

Autonomous Driving in Intermodal Goods Transport

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Introduction

At the present moment it seems rather unrealistic that autonomous driving will become available for the scope of everyday traffic in the next decade. That is quite another matter for the narrower scope of non-public traffic. Based on the technical equipment of today's series trucks time seems ripe to think about continental concepts of interleaved driver-based and driverless goods transports. Together with a truck producer our institute investigates several promising application areas for autonomous goods transport with heavy goods vehicles. The following application areas have been identified:

- Autonomous driving for haulage firms: charging and discharging of goods on haulier's yards, washing (see picture), maintenance, refuelling
- Roll-on-roll-off intermodal traffic: autonomous roll-on-roll-off traffic from road to train, road to ship and train to ship
- Test operation of trucks: endurance test for new series trucks under specific road and off-road conditions

For a further understanding of the benefits, the technical requirements, the necessary infrastructure and the continental or even global information flow we concentrate in the following of the items listed above: the intermodal traffic of series trucks and trailers rolling on and rolling off special goods trains at railway terminals, for short called *roro-traffic*.



Autonomous goods transport is strongly based on the trucks capabilities already available today:

- Series trucks are equipped with interfaces for all driving functions like steering, accelerating and braking. The development of this technology has been funded by several projects of multinational associations, e.g. the PEIT-Project of the EU. The existence of adequate interfaces essentially facilitates the integration of precise elementary driving maneuvers into the wider context of automated driving.
- The kinematics and dynamics of vehicles has already reached the state of the art which is sufficient for autonomous maneuvers. The particular interest of our institute is focused on precision maneuvering for articulated vehicles forward and backward.

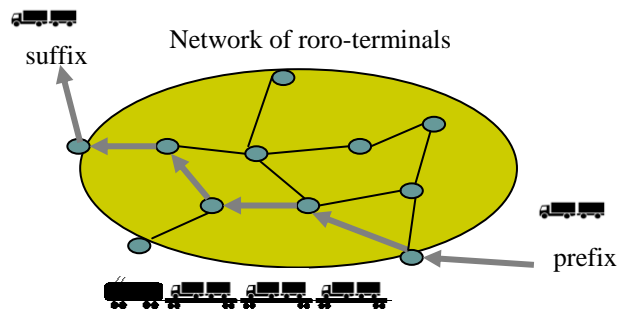
These capabilities are combined for the development of automatic transshipment stations. Only a few gadgets have to be integrated into the autonomous trucks: a positioning system, a communication system and some on-board control logic. The disposition, supervision, and coordination of the vehicles on an yard has to be done by a local control center. To demonstrate the feasibility of guiding a large number of articulated vehicles in real-time a corresponding simulation and visualization (called *RoRoVis*) of a roro-terminal has been developed and establishes the basis for local and global deliberations.

Local and global impacts

Under logistic aspects the operative potential of RoRoVis is based upon two capabilities:

- Any automated guided truck carries goods and, in contrast to straddle carriers and crane systems, is principally able to operate parallel to each other carrier of goods.
- In a network of roro-terminals (e.g. covering Central-Europe) trucks and trailers can be switched and shipped to optimize the respective constraints (e.g. available capacities, short distances to the network).

On a **local** level quantitative results for a single roro-terminal can be derived. Based on the experiences with real trucks the first operative goal was to get a solid estimate of the time necessary for the automated unloading and loading procedure of a complete train. Assuming realistic velocities for these vehicles and driving with high safety precautions it has been shown that unloading and loading can be realized in less than 30 minutes.



At an **intermediate** level the achievable long-term performance of the roro-terminal was investigated. Presupposing a roro-terminal with three independent rails and a frequency of one train every 40 minutes per rail we achieve a throughput of more than 2000 articulated vehicles per day. These results are achieved with very few resources, e.g. a parking area for the transient vehicles of less than 200 places, even for statistically distributed traffic volumes with high variance.



At a **global** level, which is the simulation of a network of roro-terminals, the intention is to quantify the long distance behavior achievable by this type of intermodal transport. With realistic assumptions considering the density of the network (e.g. 250km-400km between roro-terminals) and a moderate medium speed of

80km/h for the trains a distance of about 1500km per day is achievable. This capability is available 24 hours a day and 7 days a week.

We know about the weakness and dependencies of the results achieved by simulation. However, these figures give a clue about the potential of this concept in the wider scope of re-balancing the traffic load to a more sustainable direction. Our operative results already allow some vague estimates:

- The range of some load carrier transported by EZrola can be doubled over lifetime.
- In a network of roro-terminals the consumption of primary energy for the same amount of net load can be reduced to more than 70% with respect to road bound traffic.
- The heavy road traffic in i.e. in Central-Europe can easily be reduced for more than 10% applying roro-traffic to the existing railway net.

Challenges and milestones

The most important research challenges are, as far as predictable at the current state of the project roro-transport:

- High precision driving for articulated vehicles based on redundant position detection mechanisms and a sophisticated concept for collision free motion control.
- Standard software library for the composition any type of articulated vehicle, for the construction of areas of non-public traffic and for the concentration of information in control centres.
- The global planning of interleaved traffic flow between road and railway, traceable via internet by the railway company and the haulage contractor.

The first milestone that we are approaching within the next year is the complete conceptual and operative modelling of an existing roro-terminal. Provided that the qualitative and quantitative results of the collateral investigation are positive, the first singular roro-connection could be established within a few years. As the whole argumentation builds on a global network of roro-terminals this could – as far as we observe the technical, social and political – reach a status of up to 25 roro-terminals in Europe within the next 10 years, because traffic infrastructure is available and the necessary investigations for roro-terminals are low.

The experiences made in other rail-bound projects show that it does not suffice to develop a good idea to a prototypic status and then wait that the community of railway companies adopts this technique, even if its advantages are evident. Therefore there must be a cogent plan to start up this type of traffic. The RoRoVis simulation- and visualization-software seems to us as an indispensable preliminary means to initiate the steady migration towards realization for this cyber physical transportation concept.

Several strategic and ecological issues will propel roro-traffic, particularly in Europe:

- Several tunnel projects, first of all the 70km NEAT-tunnel (in 2012) through the Alps, are open for this kind of intermodal traffic and eliminate intolerable bottlenecks.
- The actual and future price for diesel encourages this kind of goods transport which consumes at least 40% less in primary energy.
- The highway system, despite of the fact that toll charges are steadily increasing, is congested and a new highways will not be build due to the expected public opposition.

About the author and his institute

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