ESREL 2025

Proposal for roundtable session:

Organizers:

ESRA Technical Committee for Land transportation: Prof. Pierre Dersin (LTU) & Prof. Olga Fink (EPFL)

PHM in Transportation: comparison between aerospace, railways and automotive. Possible synergies?

Motivation

In all transportation modes , either ground-based or air-based, availability and safety are key concerns, and maintenance costs represent a significant part of life-cycle cost.

Therefore it seems that condition-based maintenance (CBM) and prognostics & health management (PHM) should be a priority in all of those aeras. The remarkable success of machine learning, and in particular deep learning , enabled by both algorithmic developments and hardware break-throughs [1], has accelerated the development of PHM substantially. At the same time, there is a strong demand for combining domain expertise and AI and for ensuring explainability of the algorithms, and substantial progress in those directions is being made as well ([2], [3]) .There are still quite a few challenges , pertaining to data availability and quality and pertaining to the scaling up of proofs of concepts, among other [4].

In spite of commonalities, there are also differences between the various transportation areas ,both in technical specificities as well as in business models and regulatory environments.

Historically, aerospace applications (military, then civilian) have led the field (and coined the term PHM) since the early 2000s. The railway industry 's interest has emerged later and obstacles to the wider adoption and dissemination of those techniques are still very much present in that industry.

In the automotive industry, the emergence of electric vehicles and autonomous driving have been key motivators.

The goal of the proposed round-table discussion is , broadly speaking, to examine whether more synergies between the various transportation industries could benefit them all , and, if so, how they could take place.

The following questions could be debated (non-exhaustive list).

1) What are accelerators of PHM which are common to all transportation fields ? and what are the main obstacles ?
    a. What is the level of standardization of data formats / collected data across different OEMs?
    b. What is the level of collaboration across different operators?

2) How is the return on investment on PHM calculated in the various application areas ?
    a. How are costs and gains shared between OEMs and end users ?
    b. Which data enter the calculation and how readily available are those data ?
3) To what extent do regulations , in particular safety regulations, hamper or favor the dissemination of PHM ? For instance, it is sometimes argued that predictive maintenance can enhance safety , and on the other hand (particularly in railways), safety standards are sometimes brandished as an obstacle to moving away from traditional scheduled maintenance.
4) Is there a need for new regulations and/or standards ?
5) Data :
    a. in aerospace, the CMAPPS and N-CMAPPS databases are powerful resources for validating and comparing new algorithms without the need for proprietary data. A similar data base does not exist in railways . Could one be built ? (In automotive applications, numerous data from dealerships can be used; are those data appropriate and sufficient ?)
    b. data availability is also impacted by legal and regulatory aspects.
6) Human resources :

    Are the various fields equally successful in attracting the appropriate talents ? What can be done to improve the situation ?
7) Research funding :

    Are the various fields equally successful in attracting R&D funding ? Can synergies between the fields improve the situation ?

8) In conclusion, can the various transportation fields benefit from a greater synergy in PHM and, if so, how can such a synergy be brought about ?

References

[1] Fink, O., Wang, Q., Svensén,M., Dersin, P., Lee, W-J., and Ducoffe,M., "Potential, challenges and future directions for deep learning in prognostic and health management applications", in 'Engineering Applications of Artificial Intelligence', 92, 2020

[2] Thelen, A., Zhang, X., Fink, O., Lu, Y., Ghosh, S., Youn, B.D., Todd, M.D., Mahadevan, S., Hu, C. and Hu, Z., 2022. A comprehensive review of digital twin—part 1: modeling and twinning enabling technologies. Structural and Multidisciplinary Optimization, 65(12), p.354.

[3] Arias-Chao, M. , Kulkarni, C., Goebel, K., & Fink, O. (2022). Fusing physics-based and deep learning models for prognostics. Reliability Engineering & System Safety, 217, 107961.

(4] Zio,E., "Prognostics and Health Management (PHM): Where are we and where do we (need to) go in theory and practice ", Reliability Engineering & System Safety, Volume 218, Part A,2022.