Data-driven strategies to increase uptime and reduce downtime of mining equipment

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TALPA Solutions

TALPA provides predictive analytics solutions for both fixed and mobile assets, covering machinery and equipment in the heavy industries.

Our predictive analytics platform uses both real-time and historical data from machinery and equipment to optimize operations for equipment operators and managers.

Our end-to-end solution also serves as a bridge between asset/component manufacturers and fleet owners by fostering a community for industrial intelligence.

Heavy industries accumulate a wealth of disparate data throughout all project phases, from planning to operations and maintenance (O & M). It can be collected from various sources, including sensors embedded or retrofitted on mobile equipment and fixed assets, design records, planning software, project control systems, etc.

Unfortunately, the vast and varied volume of data is not captured or analysed systematically. Much of it remains kept among different stakeholders and gets lost over the machine life-cycle. In the near future, this unruly data mass will proliferate exponentially as the industry continues to digitize.

TALPA's Industrial Intelligence's platform allows machine owners to use their data to identify many insights, allowing increased productivity, cost reduction, and new revenue streams. We have developed a no-code high-performance cloud platform for data ingestion, processing and normalization, analysis and insight visualization, as well as providing a holistic view of the client's business.

TALPA's platform can cover all types of disparate real-time data, including:

- **the client's sensors and machinery**
- **business systems (such as ERP and CRM)**
- **geographic information systems (GIS)**

Keeping mining equipment, both fixed and mobile, functional is crucial for the economics of the operations. The breakdown of even one special-purpose machine can result not only in additional costs for its repair but, what is more important, in the loss of production for the entire mine, non-fulfillment of supply obligations, loss of profit, etc.

The mining environment, both on surface and underground, is very challenging in terms of managing and monitoring equipment conditions and performance parameters. Apart from permanently changing conditions, such as geology, infrastructure, pit design, and others, the average mining process requires a number of supporting systems, such as WiFi or private LTE, localization and positioning systems, fleet management solutions, etc., to ensure the information is up-to-date and under control. Mining machines as well need to be fit for purpose: durable, reliable, and heavily protected from environmental conditions. This results in a much higher price for such assets in comparison with other industries. The majority of mining equipment manufacturers in the last few years have not only focused on delivering high-quality "metal," but also put a lot of effort into making machines automated and controllable with various sensors. The signals registered by the sensors are normally displayed to the operator to aid his activities and can also be sent to the other participant in the process over OEM-proprietary as well as third-party systems.

Mining companies are permanently working on establishing IT systems that will allow them to gain a deeper understanding of their operations and optimize them, including the productivity and availability of their equipment. Sometimes, though, these strategies do not quite work because there are one or more missing links in the system. Some examples of such missing links are:

- **No data to analyze.** Very often, data is available on the machine but cannot be supplied in time or in the volume required for further analysis or is lost.
- **Absence of suitable instruments or knowledge.** Data is available, but the systems are not fit to turn the data into actionable insights.
- **Data silos.** Data and insights are available but are siloed in one location or one IT system, preventing their effective application to further actions.

As a result, an effective solution that allows for maximum uptime and minimal downtime of the equipment must be:

- **Agnostic:** covering equipment from various manufacturers and of different types.
- **Actionable:** allowing the right actions at the right time.
- **Affordable:** can be quickly implemented, scaled up, and adjusted to meet changing needs at a reasonable cost.

This whitepaper describes how an end-to-end digital solution can consider all of the requirements mentioned above and contribute to resolving the heavy industry's biggest challenge—reducing equipment downtime by structuring the maintenance-related data generated by the machines.

Maintenance KPIs in mining

Regular (preventive) and reactive (troubleshooting) maintenance is the set of actions performed by technicians or mechanics in the mine to keep the machinery and equipment in operational condition. Maintaining planned equipment uptime allows mining operations to meet their business objectives.

A widely quoted study by the International Society of Automation states that heavy industry is losing ca. 5% of its total production every year in downtime, amounting to $647 billion. According to Senseye, the average downtime in mining due to unpredicted failures is 23 hours a month (Link), which is less than 5%, considering that most of the operations run 24/7. However, if we add a planned maintenance percentage that can reach 10% of the total planned operational time, this figure is becoming very significant. Besides, we need to consider that the average downtime cost in mining is much higher than in most of the other industries and can amount up to $187.500 per hour with total losses reaching over $200 billion per year, which is a third of the entire heavy industry.

According to Mining Digital (Link) among other sources, maintenance costs in mining range on average from 30 to 50% of the total operating costs of a mine, involving up to 60% of the entire operational personnel. This means that ensuring effective maintenance operations must be a priority for every mine manager.

The trend of the last few years was to put a focus on predictive maintenance.
This approach is based on quite complex models and systems that must ensure that we know about the possible breakdown before it occurs. The approach is the future, of course. However, we need to admit that the question of preventive actions based on timely delivered diagnostic information is not yet quite resolved and results in a large portion of unplanned downtime. Besides, according to LimbsCMMC, for the operations currently running reactive maintenance strategies, a leap towards predictive maintenance can be too expensive and time-consuming to even think about it. In this case, preventive maintenance is the most logical step. (Link)

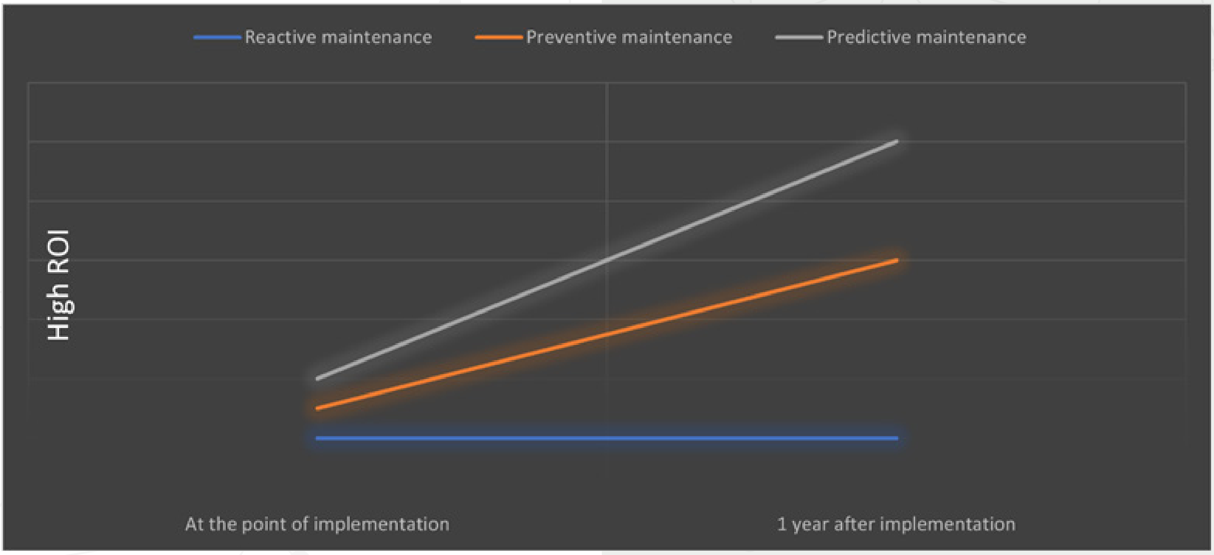

Fig. 1: Economics of various maintenance approaches

Two main KPIs the mining industry, as well as other manufacturing industries, is using are:

- **Mean Time to Repair** (MTTR)—defined by Maintenance as the average time it takes to repair an asset from the time it fails until it is returned to service (Link)

- **Mean Time between Failures** (MTBF) – defined by the same source as a measurement of how long an asset performs its intended function under normal operation before experiencing a problem (Link).

Further on, various formulas are offered to calculate these parameters. A very interesting way to calculate MTBF is given by IBM. It is suggested that MTTR is the sum of such parameters as MTTI, MTTK, MTTF, and MTTV (Link), where

- **Mean Time to Identify** (MTTI): the time between the start of an incident and the detection of the incident. The detection may be automatic via events/alarms seen in the event management system.

- **Mean Time to Know** (MTTK): the time between the detection of the incident and the identification of the root cause of the incident.

- **Mean Time to Fix** (MTTF): the time between the isolation of the root cause of the incident and the time taken to resolve the issue.

- **Mean Time to Verify** (MTTV): the time between the resolution of the issue and confirmation of successful resolution from the users or automated tests.

The definition was probably originally written for software development projects and we could argue whether the fourth definition is widely applicable. The first three components though can be very well applied to mining.

Let´s have a look at the example:

MTTI - the time between the machine displays a critical warning or has visible physical damage (not operational) and the maintenance crew becomes aware of the problem. The incident can be reported by the operator or otherwise automatically by the automated system, if in place.

MTTK - in mining, investigation of the root cause of the breakdown can last much longer than the repair itself. The process of getting to the machine, performing diagnostics, and sometimes towing it back to the garage can take hours, if not days.

MTTF - in the best case, it is a matter of minutes; however, such factors as missing spare parts, remoteness of the machine location can influence the duration of the process significantly.

Although, as mentioned previously, MTTV is not directly applicable, we can still verify whether one or the other action is effective by tracking the statistics across the fleet and assessing the efficiency of previous actions in the event that the right system to collect this data is in place.

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According to LimbleCMMS as well as other sources, MTBF calculation is generally very simple and is calculated as the sum of operating time divided by the number of failures (Link). However, the same author mentions that this equation is normally too simple and generally requires a much bigger sample of information to work with to get a more accurate prediction. In ever-changing and harsh conditions of mining operations, not only the design and performance of the equipment can cause the MTBF intervals, but also such factors as operators´ qualification, and operational conditions, such as road quality, etc.

Timely detailed information about the errors and warnings registered and displayed on the mining machines, as well as their elimination, allows for avoiding the major cause of unexpected breakdowns. Examples of such critical notifications include:

- **Levels of critical consumables, such as engine and hydraulic oil, and lubricants**
- **Tire pressures and temperatures**
- **Recurring errors and/or warnings detected by the machine sensors**
- **Registered and reported misuse cases: high RPMs, overspeeding, and operations out side of prescribed procedures**
- **Missing scheduled maintenance intervals**
- **etc.**

Last but not least, the entire approach should be contained, if not entirely user-friendly, with little risk of failure due to human error and the ability to interact with other systems. In the next chapter, we will give an example of such an approach and describe the solution features and possible use cases of a machine data-based maintenance management system.

TALPAS´s maintenance management suite – information at your fingertips to increase mobile fleet uptime.

TALPA´s end-to-end digital solution has the following architecture:

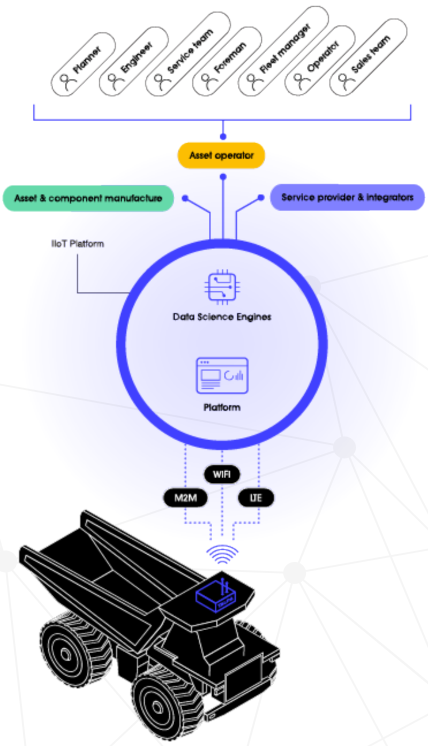

Fig. 2: architecture of TALPA´s end-to-end solution

Based purely on high-definition machine data logged by TALPA´s proprietary equipment and cloud computing, the solution, allows for the following:

- **Providing an unbiased basis for decision-making; eliminating human errors in the process**
- **Near-real-time OEM-agnostic assessment and display of actionable maintenance insights**
- **Facilitating timely, transparent, and data-based decisions by stakeholders in the process**
- **Retaining the majority of critical data for future analysis on the path to predictive main tenance strategies**

Maintenance suite logic

TALPA approaches maintenance issues of the heavy equipment in three levels.

1. Notifying the user of critical issues and engine-related issues.

2. Providing a health explorer to give a holistic view of the fleet and each asset´s technical conditions.

3. Providing an overview, insights, and statistics of each failure code.

1. Notifying the user of critical and engine issues: the user is notified of potential failure. This is achieved by sending a push notification with an asset name and issue count that have occurred in the cockpit. Engine and critical issues are separated to keep a clear distinction between the types of failures occurring. Engine issues are generated for events like engine overloading, engine overspeeding, low oil level, and low coolant level, whereas critical issues are OEM-specific. Since each OEM and customer faces criticalities in different scenarios, critical issues are reported for failure codes collected from OEM and customers.

2. Health Explorer for Fleets: From the health explorer page, users can view their fleet´s health in a specific time frame, making it easy for them to analyze the availability of their fleet as well as failure codes registered on each asset. Different levels of severity have been assigned different colors. This color coding is applied to overview, insights, and statistics pages.

3. The overview: insights and statistics pages are dedicated to providing more information about the health of each component of the asset, as well as information and statistics about failure codes and specific signal behavior, as well as signals pertaining to the selected code that have occurred in the selected asset. Users can access it here via Notifications or Health Explorer.

Use-case in the mining operations

One of the most common examples of applying such a system in practice is described below:

Step 1: potential failure detection

A critical issue with the asset is detected after logging and transmitting the data to the talpa.io cloud platform. The typical time of arrival of such information is 10 minutes.

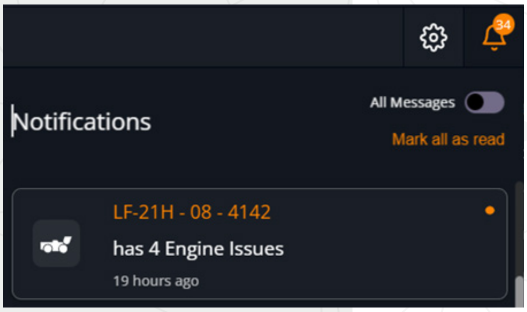

Fig 3: Notification on the engine issue

The issue will be available to all the relevant users assigned with the right to get this information to ensure a timely reaction.

Clicking on the issue will send the investigator to the Health Explorer menu. This view allows for not only seeing the time and number of occurrences but also in which process the machine was involved when the event happened and what raw signals were involved in forming the report.

CODE	TYPE	SEVERITY	START TIME (new to old)	DURATION	INTERNAL COUNT	COMPONENT
154	GHH		20.12.2022, 16:39:26	00:00:02	-	Dieselmotor, Zubehör
190-0	J1939		20.12.2022, 16:39:26	00:00:01	2	Engine #1
174	GHH		20.12.2022, 16:36:12	00:00:27	-	Hydraulik
41	GHH		20.12.2022, 06:49:32	00:47:29	-	Mechanische Antriebsaggregate

Fig. 4: Incident in question highlighted

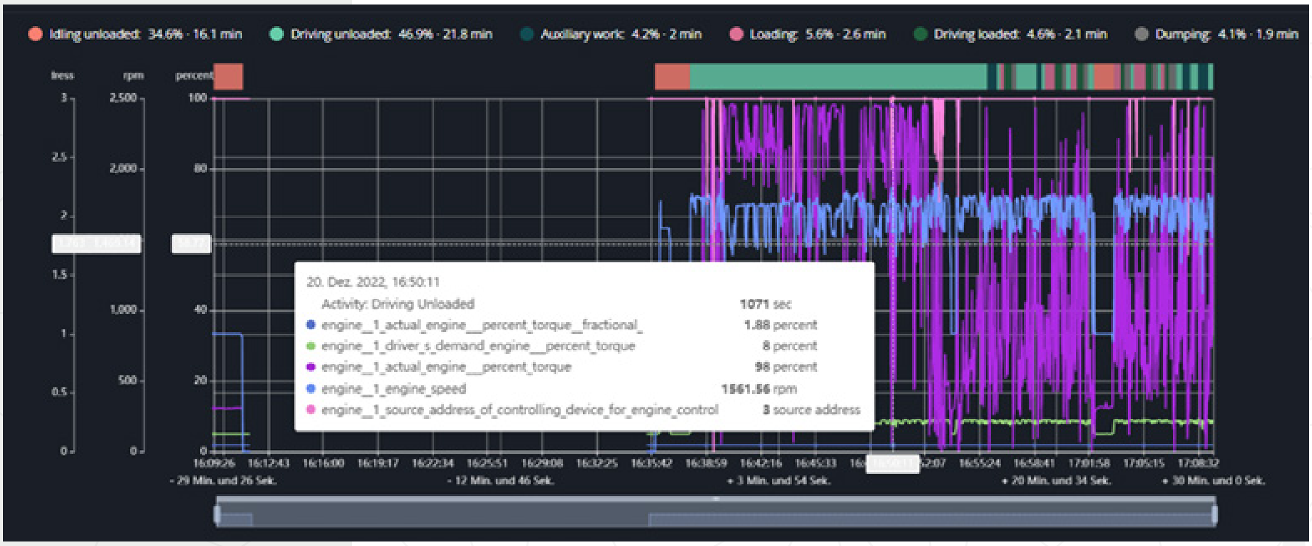

Fig 5: detailed view into the issue

If the issue can be resolved immediately, the maintenance superintendent contacts the operator or shift boss and informs them of the need to perform further inspection, which may necessitate the use of an external contractor. It can also be done using the raw data captured on the machine in question. This enables quick and transparent analysis and choice on how to eliminate the issue.

Fig 6: Showing the occurrence of the events second by second in the signal explorer

Once the root-cause is investigated the issue can be resolved and the asset can return to work.

Such workflows can be adapted to the needs of particular users if the process is different from the standard template. However, it has been recognized in a number of projects led by TALPA that such functionalities cover the majority of the information needs of users and can be adapted to facilitate proactive preventative maintenance.

Conclusion

Equipment uptime is critical for mining operations in order to meet production targets. Because the cost of equipment, spare parts, and special services can account for up to 60% of the total machine's lifetime expenses, smart maintenance management strategies are crucial in the mining process.

There are a number of approaches to identifying issues with mining machines and ensuring that they are resolved quickly and prevented in the future. They differ in terms of implementation time, cost, and desired outcome. They must, however, contain the following criteria, regardless of composition:

- **be applicable to most of the machines in the fleet**
- **use unbiased data for analysis and insights generation**
- **allow for clear actions at the right time.**

TALPA's maintenance management suite, developed in close cooperation with mining OEMs and end-users, is based on near-real-time machine data, takes into consideration any available signals from embedded and retrofit sensors on the machine, and generates insights that allow for immediate action for machines that are in danger of breaking.
The calculated impact of adopting the system at the multi-site project last year alone, covering equipment of various types and a total fleet of over 100 machines, was a 30% reduction in MTTR for connected units. Receiving important notifications and responding appropriately has also allowed for a large rise in intervals without losing time due to major breakdowns, with equipment now mostly requiring only routine maintenance.

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