



Solid-State Gyro Technology Allows Safe and Reliable Real-time Remote Operations

(Based on SPE-205870-MS)

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Content

- Background on gyro technology
- Tool verification process
- Uncrewed operations
- Increased Automation
- Case Studies
- Conclusion

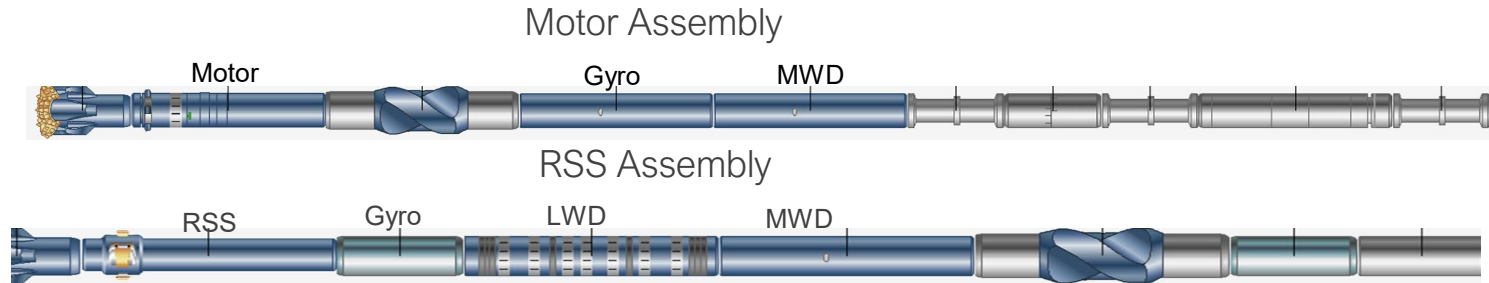
Gyro Sensors - Background

Post-drilling surveys

- The gyro is not part of the BHA
- Wireline
- Memory (drop or slickline)

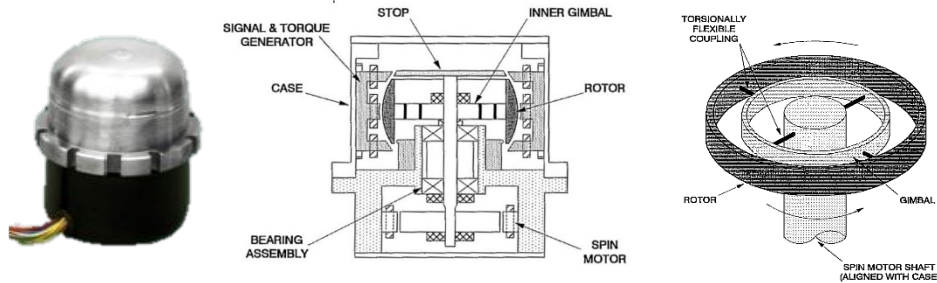
“Real-time” drilling surveys

- The gyro survey tool is part of the BHA
- Closer to the bit
- Independent survey data
- Uncertainty reduction



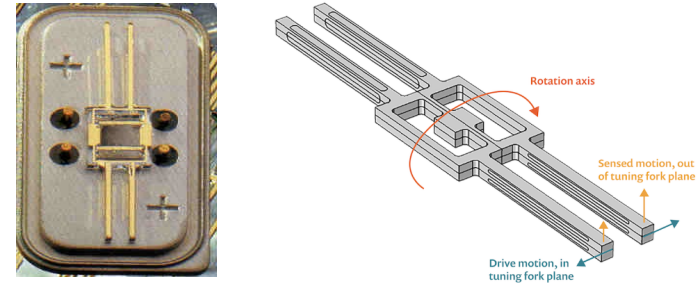
Gyro Sensors

Dry Tuned Gyroscope (DTG)



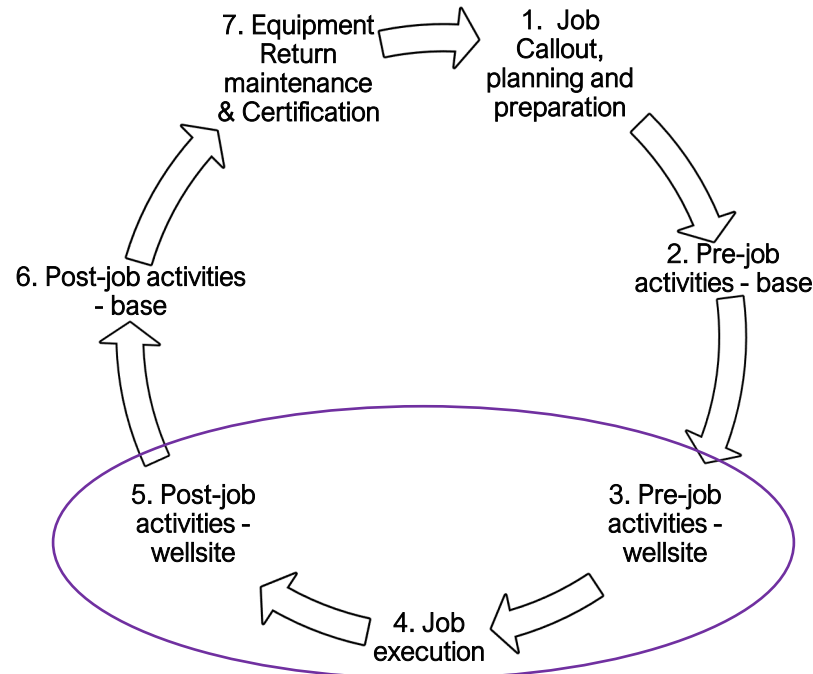
- Very low noise
- Fragile (8G's rms Vibration)
- Very complex (~16ft tool)
- High power consumption
- Spin-up time required (~30 sec)

Solid State Gyroscope

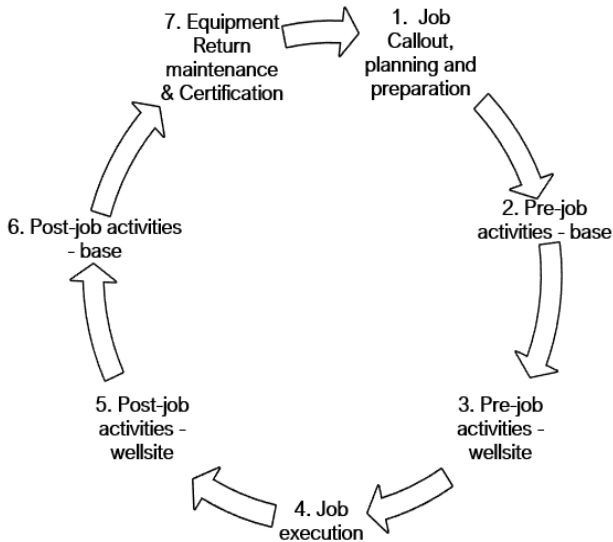


- Low noise
- Robust (20G's rms Vibration)
- Simple (~3ft tool)
- Very low power consumption
- No spin-up time

Tool Verification Process



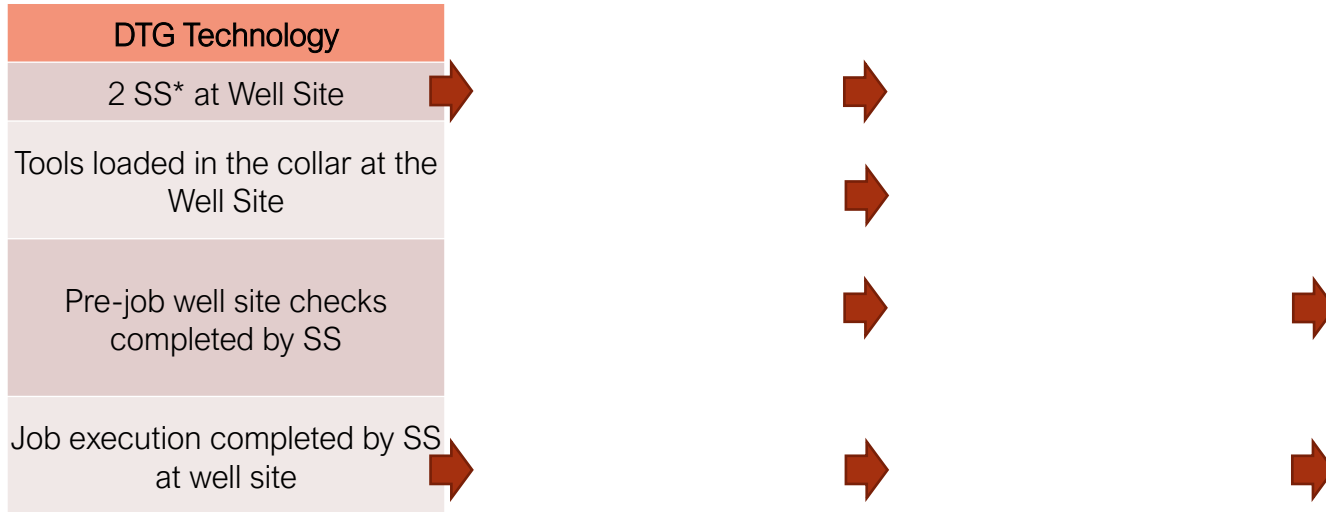
Tool Verification Process



Activity	DTG	Solid-state
1. Job Callout, Planning & Preparation	3 hrs	3 hrs
2. Pre-job Activities - Base	11.5 hrs	9 hrs
3. Pre-job Activities Well site	15 hrs	3 hrs
4. Job Execution – survey time	2m20sec - 3min35sec	2min
5. Post-job Activities – Well Site	7 hrs	1 hrs
6. Post-job Activities – Base	13 hrs	10 hrs
7. Equipment Maintenance / Recertification	10 hrs	3 hrs

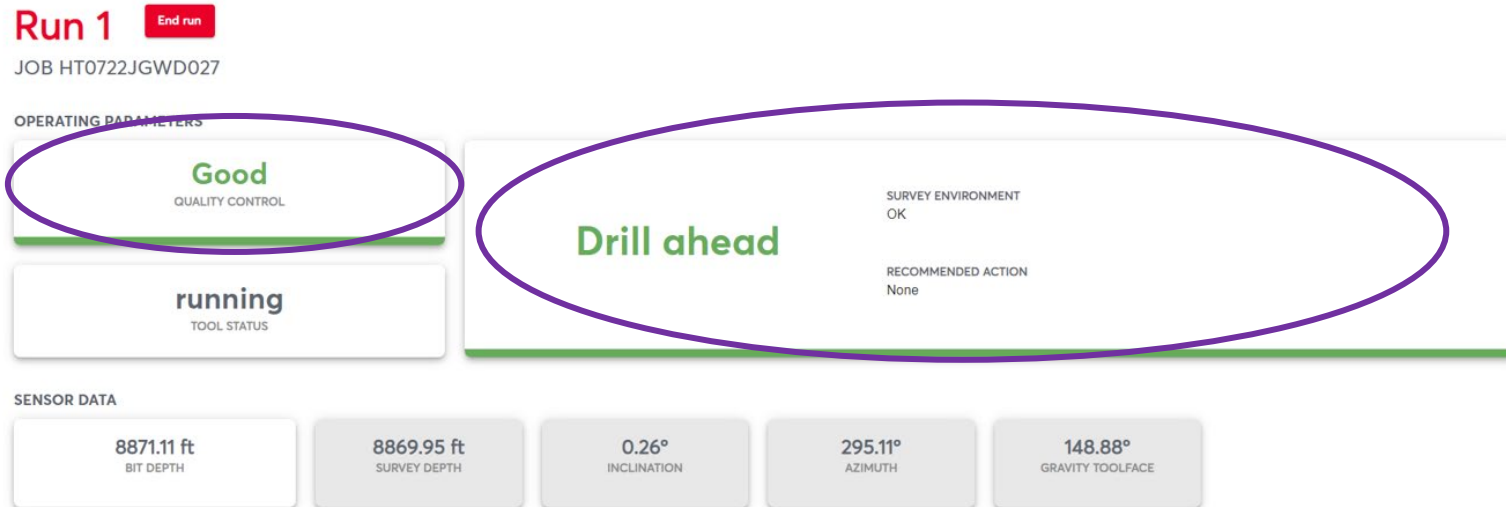


Uncrewed Operations



Survey Automation

Auto-decode of survey data means no intervention required from RMC and minimal training required for 3rd party monitoring



Run 1 End run

JOB HT0722JGWD027

OPERATING PARAMETERS

Good
QUALITY CONTROL

running
TOOL STATUS

Drill ahead

SURVEY ENVIRONMENT
OK

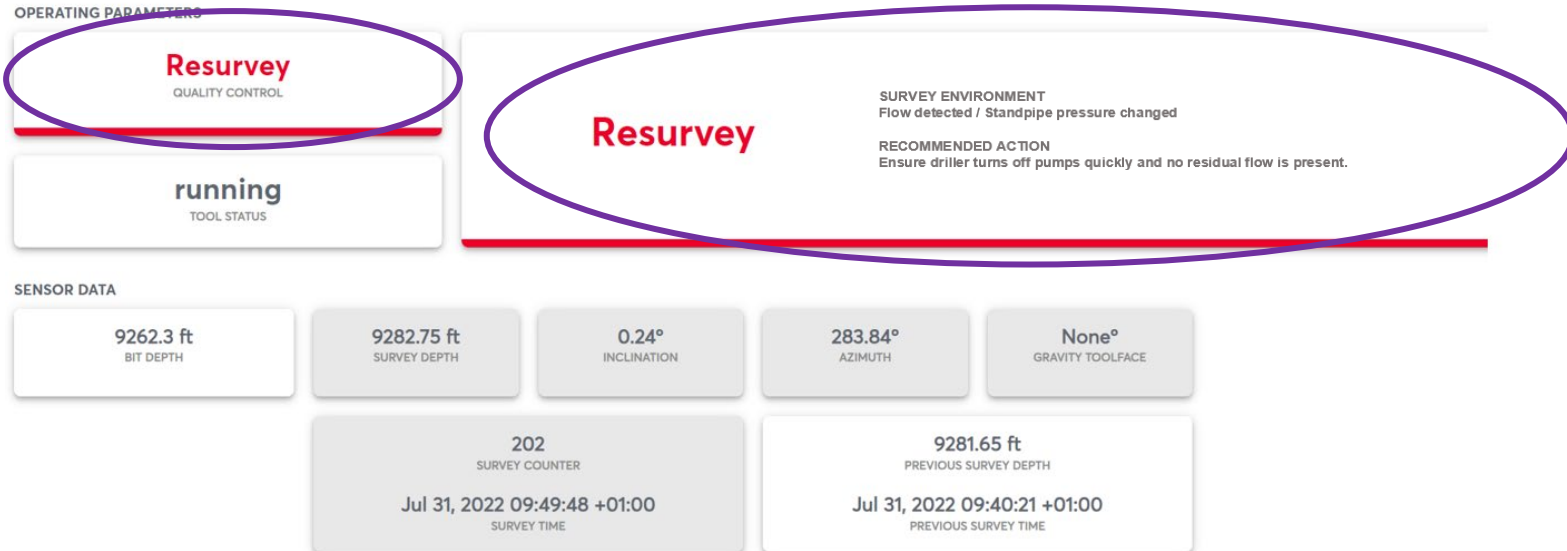
RECOMMENDED ACTION
None

SENSOR DATA

8871.11 ft BIT DEPTH	8869.95 ft SURVEY DEPTH	0.26° INCLINATION	295.11° AZIMUTH	148.88° GRAVITY TOOLFACE
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Survey Automation - Troubleshooting

Interrogation of additional data in the WITSML feed allows basic troubleshooting and recommended actions to be generated when surveys fail QC.



The screenshot displays a survey automation interface with the following components:

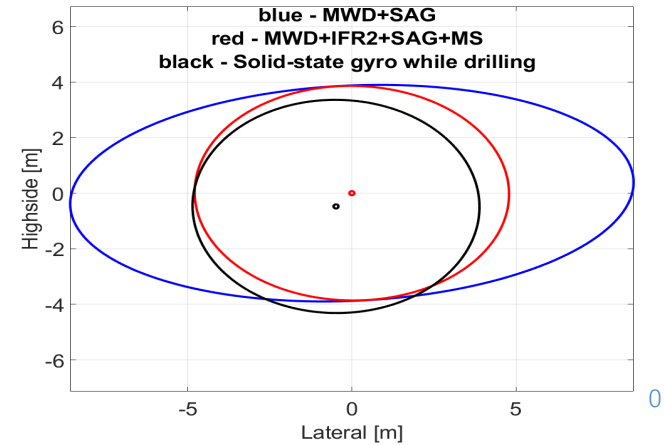
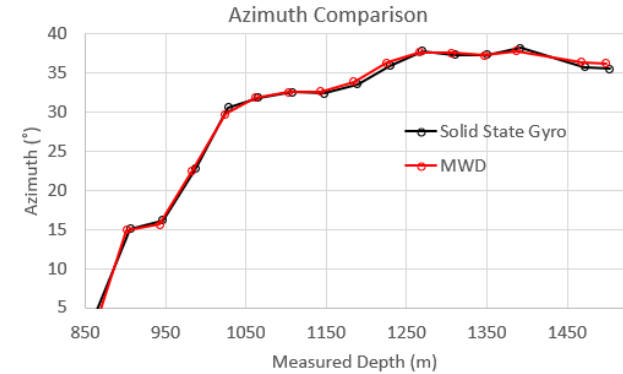
- OPERATING PARAMETERS:**
 - Resurvey** (Quality Control): A red box with a purple oval around it, indicating a failed quality control check.
 - running** (Tool Status): A white box with a red horizontal line below it, indicating the tool is running.
- Resurvey** (Status): A large red box with a purple oval around it, indicating a resurvey is required.
- SURVEY ENVIRONMENT:** Flow detected / Standpipe pressure changed
- RECOMMENDED ACTION:** Ensure driller turns off pumps quickly and no residual flow is present.
- SENSOR DATA:**
 - 9262.3 ft (Bit Depth)
 - 9282.75 ft (Survey Depth)
 - 0.24° (Inclination)
 - 283.84° (Azimuth)
 - None° (Gravity Toolface)
 - 202 (Survey Counter)
 - 9281.65 ft (Previous Survey Depth)
 - Jul 31, 2022 09:49:48 +01:00 (Survey Time)
 - Jul 31, 2022 09:40:21 +01:00 (Previous Survey Time)

Case Study I

- Jack-up - 16" hole section
- Phase II uncrewed operations.
- North Sea – Norwegian sector
- Expected magnetic interference from 550 to 850 mts.
- Inclination: 5 to 27 deg.

Benefits of the solid-state GWD:

- Seamless drilling in area of magnetic interference
- Rig-time saving of 30 minutes
- Independent validation of MWD data

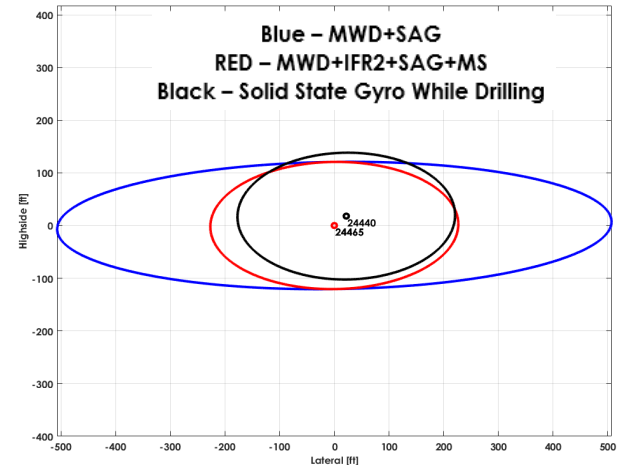
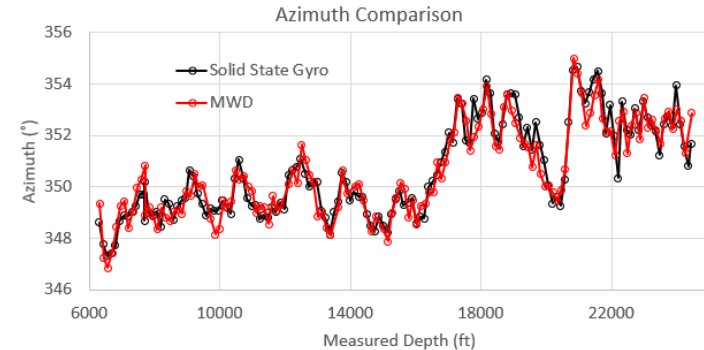


Case Study II

- Jack-up – 12.25” hole section
- Phase II uncrewed operations.
- North Sea –UK sector
- No expected magnetic interference
- Inclination: 68 to 71 deg.

Benefits of the solid-state GWD:

- MWD & Solid state GWD surveys over 18,000 ft section combined to produce reduced EOU making hitting geological target achievable.



Uncrewed Operations – Environmental Benefits Summary

Remote Operations

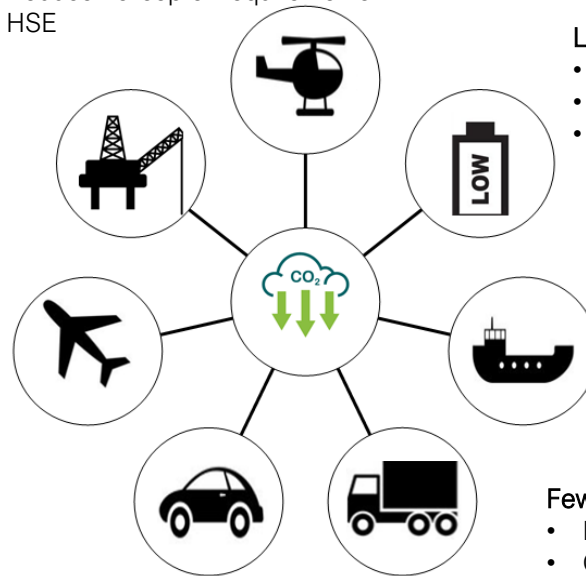
- Engineer not travelling Offshore
- Ease POB constraints & costs
- Reduce helicopter requirements
- HSE

Reduced Rig Operational impact

- Reduced Crane Operations
- Reduced Footprint On Rig
- Reduced BHA handling
- Testing /verification onshore

Engineer Travel

- Remote Operations reducing domestic & International travel



Lower Power Consumption

- Reduced Battery Consumption
- Reduced Environmental Impact
- Enabling Remote Operations

Reduced / Lighter Shipments

- Smaller shipping boxes
- Loaded out in collar no container
- Shortened collar required

Fewer Shipments

- Maintenance frequency reduced
- Calibration frequency reduced



Conclusion

- Solid state technology contains a number of benefits over spinning mass gyros to enable remote monitoring
 - Lower power consumption
 - Increased shock tolerance
 - No shift in calibration
 - No requirement for real time or post run correction
 - Simplified testing and QC
- High levels of automation are achievable allowing tools to be run by 3rd parties with minimum training requirements.



Acknowledgements

- Thanks to co-authors Adrian Ledroz (Gyrodatta) and Navin Maraj (Halliburton).