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Single wagonload production schemes improvements using GüterSim (agent-based simulation tool)

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Abstract

Single Wagonload (SWL) is still a major component of the Swiss freight transportation system. To hold the market share of the SWL system a reduction of production costs and an increasing quality is needed. To evaluate alternative production schemes and the effects of technological innovations a simulation tool is necessary. Since there are no suitable tools available which cover all needs for a SWL simulation, the IVT developed a new agent-based tool called GüterSim on the basis of the existing software MATSim. GüterSim models the routing of the freight wagons, as agents, according to the routes in the real SWL network and the production schemes. It is a scalable model with two network levels and an integrated approach.
This paper presents the following achievements: Modeling existing timetables and routing of freight trains; opportunity for improvements of train routings and schedules to optimize the existing productions scheme; integrating the capacity restrictions of the infrastructure to check the realizability of the improvements; automatic timetable generation on the existing network; and automatic generation of new production systems. A case study is presented to prove model's application. The work is based on real data from the SWL Swiss network which includes infrastructure data, schedules, rolling stock and locomotive data. Therefore the conclusions are based on real freight demand within the Swiss freight network. GüterSim is proved as a tool to improve SWL production schemes and scalable to other freight networks with fixed schedules.

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Keywords: agent-based, rail, freight, optimization, single-wagonload

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1. Introduction and motivation

Single wagonload (SWL) transport is still considered as a major component in numerous European states transport systems and in the logistics of different economic sectors such as steel, chemical industry and automotive. However changing framework conditions and increasingly demanding market requirements have led to dramatic market losses and even to complete shutdown of SWL business in some countries. As this business segment has been evaluated as important for specific transports in a European co-modal transport system also in the future, significant improvements are needed. Compared to other European Countries, the SWL in Switzerland is in a good state. About 50 percent of all domestic, import and export rail transports are handled by SWL. However, even in Switzerland, the SWL must face the pending challenges. On the one hand, a continuous optimization of the production network and a reduction of the number of shunting yards takes place. On the other hand SWL in Switzerland has to deal with rapidly growing passenger traffic, which is prioritized in the network access. Thus, the number of available train paths for SWL is reduced. To remain competitive against road transport, SWL has to cover even under these boundary conditions all national relations in Switzerland in an overnight service. To meet this requirement the production system must be continuously improved. To increase the competitiveness of SWL compared to road transport an optimization of the production schemes is necessary. The main goal is increasing the quality of SWL and the reduction of production costs. Thus, the sector has identified four approaches:

- Increase of the utilization of trains – to reduce the number of trains, because currently trains are used at 60% of capacity and therefore cost per wagon transported has room for improvement.
- Stabilization of the train occupancy to achieve a more sustainable service.
- Reduction of the deviation of wagons, due to current complicated wagon routing.
- Enhancement of the supplied services by shorter transport times because they are currently longer than road freight transport times.

In section 2, the state of the art of SWL systems and SWL optimization approaches are presented. In section 3, GüterSim model is explained. It is a SWL agent-based model that includes infrastructure, production and shunting processes. In section 4, case study for improvements on the Swiss SWL network is presented. Finally, in section 5, the conclusions summarize the work presented and evaluate the potentiality of implementation of this method as a short and mid-term solution until more technological means are implemented in daily based SWL schedule planning.

2. State of the art

The state of the art describes the two fields that influence this research, which are the current practices on the SWL network in Switzerland and the most recent research developments in SWL modelling.

2.1. Best practices in Switzerland

Nowadays most of the European railways use a modified hub-and-spoke-system for their SWL production schemes (Bruckmann 2007). In Switzerland the SWL production scheme consists of a three stage collection and distribution system. The first stage consists of the satellites including the sidings where the wagons have their origin and destination. The second stage consists of the regional production points where the trains to the shunting yards are formed and as a third stage the shunting yards.

2.2. Current modelling approaches

SWL is a complex system where several elements play an important role, e.g., freight planning, train operations, shunting processes and network structure. Literature shows different methods to optimize separately the elements of SWL systems, but no integrated approach until now is known. For instance, regarding freight planning, Marinov et al. (2012) talk about SWL services and how policy and practice can benefit from scientific methods and information