Autonomous Initiation Systems
Eliminating the Risks Associated with Downhole Conveyance

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AGENDA

- Autonomous Technology Overview
- Advantages of Autonomous Technology
- Risks Associated with Downhole Conveyance
- Introduction into Autonomous Initiation Systems (AIS)
- Obstacles of AIS Development
- AIS Testing
- Field Trials
- Future Applications of AIS
Autonomous Technology

Overview

Autonomous Technology can respond to real world conditions without human aid.
Autonomous Technology

Advantages

Safety
- Autonomous Technology mitigates the risks to people and the environment by reducing or eliminating human interaction and manpowered equipment.

Reliability
- Reliability is directly related to consistency. Inconsistencies between manpowered operations is the ultimate variable in reliable products and services.

Efficiency
- Autonomous Technology allows for faster and more consistent throughput.

Economics
- Faster and more reliable operations equals lower costs. Over time, the cost savings are exponential compared to man hours.
Downhole Conveyance for Well Completions

Risks

Safety
- Personnel exposed to high pressures, explosive operations and other hazards.

Reliability
- Areas of inconsistency include gun loading, arming, assembly, tool string lifting, winch control, pump control, etc.

Efficiency
- Wireline pump down speeds max out at ~600 ft/min due to downhole tool limitations.

Economics
- Inefficient operations lead to frac wait time.
- Fishing parted wireline could ruin the economics of the well completion.
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Introduction

Eliminate risks associated with downhole conveyance by implementing Autonomous Initiation Systems (AIS)

- AIS Tool consists of an electronics processing assembly, a CCL and the device which is to be initiated.

- Prior to deployment, the user will program the tool with a pipe tally, any marker depths and a parameter file so that the algorithm can keep track of where it is, determine velocities and initiate on depth.

- The tool contains redundant mechanical and electrical safety measures to ensure power cannot be supplied to the initiation device until the proper depth is reached.
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Developmental Obstacles - Retrieval

- To eliminate conveyance, retrieval has to be avoided.

- For certain applications, such as Plug and Abandonment, AIS tools can be left in the well.

- Perforating guns used in horizontal well completions would need to “disappear” upon initiation.
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Developmental Obstacles - Navigation

Counting Collars vs AIS

- Noise in the well was picked up as collars
- Difficulty distinguishing wellhead before "starting" collar count
- Limited speeds

AIS navigation simulation from vertical well test data
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Developmental Obstacles - Testing

1 mile long flow loop in Milford, TX USA
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Test Results

Flow loop
- Successful Navigation of the 5200+ foot flow loop with depth accuracy within 3 feet at speeds up to 1000 ft/min.
- Anomalies were placed on the outer diameter to ensure navigation system could distinguish noise from collars.
- Test AIS outfitted with sonic annunciators rather than energetics for external acoustic detection.
- Future testing includes AIS flow loop navigation at speeds up to 3000 ft/min.
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Test Results

Vertical Well
- Successful deployment in 140’ well with tethered tool.

Simulated Well
- Use flow loop data to ensure accuracy at speeds up to 3000 ft/min.
- Introduce anomalies to ensure navigation algorithm performed correctly.

AIS firing simulation from flow loop test data
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Field Trials

**Autonomous Perforating Gun**
- First field trial scheduled in late Q2 2018
- Vertical well with 8000 ft of 3.5” tubing
- Multiple deployments of 2.5” Autonomous Perforating Guns containing circulating charges to punch tubing
- Fish tools after each run followed by Caliper log to determine accuracy

**Autonomous Cutter**
- First field trial scheduled in late Q4 2018
- 2.5” tool to cut 3.5” tubing
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**Future Applications**

**P&A Tools**
- Non-frangible, non-retrievable
- Guns, plugs, severing tools and cutters
- Plug and Cut simultaneously

**Perforating**
- Frangible AIS guns for vertical and horizontal wells

“Plug and Perf”
- Frangible AIS for horizontal stage work
- Zonal isolation devices such as plugs or pods
- Selective Fire Perforating systems
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Conclusion

- Autonomous Initiation Systems (AIS) will allow perforating guns, plugs, cutters and other initiated devices to be deployed into the well without the need for conveyance.

- AIS will reduce personnel, equipment and overall footprint.

- Reliability will increase as human inconsistencies are removed from the equation.

- AIS will take minutes rather than hours to accurately perform a perforating stage.