



Contribution ID: 25

Type: **not specified**

## Fleet analytics to avoid unplanned maintenance

*Monday, 17 May 2021 11:15 (20 minutes)*

Currently established maintenance regimes aim at pre-emptive activities to avoid failures during operation. Nevertheless, in many cases a significant amount of unforeseen service effort has to be spent on reactive measures entailing significant perturbation of the production and the service process. System supervision and analytics offer the potential to facilitate preventive maintenance. However, since this benefit does not come for free there must be a business case for this approach to be established. This is the case if either the availability is of top importance or if failure costs and loss of production justify preventive measures.

In this context the scope of fleet supervision is to collect all those data, which contain information on a system's behaviour and load conditions. The focus is on detection of deviations, as they typically indicate the onset of a failure. Detection of deviations is sufficient for ad-hoc service process modifications, even if the root cause of deviations is not yet known. In order to support efficient problem-solving also the mechanisms of failures are required, for decision making on proper mitigation measures. Furthermore, an estimator for the remaining useful life is required for prioritisation of activities. The latter is of importance in many industries due to lack of service technicians or long lead times for special equipment and spare parts.

The sequence of activities from detection via diagnosis to prognosis will be presented and illustrated by examples from the renewable energy industry. The combination of domain knowledge with statistical methods turned quite fruitful for detection. Indicators for detection of deviations are further used as input for root-cause diagnosis in a model-based reasoning system. Physics of failure models for damage propagation allow for extrapolation of failure probability to estimate the end of life for a degraded instance.

This approach is implemented step-by-step with intermediate learning phases to generate a recommendation system, which is embedded into a service process with explained background and transparent reasoning for each result.

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**Session Classification:** Process analytics in railway applications

**Track Classification:** Data Science in Process Industries