

Protecting your Assets Return of Investment and Boosting Performance via **Reliability Centered Maintenance**

Customer Pre-Sales Consulting Services
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instrumentation & control

environmental control

naval engineering

marine ip communications

What Maintenance Strategy?

On-Sight Maintenance

Reactive Maintenance

Proactive Maintenance

Reliability Centered Maintenance

Predictive Maintenance

Preventive Maintenance

Maintenance Prevention

Why Advance Further our Maintenance Strategy?

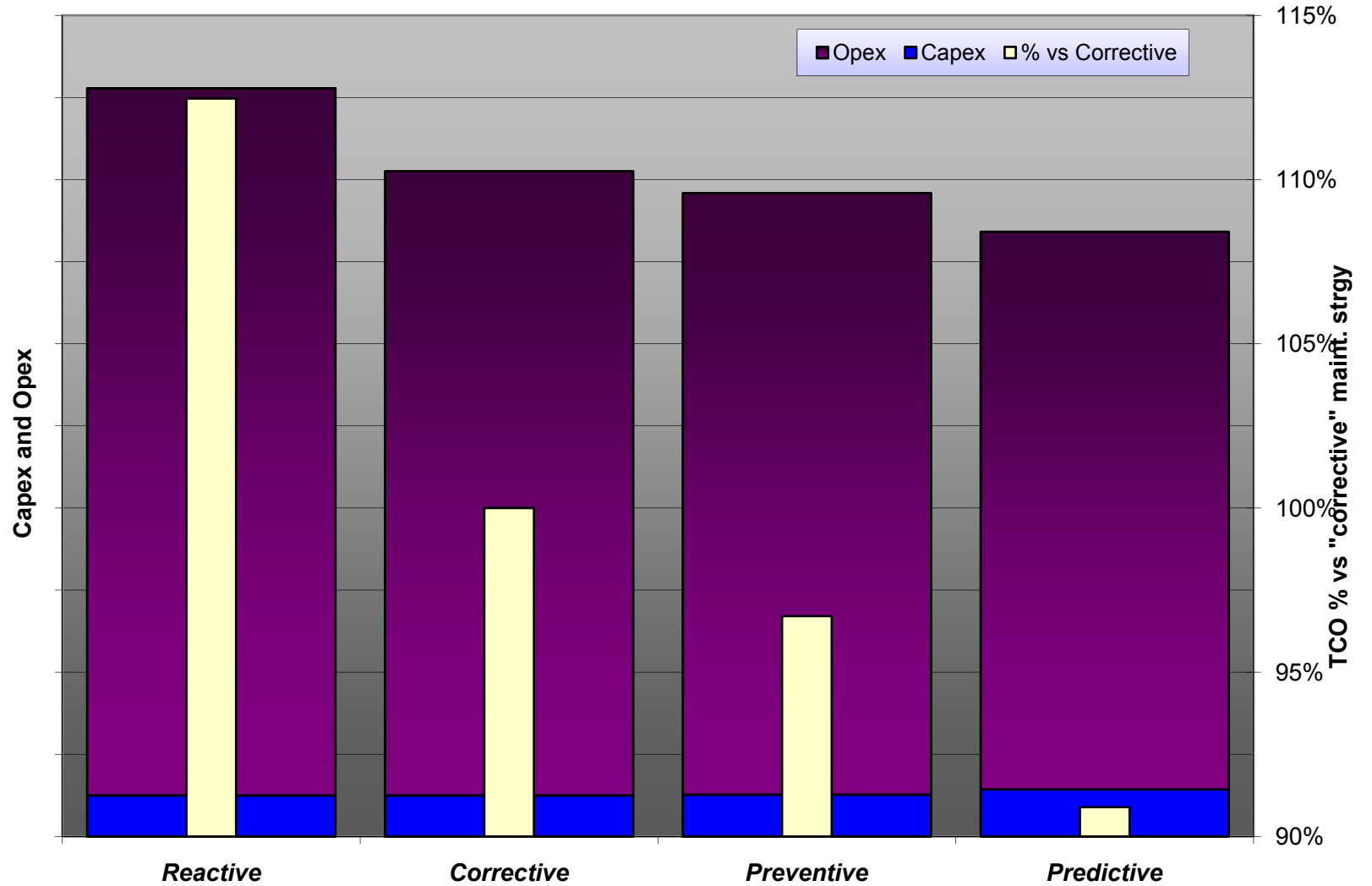
- Protect or even increase the return on investments by improving assets performance
- Increase assets lifetime; non compromising performance
- Decrease expenses
- Increase predictability on financial performance
- Reduce downtime duration and frequency
- Increase customers and shareholders satisfaction
- Build company culture and corporate quality
- Increase competitiveness

Gain over Total Cost of Ownership

**Medium to Large
Size Vessel**

TCO is the "Total Cost of Ownership" of the asset.

i.e. the Capex and the Opex over the asset lifetime

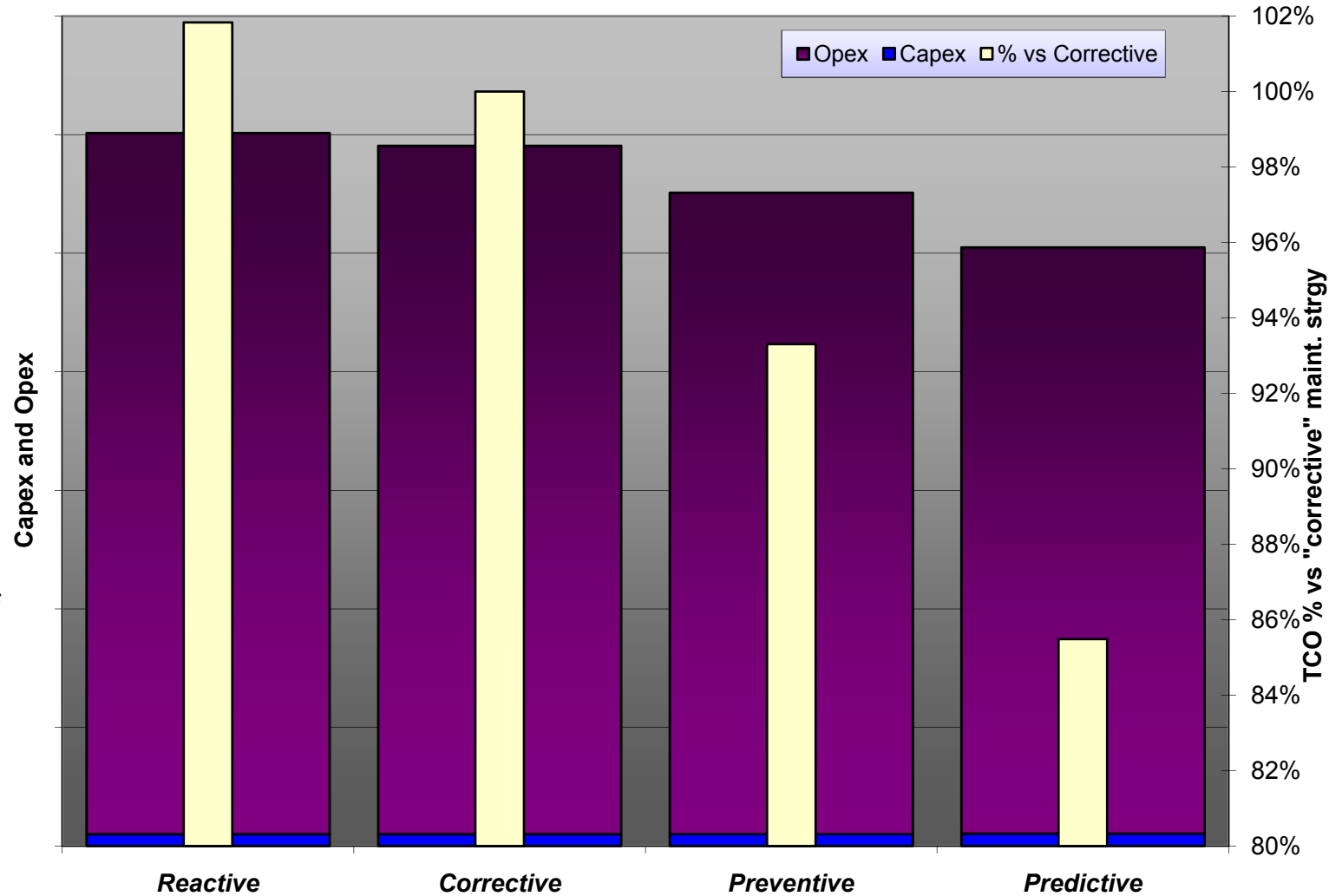


Gain over Total Cost of Ownership

**Very Large
Size Vessel**

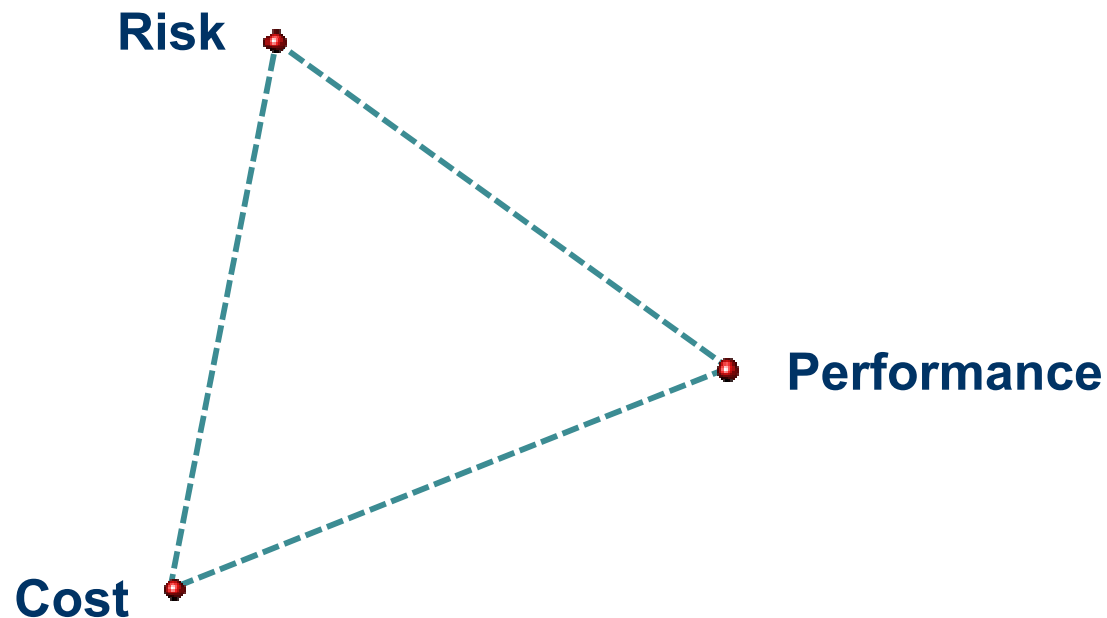
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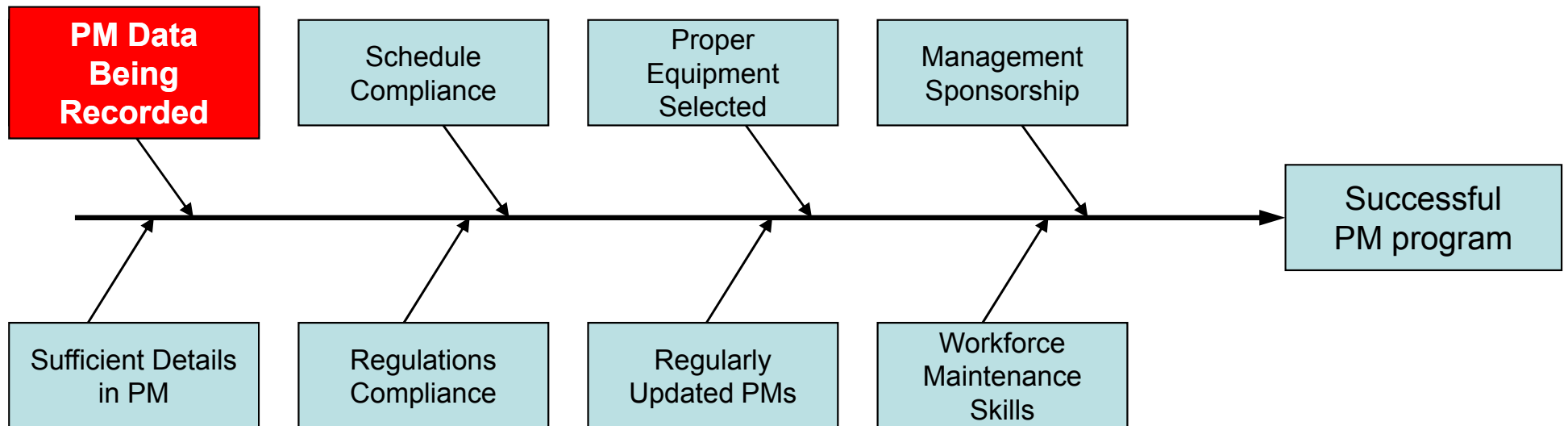
Reducing maintenance costs

- Cost is not a stand-alone variable
- It forms an inseparable part of a trilogy



Preventive Maintenance

- Preventive Maintenance (PM) is the foundation of the entire maintenance philosophy.
- PM key success contributors are:



Predictive Maintenance

- Predictive maintenance is the monitoring of equipment operating conditions to detect any signs of wear that is leading to a failure of a component.
- The goal of the predictive maintenance program is to track the component wear with a methodology that insures that any impending failure is detected at its early stages based on key indicators.
- Within the equipment operating dynamics, we may find the key indicators to use:
 - Ultrasonic
 - Vibration analysis
 - Oil analysis
 - Lubricant condition
 - Wear particles
 - etc.

Reliability Centered Maintenance

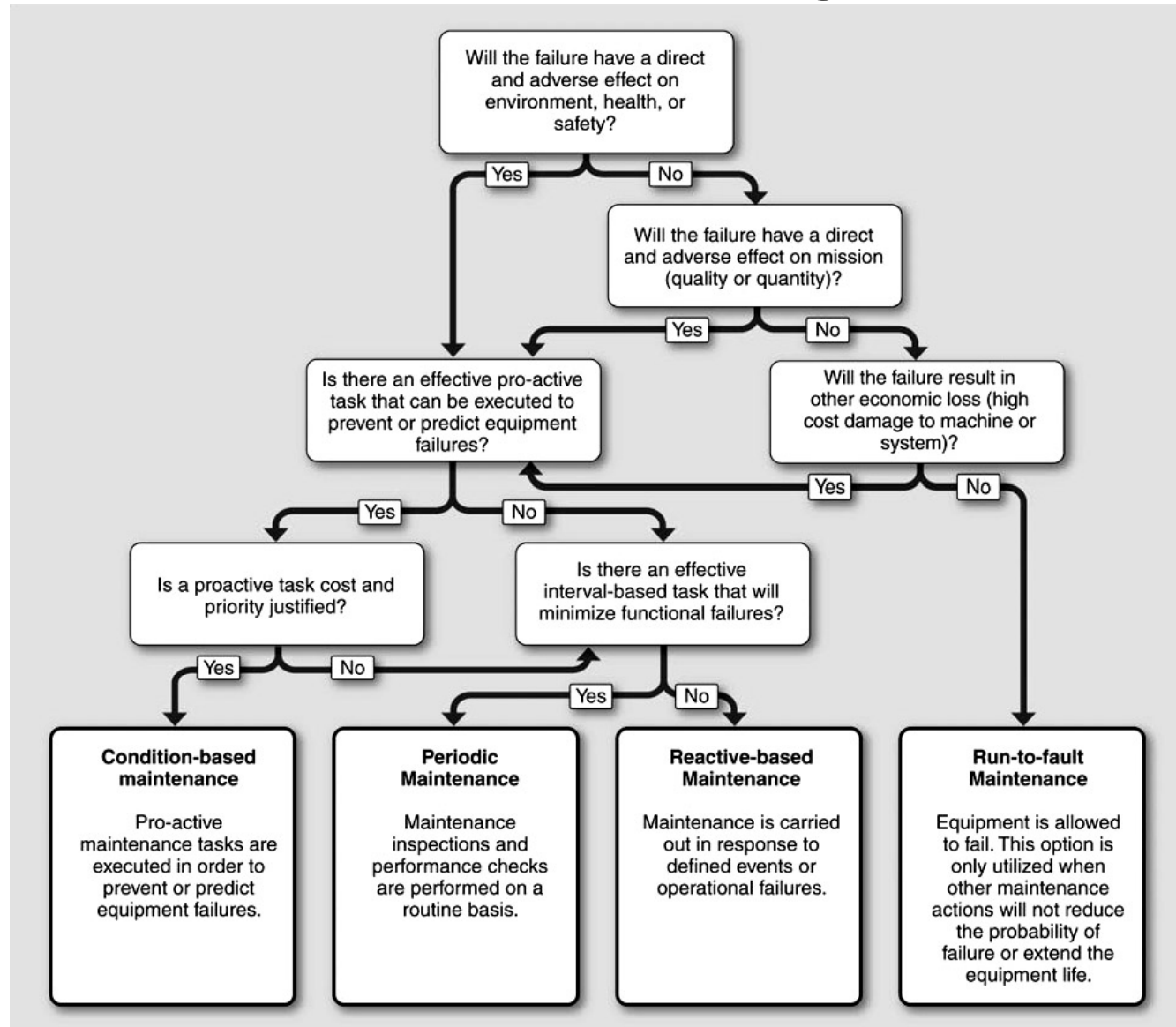
- Reliability Centered Maintenance (RCM) is an evolutionary approach to equipment reliability.
- It focuses on the **optimization** of the **preventive** and **predictive** maintenance programs to:
 - increase equipment efficiency, as:
 - Uptime
 - Performance
 - Quality
 - while, minimizing the related maintenance costs

Reliability Centered Maintenance

- Any RCM process shall ensure that all of the seven questions are answered satisfactorily and in the sequence shown below:
 1. What are the functions and associated desired standards of performance of the asset in its present operating context (functions)?
 2. In what ways can it fail to fulfill its functions (functional failures)?
 3. What causes each functional failure (failure modes)?
 4. What happens when each failure occurs (failure effects)?
 5. In what way does each failure matter (failure consequences)?
 6. What should be done to predict or prevent each functional failure (proactive tasks and task intervals)?
 7. What should be done if a suitable proactive task cannot be found (default actions)?
- To answer each of the previous questions “satisfactorily”, the information shall be gathered, and the decisions shall be made.
- All information and decisions shall be documented in a way which makes the information and the decisions fully available and acceptable to the owner of the asset

Source: SAE JA1011 "Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes referencing Message Specification

RCM Decision Logic Tree



Source: USA GAO FAA RCM Maintenance Process

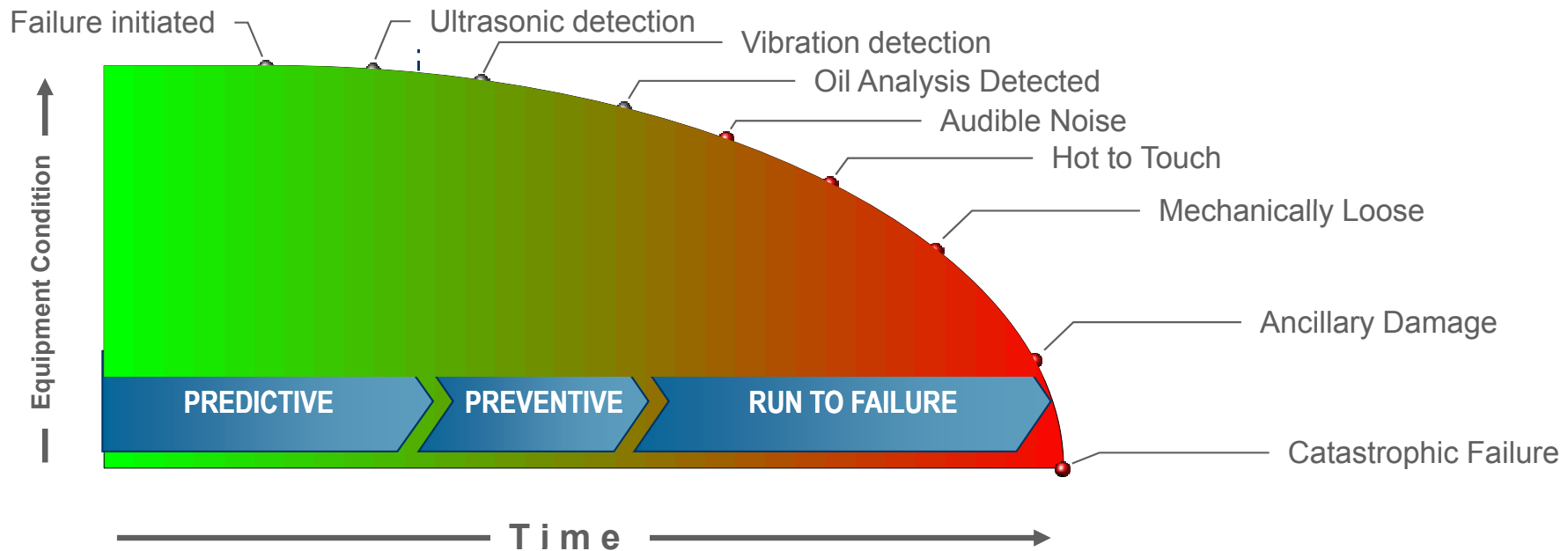
Maintenance Strategies and Early Failure Detection

On-Condition Maintenance Using P-F Interval or Failure Detection Threshold (FDT)

On-condition maintenance relies on the capability to detect failures before they happen so that preventive maintenance can be initiated. Many failure modes exhibit signs of warning as they are about to occur. If, during an inspection, maintenance personnel can find evidence that the equipment is approaching the end of its life, then it may be possible to delay the failure, prevent it from happening or replace the equipment at the earliest convenience rather than allowing the failure to occur and possibly cause severe consequences.

P-F curves and P-F Intervals

A common curve that illustrates the behavior of equipment as it approaches failure is the P-F curve. The curve shows that as a failure starts manifesting, the equipment deteriorates to the point at which it can possibly be detected (P). If the failure is not detected and mitigated, it continues until a "hard" failure occurs (F). The time range between P and F, commonly called the P-F interval, is the window of opportunity during which an inspection can possibly detect the imminent failure and address it. P-F intervals can be measured in any unit associated with the exposure to the stress (running time, cycles, miles, etc). For example, if the P-F Interval is 200 days and the item will fail at 1000 days, the approaching failure begins to be detectable at 800 days.

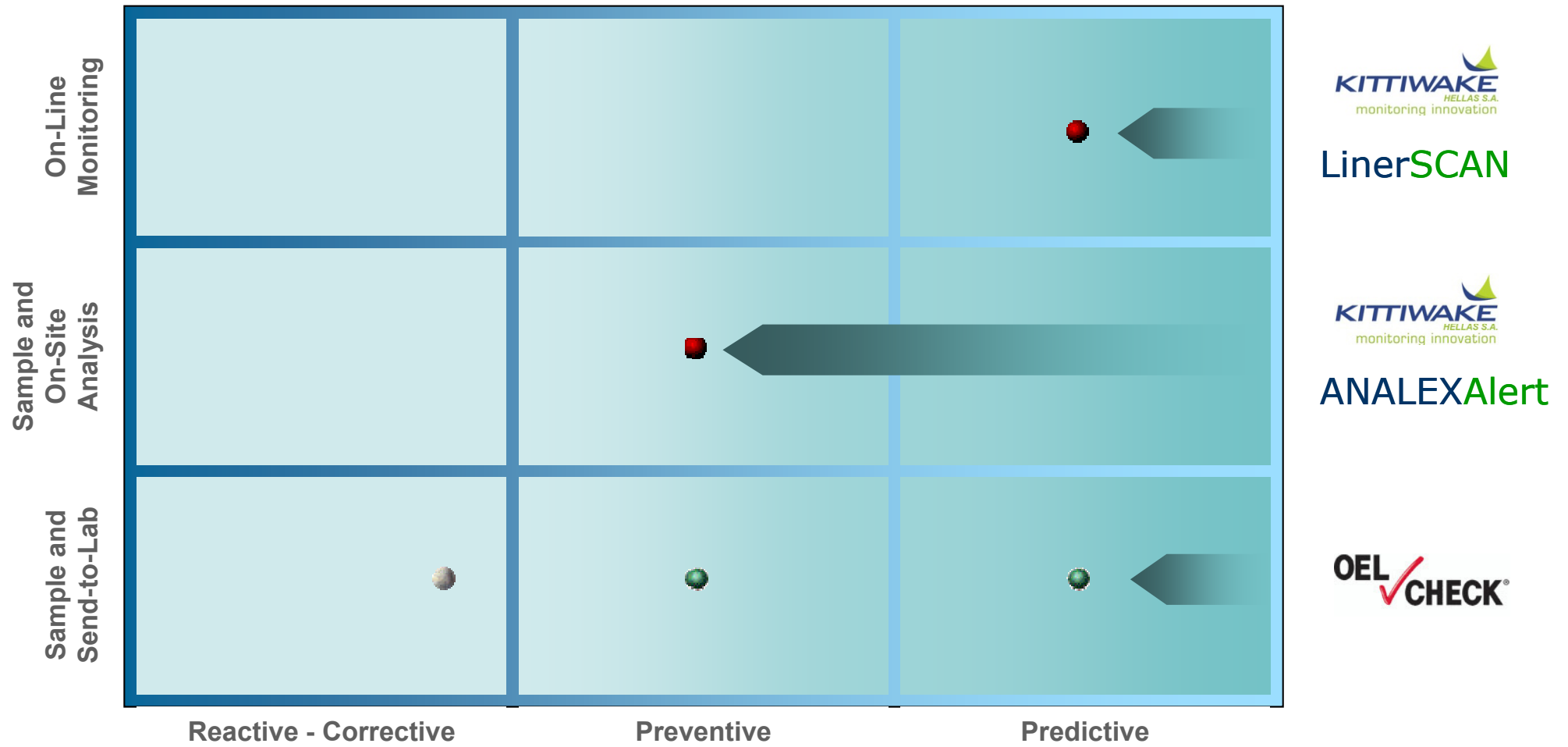


Oil Quality Analysis

an Early Warning to Equipment Failure

- Oil analysis findings are an early warning to equipment failure, and furthermore profile the wear root causes.
- To this direction oil analysis should cover the following dimensions:
 - Solid particle counts
 - associated with the root cause of system wear and additive depletion
 - Viscosity
 - Associated with determining either fluid dilution, incorrect lubricant or as an indicator of the lubricant's remaining useful life
 - Moisture
 - Preferably maintained below the saturation point to avoid additive damage and system corrosion
 - Total Acid Number (TAN) or in the case of diesel engines, Total Base Number (TBN)
 - Associated with the remaining useful life of the lubricant
 - Ferrous and Non-Ferrous metal level indication
 - Associated with the amount of wear metals in the lubricant
 - Temperature
 - Associated with lubricant damage, or incorrect system specification such as alignment problems

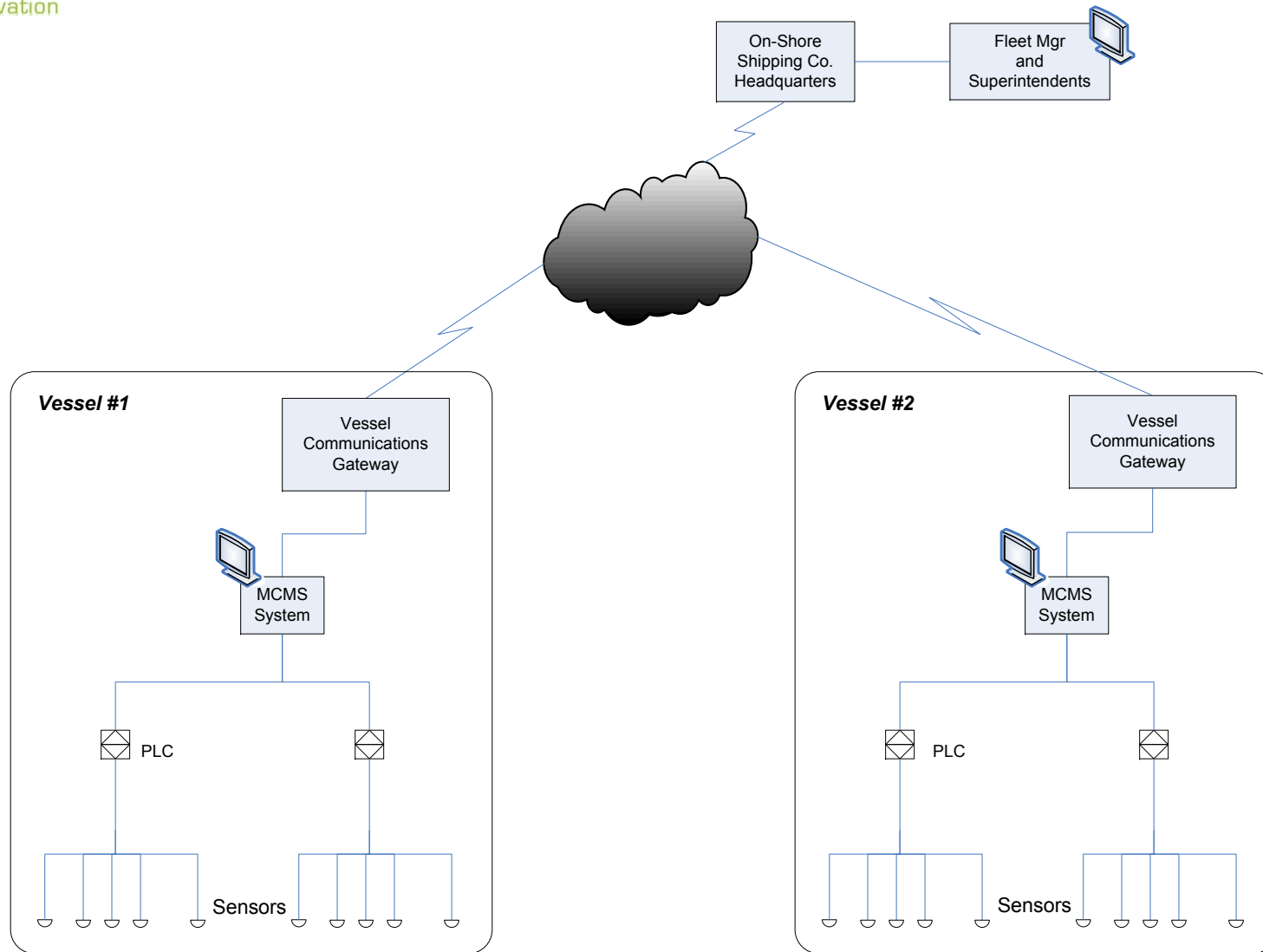
Oil Quality Monitoring Strategy



Next Generation Monitoring Today

- On-Line Sensors
 - What is measured where
- Data Aggregation
 - On-ship controllers and data aggregation on central operations system (computer)
- On-Ship Visual Monitoring
 - HMI displays and SCADA monitors On-Ship
- On-Shore Visibility and Alarm Escalation
 - Communication and synchronization with corporate H/Q
- Integration to the Enterprise Asset Management System
 - Integration to corporate EAM;
based on Asset Management PASS 55 standard (BSI PASS 55:2008)

The Complete Picture



Kittiwake Hellas your end-to-end partner in advancing your PM programme maturity level

- Assist you in Oil and Lubricants Lab analysis with root cause diagnosis
- Provide you with all equipment and training required to insure high quality Water, Oil, and Lubricants in-depth analysis on-board
- Upgrade your engines with on-line sensors, for continuous monitoring of Water, Oil, and Lubricants
- Enhance your monitoring quality with supervisory computer-based visual workstations on-ship
- Connect corporate H/Q with IP Satellite communications, enabling integration to corporate ERP system, Enterprise Asset Management subsystem

High integrity sealing, using standard automotive techniques.

Internal processing power offers wide interface options.

Stainless steel housing - rugged and long life performance

Widely used 1/2" BSP thread - quick and easy installation to a wide range of machinery

Gold oil sensing contact - long life and sensitivity



The Kittiwake Sensors Suite

instrumentation & control

environmental control

naval engineering

marine ip communications

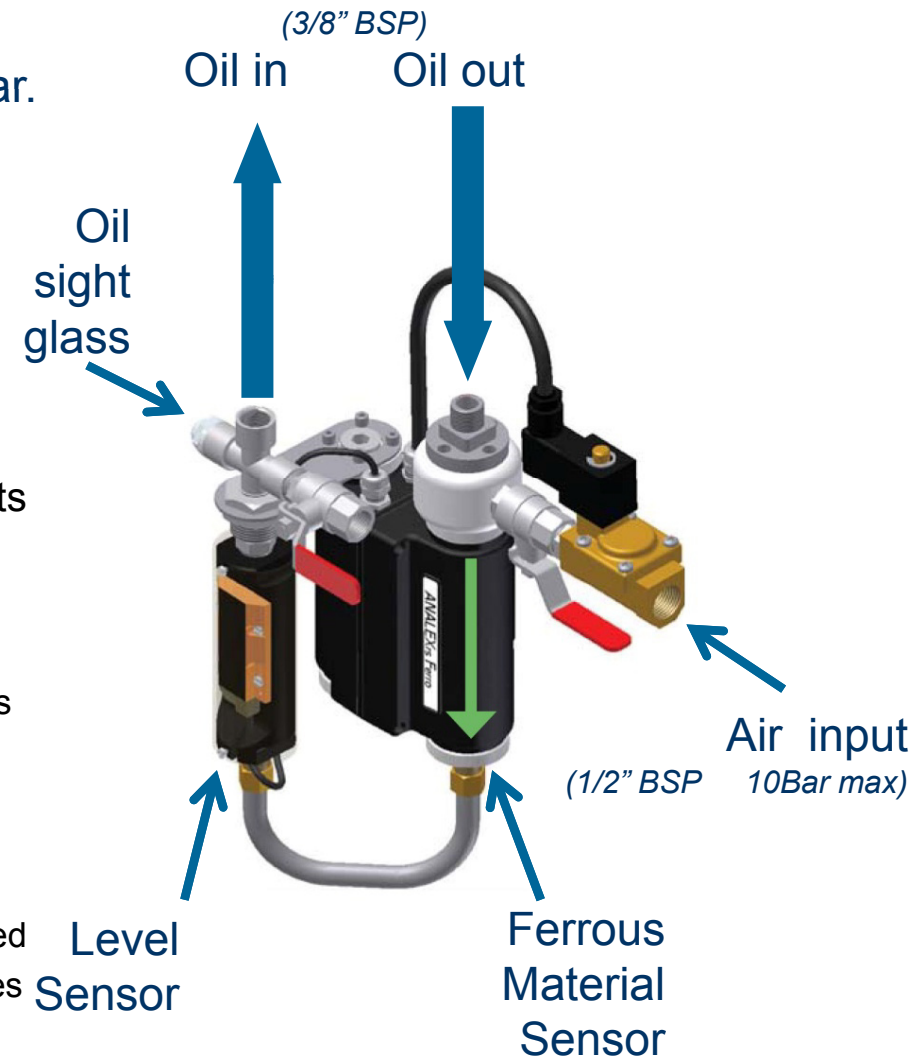
Kittiwake Sensors LinerSCAN

The world's first real-time alarm system for engine liner wear. LinerSCAN marks a new era in asset protection, providing early warning against critical damage whilst providing information needed to save on lube oil costs.

LinerSCAN measures the amount of iron in cylinder lubricant by a method known as magnetometry, where a sample is tested in a magnetic field. Utilising a novel shielding method the system exploits a fundamental physical effect namely the change inductance due to the presence of a magnetic material.

Analyzing the scavenging air space drain oil from each cylinder for iron (Fe) has been proven to give operators an indication of relative changes of cylinder liner wear. At very early stages, the sensors reported the onset of severe wear and other engine problems such as cat fines in the fuel.

The system will also highlight periods where the engine is subjected to increased stress levels and indicate changes in iron levels caused by imbedding processes and increases in wear caused by routine inspection.



Kittiwake Sensors WaterSCAN

Water and oil don't mix! Even so, water is the most common contaminant in lube oil samples and causes a multitude of problems.

WaterSCAN provides real time, high accuracy online measurements of total water and soot levels in oil.

The presence of water alters both chemical and physical properties of the oil. Changes to viscosity, lubricity, stability and additives affect the oils ability to lubricate, provide power and protect machinery. This decrease in oil quality can rapidly lead to problems such as rust, corrosion, sludge formation, and bacterial growth. These issues increase downtime, decrease efficiency and ultimately end in critical failure of the plant or machine.

Detection Ranges:

Water only (clean oils):	0 – 20,000 ppm, (0 – 2% by volume)
Accuracy:	+/- 2% w/specific oil calibration (+/- 5% by oil type only)
Soot only (dirty oils):	0 – 10,000 ppm, (0 – 1% by volume)
Max water level in dirty oils:	
For 0.5% soot content -	10,000 ppm by volume
For 1.% soot content -	500 ppm by volume.



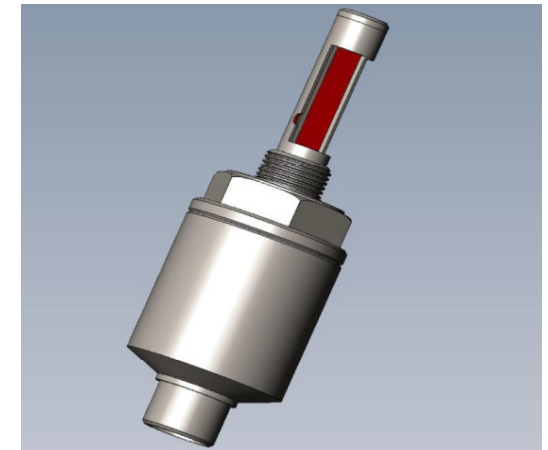
Kittiwake Sensors ViscoSCAN

Viscosity is the most important property of lubricating oils and is fundamental to providing optimum film strength with minimum frictional losses. Oil at the correct viscosity will prevent metal-to-metal contact, eliminating scuffing, and reduce microwelding and wear of machine surfaces.

ViscoSCAN provides real time, high accuracy online measurements of oil's viscosity. Using a solid state method of analysis and a smart module to calculate and provide graphical results, this sensor can be a critical informative part of any condition monitoring program.

Detection Ranges:

Absolute Viscosity range:	1 – 1000cP
Accuracy:	+/- 2% of reading or +/- 2cP whichever is greater
Temperature Measurement Range:	-40 to +150°C
Temperature Accuracy:	+/- 1°C
Outputs:	
Available outputs:	Measured viscosity in centipoise, Oil temp in Celsius
Digital:	CAN open, RS-232
Analogue:	4 – 20mA X 2
Approvals:	CE, UL



Kittiwake Sensors Oil Condition Sensor

The Oil Condition Sensor goes beyond the normal protection systems; it monitors the root cause of lubricant and machine failure. It puts you in control, by knowing exactly when to change the oil based on condition, not on historical schedules.

This sensor goes beyond the normal hand-held field go/no-go units to offer permanent mounting. Providing both check on water ingress and oxidation levels, now you can monitor real-time, and take immediate action on the first indication of change, before any harm is done to the machine oil.

The sensor detects changes caused by water and acid levels, using a combination of proven dielectric sensing, combined with smart algorithms to provide a trend.

High integrity sealing, using standard automotive techniques.

Internal processing power offers wide interface options.

Stainless steel housing - rugged and long life performance

Widely used 1/2" BSP thread - quick and easy installation to a wide range of machinery

Gold oil sensing contact - long life and sensitivity



Kittiwake Sensors Moisture Sensor

The Moisture sensor goes beyond the normal water screening tests to tell you exactly how dry your oil is. You know that the most severe moisture ingress problem, the greater the potential risk. You can ensure that your oil is always below the saturation point before free and emulsified water starts to form.

It is known that free and emulsified water cause problems. However most important is the direct increase in the oxidation rate of the lubricant by more than ten times. Bearings could lose 75% of their service life due to water, before the oil begins to start looking cloudy. Even when dissolved the water is at work, attacking the base stock, the additive package, and the machine itself. Plus, water can carry organisms with it, that could disable your critical hydraulic systems

Providing a % Relative Humidity (RH) and temperature values, now you can monitor in real-time.

The sensor can be mounted within any lubrication system on any type of machine. Moisture sensors need not be in the fluid to be effective. They can be positioned in the headspace of a piece of machinery. The sensor measures the oil's percentage RH, resulting from the dissolved water within the lubricant, using a combination of proven thin film capacitance sensors, combined with smart algorithms to provide a temperature and %RH value.

You will make informed maintenance planning decisions, whether it is to check the health of your machine, or it is an alert of changing moisture ingress rates.

High integrity sealing, using standard automotive techniques.

Widely used 1/2" BSP thread - quick and easy installation to a wide range of machinery

High pressure resistant glass to metal hermetic seal

Stainless steel housing - rugged and long life performance

Smart sensor with internal processing power offers wide range of interface options

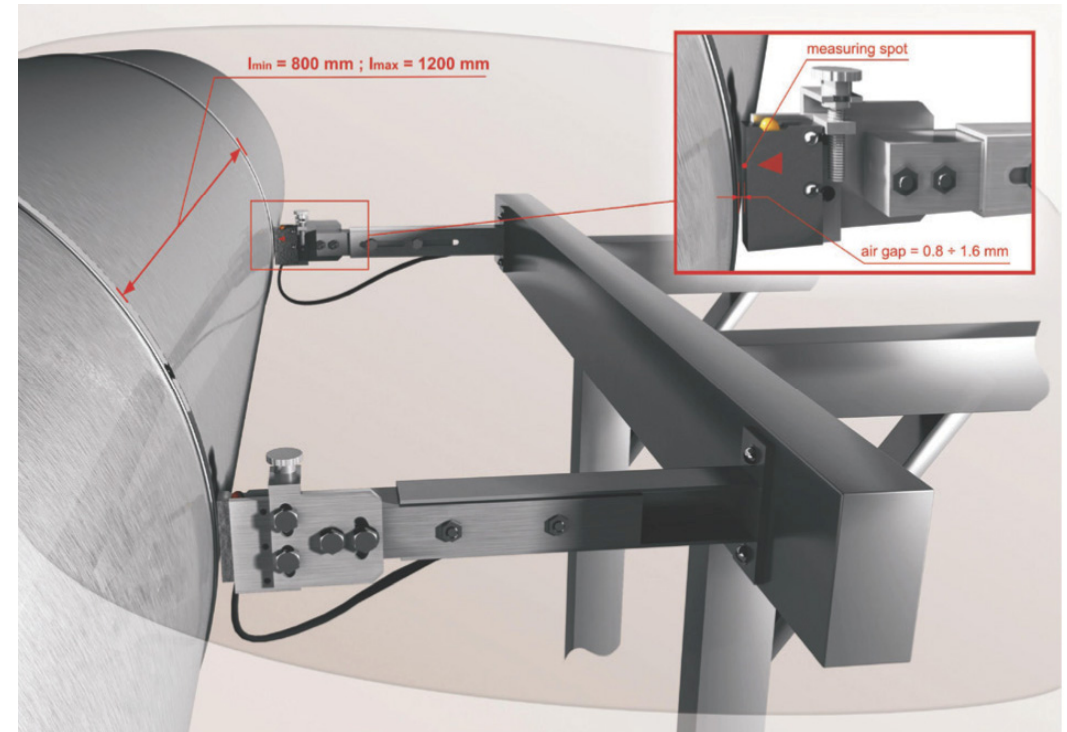


Kittiwake Sensors Torque Meter Sensor

Kittiwake's Torque Meter calculates the actual power output of a ship's propulsion engine, using a contact free method and without the use of strain gauges; this ensures a quick and easy installation and long product life without requiring regular servicing or engineer visits.

The system provides:

- Permanent torque and power display
- Remote display with 2 X 16 LCD
- Optional integration with LinerSCAN system to optimize the cylinder oil feed rate
- Ethernet or USB interface to a PC for quick calibration
- Contact-free sensors
- Simple enough to install, calibrate & maintain without factory service
- Easy to operate
- Shaft diameter 200 – 1000 mm
Other sizes on request



More Sensors...

To complete the picture of an on-board Integrated Monitoring, Alarm and Control System, it is also required a variety of more sensors, less specialized categories than those presented in the previous pages.

They are:

- Temperature sensors – mainly PT100 sensors for the lower temperature range, Thermo Couples for the high temperature range (200°C and above).
- Pressure transducers
- RPM sensors
- Speed sensors
- Heel and trim sensors (inclinometers)
- Flow meters
- Level meters
- Strain gauges
- Accelerometers – vibrations, pounding

More Vessel Subsystems...

beyond the preventive maintenance

By feeding the on-board **Integrated Monitoring, Alarm and Control System**, with real-time data from a multitude of on-line sensors, a number of vessel subsystems or operations can be assisted or even automated to a great extend.

Typically:

- Main engine monitoring, alarm and control
- Power generation subsystem monitoring, alarm and control
- Fuel efficiency (including bunkering management)
- Tank level gauging, cargo control
- Stress and stability

Your partner in this business...

We are always prepared to:

- **discuss** your needs
- **assist** you in planning forward a best practice implementation scheme
- Size and **configure** system alternatives, under fair cost approach
- Be flexible and **adaptive** to your own way of managing your fleet and the new builds operations



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Thank you



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