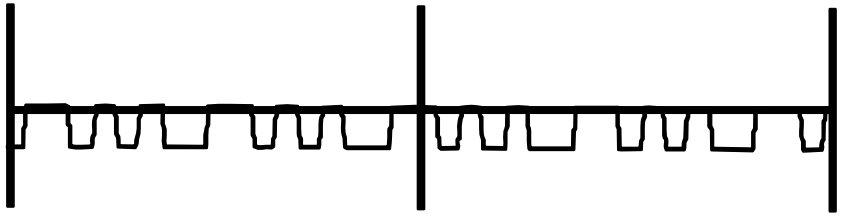
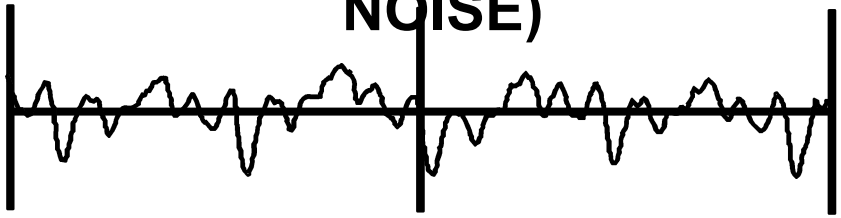
ADVANCED LWD TELEMETRY
30 BIT/SECOND DATA RATE TESTS

DOWNHOLE SIGNAL

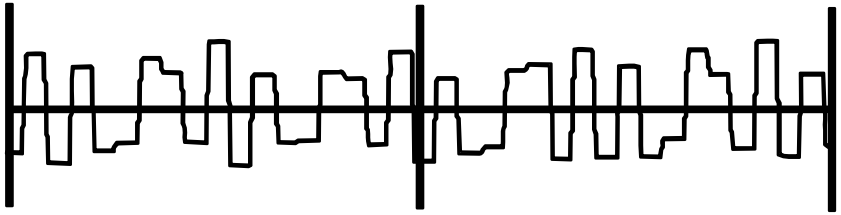


10,000 FT LSU FLOW LOOP

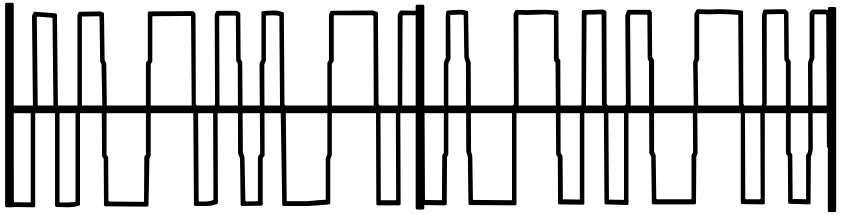
(12# MUD - NO DRILLING NOISE)



AFTER INTERMEDIATE SIGNAL PROCESSING



FINAL SIGNAL OUTPUT



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HOUSTON FLOW LOOP

Located at Halliburton s Houston Technology Center (West Houston)

11,000 ft, World s Longest MWD Flow Loop

3.5-in. OD, 3.1-in. ID Coiled Tubing

National Oil Well A-1100PT Triplex Pump

- 700 gpm at 1300 psi

Cost $125,000

- GRI Share $22,500

Construction Completed April 1996

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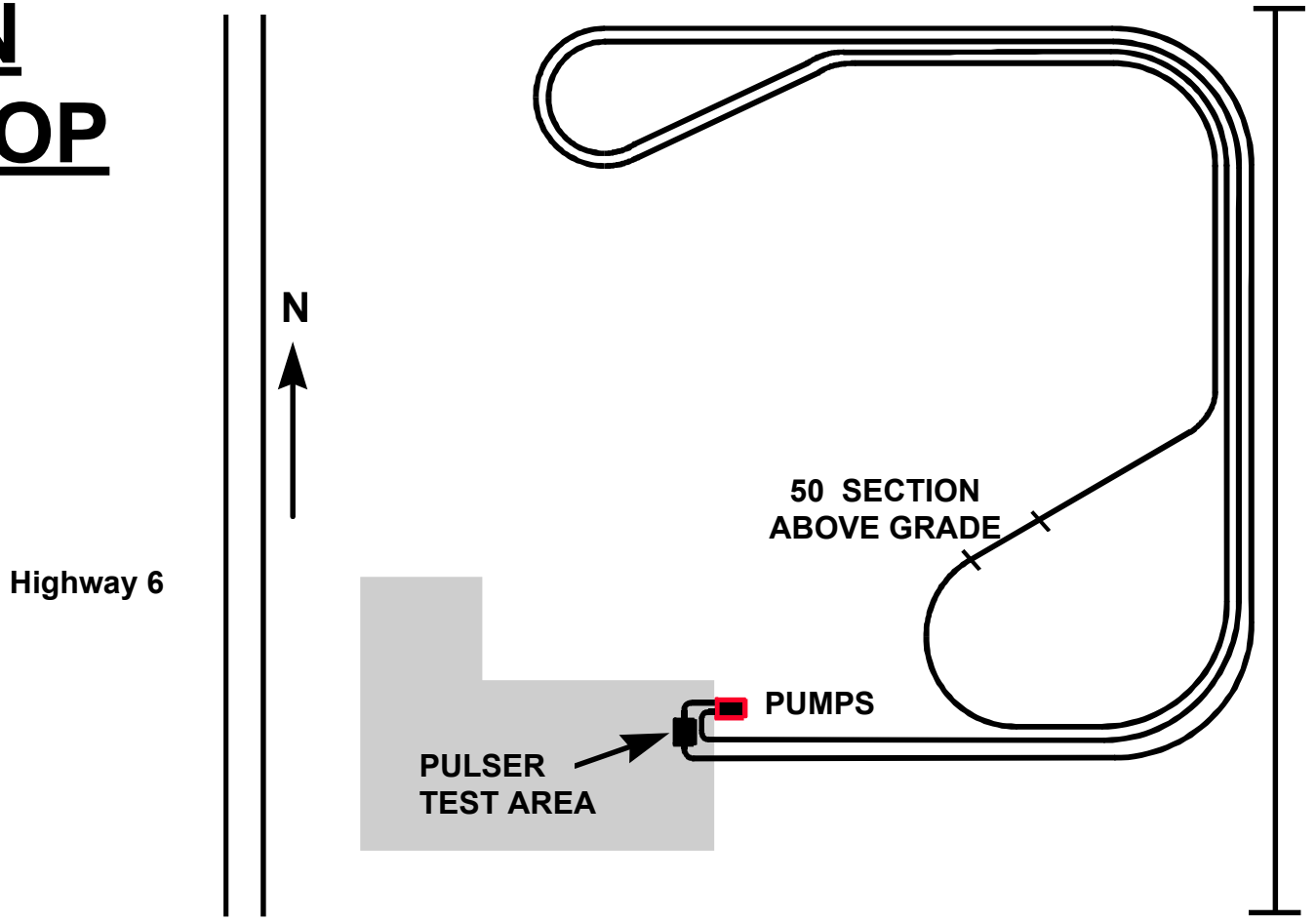
HOUSTON FLOW LOOP



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Halliburton Flow Loop Construction

Halliburton Flow Loop Construction

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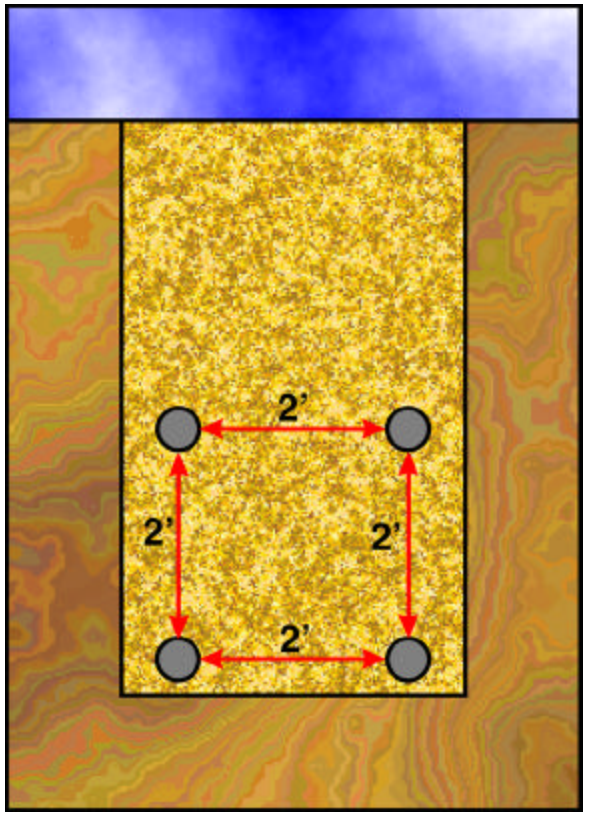
Halliburton Flow Loop Construction

Halliburton Flow Loop Construction



WHERE WE ARE GOING

- Test Alternate Pulsers
- Expect to Complete Research (Phase 1) in 1997
- Expect to Start Development (Phase 2) in 1998
- Flow Loop Testing of the Integrated System: Pulser/Receiver/Signal Processing Software

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BENEFITS TO GAS PRODUCERS

- Wireline Log Replacement
  - Benefit is Reduced Drilling Costs
- More Real-Time MWD Data
  - Better Pay Zone Steering, Drill More Productive Wells
  - Better Able to Drill Thin, Marginal Sands
  - Downhole Drilling Sensors Improve Drilling Decisions

WIRELINE LOGGING COSTS - 1995

Offshore

Logging Invoices	$ 450 million
Rig Time Cost	$ 200 million

Land

Logging Invoices	$ 720 million
Rig Time Costs	$ 130 million

LWD Can Eliminate the Rig Time Cost of WL Logs in Many Development Wells

Wireline Replacement in 25% of Offshore Wells Will Save Oil Companies $50 million/yr

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MORE REAL-TIME DATA

WL Cable Telemetry Rates Kept Up With Acquisition Rates:

	Acquired	Cable Telemetry
1970	50 bps	5 kbps
1980	200 bps	80 kbps
1985	20 kbps	120 kbps
1995	100 kbps	750 kbps
2000	350 kbps	1 mbps (est.)

Telemetry is Already a Major Limiting Factor in Application of MWD Technology (1-3 bps)

Currently Acquire Over 150 bps of MWD Data, Must Choose Which to Transmit

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BETTER PAY ZONE STEERING

- Data From Near/At-Bit Sensors Support the Steering of Boreholes into Thin Targets
  - Coupled with Horizontal Drilling, This Becomes an Enabling Technology
  - Makes Commercial Targets From Many BCF of Currently Marginal Gas Reservoirs
  - Higher Data Rates Provide More LWD Data, Better Decision Support at Rig
- Limited by Telemetry:
  - Imaging While Drilling
  - Magnetic Azimuth Corrections

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IMPROVED DRILLING

- At-Bit Sensors Enable Close Monitoring of the Drilling Process
  - Monitor Annulus Pressure
  - Detect Bit Stick & Whirl, Excessive Vibration
- Drilling Problems Add 30% to Total Drilling Cost of Typical Well
  - Potential to Reduce These by Just 10% by Early Detection by BHA Sensors
  - Reduction of Total Drilling Costs by 3%

BENEFITS TO MWD INDUSTRY

- Increased Use for Wireline Replacement
  - Every 5% Additional Replacement is an Additional $ 50 million/yr Revenue
- Increased Use of Additional Sensors
  - Resistivity-GR-Directional Has Become Standard
  - Value of Data is Partly Lost if Only Stored Due to Inadequate Telemetry
  - Expect 50% Increase in Use of Porosity & Other Sensors, Additional $ 25 million/yr
- Increased R&D Spending by MWD Industry
  - Increase of $75 Million in Revenue Will Result in Additional $5 Million/yr (6%)

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Available Logging Technology - 1960

Single Induction Electric/Short Normal/SP
Microlog
Single Laterolog
Density (uncompensated)
Neutron (uncompensated)
Sonic (uncompensated)
Gamma Ray
Caliper
Dip Meter (3-arm)
Percussion Cores

Total Data Acquired: 45 kb/1000 ft

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Available Logging Technology - 1970

Dual Induction Laterolog/SP
Microlog
Single Laterolog
Density (uncompensated)
Neutron (uncompensated)
Epithermal Neutron (uncompensated)
Sonic (compensated)
Gamma Ray
Caliper
Dip Meter (3-arm)
Formation Tester (samples only)
Percussion Sidewall Cores

Total Data Acquired: 51 kb/1000 ft

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Available Logging Technology - 1980

Dual Induction Focussed Laterolog/SP
Microlog
Dual Laterolog/MSFL
Density (with photoelectric measurement)
Neutron (compensated)
Epithermal Neutron (uncompensated)
Sonic (compensated or long-spaced)
Gamma Ray
Dip Meter (4-arm)
Dielectric Logging (high- and low-frequency)
Formation Tester (samples and pressures)
Percussion Sidewall Cores
Primitive Borehole Televiewers

Total Data Acquired: 160 kb/1000 ft

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Available Logging Technology - 1985

High Resolution Induction/Dual Induction Focussed Laterolog/SP
Microlog
Dual Laterolog/MSFL
Density (with compensated photoelectric measurement)
Neutron (compensated)
Epithermal Neutron (compensated)
Sonic (full waveform digital)
Spectral Gamma Ray
Dip Meter (6-arm)
Electric Resistivity Imaging (1-pad)
Dielectric Logging (high- and low-frequency)
Formation Tester (samples and pressures)
Rotary Sidewall Cores
Percussion Sidewall Cores
More Advanced Borehole Televiewers

Total Data Acquired: 3 Mb/1000 ft

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Available Logging Technology - 1993

High Resolution Induction/Dual Induction Focussed Laterolog/SP
Microlog
Dual Laterolog/MSFL
Density (with compensated photoelectric measurement)
Neutron (compensated)
Epithermal Neutron (compensated)
Sonic (full waveform digital)
Spectral Gamma Ray
Dip Meter (6-arm)
Electric Resistivity Imaging (6-pad)
Dielectric Logging (high- and low-frequency)
Formation Tester (samples and pressures)
Rotary Sidewall Cores
Percussion Sidewall Cores
Digital Borehole Televiewers

Total Data Acquired: 60 Mb/1000 ft

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