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

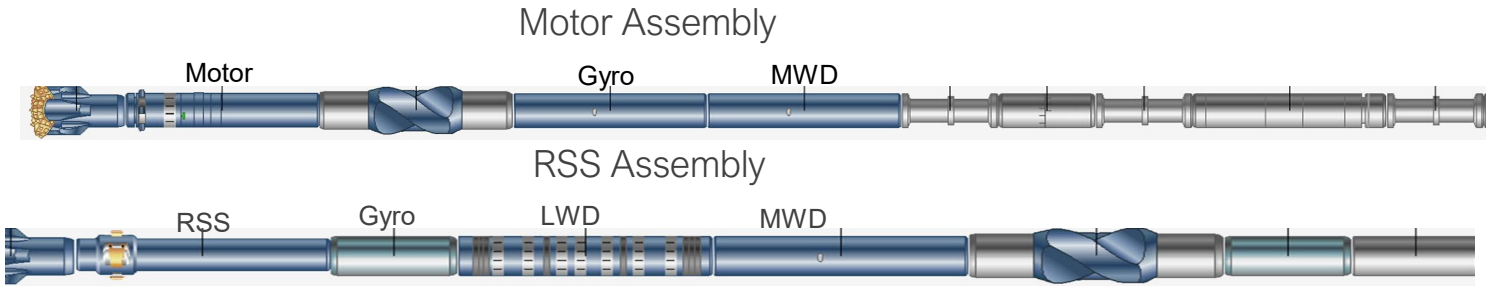
Gyro Sensors - Background

Post-drilling surveys

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

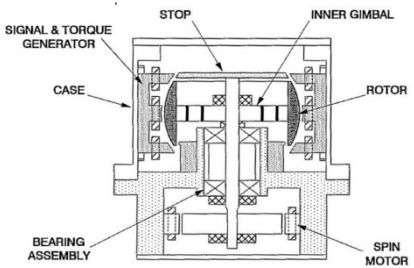
“Real-time” drilling surveys

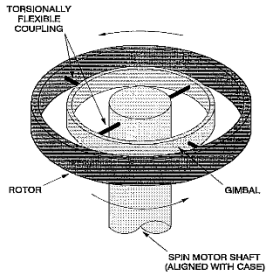
- The gyro survey tool is part of the BHA
- Closer to the bit
- Independent survey data
- Uncertainty reduction



Gyro Sensors

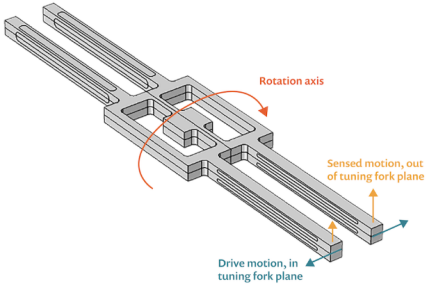
Dry Tuned Gyroscope (DTG)





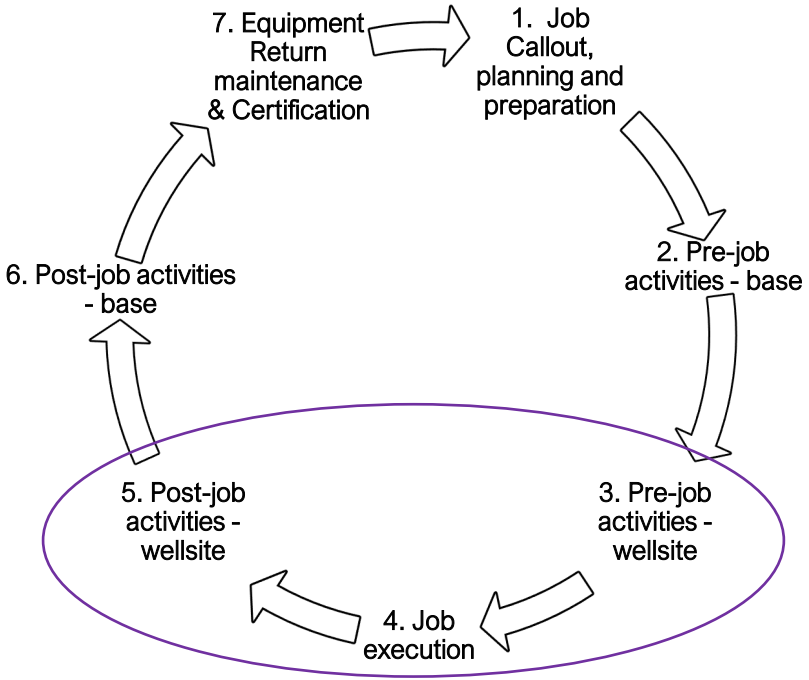
- Very low noise
- Fragile (8G's rms Vibration)
- Very complex (~16ft tool)
- High power consumption
- Spin-up time required (~30 sec)

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

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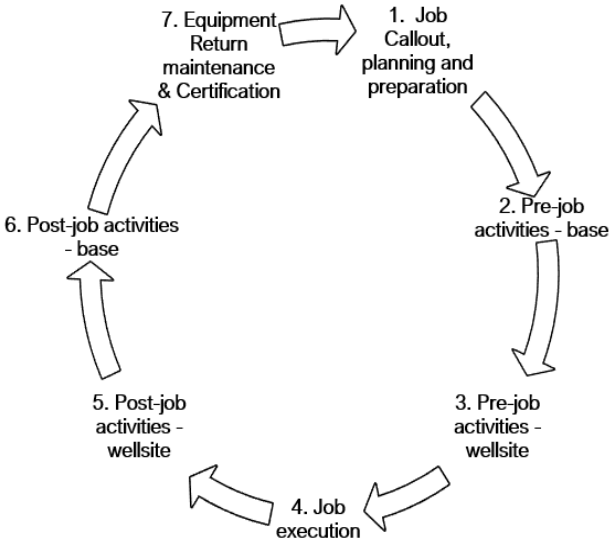
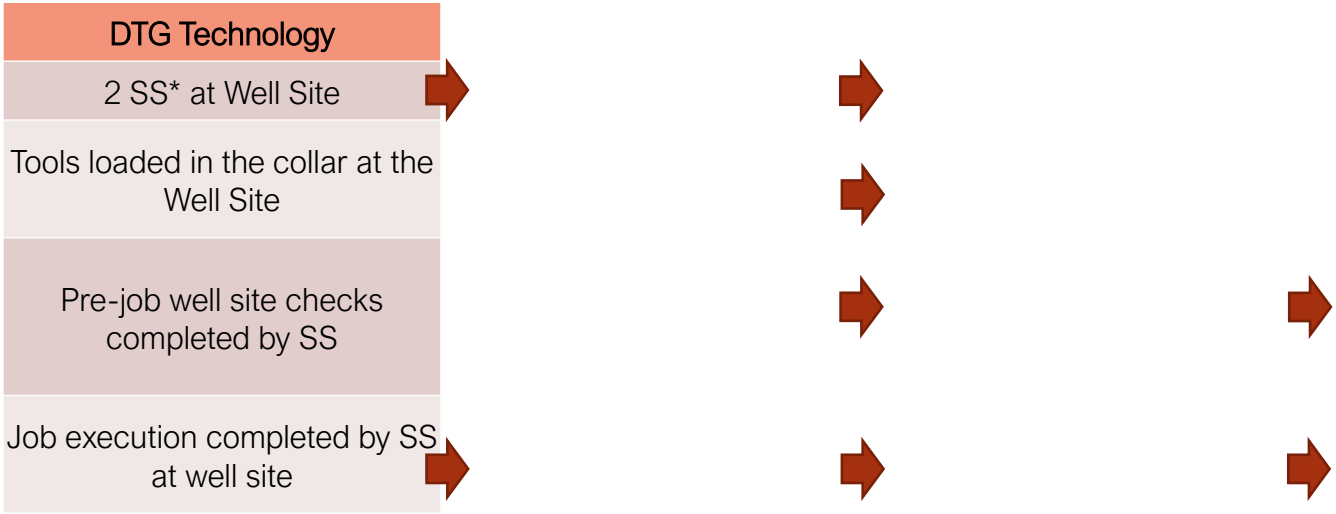


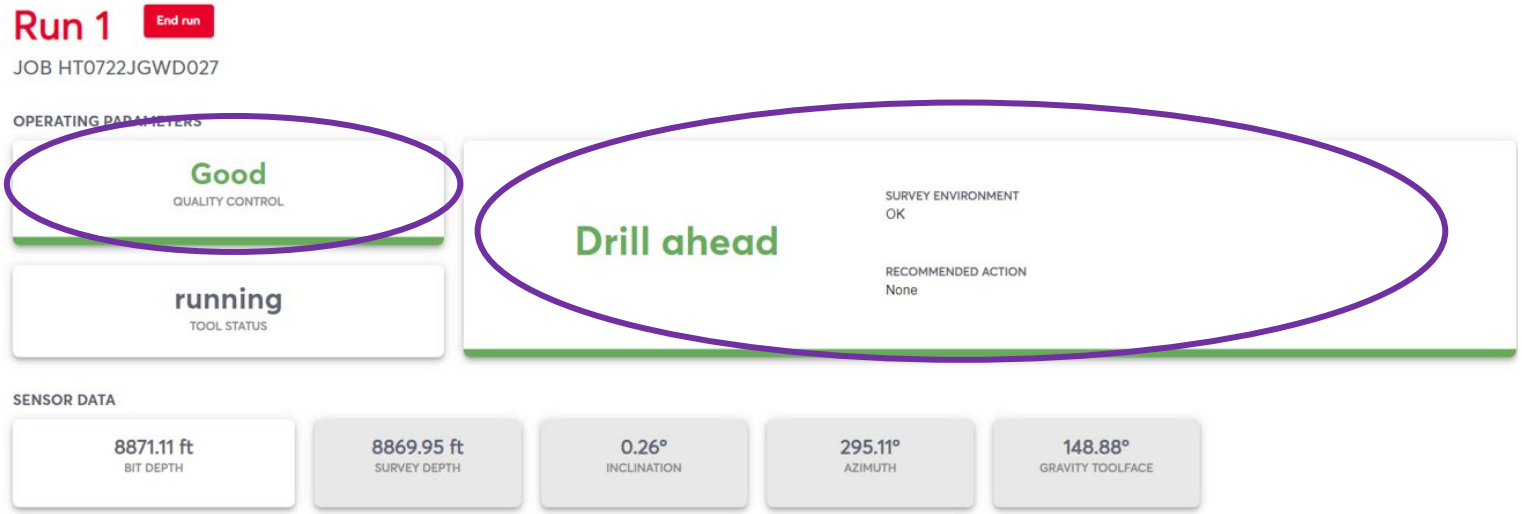
Activity	DTG	Solid-state
1. Job Callout, Planning & Preparation	3 hrs	3 hrs
2. Pre-job Activities - Base	11.5 hrs	9 hrs
3. Pre-job Activities Well site	15 hrs	3 hrs
4. Job Execution – survey time	2m20sec - 3min35sec	2min
5. Post-job Activities – Well Site	7 hrs	1 hrs
6. Post-job Activities – Base	13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



Survey Automation - Troubleshooting

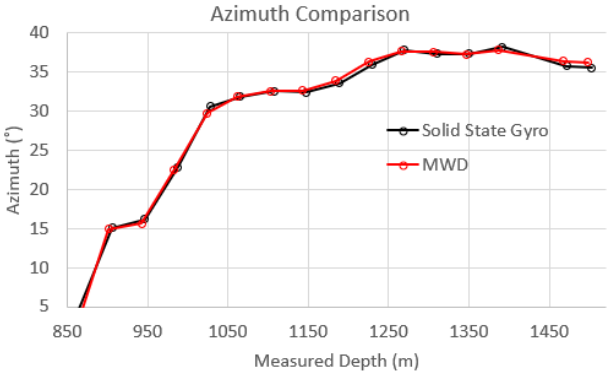
Interrogation of additional data in the WITSML feed allows basic troubleshooting and recommended actions to be generated when surveys fail QC.

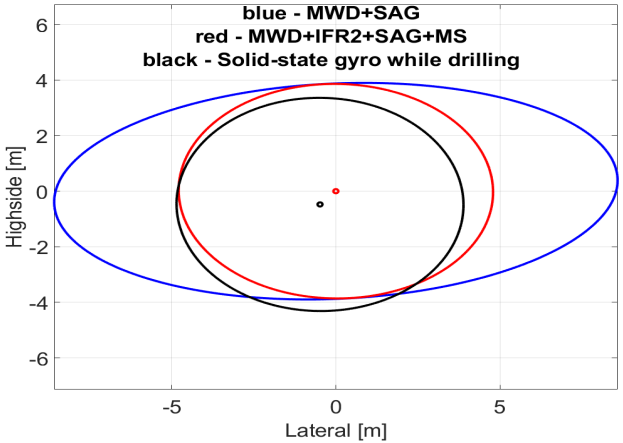
Case Study I

- 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:

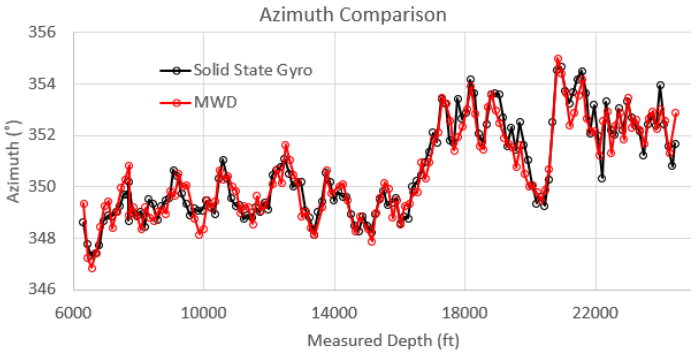
- Seamless drilling in area of magnetic interference
- Rig-time saving of 30 minutes
- Independent validation of MWD data





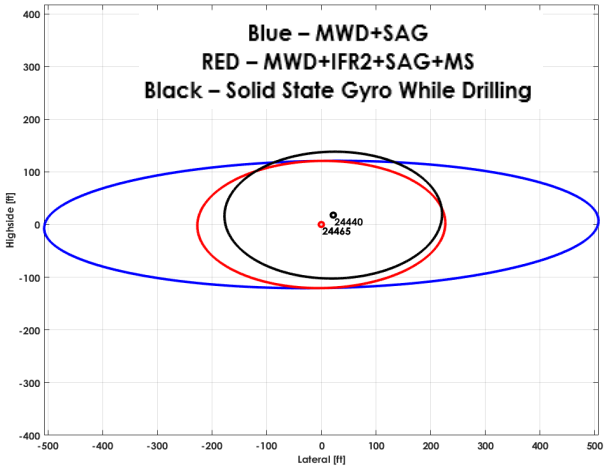
Case Study II

- 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.

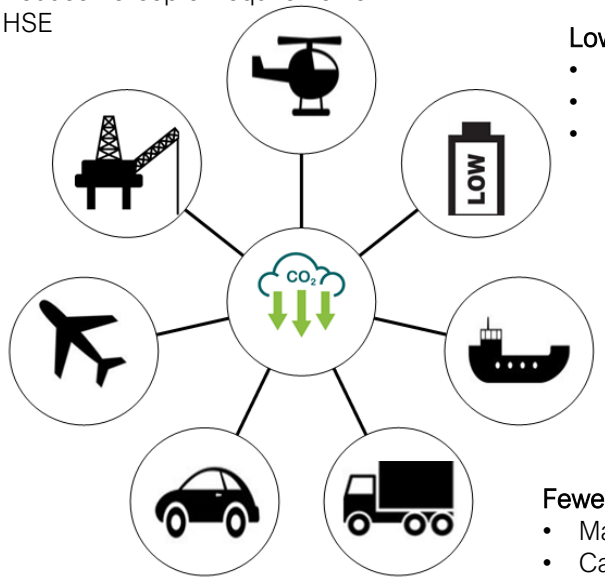


Uncrewed Operations – Environmental Benefits Summary

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

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

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



Reduced / Lighter Shipments
- Smaller shipping boxes
- Loaded out in collar no container
- Shortened collar required

Engineer Travel
- Remote Operations reducing domestic & International travel

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

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