# Position Description

## 1. General Information

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| **Name of the position** | **AI-Assisted Machine Condition Monitoring** |
| **Foreseen enrolment date** | 1 July 2024 |
| **Position is funded by** | • COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union<br>• Institut National des Sciences Appliquées de Lyon (INSA-L)<br>• The University of New South Wales (UNSW) |
| **Research Host** | Institut National des Sciences Appliquées de Lyon |
| **PhD awarding institutions** | Institut National des Sciences Appliquées de Lyon & The University of New South Wales |
| **Locations** | Primary: Lyon, France<br>Secondary: Sydney, Australia |
| **Supervisors** | Professor Jérôme Antoni, INSA-Lyon, France<br>Prof. Zhongxiao Peng & A/Prof. Pietro Borghesani, UNSW Sydney, Australia |
| **Group of discipline** | Mechanical, industrial and aerospace engineering – mechanical system dynamics and modelling, measurements and signal processing, and machine condition monitoring |

## 2. Research topics (only one of these projects will be funded)

| Project 1: *Digital-twins and artificial intelligence for robust machine condition monitoring* |
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| Artificial intelligence (AI) has attracted immense interest in machine condition monitoring (MCM). The enthusiasm of researchers in this relatively new approach stems from its proven value in other image and signal processing applications, like computer-vision and speech recognition. Recent works have however highlighted the key difference of MCM from these more traditional AI applications: the scarcity of fault data. In MCM-intensive engineering applications, failure is often very expensive and prevented by strict maintenance procedures, resulting in just a handful of failure observations. Another complementary criticism that has been made to AI approaches to MCM is that they neglect decades of accumulated knowledge in degradation dynamics and machine reliability. A solution to these problems is offered by the combination of AI methods with digital twins. The latter can produce large amount of data in any condition and codify knowledge about the machine behaviour. Yet, the portability of AI solutions developed in simulated environments to the real-world is still to be proven. A clear picture of the digital-twin characteristics which |

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ensure this approach is successful is yet to be studied, and methods to combine scarce, yet valuable, experimental data with simulations have to be developed for MCM.

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Non-academic partner: SAFRAN-TECH, Paris Saclay

**Research Fields:** Applied science, mechanics, signal processing, machine learning

## Project 2: *Industry 4.0 sensing for machine condition monitoring*

Machine condition monitoring (MCM) is still largely based on the installation of a few expensive accelerometers on few critical machines, acquired by means of expensive and centralised electronics. In a world moving towards fleets of assets (e.g., wind farms, drones for delivery) it is paramount that this approach is replaced by more affordable, scalable and self-sufficient senor technologies. This thesis aims at exploring self-powered, inexpensive sensor network technologies for MCM. Alternatives to traditional piezoelectric accelerometers (e.g., MEMS) will be investigated, both in terms of diagnostic capabilities but also in their suitability for integration with non-invasive, easy-to-install and self-powered data-acquisition systems, able to communicate a sufficient amount of diagnostic information wirelessly in a network of monitored machines. This thesis aims at revolutionising the way diagnostic data is collected, thus enabling the collection of big-data necessary for popular data-driven approaches (artificial intelligence) and the Industry 4.0 transformation.

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## Project 3: *AI-Assisted Condition Monitoring (AIA-CM) based on data-driven optimal signal processing*

Condition monitoring critically relies on signal processing for transforming the raw data (vibration, angular speed, strain, etc.) into interpretable features (scalar indicators, spectra, histogram, etc.). One everlasting challenge is to select the signal processing algorithms among a huge number of candidates, while the best choice is obviously case-dependent. Another challenge is to properly use signal processing algorithms, while they often rely on several critical hyperparameters whose optimal setting is again data dependent. The aim of this research project is to propose a solution to these issues, by making signal processing transparent to the user. It consists in developing a machine learning approach, where each algorithm together with its set of hyperparameters is seen as a probabilistic object in a Bayesian hierarchical framework. The idea is to simultaneously test several candidate algorithms and select the best ones, or a combination of them, according to a given dataset, and to jointly update the values of the hyperparameters that most likely explain the data.
The approach will be demonstrated for bid data processing, on open datasets consisting of large numbers of signals recorded on different machines.

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## 3. Employment Benefits and Conditions

INSA Lyon offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months) with 2 months of probation period and 35 working hours per week.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 28,800 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,928 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

### Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to the to the facilities and premises of the two laboratories involved in the project .
- Tuition fees exemption at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for 12 months in Australia (which may be taken in several blocks over the period of the employment term as best suits the needs of the researcher).
- 25 days paid holiday leave.
- 12 weeks maternity leave.
- 28 days paternity leave.

## 4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a Master's degree or another qualification conferring the status of Master (5 years of higher education).

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 6.5 and no band below 6. Note that the test needs to be completed no more than two years before enrolment. For more information about the tests accepted and scores required, visit:
https://www.unsw.edu.au/study/how-to-apply/english-language-requirements

### More information on INSA Lyon's requirements

Visit the website: https://www.insa-lyon.fr/en/formation-doctorale

### More information on UNSW's requirements

Visit the website: https://research.unsw.edu.au/higher-degree-research-programs

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