COOPERATIVE SYSTEM FOR TRUCK GUIDANCE AND CONTROL – IS A WIN-WIN-SITUATION POSSIBLE?

Solveig Meland, SINTEF Transport Research, solveig.meland@sintef.no

Thomas Engen, SINTEF Transport Research, Thomas.Engen@sintef.no

Cato Mausethagen, SINTEF Transport Research, Cato.Mausethagen@sintef.no

Ola Martin Rennemo, SINTEF Transport Research, OlaMartin.Rennemo@sintef.no

ABSTRACT

Trucks are important contributors to urban environmental challenges related to emissions of pollutants and noise. Allowing heavy vehicles to keep a constant speed level, if possible keeping them out of queues, or moving queues to less unfavourable areas, are measures to reduce local pollution in urban areas. The project idea is to develop concepts which facilitate control and management of heavy freight vehicles, much the same way as the air control manages airplanes approaching or leaving an airport. This requires the acceptance from all stakeholders, and demands the establishing of a win-win-situation, where all participants benefits. Is this possible? Findings from the GOFER project indicate that this may be the case.

Keywords: Freight, ITS, traffic management

INTRODUCTION

In many urban areas, freight vehicles represent a modest proportion of the vehicles, but a large proportion of the traffic-related emissions. Heavy freight vehicles waiting to be served at terminals, frequently cause queues inside and outside the terminal areas, making the approach to and operations in the terminal areas difficult and less efficient. Emissions from heavy vehicles increase when the vehicles are forced to keep a low or uneven speed profile (Rexeis et al, 2005), which is typical of queuing situations in urban areas. Thus, reducing the heavy vehicles' exposure to queuing situations, either by giving them priority or restricting their access to parts of the road network under certain conditions – or a combination of these - could be ways to reduce this problem.

The Norwegian Research Council sponsors a research project called GOFER (2009-2012), involving the national and local road authorities, municipalities, terminal- and freight operators, technology suppliers as well as R&D-organisations in Norway, targeting these challenges.

The main objective for the GOFER project is to contribute to a reduction in emissions, queues, accidents and operator costs related to heavy freight, by introducing new technical solutions and ways of cooperation.

Project idea

The GOFER project idea is to develop concepts which facilitate individual control and management of heavy freight vehicles, much the same way as the air control manages airplanes approaching or leaving an airport. This could mean directing vehicles to specific routes in order to avoid queues, or to designated areas for waiting/resting until they are allowed to continue, but then while being given priority by means of for instance green wave through traffic lights or access to public transport lanes. Such a system could contribute to moving heavy vehicles out of rush-hour traffic and terminal-related queues to areas and time periods where the negative environmental impacts would be fewer and smaller. At the same time this could provide more predictability to the drivers and the terminal operator alike, and time spent in queues could be transformed to resting time or be spent on other tasks.

The GOFER project ambition has been to contribute to uncover opportunities and problems, provide common understanding and platform for the stakeholders involved, and to identify and explore some possible technical solutions related to heavy freight vehicles in the city.

Project activities

The first phase of the project focussed on user needs and requirements. This formed the basis for the demonstration activities in the project:

- A ten week long live demonstration of a cooperative system on a 500 km route allowing truck drivers to exchange information with other professional drivers, transport and terminal operators and public authorities.
- A test in a heavy vehicle driving simulator, studying possible effects of measures prioritizing heavy vehicles in urban areas, such as access to public transport lanes and priority in traffic lights.
- A study of full scale effects of and necessary requirements for the implementation of the truck management system, by means of a micro simulation model.

USER NEEDS AND REQUIREMENTS

During the first part of the project, the project activities were concentrated on identifying issues and challenges related to transport in the city and terminal areas, and collecting input on how a GOFER-regime can create good solutions to make the road transport more efficient, and at the same time to facilitate intermodal transport. This process included workshops and meeting with project partners as well as stakeholders outside the project consortium. There was also collaboration with other national research projects, and information gathering about international activities/experiments and research projects that might be relevant to GOFER.

The project started out with a focus on freight in an urban setting. During the run of the project, the scope was expanded to include long-distance aspects of the transport as well. A survey was carried out in order to get an overview of relevant framework conditions for heavy transport, including regulations regarding driving-/rest time and transport of dangerous goods, on-going activities related to the establishment of safe resting areas/intelligent truck parking (ITP), as well as other relevant development and implementation of ITS in Norway.

The project partners expressed expectations that a GOFER system could contribute to an increase in capacity utilization, effectiveness, and predictability, intermodality and positive environmental effects. However, a GOFER system could also be seen to stimulate to more freight on the road. This is considered an undesirable effect by the authorities, but may be requested by the transport industry.

The common denominator for all involved parties was a wish for increased efficiency within their own area of responsibility:

- For public authorities, it is important with reductions in queues and emissions, and improved road safety.
- For transport practitioners, capacity utilisation and drivers' security are important issues
- For terminal operators, traffic through-put in the terminal is important, with the correct vehicle arriving at the right time, and the environmental effects of this.

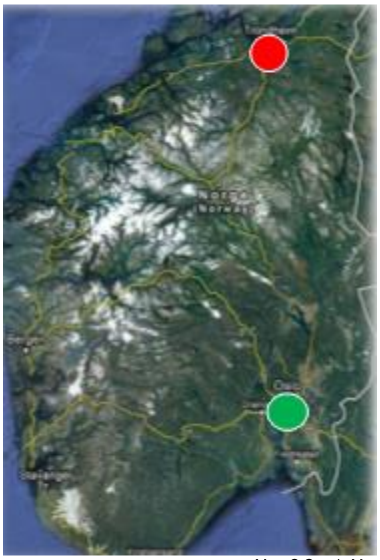
The input from this user needs study formed the basis for the work with defining the demonstration activities within the GOFER project, aiming at creating a "win-win"-situation, where all participants could benefit from taking part.

DEMONSTRATION ACTIVITIES

The demonstration activities in GOFER were not primarily tests of technology, but demonstrations of services and functionality. Data from vehicle position logs from all three demonstrators, along with interviews with test drivers and representatives of participating transport operators and public authorities, provide the basis for studying acceptance, environmental effects, potential benefits from and requirements for the implementation of a cooperative system for heavy vehicle traffic management.

Live demonstration of cooperative system

During the winter season of 2011-12, eight heavy duty vehicles from the Norwegian transport operator Bring took part in a ten-week long live demonstration on the 500 km long route from Oslo to Trondheim, from mid-November 2011 through January 2012. The vehicles would typically depart from the terminal in Oslo in the afternoon or evening, and arrive at the terminal in Trondheim some time during the night.



Map: © Google Maps

Figure 1: GOFER demonstration vehicle and route

The vehicles were equipped with on-board equipment (OBE) (Figure 2) for exchange of information between the drivers involved in the demonstration, between the drivers and the terminal, and between the road authorities and the drivers, using an information system with functionality specially developed for the project. The OBEs had a touch-screen, allowing the drivers to receive information, make choices and enter information to the system, by touching the screen. The drivers who were loyal to the test scheme got to keep the equipment after the demonstration period.

Demonstration functionality

The live demonstration included the following features:

- The drivers could send pre-defined messages (GOFER messages) about conditions along the route to their fellow demo-drivers, by touching a simple symbol on the OBE screen (Figure 3).
- In addition to the GOFER messages, the drivers would also receive ordinary road messages, distributed by the Norwegian Public Roads Administration (NPRA), on the same equipment.
- Expected remaining driving time to first place of delivery in Trondheim was calculated using formulas for a newly developed Speed model for heavy vehicles (Tørset, 2011).

These calculations are based on factors which affects the actual driving speed for heavy vehicles under different conditions: Total vehicle weight and engine power, and road characteristics such as curvature, slope and width.

- Arrival time at destination in Trondheim was predicted, based on the remaining driving time, combined with logging of how much of the mandatory 45 minutes resting time had been used.
- The staff at the Trondheim terminal could see the predicted arrival time for each vehicle on a GOFER website, "airport-style".
- When approaching Trondheim, the driver would get information about recommended route to first destination, and a message with information about space/time slot booked at the terminal.

Figure 2: GOFER On-board equipment

Figure 3: Icons for the pre-defined GOFER messages

Creating a win-win-situation is particularly important for a demonstration where participation is voluntarily, and with a risk of the participants dropping out if the system imposes too much hassle and disturbance without any compensating measures. Initial plans were to include real-life prioritizing with access to public transport lanes and green waves in traffic signals. This, however, turned out to be not feasible. Effects of these prioritizing measures were instead studied in a heavy vehicle driving simulator, presented later in this paper. With the planned prioritizing instruments gone from the demonstrator, any measures imposing delays, such as ordering the vehicle to a holding area, was out of the question. Also, route guidance had to be given as recommendations, not as orders. In the process of identifying alternative functionality which could make the participation more interesting and worthwhile for the drivers, the geographical scope of the demonstration was expanded from the initial plan to just cover the Trondheim area, to include the entire 500 km route between Oslo and Trondheim, and the GOFER messages were included in the functionality. The introduction and contents of these messages was based on input from the drivers during the demonstration planning.

As mentioned initially, the GOFER project idea is to develop concepts which facilitate individual control and management of heavy freight vehicles, much the same way as the air control manages airplanes approaching or leaving an airport. The data system developed in GOFER has been prepared to communicate with traffic management systems and booking systems for terminal facilities, resting areas etc. It is these systems which will provide the GOFER system with the rules and policies which the individual control and management of the heavy vehicles is based. However, due to the lack of such systems in the Trondheim area and the terminal involved, the messages regarding route guidance in Trondheim and booking of slot time at the terminal were generated within the GOFER data system for demonstration purposes, and served as examples of how such messages could be given. The recommended route was based on information about the location of the destination, vehicle characteristics, and any restrictions with regard to weight or height in the road system, or road closures. The slot time reservations were based on the calculated time of arrival. As mentioned, functionality such as ordering the vehicles to a holding area, was not included in the test due to lack of relevant priotizing instruments for the live demonstration. As the vehicles included in the demonstration all arrived in Trondheim during late evening or night, when there is no congestion, this functionality would not have been very relevant for the demonstration situation as it ended up to be.

Data system:

The GOFER data system (Figure 4) was specially developed for the project, and is based on open source or free software, including Android, Java and PostGIS. The system is based on the ARKTRANS definition of roles (Natvig et al, 2009).

Information regarding road messages were partly distributed via a system named TRIP (Transport Related Information Platform), courtesy of one of the project partners, Triona. The information platform gives access to road related information, e.g. weather conditions, road mappings, road messages and speed limits.

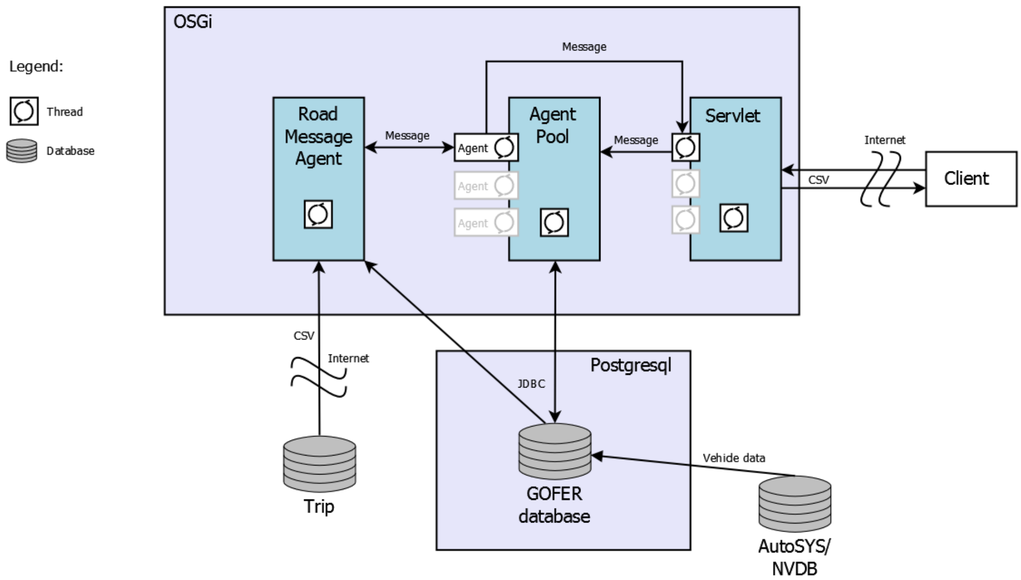


Figure 4: The GOFER System Architecture

For the live demonstrator, the road messages for the routes included in the demonstration were periodically imported from TRIP and stored locally in the GOFER database, along with the GOFER messages initiated by the drivers included in the test. The road messages are distributed to the TRIP system by the NPRA. In a full scale system, the GOFER system could send the GOFER messages to the TRIP system, for public access.

AutoSYS holds information about all vehicles registered in Norway. For the GOFER demonstration, this data base was used to collect the necessary vehicle data before the test started. The data included engine power, vehicle height and vehicle weight for the vehicles and trailers involved in the demonstration. These parameters were used to calculate estimated arrival time at the destination terminal. In a full scale system, the GOFER system could link directly to the full AutoSYS data base.

The Norwegian Road Data Bank (NVDB) was used to build the transport network with all necessary parameters. The parameters were used in the calculations of the estimated arrival time at the terminal, as well as filtering relevant road- and GOFER messages.

In the GOFER demonstration, the data system did not communicate directly with the transport operator's internal systems, but the system is prepared for this as well. In the demonstration, the drivers entered information about total cargo weight and location of destination, but in a fully integrated system, this information could be provided from the operator's planning/scheduling system, along with other relevant information about the cargo, e.g. dangerous goods.

Demonstration statistics:

During the ten week demonstration period, a total of 135 trips were registered in the system. The eight drivers sent from 1 to 44 GOFER messages each - a total of 138 between them. This gives an average of one message per trip, and 17 messages per driver over the entire test period.

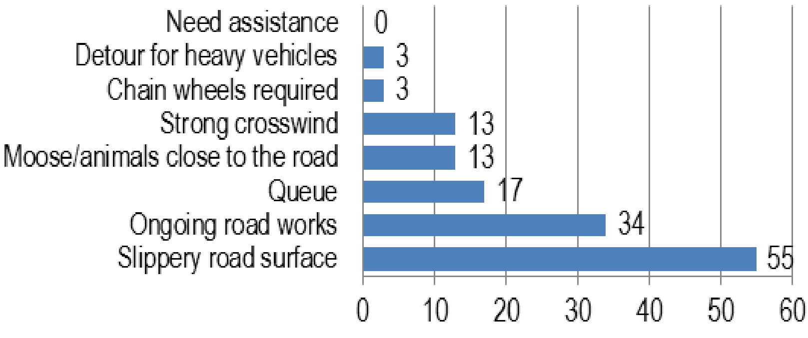


Figure 6: GOFER messages sent during the test period

The live demonstration was carried during mid-winter, and of the eight pre-defines GOFER messages, the message about slippery road surface was most frequently used among the drivers (Figure 6).

Map: © Google Maps

Figure 5: GOFER messages about slippery road surface sent during the demonstration period

The drivers' assessment

As part of the evaluation process, the drivers taking part in the demonstration were all interviewed at the end of the demonstration period. The interview gave information about the driver; background and previous experience with information systems and technology, and about how the drivers assessed the equipment and functionality of the information system, the various types of information included in the test, and the demonstration overall.

All eight participants drove the test route several times per week, and most of them had long experience operating a heavy vehicle: at least six years - on average 28 years. Two of the drivers had little experience with digital media before the test started.

Overall, the test was considered useful and realistic, and the system was easy to understand and use. Most of the information from the system was considered helpful. The drivers proposed additional features for the message-services, and also suggested a range of possible improvements to the functionality of the screen and on-board equipment, which some of the drivers found to be emitting too much (annoying) light while driving in the dark.

The drivers considered messages about recommended route and information about the waiting area and slot-time to be very useful as instruments to prevent heavy vehicles from being stuck in queues related to terminals and urban traffic.

Access to the use of the public transport lanes was the most popular measure in order to "compensate" for any imposed waiting, while the development of service facilities at the waiting area was ranked second.

Figure 7: The OBE used in the live GOFER demonstration mounted in the vehicle

A full scale introduction of the GOFER system was predicted to have positive effects on heavy vehicle drivers' work situation, traffic safety and the environment. Safety and driving time were considered to be the most important arguments for introducing a GOFER system, and the majority of drivers believed such a system should be introduced as soon as possible. At the same time a majority also believed that one should be allowed to switch off the equipment, if it became standard equipment in heavy vehicles. All the drivers would have advised his employer or others to adopt this system, but only half of them would demand this system in the car at the time the test was terminated.

Study of prioritizing measures

As mentioned, initial plans for including measures in the live demonstration giving priority to heavy freight vehicles in an urban traffic environment, turned out to be not feasible. Access to public transport lanes was not allowed due to needs for changes in regulation, while prioritizing by use of green waves in traffic lights was too costly and difficult to implement. As a second best option to a live test of these prioritizing measures, the project included a study using a driving simulator to investigate effects of traffic management measures giving priority to heavy freight vehicles:

- Access to public transport lanes during the daytime between-peaks period.
- Green waves in traffic lights during low-traffic periods. As many of the freight vehicles arrive in Trondheim during the night, this measure was tested in a night-time situation.

Four different test scenarios were created, for the between-peaks and the low traffic periods, with the current conditions, and with the prioritizing measure.

The experiment involved seven drivers. Eight participants were recruited from the project partner Bring, but only seven were able to complete all test runs, as one person got sick driving in the simulator and was excluded from further analysis. All the other drivers completed four test runs each – one for each test scenario.

The driving simulator

The GOFER tests in the driving simulator were carried out in January 2012. The SINTEF/NTNU driving simulator has both a heavy vehicle cabin and an ordinary car cabin which can easily be exchanged within hours. The heavy vehicle cabin was used in this experiment. The visual system is based on PCs and five rear projected screens, three in front of the vehicle and two behind the vehicle, providing in sum respectively a 180° and 90° horizontal field of view.

Figure 8: Example of visual representation of the transport system and traffic conditions in the driving simulator

Sound is provided by a sound system with loudspeakers inside the cabin and a subwoofer in the trunk. The system provides sound from the driver's vehicle as well as from other vehicles, and lets the driver experience both directional and Doppler effects.

The heavy vehicle simulator does not have a motion base. Some motion is provided by seat vibration, but turning, acceleration and braking motions are not simulated.

Road design and traffic scenarios

The simulator tests were carried out on coded parts of the main road network in Trondheim, Norway. The coded network comprises the town centre, tunnels, and rural roads. The total length of the simulator network is 55 km. In the GOFER test, a section of approximately 7 km of the main road from the south was used. The first 4 km of this road section has a speed limit of 80 km/h, and the last 3 km of has a speed limit varying between 50 and 60 km/h. The prioritizing measures were introduced for the last 3 km of the test distance.

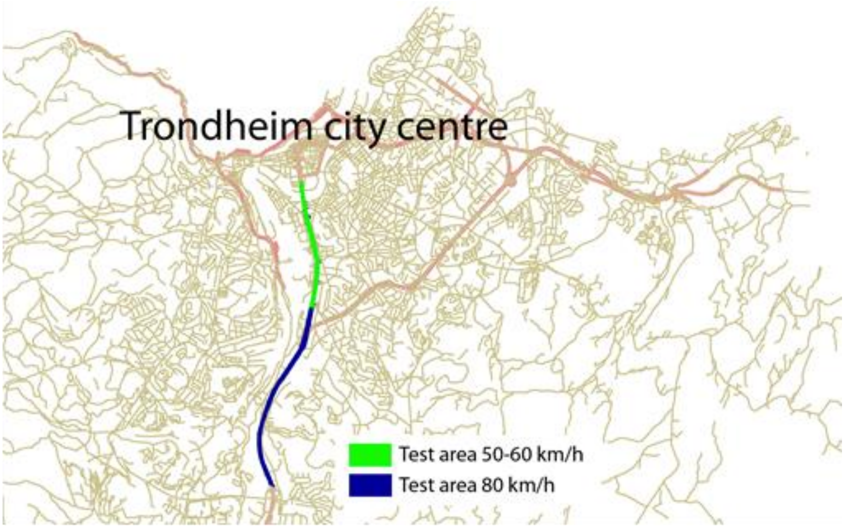


Figure 9: Map of the GOFER driving simulator test section of the Trondheim road network

There are two vehicle types in the driving simulator traffic scenarios: The test driver controls the interactive vehicle, while all other traffic is represented by so called autonomous vehicles, controlled by the computer system. In the GOFER test, the traffic situation in the respective scenarios was based on video recordings. The night-time scenario without the prioritizing measure was based on a video recording made at night, and with the changes of the light signals which occurred in that recording. In the night-time scenario with "green wave", changes in traffic lights were triggered by the approach of the interactive vehicle. The two daytime scenarios without/with access to public transport lanes were based on simultaneous video recordings respectively from a vehicle using the common traffic lanes, and a vehicle using the public transport lane.

Test statistics

The test runs in the driving simulator provided logged data on vehicle positions, speed, acceleration and lane position, as well as more detailed data about the vehicle, such as engine speed which can be used as a basis for calculating fuel consumption and emissions.

The prioritizing measures were implemented on the road sections with speed limits between 50 and 60 km/h (marked with straight red line in the graphs in Figure 10). It is therefore the speed profiles and time use in this section of the road which is presented in the following: The potential for time savings was much bigger in the between peaks-period than in the low traffic period. The average driving time on this stretch of the road network was ten minutes and five minutes respectively in the two "base" scenarios. For the between peaks period, the scenario with access to PT lanes gave an average driving time of six minutes – a four minute or 40 % reduction compared to the base scenario. For the low traffic situation, the green wave also gave a reduction in average driving time, but the overall effect was smaller; the time saving was one minute or 20 %.

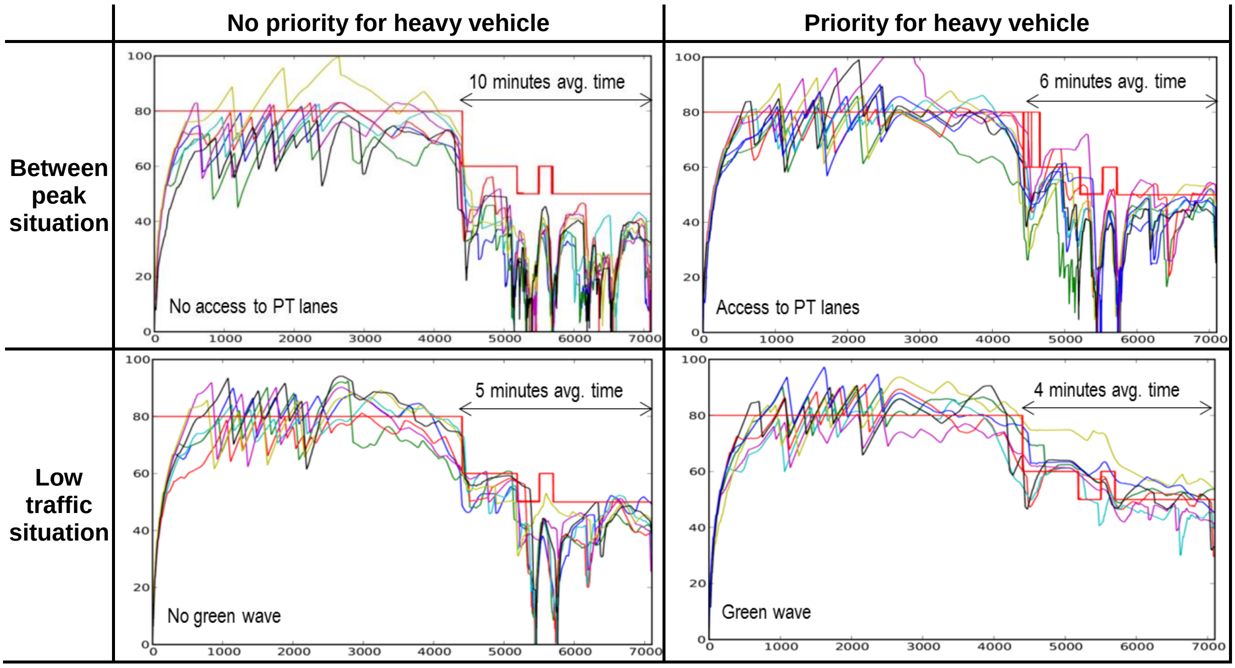


Figure 10: Speed profiles (km/h) along the 7 km test route in the four test scenarios in the driving simulator

The average speed was affected correspondingly: For the between peaks situation, the average speed increased from 17 km/h in the base scenario, to 30 km/h in the scenario with access to the PT lanes. Also for the low traffic situation there was an increase in average speed in the second part of the route; the average speed changed from 33 km/h in the base scenario to 52 km/h with the green wave scenario.

Most of the drivers found environmental effects to be a major argument for introducing the measures included in the test. The graphs in Figure 10 suggest that they are right. As referred to in the introduction, research show that the emissions from heavy vehicles increase when the vehicles are forced to keep a low or uneven speed profile. The findings from the test in the driving simulator show that the introduction of the prioritizing measures results in an increase in average speed levels. Especially for the green wave during low traffic periods, the graphs also show that this measure gives a more even speed profile, with fewer and less prominent brakes and accelerations along the road sections where this measure was implemented. This is a positive effect in terms of emissions, but also gives less traffic noise during evening and night time for the residents along the route in question.

The test drivers' acceptance and assessment of the measures

The drivers taking part in the test in the driving simulator were interviewed during the test. After each test round, the driver filled in the appropriate part of the questionnaire. They were asked to assess the realism and relevance of various aspects of the test scenarios, and how suited the simulator was to study the measures.

In general, the drivers were positive to the measures included in the test. They all considered access to public transport lane to have positive effect on the driver's stress level, and most perceived a positive effect on driving performance, comfort and time use. A few expressed concern about possible negative effects on traffic safety and the driver's attention.

Figure 11: Unused capacity in public transport lanes can give room for freight vehicles between peaks

Giving heavy vehicles a green wave in traffic lights during low traffic periods was unanimously considered to have only positive effects, especially on driving comfort, but also on driving performance, driving time and stress levels.

The positive effects the measures could have on the environment and the drivers' stress level were considered to be the two most important arguments for introducing these measures.

Five out of the seven test drivers considered access to the public transport lanes to be the most important and efficient measure of the two tested. This perception is confirmed by the results from the logged data from the test runs, presented in Figure 10.

SYSTEM REQUIREMENTS

The GOFER demonstration activities have far from covered all aspects of a fully working cooperative traffic management system for individual heavy vehicles, and the fact that it was not possible to include real prioritizing measures in the live demonstration, illustrates some of the obstacles which must be dealt with in order to establish such a system. Through the initial project activities on user needs and requirements, a wide range of conditions affecting the possibility for a GOFER system to succeed were identified. These factors include physical infrastructure, regulations and laws, models for cooperation, technology and systems for exchange of information. Some examples are commented in the following.

Holding areas

Crucial to an "air control"-like system will be provision of suitably located resting-/holding areas close enough to the city or terminal areas in question. How to ensure sufficient surface area will be a challenge in most cities. In order to make the facility attractive and the time spent there worthwhile for the drivers who may be directed to wait there, one should consider combining the holding area with service facilities such as restaurant, shower, and access to the Internet and TV. This could be important for gaining the drivers' acceptance. In the survey among the drivers in the GOFER live demonstration, service facilities at the holding area were identified as a possible viable compensation for being directed to a holding area.

Figure 12: Trucks at an Intelligent Truck Parking facility

In order to achieve increased efficiency for the public authorities, a holding area could also be combined with area for control of heavy vehicles. In order to increase et efficiency of such control activities, the NPRA have ambitions to use weigh-in-motion (WIM) and other ITS solutions to target the vehicles which are most likely to be violating regulations regarding weight, driving-/resting hours, fees and tolls etc. Drivers of vehicles with a "clean track record" will indirectly be given priority, by not being in focus of the control activities.

Designated routes

As an alternative to or in combination with directing vehicles to a holding area in order to avoid queues, the system could also be used to instruct vehicles to use designated routes to their final destination, in order to reduce the environmental effects. This measure could be used for specific times of day (e.g. night-time, in order to reduce noise in specific areas), or be based on cargo characteristics (e.g. keeping vehicles with dangerous goods out of heavily populated areas/routes).

Prioritizing instruments

If directing vehicles to a holding area is being used as part of a queue management regime, it is important to introduce prioritizing measures which can represent a "compensation" for having had to wait at the holding area, in order to gain acceptance from the drivers. The drivers involved in the GOFER demonstration activities rated being granted access to public transport lanes as the best compensation.

Finding good combinations of priority policies and -measures will be a challenge in most settings. In addition to the two measures included in the driving simulator test, priority at terminal gates and/or loading/unloading bays could be included in such a system, if possible combined with assignment of slot times at the facility. This could improve the predictability for the driver and transport operator, and allow the driver to use the information about assigned slot time when scheduling activities.

Prioritizing criteria

Drivers may be directed to a holding area for a range of different reasons, depending of the design and purpose of the system. If a vehicle is scheduled for picking up or dropping off cargo for a train or a freighter which is delayed, the driver may be told to wait at the holding area rather than continuing to the terminal area, where it would contribute to queues and hindering other traffic.

Priority should be given to all vehicles which are being directed to a holding area as a consequence of queue management. However, if a system for giving priority to individual vehicles is in place, this could be designed to assign priority based on a range of different criteria, e.g. as part of a strategy to encourage a shift towards more environmentally friendly solutions. Possible strategies include:

- Give priority to those who pollute the least, e.g. based on fuel and engine characteristics: This can encourage the use of more environmentally friendly vehicles, but can also cause those who pollute the most, to spend more time in a queue, and thus resulting in more pollution – at least in the short run.
- Access control to environmental zones or rush hour traffic based on vehicle and/or cargo characteristics: Priority could be given based on vehicle load, e.g. priority to vehicles with a full load, etc.

- Prioritizing so that deadlines are complied with: Priority to vehicles that have a time slot on a terminal coming up soon, or to drivers who are close to the limit for the allowed driving times.

Different levels of priority could also be given depending on whether or not the vehicle is on the way to an intermodal terminal, in order to promote intermodal transports, and the measures can be combined with price mechanisms in order to utilize capacity better, both on rail, and road.

Collaborative models and issues

What strategies to apply, must be decided by the local authorities, preferably in close cooperation with the transport industry, in order to secure acceptance for the regime. This requires dedicated effort from all parties in order to compose a suitable mix of measures and prioritizing criteria which represent a "win-win"-situation for all participants. An important issue will be to identify who are experiencing the benefits and the impediments of the system, and to avoid that it is possible/advantageous to remain "outside" the system.

The parties should be able to give up information to the system and trust that the information cannot be misused by competitors. This requires a collaborative climate, based on mutual trust and the possibility for a real win-win situation which can stimulate the serious actors, highlighting the benefits and gains, and with a realistic level of ambition.

A system like this raises a whole range of questions regarding the organising and responsibilities: Who should be the system owner? Who should prioritize? Who sits in the "control tower"? There will be a need for overview of traffic in the road network, schedules and assigned slot times at terminals, schedules and delays for freight trains and freighters, and development of the "air traffic controller role" in a traffic control for terminal/urban areas.

Technology and information requirements

The technology required is already at hand. The GOFER system is based on off-the-shelf equipment and free or open source software.

The data system must be able to communicate with the individual in-house data systems for the different parties, through defined data formats. Although some components of the GOFER live demonstration were just examples of how information for the individual vehicle/driver could be communicated, the system is prepared for communicating with real booking systems, and more complex route guidance criteria, based on e.g. vehicle- and/or cargo characteristics.

Access to and quality of information is a crucial factor. The system requires a reliable information flow which provides correct and sufficient information at the right time about traffic conditions and events in the transport network (real-time), information about the vehicle, cargo, destination and planned time of delivery, etc. Routes and slot times must be defined and communicated to drivers, control personnel and cargo terminals/recipients if relevant. Along with increasing focus on open data, the emerging technologies and new transport related applications can provide new sources of information about the traffic situation in the transport network. The system must be organised and designed to provide the transport operators with trust and benefits which outweigh issues they may have regarding providing information about their business operation (cargo weight, dangerous goods, destinations, planned arrival times etc.).

Regulations and laws

Introduction of a system for control/management of individual freight vehicles may require revisions of a range of regulations and laws. Examples are regulations regarding access to dedicated lanes in the transport system, the driving-/resting time regulations, and restrictions for transport of dangerous goods in tunnels and on ferries, and on night-time deliveries.

CONCLUSIONS

Findings from the project suggest that it is feasible to establish a system which allows the public authorities to manage heavy vehicles in urban areas, while at the same time securing acceptance by providing the drivers and transport operators with information or services to compensate for regulatory measures. The findings also suggest the potential for positive effects on efficiency and predictability for the transport industry, urban environmental issues, and work conditions for the drivers. At the same time, a large number of issues and requirements must be dealt with and resolved before a system like this can be introduced in an urban area.

User assessment and responses

At a project workshop held after the demonstration activities were finished, the project partners presented their thoughts about what role a GOFER system can have in meeting the challenges related to heavy goods transport in urban areas, and how such a system can be brought forward.

The transport operator (Bring) considered the GOFER live-demonstration to be a further development of navigation systems, with an "online" future. To get to a more integrated solution and direct access to input data such as weight, car manufacturers should be involved in any further development. Bring also sees the possibility to include available models of eco-driving in the system. The technical solutions and user interfaces applied in the test were considered very intuitive and easy for the drivers to understand.

The transport operator also found the test in the driving simulator to provide useful insight in the potential benefit for the drivers and transport operators from the prioritizing measures included in the study. The environment, health and safety of the drivers are important for the employer. They see a lot of potential in the driving simulator tests, e.g. regarding cost reduction, environmentally friendly transport, and in improved working conditions for the drivers. They commented that the measures tested "would be like a dream" if they could be implemented.

The Norwegian Public Roads Administration considers the results from the GOFER demonstration to be relevant for many of their areas of responsibility. Driver-initiated messages about the road conditions, especially during winter time, can be a useful source of information to identify the need for winter maintenance measures. They also consider initiating a follow-up demonstration, distributing information about friction conditions in the road network, to the public. The NPRA are responsible for following up Action 3.5: Services for safe and secure truck parking places in the ITS Action Plan (EU DG MOVE, 2011). Although the GOFER demonstration did not include a real booking system, the NPRA are interested in following up the possibilities to use a GOFER-like system to facilitate booking for such facilities.

Based on the drivers' assessment of the demonstration, one can also see some suitable ingredients for a possible commercial "Road information system for the freight industry", with predictions of driving time for heavy vehicles, and driver-initiated messages.

Implications for Policy

The test drivers' assessment of a range of information types and measures giving priority to heavy vehicles, suggest several options for compensating for restrictions inflicted on them by a truck management system. The driver-to-driver message system included in the live demonstration was considered especially useful. This also holds the potential for providing the road authorities with improved information about conditions along the road network.

Results from the test in the heavy vehicle simulator shows that giving heavy vehicles a "green wave" in traffic lights during low traffic periods, allows the vehicles to keep an even speed level, resulting in lower fuel consumption, less emissions and noise, and improved driver comfort.

Implications for Research

Results from the live demonstration will be used to contribute to the development of new information services specifically aimed at the drivers of heavy vehicles.

Data from the position logging and calculated driving times will be used to further develop the tool for calculating realistic driving times for heavy vehicles on the Norwegian road network, and to seek to further develop tools for calculations of the fuel consumption and emissions from heavy vehicles.

Results from the test in the driving simulator will be used to contribute to the development of new tests and analysis aimed at the effects of potential of prioritizing measures. Data from the logging will be available to future projects to improve micro simulation modelling and to make detailed calculations about environmental effects.

As the drivers found the prioritizing measures to have positive effects on the stress level, monitoring of the driver's stress level should be included in any future studies of such measures.

As far as we know, this may be the first time a driving simulator has been used to study the effects of this type of policy-related measures. The finding from the test indicates that the driving simulator can be used to investigate traffic management measures for heavy vehicles. The drivers found the simulator to give a realistic driving experience, the measures to be represented in a realistic way, and most of the effects of the measures were perceived as realistic. The logged data can also be further analysed and can be used to estimate environmental effects. At the same time, one has to look at alternatives like live demo and micro simulations and consider the advantages and limitations of every method before using the driving simulator.

Based on the experience from the test in the driving simulator, the transport operator and the NPRA both saw potential for further use of the simulator to study policy measures, and especially for testing scenarios which cannot be tested in live traffic.

ACKNOWLEDGEMENTS

The authors would like to give a special thanks to Bring and their drivers for their enthusiasm, patience and constructive feedback before, during and after the demonstration. Thanks also to The Norwegian Research Council, ITS Norway, NPRA and the rest of the GOFER consortium.

REFERENCES

Engen T. and S. Meland (2012) Can a driving simulator be used to investigate traffic management measures for heavy vehicles? Proceedings of the 40th European Transport Conference, AET, London. http://www.etcproceedings.org

The EU Commission's DG MOVE (2011) Intelligent Transport Systems in action. Action plan and legal framework for the deployment of intelligent transport systems (ITS) in Europe.
http://ec.europa.eu/transport/its/road/action_plan/action_plan_en.htm

GOFER project web-site: http://www.sintef.no/gofereng

Meland S., C. Mausethagen and O.M. Rennemo, (2012) Demonstration of a cooperative information system for heavy vehicles, Proceedings of the 40th European Transport Conference, AET, London. http://www.etcproceedings.org

Natvig, M.K., H. Westerheim, T.K. Moseng, A. Vennesland, (2009) ARKTRANS The multimodal ITS framework architecture Version 6. SINTEF Report A12001, SINTEF, Norway. http://arktrans.no/english

Rexeis, M., Hausberger, S., Riemersma, I., Tartakovsky, L., Zvirin, Y., Van Poppel, M., Cornelis, E. (2005) Heavy duty vehicle emissions, WP 400 Final report under the ARTEMIS project, DGTREN Contract 1999-RD.10429.
http://inrets.fr/ur/lte/publi.../ficheartemis/road3/.../Artemis_del4_HDV.pdf

Tørset T. (2011) The speed prediction model for heavy vehicles, Proceedings of the 39th European Transport Conference, AET, London.
http://www.etcproceedings.org/paper/the-speed-prediction-model-for-heavy-vehicles