TRAFFIC SAFETY RISKS WITH
EU TRACTOR-SEMITRAILER RIGS ON SLIPPERY ROADS

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Abstract

Heavy goods vehicles (HGV) for long haulage within the EU Nordic countries have due to regional evolution mostly been straight trucks with drawbar trailers. In the past decade, there has been a significant increase in articulated EU tractor/semitrailer rigs within the Nordic countries, a trend driven by lower freight costs when using low paid drivers from Eastern Europe. Heavy trucks are often involved in crashes and traffic jams on ice-slippery winter roads. An ever-increasing number of voices are stating that the articulated vehicles present disproportionate high traffic safety risks on icy winter roads. This paper discusses some regulatory & design factors that partially explain why EU semitrailer rigs are particularly associated with jamming long steep icy upgrades, and with loss-of-control crashes such as jackknifing and trailer swing. A novel analysis was made with TruckSim software. Preliminary results support the opinion that EU semitrailer rigs are an unsafe vehicle combination on slippery roads. This finding calls for deeper research about the winter road safety risks with the EU tractor/semitrailer vehicle combination, as well as on how to mitigate its safety risks. Results from such research are likely to be useful arguments for modifying the EU directive 96/53/EC, so that tractor units with longer wheelbase can be used without conflict on trailer length and payload volume.

Keywords: Winter Road Condition, Road Slipperiness, Traffic Jamming, Upgrades, Loss-of-Control Crashes, Adverse Cambered Curves, Vehicle Dynamics, Commercial Motor Vehicle, Articulated Vehicle, Truck, Prime Mover, Tractor, Semitrailer, 5th Wheel Friction.

1. Background

By tradition, most heavy goods vehicles (HGV) for long haulage within the EU Nordic countries have been straight trucks with drawbar trailers. However, over the past decade there has been a significant increase in articulated EU tractor/semitrailer rigs in the Nordic countries. This is not solely due to increased trade with the rest of the EU, but also because this vehicle combination (frequently driven by low paid drivers from Eastern Europe) has taken over a significant proportion of domestic long haul traffic in the Nordics. The EU-semitrailer rigs are due to EU weight & dimension legislation characterized by very short tractor units, often without bogie axle. With 16.5 m length, the capacity is only 66 % of a traditional Nordic European Modular System (EMS) combination, see Figure 1. Hence, freight by EU semitrailer rigs leads to increased number of trucks on the road network. In many cases, these semitrailer rigs exhibit high friction forces in the articulation joint. Typical high articulation friction cases include tractor units where the 5th wheel lacks grease, or is lubricated with "summer grease" so the articulation joint stiffens in cold winter temperatures.

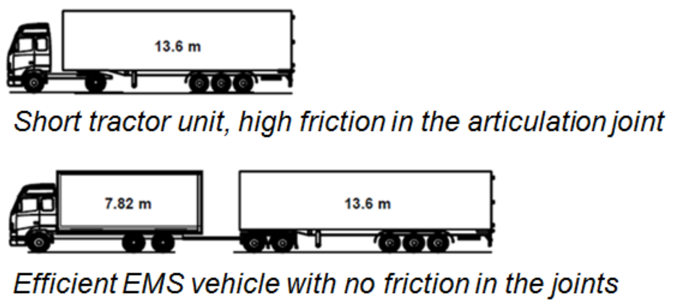

Figure 1 – EU Tractor/Semitrailer Rig vs EMS Truck with Drawbar Trailer

With the increased number of EU-semitrailers on Nordic roads, an ever-increasing number of voices states that articulated vehicles ("artic´s") create disproportionate traffic jams and safety risks on ice-slippery winter roads. Annually, at the first snow, hundreds of long haul vehicles fail to manage slippery uphill climbs. The problem continues over the whole winter season; summing up to thousands of traffic stops on narrow roads in Nordic countries.

Two types of problems have emerged, associated with EU-semitrailer rigs (Thomson, 2011):

- Long steep icy upgrades are often jammed, causing traffic delays and long redirections (as the EU Northern Periphery road network is sparse, detours may become several hundreds of km), as well as risk for queue end crashes. Read also Stølen (2016).

- Loss-of-control crashes, such as jackknifing and trailer swing. This type of crashes typically happens at high speed on normally good roads, but during winter conditions contaminated by snow slush or an icy surface.

Furthermore, semitrailer rigs have been identified as an unusually frequent HGV type involved in rollover crashes (92 % in Norway, and over 50 % in Volvo´s database over fatal crashes), see Granlund (2016). However, <u>primary</u>* rollover crashes on the pavement are normally occurring on high friction surfaces. They are therefore out-of-scope for this paper. **Not to be confused with skidding, followed by <u>secondary</u> trip-and-fall rollover at curbs etc.*

2. Research Objective and Aim of the Paper

A loose network is growing in the Nordic countries, with the objective of finding out if it is correct that EU-semitrailers create disproportionate traffic jams and safety risks on slippery roads, and if so then facilitate consensus on whether or not these articulated vehicles are suitable for "outdoor use during wintertime" in the Nordic countries with large low volume road network in sparsely populated remote areas. This paper aims to present the problem, from background to on-going work.

The crash frequency for various HGV types should, if possible, be normalized to the unit "payload tonnes * km". This makes it possible to evaluate the safety risk for complete transport tasks and the aggregated problem on the entire road network, rather than only focusing at a single truck itself as measured by the blunt unit "crashes per vehicle * km".

Furthermore, if the problems are confirmed disproportionate between traditional Nordic straight trucks with drawbar trailers and the EU artic´s, yet an aim is to identify feasible actions to reduce the problems with the artic´s.

Since both types of vehicle combinations currently are in use in the Nordic countries, it should be possible to find out the actual risk-relationship between them.

Admittedly, the driving skills are of great importance to avoid crashes on slippery road conditions, including also influence from vehicle maintenance and tire properties on cold icy roads. However, this work is limited to only deal with technical issues that are likely to explain if and why the EU-semitrailer rig is less able to cope with winter conditions.

2.1 Research Approaches

After a period of novel mapping knowledge on safety risks with semitrailer rigs on slippery roads, various Nordic stakeholders were invited to present facts and to discuss the topic at a seminar in Sweden. The stakeholders ranged from insurance companies, road agencies, tow truck operators, logistic experts, experienced HGV-drivers, safety researchers, heavy vehicle dynamics researchers, truck tire experts, politicians, hauliers and consultants to transport legislators.

After the Nordic seminar, the TruckSim® software was used for novel tests of double lane changes with a semitrailer rig on slippery road surface.

3. Results and Conclusions

3.1 Outcome from the Nordic Seminar

A wrap up of the seminar on safety risks with semitrailer rigs on slippery roads is available on the website of the Nordic Road Association (NVF).

Based on the following results, the overall conclusion was a confirmation that EU-semitrailers do bring disproportionate risks for traffic jams and safety risks on slippery roads, during winter season in Nordic countries. An illustrating video "Foreign Truckers on Norwegian Snow" is available in YouTube.

EU-Semitrailers are Overrepresented in Roadside Assistance Statistics

In the project "R&D in Towing" in Norway, selected roadside assistance personnel from the company Falck (an international vehicle recovery operator) are collecting records of recovery actions involving positions and reports to the Norwegian Public Roads Administration. The goal is to identify the places and routes where crashes and other incidents often occur. Between 1 Jan 2013 and 11 Nov 2015, 3 410 incidents involving HGV´s were registered. 747 of these, i.e. 22 %, were foreign HGV´s and mostly EU-semitrailers. Of 1 781 incidents in slippery gradients where HGV´s developed wheel spin until they stopped or the engine stalled, foreign HGV´s caused 590 (33 %). Since foreign HGV´s stands for only about 6 % of domestic HGV-traffic in Norway, the mentioned incident rates implies that EU-semitrailers are overrepresented and are in fact at multiplied risk for needing recovery aid.

Data from the Swedish company Assistancekåren confirm the picture given by Falck Norway. The Swedish data also show that the number of loss-of-control crashes among heavy vehicles increases two- to threefold, when comparing summer and winter seasons.

The findings in roadside assistance statistics confirm that EU-trailers are much more often in need for recovery aid at slippery upgrades, as they are prone to fail managing slippery upgrades. The EU-semitrailer rig therefore cause more traffic jams to the vehicles following behind, and thus add risk of queue end crashes during the winter.

EU-Semitrailers Multiplies the Risk for Crashes with Human Injuries

The Norwegian project SAFE Foreign Transportation investigates the impact on crash risk among foreign operators in the transport of goods, aiming to provide knowledge useful for implementation of effective prevention of crashes, see Nævestad et al (2014).

While Scandinavian trucks show a modest difference in crash rates between summer and winter, non-Scandinavian trucks exhibits a significantly increased proportion of crashes during the winter season.

The crash rate also differs between parts of the country. The Southern and Eastern parts of Norway have less mountainous roads and thus less risky roads than Western and Northern Norway. Scandinavian HGV´s show a rate of 0.30 crashes per million vehicle * km in the southeast, increasing to 0.38 in the North & West; corresponding to +27 % on the most dangerous road network. This compares with non-Scandinavian HGV´s that have 0.63 crashes per million vehicle * km in the Southeast, but in the North and the West as much as 1.23 (doubled rate). At the bottom line, EU-trailers exhibit more than three times higher rate for human injuries than the Scandinavian HGV´s on the risky road networks in Western Norway and in the North.

Bálint et al (2013) studied crash frequency on Swedish highways as function of HGV length. The results show that HGV combinations with length between 12 and 18.75 m (including 16.5 m long EU semitrailer rigs) have 27 % higher crash rate per km, compared to HGV combinations with length over 18.75 m (including traditional Nordic style rigid trucks with drawbar trailers). If crash rate would have been normalized to work done (crash rate per ton * km), the difference would have been enhanced.

The EU-Semitrailer Rig Design Principle Increases Crash Risk on Slippery Roads

A series of recent tragic crashes have been linked to the design of the EU-semitrailer rig itself; a short two-axle tractor unit with a 5^{th} wheel coupling transferring high friction forces. These include the largest fatal mass collision in Sweden (jackknifing on the E4 Bridge in Tranarp) and an infamous fatal trailer swing collision at Hw 50 north of Örebro. A number of examples were given of highway crashes where semitrailer rigs have "rocketed" across the central median and its flimsy wire rope safety barrier, after which the rigs run into oncoming high-speed traffic. The Police reported on artic´s being repeatedly (sic!) ditched in less than 10 km intervals on slippery freeways, while trucks with drawbar trailers faced no problem.

Previous studies such as Woodrooffe & El-Gindy (1990) have highlighted the influence of tractor wheelbase, tandem-axle spread and 5th wheel offset. However, little or no focus has been given to the friction forces transferred through the 5th wheel, as well as on operating on ice-slippery road conditions. Longer tractors deliver more stable rigs. Very important on slippery road surfaces, a long tractor also gives the front wheels a greater opportunity to outbalance the 5th wheel friction forces. Furthermore, longer trucks make it more interesting to equip the tractor with a bogie axle. By temporarily lifting the tractor bogie axle of a laden rig, the weight on the drive wheels is increased and the ability to climb slippery upgrades is improved. Axle lift on icy stiff frozen pavements at upgrades has been practiced by Scandinavian HGV drivers for many decades. Another solution could be twin drive axles, but twin drive adds costs for the second driven axle, for tire scrubbing and for increased fuel consumption while also decreasing payload capacity due to increased dead weight, and increasing CO_2 emissions. Tandem axle lift was invented by Finnish Vanaja in 1957 and is nowadays available on new Volvo trucks. Another measure is to reduce the friction in the coupling between the tractor and trailer by mounting the kingpin on a turntable. A further measure to improve road safety for roads with thick snow slush is to require a device that dampens the pitching motion of the prime mover. This is basically done by installing a shock absorber between the tractor frame and its 5th wheel, in order to keep the steer tires in better contact with the slushy road.

A possible action to reduce the tendency of instability among EU-trailer rigs is to modify the regulations in EU directive 96/53/EC for truck dimensions. The tractor units' distance between steering axle and drive axle (or tandem axle centre) should be possible to increase, without reducing the trailer's length and volume for payload.

As reported by Freund (2010), US Commercial Motor Vehicle (CMV) regulations have proven successful in terms of improved safety, and could serve as inspiration to future improvement of the EU directives on HGV mass and dimensions:

"*The 1982 Surface Transportation Assistance Act formed the basis for Federal regulation of CMV dimensions. Among other things, this Act changed the law from regulating maximum vehicle length to regulating the length of the trailers. Because it was no longer necessary to limit the length of truck-tractors, the predominant tractor configuration shifted from the short-wheelbase cab-over-engine type to the conventional engine ahead of the cab type.*"

Computer Simulations and Experiments on Proving Ground Test Track

Previous simulations and tests on roads with high road friction have demonstrated good stability of the EU-semitrailer rigs. However, their performance on roads with low friction has not been analysed properly. Hence, there is a need for such computer simulations in order to increase the understanding for the EU-semitrailer rig and to identify possible technical solutions for prevention of incidents on slippery roads. Such simulations should take into account:

- Friction in the 5th wheel and its influence when driving on slippery roads.
- Various road friction conditions, particularly slippery winter conditions.

- Various tire and payload circumstances, such as type of load, load weight, tire pressure, centre of gravity position, etc.
- Braking while making various manoeuvres, such as when trying to avoid a crash.

Similarly, there is a need for full-scale real world comparative tests on a proving ground test track, between EU-semitrailer rigs and the reference conventional Nordic straight trucks with drawbar trailers.

High Road Friction is of Outmost Importance

A comprehensive study have been made of climbing performance by semitrailer rigs and straight trucks with drawbar trailers in a 600 m long and 7.2% steep slippery upgrade in Norway, see Vaa (2015). The tests included a handful of HGV´s with varying horsepower & torque, different drive tires (including hard "plastic tires" with low grip on ice and snow) and various payload weights. The tests were conducted with and without bogie axle lift for increased weight on the drive wheels, as well as with and without snow chains. The researchers periodically measured road friction during the trials, and regulated the road friction by watering and compaction of the snow slush. The results confirmed the old opinion that the weight on the drive wheels is of outmost importance. It is advantageous to temporarily, with the bogie axle lift, increase drive axle load beyond normal maximum 10, or 11.5 tonnes. Axle lift should be carried out proactive, while at reasonably high speed above 30 km/h, in order to be efficient against getting stuck in the upgrade. In addition, the drive tires greatly affect the HGV´s hill climbing performance. Drive tires made of hard rubber, so-called "plastic tires" makes it difficult to get started after having stalled in a slippery upgrade. At road friction coefficients above 0.25, also trailers with plastic tires managed to climb the severe upgrade. This is a very interesting result, since 0.25 is the lowest allowed road friction after a winter weather event, both in Norway and in Sweden. If the road is more slippery than 0.25 when the road service response time expired, then the road contractor has not delivered the ordered ploughing and gritting or de-icing road service works properly. See *Standardbeskrivning för Basunderhåll Väg* (2014).

3.2 Outcome from Simulations of a Semitrailer Rig on Slippery Road

Using the TruckSim® software, novel simulations were made of the double lane change maneuver with a semitrailer rig on slippery road.

Despite most HGV´s are operated with a payload, Rutherford (2015) states that "*Most jack-knifing incidences involve an empty or nearly empty trailer*". Hence the simulations were made with the trailer both in laden and unladen condition. Simulations were made at steady speed; no braking was applied. The 5th wheel friction was set to 0 and tire was inflated to normal pressure for full payload, regardless of unladen or laden trailer.

In Sweden, bare asphalt must provide wet road friction higher than $\mu = 0.5$. (Norway accepts lower wet friction on minor roads). The highest legal speed limit for HGV´s with trailers on Nordic public roads is 80 km/h. The results for double lane change at 80 km/h on a road surface providing $\mu = 0.5$ confirmed stable maneuvering, both with laden and unladen trailer.

In Sweden and Norway, winter roads must be kept in such condition that road friction is not lower than $\mu = 0.25$ after the gritting response time (up to 6 hours, depending on road class) is exceeded. The results for double lane change a road surface providing approved $\mu = 0.25$

showed that in laden condition, jackknifing occurred at 68 km/h. In unladen condition, jackknifing occurred at 61 km/h. These results support the opinion that EU semitrailer rigs are an unsafe vehicle combination on slippery roads. The results also support Rutherford´s statement above; that an unladen trailer is significantly more prone to jackknife than a loaded trailer is. Maybe this difference in safety between unladen and loaded trailer can be eliminated or at least reduced, by reducing the tire pressure when the trailer is unladen and thereby increasing the length of the tire footprint?

A screenshot of unladen rig at 67 km/h on approved winter road slipperiness $\mu = 0.25$ is showed in Figure 2. As seen, the rig is unable to keep the target path (marked with a line between cones), jackknifes and ends up many meters beside the target path.

During the road contractors response time for gritting and/or deicing, a period of up to 6 hours on certain public roads in Nordic countries, the road friction may go down below $\mu = 0.25$. Two of the most fatal conditions are wet thin ice on the asphalt, or when the deicing road salt re-freezes at very cold temperatures. During these conditions road friction may reach down to $\mu = 0.10$, or even drop further. Simulations showed that on road friction $\mu = 0.10$, dual lane change with the semitrailer rig results in jackknifing at about 24 km/h both in unladen and laden condition.

Figure 2 – Semitrailer Rig Jackknifes on Approved Winter Road Slipperiness; μ = 0.25

The results underline the outmost importance of proper road friction by good road service. Unfortunately, it seem unrealistic to expect dramatic improvement of the expensive deicing and gritting services on the large road networks in the sparsely populated Nordic countries. Simulations could be done with iteratively varied road friction, in order to identify lowest road friction that is sufficient for safe operation with EU-semitrailer rigs with short 2-axled tractor units.

4. Future Work

The seminar in Sweden was well covered by trucking media in the Nordic countries. Hopefully, there will be an R&D project co-sponsored between authorities in several Nordic countries. Such a project should ideally include three tasks; in-depth statistical analysis, computer simulations, as well as full-scale tests. These three tasks are described below.

In discussions following the Nordic seminar, some additional activities were drafted:

- Improve control measurements of winter road friction before and after ploughing, gritting and deicing.
- Inform drivers and stakeholders about the key importance of spreading the payload within the vehicle to create a suitable weight distribution (high load on drive tires, etc.).
- Formalize the Norwegian practice implemented in the winter 2015/2016, where EU-semitrailers with short 2-axled tractor units are banned from driving until the icy road is gritted or deiced. Implement similar practice in Sweden and Finland too.

4.1 In-Depth Statistical Analysis

Up until the Nordic seminar, governmental crash databases have been unable to distinguish between articulated vehicles and traditional Nordic HGV combinations. After fixing this data logging deficiency, it will be possible to compare the safety performance in detail between EU-semitrailer rigs and traditional Nordic HGV-combinations for long distance haulage. Such analysis can strengthen the statement that EU-semitrailer rigs do not perform with acceptable traffic safety on ice-slippery (and in many cases low traffic volume) roads in the Nordics.

Hassall et al (2014) reports data from Australia, revealing that short artic´s had 29.0 serious or major truck crashes per 100 million km, while rigid High Productivity Vehicles (truck and dog, fairly similar to the Nordic HGV´s) had only 6.6 per 100 million km. This shows that short artic´s created 239 % higher risk for serious or major crashes, already without icy roads.

4.2 Computer Simulations

Results from the novel simulations made so far, supports the opinion that the EU-semitrailer rig is not an optimal design for outdoor operation on Nordic roads during winter time.

The EU-type of tractor-semitrailer combination consist of a short two-axle tractor of only 7 tonnes weight, and a 33 tonnes heavy semitrailer on a triple-axle configuration. The tractor carries legally 11 tonnes of "articulated load" from the semitrailer. Question is how well the light short tractor is capable to handle the 33 tonnes coming behind it? The total length of the EU-semitrailer rig is limited to 16.5 m, which together with other dimension limitations gives a maximum length for the semitrailer of 13.6 m. These dimension restrictions do not allow for long tractors without sacrificing load capacity.

Additional computer simulations should include different HGV configurations, for example, short two-axle tractors and, beyond current EU-concept, longer triple-axle tractors. The simulations should also include comparisons between the semitrailer rigs (with high friction in the vehicle´s articulated joint) versus traditional Nordic HGV-combinations on low friction surfaces. Results from such simulations should be relevant input when drafting recommendations on improved HGV dimension regulations for safer winter operation in the Nordic countries. Simulations should also be done with iteratively varied road friction, in order to identify lowest road friction that is sufficient for safe operation with EU-semitrailer rigs with short 2-axled tractor units. Furthermore, simulations should be made to investigate difference in jackknifing speed when the unloaded trailer has normal (full) tire pressure and when it has reduced tire pressure.

For a typical EU-tractor, the distance from the steering axle to the 5th wheel is about 3.0 meter. Provisional computations show that an extension of this measure with 1.0 meter may reduce the need of road friction at the front wheels to outbalance the 5th wheel friction forces by as much as 30 %. A reasonable expectation is therefore that longer EU-tractors would significantly improve the safety on ice-slippery Nordic roads.

4.3 Full-Scale Tests

Full-scale tests are important for checking validity of simulation tests against reality.

An example of need for validation is whether the simulation model is relevant for instability risk in a split friction condition, where one of the front tires gets into a string of thick snow slush. This is a rather common condition in situations where an HGV is overtaking another HGV using the sparsely trafficked overtaking lane on Nordic freeways. The situation is illustrated in Figure 3 and Figure 4. Since left wheel is exposed to transient snow slush forces, while right wheel is not affected, the vehicle may fling into the weak wire rope passenger car crash barrier and in worst case end up in the oncoming lanes. Such crashes of course have extremely high potential for fatalities. A photo from such a situation is showed in Figure 5.

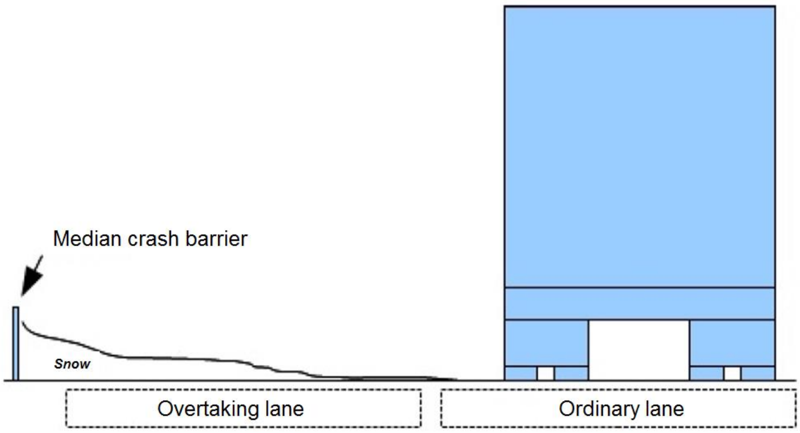

Figure 3 – Nordic Freeway Overtaking Lanes Often Provide Split Friction

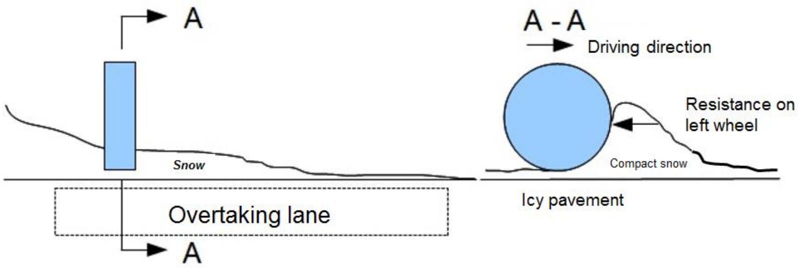

Figure 4 – Slush Forces Acting on the Left Wheel (Left: Rear View. Right: Side View)

Figure 5 – A EU-Semitrailer Rig Being Towed After Ending in Oncoming Freeway Lane

4.4 Improving Regulations for Vehicle Dimensions for Safety Reasons

Assuming that both comprehensive simulation and reality tests confirms that longer tractor units reduce the risk of instability crashes at highway speed, there remains lobbying work to convince decision makers that vehicle dimension regulations should be more flexible and improved to not hamper implementation of longer tractors. This means increasing permitted truck-tractor length without changing trailer and payload length.

The US *Surface Transportation Assistance Act* is reported by Freund (2010) as successful in shifting the predominant truck-tractor from less safe short-wheelbase cab-over-engine type to the longer and more directional-stable engine ahead of the cab type. This Act could therefore serve as inspiration to improvement to dimension regulations such as in directive 96/53/EC.

Increasing the tractor length - without reduced payload - may have some other advantages than the traction and stability on slippery roads. The 96/53/EC directive was recently revised. The amendments in EU directive 2015/719 opens the door to a slight tractor length increase (a couple of decimetres) for crash safety and aerodynamic improvements. There are also some low-speed disadvantages of increasing the tractor length: minor issues on saturated parking lots, more trouble in urban areas, in narrow curves, etc. Public parking stalls for trucks in in EU are designed for at least 18.75 m long truck and drawbar trailers. Therefore an increase in truck-tractor length by up to 2.25 m (from 16.5 m to 18.75 m rig length) is no problem. Another issue is the fee for occupied area on ferries. However, in the best of worlds, the tractor semitrailer system should be used as it was meant to in the beginning; just the semitrailer should be shipped, not the truck-tractor.

Norway has some of Europe´s most narrow curves, also at very steep grades. Norway also has a long experience of using longer truck-tractor units, since they allow 1 m longer semitrailer rigs (17.5 m) than the EU directive does (16.5 m), see Lovdata (1990). A general opinion among Norwegian stakeholders is that the longer tractors (typically with bogie axle) are superior with respect to traction at upgrades (due to temporary axle lift) as well as stability (risk for jackknifing or trailer swing), compared to less safe EU standard length tractors. The common opinion in Norway is that shorter EU-semitrailer rigs should be totally banned during the winter season, as illustrated by Stølen (2016).

Formal discussions regarding mountainous roads have so far not involved Alpine countries Austria, France, Italy and Switzerland. However, these countries lacks benchmark in stability benefits from 24+ m Nordic style rigid truck with drawbar trailers, since the Alpine countries does not allow longer than the EU standard 18.75 m for truck with drawbar trailers.

Slippery road conditions (wet, low friction coefficient due to the pavement polishing, etc.) occur more or less in all EU member states. The combined extent of the problem in terms of length of road in slippery condition, half-year duration of winter slipperiness, extremely low road friction during up to 6 hours long road service response time allowed up North, severe road roughness and adverse cambered curves (where the need for friction increase), makes the situation on Nordic road networks during winter season quite worse than in central Europe.

4.5 Restricted Operation of EU-Semitrailer Rigs on Nordic Roads in the Winter Season

Besides improving vehicle dimension regulations, another option is to issue restrictions against operating EU-semitrailer combinations with short 2-axle tractor units in the Nordic countries during the winter season. Temporary restrictions for EU 16.5 m articulated vehicles have been implemented in Norway since the winter 2015/2016, during the most slippery road conditions. See tweet from the Norwegian Public Roads Administration (NPRA) in Figure 6:

“*Due to unsafe road condition in lanes South-bound for Oslo on the E6 freeway, particularly in Djupdalen valley, semitrailers with short two-axled truck-tractors are prohibited to pass the traffic control station at Jessheim until gritting is finished at 11 o´clock.*”

Figure 6 – NPRA on Restriction against 2-axled Tractor Units at the E6 Freeway

It is recommended to use 3-axled truck-tractor units when entering the Nordic countries during the winter season.

Much effort are now being made on implementing autonomous HGV´s. Research should be done to answer the question “Should autonomous HGV´s - such as based on EU-semitrailer rigs - be prohibited to operate on ice-slippery Nordic winter roads?”

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