

ETT- Modular System for Timber Transport



PREFACE

In 2006, Skogforsk initiated the project ETT Modular System for Timber Transport. ETT stands for One More Stack. Using developments in transport technology and greater gross weights, the project aims to reduce the total number of timber transports in Sweden, thereby cutting diesel consumption and carbon dioxide emissions. The project was up and running quickly and has been successful, largely because all the collaboration partners were genuinely interested in finding concrete solutions.

A project of this significance requires the involvement and collaboration of many different players, such as forestry companies, manufacturers of vehicles and other equipment, public agencies, hauliers, research funders, etc. We express our thanks to everyone who, in one way or another, has participated in the project. The following have been particularly important for the implementation of the project:

Forestry companies

Holmen Skog AB
SCA Skog AB
Stora Enso Skog AB
Sveaskog
Södra Skogsägarna

Manufacturers

Volvo Trucks
Parator
SSAB
Wabco
VBG

Hauliers

TLV, Transport Logistik Väst
Bjälmsjö Skog AB

Public agencies and other organisations

Swedish Transport Administration
Swedish Transport Agency
VTI, Swedish National Road and Transport Research Institute
Swedish Forestry Industries Federation
Swedish Association of Road Transport Companies
VINNOVA (Swedish Governmental Agency for Innovation Systems) /FFI – Strategic Vehicle Research and Innovation
FKG, Vehicle Component Group

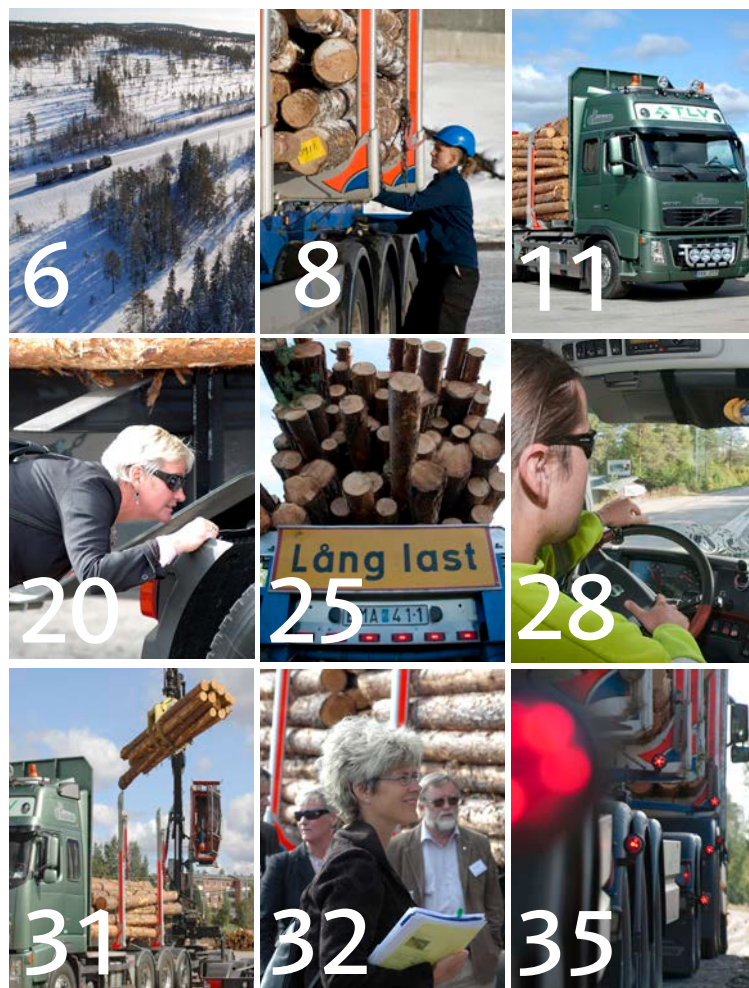


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SUMMARY

SUMMARY

The project (ETT) Modular System for Timber Transport Project showed that heavier and longer vehicles can significantly reduce fuel consumption, carbon dioxide emissions and transport costs. At the same time, no negative impact was observed in terms of road safety or road wear.

We are currently facing the global challenge of radically reducing our greenhouse gas emissions. This is evident in the environmental goals set at national and international levels. The Swedish national goal is to reduce emissions by 40% compared to the 1990 level, while the goal at EU level is a 20% reduction compared to 2005.

Timber transports must be made more energy efficient if Swedish forestry is to contribute to a cleaner environment. Consequently, in 2006, Skogforsk initiated a project aimed at lowering the total number of timber transports needed in Sweden and reducing the associated diesel consumption and emissions of carbon dioxide and other substances. This was to be attained through advances in transport technology and by using vehicles with higher gross weights, but with no negative effects in terms of road wear or road safety. A literature study indicated that there would be no negative impact on road safety.

Current conventional timber transport vehicles have a gross weight of 60 metric tonnes and are 24 metres long. They generally comprise a three-axle truck with space for one stack of wood, and a four-axle trailer that carries two stacks. Over 2,000 wood and chip vehicles are in operation in Sweden.

The project was given the name One More Stack ('En Trave Till', ETT). The aim was to use longer rigs with higher gross weights than conventional rigs in order to accommodate an additional six-metre stack of wood, i.e. four stacks instead of the usual three. Because the stacks on the ETT vehicles are also bigger, two ETT vehicles could replace three conventional timber vehicles.

At an early stage, Skogforsk contacted Parator and asked them to design a four-stack vehicle. After theoretical calculations of stability, turning radius, and anticipated road wear for such a vehicle, it was built under the direction of Volvo in 2008.

The ETT vehicle was completed in December 2008 and began operation in January 2009. The Swedish Transport Administration had granted dispensation for the new 30-

PHOTOS: ANNA FRANCK & ERIK VIKLUND





metre-long vehicle, so we were permitted to run the vehicle, which had a gross weight of 90 metric tonnes, on public roads during the test period. The ETT vehicle was driven with 65 tonnes of timber between Överkalix and Piteå.

After six months, the ETT project was supplemented with a secondary project known as Bigger Stacks ('Större Travar', ST), in which timber vehicles were compiled in a way that increased the payload, while complying with applicable vehicle length and axle pressure regulations. 'ETT Modular System for Timber Transport' serves as the collective name for both projects. In the project, we used the loading units (modules) of the European Modular System (EMS), a standardised design for load units currently used in the vehicle industry. The modules were dolly, link and trailer.

The ST vehicles comprised two types of rig: a four-axle crane truck with dolly and trailer, and a tractor with link and trailer. They have been tested both as part of a staging system and as separate vehicles. In the staging system the crane truck loads the wood in the forest and transports it to a staging area, and then the tractor transports the wood from the staging area to the mill. This allows optimisation of the various advantages offered by the two vehicles, thereby increasing the payload and reducing fuel consumption.

As separate vehicles, the ST crane truck and ST tractor have carried timber from forest or terminal directly to the mills. Both the crane truck and the tractor had gross weights of 74 tonnes so, once again, dispensation was required from the Swedish Transport Administration before the system could be driven on public roads. The ST vehicles were tested in the counties of Dalsland, Bohuslän and Värmland in western Sweden.

All the vehicles tested in the project were fitted with air suspension system with loading scale indicator and alcohol ignition interlock devices (alcolocks) Air suspension system with loading scale indicator as well as computer systems to enable real-time analysis of transport performance. Productivity, fuel consumption, etc. was monitored via studies and measurements during the project period.

The project involved extensive collaboration between around 30 companies, organisations and public agencies, and yielded three new modular forest vehicles that effectively reduce environmental impact and lower the number of timber vehicles needed to transport wood.

Results from studies of the ETT rig

- Diesel consumption was reduced by just over 20%, and carbon dioxide emissions were reduced accordingly. Emissions of other environmental contaminants were also reduced accordingly.
- The number of vehicles needed to transport a given amount of wood is approximately 35% less than if the same wood volume had been transported using conventional timber vehicles.
- The studies that Skogforsk performed on 700 runs using the ETT rig found no negative reactions overtakes other road users.
- The Swedish National Road and Transport Research Institute (VTI) carried out four different studies to determine how road safety is impacted by heavier and longer lorry combinations compared with current conventional heavy vehicles. The emphasis was on overtaking scenarios. The conclusion was that no definite demonstrable differences could be shown, and that more studies were needed.
- Transport costs were reduced by just over 20%.
- The manoeuvrability, stability, and braking capacity of the ETT rig were comparable to that of a conventional 60-tonne timber vehicle.
- No increase in road wear was shown. This is because the greater gross weight is distributed over more axles. However, the load on long bridges is increased.
- During the test period, the ETT rig drove a total of 800,000 kilometres and transported approximately 150,000 cubic metres solid volume.

SUMMARY

Results from studies of the ST rigs

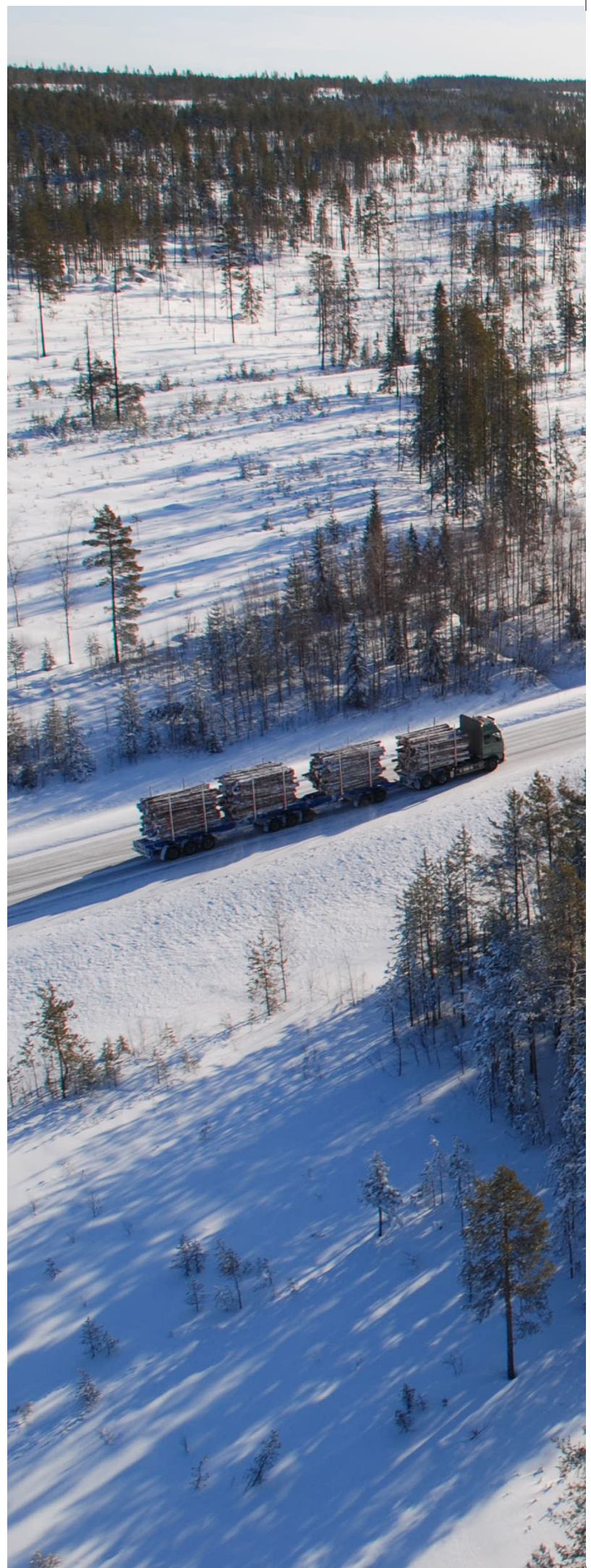
- When vehicles were used in the staging system, fuel consumption was reduced by up to 8%, and emissions of carbon dioxide and other environmental contaminants were also reduced accordingly.
- Estimates indicate that transport costs were reduced by up to 5-10%.
- Staging can pay off under certain conditions, but the logistics pose a challenge.
- No increase in road wear was shown. This is because the greater gross weight is distributed over more axles. However, the load on long bridges is increased.
- The manoeuvrability of the ST rigs was comparable to that of a conventional 60-tonne vehicle.
- The ST rigs were driven over 500,000 km in total, and they transported 190,000 cubic metres solid volume.

Reflections from some of the project participants

The key participating organisations submitted comments on the project. The organisations were unanimous on the following.

Successful collaboration between a large number of organisations helped the project ETT Modular System for TimberTransport achieve the common goals that were set. The project showed that heavier and longer timber vehicles could reduce fuel consumption and transport costs with no negative impact on either road safety or road wear.

Participants also agreed that the move towards more energy-efficient road transport through heavier and longer vehicles that has now been initiated must continue in some form.



BACKGROUND

The efficiency of timber transport must be improved, both for environmental and financial reasons. A general problem for forestry companies is that return transports are impossible. This is because the transport flow is one-way and because vehicles are only designed to transport timber.

For many years forestry companies have been interested in achieving more energy-efficient timber transport through greater gross weights. At the end of the 1960s, SCA Skog AB tested road trains of approximately 30 m in the form of a tractor with two semitrailers, the last of which was connected to a dolly (see Figure 1). The rig was loaded with four stacks of roundwood and each stack weighed approximately 15 tonnes, so the total payload was approximately 60 tonnes. The unladen weight of the entire road train was 23 tonnes. The total weight of 83 tonnes was spread over nine axles, i.e. approximately 10 tonnes per axle. The limitations were high ground pressure (diagonal tyres) and engines that lacked sufficient power.

At the end of the 1960's SCA Skog tested road trains with a GVW of approximately 85 tonnes.



PHOTO: ANDERS BERGSTEDT, SCA SKOG AB

BAKGRUND

Forestry companies are now working to improve transport efficiency through timber exchange and route optimisation, and are also developing lighter vehicles in order to increase payloads within the framework of applicable regulations.

Another way to improve the efficiency of timber transports is to increase the gross weight and length of timber vehicles. With its good infrastructure, Sweden could implement this.

The maximum length for timber rigs is currently 24 m, in certain cases 25.25 m, and the maximum permitted gross weight is 60 tonnes. By increasing the permitted vehicle length to 30 m and the gross weight to 90 tonnes, the vehicle could accommodate an extra stack of timber.

Vehicle lengths in the EU are currently approximately 18 m, but a number of trials are taking place with heavier and longer vehicles. Certain regions in France have local regulations allowing higher gross weights. In Denmark and the Netherlands, modular vehicles of 60 tonnes with lengths of 25.25 m are being tested. Several of our important competitor countries outside the EU allow road trains of 100-120

tonnes, thereby reducing the cost of wood to the mills.

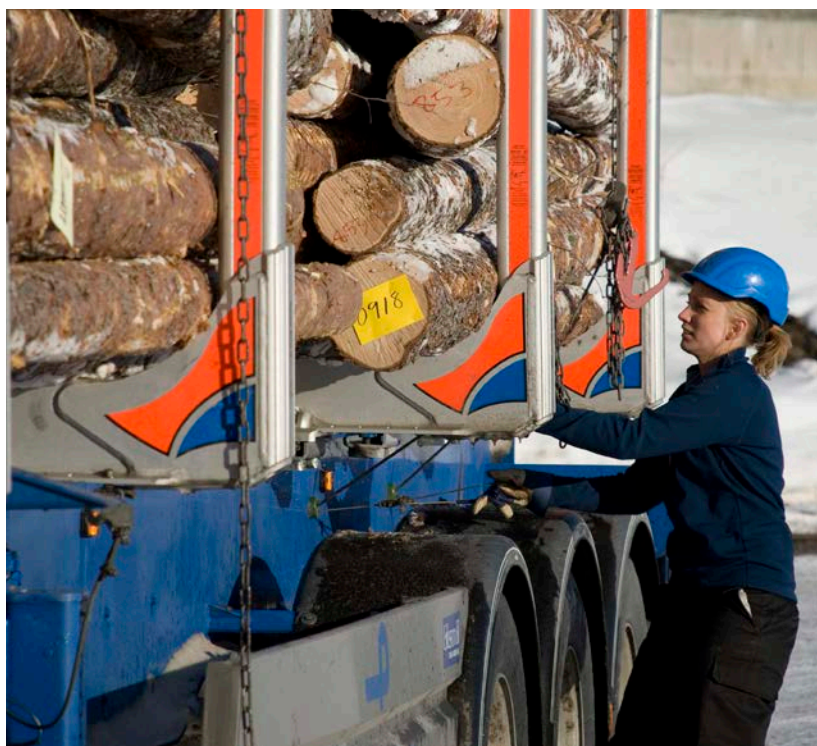
In the 1980s and 1990s, Sweden increased the gross weight for road haulage vehicles from just over 50 tonnes to the present limit of 60 tonnes. The increase led to a distinct reduction in fuel consumption measured per cubic metre of timber transported because fewer vehicles were needed to transport the same volume. A further increase in gross weight would also reduce emissions of greenhouse gases.

The positive development we have seen in recent years, with lighter vehicles, more efficient logistics and greater utilisation of the rigs, has not been sufficient to offset increases in costs. In the past ten-year period, transport costs have increased by 1-2% annually, mainly because of higher diesel prices. Structural changes and specialisation in the forestry sector has increased transport distances to the mills, thereby increasing transport costs. Transport costs currently comprise about 25% of the price the mills pay for timber, and fuel costs account for over one-third of the total transport cost.

For forestry companies, increasing the gross weight of rigs by 30 tonnes could reduce transport costs and environmental emissions by over 20%. This would fit in with the forestry industry's target to reduce carbon dioxide emissions by 20% before 2020. It is also in line with the targets of many other countries to reduce emissions and improve road safety by reducing the number of heavy vehicles on the roads.

In 2006, Skogforsk initiated a project aimed at reducing the total number of timber transports in Sweden, thereby cutting diesel consumption and emissions of carbon and other contaminants. This was to be achieved through developments in transport technology and higher gross weights. The project was initially called One More Stack ('En Trave Till', ETT). In early 2009 trials were started in the north of Sweden of the ETT timber vehicle, a rig 30 metres long with a gross weight of 90 tonnes.

In August 2009 a secondary project was started with trials in western Sweden of two different 25-metre rigs, each with a gross weight of 74 tonnes. This secondary project was called Bigger Stacks ('Större Travar', ST). The collective name for the two projects was 'ETT Modular System for Timber Transport'. The project was run by Skogforsk in collaboration with a large number of organisations, including the Swedish Transport Administration, the Swedish Forest Industries Federation and Volvo Trucks.



Lead-up to the project

A study carried out at the start of the 2000s (Löfroth, C., 2001) indicated that the technical solutions were already in place to increase gross weights of timber rigs, and that costs and environment impact could be reduced by 20% if 60-tonne vehicles were replaced by 80-tonne vehicles.

A study trip to New Zealand and Australia in 2006 examined timber vehicles with high gross weights (Ekstrand, M., 2007). This trip showed that technology was not a barrier to increasing the gross weight (see Figure 2). The participants on the trip formed a working group and a steering group to continue the work on testing increased gross weight on timber vehicles in Sweden.

One condition for using heavier and longer vehicles on public roads is that road safety is not compromised. In order to study how heavier and longer rigs affect road safety,

international research literature was compiled and analysed quantitatively (af Wählberg, A. E., 2007). The study showed that the effects of accidents are greater when heavier and longer vehicles are involved. However, if it is taken into account that fewer vehicles would be on the roads if 60-tonne vehicles were replaced with 90-tonne vehicles, the conclusion was that a switch to heavier vehicles would, in the worst-case scenario, have no effect at all on road safety and, in the best-case scenario, would have a clearly positive effect.

Various types of vehicle combinations were discussed and the towed modules, dolly, link and trailer, common in other road haulage sectors, were introduced. Theoretical calculations were made for turning radius, stability, road wear, etc. for the various combinations. In addition, Volvo made theoretical calculations of fuel efficiency, stability, agility, turning radius, road wear, etc (see Appendix 1 and 2).

B-Triple from Elphinstone, an example of a long, 90-tonnes vehicle. Tasmania, Australia..



FOTO: CLAES LÖFROTH/SKOGFORSK

PROJECT AIMS AND OBJECTIVES

The aim of the project was to study and evaluate potential for and consequences of greater gross weights and vehicle lengths for timber transports. Studies examined effects on diesel consumption, emissions of greenhouse gases, transport costs, road safety and road wear.

The objective of the project ETT Modular System for Forest Transport was to develop, evaluate and implement a modular system for timber transports that would improve efficiency and reduce environmental impact, without compromising road safety, road standard or driver environment.

IMPLEMENTATION

The project included a number of studies: Environmental Impact, Road Safety, Fuel Consumption, Financial Consequences, Road Wear and Damage, Vehicle Wear, Physical and Mental Driver Environments, and Technical Improvements.



A detailed description of the aims and objectives of each study is given in Appendix 4. The description also shows which organisations were responsible for each study.

The vehicles were composed according to the EMS (European Modular System), which is a standardised system of load-carrying units applied by the road haulage sector today. The following EMS components were used in the project: timber truck, tractor, dolly, link and trailer.

Components in brief

- Dolly is a two-axle module with a turntable/fifth wheel that in this case is used to couple the truck with a semi-trailer or link. (The turntable is the rest surface on which the front of, for example, a link or a semitrailer rests.)
- Link is a short trailer on which cargo can be loaded. The kingpin at the front enables connection to, for example, a dolly, and a turntable at the back allows coupling of, for example, a semitrailer. (A kingpin is a vertical pin that fits in a hole on the turntable.)
- Semitrailer is a long trailer with a kingpin at the front.

Advantages of the modular system include lower investment costs, interchangeability and greater flexibility.

IMPLEMENTATION

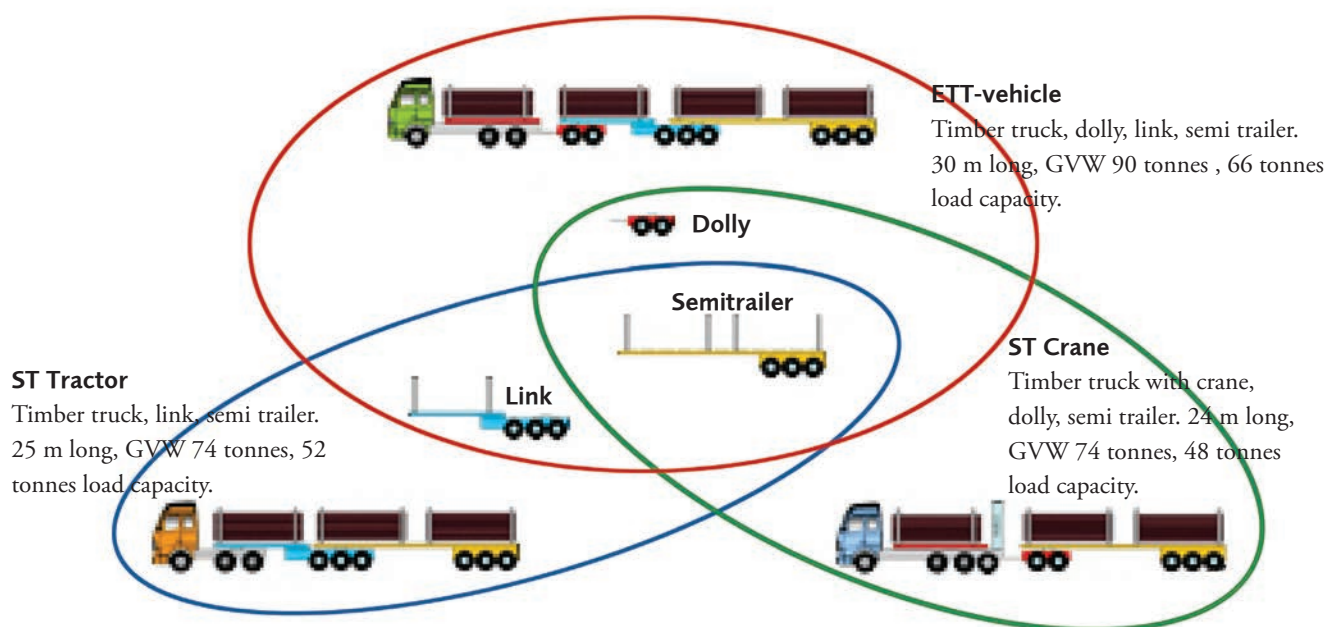


Figure 3. EMS, European Modular System includes standard vehicle components. In the figure the combinations of the ETT- and ST-vehicles are described.

Project organisation

The ETT Modular System for Timber Transport Project involved a large number of participating companies and organisations that were represented in a steering group, and a number of working groups, see Appendix 3. Skogforsk was responsible for project management.

The ETT Modular System for Timber Transport Project comprised two separate projects: The ETT (En Trave Till) Project, where trials were carried out in Norrbotten in northern Sweden with a 30 metre-long, 90-tonne vehicle, and the ST (Större Travar) Project, where two vehicles of 25 metres and a gross weight of 74 tonnes were studied in western Sweden.

The project and research plan is shown in Appendix 4. The research plan formed the basis of decisions about how the research was to be carried out, documented, communicated and financed.

The ETT project is also one of several demonstration projects in the Co-modality Project run by VTI, the Swedish National Road and Transport Research Institute. The Co-modality Project was started in 2009 and is funded by VINNOVA and the Swedish Transport Administration (see Appendix 5).



Figure 4. Representatives for participating companies and organizations in the "ETT Modular System for Timber Transport project" at a meeting on Överkalix, June 2010.

Description of the ETT Project

The ETT Project evaluated the effects of transporting timber on a vehicle that is 30 metres long and with a gross weight of 90 tonnes in a normal road traffic environment. When the project started the expectation was that, in comparison with conventional timber vehicles, fuel consumption, carbon dioxide emission and transport costs could be reduced by 20-25%.

The basic premise was that gross weight can be increased without any negative effect on road safety. The argument is that fewer vehicles are needed to transport the same volume of timber, and that road wear would not increase because the weight is distributed evenly over the vehicle and over more axles. However, the load-bearing capacity of bridges with long spans will need to be calculated and bridges may need to be reinforced.

The vehicle was loaded at a timber terminal in Överkalix and each trip comprised a journey of 160 kilometres to a sawmill in Munksund outside Piteå (see Figure 5).

Technical description of the ETT vehicle The ETT rig comprises four modules: truck, dolly, link and trailer (see Figure 6). The truck is a Volvo FH16, 6/4 (= 6 wheels, of which 4 are drive wheels). The six-cylinder engine delivers 485 kW (660 hp). The gearbox is the Volvo I-shift, and gears can be shifted both automatically and manually. Gear shift is adapted to prevailing driving conditions through the electronics in the engine and gearbox. This technology contributes to high efficiency and low fuel consumption. The truck has air springs on the back axle and parabolic plate springs on the front axle.

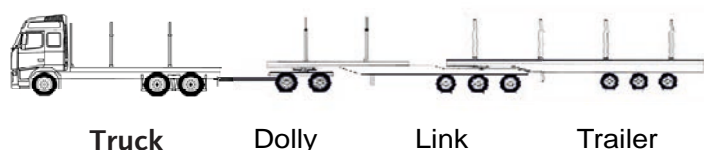
The ETT rig is fitted with EBS (Electronic Brake System), which is connected to the tractor and all trailers. This new technology means that the brakes can be applied to all wheels simultaneously. This ensures effective braking and means that the breaking distance of the ETT rig is no longer than that of a conventional 60-tonne vehicle.

The vehicle is equipped with a scale that ensures the cor-



Figure 5. The vehicle was loaded at a timber terminal in Överkalix and each trip comprised a journey of 160 kilometres to a sawmill in Munksund.

IMPLEMENTATION



Gross vehicle length: 30 m
Gross vehicle weight: 90 tonnes
Net vehicle weight: 24 tonnes
Load capacity: 66 tonnes

Figure 6. The ETT-vehicle, Volvo FH16, 6x4, with dolly, link and trailer.

rect total weight is loaded, and that the load is distributed in such a way that the permitted total weight and axle pressures are not exceeded.

The truck was built by Volvo Trucks and the adaptation by Bergs Fegen AB. Dolly, link and trailer were built by Parator AB. The trailer was made using steel quality Domex 700 from SSAB, which is lighter and stronger than the steel normally used in trailers. Bunks and stakes from ExTe Fabriks AB were used throughout. The truck was fitted with an alcolock. The compressed air-based braking, spring and weighing systems were developed by Volvo and Wabco AB.

In 2011 the option of raising 5 of the 11 axles on the ETT rig when empty, including one of the two drive axles, was introduced. This increases manoeuvrability and reduces fuel consumption. In the project, tests were also carried out with lowered stakes to reduce air resistance and thereby fuel consumption.

The truck is fitted with Volvo Truck's online management system, Dynafleet, which monitors vehicle performance in real time. In the project, the system was used to monitor fuel consumption, speed, environmental impact and the driving behaviour of different drivers, etc.

The ETT vehicle was run on 100% diesel of environmental class 1 quality, with no blending of FAME or other biofuels. The fuel was supplied by Skoogs bränsle AB in Kalix and the vehicle was refuelled at a filling station in Överkalix. Control measurements were also carried out at this filling station, including calibration of the Dynafleet system. The

SP Technical Research Institute of Sweden checks the accuracy of the pump annually. For more technical information, see Appendix 6.

Description of route. The rig left a terminal in Överkalix and then crossed the bridge over the Ängesån river (Figure 7). The vehicle then followed the E10 motorway down to Töre. The road is a 9-metre public road, with one lane in each direction (1+1). From Töre to Piteå, the vehicle was driven along the E4 motorway. On this stretch, the road is of varying standards, 1+1, 1+2, 2+2, with or without a central reservation barrier.

The route was relatively flat, with a maximum gradient of 4% and a total ascent of 690 m.

In Piteå the vehicle was driven in a typical urban environment, with roundabouts, traffic lights, schools, sports facilities, etc.

On arrival in Munksund, the load was weighed and measured. The rig was unloaded in the sawmill timber yard.

The return journey to Överkalix passed along the same route.



Figure 7. map of the ETT-vehicle route from Överkalix to Munksund sawmill in Piteå, Sweden

IMPLEMENTATION





Hosting company

SCA Skog AB.

Haulier

Bjälmsjö Skog och Transport AB, Överkalix.

Drivers

Torbjörn Pettersson

Johanna Funck (daily until the end of October 2009)

Simon Drugge

Sonja Engfors

Pernilla Gustavsson

Jocke Andersson

Kent Bjälmsjö

Anders Lindén, test driver, Volvo Trucks

Regulations of the Swedish Transport Administration

In order to run the ETT vehicle on public roads, a dispensation was required from the regulatory framework for road haulage. The permit to run the ETT vehicle is described in a new regulation formulated by the Swedish Transport Administration (then called the Swedish Road Administration), and is shown in Appendix 7. The permit regulates, for example, the speed of the vehicle and the route it may take.

New investments for the contractor and SCA

Bjälmsjö Skog and Transport AB invested in a new terminal in Överkalix and a separate loader for an ETT vehicle.

Together with the Timber Measurement Association, SCA Skog AB built a new measurement station in Överkalix. This was accessible remotely from the delivery measurement station in Munksund outside Piteå.

Driving and resting times

The route was specifically chosen so that two trips could be made in one shift. However, on a number of occasions, delays were caused by, for example, queues for delivery measurement and unloading at Munksund and problematical traffic situations. On these occasions, a change of shift occurred on the way back to Överkalix.

Training of drivers

Drivers were trained before the test runs began. Training was carried out by the Swedish Association of Road Transport Companies together with Volvo's instructors, and by SCA Skog AB. Road safety, gentle driving (max 80 km/h) and fuel-efficient driving techniques were emphasised.

Description of the ST Project

The ST vehicles were of two types, an ST crane truck and an ST tractor. In the ST Project, these vehicles underwent practical trials in western Sweden, both as part of a staging system as well as independently. The ST rigs were introduced in August 2009 and have been studied for a shorter period than the ETT rig.

The ST crane truck is a specially-built timber truck with a crane and dolly, as well as a trailer for driving on forest roads (see Figures 8 and 10). The ST tractor is a conventional tractor with link and trailer for road transports (see Figures 9 and 11). Both vehicles have a maximum length of 24 metres and a gross weight of 74 tonnes. This means that their payloads can be 30% greater than traditional timber vehicles. The expectation was that these vehicles could reduce environmental impact and costs by 10%.

In the staging system, the driver of the ST crane truck loads the timber at a landing in the forest and drives a short distance to a staging area. The trailer is uncoupled and the timber on the truck is loaded onto an empty link. The ST crane truck then returns to the forest for the next load. When the ST tractor arrives at the staging area, it uncouples an empty link and trailer, then couples the loaded link and carries the timber to the mill. In certain situations, the ST crane truck carried the timber directly from the forest to the mill.

The distance from the forest to the staging area was between 30 and 60 km, and from the load transfer point to the mill just over 100 km. The idea was to utilise the respective advantages of each vehicle, i.e. operate light vehicles without extra equipment on roads and forest vehicles with cranes in the forest.

As separate vehicles, the ST crane truck and ST tractor



Figure 8. ST Crane consist of a 8x6 truck with crane, a two axel dolly and a three axel trailer.

IMPLEMENTATION

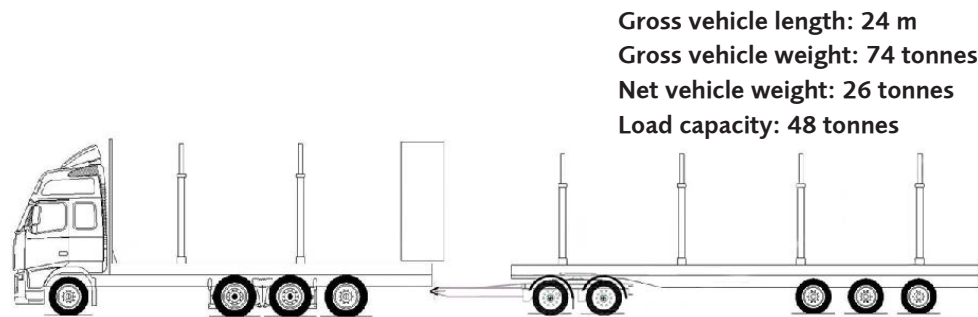


Figure 9. ST Crane consist of a 8x6 truck with crane, a two axel dolly and a three axel trailer.

carried timber from the forest or terminal directly to the mill without transferring the load.

Technical description of the ST rig

One of the ST rigs comprised a truck with crane, dolly and trailer, and the other a tractor with link and trailer. The ST rig was also built according to the EMS system (European Modular System). Both crane truck and tractor were a Volvo FH16 (crane truck 8x4, tractor 6x4) with six-cylinder engines. The crane truck engine generates 485 kW (660 hp) and the tractor 515 kW (700 hp). The gearbox is the Volvo I shift. The truck has air springs on the back axle and parabolic plate springs on the front axle.

The vehicles are fitted with EBS (Electronic Brake System), which is connected to the tractor and all trailers. The truck has a crane from Hiab AB, Jonsered, 14.4 tonne-metre, and is equipped with a crane scale supplied by Intermercato AB. The scale is type-approved and verified in the field, allowing great accuracy in the loading work.

In order to increase manoeuvrability and to comply with applicable axle pressure regulations, the ST crane truck was fitted with three rear axles, supplemented during the course of the project with hydraulic front wheel drive. For more technical information, see Appendix 6.

In autumn 2011, the ST tractor was adapted to facilitate inclusion in group driving. The adaptations reduced the weight of the vehicle by approximately 1.3 tonnes.

Weighing of loads

The ST crane truck is fitted with the first type-approved and verified crane scale in Sweden for automatic dynamic weighing of suspended load, i.e. a scale that can weigh a load in movement (Figure 12). The weighing device is manufactured by Intermercato and is type-approved and verified by the SP Technical Research Institute of Sweden. The verification means that the weight data provided by the scale can legally form the basis for invoicing.

The scale is based on traditional strain gauge technology. A metal body (load cell) senses the strain, which is registered by several sensors. A current signal from the load cell is converted and interpreted by a special unit in the scale. The unit then sends measurement data in digital form via radio to the crane cab.

The load can be weighed while in motion, so the scale itself must compensate for the crane's movement during loading/unloading. This is done in a special calculation model.

The load cell is temperature compensated, so the ambient temperature does not affect the result. The monitor in the crane cab is a hand-held computer, in which all measurements are stored so that the operator can see the load in every stack and the total load on the vehicle and trailer respectively.



Figure 10. ST Tractor consist of a 6x4 tractor, a three axel link and a three axel trailer.

Gross vehicle length: 24 m
Gross vehicle weight: 74 tonnes
Net vehicle weight: 22 tonnes
Load capacity: 52 tonnes

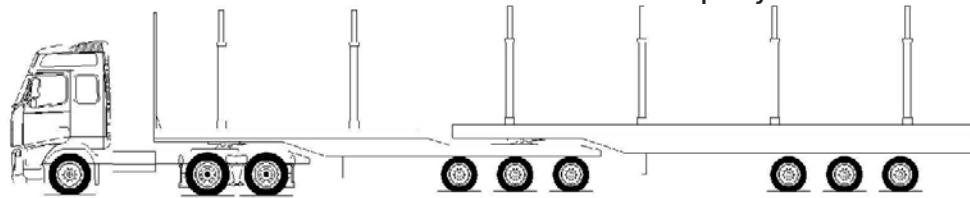


Figure 11. ST Tractor consist of a 6x4 tractor, a three axel link and a three axel trailer.



PHOTO: CLAES LÖFROTH/SKOGFORSK



Figure 12. The Intermercato scale is mounted between the rotator and the boom tip. Instrument readings are placed in the crane cab.

Location of the trials

The counties of Dalsland, Värmland and Bohuslän were chosen for trials, partly because the landscape is very undulating, which should be advantageous for the combination that was tested (Figure 13). The gradients of the roads in the test area can be up to 13%. The total ascent for the ST combinations during a wood transport can be nearly 2,000 m.



Figure 13. Map showing the western Sweden operating area of the ST vehicles.

Hosting company

Stora Enso Skog AB.

Hauliers

N. Wedin Timber Transport AB (up to and including spring 2010).

Eds Träfrakt AB.

Both hauliers are members of TLV, TimmerLogistik Väst.

Drivers

Emil Bengtsson

Jerry Olofsson

Joel Wennberg

Sune Henriksson

Tommy Sandström

Bo Andreasson

Patrik Andreasson

Anders Lindén, test driver, Volvo Trucks

Dispensation from Swedish Transport Administration

In order to test the system on public roads, dispensation was needed from the regulatory framework for road haulage. The dispensation permitted increase of the gross weight to 74 tonnes within the limits of a 25.25 metre length and normal axle pressure.

Practical problems

One practical problem was to find suitable sites for staging, because the vehicle required space in which to manoeuvre and strong bearing capacity.

The staging system presented a logistical challenge, involving two vehicles with different transport distances. The problem was solved by using the ST crane truck to occasionally carry the timber direct to the mill.

Training of drivers

Drivers were trained before the test runs began. Training was carried out by the Swedish Association of Road Transport Companies together with Volvo's instructors. Road safety, gentle driving (max 80 km/h) and fuel-efficient driving techniques were emphasised.



STUDIES AND MONITORING

Studies in the ETT project focused on environment, road safety, finance, technology, road wear and driver environment. The following section describes the most important studies. All the studies are described in Appendix 8, which can be downloaded from skogforsk.se/ETT..

Fuel consumption

The Volvo Dynafleet system was used to monitor fuel consumption and environmental data for the both the ETT and the ST vehicles. This system enables monitoring in real time of the location of the vehicle and the identity of the driver. Driving times, driving behaviour, speed and load on each wheel axle can also be monitored.

The Dynafleet system, which was used for long-term monitoring of fuel consumption, was calibrated in relation to the drivers' manual monitoring of refuelling. The precision of fuel volumes is verified through the annual checks made by the SP Technical Research Institute of Sweden of the accuracy of the pump.

The Dynafleet system was also verified through accurate control measurement in conjunction with the time studies of the ETT and ST vehicles. The studies were carried out by Skogforsk engineers, both directly on site and via the Dynafleet system. The system gives overall precision in fuel monitoring of ± 1 %.

In three comparative studies of fuel consumption, the 60-tonne version of the ETT vehicle served as reference vehicle. The reference vehicle was the truck of the ETT vehicle. In one of the studies, the truck pulled a conventional 4-axle trailer, and in the two other studies pulled a dolly and trailer. The comparative studies between the 90 and 60-tonne vehicles were carried out under similar conditions. The same driver drove the ETT vehicle and the reference vehicle. For all vehicles, the maximum speed was limited to 80 km/h.

Diesel quality for the ETT vehicle was environmental class

Bränsle	Energiinnehåll, kWh/m ³	Densitet, kg/m ³ vid 15° C	Koldioxidemission, kg CO ₂ /liter
Diesel – Mk1	9 800	815	2,54
Diesel – Mk1 med 5 % FAME (B5)	9 770	818	2,41

Table 1. Energy content, density and carbon emissions of the fuel used. (SPI, 2010).



1 with no blending of FAME (fatty acid methyl esters).

The ST vehicle used environmental class 1 diesel with 5% FAME, usually from rapeseed oil.

Fuel efficiency (litres/tonne-km) was calculated by dividing the total consumption (return trip) by distance and the payload.

Productivity

Productivity was monitored, both as field studies of time taken for various stages and also based on reported timber volumes from the companies' normal reporting systems and the local timber measurement associations..

Road safety

Skogforsk's studies of overtaking were carried out in conjunction with time and fuel studies. Researchers accompanied the ETT vehicle and noted time, place and behaviour of the overtaking vehicles. A small number of drivers were interviewed via mobile telephone directly after the overtaking manoeuvre.

In a more comprehensive study of road safety that VTI carried out on commission from the Swedish Transport Administration in 2010, overtaking of the ETT vehicle and a reference vehicle were filmed and studied. In the study, the concept of time margin before meeting an approaching vehicle was used as a measure of the influence of vehicle length on the risk of accident caused by overtaking. The time margin is the time in seconds from the conclusion of an overtaking manoeuvre until the overtaking vehicle meets a vehicle approaching on the other carriageway. Time margins were estimated using video material from four cameras fitted on the ETT vehicle and on a conventional 24-metre timber vehicle. Between June and October 2010, approximately 1,500 relevant overtakings were recorded on the route between Piteå and Överkalix. The time margins in these overtakings were analysed. An earlier VTI study from 1976 showed very small differences in time margin for overtakings of a 24 m vehicle compared with an 18 m vehicle (Hammarström, U., 1976).

Financial calculations

Calculations for the ETT and ST vehicles were done using the spreadsheet program SÅ-Calc (Swedish Association of Road Transport Companies, 2009). The program, which is an add-in to Excel, was developed by the Swedish Association of Road Transport Companies to make it easier for hauliers and transport buyers to calculate costs, create price tables, follow-up calculations, etc.

Road wear

The Swedish Transport Administration studied road wear and the effect of the ETT vehicle on the road body through analysis of data from sensors from the Percostation system (Roadscanners Oy, 2010) that were inserted in the road surface (see Appendix 9). The analyses also included data from the registrations of the axle loadings of the vehicle at Råktforsen by the E10 motorway..

Driver follow-up

The drivers kept a daily journal of refuelling, productivity and technical anomalies. They also kept a journal of anomalies regarding traffic incidents.

Technical inspections

After one and two years of driving respectively, the ETT vehicle underwent comprehensive technical inspection. The ST vehicle was inspected after one year of driving. All equipment suppliers took part in the inspections.

Physical and mental driver environment

Drivers were interviewed. Measurements of whole-body vibrations were carried out using vibration dosimeters placed in the driver's seat.

RESULTS: ETT RIG

Fuel consumption and environmental impact

Fuel consumption studies show distinct reductions compared to if the same volume of wood had been transported on conventional timber vehicles. Both fuel consumption and carbon dioxide emissions were reduced by 21%. Appendix 10 shows a summary of the studies and follow-ups of fuel consumption.

The comparative studies of the ETT vehicle and the reference vehicle in March and June 2009 and October 2010 showed that:

- Fuel consumption of the ETT vehicle with gross weight of 90 tonnes was 0.54 litres/km. This corresponds to 2.6 litres/tonne on the whole route, return trip (just over 320 km).
- Fuel consumption of the reference vehicle, 60 tonnes, was 0.43 litres/km. This corresponds to 3.3 litres/tonne on the whole route, round trip (just over 320 km).
- Conclusion: the fuel consumption of the ETT vehicle was 21% less than the reference vehicle.

Fuel consumption, and thereby carbon dioxide emission, varies during the year, with a peak during the winter season (Figure 14). When the rig was fully-loaded, fuel consumption varied between approximately 0.6 and 0.7 litres/km depending on the season. When empty, fuel consumption varied between 0.35 and 0.43 litres/km depending on the season. The difference in fuel consumption between driving empty and driving fully-loaded was approximately 0.27 litres/km.

Figure 15 shows fuel efficiency, litres/tonne-km, for the ETT vehicle and a theoretical calculation for the reference vehicle (60 tonnes). The calculation is based on data from the comparative studies that were carried out between the 90- and 60-tonne vehicles, which were carried out under similar conditions, i.e. on the same route with the same driver.

Figure 16 shows mean fuel efficiency, expressed as litres per tonne-km. The diagram shows that the ETT vehicle is

Fuel consumption

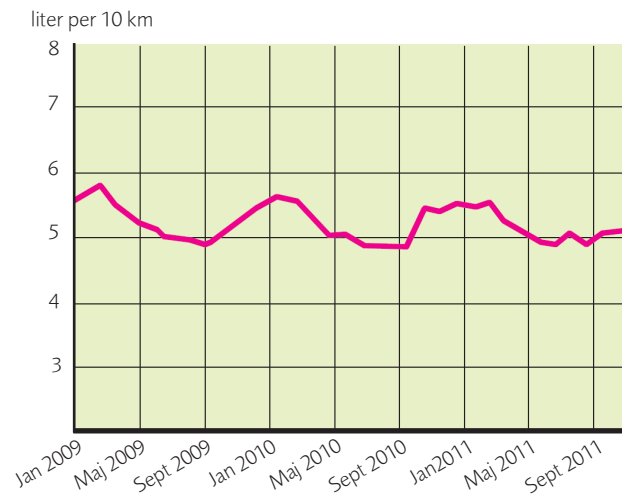


Figure 14. ETT vehicle average round trip fuel consumption per month during the period Januari 2009 to October 2011. Liters/10 km.

ETT vehicle fuel efficiency compared with fuel efficiency for a conventional vehicle.

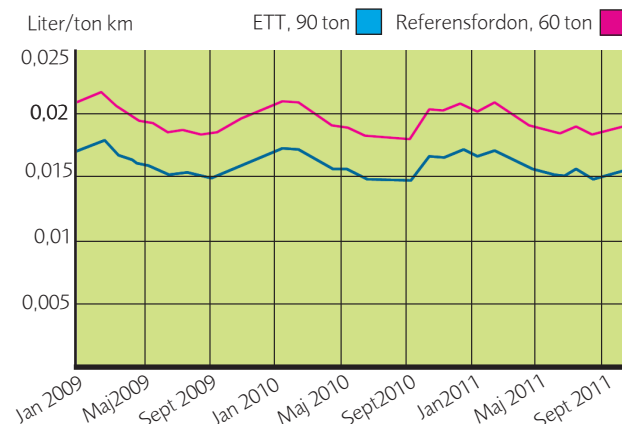


Figure 15. ETT vehicle fuel efficiency compared with a theoretically estimated fuel efficiency for a conventional 24 meter and 60 tonnes vehicle. The estimation is based on results from comparative studies.

RESULTS: ETT RIG

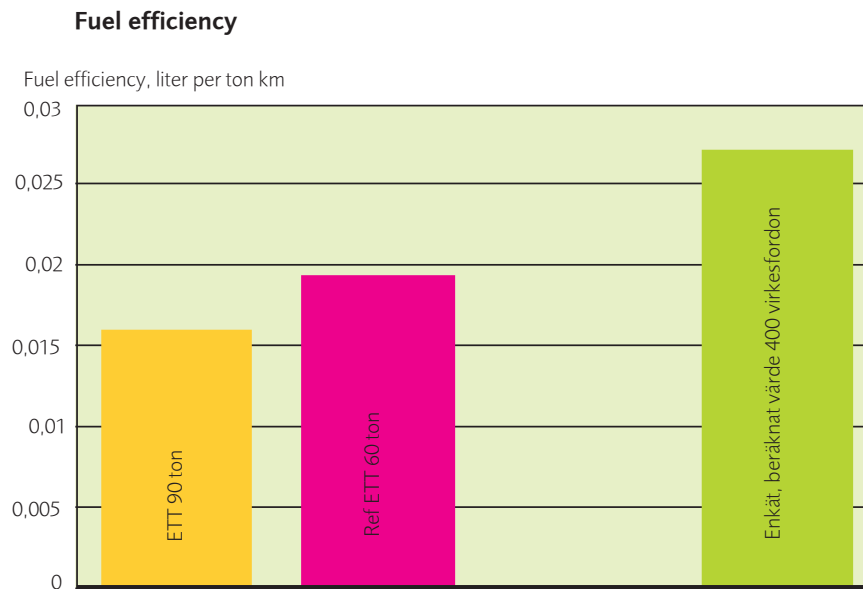


Figure 16. Fuel efficiency, liter per ton km, for the ETT vehicle (yellow bar) and reference (pink bar). Green bar shows the average fuel efficiency for conventional timber transport in Sweden. This indicates a huge potential in more fuel efficient transportation.

approximately 20% more fuel efficient than the reference vehicle. The fuel efficiency is not comparable but it can still be interesting in this context to show an average figure for timber vehicles in Sweden. Consequently, Figure 16 also shows average fuel efficiency for over 400 timber vehicles operating on scheduled runs during two test weeks in 2008 (one week in May and one week in December). Note that the survey includes timber vehicles operating along varied routes and under various road conditions. Drivers, vehicle combinations (group vehicle/crane truck) and season also varied. The results in Figure 16 are based on a survey that Skogforsk carried out of conventional timber trucks throughout Sweden (Brunberg, T., Enström, J. & Löfroth, C. 2009).

Driving behaviour varies, and this affects fuel consumption. Data from Dynafleet shows a difference of 1.7 % between drivers. One of the reasons for the difference is the proportion of coasting, i.e. when the accelerator pedal is released and fuel consumption becomes 0 litres/km.

In 2011 the option of raising 5 of the 11 axles on the ETT vehicle when the vehicle was empty, including one of the two drive axles, was introduced. Volvo's own study showed that this reduced fuel consumption by 8% when the vehicle was empty, or a total of 3% on return trips. This measure also decreased tyre wear and improved manoeuvrability. Tests were also carried out of lowering the timber stakes to reduce air resistance. This decreased fuel consumption even more.

Productivity

During the test period 2009-2011, the ETT vehicle drove a total of 800,000 km and transported approximately 150,000 cubic metres solid volume from Överkalix to Munksund in Piteå. The corresponding total number of trips for the same volume was calculated for a conventional 60-tonne vehicle. The ETT vehicle improved transport efficiency, because the payload of each vehicle is 50% greater. Two ETT vehicles are as productive as three 60-tonne vehicles.



RESULTS: ETT RIG



Road safety

In conjunction with Skogforsk's time and fuel studies, driver behaviour in 700 overtakings was recorded. No negative reactions from overtaking drivers were observed. Five of these drivers were contacted by mobile telephone directly after the overtaking manoeuvre. None of them had any negative comments about the ETT vehicle, and a couple of them had not even noticed that the vehicle they overtook was longer than usual.

Volvo's internal accident commission carried out a study, which showed that the overall risk of accidents was lower for the ETT vehicle. See Appendix 11.

VTI carried out four different studies to illustrate the impact of heavier and longer lorry combinations on road safety compared with current conventional heavy vehicles. The emphasis in the studies was on overtaking situations. The conclusion was that no definite differences could be proved and that more studies are required (Appendix 12).

During the project period, the ETT vehicle was involved in two traffic incidents (Appendix 12). Both incidents occurred on a 2+1 road with a central reservation barrier, when overtaking vehicles tried to overtake precisely before two lanes merged into one.

The incidents did not cause any injuries.

When the project started, a crisis group had been set up that could be convened at short notice and decide on measures and spread information after, for example, a traffic incident. The group was activated after both incidents. For the first incident, deemed to be the most serious, information was quickly compiled about what had happened and was passed on to an external information officer.

Road wear

The Swedish Transport Administration continually measured road wear, using sensors from the Percostation system (see Appendix 9) inserted in the road surface.

The conclusions were as follows:

1. Because the ETT vehicle does not exceed permitted axle loads, the sensors could not distinguish between passage of the ETT vehicle and other heavy traffic.

RESULTS: ETT RIG

2. On the basis of these results, the ETT vehicle had no identified effect on the structure of the road.

However, the road structure where the measurements were taken (at Råktforsen) is judged to be comparatively strong

Technical follow-up

No abnormal wear on the ETT vehicle or its equipment was indicated by the drivers' daily journal or the comprehensive technical inspections. See Appendix 13..

Payloads and gross weights

The system fitted on the vehicle for measuring axle pressure comprises three parts. Two were developed by Volvo and are placed on the tractor, and the third, which sits on the trailers, was developed by Wabco. The system overestimated total weight by 1% for the 60-tonne ETT vehicle and by 3% for the 90-tonne ETT vehicle (see Appendix 14). In this context (axle loading) the precision must be regarded as satisfactory. Police carried out control measurements of axle pressure and gross weight on several occasions at their permanent weighing station outside Piteå. No excess weights were recorded.

Driver environment

Throughout the test period, the drivers experienced the ETT vehicles as easy to drive and stable. The vehicle performed well on bends and through roundabouts.

According to the drivers, the EBS fitted on the ETT vehicle worked very well. Braking was smooth and the system eliminates the risk of jack-knife because the brakes are applied to all wheels simultaneously. The drivers also report that the braking distance of the ETT vehicle was no longer than that of a conventional 60-tonne vehicle.

Vibration was measured in the winter of 2010 by placing a vibration dosimeter on the driver's seat. The equipment was supplied by CVK AB in Luleå. The measurements showed that a driver of an ETT vehicle on the route Överkalix-Piteå was not exposed to greater vibration than a driver of a conventional timber vehicle

“Driving the ETT vehicle is like driving any other timber truck. Actually, it is more stable than conventional timber trucks.”



Figure 18. "Driving the ETT vehicle is like driving any other timber truck says driver Torbjörn Petterson, Bjälmsjö Skog och Transport AB. "Actually, it is more stable than conventional timber trucks."

Financial comparison

In the financial calculations, the ETT vehicle was compared with a conventional timber truck, which carries 42 tonnes compared with the 65 tonnes of the ETT vehicle.

The ETT vehicle comprises truck with link, dolly and trailer. Conventional timber trucks comprise a forest truck with four-axle trailer without crane (group vehicle).

In both cases, the same truck was used and the same driver. The study showed that the payload increased from an average 42 tonnes to approximately 65 tonnes, an increase of 55%. The driving time for the transport was basically the same, but the ETT vehicle took more time per transport because of loading and unloading. The transport distance between Överkalix and Piteå was suitable from a shift perspective because, under normal driving conditions, the vehicles had time for two return trips per 10-hour shift.

In the cost calculations, the cost of transporting 1,000 tonnes of timber was compared. The cost using the ETT vehicle was SEK 79,000 and for a conventional group vehicle, just over SEK 102,000. The saving of SEK 23,000 means a 23% reduction in costs. See also Appendix 15





RESULTS: ST RIG

Fuel consumption and environmental impact

In autumn 2010 a study compared fuel consumption of the ST tractor and a conventional group vehicle. The results showed that fuel consumption of the ST tractor was 8% less per transported tonne. See Appendix 16.

Figures 19 and 20 show fuel consumption of the ST vehicle, in terms of fuel efficiency (litres per tonne-km) and as litres per 100 km (average consumption per month with

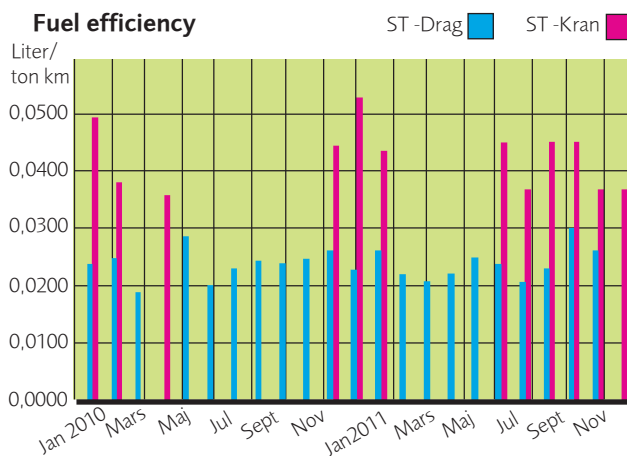


Figure 19. ST vehicle fuel efficiency over the two year period 2010/2011. The break in the curve is due to missing data.

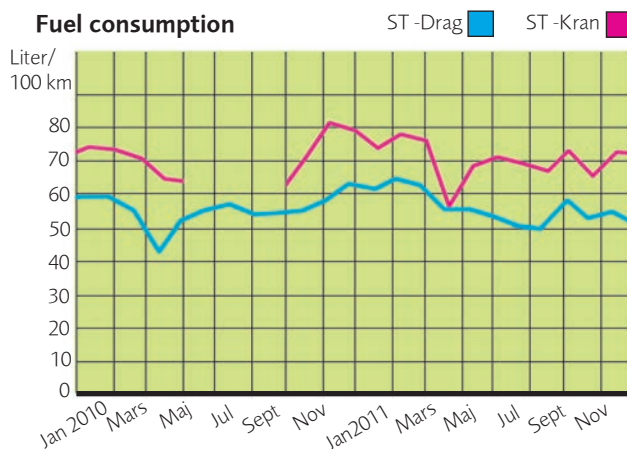


Figure 20. ST vehicle fuel consumption over the two year period 2010/2011, liter/100 km. The break in the curve is due to missing data.

laden and unladen vehicles). Input data was provided by the Dynafleet system, and data on reported wood volumes transported was from Stora Enso

Productivity

The ST vehicle drove a total of just over 500,000 km and transported 190,000 cubic metres solid volume. Of this volume, the ST tractor drove nearly 10,000 cubic metres solid volume in a group loader belonging to Skogsåkarna. From 1 December 2011, the vehicles were driven separately as crane truck and group vehicle.

Road safety

No formal studies of road safety were carried out. Overtaking studies were not applicable as the ST vehicle is the same length and breadth as a conventional timber vehicle. During the project period, the ST tractor was involved in one traffic incident, on a curve when it met another timber vehicle on a snow-packed winter road (see Appendix 12). The ST tractor, which was empty on a return journey, skidded, and the vehicles collided, causing bodywork damage but no injuries..

Road wear

No abnormal wear on forest roads was observed. The Swedish Transport Administration's studies of the ETT vehicle's road wear on a public road at Råktforsen showed no increased loadings in the road body. The axle pressure on the ETT vehicle and the ST vehicle are the same, so the results from Råktforsen should also apply to the ST vehicle.

Technical follow-up

Follow-up and studies of the ST vehicle driven under difficult conditions were very useful to the vehicle manufacturers in their tests of various structural components. For example, a new type of hydraulic front wheel drive was tested on the crane truck, which considerably increased manoeuvrability, particularly on snow-covered roads. The ST vehicle was also fitted with a new type of forest crane with a type-approved and verified crane scale. More trials will be carried out of the ST tractor in group driving. Consequently, the vehicle will be partly rebuilt to match the requirements of group driving .

RESULTS: ST RIG

Financial comparison

In the ST project, the consequences of transporting timber on vehicles with greater payloads compared with traditional timber vehicles were compared. The comparison was based on six different calculations (Appendix 17)..

1. ST crane truck drives from the landing in the forest to the staging area and ST tractor drives from the ranging area to the mill.
2. Conventional crane truck drives directly from forest to mill, leaving the crane in the forest.
3. Conventional crane truck drives directly from forest to mill, retaining the crane.
4. ST crane truck drives directly from forest to mill.
5. Direct driving forest – mill. Loading of ST tractor with separate loader on the landing in the forest.
6. Direct driving forest – mill. Loading of conventional group vehicle (timber vehicle without its own crane) with separate loader at the landing in the forest.

All comparisons involved fixed conditions regarding driving distances, so the results will change if the same comparisons are made for completely different distances.

A general conclusion from the studies is that vehicles with greater load capacity than conventional vehicles will reduce transport costs under suitable driving distances

Comparison A: calculations 1 and 3**Conditions**

ST crane truck loads at a landing in the forest and drives to a staging area. The timber is unloaded from the vehicle and loaded onto a waiting link. The trailer is uncoupled. The ST tractor leaves an empty link and an empty trailer, and couples the loaded link and trailer. This setup was compared with alternative 3, a conventional timber crane truck.

In the comparison, the forest vehicle drives 5 km on a forest road to the site where the ST tractor fetches the loaded link and trailer. The ST tractor drives 100 km on a public road to the mill. The tractor carries 52 tonnes, and the forest vehicle without crane carries 42 tonnes

Results

When the systems are compared, the ST crane truck + ST tractor is approximately 5% cheaper

Comparison B: calculations 3 and 4**Conditions**

ST crane truck loads at a landing in the forest and drives to a staging area. The timber is unloaded from the vehicle and loaded onto a waiting link. The trailer is uncoupled. The ST

tractor leaves an empty link and an empty trailer, and couples the loaded link and trailer. This setup was compared with alternative 3, a conventional timber crane truck.

In the comparison, the forest vehicle drives 5 km on a forest road to the site where the ST tractor fetches the loaded link and trailer. The ST tractor drives 100 km on a public road to the mill. The tractor carries 52 tonnes, and the forest vehicle without crane carries 42 tonnes

Results

When the systems are compared, the ST crane truck + ST tractor is approximately 5% cheaper

Comparison B: calculations 3 and 4**Conditions**

The ST crane truck is driven directly from the landing in the forest to the mill, where the wood is unloaded using the crane. The ST crane truck was compared with a conventional crane truck that retains its crane. The distances are 3 km on forest roads and 80 km on public roads. The payload of the ST crane truck is 48 tonnes and that of the conventional crane truck is 39 tonnes, so the payload of the ST crane truck is 23% greater.

Results

Under these conditions, the ST crane truck reduces transport cost by 7%.

Comparison C: calculation 2 and 4**Conditions**

In this comparison, the cranes are left in the forest. The setup shows approximately the same financial consequences as when the vehicles retain the cranes.

Results

The total cost falls by 6% when the ST crane truck is used compared with the conventional timber truck.

Comparison D: calculation 5 and 6**Conditions**

In calculation 5, the ST tractor is loaded using a separate loader in the forest and is then driven directly to the mill. This is compared with calculation 6, a conventional group vehicle. The payload of the ST tractor is 52 tonnes, compared with 43.5 tonnes for the group vehicle. The comparison does not include the cost of the separate loader.

Results

Under these conditions, and assuming the same driving distance as in the earlier alternatives, the ST tractor reduces costs by just over 10%.

RESULTS: ST RIG



COMMUNICATION

The project aroused great external interest, and attracted the attention of various media. The project involved a large number of information activities on varying scales, including 45 conferences attended by a total of almost 6,000 participants (Appendix 18). The following is a selection.



Public demonstrations

Introduction of the ETT vehicle. Munksund, Piteå, 9 December 2008. Target groups: politicians, police, rescue service, Swedish Transport Administration, and other associated parties in Norrbotten. Local and national media. Other interested parties.

Demonstration of the ETT vehicle at Volvo Democenter, Göteborg 5 March 2009. Target group: National and international media.

Introduction of the ST vehicle, 13 August 2009, at the Mittia Trade Fair in Ljusdal. Target groups: politicians, police, rescue service, Swedish Transport Administration, and other associated parties in Värmland and Dalsland. Local and national media. Other interested parties.

A large number of demonstrations of the ETT vehicle locally in Överkalix and Piteå/Luleå for various target groups, including local politicians

Conferences

Skogforsk Development Conferences, 2008 and 2010.

Skogforsk LOGISTIK Conference, 2007 and 2009.

Skogsvårdsförbundet Autumn Excursion, 2009.

Nordic Road Safety Conference in Finland, spring 2010.

OSCAR (regular conference for Nordic forest researchers), autumn 2010.

FFI – Strategic Vehicle Research and Innovation, 2010 and 2011.

Standing Committee on Transport and Communications, March 2011.

Logistics and Transport, May 2011.

Overseas Baltic Conference, June 2011.

Almedalen, July 2011.

Transport Fair, Mittia, August 2011.

Nordic Road Association, Göteborg, 2011.

Miscellaneous

Films and brochures were produced and disseminated in various arenas. Presentation material for media and other target groups was published on the Skogforsk website.

DISCUSSION

Results so far indicate that the ETT and ST concepts are very successful. There can be no doubt that the concepts have great potential in terms of:

- Lower diesel consumption.
- Less environmental impact.
- Reduced transport costs.
- Fewer timber vehicles on the roads.

So far there have been no indications that road safety is affected negatively. Nor is there any indication that load bearing capacity and wear on roads are affected negatively.

During the course of the work, further improvement potential was identified and tested on both the ETT and ST vehicles, which can benefit timber transports in general. For example:

- Wheel axles can be raised when the vehicle is empty, to reduce rolling friction.
- Improved aerodynamics by lowering bunks and stakes when the vehicle is empty.
- Hydraulic front wheel drive for greater manoeuvrability.
- Single, extra wide tyres instead of double tyres, which reduces fuel consumption.

Direct loading of the ETT vehicle in the forest reduces costs even more.

The ST vehicles in staging systems have shown fuel savings of up to 8-10% so far. However, a challenge for the staging system has been the logistical setup, particularly the limitation of only having two vehicles operating. Since autumn 2011, Stora Enso AB has also been carrying out trials in which an ST crane truck drives directly to the mill, and the ST tractor is part of a conventional group driving system.

Technically, the vehicles have performed well. SSAB's new steel quality, Domex 700, used on the trailer, performed well and no fracturing or exhaustion tendencies was observed. This new steel quality reduces the unladen weight of the vehicle, thereby allowing payloads to be increased accordingly. Greater use of new stronger steel types in general would reduce vehicle weights and thereby allow greater payloads.

The ST crane truck is currently being tested in direct

driving to mills and the ST tractor is part of a group driving system comprising separate loaders and a number of conventional 60-tonne group driving vehicles. Both the ST vehicles can now be adapted to the conventional transport system, but with a gross weight of 74 tonnes. These vehicles will be part of the new demonstration project whose working title is ETT Demo.

Reflections from some of the project participants

The key participating organisations submitted comments on the project. The organisations were unanimous on the following.

Successful collaboration between a large number of organisations helped the ETT Modular System for Timber Transport project achieve the common goals that were set. The project showed that heavier and longer timber vehicles could reduce fuel consumption and transport costs with no negative impact on either road safety or road wear.

Participants also agreed that the move toward more energy-efficient road transport through heavier and longer vehicles that has now been initiated must continue in some form.

Recommendations from the project

In the next stage, it would be desirable to expand the experiment to cover more vehicles in other geographical environments. This would provide more experience of new logistical solutions for timber transport from forest to industry. We also need more experience of how the systems work in different parts of Sweden and in different traffic environments with broader application.

With this in mind, an extension of the ETT Modular System for Forest Transport project has been initiated in a new project with the working title ETT Demo. The aim of the project is to demonstrate the operation of the ETT and ST concepts in various supply chains and in various applications and geographical areas. An experience bank will be built up quickly and the concepts implemented.

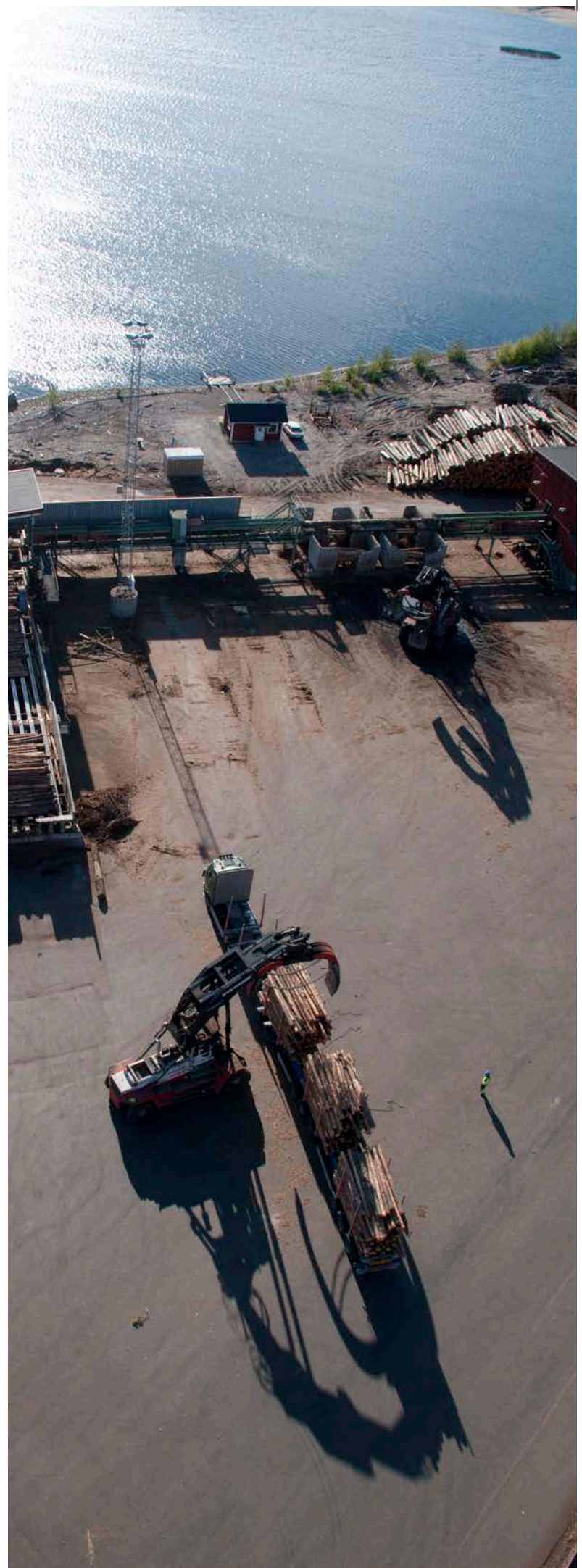
DISCUSSION

Important issues to investigate in the ETT Demo project

- How do the vehicles perform over different transport distances?
- How do the vehicles perform in transporting different forest products?
- How does the ETT vehicle perform on the private road network and in group driving?
- Using independent loader and 2-4 ETT-vehicles.
- What is the nature of possible bottlenecks in the existing road network?
- How can the vehicles be included in logistical solutions that combine road haulage with, for example, rail transport?
- Can the hypothesis be confirmed that cheaper wood chip transports increase the catchment area for forest fuel and thereby increase the use of bioenergy?

The ETT Demo project is part of the HCT (High Capacity Transports) programme initiated by the Swedish Transport Administration. This is a research and innovation programme that will work for broader implementation of concepts involving transports with greater capacity. Some important issues in the programme are:

- How well can the forestry sector and other sectors utilise greater carrying capacity? How much can we reduce emissions of greenhouse gases?
- How will competition develop in relation to other forms of transport?
- What are the infrastructural consequences of broader implementation?
- What are the administrative and cultural barriers to broader implementation?
- How can the vehicles be optimised further in terms of logistics, environment and road safety?



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APPENDICES

All appendices can be downloaded as PDF files from the website: skogforsk.se/ett-slutrapport

- Bilaga 1 Teoretiska beräkningar – konstruktion och vägsitage
- Bilaga 2 Teoretiska beräkningar – bränsleeffektivitet
- Bilaga 3 Styr- och arbetsgrupper
- Bilaga 4 Projekt- och forskningsplan
- Bilaga 5 Beskrivning av Sammodalitetsprojektet
- Bilaga 6 Teknisk specifikation av ETT- och ST-fordonen
- Bilaga 7 Vägverkets föreskrifter för ETT-fordonet (VVFS 2008:418)
- Bilaga 8 Genomförda studier
- Bilaga 9 Mätning av vägnedbrytning – Percostation
- Bilaga 10 Bränsleförbrukning – Dynafleet data
- Bilaga 11 Trafiksäkerhet, Volvo Lastvagnars haverikommission
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- Bilaga 18 Projektets medverkan i konferenser och motsvarande informationsinsatser
- Bilaga 19 Reflektioner från några deltagande organisationer





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