Tritech RAMS®

Real-Time Continuous Integrity Monitoring of FPSO Mooring Lines & Risers Using Multibeam Sonar Technology

Outstanding Performance in Underwater Technology
Sonar Technology for FPSO’s
Presentation Objectives

1. Review current mooring line monitoring technologies.
2. Understand how sonar can be used as an integrity monitoring tool.
3. Assess the benefits of continuous real-time integrity monitoring using sonar.
About Us

Tritech

• Reliable imaging and ancillary equipment for use in underwater applications.

• Key markets include; Defence, Energy, Engineering, Survey and Underwater Vehicles.

• We remain an industry leader in the provision of sensors and tools for ROV and AUV markets.

• Established in 1991.

• Approximately 100 staff across 4 international sites.

• Wholly owned subsidiary of Moog, Inc
The Need for Asset Integrity Monitoring on an FPSO

Increased focus on asset integrity management.

Older FPSO’s present increased insurance risk.

Financial loss + global reputational damage in the event of an incident.

Increasing number of near misses.

Limitations of General Visual Inspection (GVI).

Limitations of some existing technologies.

Field proven sonar technology provides a possible solution.
# Current monitoring & inspection technologies

<table>
<thead>
<tr>
<th>Monitoring System</th>
<th>Description</th>
<th>Advantages</th>
<th>Limitations</th>
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</table>
| Scanning Sonar    | Periodic snapshot, monitors presence and estimated position of mooring lines and risers | • Low cost, simple to deploy  
• Field proven  
• Single sensor – monitors all lines | • Only observes presence and estimated position  
• Single snapshot only  
• Not suitable for permanent deployment |
| Load Cell Tension Monitoring | Load monitoring at mooring pin; hardwired to surface | • Direct tension  
• Continuous data | • Exposed environment leads to frequent loss and damage  
• Single point measurement  
• Regular maintenance required |
| Inclination Monitoring – Acoustic | Monitors angle of mooring lines; acoustic data transmission to surface | • Field proven  
• No cables  
• Data on demand | • Single point measurement  
• Subject to regular damage  
• Battery life  
• Diver or ROV intervention required for maintenance |
| Inclination Monitoring – Standalone | Monitors angle of mooring lines | • Low cost  
• No cables  
• Field proven | • Single point measurement  
• Subject to regular damage  
• Battery life  
• Diver or ROV needed to retrieve data |
| Combined Acoustic/Hardwire Inclination and Tension Monitoring | Monitors angle of mooring lines and direct in-line tension | • Direct tension measurement  
• Option of continuous data  
• Inline mounting, so more robust | • Single point measurement  
• Potential cable failure  
• Battery life  
• Diver or ROV needed for servicing |
Sonar Technology for FPSO’s

Presentation Outline

✓ An introduction to Tritech International

✓ Overview of current Asset Integrity Management problems

✓ Introduction to current monitoring technologies and methodologies

➢ Use of sonar as a monitoring technology
Introduction to Sonar Technology

The different types of sonar technology
Introduction to Sonar Technology

Scanning sonars explained

Variations between 0.5° and 1° wide depending upon system

About 30° high

Outstanding Performance in Underwater Technology

Image from Alba FSU courtesy of Chevron
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➢ The move from periodic inspection to real-time continuous monitoring

Outstanding Performance in Underwater Technology
RAMS® Technology
Technical Specification

RAMS® 360 sonar head as used on Foinaven and Schiehallion FPSO

New RAMS® 360 ATEX compliant sonar head designed for QUAD204

NOTES:
1. - WEIGHT IN AIR ≥ 43 Kg
   - WEIGHT IN WATER ≥ 27 Kg
2. - PRESSURE RATING ≥ 100 PSI
3. - HOUSING MATERIALS: SUPER DUPLEX UNS 332760
   BLACK NYLON 6X-AU
   PEEK 450G
   POLYURETHANE

Outstanding Performance in Underwater Technology
RAMS® Technology

How it Works

Sonar transmits acoustic energy and processes the received echoes.

Measure relative position of each target and calculate offset to expected position.

Translates received echoes into X&Y coordinates.

Each target is defined as a model in the software.

Targets within the search areas are used to update the models in real time.

Data used to generate alarms and for fatigue/cycle analysis.
RAMS® Technology

Topside Processor

Outstanding Performance in Underwater Technology
RAMS® Testing
LabOceano Facility, Brazil

Outstanding Performance in Underwater Technology
RAMS® Testing
Technology Testing & Evaluation

Concept discussion with BP in 2003

Successful simulation and tank trials with BP 2003

Successful sea trials with BP in 2007

Installed on Teekay Petrojarl Foinaven FPSO operating in major BP field in 2009

Selected by BP/SBM as primary mooring monitoring tool for QUAD204

Proven to be 100% effective in detection and measurement capabilities
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» FPSO Case Study example
RAMS® Failure Detection
Bend Stiffener Failure Detection Example

Outstanding Performance in Underwater Technology
A BP Representative commented that

“RAMS® has been installed on the Foinaven FPSO since 2009 and shown to be 100% effective. We are confident of the system and its ability to monitor the integrity of risers and umbilicals and its capability for data export in order to analyse riser/bend stiffener movement which is very important, not only to maintain the asset but to identify the corrective need for corrective actions.”
Summary & Benefits of RAMS® Technology

- Permanently deployed dual purpose autonomous monitoring system.
- High update rate means accurate real time movement detection and measurement.
- No moving parts.
- Non-intrusive – provides remote measurement and tracking from stand off position.
- No need for additional sensors, cables and power sources on individual targets.
- Mature, field proven technology.
- Continually monitors presence and position with optional inclination and tension calculation capabilities.
Sonar Technology for FPSO’s
Presentation Objectives Review

✓ Reviewed current mooring line monitoring technologies.

✓ Understood how sonar can be used as an integrity monitoring tool.

✓ Assessed the benefits of using sonar for continuous real-time integrity monitoring.
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