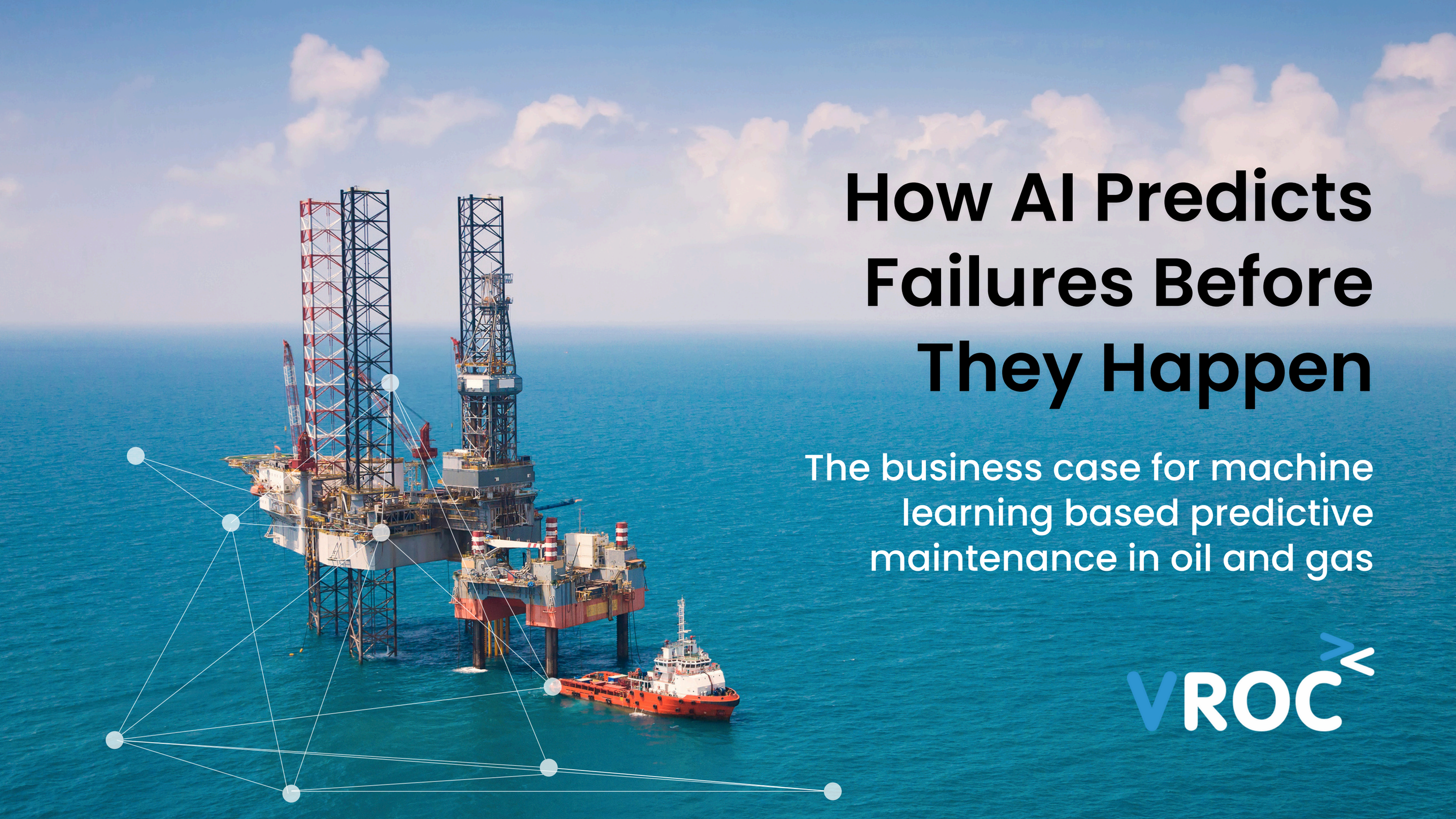


How AI Predicts Failures Before They Happen

The business case for machine learning based predictive maintenance in oil and gas

VROC

Executive Summary

Unplanned downtime remains one of the biggest challenges for oil and gas operators — with the average plant losing around 27 days of production each year, costing up to USD 38 million annually. Despite decades of progress in maintenance practices, most operators still react to problems only after they occur, or rely on scheduled maintenance that doesn't address real-time risk.

Artificial Intelligence (AI) and Machine Learning (ML) now make it possible to predict equipment failures days or even weeks before they occur. By continuously learning from plant data — sensor readings, process parameters, control system logs, and maintenance records — AI models can detect subtle deviations long before threshold alarms are triggered.

This whitepaper explains:

- How AI predictive maintenance works in real-world operations
- The difference between traditional and AI-driven approaches
- Proven results achieved by oil and gas operators using VROC.AI

The Hidden Cost of Downtime

Every hour of unplanned downtime ripples across the value chain — lost production, emergency maintenance costs, safety exposure, and regulatory penalties.

Maintenance teams know the pain:

- **Aging assets** prone to failure and corrosion
- **Data overload** from modern plants with too many sensor streams
- **Lean workforces** stretched thin across remote operations
- **Siloed systems** that hide relationships between causes and effects

AI bridges these challenges by turning raw plant data into continuous, real-time insights.

Downtime Facts

- *Single hour of downtime costs oil and gas facilities nearly $500,000.*
- *Unplanned downtime of Fortune Global 500 Industrial organizations costs $1.5 trillion per year.*
- *1% of downtime (3.65 days) leads to annual losses in excess of $5 million*
- *Upstream operators have an average of 27 days of unplanned downtime per year, resulting in $38 million in costs.*
- *Unplanned maintenance accounts for 20% of operational budgets.*
- *Only 18% of assets have aged-related failure patterns, limiting the effectiveness of time-based preventive maintenance*

IoT Analytics reported that in the period between 2021 and 2024 IoT adoption use cases for Quality Control & Management grew by 25%, driven by the ability to use data to detect and correct issues before they arise.

From Reactive to Predictive: A Shift in Maintenance Thinking

Traditional condition-based systems rely on predefined limits — a pump vibration threshold, or a temperature ceiling. But by the time the limit is crossed, the failure is already in motion.
AI models detect the *pattern leading up* to that event, giving teams days or weeks of advance warning.

Maintenance Type	Description	Typical Outcome
Reactive	Run to failure, then repair.	High cost, unplanned outages, safety risk.
Preventive	Time or usage-based maintenance schedules.	Unnecessary interventions, wasted effort
Predictive (Rule-Based)	Uses fixed thresholds and condition monitoring to raise alerts	Limited accuracy (~20% of anomalies detected)
Predictive (AI-Driven)	Uses ML models trained on historical and live data to detect early deviations	High accuracy, early intervention, continuous learning

Table 1. Comparison of Maintenance Methods

Image 1. Example of high level Plant dashboard, displaying AI predicted performance for key systems

This gives me confidence that my equipment is working and we are on top of our maintenance.
Maintenance Superintendent, North Sea

How AI Predicts Failures Before They Happen

Data Driven Parameters Deviation

In real time, machine learning models learn from normal behaviour and predict sensor values at each point in time. When the actual data diverges from the models prediction, AI flags an anomaly — often long before it breaches any set threshold.

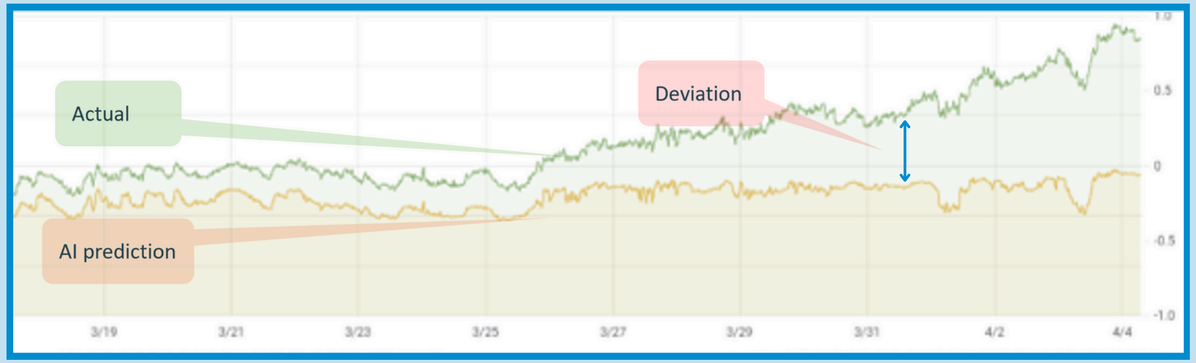


Image 2. Graph showing the deviation between actual sensor values and AI predicted values. The AI model continuously predicts what the value should be. When the actual value deviates from the expected value, this is considered a deviation. The AI model then calculates the impact of this deviation, alerting teams as necessary.

Time to Failure Predictions

Machine learning models study anomalies in historical data from across the facility: sensors, SCADA, ERP, and CMMS records. They learn how each asset behaves under varying loads, temperatures, and pressures. They apply this learning to live plant data, mapping the transition from normal to abnormal, predicting time to failure, providing teams with advanced warning and lead-time.

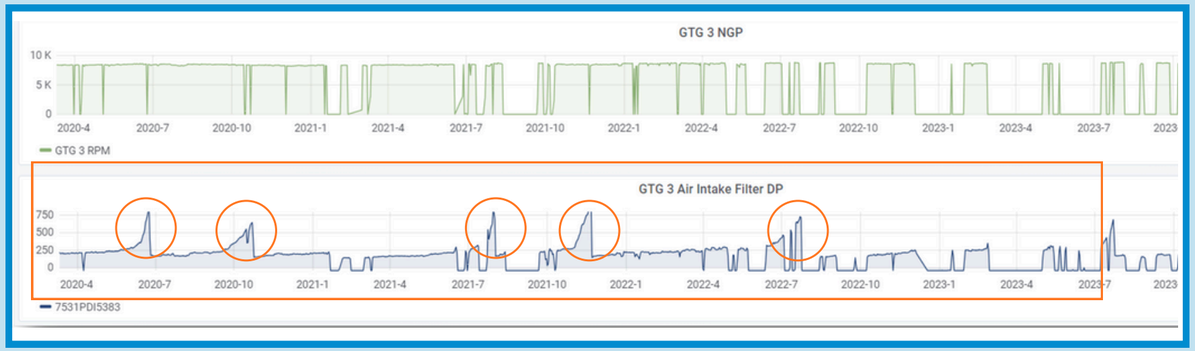
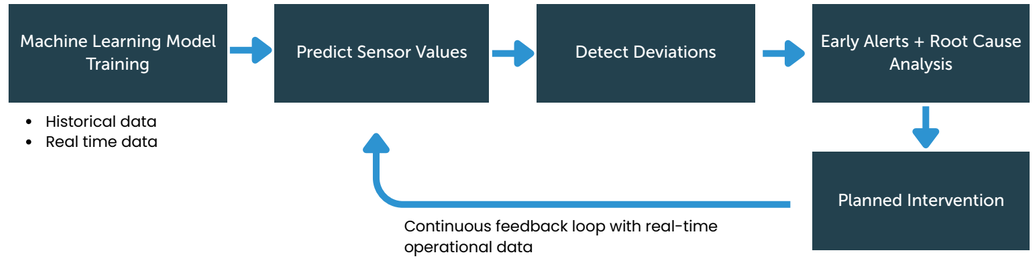
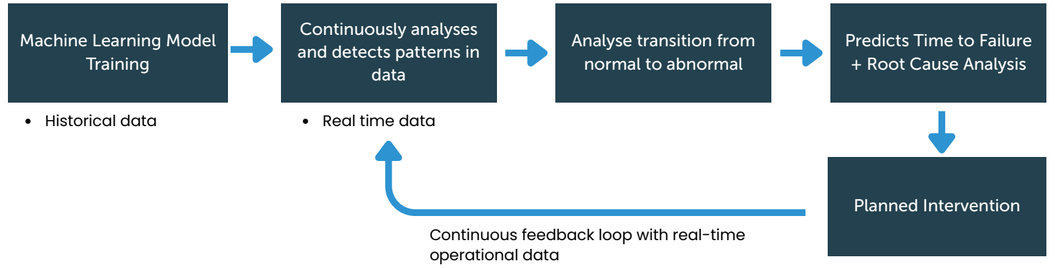


Image 3. Example of historical training period for a Gas Turbine Generator. The training period included five historical anomalies.

Machine Learning Process - Deviation Model



Machine Learning Process - Time to Failure Model



Identify Root Cause and Contributing Factors

Because VROC.AI models analyse the whole process, not isolated components, they detect interdependencies — for example, how pressure changes upstream may predict compressor issues downstream.

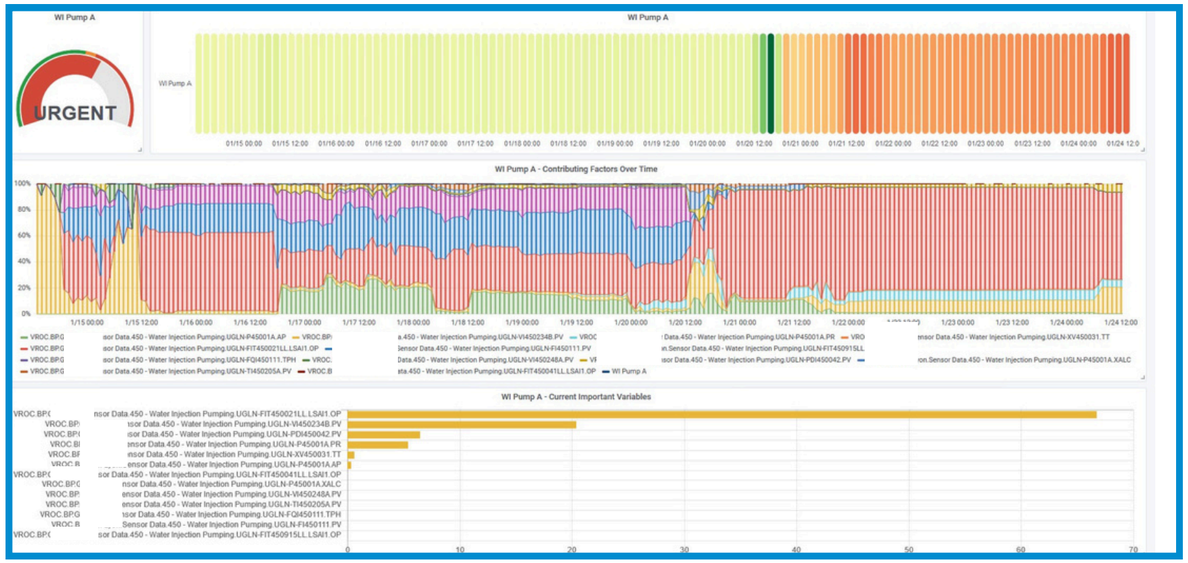


Image 4. Mapping contributing factors over time for a prediction. The important variables are listed in order of priority, providing teams with critical insights to direct maintenance efforts and interventions.

Continuous Feedback Loop

After maintenance is completed, the models refresh automatically. If work is successful, readings return to normal; if not, AI highlights persisting deviations or failure prediction, ensuring reliability teams close the loop.

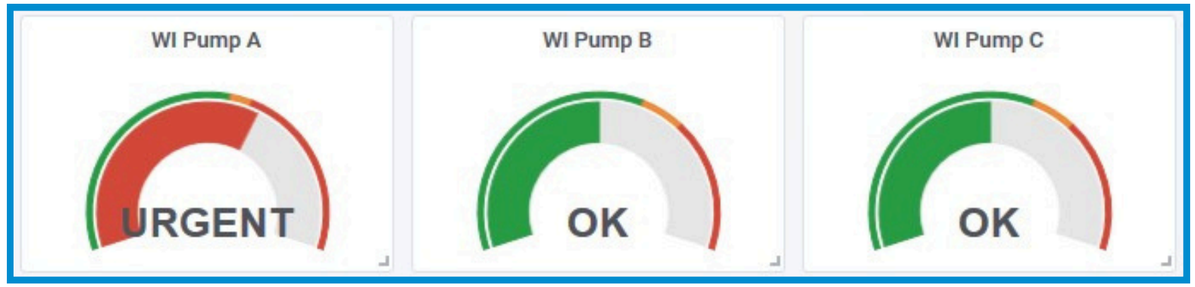


Image 5. Showing an urgent issue on Pump A

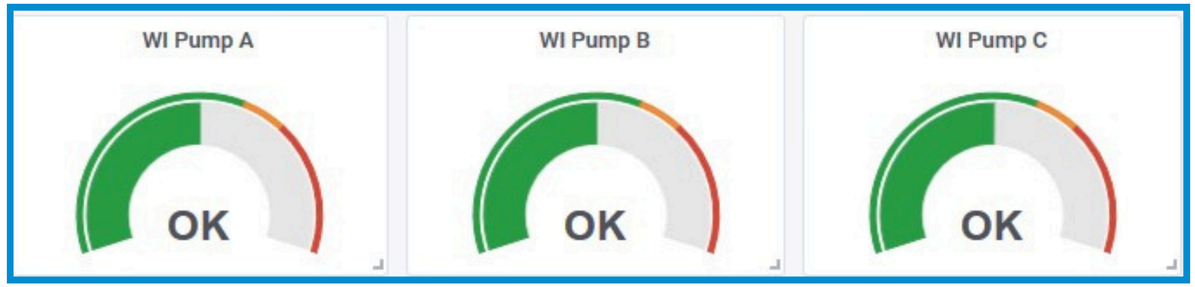


Image 6. Following maintenance, the AI models predict future condition. Pump A is now considered healthy with no issues predicted.

Predicting faults despite lack of sensor data:

An urgent fault was predicted on a turbine generator on an offshore platform, resulting from an undiagnosed cooling issue. Despite lack of vibration sensors at the fan level, the outcome of failing fan belt manifested as isolated high temperature in turbine enclosure implying cooling deficiencies. The offshore team were able to intervene and bring online another generator with full availability, preventing a site blackout.

Image 7. High level dashboard. Insights from 65 live AI models running in parallel.

Image 8. Turbine generator temperature tags summary health map.

Holistic modelling for improved fault detection

VROC's AI solution learns from a broad data field to identify seemingly un-connected processes and inter-related problems. Finding contributing factors and root causes.

This is different to modelling of a single asset or equipment type, which can misdiagnose a root cause, leading to unnecessary maintenance and higher costs.

VROC's solution ingests data from the whole operation. It is designed to be interoperable with legacy systems, easily digesting data directly from PLCs, DCS, ERPs, CMMS, APM, ICSS, SCADA and Historians.

In the case of VROC AI when we deployed in Dulung offshore, in a span of 2 years we recorded close to $24 million USD worth of cost avoidance, that is money well spent when we can avoid future cost to our operations.

Head of Innovation, Malaysia

Predictive Insights In Action

Early Detection on a New FPSO Asset

Two years of historical data from 30 000 sensor tags were ingested into the VROC platform. Models were trained using relevant parameters, detecting a deviation on a Produced Water Pump. The root cause — a leaking non-driven end mechanical seal — was identified **five days before failure**, enabling a controlled change-over and avoiding a full production loss.

Estimated value: Up to £1M if not caught in time for trip and restart.

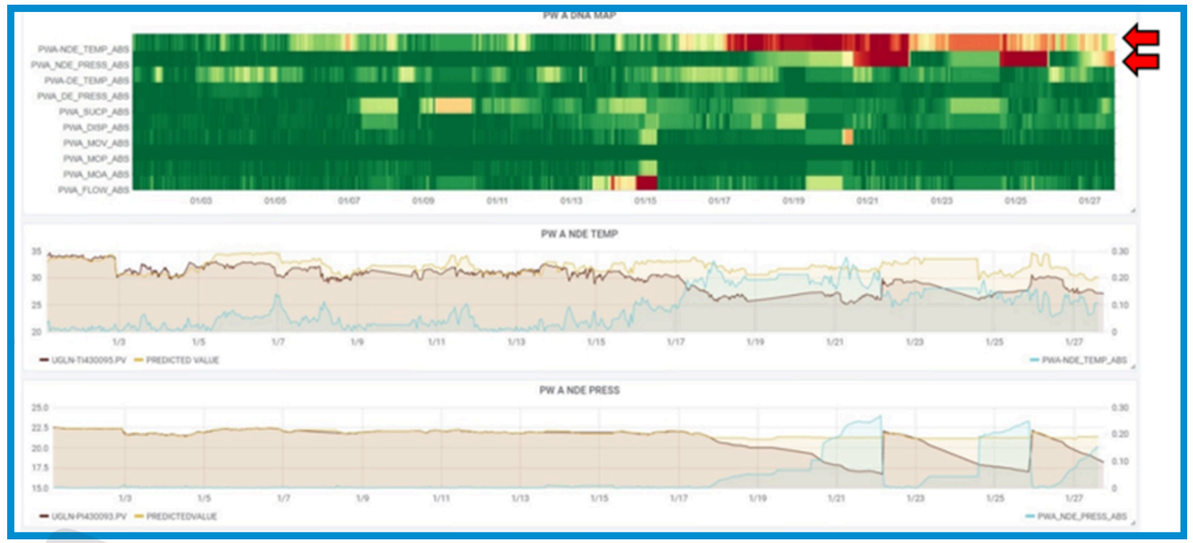


Image 9. Produced water pump A seal leakage failure. Arrows indicate components showing degradation over time worsening.

Root Cause Analysis for Recurring Asset Reliability Issue

An offshore platform suffered with a recurring asset reliability problem with its Gas Compressor. Over two years internal and external experts were unable to identify the root cause. AI models were trained on 12 months of operational data identifying a list of contributing factors, including an incorrect operating mode. The engineering team were able intervene and extend the assets reliability, resulting in improved production.

Estimated value: $21.7m USD from asset uptime improvement

Image 10. Showing a list of contributing factors by order of priority

AI identified 22 possible problems in ten minutes, allowing us to prolong the gas compressor reliability to four months, from a maximum of 2 weeks, to a value of 21.7m USD.
Head of Offshore Operations, Malaysia

The ROI of Predictive AI in Oil and Gas

	Metric	Result	Client Example
	**Reduced Unplanned Downtime**	Early detection and alert to deviations allow operations teams to intervene to avoid unplanned downtime.	Operator saved USD 21.7 million in four months by increasing uptime and reliability of its Gas Compressor. more
	**Improved Maintenance Planning**	Early alerts enable safe, cost-effective scheduling and reduced freight/logistics costs.	AI alerts offshore team to Produced Water Filter clogging events, advanced warning allows for scheduling of change out and inventory management. more
	**Lower Spare-Parts Inventory**	Precise fault identification decreases stock holdings and wasted purchases.	Singapore operator was able to reduce spares holding by 50%. more
	**Efficient Manpower Utilisation**	Teams focus on high-impact tasks, not false alarms.	North sea operator mobilises technical maintenance personnel with correct spares, maintaining asset integrity and performance, whilst limiting offshore headcount. more
	**Safer Remote Operations**	Reliable insight supports offshore and remote monitoring.	AI identified the root cause of a loss of a primary containment, avoiding a site shutdown and safety incident. Leakage avoidance saved $1 million USD. more
	**Sustainability Gains**	Stable operation reduces flaring and emissions.	SEA operator increases flaring compliance from 50% to 100%. more
	**Extended Asset Life**	Continuous monitoring prevents wear accumulation and identifies optimal operating bands.	AI identified an unknown critical speed band on a gearbox at a North Sea platform. The team were able to reduce the pumps speed, while waiting for replacement parts. Extending the life of the existing component. more

Summary

Machine-learning predictive maintenance is transforming how oil and gas companies manage reliability.

By predicting failures before they happen, operators gain the twin advantages of **time and insight** — the ability to act early, reduce cost, and operate safely.

AI doesn't just predict failures — it prevents them.

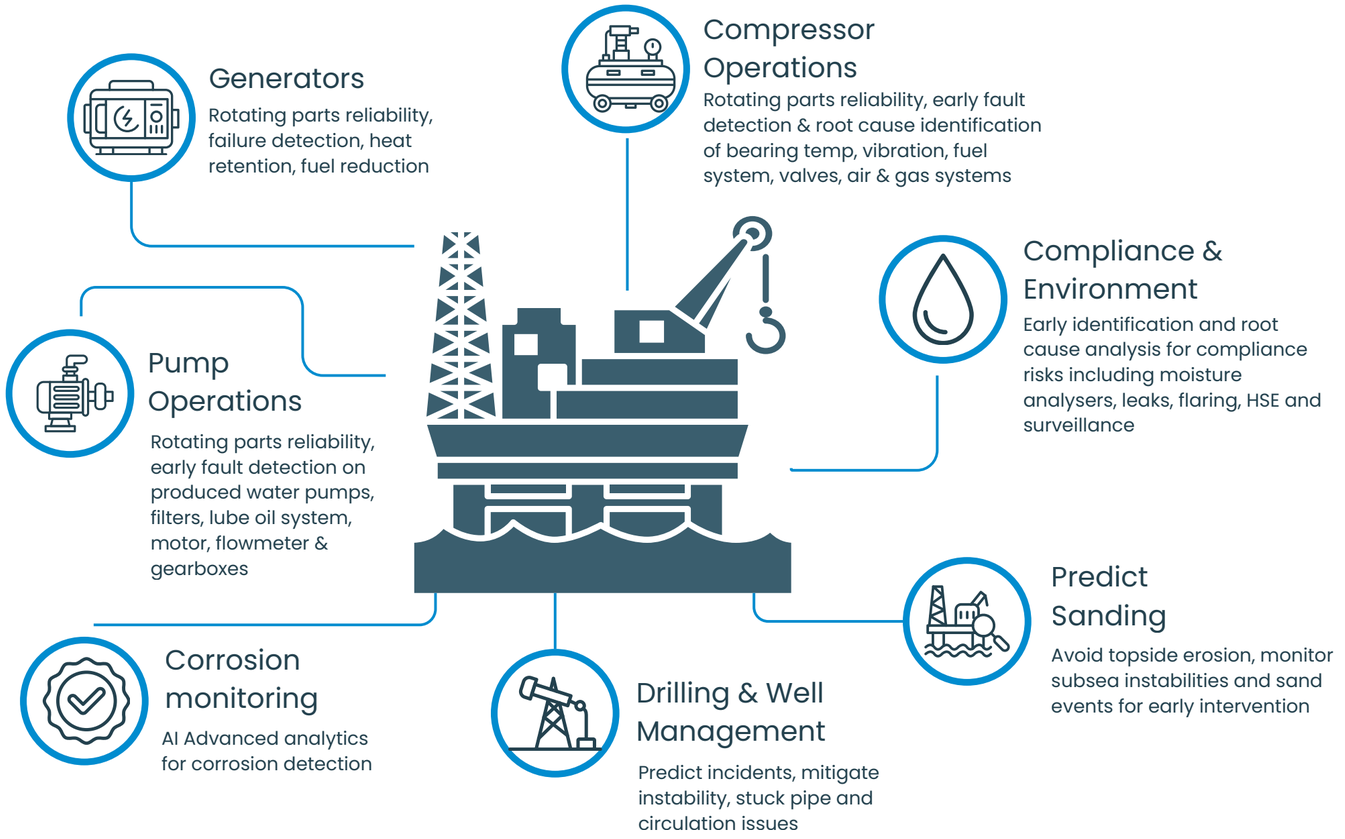


Image 11. Diagram showing the systems that can benefit from AI on an offshore oil and gas platform

[BONUS] Getting Started:
What You Need for AI Predictive Maintenance

Historical time-series data
VROC typically recommends 2 years historical time-series data if available.

Known failure events or maintenance logs
These help with model training.

Connectivity to live data feeds or existing systems
Data can be ingested directly from sensors or from existing systems. We recommending connecting all data sources, for comprehensive AI analysis.

Subject matter expert review for verification
Engineers and subject matter experts will review AI insights and alerts, providing contextualised information, making informed business decision.

Readiness to incorporate AI predictions into daily processes
Incorporating AI dashboards into daily process provides teams with continual data insights for improved decision making

Let everyone use, don't restrict to any process engineer or operation engineer, let everyone use it. Because the beauty of this is that it will open the eyes of the importance of artificial intelligence in Oil and Gas.
Head Strategy & Performance Health Safety & Environment, Gas and New Energy, SEA

Why Choose VROC

No-Code AI Platform

- No data-science expertise required
- Models automated and continually refresh - freeing up your team, supplying them with insights for enhanced decision making

Rapid Deployment

- Operational within days from data ingestion
- Data and system agnostic for easy deployment
- Provision of IoT Sensors, Communication Gateways

Enterprise-Wide Visibility

- From single compressor to multi-plant network, the VROC platform easily handles billions of data points for holistic monitoring

Round the Clock Support

- VROC's data science and engineering team provide round the clock support to capitalise on your investment

Data Security & Sovereignty

- Deploy to the Edge, On Premise or on Private Cloud depending on data security business requirements

Proven Results

- Demonstrated ROI across upstream and downstream operations.
- VROC has over 10 years of AI/ML experience

Ready to predict your next failure before it happens?

Request a demo at VROC.AI

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For a demo or to learn more visit VROC.AI

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