

Report on wintertime High Capacity Transport (HCT) 2015-2016

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Otto Lahti & Anneli Tantt

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Summary

As the winter season (October 2015–March 2016) began, there were six permit holders operating with a total of nine HCT combinations. In both October and November, the HCT combination of one new permit holder began running, whereas in December two HCT combinations began running under one new permit holder.

HCT combinations transported raw timber, LVL beams, pulp, long shipping containers and retail goods, as well as sulphur and hydrochloric acid transported as dangerous goods. Large HCT combinations were driven a total of over 1.8 million km, of which 950,000 km were driven during the winter season. In addition, HCT semi-trailer combinations were driven 250,000 km during the winter season.

The main routes were the Vantaa-Kempele and Espoo-Lahti legs of national road 4 for retail goods; and the Helsinki-Tampere leg of national road 3, national road 6, and the Kotka-Imatra leg of national roads 15 and 26 for shipping containers. Raw timber was transported in the Saimaa region on national roads 5, 6, 13 and 15, as well as in Lapland on national road 4 from Ivalo to Rovaniemi. Dangerous goods were transported in the Satakunta region.

HCT combination traffic flowed as smoothly as other heavy combinations. In very bad weather, the final trailer was omitted from HCT combinations, or the journey was abandoned altogether. Automatic tyre chains, locks and lift axles were required during departure from terminals and yards in poor weather, particularly if the going was soft. No such gear was needed in actual driving on roads.

Winter maintenance requirements are the same for HCT combinations as for other heavy traffic. Winter maintenance was fairly satisfactory in the south, but the level was unsatisfactory on some stretches, particularly on national road 4.

Studded tires were viewed as clearly beneficial by some permit holders, particularly at icy road intersections. Vehicles with studless winter tyres also coped well in winter traffic. Features such as snow chains in exceptional situations and sand applicators for the drive wheels of normal weight combinations are being planned for next winter.

Most detours on HCT routes occurred due to accidents. In most cases, the detours were suitable for the combination and the driver/traffic controller acted logically. However, the Viitasaari police directed a long, overweight transport onto a detour where the last trailer in the combination swung onto the verge, but no harm resulted. The Laukaa police stopped a long HCT combination in a cramped rest area for a stop check, from which it was difficult to rejoin the traffic. According to the permit holders, traffic controllers are not always able to provide HCT drivers with sufficiently accurate information on the suitability of detours and rest areas for HCT combinations which, for example in individual cases, has led to the vehicles entering tight spaces. However, the driving speeds were very low and no incidents resulted.

Several permit holders have developed or are developing various user interfaces for the drivers, which will gather information on disruptions, driving patterns, the weather etc. Driving patterns reveal the whereabouts of vehicles on the road and can warn of disruptions ahead, identifying suitable detours in advance.

HCT combinations were also involved in a few incidents, from which they emerged undamaged. In a couple of the incidents, a camcorder installed in the vehicle took pictures, which the HCT steering group has examined. In these cases, the conduct of the HCT drivers was impeccable.

In winter, fuel consumption is increased by the characteristics of winter diesel fuel, and icy and snowy conditions. In slippery conditions, consumption is also increased by the fact that cruise control cannot be used for safety reasons. Rolling resistance on wet snow increases consumption and the snow adds to the weight of the combination. The difference in fuel consumption can be over 10 l/100 km in different road conditions. In comparison to reference combinations, HCT combinations consume 1–4 li-

tres/100 km more fuel in winter than in the summer. However, the energy efficiency of HCT combinations tends to outstrip that of reference combinations no matter the season, although the gap is smaller in winter.

1. Introduction

The Finnish Transport Safety Agency Trafi has been able to grant permits of exception for High Capacity Transport (HCT) combinations exceeding the maximum allowed dimension and/or weight limit values since 2013, when authority to grant permits of exception was expanded to cover modular combinations. The purpose of the trials made possible with these permits is to develop technology related to larger-than-usual vehicle combinations and collect data on the suitability of vehicles – which are larger than before – for the Finnish transport system.

In the summer of 2013, Trafi and the Finnish Transport Agency established an HCT steering group with the purpose of steering and coordinating trials including the permit process, and drawing conclusions on the development of legislation based on the trial results. The steering group comprises representatives from Trafi and the Finnish Transport Agency, and a consultant serving as the secretary of the working group.

The HCT steering group requires monthly traffic reports from all permit holders, who must also report biannually, or separately for the summer and winter seasons, in accordance with the permit-specific study plan. For the first winter season, the permit holders were requested to report, in particular, on the effect of winter conditions on operations, changes in fuel consumption compared to the summer, wear and tear on vehicles, experiences of ITS, the practicality of permit exemption terms and conditions, and the progress made with the research projects.

This report covers operations during the winter of 2015–2016, which is restricted to the period 1 October 2015–31 March 2016. A third HCT forum, to which all interested stakeholders were invited, was convened at the end of January 2016. The level of interest and number of participants in the forum grew further compared to the two previous forums. In addition, the forum was a success according to a feedback survey.

HCT combinations have aroused interest in the media and have featured in several Finnish presentations for e.g. municipal and state transport sector operators and police cadets, and in various trials. Road users tend to form certain impressions of how larger-than-normal vehicle combinations affect normal traffic. However, the aim of trials is to provide research information on their actual impacts. These effects have been made very clear in presentations, which we will continue to organise, held for the authorities and experts.

The European Parliament Committee on Transport and Tourism visited Finland in February. In winter conditions at Levittunturi, the transport entrepreneurs and Trafi presented existing 76 tonne combinations and two HCT combinations. This markedly improved the committee's understanding of Finnish conditions and heavy traffic. The Finnish Transport Agency is involved in the OECD's international working group investigating HCT-type combinations, which began meeting in early 2016. Trafi is also actively maintaining contacts with the Swedish authorities and automotive industry representatives investigating HCT combinations.

HCT traffic is still growing. Since the winter season, the HCT combinations of five permit holders have begun operating, while those of three permit holders will take to the roads this summer. The total number of permit holders is now 18 and over 20 HCT combinations will be on Finnish roads from the end of the summer. Around 40 drivers now drive HCT combinations.

For further information on HCT traffic, see Trafi's website <http://www.trafi.fi/hct>.

2. Combinations that operated during the winter season

Six permit holders with a total of nine HCT combinations operated throughout the winter season. In both October and November, the HCT combination of one new permit holder began running, whereas in early December two HCT combinations began running under another new permit holder.

The four combinations of Speed Group, Orpe's combination, that of Keslog, that of Kuljetusliike Kalevi Huhtala and that of Kilon Osuus-Auto KOA were already running during the summer. During the winter, they were joined by the combinations of Ketosen Kuljetus Oy, Fisolet Oy and Oulun Autokuljetus OAK, as well as the two combinations of Kiitosimeon Oy.

2.1 Speed Group Oy

Speed holds permits of exception for four 11-axle Duo2 combinations with lengths between 32 and 33.5 metres and maximum allowed weights between 68 and 90 tonnes. These combinations are used to transport two long shipping containers instead of the one that fits a normal semi-trailer combination. The combinations transport containers from the Vuosaari Harbour in Helsinki to the Tampere, Lahti and Heinola regions, and from the Mussalo Harbour in Kotka to the Kouvola, Lappeenranta and Imatra regions. Transports have also begun on the Helsinki-Oulu route. The aim of the trial is to find the best way of transporting shipping containers along well-maintained main roads in Finland, taking account of the costs, environmental impacts, traffic flow and road safety.



2.2 Orpe Kuljetus Oy

Orpe holds a permit of exception for a 12-axle Duo2 combination that is 31 metres long and has a maximum allowed weight of 94 tonnes. The large combination transported timber in the Saimaa region on the Lappeenranta-Savonlinna-Mikkeli-Lappeenranta and Lappeenranta-Kouvola-Kotka routes.

In the trial, UPM's objective is to develop more efficient methods for the large-volume trunk line transport of timber. The Orpe combination is able to transport one third more timber than a traditional timber combination. The vehicle is specifically designed for driving on main roads. Different combinations are used for picking up timber from alongside forest roads and transports between plants.



2.3 Keslog Oy/Mikko Niskala Oy

Kuljetusliike Mikko Niskala Oy holds a permit of exception for an 11-axle Duo2 combination with a maximum allowed weight of 90 tonnes and a maximum allowed length of 34 metres. Mikko Niskala Oy operates as a contractor for Keslog Oy, which handles daily transports for K-food stores.

The two double deck trailers of this combination developed jointly by Volvo and VAK hold double the number of rolltainers compared to a regular modular combination. This large combination operated on national road 4 between Vantaa and Kempele. The aim of the project is to improve the efficiency of commercial transport, particularly on long-distance routes between northern and southern Finland.



2.4 Kuljetusliike Kalevi Huhtala Oy

Kuljetusliike Kalevi Huhtala has a permit of exception for a semi-trailer combination with a maximum length of 22 metres and a maximum weight of 60 tonnes. The combination transports long LVL beams from manufacturing plants to harbours, with general cargo, such as pulp bales, forming the return load. This HCT combination travels along a route with a total distance of 1,320 km. The route is not specified in the permit. Such beams were previously transported by rail, but VR discontinued the service due to the low number of transports. Without the HCT permit, the beams would have had to be transported as special transports without a return load. The aim of the project is to explore the road safety and energy efficiency of the combination.



2.5 Kilon Osuus-Auto KOA

Kilon Osuus-Auto holds a permit of exception for an 11-axle Duo2 combination. The combination's maximum allowed length is 32 metres and maximum allowed weight 68 tonnes. It transports S-Group deliveries between Espoo and Lahti. Compared to a regular modular combination, this combination has the benefit of high transport efficiency combined with a reasonably affordable vehicle.

The objective of the project is to draw up a recommendation on vehicle combinations suitable for delivery, food, refrigerated and frozen cargoes, and on the use of such combinations in trunk and delivery transports between terminals.



2.6 Ketosen Kuljetus Oy

Ketosen Kuljetus has been granted a permit of exemption for a Duo2 combination. The combination can weigh up to 104 tonnes and be 33 metres long.

Ketosen Kuljetus hauls raw timber for Metsähallitus, Stora Enso and Metsä Group along the Inari-Rovaniemi-Kemi route from North Lapland. Journeys from logging sites in the north are three times longer than elsewhere in Finland. The aim of the trial is to investigate the effects and benefits of larger combinations on long-haul, raw-timber transport routes.



2.7 Fisole Oy

Fisole has a permit of exemption for a combination with a length of 28.5 metres and a weight of 68 tonnes. The combination mainly operates between Hämeenlinna and Vuosaari.

The Fisole combination has the capacity to carry two – in place of the normal one – 40-foot shipping containers. This totally distinguishes this vehicle combination from previous trials on Finnish roads. In its first trailer of this kind, domestic trailer manufacturer VAK Oy has combined its experiences of long semi-trailers and the V-Slider B Train delivered to the Swedish market, resulting in a 9-axle, B-Train type combination that can carry two 40-foot shipping containers at a time.

The aim of the experiment is to explore issues such as the suitability of long combinations for various routes and terminals, as well as the functioning of axle solutions required for long B-Trains.



2.8 Oulun Autokuljetus OAK

OAK has a permit of exemption for a combination with a maximum permitted length of 32 metres and weight of 88 tonnes. The combination has mainly been operating on routes between Oulu, Tervakoski, Espoo and Oulu.

OAK provides customised transport services for trade and industry in Finland and the Nordic countries. A major part of its operations involve temperature-controlled food transport. Its fleet has been customised for the haulage of products requiring temperature control and to meet a broad range of industrial needs.

The Green Double-HCT trial combination operated by Eero Sjögren Oy is a new version of the A-double combination, based on two semi-trailers. This solution has provided agility at junctions, stability at high road speeds and good weight distribution across the drive axles. The main goal of the trial is to use a larger combination to improve the energy efficiency of round-trip transportation.



2.9 Kiitosimeon Oy

Kiitosimeon Oy has a permit of exemption for two semi-trailer combinations with a maximum permitted length of 20 metres and weight of 68 tonnes. These are the only HCT combinations so far intended for the carriage of dangerous goods.

One combination transports sulphuric acid between Harjavalta and Tahkoluoto, along national road 2 in Satakunta.



The other transports salt and chlorate within Satakunta, mainly on round trips from Äetsä to Tahkoluoto, Mäntyluoto and Rauma on national road 2.



The aim of the trial is to study the agility and, in particular, the safety of a long semi-trailer in relation to a full trailer combination, and the impact on the road and the environment.

3. Wintertime transport operations

3.1 Traffic volumes

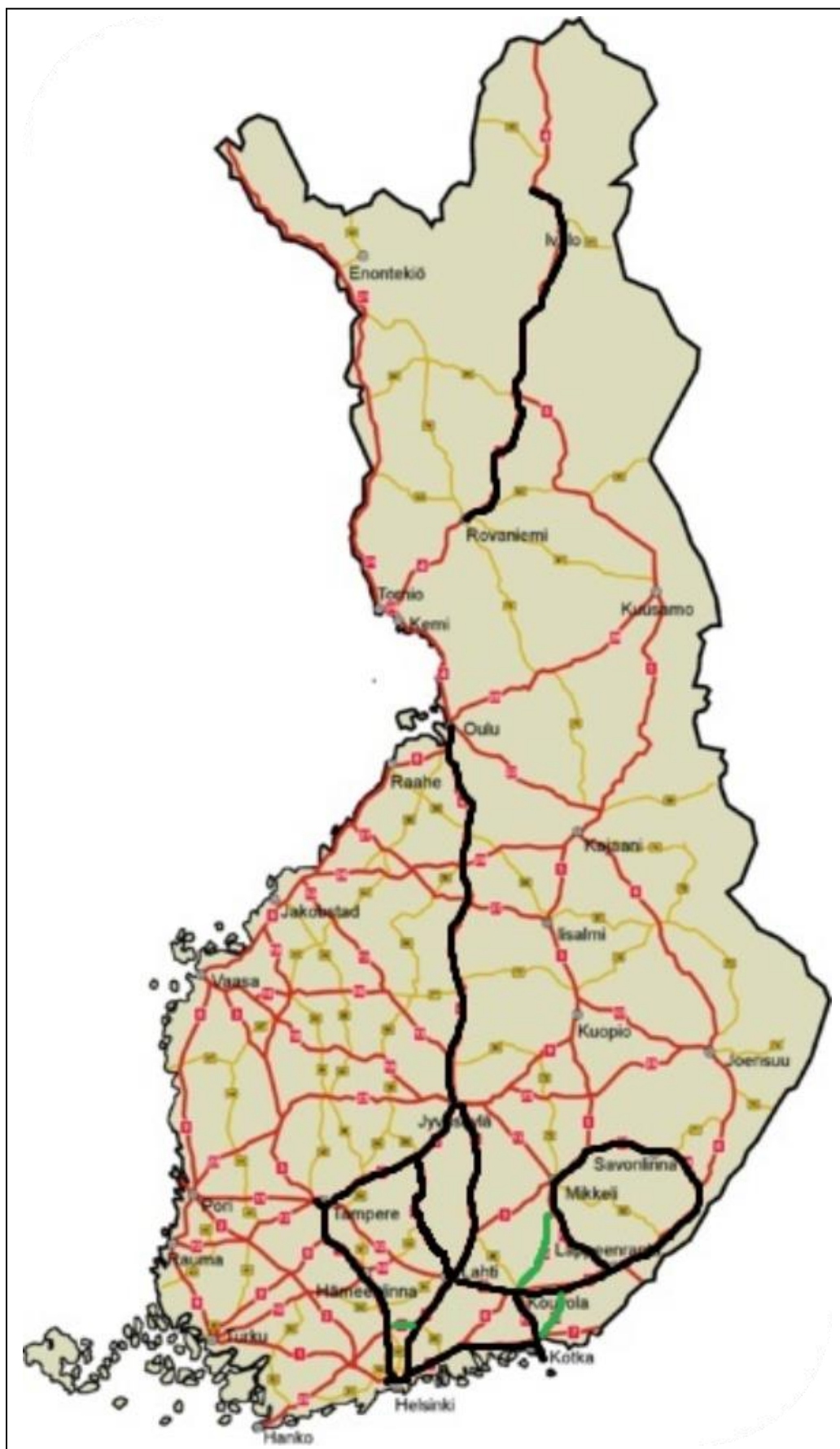
HCT combinations have been operating for a total of two and a half years. Large HCT combinations were driven a total of over 1.8 million kilometres, of which 950,000 km were driven during the last winter season. On the other hand, HCT semi-trailer combinations were driven 250,000 km during the winter season.

Overweight (over 76t) HCT combinations have mainly operated on national road 6 between Kouvola and Lappeenranta in Kymenlaakso (around 10 combinations a day) and national road 4 between Vantaa and Lahti (around 7 combinations a day). On the busiest stretches, HCT combinations account for less than one percent of the total heavy traffic. A great deal of HCT traffic has operated on national road 4, but very little of this has been overweight. In total, HCT combinations clocked up 790,000 km during the winter season.

Normal weight, but overly long HCT combinations mainly operated on national road 4 between Espoo and Lahti, and national road 3 between Tampere and Helsinki. Their overall distance covered was 160,000 km during the winter.

Trafi can provide parties responsible for road maintenance with accurate information on the operations of HCT combinations. Data on the traffic volumes and weights of HCT combinations on various road sections is recorded meticulously.

The following map shows the routes used by HCT combinations during the winter season. The routes of overweight HCT combinations are marked in black and those of normal weight combinations are marked in green. The map does not show the routes of HCT semi-trailer combinations.



3.2 Experiences in winter conditions

In terms of the weather and road conditions, the winter of 2015–2016 was highly uneven. While the early winter was mild and snowless, extremely cold weather arrived in January and snow, rain and freezing rain fell in February. In Lapland, the winter was exceptionally snowy.

Normal winter conditions posed no problems for HCT combinations. The drivers experienced no major differences between the winter driving characteristics of normal combinations and HCT combinations. In general, they view the driving characteristics of HCT combinations as excellent.

January In southern Finland, the weather was so bad for several days (12th, 13th, 26th, 27th, 28th and 29th) that the rearmost trailer was omitted from several combinations, or the combination did not run at all. Such weather is just as problematic for conventional heavy combinations.

Due to extremely frosty conditions, problems with the fuel system led to one HCT combination freezing twice during its journey. Hard frosts also increased journey times to the extent that not all trips were made as planned. Extreme frosts affected large combinations in the same way as any other vehicle combinations.

In January, one HCT combination was stranded on a hill leading from a terminal to a national road and had to be towed into the traffic by a wheel loader. On national road 4 on the same day, two regular vehicle combinations were stranded on a hill side by side, forcing an HCT combination approaching them from behind to halt on the icy slope. All of the stranded combinations needed the help of a sanding vehicle to continue their journeys.

February also included a few days (3rd, 8th, 18th and 20th) with very poor road conditions. Once again, several permit holders omitted a trailer from their combinations. During the winter, larger combinations use differential locks when setting off and on the worst hills; this is often unavoidable.

The towing vehicle of one HCT semi-trailer combination was changed from a tandem-drive vehicle to a lift axle one (6x2). The permit holder believes that this combination works very well on slippery roads.

When freezing rain began to fall in Lapland, it became clear that an HCT combination would not have cleared the Magneettimäki hill in Saariselkä, Ivalo, while loaded. Automatic tyre chains, a lock and lift axle were used. When the sand applicator did not work, as a precaution the driver left the full trailer by the road before climbing the final rise. The conditions were extremely difficult, given that the climb was also difficult for a 76-tonne combination and another vehicle had been stranded on the hill a moment earlier. A minibus had to be pushed out of the roadside ditch on the upper section of the hill. A sanding vehicle arrived after these events had occurred.

The motorways in Southern Finland were so well maintained throughout the winter that HCT combinations were able to operate without special arrangements in severe weather. Single HCT combinations were unable to continue operating on 3–4 occasions elsewhere in Finland.

Feedback for road maintenance organisations

Some combination drivers reported a range of flaws in winter maintenance, while others pointed out certain problem areas. The winter maintenance of terminals and yards ranged from good to bad.

Drivers of HCT combinations operating on national road 4 viewed the stretch between Pyhäsalmi and Lintulahti as being most in need of improvement. In addition, last winter the road between Leivonmäki and Joutsa was in poorer condition than previously. In late January, two normal combinations were stranded in Petomäki in Äänekoski.

During the same period, the stretch between Jyväskylä and Pyhäsalmi was slippery in places and one lorry ended up in a ditch in Tikkakoski.

Drivers of HCT combinations operating in Kymenlaakso focused their criticism on winter road maintenance on certain sections between Kotka and Imatra. They suspect that the sections of national road 26 between Hamina and Taavetti and national road 15 between Kouvola and Kotka are barely maintained at all during the nights. One driver reported that, on 20 February, the entire road section between Lappeenranta and Kouvola had a 20 cm snow covering and the occasional, deeper snowdrift. The Tykkimäki ramps in particular were extremely slippery, even – on occasions – in normal driving conditions.

National road 4 between Tiainen and Sodankylä was a problematic road section in Lapland.

Drivers of HCT combinations moving between Tampere and Helsinki view winter road maintenance on that stretch as good. Those driving in Satakunta also have a favourable view of winter maintenance. However, roundabouts in the neighbourhood of Eura were very slippery at times.

In general, HCT combinations have encountered similar winter maintenance problems to other heavy vehicle combinations. The worst problem is slippery and abundant snow.

What equipment was needed?

A significant proportion of the permit holders view differential locks, automatic tyre chains and lift axles as necessary, particularly when getting started in soft road conditions. Studded tires are also regarded as necessary, particularly on drive wheels. However, some trust in non-studded winter tyres. The following are extracts from reports by permit holders:

- Additional weight was added to the fifth wheel when using a lorry to move a full trailer in the terminal area. On spot automatic tyre chains were used in yard and rest areas, as well as at junctions and on ramps.
- Differential locks and lift axles are used on an almost daily basis at junctions, in petrol station and terminal yards, and in ports during the winter. Antiskid work is often poor in such areas. No significant difference was noted between the locomotion of the HCT combination and that of normal 25,25-long, full trailer combinations. The greatest problems occur when starting out with an empty vehicle because, during weight transfer, the lift axle does not match up with the tandem axle to be lifted.
- Automatic tyre chains, locks and lift axles are necessary. A differential lock is needed when starting out on a soft surface in particular.
- Studs are undeniably useful, especially when pulling out. Studded tires are used, for example, on the first or both drive axles, or on the dolly's axle.
- Only a lift axle and differential locks were used for the HCT semi-trailer combination. A lift axle improved the turnability of the vehicle and its mobility when starting off. The conditions in western Finland were so good that weight transfers were unnecessary.
- When setting off uphill from a loading bay in bad weather, automatic tyre chains are insufficient – the combination must be halved and proper sanding is needed.

3.3 Unusual traffic situations in winter

Detours

Detours occurred on HCT combination routes during the winter too. In most cases, the detours were suitable for the combination and the driver/traffic controller acted logically. However, in late February, police officers directed an HCT combination onto a detour without being able to confirm the route's suitability for a long combination. Luckily, no harm was done, despite the fact that the rearmost trailer strayed onto the verge. Permit holders pointed out that the traffic controllers were not always sufficiently aware of whether detours were suitable for HCT combinations. On one occasion, a traffic sign on a detour route had to be removed so that the combination could pass through a junction.

During the winter, the HCT steering group gave permit holders further information on where to find the most up-to-date information on new detours. In addition, revised guidance was drawn up in April on how to act when taking a detour. Intelligent Transport Systems, which are being or have already been developed by many permit holders, also help in such situations.

Many drivers believe that there has been a considerable decrease in general communication by drivers, via VHF-phones, during disruptions. Traditional warnings and replies to questions about problematic locations have become very rare. In many cases, information is only exchanged within a single company.

Stop checks

Two HCT combinations were stopped by police stop checks during the winter season. In Jyväskylä, the police checked the tachograph and permit of an HCT combination. Another HCT combination was stopped at a rest area in Laukaa. In both cases, everything was in order. The combination at Laukaa had to wait for some time before being able to rejoin the traffic. Stop checks during the winter can cause major problems for combinations, for example when rejoining the traffic from an unplanned lay-by.

Incidents

In Lapland, a deer ran across the path of an overweight HCT combination carrying timber; the sudden braking caused the upper timber on the front pile to shift by half a metre. An unfortunately high number of corresponding incidents also occur in the case of normal timber combinations in winter. Although the new combinations stop quickly and stably, their loads are not always secured sufficiently well.

An HCT combination was involved in a serious incident on national road 4, when it began to overtake a tractor. The tractor turned left without blinking and the combination swerved quickly leftwards to avoid it. The combination was fully loaded (88 tonnes). The road was not frozen and the trailers did not start swinging.

At the very end of winter (April), a rear-view camera on an HCT combination filmed an accident in Saariselkä, in which two trucks collided with one another, with one plunging off the road. No injuries occurred. The incident began when a car travelling ahead of the HCT combination braked due to an oncoming ambulance. The HCT combination also succeeded in braking, but another combination behind it swerved onto the opposite lane to avoid driving into the HCT combination. It collided with another heavy combination driving ahead of the ambulance.

The Jeesiöjoki bridge in Sodankylä has a traffic light system which allows an overweight, fully loaded HCT combination to cross the bridge alone, along the middle of the road. Drivers have reported oncoming car drivers that have driven against a red light and then had to reverse off the bridge. One car also drove onto the bridge behind an HCT combination.

3.4 Equipment failures, wear and adjustment

Because the stock used in HCT combinations is new, there have been few reports of wear and tear despite the high number of journeys. Observations have related to normal wear and tear of heavy vehicles and trailers.

HCT permit holders were somewhat inconsistent in reporting on wear and tear on combinations. On the other hand, most cases of defects requiring immediate repair are reported. Towing equipment is actively maintained and submitted to the manufacturer for analysis.

Problems in the trailer suspension appeared in the case of one HCT semi-trailer combination, which was taken back to the factory. The combination was briefly out of service.

A crack was found in the body of one HCT combination's trailer, which was repaired immediately. Permit holders have been pleasantly surprised by the low level of tyre wear.

In one HCT combination, axle lifting was shifted to the first axle on the tandem axle, in order to improve manoeuvrability.

Modifications were made to the fuel system of an HCT towing vehicle operating in the north. In addition, drivers performed interim refuelling in difficult weather conditions.

The reliability of sanders has proven to be a problem in extremely cold weather, as they may freeze.

No particular wear had occurred in the brakes of HCT semi-trailer combinations. In the case of the HCT semi-trailer combination of another permit holder, there were signs of wear in the drawbar and slack in the towing pin/fifth wheel.

3.5 Experiences of intelligent transport solutions

Several permit holders have developed or are developing various user interfaces for the drivers, which will gather information on disruptions, driving patterns, the weather etc. Driving patterns reveal the whereabouts of vehicles on the road and can warn of disruptions ahead, identifying suitable detours in advance.

All permit holders have some sort of camera system on their HCT combinations. Around half of the combinations have forward-facing cameras and some also have rear-facing ones. The image is saved automatically and, in the event - say - of an accident, the incident can be reviewed using the cameras. Some of the vehicles are participating in university research and their footage is reviewed systematically.

In many cases, the applications also store the previous day's data and working time information for drivers. One of the permit holders also aims to further investigate how the feeding of various kinds of information into the drivers' devices affects their driving styles.

3.6 Improvements for next winter

The permit holders are considering new equipment for next winter. They intend to try studded front tyres in overweight combinations operating in the north. In addition, frost protection will be added to sand applicators. Another operator is planning actual snow chains as on-road equipment, for improved grip when reversing semi-trailers from loading ramps or reversing a vehicle under the trailer.

A sand applicator for drive wheels is being planned for one of the HCT normal-weight combinations next year.

4. Wintertime fuel consumption of HCT transports

In winter, fuel consumption increases during cold and snowy weather. In slippery conditions, cruise control cannot be used for safety reasons, which also increases consumption. Rolling resistance on wet snow increases consumption and the snow adds to the weight of the combination. On slippery roads, a vehicle must also decelerate more

at junctions. This increases the energy consumption of heavy road transports in particular. In different road conditions, the difference in fuel consumption can be over 10 l/100 km.

In the case of retail goods, the fuel consumption of overweight HCT combinations per driven kilometre has been 14 % more during the winter than the summer, whereas the growth in consumption in the reference combination was 9 % and 12 %, i.e. the growth in consumption was slightly greater than in the case of the reference combination. In comparison to the reference combinations, during winter the HCT combinations consumed 3-4 litres/100 km more fuel than during the summer. Although the reason for this difference is unknown, HCT combinations are probably driven more carefully than the reference combinations, for example by braking while driving downhill.

The permit holder of a normal weight HCT combination reported that, during the winter, an HCT combination consumes around 1-3 litres/100 km more than a reference combination. This difference in consumption is rather small in summer road conditions. Another normal-weight HCT combination consumes 2 litres/100 km more in winter.

Only in the case of HCT semi-trailer combinations operating during the winter was fuel consumption in the same range or slightly lower (0-2%) than for the reference semi-trailer combination.

5. Research and development activities

5.1 Practicality of terms of permit exemptions

The separate coupling terms for the trailer specified in the registration certificate were regarded as irrelevant in situations involving an ordinary towing vehicle.

The several months taken to update routes drew criticism – permit holders feel that this leads to heavy costs and creates the impression that Trafi is not supportive of their R&D projects.

Trafi will develop its permits of exception on the basis of the feedback received. The terms and conditions were deliberately kept fairly strict for the first permits issued. Trafi has learned how to better serve its customers in the light of experience. In new permits, greater emphasis will be given to the responsibility of the transport operator.

5.2 Research activities of permit holders in 2016

HCT transports featured in a customer satisfaction survey of major customers performed by one of the permit holders, and drew a great deal of positive feedback. Almost no straightforwardly negative feedback was received. Respondents who praised HCT transports mentioned issues such as the reduction in the number of vehicles required for transportation, cost savings and positive publicity. Indecisive responses included a request for more detailed research data, the statement that HCT-transports were "OK" if they impose no additional burden on roads, and the view that the savings achieved with HCT transports might have been achieved through fuel and engineering solutions.

5.3 Metsäteho's studies

Metsäteho is engaged in and beginning a range of studies in collaboration with various parties:

- Tie- ja siltarastitus (Road and bridge stress), TTY & Roadscanners (Finnish Transport Agency), Aalto, OY

- Polttoaineen kulutus ja päästöt (Fuel consumption and emissions), Metsäteho, Thesis for UH
- Kuljetustehokkuus ja kuljetuskustannukset (Transport efficiency and costs), Metsäteho
- Terminaalien rooli HCT-logistiikassa (The role of terminals in HCT logistics), Metsäteho & LUT

Forthcoming

- Älyliikennetutkimus (Research on Smart Traffic Solutions) (part of the follow-up projects for the Forest Big Data project)
- HCT-kuljetuskäytävät (HCT transport corridors)
- Summaries of driver reports and possible interviews
- Summaries of research results and a national impact study on timber haulage

5.4

Universities

The University of Oulu is investigating the performance of HCT vehicles mainly engaged in transporting timber in the challenging conditions of northern Finland. This involves the investigation of driving behaviour, using various computer simulations and practical field measurements. The project also includes heavy-duty tyres, as well studies of road and bridge structures.

According to the results of simulations carried out during the winter, the optimisation of coupling dimensions is important, particularly in so-called challenging combination types (e.g. one or more centre-axle trailers). In the future, an attempt will be made to assess the effect on driving stability of the vertical force directed at the drawbar of a centre-axle trailer.

A measurement system was installed in a Ketosen Kuljetuksen HCT combination at the end of last year. Measurements suggest that the yaw rates of the HCT combination's semi-trailer during road transport are seldom greater than that of the towing vehicle. On the other hand, the yaw rates of the front drop axle and centre of gravity are often 3–4 times greater than that of a towing vehicle. Based on an initial analysis, it appears that the yaw rate increases by the same order of magnitude in the case of a 76 tonne reference combination on a road; and is even greater in some cases. In the case of HCT combinations with semi-trailers, lateral acceleration is increased by a factor of 1–2 and 1.5–3 times in the case of a full trailer, relative to the towing vehicle and depending on the measuring point and driving situation. However, during road driving the numerical values for accelerations and the yaw rates of vehicle units tend to be small.

Field trials were held at Ivalo Airport in March. In braking tests, the stopping distance for combinations within a speed range of 55–60 km/h was around 10 % longer than for a 76 tonne combination. In an acceleration test, a 76 tonne combination accelerated 56 % faster than an HCT combination. Acceleration is poorer in the case of an HCT combination because, while the number of drive axles and the engine power are the same, the weight is much greater. In winter conditions, the HCT combination's longer breaking distance compared to a normal combination is probably due to the road surface being polished by the first braking wheels, with the rearmost axles no longer achieving as much braking force in relation to the axle weight.

A conventional 76 tonne full trailer combination was driven with ease through a roundabout marked on a runway. An HCT combination only just managed to negotiate the roundabout, with the towing vehicle ploughing through the packed snow. The HCT combination had no problems at roundabouts in normal traffic, but careful attention must be paid to the choice of driving line during tight turns in winter conditions.

No comparison has been made of drawbars, because the results for smaller combinations have yet to come in.

The results for twin lane changes and changes of lane were incomplete for the winter because the packed snow on the runway had insufficient carrying capacity for large vehicle combinations.

Checks on winter tyres revealed less wear than expected on the tyres of the Ketosen combination. Tyres appear not to wear on a road covered in hard-packed snow, despite the accumulation of large numbers of kilometres. Tyre wear accelerated in the spring, with the outer edges of the right-hand tyres on the semi-trailer wearing most, probably due to normal rutting of the road.

Road and bridge stresses will be studied by determining and measuring the deformations in the road base caused by HCT combinations. The results will be compared to road stresses caused by regular vehicle combinations, with the purpose of drawing conclusions on road durability. Measurement of road stresses will begin during the summer of 2016. A suitable method is still being sought for the measurement of bridge stresses.

A master's thesis on the impact of HCT combinations on the traffic flow has been completed at **Aalto University**. In practice, this study was performed by filming the traffic behind, in front of and to the sides of each Ketosen combination hauling timber, using a total of three video cameras, before analysing the data thereby generated.

The Master's thesis will be published in Aalto University's Aaltodoc publication archive in June, where the entire thesis can be read thereafter.

Differences in the overtaking behaviour of vehicle combinations were found to be minor in the work undertaken for the thesis. HCT combination's needed slightly more time to overtake than reference combinations. In addition, HCT combinations needed slightly longer gaps in oncoming traffic in order to overtake. No significant difference in overtaking safety could be observed between the vehicle combinations. With respect to tailbacks, it was found that the average length of tailbacks behind the HCT combination was slightly greater than behind the reference combination. In addition, drivers were willing to drive longer distances without overtaking when behind an HCT vehicle combination.

In terms of the behaviour of vehicle combinations, it was observed that the speeds of the HCT vehicle combination were slightly lower than those of the reference combination. In addition, the longer-than-normal vehicle combination required more space at junctions and roundabouts than the reference combination, but still managed to operate without major problems at junctions on the route.

It should be noted that traffic volumes on the Ketosen Kuljetus routes were fairly low and a limited amount of material was analysed. The routes studied in future will be busier and more material will be analysed, enabling detailed conclusions to be drawn after the completion of the overall report.

At Aalto University, the analysis of material on other routes (Mikko Niskala Oy: Kempele-Vantaa and Orpe Kuljetus: Saimaan ympäristö) is under way. An overall report, giving the results for all routes included in the report, will be drawn up late in the year. The customer is the Finnish Transport Agency.

5.5 Finnish Transport Agency

Together with Roadscanners, Tampere University of Technology is engaged in a study commissioned by the Finnish Transport Agency using pore water pressure measurement to ascertain whether seven 13-axle vehicle combinations cause more road wear than 13 7-axle combinations. Although the preliminary results have already been obtained, more measurements will be made this summer in order to evaluate the differences on various subsoils.

Ramboll Oy has been commissioned by the Finnish Transport Agency to investigate the impact on road structures of the transportation of transformers; it will make rec-

ommendations on what soft soil characteristics should be investigated before transporting overloaded transformers on the road network. Some of the results can also be used when planning HCT routes for overweight vehicle combinations.

The Finnish Transport Agency will also embark on a comparison of tractive resistance in vehicle combinations, exploring how much fuel an HCT combination saves compared to a combination in line with the regulations and how much a single-wheeled trailer saves compared to a twin-wheeled trailer.

The results of all of the above-mentioned studies will be obtained in May 2017.

6. Conclusions

Overall, the HCT trials are still in their initial phase and the results are only indicative at this stage. Reporting is still being developed in order to better meet the requirements of the authorities in drawing final conclusions. In addition to studies performed by the permit holders, information will be obtained from several university-level studies *In the future, the variety of research activities should be both ensured and expanded to cover logistical operating concepts and guarantee the efficiency of the transport system.*

Loaded HCT combinations have so far proven to be stable, have functioned well on roads and are safe in traffic. HCT transport has been a success in winter too and the combinations have encountered no major problems. In the winter, most challenges have occurred when leaving terminals and yards in poor weather conditions. It is also clear that there is room for improvement in the use of devices and equipment intended for the winter period in particular. *Drivers of HCT combinations should be better trained in the use and characteristics of equipment and devices.*

As a result of traffic accidents in particular, several unexpected detours occurred during the winter. Most of the detours were suitable for HCT combinations. However, the traffic controllers did not always have sufficient insight as to whether the detour was suitable for HCT combinations. *In the future, immediate evaluation of the suitability of detours could be achieved through a range of digital solutions and the training and guidance of traffic controllers.*

HCT combinations were involved in a few incidents, but without serious repercussions. The fact that the HCT combinations were longer and/or heavier than usual had no impact on the situations. The drivers of the HCT combinations had behaved impeccably. *The traffic safety of HCT combinations will continue to be subject to careful scrutiny in the future.*

Stakeholders and the general public, both in Finland and internationally, are interested in HCT combinations. The authorities, students and researchers also obtain additional information on the project via the related publicity. The Finnish Transport Agency and Trafi are actively participating in international cooperation on HCT combinations. *The organisation of events such as HCT forums should be continued. The joint HCT steering group of Trafi and the Finnish Transport Agency also provides tips on thesis topics and on research themes for permit holders and universities.*

Improving logistical efficiency depends on the efficiency of the entire transport system. The operational concept of forest vehicles supplying timber to HCT combinations plays a fundamental role in the logistical efficiency of timber transports. On the other hand, terminal logistics is a huge factor in the overall efficiency of general cargo transports. *The gains achieved on the road can easily be lost during operations at the terminal.*

Increasing the length of the vehicles seems to improve transport efficiency more than increasing their weight. Preliminary limit values for length have been identified in or-

der to promote turnability. Some HCT combinations that are more than 30 metres long can negotiate their way through tight junctions almost as neatly as 25.25-metre combinations, while others need much more space. *Furthermore, increasing the vehicle length requires no major changes to the transport environment, thereby avoiding extra costs to society. It does, however, require sophisticated axle solutions in the trailers.*

Reducing fuel consumption per transported unit is more challenging in the transport of large weights than lightweight goods. If the transported number of units is doubled, and the transport is not overweight, an HCT combination has high energy efficiency. *The guidelines on the energy efficiency of HCT transports should be improved in order to facilitate systematic follow-up.*

In comparison to reference combinations, during winter HCT combinations consume 1-4 litres/100 km more fuel than during the summer. *However, the energy efficiency of HCT combinations tends to outstrip that of reference combinations at all times of the year, although the gap is smaller in winter.*