PhD THESIS OFFER
2022-2025

Hyperconnected system for on-demand planning of freight flows in connection with the implementation of an autonomous light train

Keywords:
Supply Chain Management, Logistics, Physical Internet, Train, Planning, Operational Research, Optimization.

Partners:
The Industrial Engineering Centre of the IMT Mines Albi engineering school (Albi, France):
https://cgi.imt-mines-albi.fr/
The Engineering Systems and Services (ESS) Department of Delft University of Technology (Delft, The Netherlands):
https://www.tudelft.nl/tbm/over-de-faculteit/afdelingen/engineering-systems-and-services

Management Team:
Thesis Supervisors:
- Prof. Xavier LORCA (IMT Mines Albi)
- Prof. Lori TAVASSZY (TU Delft)
Advisors:
- Dr. Eva PETITDEMANGE (IMT Mines Albi)
- Prof. Matthieu LAURAS (IMT Mines Albi)
- Prof. Tina COMES (TU Delft)

Location:
The thesis will be located in Albi (France). Stays in Delft (Netherlands) will also be planned (TU Delft). The periods will be defined with the person who will be recruited.

Contract:
3-year fixed-term contract (10/2022 to 09/2025), Training through Research Contract. Executive status.
Remuneration: ~ 1679 € net/month + ~ 150 to 250 €/month for teaching activities.

Application:
Applications (CV, covering letter, transcript of marks from the Master's degree, and any document that could help to assess the candidate’s level and motivations) should be sent by email to matthieu.lauras@mines-albi.fr before 15 June 2022. Shortlisted candidates will have the opportunity to present their motivations orally during an interview to be scheduled at the end of June 2022. For more information, please contact matthieu.lauras@mines-albi.fr.
Context:
The ECOTRAIN project is a system of autonomous light rail shuttles powered by batteries and allowing automated traffic without drivers. Two types of shuttles will be developed on a common technical basis, "micro freight" and "passenger". The objective is to develop an autonomous 30-seat rail-guided shuttle, with both passenger and freight versions, with a breakthrough compared to the existing system (weight, rapid automation, vehicle versatility), with a lower operating cost due to the automation of the service (without a driver). Given its low axle load, the ultralight vehicle proposed by ECOTRAIN will be compatible with infrastructures (rails) that are currently disused or little used. It is likely to improve the potential overall cost balance of investment and "standard" equipment for the territory's fine service lines. Several hundred ECOTRAIN lines (less than 50 km) are envisaged in France alone within ten years.

The France 2030 Program has decided to support a first wave of funding for the ECOTRAIN initiative aimed at developing a first prototype of rolling system and investigating the organizational schemes associated with the project (pre- and post-routing modalities, activity planning principles and tools, etc.). The present PhD project focuses on this last ambition of the project. The ECOTRAIN system includes single-track autonomous shuttles over short distances with recharging centers on each line. From a perspective of freight logistics, an important task is the design of the system to be able to serve supply chains. There is no technology comparable to autonomous micro-freight in the world, and the overall optimization of freight management has never really been studied in rural areas.

The future global “Physical Internet” will serve as a starting point for developing the design of the logistics of the ECOTRAIN ecosystem. The vision of the Physical Internet was conceived in order to satisfy the growing requirements in terms of environment and performance of services. It entails the creation of logistics services that are resilient, efficient, sustainable and adaptable for its users. It is constructed as "a global logistics system built from the interconnection of logistics networks through a standardized set of collaboration protocols, modular containers and intelligent interfaces for increased efficiency and sustainability" (Montreuil et al., 2012; Ballot, 2014). It has been shown that the more interconnected the logistics, transport and production networks are the more options there are to seize opportunities and counteract the risks and disruptions experienced. In the field of logistics several works have demonstrated this interest for both freight and inventory management, including the resilience of these solutions (Yang et al., 2017) and (Kim, 2021). However, no publication has yet addressed the issue of transposing these principles to transportation problems outside urban areas or to light rail-type transportation modes.

The idea is no longer simply to optimize a logistics system in relation to a real or assumed demand, but rather to develop reaction and pro-action capacities based on the dynamics of detection and adaptation to observed and potential events. This approach relies in particular on the ability to identify in real time the production capacities of a network of active or potential partners on the one hand, and to generate and evaluate significant sets of scenarios enabling the activation, on demand, of adapted and robust organizational solutions on the other hand.
It should be noted that such a paradigm shift in logistics will require major transformations at various levels, and particularly at the planning and scheduling one.

**Topic:**
The objective of this thesis is to support the planning and scheduling of operations by considering all the features of the ECOTRAIN (single track, autonomy, crossing areas, etc.), its ecosystem (users, battery charging plant, other train lines, inbound/outbound logistics providers, etc.) and all potential hazards and disruptions which can occur. On this basis, the processes to be implemented to plan ECOTRAIN’s logistics activities will be defined with an “a priori” perspective and should be duplicable on any kind of ECOTRAIN implementation. This phase is in line with the planning approaches traditionally encountered in the world of operations management, but in a context specific to the autonomous train. Particular attention will be paid to the "on-demand" planning of the shuttles, taking into account the constraints inherent to the project, described above.

5 main tasks are expected in this doctoral thesis:

- Sizing the number of shuttles that can circulate on the network by taking into account the various constraints associated with the project: in a non-exhaustive way, the adequacy of the forecasted volume of freight with track capacity and safety standards.
- Development of reasoning mechanisms to deduce a nominal but robust planning given the available information on the state of the system, the needs and the expected events. Planning of ECOTRAIN operations but also of pre- and post-routing activities (last mile).
- Definition of a principle of interaction with upstream/downstream players to facilitate the execution of the processes selected, whether planned or on request, by interacting with the various systems in place in the ECOTRAIN system (users, suppliers, customers, service providers, etc.).
- Definition of use cases in connection with LA POSTE.
- Experimentation on use cases, evaluation and recommendations.

The thesis project plans to undertake a major R&D effort to design, test and adapt appropriate responses. With a view to rapid dissemination of the technologies developed and the creation of technological and commercial outlets, this R&D approach will be based on the provision of a dedicated pilot site (Albi - Puygouzon) to conduct all the tests required to implement this innovation.

**Research team:**
The Industrial Engineering Centre of IMT Mines Albi is a human-sized, friendly, competent and ambitious team, open to the international scene, and in permanent contact with the reality of the field. With nearly 2M€ of annual contractual activity, 1 industrial chair and 6 public-private Joint Research Laboratories, the Industrial Engineering Centre develops applied research activities that are definitely oriented towards the needs of the business world. The team also displays a proven scientific excellence with more than 70 annual publications in international conferences and scientific journals of rank A, and numerous international academic partnerships with renowned universities such as TU Delft (The Netherlands) or Georgia Institute of Technology (United States) via the SIReN International Associated Laboratory.

**Profile of the candidate sought:**
Master’s degree in engineering, science or management with proven knowledge in one or more of the following areas: industrial engineering, logistics network management, data science, operations research, applied mathematics, simulation models, decision support systems, business intelligence. A good level of English is required as well as good writing skills in French and English. An interest in operational research and computer programming is required.