Contribution to the safety analysis of the latest generation of railway control-command and signalling systems based on "moving block"

Context

This position is part of the "Safety Assessment of Railway Systems" axis of the "Safety of Railway Systems" Chair. The latter is supported by CERTIFER Association and GAPAVE, a grouping that includes several actors in the railway field: operators, manufacturers and independent safety assessors. The research work that will be carried out within the framework of this position aims to contribute to the challenge of verifying the safety of the future ERTMS / ETCS (*European Rail Traffic Management System* / *European Train Control System*) level 3 system. It is a rail control-command and signalling system that integrates new location and communication technologies. Taking part in this challenge will greatly facilitate the implementation of this system that can allow mobilities to progress in an efficient and sustainable manner. This work will be based on our existing formal models of behaviour [Himrane 2022] [Saddem et al. 2022] [Ghazel 2014], some of which have been developed in the framework of European Shift2Rail projects. Moreover, a group of railway experts, members of the grouping and constituted around this theme, offers a privileged environment of exchanges on technical knowledge, which confers a very enriching context to rigorously model a set of functions intervening in the complete cycle of train control (from route control to movement authorities granted to trains).

Candidate profile
Master's or engineering degree in dependability, systems engineering or automation/computing

Location
ESTAS laboratory
Lille Campus

Starting date
ASAP

Duration
3 years

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Work description

ERTMS level 3 aims to operate trains in an optimal and safe way by using moving blocks. This operating mode requires transferring certain train protection functionalities from trackside equipment to on-board train equipment. In particular, track occupancy information (the position of the front and rear of the train with their margins related to inaccuracy) will stem from the trains and not from the infrastructure. On-board/trackside communication will then enable the infrastructure to get this information in order to manage all train routes and track occupancies in safety on the railway network.

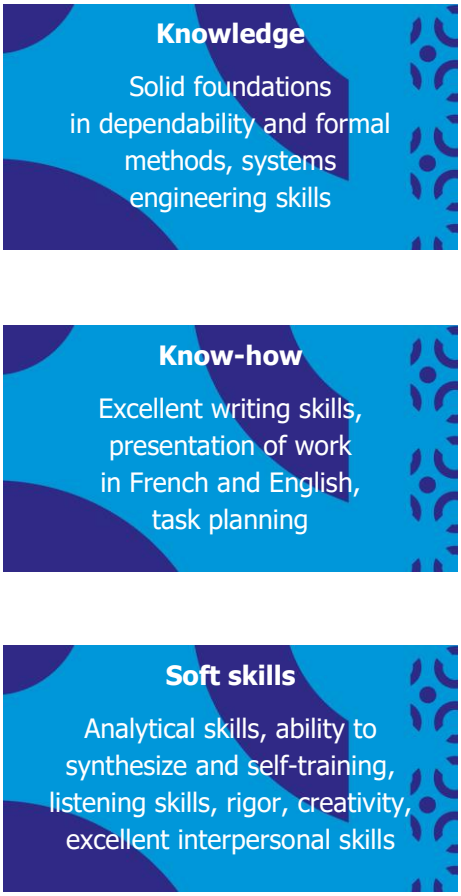
The use of advanced technologies for train integrity monitoring (no broken couplings) and positioning, makes it possible to determine the precise track occupancy of a vehicle, in particular with satellite localisation technologies (GNSS, Global Navigation Satellite Systems) in conjunction with various sensors and processing. However, the current work on ERTMS level 3 and its variants (with virtual blocks or hybrid variants) is hampered by the lack of safety assessment methods that allow the complex interactions between the different parts of the control-command system to be understood during its operation, additionally to the fact that the railway environment has a highly variable and disturbing impact on the on-board equipment incorporating GNSS.

To contribute to the safety analysis of mobile block operations, the proposed work aims at developing a process based on the modelling of complex functional interactions within ERTMS level 3 to assess operational safety properties and evaluate different hazard situations. The performance pertaining to integrity monitoring, communications and positioning equipment (in particular, related to satellite localisation) will be considered in the process as parameters to show their impact on safety properties.

The first step will be to understand and analyse the complex functional interactions in a control-command system using moving blocks and including the inaccuracies specific to satellite localisation. Since the train movement is

subject not only to temporal constraints, but also to spatial constraints (e.g., specific points to be passed with a given speed) and speed constraints (static and dynamic speed profile, temporary speed restriction) along the railway track, a difficult challenge is to take into account, in adapted models, position and speed inaccuracies in the context of moving block operation. This information, measured by the train, is transmitted to the trackside subsystem with a time delay. Despite this delay, the subsystem uses this information to identify occupied track sections and thus manage the different train itineraries.

Recent work includes interesting modelling elements linked to existing or planned control-command systems, the principles of which are adaptable to ERTMS/ETCS level 3 [Basile 2021, 2022] [Berger 2018]. The second phase aims to develop and come up with a process using advanced techniques for modelling complex behaviours for the verification of safety properties linked to ERTMS/ETCS level 3. Behavioural models may be based, for example, on timed automata (of probabilistic, stochastic, hybrid types) or Petri nets (timed, coloured, stochastic, interpreted), with approaches to failure analysis or reachability of feared events based on model checking (of classical, statistical, probabilistic type).



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