Opportunities for autonomous rail transport in mixed passenger-freight systems in rural areas

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Keywords : *Transportation, Railway Network, Autonomous Vehicles, Rural Areas, Operational Research, Physical Internet*

While urban areas have developed several new forms of transportation over the past century in response to economic, environmental, and social constraints, rural areas have not evolved, at the same level, in terms of logistics and supply chain. In order to move them away from legacy transport modes and make them more viable, a more interconnected and intelligent collaborative supply chain network, on a global scale, can represent a real opportunity, not only for the users, but for all the stakeholders; this is the concept we now call the Physical Internet network [1]. Much research has developed and applied the concept on road transport, but not much has been done yet in rail transport, which gives us a new research deviation.

The accessibility of public transportation in rural areas influences not only the economic and social indicators of the region, but also the environmental ones, since it favors the use of public transportation over private vehicles [2]. The low number of transport services in rural areas is explained by the interest of transport companies in the most competitive zones, *i.e.* cities. Therefore, there is a need to develop transport projects that meet both the economic and the environmental requirements of this era and the areas. Similar projects are already being implemented; Ecotrain is a sustainable project aiming to deploy autonomous trains in rural zones to ensure a level of continuous quality of logistics services in rural areas, close to the one in urban ones, and emerge them from isolation. To do so, we need to look for new methods that are flexible and adaptable to this new type of transport. The hyper-connected Physical Internet represents a real opportunity for the rural areas to get into a global hyper-connected supply chain, and for the autonomous trains to meet the requirements of efficiency and sustainability. But what configuration can we adopt to make this new railway system integrate the Physical Internet network?

The System Configuration. To better answer this question, we should analyze the system configuration at two levels: strategic and operational. The problem at the strategic level is not only about sizing the network capacity and the demand volume, under the constraints of the railway usage rules, but also about taking into account all the other possible transport opportunities. This leads us to define the second level parameters; *i.e.* the operational level:

- The demand variable can be classified into one of the following classical demand categories: Smooth, Intermittent, Lumpy, or Erratic.
- External transportation options are also a variable that can be represented by a forecasting model. These variables directly affect the chosen scenarios.
- The railway configuration and the safety regulations are a set of constraints that influences directly the trains scheduling models.

The integration of the Physical Internet adds more parameters at the operational level and defines new interactions between the different system stakeholders. In this part we will explain the proposed system configuration. The main decision unit is the π-*hubs* (in a first instance we assume an equivalence between train stations and π-*hubs*) where passengers, parcels and delivery services converge. The π-*hub* generates two types of local train schedules (Figure 1): *long-term schedules*, which get based on the analysis of data history, and *short-term schedules*, that provide an adapted dynamic schedule based on the long-term one, the analysis of the current demand volume, and the current railway availability, with an objective function of maximizing demand satisfaction. A set of parcels is represented by a π-*container*, which is a smart container connected to the network and containing a set of data and parameters defining its priority. From these embedded data, each π-*container* benefits from an appropriate local routing from the related π-*hub*.

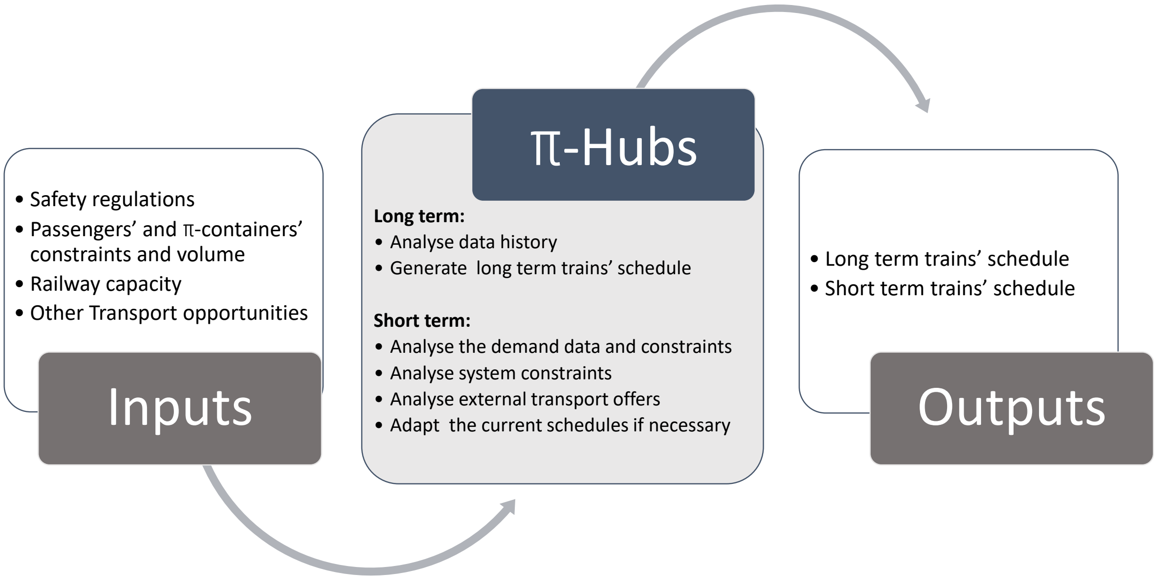

FIG. 1: π-*hubs* process

Conclusion. The technical solution of Ecotrain project is still in the conceptual phase, and in parallel, research is being carried out on the dimensioning of the logistical solution for this new type of demanding transport. The integration of the concept of the Physical Internet and the various constraints distinguish this project from the regular classical railway problems that have been studied so far. Our mission is to provide a robust dynamic scheduling program, able to respond to the demand constraints variation within the context of the Physical Internet. The next research steps will therefore address network capacity sizing, system modeling, and investigation of possible scenarios in order to bring the application of the Physical Internet in railway systems out into the reality.

References

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