Subsea Surveys
Types of Survey & Application
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Applications
Construction - Subsea Field Development - CAPEX

- Project management
- Detailed design, fabrication & installation
- Subsea construction and tie-ins
- Trenching and burial services
- ROV and tooling solutions
- Survey & positioning services
- Diving services
- Commissioning
Example project - Total CLOV (Cravo, Lirio, Orquidea, Violeta)

- An **EPIC** Project
- **Engineering**
- **Procurement**
- **Installation**
- **Commissioning**

- 130km of flowlines
- 2 Hybrid Riser Towers
- 1 gas export SHR
- 80km of umbilicals
- 52 subsea structures (FLET, ILT, SIV)
- 52 spools and jumpers
- Manifolds and MPP umbilical
Life of Field - OPEX

- Integrity management
- Repair and maintenance
- Survey and inspection
- ROV, AUV and tooling solutions
- Diving services
- Data management, analysis, reporting
- Decommissioning, disposal, recycling
Pipelay and Pipelay Support

- Vessel positioning and navigation (lay and support vessel)
- Precise positioning of ROV in all water depths (>2000m)
- Identification and determination of pipeline touchdown
- Support at initiation, crossings, cut to length and laydown
- Wireless transmission of information between vessels
Bundle Tow and Installation
Bundle monitoring software
Pipeline Surveys

Types of survey:
- Route survey
- Pre-lay
- As-laid / As-built
- General Visual Inspection (GVI)

Typical Focus Areas:
- Lay comfort
- Freespans
- Pipeline damage
- Debris
- Anodes and cathodic protection
- Seabed features and targets
- Pipeline and cable crossings
- Lateral movement
Out of Straightness Survey (OOS)

• Upheaval buckling (UHB)

• Precise vertical OOS with INS

• Precise lateral OOS with INS
Structure Installation Support

- Surface Positioning
- Sub-Surface Positioning
- Depth and altitude monitoring
- Orientation and attitude
- Levelment surveys
- As-installed GVI surveys
Dimensional Control & Metrology

• Onshore
  – Dimensional control (total stations, laser, photogrammetry)

• Offshore
  – LBL Acoustics
  – Subsea laser scanning
  – Inertial Navigation
  – Photogrammetry
  – Taut Wire / Diver
Integrity Management
Platforms for Subsea Sensors

- Vessels
- ROVs
- ROTV/towed sensors
- AIV/AUVs
- Subsea structures
- Surface structures
- Highly dynamic platforms

- All require a number of integrated survey sensors
Subsea Sensors

- What is the first thing we want to find when a platform enters the water?
- Position: e.g. via USBL
- What sensors are needed?
  - Acoustic transceiver/transducer
  - Acoustic transponder
  - Derives horiz + vert angles + range to txp
- What other sensors are needed?
  - Heading and motion sensors
- What is to measure and calibrate?
  - Offsets
  - Heading and motion sensor alignment
  - USBL transducer alignment
Subsea Positioning

- Subsea positioning has relatively low precision and update rates
- USBL, 2-5 second update rate

- INS aided by USBL and DVL provides:
  - Increased precision
  - Faster update rates
- Accuracy is still depended on USBL
Subsea Positioning Long Baseline (LBL)

- A network of transponders is deployed on the seabed
- Transducer fixed to platform (either surface and/or subsurface)
- Positions of transponders are calibrated relative to each other
- By measuring multiple ranges to a network of transponders, the transducer position may be calculated using trilateration (ranges only – like GNSS)
- Depths of the transponders and transducer must be known
- Minimum of three transponders required
- Four or more provides range redundancy for quality estimation
- Baselines: few metres up to 2km
Positioning systems

Rough guideline depths for use

- **USBL only**
- **USBL aided INS**
- **USBL aided INS / LBL**
- **LBL**

Depth levels:
- **Surface**
- **500m**
- **1200m**
- **2000m**
Subsea Sensors

- What next might we wish to determine?
- ROV Depth

Essentially this can be done in two ways:
  - Depth from USBL (Z component)
  - Depth (pressure) sensor

Which is better?
Subsea Sensors

- We now know ROV depth, what next?
- **Seabed depth**
- (or depth of what is on it)
- Known as bathymetry
- Although most of the time the depth sensor is affectionately known as the “bathy”
- What sensor is needed?
- **Echosounder: single, scanning or multibeam**
- Normally dual head
ROV based pipeline survey
Multibeam / DHSS pipeline profiling

• How do we survey a pipeline?
Multibeam pipeline profiling

courtesy

The Hydrographic Society in Scotland
Sound Velocity Sensors

• SV Probe
  – Measures time of flight of an acoustic pulse over a known baseline length
  – Very precise; required for MBE and LBL metrology
  – Does not provide environmental information

• CTD Probe
  – Measures conductivity, temperature and density
  – Derives sound velocity using standard formulae
    • Chen & Millero WD <1000m
    • Del Grosso WD >1000m
Sound Velocity

- What else is sound velocity important for?
- It is also needed to apply the full water column sound velocity profile to the USBL system to correct for refraction effects in positioning
- Sound bends through layers in the water column
- The sound velocity profile is used to model the path of sound taken
Subsea Sensors

• We can determine ROV position and depth, and even depth of seabed, how do we know where we are going?

• Cameras
  • A variety of cameras may be used
  • For pipeline survey typically there are three cameras: one centre and two booms
Subsea Sensors

• But what if there is zero visibility?
• **Obstacle avoidance sonar (OAS)**
• May be mechanical scanning type or beam-forming
ROV Sensors

- What if the product we are trying to survey is buried?

- **Pipetracker**
  - Essentially a big metal detector – 3 coils
  - Uses pulse induction techniques to induce a voltage in ferrous targets
  - Calculates range to target both vertically and horizontally from centre coil
  - Requires knowledge of target size and composition (diameter and material)
  - Best results using “target scaling”
  - Requires altimeter in order to calculate depth of cover (DOC)
Pipetracker

- Pipetracker

Pressure Sensor Measures Depth Of Vehicle

Coils Determine Depth Of Pipe Below Vehicle

Altimeter Measures Height Of Coils Above Seabed

Maximum Detection Depth Dependent On Size And Construction Of Pipeline.
Sensor Integration summary

ROV Sensors
- HPR TXP/RXP
- Gyro
- Attitude
- Bathy/Altimeter
- OAS
- Pipetracker
- DHSS / MBE
The future – AUVs?
The Future - AIV

• Provides a cost-effective, low-risk inspection system to aid field survey and integrity management and intervention activities

• Operates directly from a host facility e.g. FPSO, platform or infield support vessels

• The AIV has no tether which enhances vehicle manoeuvrability and the capability to access confined spaces

• The AIV carries an array of navigation tools and sensors that are powered by its own onboard battery power source.
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