Implementing Subsea Surveillance in an Integrity Management Plan
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Content

- Schlumberger subsea surveillance overview
- Customer motivation towards subsea surveillance
- Applications: Green and Brown fields
- Technology overview: sensors, power distribution, data collection, processing, delivery and interpretation.
- Value: direct and indirect
Schlumberger Subsea Surveillance

Discrete- Multipoint Fibre Optic Measurements
(Strain, Vibration, Pressure, Temp)

Integrated “data to desk”
- Interpretation & Analysis → Decision
Surveillance Organisation

Distributed Fibre Optic Measurements
(Temp, Vibration, Pressure, Strain)

Subsurface and Subsea monitoring
data transfer & control
(DH gauge, Flow Control, Pressure, Temp, Erosion, Corrosion, Production control, SSSV, +sensors, process)
Schlumberger Sensor to Customer Workflow

- **Subsea**
  - Subsea Sensors

- **Platform**
  - Offshore SCADA System
  - Customer Offshore Data Management

- **Office**
  - Offshore to Onshore Database
  - Advanced Data Analysis Tools

**Processing**
- Sensors
- Acquisition Network
- Acquisition Data Processing
- Secure Data Transmission

**Tools**
- SLB tools: Avocet!, PipeSim, THERMA, etc.
- SLB InterAct, PRTI
- IMMS/ICSS

**Acquisition Data**
- MRU Motion sensors
- subC-collar Strain sensors
- P/T Gauges
Customer motivations towards asset integrity surveillance

- **Corporate management**: Policy statement and organizational implementation to preserve Company Reputation.

- **Discipline Experts**: Knowledge capitalization to provide better support to operation and to optimize CAPEX of future field development.

- **Operational team**: Alarms and warnings to avoid failures and to optimize OPEX.

- **Project Development team**: Manage and mitigate risks resulting from SoW added complexity.
Application: Green Field

- Intimate sensor integration to the asset
- Possibility to use intrusive sensors
- Improved data accuracy and reliability.
- Longer design life allow to use it as safety alarm
- Reduced installation cost
Application: Brown Field

- Non intrusive sensor only
- Possible loss accuracy due coating or additional interfaces between structure and sensor
- Limited mission profile
- Installation campaign and demobilization.
Technology: choice of sensors

- Understand the decision to be made and associated support information/precision required.
- Define the process from sensor readings to information delivery to end user desk.
- Define time and spatial resolution, accuracy, precision, expected operating life etc...
- Understand the environment of integration and associated interfaces
Technology: sensors

- Strain gauges (axial, hoop and vibration)
- Pressure and temperature sensor
- **Flow meter**
- Fibre Optic (Bragg Grating or back scattering light analysis)
- Corrosion, erosion, wall thickness
- Motion recording units (acceleration)
- Inclinometers, Depth sensor, Sonar, acoustic transponders etc…
Technology: power distribution & data collection

- DC or AC Voltage?
- Battery and data logger. ROV intervention.
- Surface umbilical (dedicated or tie-back).
- Fibre optic (up to 150km).
- **Choice of an architecture and a communication protocol: serial, power line or acoustic modems.**
- Flying leads, junction boxes, connectors etc..
Technology: data processing delivery and interpretation

- Reliability to cover both Structural and instrument expertise
- Data storage, checking and validation.
- **Data processing from sensor raw reading into interpretable information.**
- Delivery to the end user: alarms, data display, reports.
- Subsea surveillance facilities maintenance
- **Organization to deal with interpretation reports and recommendation.**
Value

- Return value of the system = value of the decision made with interpreted data.
- Substantial gain in knowledge capitalization.
- Subsea Surveillance Technology may provide information not accessible by standard maintenance plan.
- Example: decision to extend operating life of a subsea field equipped with dynamic risers.
- Use existing architecture to extend subsea asset integrity network to production optimization (flow assurance)
Contact information

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Attachments and callout slides

1. **Flow meter**
2. **Bragg Grating**
3. **back scattering light analysis**
4. **Choice of an architecture and a communication protocol: serial, power line or acoustic modems.**
5. **Data processing from sensor raw reading into interpretable information.**
6. **Organization to deal with interpretation reports and recommendation.**
1- subC-racs to monitor flexible riser annulus
1- subC-Racs principle

Temperature measurement

Pressure and flow rate measurement

Solenoid valve

Gas output to flare (or vacuum pump)

WATER TRAP

SAMPLE / PURGE

GRV

Orifice

Graph showing annulus pressure over time with labels for different stages:
- Gas diffusion
- Venting - Drawdown
- Buildup
- Gas diffusion

The graph indicates a pressure drop over time.
2- Discrete Strain Sensing Technology

- FBG “written” into fibre core

FBG wavelength increases linearly with applied strain

Direct Strain Measurement
No Calibration Required
2- Discrete Strain Sensing Technology

- Emitted light from light source
- Reflected light received at different timeslots
- Processor
- Reflected light from FBGs
- Sensor array

Light Source

$\text{Reflected light received at different timeslots}$

$t_1$, $t_2$, $t_3$, $t_4$, $t_5$, $t_6$, $t_7$, $t_8$

$g_1$, $g_6$
2- Discrete Sensing Composite Carrier

Sensors are deployed within a composite carrier to:
- Protect the optical fibre during use and handling
- Optimise strain transfer
- Locate sensors accurately
- Provide rugged connector interface

Geometry of carrier can take many forms

Composite has excellent fatigue performance
2- Discrete Strain Sensing Products

subC-rod, subC-mat, subC-strip, SURF subC-collarsubC-flex, subC-pts

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3- Distributed Temperature Sensing Technology

Detection of hot/cold fluid leaks
3- DTS Measurement Principle

- **Incident Laser Light**
- **Backscattered Light**
- **Laser Source**
- **Receiver**
- **Directional Coupler**
- **Brillouin Lines**
  - **Strain**
- **Rayleigh Band**
- **Stokes Raman Band**
- **DTS System**
- **Temperature sensitive**
- **Not Temperature sensitive**
- **Vibration**

**ΔT** is not temperature sensitive.
4- Subsea Control / Monitoring; SURF application
5-Data collection/processing Tension and Bending of drilling riser

Tension-Joint
Histogram of Tension Cycles

Tension-Joint
Histogram of Bending Moment Cycles

Tension-Joint
Tension
Average Spectral Density of Tension per Period Bin

Period Bins
- 2 to 4 sec
- 4 to 8 sec
- 8 to 16 sec
- 16 to 32 sec

Tension-Joint
Bending Moment
Average Spectral Density of Bending-Moment per Period Bin

Period Bins
- 2 to 4 sec
- 4 to 8 sec
- 8 to 16 sec
- 16 to 32 sec
6-Interpretation: fatigue damage assessment

- Residual service life
  - Fatigue in air
  - Annulus dry
  - Fatigue corrosion
  - Annulus flooded

- Time: t1 to t2