AUV Pipeline Inspection (PI) Development Project Close out and way forward

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AGENDA

- Introduction
- AUV PI Development Objectives
- Development Time Line
- Technology Evolution
- Key Technologies Development
- AUV PI Key Achievements
- Conclusion / Way Forward
Introduction

• A 2 years R&D industrial collaboration project to respond to the needs to both reduce the cost of the subsea pipeline inspection and to increase its frequency in a context of ageing facilities

• Total and Chevron common specification was used to select Oceaneering Survey Services through an RFI& RFQ
AUV PI development objectives

- To reduce significantly the cost of the pipeline survey/inspection by achieving pipeline detection and tracking at low altitude and increase the frequency of the AUV PI.
- Application: To replace the conventional pipeline inspection campaign by ROV or the Deep Tow (ROTV) acquisition for long distance Pipeline inspection.
- Pipeline integrity = free span detection, pipe displacement (lateral or upheaval buckling), crossings, pipe walking, anodes status, CP measurement, coating damages, pipeline marks.
**Development Time Line**

**PHASE I : 2014 – 2015**
- Collection of data from pipelines
- Demonstrate basic reacquisition of lost/buried P/L
- Logging of all sensor data.
- Demonstrate navigation constraints, endurance, and speed

**PHASE II : 2015-2016**
- P/L tracking with MBES – LASER
- Recognize P/L crossings
- Recognition of some subsea features
- Track buried P/L

**PHASE III : 2016-2017**
- Flying at slower speeds / lower altitude
- Correction of navigation error based on subsea features
- Obstacle avoidance behaviors
- Demonstrate full P/L inspection
- Invite inspection managers from affiliates to witness the field demonstration

_A TOTAL, CHEVRON & OCEANEERING R&D COLLABORATION PROJECT_
Technology Evolution

**ROV**
- Altitude <1m above pipeline
- Speed (<.5 knot)
- 100 Km of Pipe Takes ~ 5 Days
- Need Min. DPII Vessel
- Visual Navigation
- Post Processing of Data
- CP Survey
- Manual Obstacle Avoidance

**AUV today**
- Altitude ~6 m above pipeline
- Speed (<= 4 knot)
- 100 Km of Pipe Takes ~ 15h
- No Need for DP Vessel
- Navigate using As Built Data
- Post Processing of Data
- No CP (Technology Gap)
- No Obstacle Avoidance Sonar

**Innovative Inspection AUV**
- Altitude ~2.5 m above pipeline
- Speed (<= 4 knot)
- 100 Km of Pipe Takes ~ 15 h
- No Need for DP Vessel
- Navigate using Auto-Tracking
- Real-time Data Processing
- Pipe defects – Features
- CP Survey (Under Development)
- Automatic Obstacle Avoidance Sonar
Key Technologies Development - Pipeline Auto-Tracking

As-Built Data

FLS

Multi-Beam

LASER

Camera

Pipeline Tracker

Actual Pipeline Position

Cross-Track < 1 m

Navigation Aid

Accurate Data

Status: following
Altitude: 2,493,929
Key Technologies Development - Auto-Detection of Pipeline Features
Key Technologies Development - Obstacle Avoidance
Key Technologies Development - Smart behaviour

1. Inspecting Primary Pipeline
2. Crossing Detected
3. Breakaway from Primary Path
4. Acquire Crossing Pipeline
5. Breakaway from Cross Over Path
6. Reacquire Primary Pipeline
7. Pipe Line Inspection Resumed

Leak Detected
Key Technologies Development - Pipeline Feature Based Navigation
Key Technologies Development - Cathodic Protection Measurements

- Proof Of Concept (POC) tested in Field Conditions:
AUV PI - Key Achievements

• Pipeline Auto-Tracking
  ✓ Capability to maintain the vehicle at low altitude with a cross track +/-1m

• Auto-Detection of pipeline features
  ✓ Real-time detection of mattresses, Anodes, free spans

• Obstacle Avoidance
  ✓ The AUV detected obstacles using the Forward Looking Sonar and avoided simulated obstacles

• Smart Behaviour
  ✓ AUV route modification while passing through pre-programmed features (crossing, free-spans)

• CP measurement
  ✓ Demonstration of the Proof of Concept during a field trial by measuring some potential difference while the AUV was flying above the pipeline using the pipeline auto-tracking
Conclusions and way forward

- AUV PI system fully industrial Q3 2017
- Cost divided by 3 in average for subsea pipeline inspection
- AUV for PI is a major milestone in our way to full subsea robotics deployment:

Today:
- Inspection AUV and workclass ROV

2020:
- Inspection AUV
- Workclass AUV/USV deployed ROV
- Embedded robotics in Subsea Production systems
A Mission
Pipelines Inspection

→ Surface defects on equipment
→ Movement of equipment
→ Free-spans
→ Cathodic protection measurements
→ Today, done with ROV

A Technology
Autonomous Underwater Vehicle (AUV)

→ Launch and Recovery
→ Propulsion and Power
→ Collect and Store Data
→ Avoid Obstacles

Goal of our innovation:
Develop AUV to meet pipeline inspection specification for global pipeline inspection services