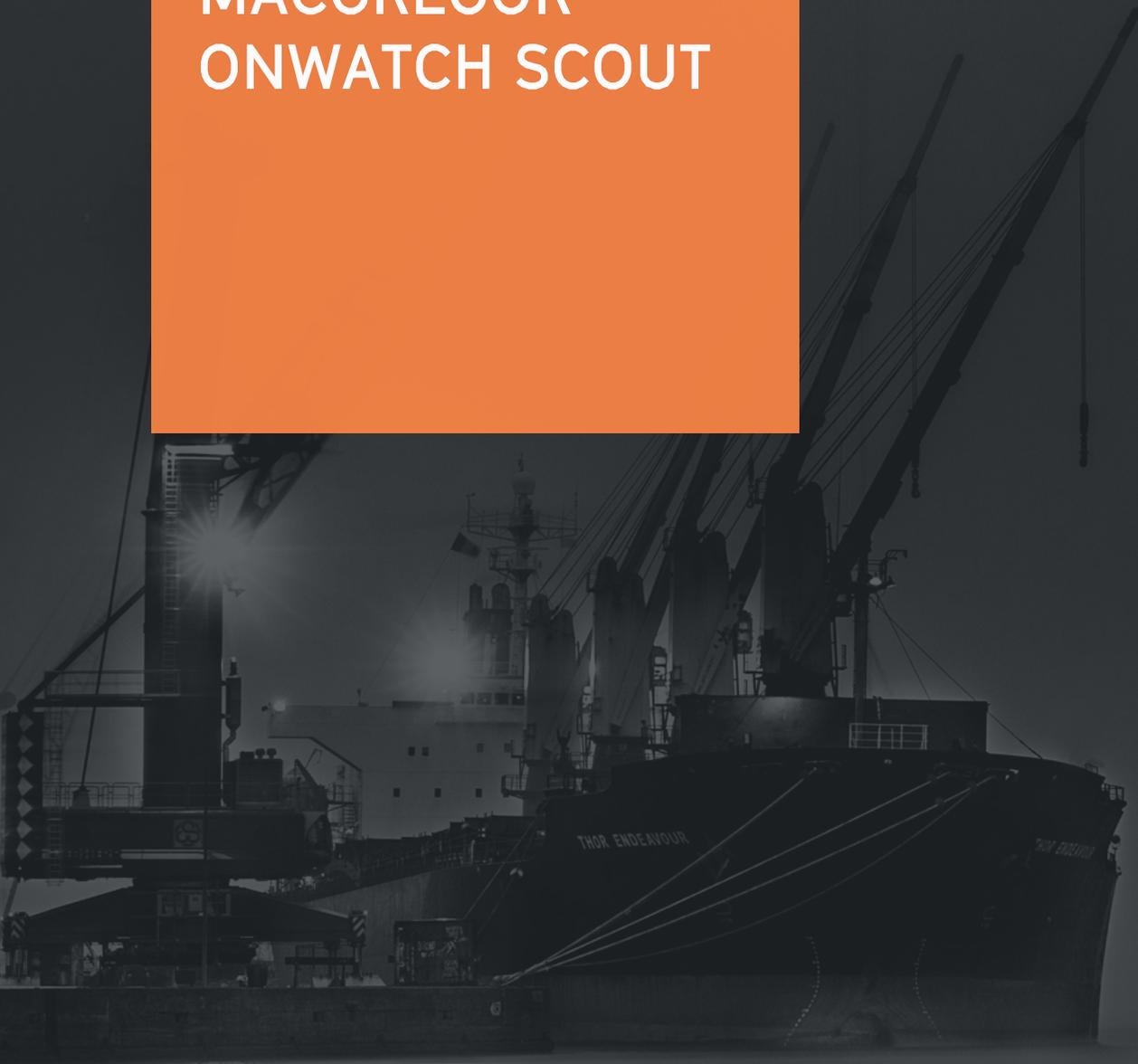

ARUNDO

THE STORY OF
MACGREGOR
ONWATCH SCOUT



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OVERVIEW

Seizing the data opportunity

MacGregor has the strategic objective to work across the full product lifecycle to offer its customers a lower total cost of ownership (TCO). Achieving this objective allows MacGregor to seize the following opportunities:

- MacGregor can continuously improve its future product/service design processes by analysing the performance of a product sent to a customer after delivery;
- Service-focused offerings allows MacGregor to gain intelligence on the use, reliability and performance of its products which can lead to better customer service, customer satisfaction and resources efficiency;
- MacGregor can avoid having its aftermarket business poached by competitors, and creates broader touch points throughout the customer organization and the life-cycle of the equipment.

In order to successfully deliver on this objective, MacGregor decided to leverage its own deep crane design expertise as well as the vast amounts of usage and performance data available from its installed base of equipment. By using this available data in real time to create operational and advanced analytics, MacGregor is able to effectively manage the asset 'end to end', from product design through to service delivery across the whole product life cycle.

Hence, in order to make a transition from being "data rich" to being "data smart", MacGregor decided to embark on a corporate wide development digital transformation program leading to the creation of a new service offering and software: OnWatch Scout.

Opportunities

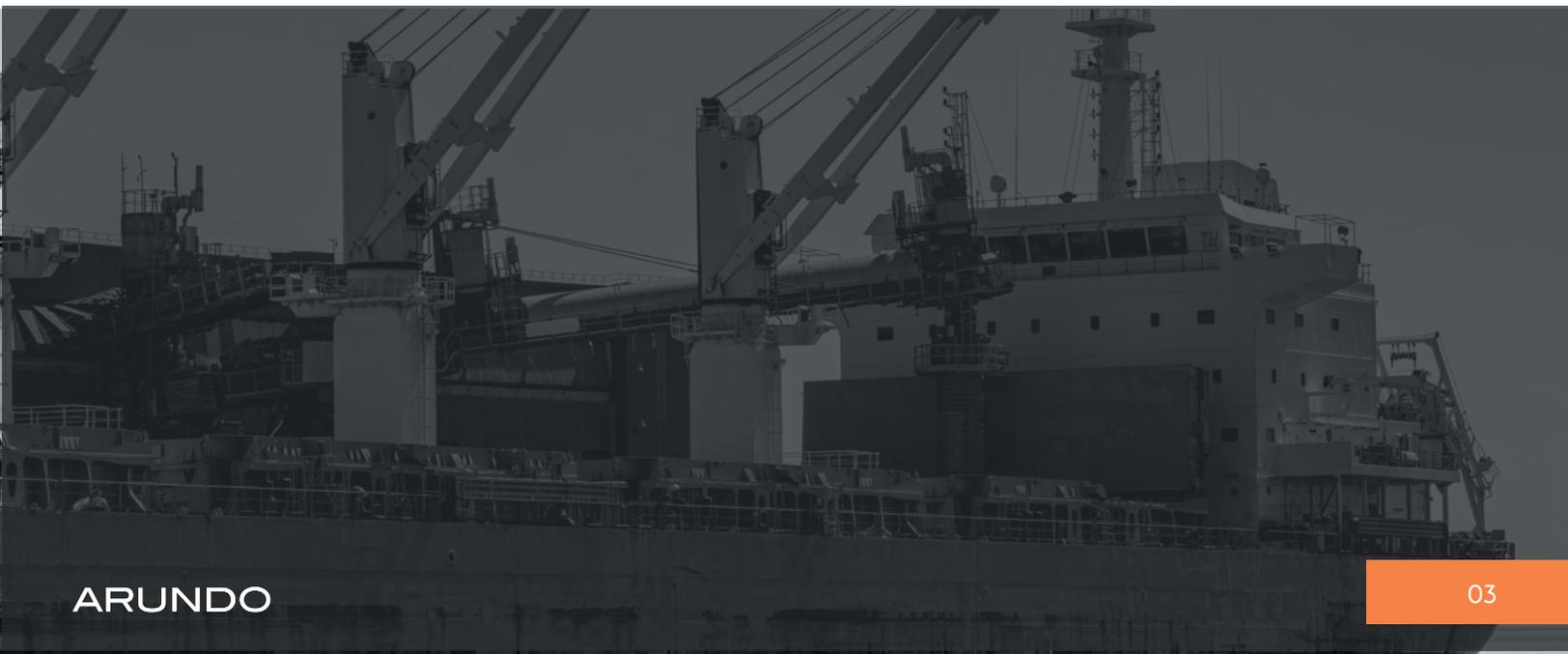
- Ability to offer customers a lower total cost of ownership
- Ability to own the whole product life cycle
- Move from being "data rich" to being "data smart"
- Avoid aftermarket business poached by competitors

Arundo Solution

- Predictive maintenance to reduce downtime
- Models detect complex anomalies from real-time sensor data at the edge
- Deploy the same models across a variety of assets and failure modes
- Update configuration, tune and monitor AI models remotely across thousands of assets
- Uncover component- and sensor-level factors that resulted in the failure

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At Arundo, we learned an approach and built a set of capabilities that works:

- Focus on the business problem at hand: we have a use-case driven approach to quickly prove value from digital analytics solutions and scale over time - without need for significant upfront IT investments.
- Built with the users: having a design driven and user centric product development process - understanding user situation and needs, rapid prototyping and testing, and iterative improvements.
- Deploy quick and learn: working closely with subject matter experts to rapidly configure, tailor and/or develop fit-for-purpose and pre-built analytics models blueprint, and improve these over time based on feedback from users and technical experts.
- Proven technology, proprietary cloud and edge software - we quickly develop and deliver prototypes and production ready solutions built on industrial production grade software components, and scale across assets.
- Standardization: standardized approach for configuring hundreds of machine learning models and KPIs per vessel by leveraging on our Arundo Marathon Edge and Edge manager technologies.
- Built for scale: automated workflows and data science preprocessing pipelines for rapidly scaling insights across assets.
- Lives on top: Arundo Marathon suites protects and leverages existing technology investments - a smart analytics layer on top of existing IT infrastructure.
- Catalyst for change and innovation - entrepreneurial spirit, agility and rapid time to value, helping create momentum and progress in cooperation with the MacGregor team.



ARUNDO AND MACGREGOR PARTNERSHIP AND ONWATCH SCOUT

In late 2018, Cargotec became one of the main partners of Rainmaking's Trade & Transport Impact programme, which brings large corporations together with the most promising startups in the industry.

During spring 2019, Arundo entered the Trade & Transport programme to find corporate partners that could utilise its enterprise-scale machine learning and analytics and around April 2019 a partnership between MacGregor and Arundo was formed.

The partnership brought mutual benefits to the two actors: on one side Arundo tested further and refined its approach on advanced analytics at scale, on the other MacGregor benefited by working with an agile startup with an entrepreneurial spirit. According to Daniel Lundberg, OnWatch Scout project manager at the time: "Together with Arundo, we were able to considerably increase development speed" and in addition "Working with a truly agile scale-up also challenged us to progress at the same pace. It shifted more than a few gears in the development work."

MacGregor engaged Arundo to develop the analytics KPIs and predictive machine learning models which would become the analytics engine of MacGregor's OnWatch Scout (OWS), a predictive software able to ensure that the equipment is able to operate continuously with minimal or no unplanned downtime.



DELIVERING REAL TIME INSIGHTS AT THE EDGE: HOW WE ENABLED PREDICTIVE ANALYTICS IN ONWATCH SCOUT

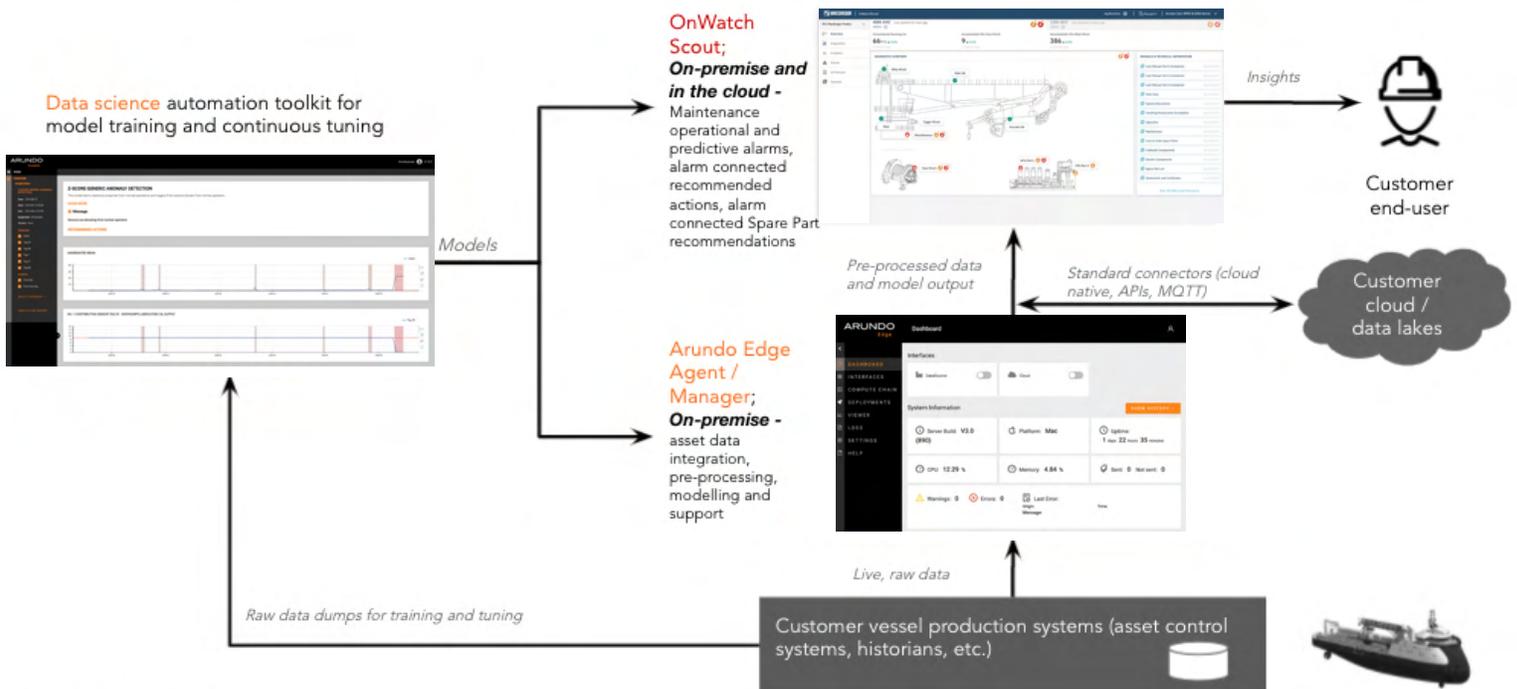
Arundo provided MacGregor with the predictive models engine feeding into the OwS application by:

1. Developing a data infrastructure pipeline and computing capabilities at the edge: a data pipeline infrastructure capable of scaling analytics insights from edge to cloud on hundreds of different assets, equipments, signals, models;
2. Developing hundreds of machine learning models that scale: analytics quickly built, operationalized and operated at scale.

1. Develop an infrastructure that scales

Any industrial enterprise which is launching an advanced analytics solution on a remote and mobile asset needs to build a data pipeline infrastructure which is reliably capable of scaling from edge to cloud across hundreds of different equipment, signals, analytics models. This is usually a complex challenge due to the plethora of different equipment, signals, and network configurations which is found on each single asset or equipment (E.g., even similar pumps can have anything from zero to hundreds of sensors which are identified in different ways across different customers and asset fleets).

High level solution architecture



In order to develop the aforementioned data pipeline infrastructure for MacGregor and OnWatch scout, Arundo leveraged its Arundo Edge computing technologies (lower part of above architecture) and its unique ML automation capabilities (on the left) to:

- Prepare MacGregor’s hardware with Arundo Marathon Edge software including the diverse individual vessel configuration;
- Remotely install and test Arundo Edge software onboard ship computers: to enable data to be buffered even when there is suboptimal or non existent internet connectivity;
- Update signals configuration, tune and monitor it remotely by using Arundo Edge Manager: by adding new signal tags, accounting for equipment upgrades or defining new data streaming destinations;
- Deploy, manage and monitor machine learning predictive models versions remotely;
- Run data ingestion and enrichment pipeline at the edge including decoding, filtering and data pre-processing as well as raw data manipulation, compliance to specific asset configuration, event generation and alerts, data buffering and publishing;
- Monitor machine model executions by checking if they match their schedule or if they are drifting over time;
- Monitor and troubleshoot any issue such as missing data or data quality issues (data drifting in production).

2. Develop hundreds of machine learning models that scale

In traditional software development, a set of practices known as DevOps have made it possible to ship software to production in minutes and to keep it running reliably.

Any enterprise, willing to build data science models which sit not only on a data scientist laptop but that live and execute in production on thousands of assets, faces a big barrier due to the nature of ML algorithms. ML is not just code, it's code plus data.

While code is carefully crafted in a controlled development environment, data, in "the real world", never stops changing. The challenge of an ML process is to create a bridge between data in production and the algorithmic code, in a controlled way and at a scale.

Arundo tackled the above challenges by:

- Using Arundo's proven methodology which combines available data together with years of subject matter experts knowledge - (Figure 2) below.



Figure 2 : Arundo's models development process

Arundo's model development started with prioritization of failure modes based on impact and criticality and involved the subject matter experts (SME) for cranes to iteratively validate hypotheses on the failure patterns - aka how the signal looks like when a failure is about to happen.

When working with MacGregor to productionalize its models, Arundo was entering a domain in which MacGregor service engineers were the experts on cranes. In many cases, data science models are looking to automate a manual process or replace a set of carefully crafted business or engineering rules. However, handing off a black-box machine learning algorithm and telling the business that it is going to replace their current way of working was a challenging task both due to lack of interpretability and the adoption inherent of this type of models.

Hence, Arundo had a different approach: by leveraging its whitebox model development Arundo iteratively involved MacGregor's SMEs and presented them with visual results of the models which were easier to interpret and comment on. Arundo built the data pipeline, starting with a basic baseline model which was based on engineering rules built together with MacGregor's SME and their multiple years of experience, and then exposed the predictions to the Macgregor SMEs in an iterative way.



This approach yielded three positive results:

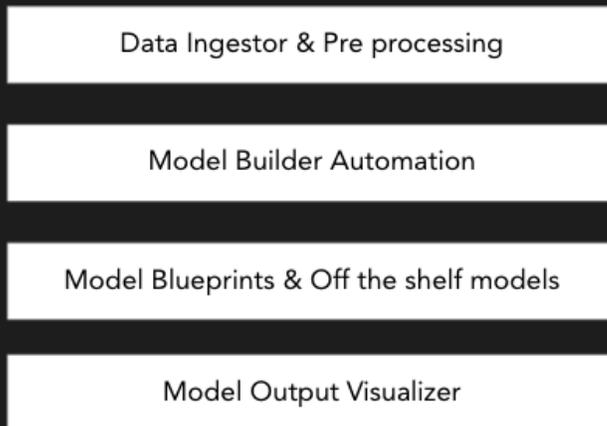
1. White-box model interpretability and collaborative approach allowed for easier understanding and adoption by machine operators into existing workflows;
2. Models were tailored to the customer's operations, with a focus on customer success;
3. Time required to develop hundreds of machine learning models on multiple vessels having diverse equipment, systems, and instrumentation sensors was considerably shortened as the project went on.

Arundo leveraged on its proprietary data science automation toolkit (Figure 3) to automate data ingestion and pre-processing, automate model building and leveraging on its existing model blueprints and model output visualizer to seamlessly overcome the challenges of building and deploying 100+ of models live in production. This toolkit sits on top of existing MacGregor IT infrastructure and allows MacGregor and Arundo to automate model creation and deployment at scale and on multiple customers' assets (ships).

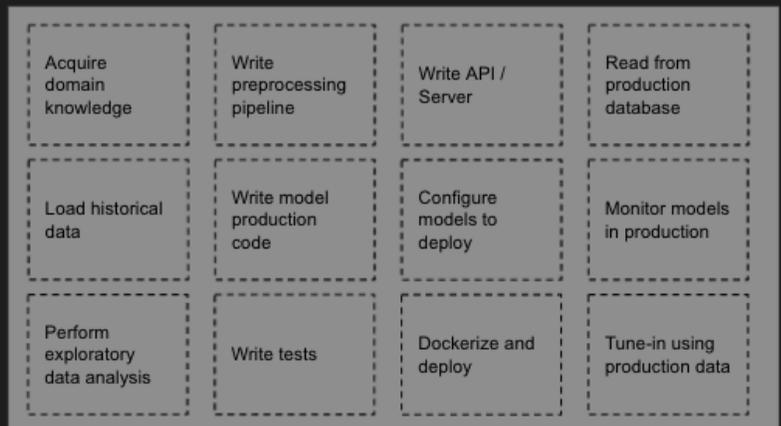
In addition, Arundo was able to automate machine learning models development, management and deployment completely remotely. This was achieved via Arundo Marathon Edge which allows to align, pivot, re-index, populate missing data and preprocess data prior to the execution of machine learning (ML) models and to discover anomalous patterns and alert on upcoming equipment failures in real time.

Efficient and scalable model development and deployment

Key areas of automation



Typical steps taken to develop and deploy ML model(s)



Data science automated workflow reducing model creation and deployment from months to a few hours

THE COMBINED POWER OF MACGREGOR SCOUT AND ARUNDO THE EDGE: HOW WE ENABLED PREDICTIVE ANALYTICS IN ONWATCH SCOUT

MacGregor customers reckon they are already saving up to six hours every time an alarm is triggered - because the crew onboard has all the information available in one place and the improved situational awareness and communication between onshore, offshore and MacGregor service engineers. Having OnWatch Scout is like having an operator looking at your equipment 24/7. Insights coming from Arundo's predictive models allowed chief engineers and technical superintendents to augment their equipment monitoring capabilities at scale on thousands of cranes globally.

In a nutshell, OnWatch Scout enabled the user to be proactively informed with real time predictive alarms about:

- a. Whether a problem is about to happen
- b. What to do in terms of specific maintenance activity
- c. Which specific spare parts to order and when to avoid unplanned downtime.

Today OnWatch Scout is deployed live on many customer vessels across the world. Using OnWatch Scout and Arundo Marathon Edge to create real-time insights on the cranes and other cargo loading equipment, customers were able to anticipate maintenance needs, improve utilization, minimize unplanned downtime, and ensure a high level of customer satisfaction with nimbler response time.

Arundo Marathon Edge streams ca. 4000 signals per vessel at up to 10 Hz resolution and executes over 700 models on a configurable schedule. This allows OnWatch Scout to monitor 24/7 over 200 different types of equipment (incl. Pumps, motors, MRU, jibs, winches, electric motors, VFD, etc.) across completely different types of vessels, control systems, assets types.

- [Click here to know more about MacGregor OnWatch Scout:](#)

<https://www.macgregor.com/onwatchscout>

MacGregor is a leader in intelligent maritime cargo and load handling with a strong portfolio of MacGregor, Hatlapa, NMF, Porsgrunn, Pusnes, Rapp, Triplex and TTS products, services and solutions, all designed to perform with the sea. Shipbuilders, shipowners and operators are able to optimise the lifetime profitability, safety, reliability and environmental sustainability of their operations by working in close cooperation with MacGregor.

- [Click here to know more about Arundo Marathon:](#)

<https://www.arundo.com/products/marathon>

Founded in 2015, Arundo's proprietary software for asset-intensive industries enables applications for oil & gas, maritime, power, chemicals, and industrial equipment productivity and performance improvement. Our products are built for industrial users, and focus on creating rapid value from industrial analytics. Our vision is to build a more sustainable world by creating data-driven insights for industrial operations.

