“PHM for Rail Maintenance Management : at the cross-roads between data science and physics”.

P.Dersin,Ph.D.

PHM Director, Alstom Digital Mobility

Abstract

Although with some lag with respect to other industries such as aerospace, the rail industry now fully realizes the huge potential benefits that can be derived from prognostics and health management, in terms of reduction in unscheduled down time and decrease in maintenance costs. Therefore most OEMs, operators and asset managers have launched ambitious programs to implement condition-based or predictive maintenance. The impressive developments in data science in recent years provide a powerful enabler. In this presentation, we would like to argue that a suitable combination of data science and physics probably constitutes the optimal development path for the rail industry (at least until more revolutions in data science appear...)

Purely data-driven approaches require no physical understanding and are quite flexible but require large volumes of data (pertaining to both healthy and degraded conditions) and their performance is highly dependent on the quality of those data. Computational load can be very high.

Physics-based approaches provide intuitive results and require limited volumes of data; they allow for accurate predictions provided detailed knowledge of failure mechanisms is available. However, knowledge of physics of failure is usually limited and component- and failure mechanism-specific; hence those methods lack flexibility. Implementation costs tend to be high as compared with those of data-driven approaches.

In both approaches, a key challenge is taking uncertainty into account, for instance uncertainty in future operating conditions.

We recommend hybrid approaches, i.e. combining knowledge of physical processes and information from sensor readings to enhance diagnostics and prognostics capabilities. Model predictions can be adjusted using measured data (either off-line or on-line).In particular, the virtual prototyping method consists of designing a digital (software-based) model of an asset to simulate the dynamics of interest, in both healthy and degraded conditions, with due allowance for uncertainty. Monte-Carlo simulations are utilized for that purpose and the computational load challenge must be addressed. Virtual prototyping can also be combined with classical test benches in order to increase confidence in results.

The above considerations will be illustrated on railway subsystems, such as HVAC (heating, ventilation and air-conditioning).