



## PhD thesis

### **Real-time estimation and modeling of vehicle lateral dynamics from onboard signals**

#### **Application to lateral displacement, tire lateral forces, and side-slip / slip-angle estimation**

*We have a vacancy for a PhD student (3 years) within Michelin's Embedded Tire Digital Twin program and the joint laboratory LabCom I-TireLab, supported by Michelin, Université de Poitiers, Université Grenoble Alpes, Grenoble INP, and CNRS, through the research laboratories LIAS and GIPSA-Lab.*

*You will join a multidisciplinary team (data scientists, physicists, software developers, etc.), working in close collaboration with Michelin R&D teams, and in direct interface with car manufacturers and fleet customers.*

**Keywords:** vehicle lateral dynamics, tire-road interaction, observers, Kalman filtering, state estimation, robustness, sensitivity analysis, real-time embedded implementation, data-driven / hybrid modeling.

### **Context and Project Description**

#### **Michelin context - Embedded Tire Digital Twin**

Michelin is accelerating the development and go-to-market of embedded software solutions that predict tire conditions and performance (wear, pressure, grip, etc.). To reinforce the Embedded Tire Digital Twin program, this PhD aims to develop robust algorithmic building blocks for real-world deployment, contributing to the broader product ecosystem and industrialization roadmap.

#### **LabCom I-TireLab context - research ecosystem and ambition**

This PhD is part of LabCom I-TireLab, a joint public-private laboratory focused on modeling, estimation, and control for connected tires and rubber manufacturing processes. The laboratory is supported by Michelin, Université de Poitiers, Université Grenoble Alpes, Grenoble INP, and CNRS.

A primary vision of the LabCom is to leverage data and scientific tools to design mobility solutions that are more efficient, safer, and environmentally responsible. Past collaborations have highlighted key challenges: (i) best use of onboard vehicle data, (ii) ensuring real-time performance using standard sensors/actuators, and (iii) translating theoretical advances into real-world applications.

To address these challenges, LabCom I-TireLab follows a structured approach based on three pillars:

- Developing strong theoretical foundations, backed by mathematical proofs to ensure reliability of the solutions.
- Designing efficient algorithmic tools, capable of processing vehicle and industrial process data in real time.
- Deploying demonstrators, to validate approaches in real-world conditions and showcase their added value.

Finally, the LabCom imposes strong industrial constraints: solutions must leverage existing sensors and actuators in passenger vehicles and Michelin's facilities, and must be compatible with real-time implementation.

## **Scientific focus - lateral dynamics as the backbone**

While many industrial estimation approaches start with longitudinal dynamics (often simpler), this can be limiting because it solicits the tire less and provides less information about lateral behavior. The focus of this PhD is therefore vehicle lateral dynamics, to improve the understanding, modeling and estimation of lateral phenomena in real driving conditions.

## **Quantities and phenomena of interest**

The thesis will investigate real-time estimation of:

- Lateral displacement (noted  $D_z$  in the internal framing),
- Tire lateral forces at the tire/road interface,
- The link between lateral forces, vehicle states and global dynamic behavior, with early clarification of how this supports downstream tire digital twin needs.

## **Intermediate estimates likely required**

To reach the above targets from available signals, intermediate quantities may be required, including:

- Vehicle side-slip angle (body side-slip  $\beta$ ), a key variable for lateral dynamics and stability; one expected direction is IMU + vehicle speed based estimation, with real-world robustness analysis.
- Tire slip angle, its relation to lateral forces and the associated observability / circular dependency risks when relying on tire models—explicitly investigated as part of the thesis.

## **Modeling, estimation and robustness themes**

The thesis will cover lateral dynamics models (from simple to more elaborate), and estimation approaches (physics-based observers, Kalman filtering, and potentially hybrid/data-driven components where justified). A major theme will be sensitivity and robustness to uncertain parameters (vehicle mass, center of gravity, tire parameters, load distribution, etc.) and their impact on estimation performance.

## **Project Goals**

As indicated above, the main objective of this PhD is to develop robust real-time estimation tools for vehicle lateral dynamics, compatible with embedded deployment, and aligned with the Michelin Embedded Tire Digital Twin roadmap and LabCom I-TireLab pillars (theory → algorithms → demonstrators).

The scientific and technical goals include:

- Defining and formalizing estimation targets ( $D_z$ , lateral forces, side-slip and/or tire slip angles) and their conditions of observability,
- Designing and evaluating real-time estimators (e.g., Kalman-filter-based observers and variants) robust to noise, biases and modeling uncertainties,
- Building a systematic sensitivity/robustness assessment framework to guide estimator choices and parameterization,
- Validating the selected approach through a progressive validation path (simulation → replay on recorded data → demonstrator when available), consistent with LabCom's demonstrator pillar.

## Supervision team

This PhD project will be jointly supervised by academic and industrial partners within the LabCom I-TireLab (Michelin, LIAS, GIPSA-Lab). The supervisory team will consist of:

- Guillaume Mercère, Full Professor at Université de Poitiers / LIAS (PhD Director)
- Emmanuel Witrant, Full Professor at Université Grenoble Alpes / GIPSA-Lab (PhD Co-Director)
- Hugo Koide and Romain Tomasso, Research Engineers at Michelin, Embedded Tire Digital Twin Group.

## Appointment

This position is a three-year PhD thesis within LabCom I-TireLab and Michelin's Embedded Tire Digital Twin environment.

## Candidate requirements

Applicants should hold an Engineering degree or an MSc in engineering or applied sciences, with a specialization in control, signal processing, and/or applied mathematics. They should demonstrate a strong background and a clear interest in control and estimation, supported by solid skills in dynamical system modeling and algorithm development. Proficiency in programming (e.g., Python, MATLAB, or C++) is required. The candidate must also have excellent written and oral communication skills in English to effectively operate in a joint academic-industrial environment.

## Application procedure

If you are interested in this challenging project, please contact Guillaume Mercère ([guillaume.mercere@univ-poitiers.fr](mailto:guillaume.mercere@univ-poitiers.fr)), Emmanuel Witrant ([emmanuel.witrant@univ-grenoble-alpes.fr](mailto:emmanuel.witrant@univ-grenoble-alpes.fr)), Hugo Koide ([hugo.koide@michelin.com](mailto:hugo.koide@michelin.com)), and Romain Tomasso ([romain.tomasso@michelin.com](mailto:romain.tomasso@michelin.com)). Please use the email subject: "PhD application - Real-time estimation of vehicle lateral dynamics (LabCom I-TireLab)" and attach a CV, cover letter, transcripts/diplomas, and any additional material that can support your application (projects, publications, code portfolio).