UTECE Survey
Pipeline Inspection Using Low Logistic AUV
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Product Line Manager
GLOBAL FOOTPRINT

UTEC has offices across most of the major oil & gas producing regions worldwide.
Recognised branded service providers, aligned across four expert capabilities

Acteon Group of Companies

Survey, Monitoring and Data
- Clarus
- J2 Subsea
- Pulse
- Seatronics
- UTEC

Risers and Moorings
- 2H Offshore
- Claxton
- INTERMOOR
- PROBE Oil Tools
- SRP

Seabed Foundation Technologies
- Core Grouting Services
- LM Handling
- MENCK

Project Support Services
- Aquatic
- InterAct
- Mirage
- OIS
- TEAM

Please note: Acteon’s branded services each align with one lead capability, but this does not preclude offering additional services according to customer need. The segments highlight a primary activity driver, but are not mutually exclusive.
Introduction

• UTEC operates the largest fleet of low logistics AUV in the world with over 50 projects completed on six continents.

• Today we will focus on a subsea inspection project carried out in Australia in July 2014.

• UTEC’s client was Quadrant Energy.
  • 43 pipelines of total length 571km.
  • 20 platform site surveys.
  • Carried out using two Teledyne-Gavia AUVs.
  • Deployed from support vessel MV Yardie Creek.
• All Varanus Island hub subsea facilities and platforms.
• Stag and Reindeer fields.
• Sales Gas pipeline to the mainland.
• 43 pipelines, 20 platform and structures.
• Water depths – 0 to 110 metres
• UTEC owns and operates a fleet of seven Gavia AUVs.
• Operating depth range from <2m to 1,000m.
• Small footprint - < 3m long; < 120kg with compact spread layout
• Low logistics – Modular and easy to ship via air freight, mission configurable, small on-deck footprint, lightweight for launch and recovery.
Project AUV Configuration

- Camera & Obstacle Avoidance Sonar
- INS/DVL navigation
- 1800kHz & 900kHz high resolution SSS
- Interferometric multi-beam bathymetry (500kHz)
- LBL/USBL Acoustic Comms
- DGPS navigation
- Twin battery pack configuration for long duration mission capability
- Propulsion Module
- SBP Module Not Shown

Twin battery pack configuration for long duration mission capability.
Support Vessel - MV Yardie Creek

- 34m LOA Multi-Purpose Vessel.
- 2.2m draft.
- Large back deck.
- 6 tonne A-frame.
- Hiab deck crane.
- 21 berths.
- Large survey room.
- 5.8m rigid-hulled inflatable boat.
Launch and Recovery

- Stern launched using winch and A-frame in deeper water.
- Manually deployed from the RHIB in shallow water.
- Used RHIB as standard recovery method – manual lift into custom chocks in the RHIB, then AUV lifted by vessel crane to deck.
- In marginal weather, RHIB would tow AUV to stern and place it in purpose-built lifting cradle for A-frame recovery – four occasions
Field Operations

• Our AUV capability is global with Centres of Excellence in Houston and Aberdeen – completed 50 projects on six continents.

• We have encountered challenges and learned from these.

• Our first AUV job in Australia – drew on that expertise and applied the global learning.

• The people were the catalyst for the success of the project.

• Nine man team drawn from global UTEC AUV pool:

<table>
<thead>
<tr>
<th>1 x Party Chief</th>
<th>1 x Data Processor</th>
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<tbody>
<tr>
<td>3 x AUV Operators</td>
<td>1 x Geophysicist</td>
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<tr>
<td>1 x AUV Engineer</td>
<td>2 x Online Surveyors</td>
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Health, Safety and Environment

- Total Operational Man Hours = 3,408.
- No injuries to any marine, AUV or survey personnel.
- No Environmental Incidents.
- No Asset Damage.
- No Near Misses during operations.
- Risk Assessments / Job Safety Analyses completed and reviewed daily.
- Safety Briefings / Drills = 53.
- Tool Box Talks = 45.
• 27 day project averaging 45km of AUV line survey per day.

• Average includes non-productive time - weather, transits, calibrations and equipment downtime.

• Set a new UTEC record on July 11th with 80.5 line km of survey.

• Surveyed a total of 1,142 line km on pipelines plus 20 platform and structure site surveys.
Key to Productivity

• UTEC used two AUVs ‘back-to-back’ for the first time.
  • While one AUV was deployed the other was readied for its mission.
  • Each mission duration was between 5 and 6 hours.
• Reduced the on-deck turnaround time from >2 hours for single vehicle ops to <1 hour, which included data download, battery change-out, INS re-alignment.
• The increase in productivity more than offset additional costs.
• Productivity approached that of larger, more expensive AUVs which offer longer mission time due to battery capacity.
Platform Site Surveys:

- Greatest risk in AUV missions – surfacing under a platform, colliding with platform legs or subsea structures.
- Ran high altitude reconnaissance missions to identify hazards.
- Gained understanding of speed and direction of currents.
- Turned down sensitivity of object avoidance sonar to reduce number of aborted missions due to extensive marine life (fish) under platforms.
Challenges Faced (2)

Shallow Water – Near Shore:

• Several pipelines terminated at Varanus Island or mainland.
• Scope called for surveying as near to shore as possible.
• RHIB enabled us to get very close to shore while vessel stayed in deeper water.
• Missions planned to coincide with peaks of high tide.
• Ran AUV on surface at ½ speed.
• Successfully collected high quality data in water depths of 2m and in a couple of cases in less than 1m.
Challenges Faced (3)

Shallow Water – vertical accuracy:

- AUV is a submerged survey platform - acoustic depths must be combined with AUV depth to resolve final sounding depth.

- Waves and swells introduce pressure fluctuations = modulate pressure sensor output without any vertical movement of AUV = vertical offsets in seabed profile; looks like the AUV is ‘porpoising’.

- In shallow water even small waves cause significant artifacts in seabed profiles.

- The Z (vertical) coordinate from the INS is recorded in the raw sonar file and we use that to correct these artifacts.
• Data processors, geophysicists and charting specialists create comprehensive data sets for reporting and charting.

• Four stage iterative process:

  - Process Bathymetry Data
  - Navigation processing to remove INS drift and surface swell artifacts
  - Re-process Bathymetry Data. Process Side-scan Sonar data
  - Perform Geophysical Interpretation
Ocean Imaging Consultants ‘CleanSweep’ software:

- Corrections for any positional drift from Inertial Navigation System.
- Filters for Navigation and Attitude.
- Filters for cleaning any ‘outlier’ soundings.
- Algorithms for applying tides, including interpolated tides between multiple stations.
- Angle Varying Gain corrections for the backscatter.

*Kongsberg Geoswathe (500kHz) example showing spud can depressions*
Removing INS Drift

- A small linear drift over time or distance traveled is expected from the Inertial Navigation System.
- We used InterNav (part of CleanSweep) to correct.
- This matches adjacent swathes and applies a weighting to positions near the start of a mission in preference to those near the end.
- By overlapping start and end of consecutive missions we constrain the positional uncertainty.
- Horizontal uncertainty was constrained to less than 2m over the project.
Removing Swell / Wave Artifacts

- Caused by pressure fluctuations from surface swells and waves.

- AUV position appears to be ‘porpoising’ when it is in fact stable.

- A secondary record of the INS ‘Z’ (vertical) co-ordinate is captured in the raw GeoSwath files.

- Apply a smoothing filter to the pressure sensor depth observation gives a long period trend of AUV depth.

- Applying a high-pass filter to the INS ‘Z’ coordinate leaves a zero mean high frequency record of vertical movement.

- Combining the two processed records provides an accurate AUV depth record free of swell and wave artifacts.
Swell / Wave Artifacts Removed

Digital Elevation Model with pressure sensor depth only, revealing the artifacts of 40cm wave heights and 30m wave lengths.

Combined depths with artifacts filtered and removed
Processing Side Scan Sonar Data

- MST SSS operates at 900kHz - an appreciable increase in resolution over GeoSwath SSS.

- GeoSwath navigation is more accurate.

- By using CleanSweep’s import/export tools we applied the GeoSwath navigation and altitude data to improve the MST record position data.

- High resolution MST SSS mosaics were used for areas requiring a high level of detail.
Processing Side-scan Sonar Data

GeoSwath SSS (Left) vs MST SSS (Right)

Tripod platform with pipelines
Geophysical Interpretation

- Processed GeoSwath and MST SSS data exported in XTF format to Chesapeake Technology ‘SonarWiz’ software.

- **SonarWiz** used to:
  - identify freespans, pipeline burial and other contacts.
  - identifying, measuring and cataloguing events into a database for export to spreadsheets.

- The freespan tool developed for UTEC combines point contact attributes with a linear feature allowing the feature to be catalogued with height of freespan.

- Databases then exported to Excel and used for event listing and Pipeline Alignment Charts.
Data Presentation

• Field reports identified areas of concern while still in the field.

• Interim reports identified critical freespans and cross-checked these against prior year surveys.

• Fully processed data exported to Geographical Information System (GIS) for final QC checks.

• Having all items in a single GIS allows consistency checks prior to charting.

• Each event target is checked against the digital elevation model and the mosaics to ensure correct identification and position.

• Final report provided Pipeline Alignment Charts (plan view and pipeline events) and full Pipeline Events Listings (freespans, debris, sections of burial etc.)
Pipeline Charts
Meeting Quadrant’s Expectations

- Project met Quadrant’s expectation as set out in the Scope of Work.
- AUV operations in very shallow water meant that 92% of all pipeline kms were surveyed.
- Total of 571km of pipe surveyed with one-pass each side i.e. 1,142 km of AUV track-line.
- Twenty platforms and subsea structures surveyed, which was 100% of subsea assets specified in Scope of Work.
- Total duration was 27 days in mid-winter including mob, demob and transits.
- Less than 2% operational downtime and only 18% weather downtime impacting launch and recovery.
- On a per kilometre basis AUV surveys are calculated to be less than 50% of the cost of an ROV survey.
- AUV surveys substantially contribute to subsea integrity management strategies.
New Technology - Blue View Sonar MB2250

- High frequency (2250 kHz) for greater resolution bathymetry
- Low power and compact

Ideal for a variety of applications including:

- Detailed sub sea survey
- Pipeline inspections
- Side Scan Sonar nadir gap fill improves operational efficiency
Blue View Sonar MB2250

Data from a pipeline inspection survey
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Questions?

Thank you!
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