

PREDICTIVE MAINTENANCE IN THE MINING INDUSTRY

A comprehensive predictive maintenance system with a robust data engineering layer shaves millions off maintenance cost



AT A GLANCE

Challenges

- Owning over 350 units of HD785 dump trucks, PC2000 excavators, and CAT777 haul trucks, the manual maintenance activity planning to keep every heavy equipment in their optimal condition incur manpower and costs upward of tens of millions of dollars.
- Heavy equipment maintenance-related data are **scattered** across various data sources, limiting the accessibility of the data without prior manual compilation procedure.
- This, in turn, impede the company's ability in retrospective diagnosis as well as proactive analysis that reduces unanticipated equipment failures resulting in reactive maintenance ("unplanned maintenance")

BACKGROUND

PT. SAPTAINDRA SEJATI (SIS), part of the Adaro Group, is an industry-leading mining contractor providing a broad range of mining services to related industries in Kalimantan, and boasts more than 7200 employees of various expertise. SIS maintains a fleet of heavy machinery primarily used by their coal mining clients in high-cost mining and construction operations, where mining productivity is highly dependent on the equipment's condition. The fleet comprises:

- 1.HD785-7 Dump Trucks (~169 units): These are large off-highway trucks designed for transporting heavy loads of materials such as earth, rock, and minerals from mining or construction sites. They offer substantial payload capacities and are known for their durability and efficiency.
- 2.PC2000-8 Excavators (~37 units): These are powerful excavators commonly used for digging and loading tasks in mining and large-scale construction projects. They are equipped with advanced hydraulic systems and attachments to handle various materials and tasks efficiently.
- 3.CAT777 Haul Trucks (~45 units): Caterpillar 777 Haul Trucks are renowned in the mining industry for their robustness and capacity to transport large quantities of material across rugged terrains. They are designed for hauling heavy loads of materials over long distances.

The fleet consists of dump trucks for material transports, excavators for digging and loading, and haul trucks for efficient material transportation in mining environments. The significant industrial operation involved in large-scale mining puts SIS at a centrally important position, providing key services across the supply chain in ensuring seamless extraction, movement and distribution of heavy machinery resources.

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CHALLENGES

Maintaining all of the heavy equipment in their optimal condition is crucial, as any unexpected breakdown of these capital-intensive assets during a mining process imposes a safety risk to their operators, decreases the overall profitability of the activity, and incurs an exorbitant amount of expenses to SIS on top of the general maintenance costs.

These challenges underscore the the necessity for a robust preventive maintenance strategy powered by advanced predictive analytics, logistical foresight, and machine learning methodologies. Prior to working with Supertype, this process requires tedious and labour-intensive compilation of machinery data scattered across different sources. A large part of the data is not utilized and the results presented are highly subjective since they depend upon the opinion of the individual personnel conducting the logs analysis. Delays in analysis further poses a challenge when components unexpectedly breakdown with no available parts available. This culminates in an environment where breakdowns are costly and oftentimes disruptive, and one where potential issues are not proactively identified to a degree deemed desirable.

AT A GLANCE

Benefits

- Implementation of predictive maintenance and an intelligent health index enhance the longevity (usable lifetime) of the machinery while allowing them to operate at optimal levels longer, saving the company up to **\$1.2m** annually for **each type** of heavy equipment.
- Tracking the health index and RULs of these machinery enables timely interventions and planned downtime; This significantly enhance the reliability, safety and cost-effectiveness of the company's mining operations

SOLUTIONS

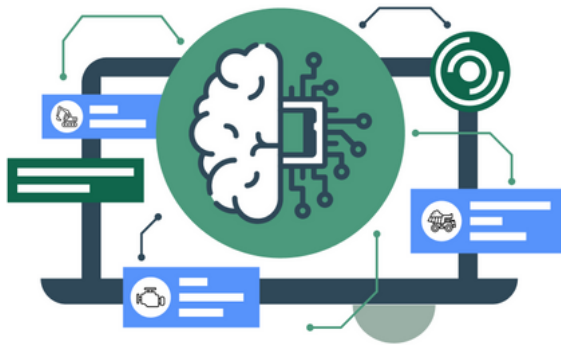
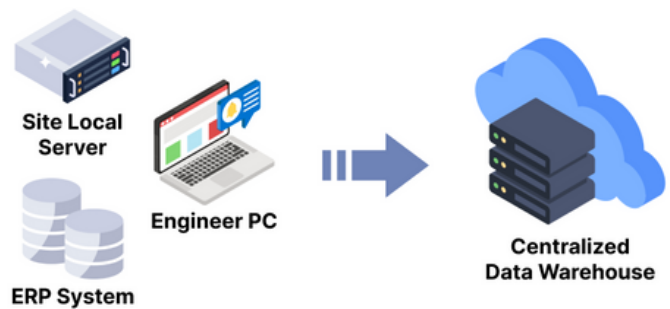
- Over the span of 24 months, Supertype work with SIS to develop an end-to-end data infrastructure on Microsoft Azure, one where data are automatically compiled, centrally stored and analyzed, and turned into proactive insights and alerts. The data warehouse enables SIS to integrate data from key services into a downstream business intelligence service, providing a near real-time and holistic monitoring tool on their machinery and parts.
- Supertype devise a hyper-specialized model for each type of equipment, estimating the RUL (Remaining Useful Life) of each parts, and accounting for other factors, estimate a real-time Health Index of each equipment with only 1-3% of deviation

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PROCESS

i. Azure Synapse: Data Centralization

PT Saptaindra Sejati (SIS) provide Supertype with up to 15 years of maintenance logs and performance measurement data for its inventory of machinery. The data being scattered across various data storage require considerable work on **creating an optimized data pipeline** that brings every data into a centralized data warehouse hosted on Azure Synapse.



ii. Model Development and Tuning

For every type of heavy equipment: HD785 dump trucks, PC2000 excavators, and CAT777 haul trucks, Supertype develops a localized, high-specificity model for predicting the **remaining useful lifetime (RUL)** and **health index** of the equipment's components. With respect to the prediction range, the model perform admirably well in its prediction, coming well **within 1-3% of deviation**.

iii. Predictive Analytics and Continual Learning

The developed machine learning models are continually re-trained on Azure Synapse to generate accurate, forward-looking RUL and health index prediction as new data are streamed in. Automated pipelines put in place by the technical team ensures that these periodically generated prediction tables are fed into Azure Synapse data warehouse, thus enabling seamless integration with SIS' business intelligence process. The client is given access to a dashboard for **near real-time** monitoring on every available heavy equipment in their fleet.



Despite being relatively new to the field of heavy machinery (in service of the mining industry), Supertype's capabilities are beyond impressive. They understood the technical needs related to prolonging every key component's health index while demonstrate exceptional statistical capabilities during the development of highly tuned Machine Learning models. We are pleased by the work produced by Supertype and look forward to cooperating again in the future.

Mungky Andyan

Plant Engineering Manager, PT Saptaindra Sejati

PREDICTIVE MAINTENANCE IN THE MINING INDUSTRY

KEY DELIVERABLES

- A proper, centralized cloud data warehouse that consolidates:
 - (1) Heavy equipment's technical condition monitoring data
 - (2) Component's historical replacement data
 - (3) Remaining useful lifetime (RUL) and health index prediction that is the result of **continually trained, model-specific machine learning algorithms**.
- Custom-trained machine learning model artifacts that are continually trained to return accurate RUL and health index prediction of every heavy equipment's component with a deviation of only up to **1-3% (<250 hours)**.
- **Fully automated** business intelligence built on the foundation of predictive analytics and 15+ years of maintenance logs, offering a **near real-time view of the health** of SIS' entire fleet.

Key Technology



KEY BENEFITS

Ease of access to all data

A centralized data warehouse enables SIS to easily access every data point (up to 500,000+ per model) relating to the condition and performance of their heavy equipment. This provides a near real-time interface to monitoring the company's most valuable assets with unparalleled confidence and ease of use.

Cost reduction from efficiency and reliability

Compared to the manual maintenance procedure which is time- and labor-intensive, an end-to-end prediction pipeline facilitates a much more integrated and streamlined operation. SIS is thus able to optimize equipment usage, reduce unnecessary wear and time, minimize unwanted downtime, prevent costly disruptions, and enhance the overall longevity of each machinery and parts.

Timely intervention from accurate diagnostics

Manual maintenance procedures heavily rely on the subjective judgement of the personnel. It is very prone to error, imposing a huge safety risk to the operators. The RUL and health index generated by the machine learning model enables the team to deploy only the heavy equipment in their optimal condition for mining operations, and these models are built on 500,000+ signals over a 15 years period and thus more robust and timely.

The convergence of predictive analytics and logistical acumen culminates in a holistic, continually-trained analytics infrastructure that shaves **~\$1.2 million off** each year for every component / machinery unit.