Technical, economic and energetic competitiveness of rail-road combined transport: evaluation of the effects of possible ITS applications on intermodal terminal.

Summary

Road transport has been the most used mode for freight transport in many European countries for several decades. In this century, due to the growing awareness of sustainability problems in this field, the European regulations provide much guidance to meet requirements of environmental sustainability. The intermodal transport could be a good solution to achieve these requirements and can be an eco-friendly option for medium/long distance connections thanks to the use of railway for the longer part of the path. The research activities focused on two main elements: the rail-road combined transport (chain level) and the intermodal terminal (node level). These aspects are strictly correlated due to the important role of the intermodal terminal in the competitiveness of rail-road combined transport. On the other hand, the study of the entire transport process is fundamental to define the terminal requirements and performance.

The typical rail-road combined transport process is described by standard language (*Systems Modelling Language*) to represent the complex relations between the actors involved in the process and their main activities.

After examining the process, the range of competitiveness of rail-road combined transport in terms of covered distance is analysed. The analytic approach considers the different phases of transport chain and investigates parameters such as the external costs and the location of terminals. The function obtained for rail-road combined transport costs is obviously discontinuous due to the presence of terminals and their costs items which are independent on covered distance. The main results obtained show that the rail-road transport may be competitive if the external costs are internalised and if the total distances are enough to exploit the advantages of rail transport. The cost for terminal operations can limit the competitiveness of combined transport solution, confirming its essential role. These considerations may not be suitable in some cases, such as in case of a short distance (seaport and dry port connection) covered by a shuttle train: scheduled and fixed composition, large quantities of goods with the same path. This type of service allows lower costs for terminal operations and the elimination of initial part covered by road. To better analyse the freight door-to-door movement, the thesis includes a focus on section of transport chain: the last mile covered by road and the role of GPS positions on accessibility measure. The method proposed has the potential to solve the issue of hubs locations, to better evaluate the compatibility between electric vehicles and urban trips and to evaluate the role of ITS (AVL - Automatic Vehicle Location, for instance).

In the second part of this thesis, the typical internal process for intermodal terminal is investigated and represented through standard language. After that some performance indicators for each phase of terminal process obtained through an extensive literature review are collected and classified with traceability matrices correlating them to actors involved and the scope. Later, the focus was on the

manual or automatic terminal gate operations. The manual identification of transport units and vehicles may cause a chance of errors while automatic identification sensors can avoid them improving, among other things, this part of terminal process. Two main classes of sensors are considered: one based on optical identification and other on the radiofrequency. To sum up, the technologies can contribute to terminal performance improvement or can help the computation of the indicators itself.

One of the goals of this thesis is to propose and evaluate, through simulation and analytical approach, the effects of possible ITS (*Intelligent Transport Systems*) applications on intermodal terminals, in terms of throughput and energy efficiency. The first method is the standard system architectures representation to support the calculation of indicators. The architectures allow a clear communication with stakeholders and show at which points of the process the indicator can be measured also in different scenarios. The second approach is the terminal simulation to evaluate the quality and energy performance of inland freight terminals, using a quantitative approach based on traffic microsimulation models. The model allows a comparison of chosen performance indicators in several scenarios using realistic data. The main results show that the fuel consumption is consistent with the level of congestion inside the terminal and the use of technologies could improve the performance of intermodal terminal also in the case of worst scenario. Finally, the third approach is the application in the field. The monitoring phase aims to elaborate the data from the use of video technologies in the first phase and after of Bluetooth and Wi-Fi sensors. After investigating different monitoring scenario, the final trends obtained from data collected with BT sensors are relatively similar to the typical traffic flow inside the terminal.