ADVANCING PUBLIC TRANSPORT

KNOWLEDGE BRIEF

DIGITALISATION IN PUBLIC TRANSPORT:
IMPLEMENTING PREDICTIVE ASSET MAINTENANCE

MARCH | 2020

INTRODUCTION

The purpose of maintenance is to keep assets performing their prescribed functions at the optimum cost. Along with design, acquisition, operation and de-commissioning, maintenance is a key component of a wider asset management strategy[1].
The impact of digitalisation will be a game-changer on all asset maintenance activities in the public transport sector. Research and discussion with asset designers, manufacturers, owners, operators and maintainers showed that condition-based maintenance (CBM) is still in its infancy. This brief clarifies the principles of CBM, provides a strategic vision of a new maintenance regime and expected benefits, challenges and recommendations.


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FROM PREVENTIVE TO PREDICTIVE MAINTENANCE

Maintenance of public transport assets has traditionally been performed by a combination of corrective and preventive actions. Preventive action means that equipment or devices are inspected and maintained before any failures occur. The intervals for maintenance are defined based on experience and understanding, and apply uniformly to all items of a given asset type, regardless of the real health state of individual items. In many cases, assets are deliberately maintained or replaced too early to avoid failure which would lead to higher financial costs.

New and emerging technologies have started to impact the transport business; together with interconnected sensors and diagnosis tools, big data analytics, Internet of Things (IoT), machine learning and Artificial Intelligence begin to allow intelligent and rapid interpretation of data into meaningful information. This will lead to a radical transformation of business planning, operation and maintenance activities, delivering increased asset availability and cost-efficiency.

Smarter asset management is possible with systems that learn, diagnoses, predict failures and trigger specific maintenance. Data from multiple sources are processed for predictive analytics, based on forecasting of the assets' remaining useful life (RUL). Asset deterioration and precursors of failure can be identified and predicted from past asset behaviour. This makes it possible to plan maintenance activities for each specific asset when necessary.

1 UITP, 2017. Strategic asset management for safer, more efficient and sustainable metros, Report. Available for UITP members on MyLibrary.

1 INTERVAL-BASED PREVENTIVE MAINTENANCE

Based on predefined intervals such as time, mileage or cycles. **Example:** Change the filter every 15,000 km.

2 CONDITIONAL PREVENTIVE MAINTENANCE

Based on checking the condition criteria and value threshold to assess the need for intervention/replacement at given intervals. **Example**: Check every 15,000 km if the filter needs changing.

3 CBM

Based on real-time checking the condition criteria and value threshold to warn for the need of intervention/replacement. In this case, looking back at past experiences in order to decide on maintenance interventions. **Example**: The system will indicate if the filter needs to be changed.

4 PREDICTIVE MAINTENANCE

Maintenance regime whereby the system smartly analyses asset degradation, and predicts the RUL and supports optimised maintenance duty planning. **Example:** The system will provide the assets RUL and predict the probable date of asset failure.

BENEFITS OF CONDITION-BASED AND PREDICTIVE MAINTENANCE

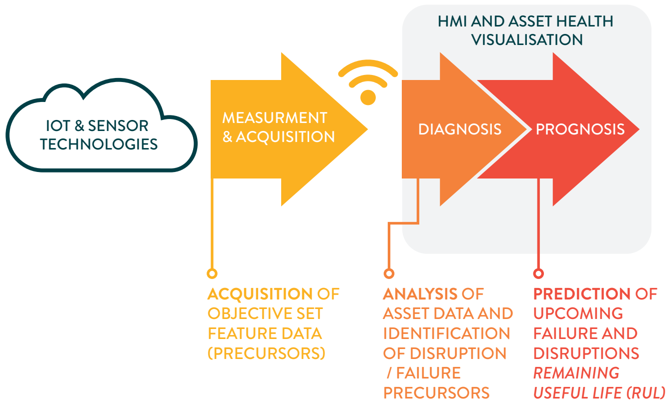
The full deployment of digitalisation for the maintenance of assets paves the way for a zero failure system. Equipment health is constantly self-checked, diagnosed and cured by performing maintenance tasks at the right time with the right method, minimising down-time and costs with the support of a proactive supply chain and spare parts logistics.

To deliver the best results for businesses, CBM and predictive maintenance systems do not just need to provide information about the state of the asset, but also need to provide meaningful recommendations for decision-making.

CBM and predictive maintenance are invaluable tools for optimised asset management decision-making and they will deliver the following benefits:

- Faster identification and timely qualification of asset deterioration
- Increased asset availability and optimised maintainability for the operators
- Improved asset reliability and safety, leading to more trust from passengers and better reputation for the operator
- Lower system life cycle costs

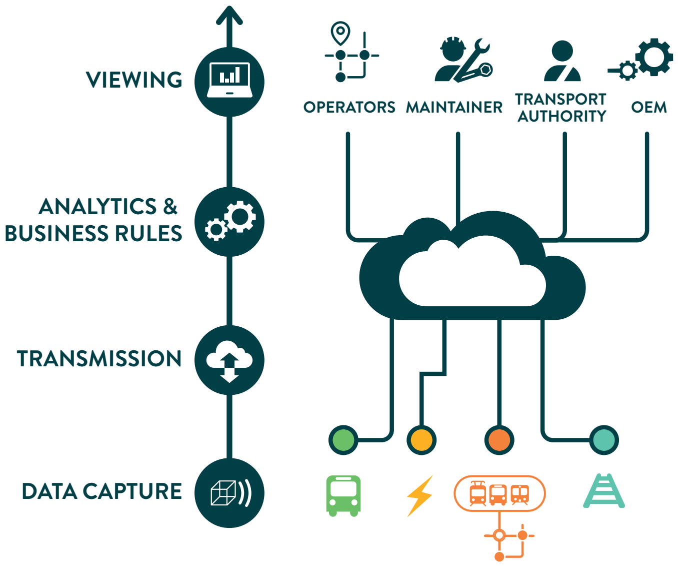
HOW DOES CBM AND PREDICTIVE MAINTENANCE WORK?



- **Measurements and data represented by different indicators are acquired** during or outside operation hours by sensors, cameras or other devices.
- **Data transmission**, either in real-time or with a given periodicity, to back-office data hubs or to the cloud.
- **Data analysis stage 1 - Diagnosis**: Heterogeneous data from different sources (e.g. sensors and diagnostic tools) is analysed to identify abnormal patterns by means of big data analytics. A timely warning shows where and when a threshold is reached on a given component, suggesting an upcoming failure.
- **Data analysis stage 2 - Prognosis**: Statistical comparison with historical data sets of identical asset classes or components helps predict the RUL of the asset or the component. This is done through the development of specific algorithms for each given asset type within its operational context. This process requires a critical base of past asset behaviour to be able to interpret any 'abnormal patterns', and needs time to be fine-tuned.

- Data exploitation and decision-making: Translating raw data and signals into useful predictive information will suggest or trigger specific maintenance actions within a given time frame in order to perform maintenance tasks at the right time with the right method ('just in time')[2].

The hardware and software for CBM and predictive maintenance uses data from different sub-systems, which is captured and transmitted to the cloud where it will be analysed and presented to different stakeholders for decision-making purposes.



ACCURACY OF ASSET INFORMATION FOR PREDICTIVE MAINTENANCE

With more technology to improve the quantity and consistency of captured data, it is important to ensure that the quality of the information derived from the data is also improved. Best practices of condition monitoring systems and CBM processes have revealed that there are four focus areas, to ensure that the underlying data is accurate and correct:

- Accuracy of failure mode determination. It is vitally important to ensure that any Failure Mode, Effects & Criticality Analysis (FMECA) or Reliability, Availability & Maintainability (RAM) analysis that has been undertaken to determine the failure modes is correct.
- Calibration of sensors. All sensors used to gather data should be correctly calibrated. Evidence of initial calibration, routine re-calibration should be checked.
- Accuracy of historical failure root cause statistics/trends/information. As root cause determination is heavily reliant on human input, tools for improvement of accuracy and consistency of historical root cause data is required. For example, control and evaluation of staff competence, standardisation of processes to control the root cause analysis activities and its compliance which leads to a reduction of errors.
- Accuracy of historical data on preventive maintenance and spares usage. Analysis of preventive maintenance data helps form a good understanding of how assets perform during their service life and what interventions were required to address any impending failures.

DEPLOYMENT OF PREDICTIVE MAINTENANCE: 10 STEPS

Implementation of predictive maintenance is part of a complex business and corporate transformative process. In the foreseeable future, predictive maintenance will be done in conjunction with some more traditional maintenance approaches.

Public transport companies should take a strategic decision to move towards predictive maintenance model. For this they are required to take the following 10 steps:

1. Define a clear vision of what they want to achieve with CBM: Return of Investment (ROI) and purpose.
2. Employ a cultural change in the organisation: Create a corporate climate open to new technologies and digitalisation.
3. Communicate the benefits of predictive maintenance to maintenance staff and engage them at an early stage in a collaborative manner.
4. Select asset classes and types to launch pilot projects with 'quick wins' and get gradual confidence through small projects before going big. However, always keep the vision in mind.
5. Procure new assets with sensors or retrofit assets with sensing technologies if the remaining life of the asset and retrofit costs yield a positive ROI.
6. Invest in data-hubs/back office and big data analysis capabilities: hardware, software and peopleware.
7. Alternatively, enter in contractual relationship with a service provider for the above task.
8. Change the organisation and structure of the maintenance departments according to experience gained, learning curves and staff adaptation/replacement.

2 Restrictions on access to an asset in order to undertake the repair/maintenance also need to be considered.

9. Review and update internal maintenance strategies, regimes, standards and procedures.
10. Formulate a collaborative relationship between stakeholders: asset owners, operators, maintainers, passengers and safety agencies, to create multiple benefits around new maintenance system.

CHALLENGES

Some of the challenges faced due to the impact of digitalisation are:

- Technical: Transmission and communication bandwidth, data accuracy, cyber security, lack of standards and obsolescence
- Commercial: Fragmented-supply chain, data governance and management, warranty, proprietary software vs open supplier software
- Economic/business case: High initial costs and maintenance costs
- Organisation and HR: Impacts on management and company culture, IT maintenance and required skills
- Law and regulations: Reluctance from safety authorities, PTOs and insurance companies and complex tendering process hindering technological experimentation

A detailed list of challenges and recommendations is available in the full report, *Digitalisation and Asset Maintenance*, which is accessible on MyLibrary for UITP members.

CONCLUSION

CBM and predictive maintenance is the new step towards a zero failure public transport system which can help to predict the health of assets and optimise maintenance duty planning. This brief highlights the benefits and challenges, as well as recommended steps to transition from the traditional way of maintenance to one of prognosis. UITP will continue to work on this topic, learning from best practice. These can be retrieved from a series of recent case studies and reports prepared by UITP Committees and/or presented at recent UITP conferences. All are available on MyLibrary.

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