RAMS™

Tritech

Real-time 360° Riser and Anchor-Chain Integrity Monitoring for FPSOs

RAMS™

Introduction to RAMS™

Tritech's RAMS™ is a real-time 360° anchor-chain and riser integrity monitoring system for Floating Production Storage and Offloading units (FPSOs).

RAMS™ is a dual-function system, designed to monitor the presence, position and integrity of mooring lines, risers and umbilicals. The RAMS™ system is deployed beneath the vessel or platform and provides simultaneous real-time feedback on the status of all lines, making it suitable for 'safety critical' requirements.

RAMS™ Sonar Head

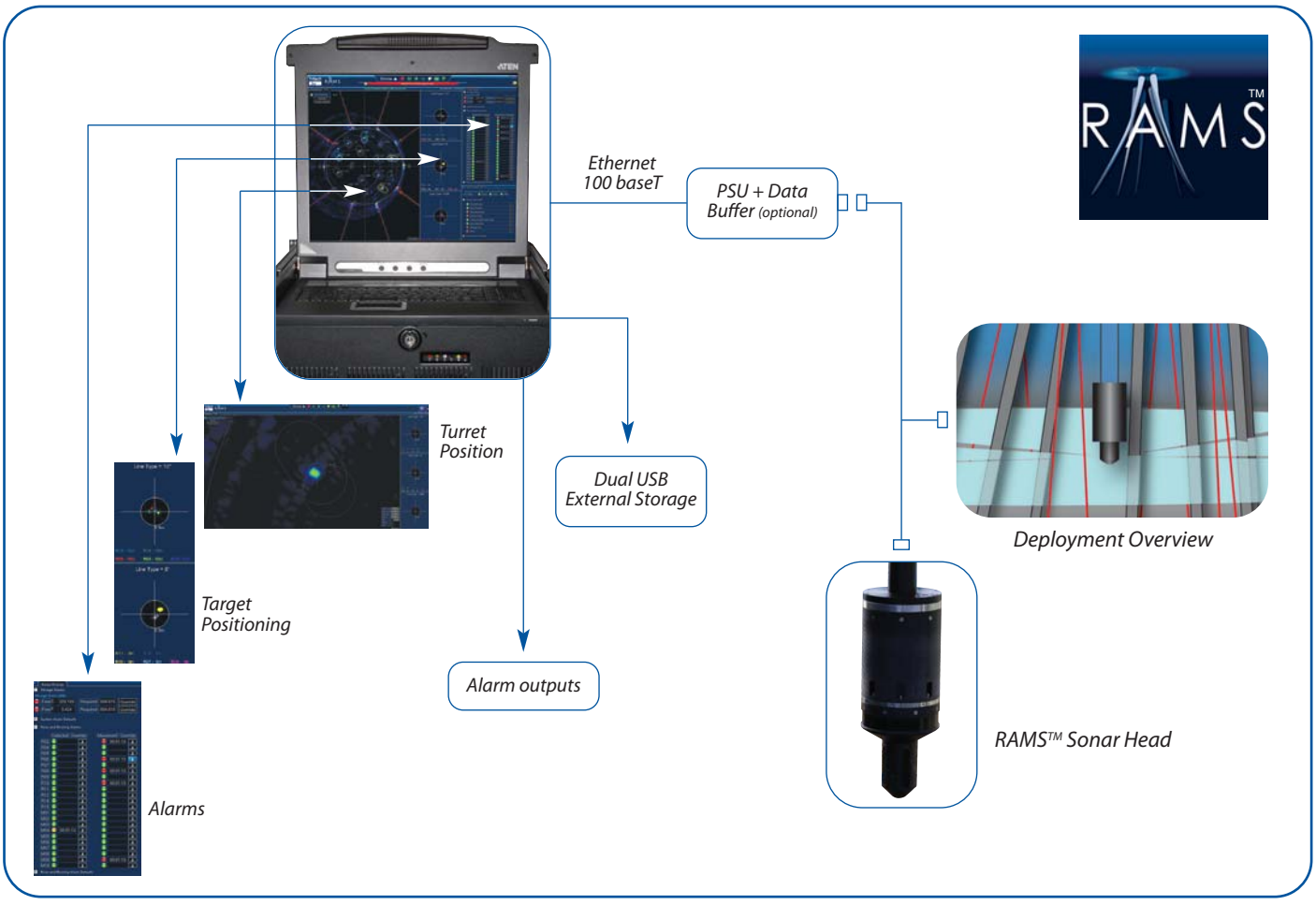
RAMS™ systems, depending upon the sonar configuration, can incorporate a unique beam steerable transmitter that allows the system to be configured on installation to ensure the optimum sonar return from the mooring lines and risers to guarantee 100% target detection and reliability.

Unlike other monitoring systems for mooring lines and risers, the Tritech RAMS™ system is suitable for long-term deployment capability as it has no mechanical moving parts. As a complete system, no added sensors need to be fitted to risers and mooring lines, therefore there is no interference with existing infrastructure.

RAMS™ provides continuous data recording, which allows detailed data export for offline trend analysis or for real-time comparison against historical records. The data can be used to improve predictions of extreme and fatigue responses, to allow maintenance to be scheduled with confidence and to assist with the design of mooring and riser components.

RAMS™ is suitable for use on internal or external turrets and fixed or disconnectable turret systems. For disconnectable turrets, the RAMS™ system may be quickly recovered prior to disconnecting and readily redeployed upon reconnection.

The system configuration is designed for each FPSO using common elements; this ensures 100% target coverage and ease of deployment. This flexible approach means RAMS™ is suitable for use in most FPSOs regardless of mooring type or configuration. Tritech carry out a detailed visibility study during the FEED phase to guarantee 100% target coverage and performance levels to meet 'safety critical' standards as required.



Installation, Commissioning & In-Field Support

Support can be provided in partnership with local in-country partners to meet local content as required and with NCS Survey, an Acteon company and leading independent survey contractor, who has extensive experience supporting projects involving high-specification multibeam sonars in the Oil & Gas Industry. The combined solutions offered by Tritech, NCS Survey and our local partners are unmatched by other solution providers, Tritech's RAMS™ technology has evolved into the most powerful real-time subsea visualisation system for the FPSO market.

24/7 Technical Support

Tritech offer unrivalled customer support with dedicated technical and software assistance available.

Our support engineers have BOSIET and MIST training certification to allow us to respond quickly to your needs. The overall support system is rated to ISO 9001 standard.

Extended support contracts are available to all RAMS™ customers.

Flexible Applications

- Real-time bend stiffener and riser monitoring
- Real-time mooring line integrity monitoring
- Deployable on any type of FPSO where there is a requirement to monitor mooring lines, risers and umbilicals
- Riser/ bend stiffener stress analysis through high-resolution data output

Additional Applications:

- RAMS™ may be deployed on decoupled subsea riser buoys to monitor risers and buoy moorings
- RAMS™ systems can be used to take periodic snapshots as part of an integrity management program where there is no requirement for permanent deployment

Benefits

- Real-time and continuous monitoring
- No additional sensors attached to mooring lines/risers
- Fully automated system to detect presence and measure movement of mooring lines and risers
- User defined alarms for immediate notification of excessive movement of target lines that may indicate mooring line or bend stiffener failure
- Long-term deployment/ immersion capability - no moving parts
- Continuous recording and data export for riser/bend stiffener analysis
- Field proven technology and deployments
- World class technical support

Features

- Field-proven compact 360° multibeam sonar technology
- Up to 30Hz continuous update rate for real time imaging
- Millimetric position accuracy
- Automated alarm facilities for:
  - Absence of expected targets indicating failure or breakage
  - Riser or mooring movement exceeds design criteria
  - Expected comparative movement exceeds criteria
  - Other custom alarms as required
- Continuous raw data logging and replay functions
- Target XY position logging and export
- Remote data display options
- Automatic software restart on power failure
- Installation, commissioning and after sales support

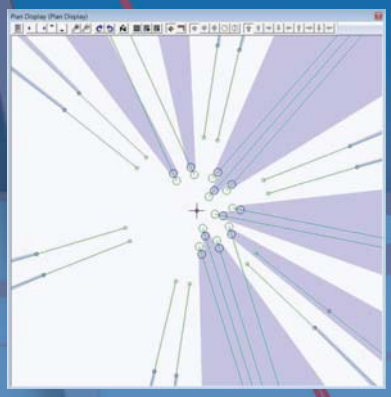
RAMS™ System Design Phase

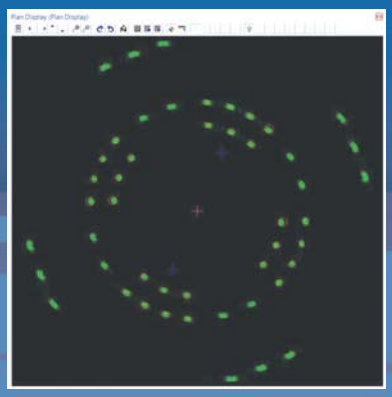
Prior to procurement, Tritech engineers carry out an extensive visibility study where information on the mooring system and riser configuration is entered into the RAMS™ visibility software. Through the software, our engineers are able to simulate and model the sonar coverage and target detection of different deployment arrangements, to determine the best position to deploy the sonar head(s).

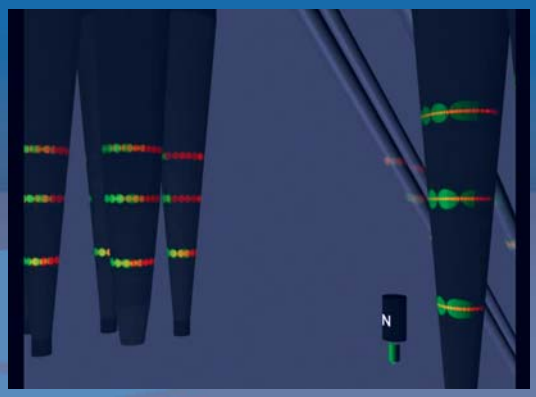
The software allows for a full sonar simulation to calculate the detection of and accuracy of expected anchor chains, risers and umbilical positions once the RAMS™ system has been installed. This significantly reduces the engineering design phase, improving the efficiency and reducing overall project costs.

The simulation information can also be used to assess the compliance with any safety critical requirements during the design phase.

Images depicting the RAMS™ visibility study







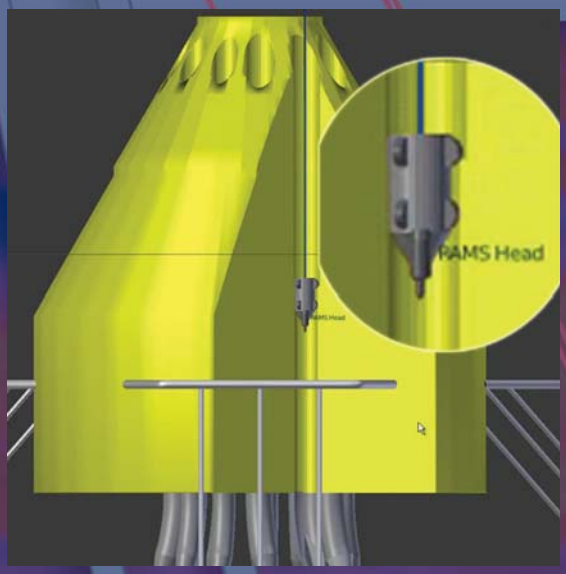


Image showing the RAMS™ sonar head on deployment sled, for installation on a disconnectable turret mooring

Requirement for Monitoring Technologies

Inspection alone will not provide full status on asset health and this is for a number of reasons.

Firstly, periodic inspection does not detect the failure mechanism or provide information on the damage rate.

Secondly, visual inspection is often hampered by poor visibility or due to marine growth.

Thirdly, inspection by Remotely Operated Vehicles (ROVs) is limited by access and weather conditions.

Fourthly, periodic inspection does not provide real-time warnings of future failure.

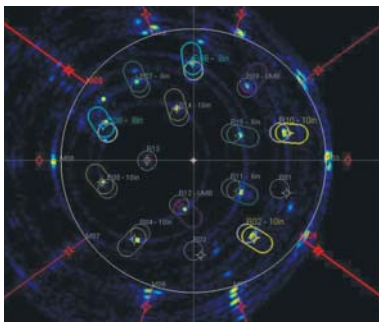
These shortfalls have lead to an increasing requirement for monitoring technologies to compliment periodic inspection.

Advantages of RAMS™ over other Anchor and Riser Integrity Monitoring Technologies

Advantages over Acoustic Positioning Technologies

In order to make positional measurements, assess curvature and measure strain, multiple acoustic transponders need to be fitted to each riser or mooring line. These may be fitted either during deployment or subsea using an ROV, or divers. Measurements are transmitted to the surface transceiver using acoustic telemetry. This technique requires multiple sensors to be fitted to each of the target lines, some or all of which are battery powered. An FPSO has many risers, umbilicals and mooring lines, in addition, sensors are often subject to adverse subsea conditions that may cause damage or loss, making the maintenance of such a complex deployment very expensive. The acoustic update rate of such a system is very slow compared to the real-time multibeam profiling technology at the core of the RAMS™ system which has an update rate of up to 30Hz, providing instantaneous position and movement data to <10mm resolution, raising alarms in real-time in the event of a range of problems.

Advantages over Strain Gauges, Accelerometers, Inclinometers, Curvature Sensors and Angle Rate Sensors



RAMS™ can be used as a supplement to many of these proven technologies and in some cases may be used as an alternative. Unlike many of these technologies, RAMS™ provides real-time imagery and status monitoring of the integrity of the mooring lines, umbilicals and risers, generating an alarm if the system identifies abnormal movement of the target. It also provides trending data that can be used for long term analysis. RAMS™ does not require sensors mounted to individual targets.

Advantages over Seabed Mounted Sonar Arrays

Seabed mounted sonars have been proposed as a methodology to measure the catenary shape and therefore tension of mooring lines and risers.

Although the upwards looking sonar technology exists, issues pertain to the deployment, recovery and maintenance of such a system in addition to the dilemma of how to transfer the sonar data to the surface.

Such sonars can only visualise some of the lines as the distance between each touchdown is often too large for the sonar to see all targets and measure their movement to the required degree of accuracy.

RAMS™ is able to record the real-time status and measure the positional movement of multiple targets in a 360° field of view. It can be deployed safely through an I-tube in the turret without any of the issues identified for a seabed mounted sonar array.

Customer Case Study

Using Tritech's RAMS™ to monitor the integrity of risers and mooring lines on the Petrojarl Foinaven FPSO

Customer Background

BP is one of the world's leading international oil and gas companies.

Teekay Corporation is an essential marine link in the global energy supply chain, serving the world's leading oil and gas companies.

Teekay's Petrojarl Foinaven FPSO is a deepwater oil development platform, operated on a BP deepwater oil field, within the UKCS (UK Continental Shelf), located approximately 19km (10mi) off the West Coast of Shetland in a water depth of 330 - 520m.

The Need for Mooring Line and Riser Monitoring

Teekay and BP, as an owner/operator partnership have paid significant attention to monitoring and maintaining riser integrity on the Petrojarl Foinaven FPSO.

RAMS™ has been developed in conjunction with BP, who had a requirement for an automated system able to monitor the series of bend stiffeners, umbilicals and risers on an FPSO. BP required a system that would record the relative movement of an FPSO's anchorage, providing a warning system should the movement fall outside the design specification.

Recognising the short falls of other monitoring technologies, we modified our proprietary multibeam sonar technology to a system that could provide a 360° field of view with the ability to detect multiple targets within close proximity of each other. In 2009, RAMS™ was installed on the Petrojarl Foinaven FPSO, where it continues to be in operation today.

The Challenge of the FPSO

The Foinaven FPSO has an internal turret, 12m in diameter with 14 riser slots of which 10 are currently in use, comprising 5 x 8" risers, 5 x 10" risers and 2 x umbilicals. There are 10 mooring lines which secure the FPSO to the seabed. The RAMS™ sonar head is deployed through an I-tube on a custom-designed deployment mechanism, at a predetermined depth, to ensure a clear line of sight to the 22 targets (10 risers, 10 mooring lines and 2 umbilicals). Electronic beam steering in the vertical plane is used at the time of installation to ensure an optimal return or acoustic reflection from the risers, mooring lines and umbilicals.

How it Works

The RAMS™ sonar head is controlled by the RAMS™ software which runs on a dedicated Surface Control Unit (SCU).

The RAMS™ software displays the known turret configuration as a background to the real-time sonar imagery. Acceptable levels of movement for the displayed targets are user definable, with any abnormal behaviour being easily identifiable. Internal and external alarms are generated when the target behaviour falls outside the defined scope of movement.

In addition to providing extremely accurate and robust real-time measurement and detection of riser or mooring line targets, all data is recorded and exported to allow for integrity trend analysis.

Measuring Success

Since installation, RAMS™ has proven to be 100% effective in its operation.

The quantity, accuracy and detail of the recorded data provides BP with the potential to conduct trend analysis.

A BP Representative, comments on RAMS™ effectiveness:
"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 need for corrective action."

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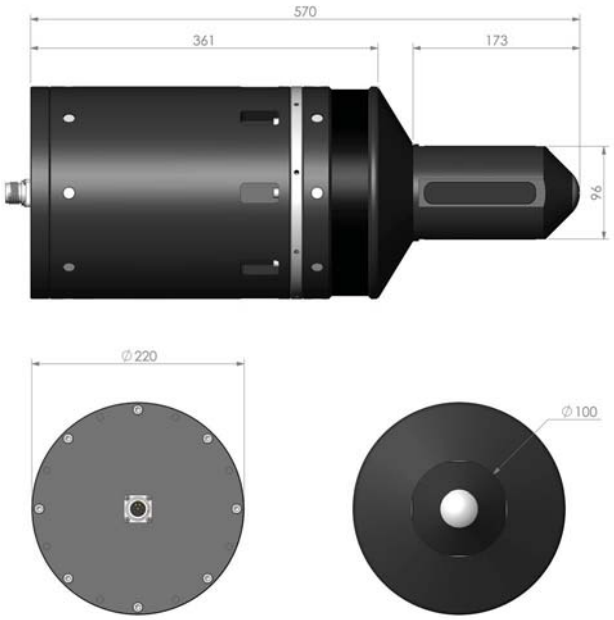
Standard Sonar Head Specifications



All dimensions are in millimetres

All specifications are subject to change in line with Tritech's policy of continual product development.

Operating frequency	240 kHz
Scanning sector	360°
Acoustic angular resolution	2.0°
Number of beams	768
Effective acoustic resolution	0.5°
Acoustic range	30m
Scan rate	up to 30Hz (range dependent)
Acoustic range resolution	37.5mm
Effective range resolution	<10mm (using software interpolation)
Power consumption	96W max
Supply voltage	20 to 28V
Comms	Ethernet (100baseT)
Depth rating	30m (98ft)
Weight in air	25kg (55lb)
Weight in water	9kg (19lb)

EDS-MLT-004.2

RAMS™ Software

Image showing RAMS™ software screen; here a simulation shows potential alarms in Riser Movement, Anchor Chain, Storage Low and Noise.

Example Software Warning and Alarm Functionality

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
Data recording storage

Marketed by:

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