

RAMS[®]

Real-Time Riser and Anchor-Chain
Integrity Monitoring for FPSOs

Outstanding Performance in Underwater Technology





REAL-TIME SYSTEM

RAMS® – Asset Integrity Monitoring Solution for FPSOs and FLNGs



Tritech is renowned for delivering expertise through high-technology products and solutions; **RAMS®** demonstrates this capability.

RAMS® provides a real-time integrity monitoring solution for operators of Floating Production Storage and Offloading units (FPSOs) and Floating Liquid Natural Gas vessels (FLNGs).

As a dual-function, ATEX compliant integrity monitoring system, **RAMS®** has been designed for life-of-field. With no mechanical moving parts, no batteries and low maintenance requirements; the system is suitable for new build or retrofit projects.

RAMS® provides 24/7 continuous and simultaneous monitoring of the presence, integrity and position of all mooring lines, risers, bend stiffeners and umbilicals to within an accuracy of 10mm.

Failure Detection

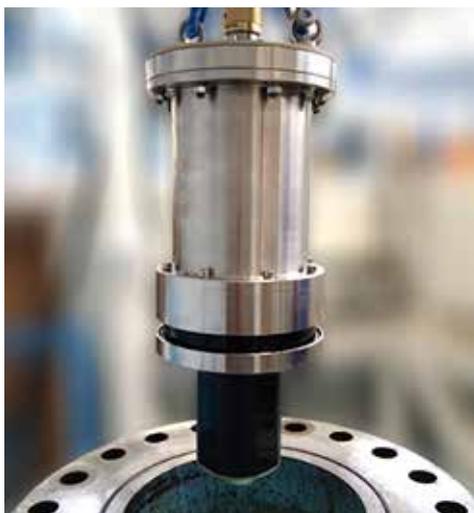
RAMS® provides an instantaneous warning alarm in the event of line failure or abnormal movement of any mooring line or riser. The system also boasts intelligent data processing, to provide an early indication of failure potential.

The user configurable alarm system includes the following pre-set alarms:

- Detection of mooring line absence (failure)
- Detection of riser absence (failure)
- Detection of mooring line outside mean/expected position
- Detection of riser position outside mean/expected position
- Detection of inconsistent mooring line position in relation to adjacent lines
- Detection of inconsistent riser position in relation to adjacent risers
- RAMS® system malfunction
- Remaining data storage

Principles of Operation

- Deployed and recovered through an I-tube or deployment tube in the FPSO turret, removing the need for divers/ Remotely Operated Vehicle (ROV) support to install or maintain
- The sonar transmits acoustic energy at 240 kHz, forming 768 discrete sonar beams
- Each mooring line, riser and umbilical is defined as an engineering model in the RAMS® software, the models are updated in real-time. In the event the model changes due to failure or out-of-scope movement, an alarm is automatically triggered
- The RAMS® software processes the received sonar echoes and measures the relative position of the acoustic return from each mooring line or riser and calculates any offset from the targets expected positions. These received echoes are translated into X&Y coordinates
- Uses dynamic search mode with time stamped GPS and motion sensor inputs to help qualify the measurements, thus avoiding false alarms
- Updates at up to 15 times a second (15Hz) to instantaneously detect line failure
- No additional sensors attached to each line
- Provides continuous data recording allowing detailed export for offline trend and fatigue analysis, with an inbuilt automated reporting module
- Option for continuous calculation of mooring line inclination which allows operators to estimate tension based on the tension/ angle principle
- Can be configured for use on disconnectable turrets and spread moored FPSOs
- System can be configured to comply with all class society requirements for high availability and redundancy



Left: Example of RAMS® sonar head

Tried, Tested and Proven:

- Field-proven development in major BP field; trialled on the Schiehallion FPSO (2007)
- Integrity monitoring of risers and mooring lines with 100% proven target detection, reliability and maintenance on Teekay Petrojarl Foinaven FPSO operating in BP field (2009)
- Primary 'safety critical' mooring and riser monitoring tool for the Glen Lyon FPSO (BP QUAD204 Project)

The Case for RAMS® as a Mooring and Riser Monitoring System

The last decade has seen an increased focus on the importance of AIM as operators seek to efficiently capture hydrocarbons in increasingly deeper water, in more remote locations and as older generation FPSOs near the end of their original design life.

There are well-documented cases of single and multiple mooring line failures, demonstrating a variety of failure factors, which have subsequently caused FPSOs to move off station and can lead to; loss of station, loss of hydrocarbons and damage to operator reputation.

Due to these potential consequences, operators, regulatory and class society bodies have an increased focus on technologies, to inspect and monitor the integrity of floating assets in order to heighten safety practices, (some have published guidelines) thus minimising potential losses.

Inspection alone will not provide the full status on asset health for a number of reasons, which include:

- **Periodic inspection does not detect the failure mechanism or provide information on the damage rate**
- **General Visual Inspection (GVI) is often hampered by poor visibility or due to marine growth**
- **Inspection by ROVs is limited by access and weather conditions and is often reliant on a third party**

In addition, periodic inspection does not provide real-time warnings of potential future failure. These shortfalls have led to an increasing requirement for real-time monitoring technologies to compliment periodic inspection.

There are a number of existing monitoring technologies including scanning sonar, inclination and tension monitoring, however these have their limitations as described in the table below.

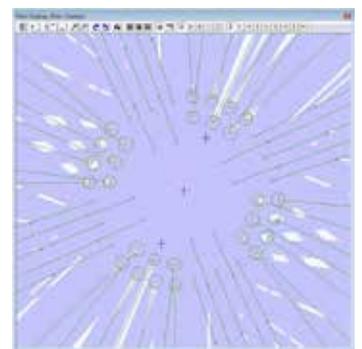
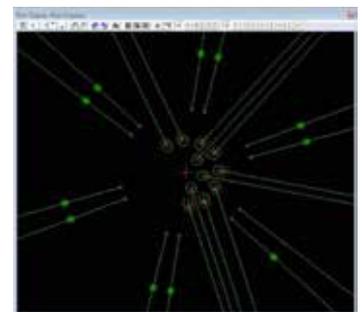
Installation, Commissioning and In-Field Support

RAMS® SYSTEM DESIGN PHASE

Prior to procurement, Tritech engineers carry out an extensive visibility study during the Front End Engineering and Design (FEED) phase, where information on the mooring system and riser configuration is entered into the RAMS® visibility software. Through the software, Tritech's engineers are able to simulate and model the sonar coverage and the target detection of different deployment arrangements, in order to determine the best position and depth beneath the FPSO's chain table to deploy the sonar head(s).

The RAMS® software allows for a full sonar simulation to calculate the detection and accuracy of expected mooring line/ anchor chains, risers and umbilical positions. This significantly reduces the risk at engineering design phase, improving the efficiency and reducing overall project costs. The simulation information can also be used to assess the compliance with any safety-critical requirements during the design phase.

LIMITATIONS OF EXISTING MONITORING TECHNOLOGIES			
Type	Description	Benefits	Weaknesses
Scanning Sonar	Periodic snapshot, monitors presence and estimated position of mooring lines and risers	<ul style="list-style-type: none"> • Low cost • Simple to deploy • Field proven • Single sensor; detects presence of all lines 	<ul style="list-style-type: none"> • Inspection rather than monitoring • 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	<ul style="list-style-type: none"> • Direct tension • Continuous data 	<ul style="list-style-type: none"> • Exposed environment leads to frequent loss and damage • Single point measurement • Regular maintenance required using divers/ ROVs
Inclination Monitoring – Acoustic	Monitors top angle of mooring lines; acoustic data transmission to surface	<ul style="list-style-type: none"> • Field proven • No cables • Data on demand 	<ul style="list-style-type: none"> • Single point measurement • Subject to regular damage • Battery life • Diver or ROV intervention required for maintenance
Inclination Monitoring – Standalone	Monitors top angle of mooring lines	<ul style="list-style-type: none"> • Low cost • No cables • Field proven 	<ul style="list-style-type: none"> • Single point measurement • Subject to regular damage • Battery life • Diver or ROV needed to retrieve data
Combined Acoustic/ Hardwire Inclination and Tension Monitoring	Monitors top angle of mooring lines and direct inline tension	<ul style="list-style-type: none"> • Direct tension measurement • Option of continuous data • Inline mounting 	<ul style="list-style-type: none"> • Single point measurement • Potential cable failure • Battery life • Diver or ROV needed for servicing



Above: Images depicting the RAMS® visibility study

S SPECIFICATIONS



Rendered drawing of ATEX RAMS® sonar head.

Technical Specifications

ATEX COMPLIANT SONAR HEAD EXAMPLE

- Weight in air: 43kg
- Weight in water: 27kg
- Pressure ratings: 100 PSI
- Housing Materials: Super duplex UNS S32760, Black nylon 6X-AU, Peek 450G, Polyurethane

ALTERNATIVE OPTIONS

– custom build as per customer requirements

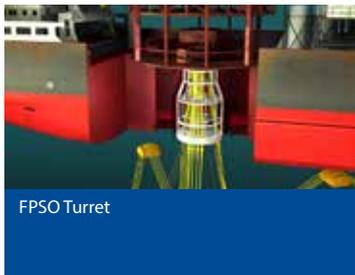
RAMS® SOFTWARE

- The Tritech RAMS® software is user configurable and provides instantaneous automated alarms in the event of the detection of mooring line failure or of abnormal movement of the mooring lines or risers
- Data is recorded 24/7 and may be processed for fatigue studies

TOPSIDE PROCESSOR

- Provided to meet project specification
- Can include provision for high availability, full redundancy and up to 2 years' data storage

Deployment and Installation of RAMS®



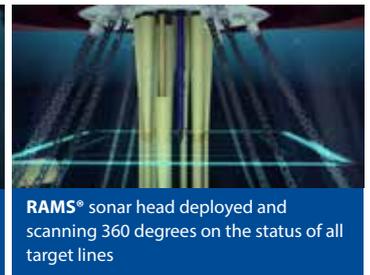
FPSO Turret



I-Tube with RAMS® sonar head on deployment pole



RAMS® sonar head in deployed position



RAMS® sonar head deployed and scanning 360 degrees on the status of all target lines

RAMS® is configured through the software, with software models created for each target during installation. Alarm limits and the associated outputs are defined by the operator and the system then automatically and concurrently tracks the position of each target, alerting the operator in the event of failure or out of scope movement.



RAMS® real-time display and status overview of turret and all mooring lines, risers and umbilicals.

Tritech Quality and Support

Support can be provided in partnership with in-country partners to meet local content as required. Tritech holds the ISO: 9001 quality management standard which rates Tritech's overall product, service and support functions.

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