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Report

Task force on the winter performance of composite brake blocks

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Contents

1. Executive summary

The last revision of the NOI TSI mandates the European Commission to issue by 30th June 2020 a report regarding operations with wagons equipped with composite brake blocks in Nordic winter conditions, based on an evidence gathered by ERA, national safety authorities and rail companies. The report shall be made public and based on evidence gathered by ERA.

This report is intended to provide the evidence requested above on the following points:

- Safety and braking performance of wagons fitted with composite brake blocks
- Existing or potential operational and technical measures applicable in Nordic winter conditions
- Impact assessment of the measures above

In order to draft this report, ERA set out a task force composed of the representatives of Nordic safety authorities, Nordic railway sector representatives plus representatives from CER, EIM, FEMFM, UIC, UIP, UNIFE and other national safety authorities.

The data collection process concerning brake performance of composite brake blocks especially under winter conditions was based on questionnaires on safety occurrences of loss of braking performance in freight wagons. A first questionnaire with a wider scope (composite brake blocks + cast-iron brake blocks all seasons) was sent to all national safety authorities and a second one with a very specific scope limited to winter conditions was sent to the Nordic national safety authorities. As another evidence, test reports from UIC, NSA FI and NSA SE were considered. NSA SE and the Nordic railway sector provided data input for the impact assessment, especially for the baseline scenario and costs related to braking systems.

ERA was not able to validate these data. However, the data were available to all task force participants and discussed.

In addition, specific data from the impact assessment of the revised NOI TSI were used.

At this stage it can only be concluded that occurrences related to winter performance of composite brake blocks happened in Finland, Norway and Sweden and not in other Member States.

A complex interplay of, among other factors, meteorological conditions (temperature, snow and humidity), type of composite brake block, type of bogie, loading conditions, other brake equipment and required braking performance and specific operating conditions jeopardises the performance of composite brake blocks in the countries above during winter.

Further testing is foreseen in order to provide additional insight regarding this preliminary conclusion. This testing should include new composite brake block types currently under development, additional technical solutions reinforcing composite brake blocks such as LAW-B and operational procedures. These tests should be performed under harder winter conditions.

In addition, the increased risk resulting from the operation of freight wagons with composite brake blocks in Sweden is currently being analysed by NSA SE in more detail.

The impact assessment analysed 4 options and retained two options which can be combined to mitigate the problem of reduced brake performance.

The retained options consist of a temporary exclusion of freight wagons for a specific time window (option 4 of the impact assessment) and in combination with another option (option 1 of the impact assessment) to create a specific pool of silent disc braked wagons which could operate in Sweden under winter conditions as well.

Concerning the option on exclusion of freight wagons, some aspects require further clarification, such as the amount of wagons needed for international transport to Nordic countries, criteria for wagons to obtain an exemption and mechanisms of control and enforcement. If such exclusion applies for a period until 8th December 2024, then it would be conforming to existing EU legislation. In this timeframe, option 1 would

need to be implemented in order to create the sufficient pool of freight wagons being able to operate under Nordic winter conditions.

However as some important information such as results from a risk analysis and from tests in harder winter conditions is currently not yet available, it is impossible to draw final conclusions.

As long as the results from further testing are not available, these two identified options can be considered as preliminary preferred options.

Current operational measures might be further optimised, such that the economic impact of the baseline might be reduced.

If the technical feasibility of LAW-B or other types of composite brake blocks is confirmed by additional testing, the other options of the impact assessment could become reasonable options as well.

Therefore, ERA recommends to update this report including its impact assessment once the additional necessary evidence is gathered.

2. Introduction

2.1. Background to the assignment

Commission Implementing Regulation (EU) 2019/774 of 16 May 2019 amending Regulation (EU) No 1304/2014 as regards application of the technical specification for interoperability relating to the subsystem ‘rolling stock — noise’ to the existing freight wagons gives a task to the European Commission to issue by 30th June 2020 a report regarding operations with wagons equipped with composite brake blocks in Nordic winter conditions, based on an evidence gathered by ERA, national safety authorities and rail companies:

‘Article 1

Regulation (EU) No 1304/2014 is amended as follows:

[...]

(3) The following Articles 5a, 5b, 5c, 5d, 5e are inserted:

[...]

Article 5e

By 30 June 2020, the Commission shall issue a report regarding operations with wagons equipped with composite brake blocks in Nordic winter conditions, based on evidence gathered by the Agency, national safety authorities and rail companies. In particular, this report shall contain an assessment of the safety and braking performance of such wagons and existing or potential operational and technical measures applicable in Nordic winter conditions. The report shall be made public.

If the report provides evidence that the use of such wagons in Nordic winter conditions poses safety issues that cannot be addressed by operational and technical measures without severe adverse impact on rail freight operations, the Commission shall propose amendments to this TSI to address those issues while preserving cross border freight traffic to and from affected Nordic regions. In particular, the proposal may if necessary include an exemption permitting the continued operation on quieter routes throughout the Union of a limited number of wagons used frequently in such cross border freight traffic, and any operational restrictions appropriate to limit the impact of the use of such wagons on quieter routes, which are compatible with the purpose of preserving the above-mentioned cross-border freight traffic.

If the revision set out in the paragraph above takes place, the Commission shall report annually thereafter on the progress on technical and operational solutions for the operation of freight wagons in winter conditions. It shall provide an estimation of the number of wagons equipped with cast iron brake blocks necessary to *ensure continued cross border traffic to and from such Nordic regions, with a view to ending the exemption in 2028 at the latest.'*

Recital (10) of Commission Implementing Regulation (EU) 2019/774 explains this addition of Article 5e in the NOI TSI:

'(10) Given the concerns raised by some stakeholders related to the operations of wagons equipped with composite brake blocks in Nordic winter conditions, the Commission, assisted by the Agency, should continue to analyse the issues and possible solutions. It should assess by June 2020 whether an amendment to this TSI is necessary, possibly in form of an exemption allowing the continued operation of limited numbers of wagons with cast iron brake blocks on quieter routes, to preserve cross border rail freight traffic to and from affected Nordic regions. According to the estimates of the Swedish authorities the number of wagons used in such a traffic does in total not exceed 17 500.'

Consequently, the objective of the task force on the winter performance of composite brake blocks is to draft a **report** for the European Commission gathering evidence on the following points of Article 5e of the amended NOI TSI:

- **Safety and braking performance of wagons fitted with composite brake blocks**
- **Existing or potential operational and technical measures applicable in Nordic winter conditions**
- **Impact assessment of the measures above**

2.2. Contents of the report

This report is the deliverable of the task force on the winter performance of composite brake blocks.

As far as the content of the report is concerned, it details the composition of the task force and focuses on the topics dealt with during the task force meetings. It lists the conclusions reached when discussing these topics and also the positions of the task force representatives on the most important ones.

3. Workgroups

3.1. Composition of the task force

ERA sent invitation to participate to the task force on the winter performance of composite brake blocks to the national safety authorities of Denmark, Finland, Germany, the Netherlands, Norway and Sweden and representative bodies, which are potentially affected by the issues with composite brake blocks in Nordic winter conditions. From other organisations, ASTOC, FEMFM and UIC were also invited to participate given their area of expertise and interest. Based on this invitation, ERA received nominations from the interested stakeholders.

The European Commission participated to all meetings of the task force.

In November 2019, ERA sent an additional invitation to the other national safety authorities proposing 2 levels of participation:

- **Basic participation**: Enabling access to the task force workspace, without direct participation to the task force meetings
- **Full participation**: Getting access to the task force workspace and participation to the task force meetings

The national safety authorities of Poland, Slovenia, Switzerland and Romania accepted this second invitation, either as basic or full participants.

Five task force meetings were organised, to which participants of the organisations listed above participated.

3.2. Task force meetings participation

The table 1 below summarises the attendance of the national safety authorities, representative bodies and other organisations, which replied to the ERA's invitation and nominated their representatives to the task force for full participation in the task force.

Table 1: Task force meetings participants

Organisation	*Kick-off meeting 29/05/2019*	*Meeting N°2 10/09/2019*	*Meeting N°3 29-30/01/2020*	*Meeting N°4 24-25/03/2020*	*Meeting N°5 07-08/05/2020*
ASTOC	Y	Y	Y	Y	Y
CER	Y	Y	Y	Y	Y
EIM	Y	Y	Y	Y	Y
FEMFM	Y	Y	Y	Y	Y
NSA DE	Y		Y	Y	Y
NSA DK	Y		Y	Y	Y
NSA FI	Y	Y	Y	Y	Y
NSA NL	Y	Y	Y	Y	Y
NSA NO	Y	Y	Y	Y	Y
NSA PL					
NSA SE	Y	Y	Y	Y	Y
UIC	Y	Y	Y	Y	Y
UIP		Y	Y	Y	Y
UNIFE			Y	Y	Y

4. Working methods

Extranet workspace of the project was established at:

https://extranet.era.europa.eu/TFCBB/SitePages/Home.aspx.

This workspace gathers all documents of the project and is accessible to task force members and their deputies as well as to all experts involved in other working parties organised by ERA.

5. Technical scope

The technical scope of this report is limited to the analysis of safety occurrences, which ended up in longer braking distances in freight trains fitted with composite brake blocks. Other occurrences having the same effects (e.g. distributor valve, human mistakes) are excluded from this report.

6. Winter and operation conditions in Finland, Norway and Sweden

Winter conditions are defined in this report as the prevailing meteorological conditions of Finland, Norway and Sweden during winter. See chapters 9.3.2, 9.4.2 and 9.2.5 of this report for more information on the winter in Finland, Norway and Sweden, respectively.

Specific operation conditions in the network of Nordic countries are also described where relevant. Swedish operation conditions are available in chapter 9.2 of this report. Norwegian operating conditions are available in chapter 9.4.3 of this report.

7. Geographical scope

The geographical scope of this report is limited to Finland, Norway and Sweden.

8. History of the homologation process of composite brake blocks

The development and homologation process of composite brake blocks was done by UIC in collaboration with relevant European railway companies. The process started at the end of the 90s.

During these processes the brake performance of composite brake blocks under winter conditions has always been an important field of investigation, next to all other aspects that needed to be investigated to ensure the composite brake blocks would suit all European conditions under which they should be able to operate (compatibility with track circuits, brake performance under long descends, running with locked brakes, impact on wheel wear and running dynamics, etc.) Because specific knowledge and field testing facilities were needed to investigate the behaviour of composite brake blocks under winter conditions, a specific working group on winter conditions was composed, in which also railway operators from the Scandinavian countries played an important role.

The first milestone that was achieved was the realisation of the system homologation of K composite brake blocks in 2004. The homologation was based on the relevant conclusions laid down in **B126 / RP33, use of composite brake blocks in freight wagons / summary report K-blocks, 2004, on the winter braking properties:**

- Proof has been furnished that it is possible to achieve satisfactory braking properties under winter conditions with organic composite brake blocks (Cosid 810).
- As part of the further development of existing organic composite brake block types (Becorit 929-1 and Jurid 816), which have so far shown unsatisfactory results, promising further developments were presented by the manufacturers and tested in the climate test chamber of RTA in Wien in March 2003 with positive results (Becorit 929-1SG and Jurid 816W). Current note: for other reasons, both composite brake blocks have not reached final approval.
- Tested sintered materials show a behaviour similar to cast-iron brake blocks, so that no problems under winter conditions are to be expected with this material.
- It is proposed that until the completion of a test bench program in UIC MB 541-4, which allows the winter properties of a friction material to be assessed qualitatively, proof of the winter braking properties in the field test or in the climatic chamber must be demonstrated for the UIC approval of a new friction material. The results are to be submitted to the UIC-UA 'Brake system' for the final approval of the new variety as 'Test report winter properties'.
- In any case, when using composite brake blocks, make sure that the operational recommendations for winter operation in UIC leaflets 410 and 421 are observed and applied.

Based on these conclusions, the K composite brake block type Cosid 810 was the first brake block that was homologated for application in the whole European usage area, including the Scandinavian countries.

Meanwhile the UIC continued working on further homologation of other K composite brake block types, the system homologation of LL composite brake blocks and further development of the requirements for winter conditions. A test bench programme for composite brake blocks under winter conditions was set up that enabled testing of winter properties on a climatic test bench. The programme was validated by track tests and included in the UIC leaflets.

The next milestone was the publication of **UIC B126 RP 36, synthesis report LL-blocks**, which was meant to be the basis for the system homologation. On specific winter properties of LL composite brake blocks this report concluded:

- Annex G of UIC leaflet 541-4 describes the test run for the demonstration of winter braking properties. The tests are performed on any desired motive power unit, maximum speed ≥ 120 km/h with brakes switched off and 5 wagons of identical construction with the same equipment in terms of bogie type, brake equipment, brake block configuration and design and type of brake blocks. Concentrating on certain main points, previous experience is based upon K brake blocks because these have a greater significance due to the lower application forces in comparison with those of LL brake blocks.
- In January 2008 test runs with the organically bonded IB 116* brake block were performed by Green Cargo. Changes in braking distance under winter conditions of 0.5 % to -1.5 % were detected in comparison to the reference tests. The bench tests performed using the test program developed in the winter working group exhibited a good correlation (deviation of -1.4 % to -12.7 %) to the results of the test runs. UIC produced the corresponding test report UIC B 126/DT 435.
- The sintered LL C952 brake block was tested in these tests and grey cast-iron brake blocks were tested for comparison. Based upon the field tests, it was possible to demonstrate that icing effects could occur with different categories of frictional material (organic and sintered) and even with P 10 grey cast-iron brake blocks. This formation can occur in a very short time under the appropriate usage / environmental conditions.
- It was found, however, that in the case of composite brake blocks of organic composition the formation of the layer of ice on the friction surface of the brake block, which impacts on braking performance, was more likely to take the form of a stuck-on core-ice layer than is the case with metallic friction materials (sintered or cast-iron P10). Sintered LL brake blocks, like grey cast-iron brake blocks, have a significantly greater heat conductivity and thus a higher resistance to the formation of ice layers than LL blocks that are organically bonded.
- Operational measures in accordance with Leaflet 410 Sections 4.1 and 4.2 ensure the braking effect, even with the use of the organically bonded LL blocks, which have a greater tendency to form ice blocks.

However, the LL composite brake blocks could not get their system homologation, mainly due to lack of insight on LCC, wheel wear and impact on equivalent conicity and running stability. Therefore, UIC launched the EuropeTrain project that aimed to investigate the use of noise reducing LL composite brake blocks regarding life cycle costs and running stability of freight wagons. It started on 5th September 2009 with the participation of 29 railways, the sector organisations CER, EIM and UIC and 8 industry partners and consisted in a special train subject to an intensive test and monitoring programme throughout Europe.

The train consisted of about 30 wagons, provided by several European railways to achieve a best selection of representative European wagons types and ran throughout Europe only for the in-service testing of LL brake blocks. The train was composed by 1 locomotive, 20 wagons fitted with LL composite brake blocks (IB 116* and C 952-1), 2 wagons fitted with Kombi blocks and 7 wagons fitted with cast-iron brake blocks.

The path of the EuropeTrain was defined in different loops, each representing certain operational, topographic and/or meteorological conditions. All operational conditions relevant for Europe had to be covered, e.g. running on different gradients with different operational modes, arctic winter areas and high temperature zones.

The duration of testing in service was planned to be at least one year taking into account all climatic seasons. In addition, a mileage of a minimum of 200,000 km needed to be achieved, to collect enough data to allow at least to recommend longer inspection intervals than defined so far in the UIC 'Usage guidelines for composite (LL) brake blocks'.

The train finally started in December 2010 with a first run on the Scandinavian loop to Sweden and ended with a summer mixed loop to the mountains of Austria combined with a one week run to Hungary. In between a second loop to Scandinavia was ran, both loops took place in winter time to be sure also the effect on harsh winter conditions could be included in the results.

Specific on operation in winter conditions, the finalizing report UIC B126 RP43 reports that:

- On the first Scandinavian run:
  - Tests north from Gävle were performed in a severe winter environment, under extreme snow conditions. The temperature was typical for operations at this time of year. In this loop braking test on sections with slopes < ±4 ‰ were carried out. The actual full retardation never normally falls below 90 % of the prescribed value. In some extreme cases, it could be measured to 85 %. In this case, the train consisted of 30 vehicles. If the train consisted of just one loco and 5 wagons, one might imagine that the risk of reducing braking effort could be greater.
- On the second Scandinavian run:
  - Tests north from Gävle were in normal winter conditions, both in terms of snow and temperature. Braking test on sections in this loop were performed on slopes of < ±4 ‰. Actual full retardation never fell below 90 % of the prescribed value.
- And on general experiences in both runs:
  - Ice and snow is more common around the brake blocks with non-metallic blocks than those made of metal/cast-iron
  - These phenomena make block inspection difficult at the departure brake test;
  - Ice and snow can lead to greater asymmetrical wear of blocks due to non-braking mode;
  - Sintered blocks appear from inspections when at a standstill, to clean the area around the block and wheel, probably due to higher internal thermal energy
  - Locomotive drivers believe that in applied braking, the effort related to a reduction in HL > 1 bar for the test train in winter conditions, would only be reduced marginally in comparison to a similar train equipped with cast-iron brake blocks

After almost two years of service all over Europe, the operation of the train came to an end in September 2012 with a mileage of over 200,000 km within 16 runs, covering in reality all operational, topographic and climatic conditions relevant for Europe.

This final project report summarizes the most important results along with the original main goals of the EuropeTrain, which were among others

- To serve as a tool to accelerate the solution process for the problem of equivalent conicity degradation by reaching enhanced understanding of equivalent conicity limit values and effects on running behaviour (UIC SET 04/TTI)
- To deliver field experience on the wear of block and wheel with LL blocks (LCC) in the short term and of high quality.

After the EuropeTrain project, UIC decided to homologate LL composite brake blocks for international use.

Another big in-service test was performed e.g. by Becorit, AAE and Green Cargo between October 2008 and October 2010 with 59 wagons equipped with LL composite brake blocks, together with some cast-iron braked wagons for comparison. No unusual stopping distances were reported here.

9. Problem description

9.1. Safety and braking performance of wagons fitted with composite brake blocks compared to those fitted with cast-iron brake blocks

9.1.1. Incidents

In Finland, experiences with sintered composite brake blocks have been gathered since the late nineties and the Finnish operator VR has been involved in the UIC winter working group. First UIC tests in Finland were made in 2008 and they were published in the UIC report B126 DT428. Once VR Ltd started whole train operation with Snps(s) timber wagons (with link suspension type bogie K16) in winter 2014-2015, they started having severe problems with unexpected and significant variation of braking distances. Problems were mainly in low speeds, but some incidents happened also in higher speeds. The reason for the braking problems has been identified as rapid snow and ice accumulating between the wheel and the block. Only efficient mean to tackle the problem has been using also wagons with cast-iron brake blocks in these trains (the operational rule of VR requires an absolute minimum amount of cast-iron braked wagons of 25 %). The current NOI TSI allows the use of cast-iron brake blocks to ensure existing safety level on the Finnish network until end of 2032. After the incidents, VR has started a project to fit the Snps(s) wagons with cast-iron brake blocks.

The Swedish railway undertakings started to notice a significant reduced brake performance of trains with a wagons fitted with composite brake blocks of K-type. Between 2015 and 2016 eleven incidents were noted where the speed of the train had to be lowered in order to achieve an appropriate brake performance and more severely a couple of SPADs occurred.

It must be noted that up until 2020 no wider experience of running trains with purely wagons with LL composite brake blocks has been recorded; especially not under winter conditions.

In 2019, one railway undertaking made the following remarks on the performance of composite brake blocks in operation in Sweden:

a) Several occasions where the railway undertaking observed a reduced brake performance on wagons with composite brake blocks in low speed operation. The reduced brake performance of composite brake block wagon sets has been significant and has been observed by the driver when he performed test braking according to the operative rules. In these cases, the railway undertaking has observed the poor brake performance and then adjusted speed and increased test braking until safe operation can be maintained. There have been examples where the driver reduced speed to slow walking speed, approximately 2 - 5 km/h. This has occurred for wagons with Jurid 822 configured as 1x Bgu at an axle load of approximately 4.8 t. Note that this is a new observation. On these wagons, the railway undertaking did not observe problems in low speed operation during last winter, 2017/2018.

b) **Several occasions where the railway undertaking has observed a reduced brake performance on wagons with composite brake blocks in normal train operation.** In these cases, the railway undertaking has observed a reduced brake performance and either:

- Reinforced the exercising of the brake until it has breached an acceptable level and/or
- Reduced V_{max} and/or
- Cancelled the train and returned to departure station (in very low speed).

c) **One safety incident in low speed operation (shunting) where the railway undertaking passed a stopping point.** The wagons had reduced braking performance, which was not observed.

d) **One safety incident in train operation.** This was a train that initially had an observation of poor brake performance at departure but then the brakes where exercised up to normal brake performance. Continually brakes where exercised during the train operation without any observations of reduced brake performance. Then at a stopping points the brakes where degenerated and SPADs occurred.

9.1.2. Safety alerts

NSA FI submitted a safety alert to the ERA's SIS system regarding composite brake blocks' winter performance on 4th July 2016. NSA SE sent a safety alert supporting NSA FI on 16th August 2016. A complementary alert was sent on 23rd February 2017.

These safety alerts are available in Annex 10.

9.1.3. Questionnaire on safety of brake blocks in freight wagons

On 16th December 2016, ERA sent a questionnaire to the national safety authorities in order to gather information on the safety performance of brake blocks fitted in freight wagons - 18 national safety authorities replied up to 18th January 2018.

The questionnaire tried to gather information on any safety problem related to brake blocks in freight wagons over a period of 3 years (2014 to 2017), regardless its consequences (e.g. a reduced braking performance leading to a longer braking distance which did not cause a signal passed at danger).

The table below contains the national safety authorities, which reported occurrences during winter in the questionnaire and a short summary of the replies.

NSA	*Summary*	*Brake block type*
Finland	Several occurrences related to a specific composite brake block and bogie/braking configuration combination	K, sintered
Norway	2 occurrences during winter with composite brake blocks	K, sintered
Sweden	12 occurrences with organic K composite brake blocks	K, organic

The results of the questionnaire were analysed by ERA and concluded the following:

'The replies given show a big difference in its degree of detail. Some NSAs (e.g. Finland) provided a great level of detail while others sent 'raw' data of occurrences, in some cases unrelated to the braking system of the wagons.

[…] It is important to take into account that there are very few LL wagons currently in operation in most of EU countries (e.g. in the Nordic countries there are none). No safety issues have been reported by NSA Germany, although there is a considerable amount of wagons retrofitted with LL blocks[1].

Safety issues with K wagons are centred in the Nordic countries, especially in Finland (sintered K blocks), and in a lesser degree Sweden (organic K blocks) and Norway (sintered K blocks).'

9.1.4. Dedicated meeting on the performance of composite brake blocks under winter conditions

On 12th December 2018, ERA chaired a dedicated meeting in order to provide the Nordic countries with the opportunity to provide evidence on operational issues with composite brake blocks, share experience on safety issues and the impact on operation and provide solutions. Main issues detected by Nordic Sector with wagons fitted with composite brake blocks (K and LL) were:

- Major ice/snow built-up on composite brake blocks can cause low brake effect
- Issues with composite brake blocks were reported, which resulted e.g. in the need of lowering the maximum speed of a train or in increased speed when going downhill despite braking
- It is difficult to predict the behaviour of composite brake blocks when the weather changes during the transport (e.g. from rain to drift snow)

[1] In Germany by 2016 half of the traffic was run with silent wagons including a significant amount of wagons fitted with LL composite brake blocks

- Tests with composite brake blocks show a loss of brake effect of about 25 % in winter conditions compared with cast-iron brake blocks
- Issues with composite brake blocks experienced when shunting and with empty trains
- Tests performed in Finland and Sweden showed lower braking forces and higher braking distances with composite brake blocks compared to cast-iron brake blocks

9.1.5. Revision of the NOI TSI - 'Quieter routes amendment'

Commission Implementing Regulation (EU) 2019/774 of 16 May 2019 amending the NOI TSI in order to make it applicable to the existing freight wagons received the positive opinion of the Railway Safety and Interoperability Committee in January 2019.

On top of the provisions in Articles 1 and 5 of the amendment above explained in chapter 2.1 of this report, this amendment also included the following specific case for both Finland and Sweden, allowing them to delay the application of the NOI TSI to the existing wagon fleet:

'7.4.1. Particular implementation rules for the application of this TSI to existing wagons (point 7.2.2)

(b) Particular implementation rules for the application of this TSI to existing wagons in Finland and Sweden

('T') The concept of quieter routes shall not apply on the Finnish and Swedish networks due to uncertainties related to the operation in severe winter conditions with composite brake blocks until 31 December 2032. This shall not prevent freight wagons from other Member States to operate on the Finnish and Swedish network.'

9.1.6. New questionnaire sent to Finland, Norway and Sweden

As the main conclusion from the previous questionnaire points out that the composite brake blocks issues is mainly related to winter conditions in Finland, Norway and Sweden, a new version of the questionnaire was agreed in the second task force meeting on 29th January 2020 to be replied by Finland, Norway and Sweden. This second version was focussed on occurrences due to brake blocks in winter conditions.

All countries reported occurrences with composite brake blocks: Finland reported 27 occurrences since 2014, Norway reported 6 occurrences since 2014 and Sweden (Hector Rail) reported 19 occurrences since 2014.

The table below shows the safety problems of composite brake blocks compared to those caused by cast-iron brake blocks and the kilometres run of freight wagons fitted with composite brake blocks and cast-iron brake blocks from 1st January 2014 to 1st January 2017 in Finland:

Type of brake block	*Material of the brake block (e.g. cast-iron, composite-organic, composite-sintered, etc.)*	*Number of safety problems since 2014*	*Kilometres run by wagons equipped with this type of brake block since 2014*
Cast-iron brake block	P10 cast-iron brake blocks	0	666,829,880
Composite brake blocks	CoFren C333 sintered brake blocks	27	111,774,850 (61.5 % of km 2x Bgu and rest 1x Bgu)
Composite brake blocks	CoFren C335 sintered brake blocks (non-UIC homologated)	0	23,141,950

The freight wagons fitted with K16 bogie and C333 K composite brake blocks are being fitted back to cast-iron brake blocks after 2017.

The table could not be filled in with the data from Norway and Sweden as they are open networks and it is not possible to control the kilometres run by wagons fitted with composite brake blocks.

Finland, Norway and Sweden reported no incidents due to reduced braking performance of cast-iron brake blocks.

Main points are:

› Temperature is not always extreme (-20 °C to 0 °C)
› Speed ranges are from 0 to 100 km/h
› Wagons can circulate empty or loaded
› Involved composite brake blocks are K and LL[2] types, sintered or organic
› Finnish issues are all related to wagons fitted with C333 block and K16 bogie
› Norwegian and Swedish issues are related to all composite brake block types operated in their network (J822, C810, IB116*). Other brake blocks are used, but very limited experience is available (J847, K40, C333, J816M).
› 16 occurrences in Sweden out of 19 are caused by Sggrrs wagons fitted with composite brake blocks
› Hector Rail provided additional operational measures performed during winter over and above the recommendations of the UIC leaflet 541-4. Other operational measures include mixed traffic (wagons fitted with cast-iron brake blocks coupled with wagons fitted with composite brake blocks).
› LKAB explained that no issues related to composite brake blocks during winter have been detected since 2014. LKAB performs metalliferous ore transport with special heavy duty wagons with an axle load of more than 30 t. These wagons are fitted with special adjusted composite brake blocks. The track goes from Abisko (Sweden) to Narvik (Norway) with large amounts of snow and a heavy slope of 17 ‰ down towards Narvik. The speed is reduced to 60 km/h and a device in the locomotive ensures that the brakes are engaged continuously and automatically in order to keep the brake blocks warm without any action from the driver.
› The wagons are sealed vehicles with clean and dry air in the braking system and brake controllers with double seals against water penetration and dust/water protection over control valves and pressure transducers.

9.1.7. Tests with composite brake blocks in Nordic climate

NSAs FI and SE began looking into the brake performance of composite brake blocks in winter conditions in more detail following the incidents reported by the railway undertakings. Following tests in winter conditions have been made during winters 2018-2020:

Time	*Location*	*Resp. organisation(s)*	*Report ID*	*Published*
Feb 2018	Finland (Rovaniemi - Kemijärvi, Pieksämäki - Joensuu)	IM FI and NSAs FI, NO and SE	VRTe/K10/05/18/1215	July 2018
Mar - Apr 2018	Sweden	IM SE, NSA SE	Results to be considered in the report of the tests held from Jan to Mar 2020	N/A
Jan - Feb 2019	Finland (Pieksämäki - Joensuu)	UIC	UIC B 126/DT 450	June 2019
Jan - Mar 2020	Sweden (Haparanda - Boden)	IM SE, NSA SE	Presentation supplied on 07/05/2020. Preliminary report available	TBD

[2] Only one incidence was reported involving LL composite brake blocks (IB 116*, operated in a train with wagons fitted with several brake blocks types).

Brake performance tests and brake force comparative tests were performed under winter conditions in Nordic countries between 2018 and 2020 by NSAs FI and SE, UIC and railway undertakings. These tests show independently a problematic loss of brake performance of wagons fitted with composite brake blocks.

In Finland 2018 tests performed at low speeds with C333 sintered K composite brake blocks showed that the braking distance under winter conditions was doubled on average, but more importantly the results showed great variation. These tests and report were funded and published by the NSAs FI, NO and SE plus the Finnish infrastructure manager. The report was approved in July 2018 and its reference is VRTe/K10/05/18/1215.

After the tests, the UIC winter working group simulated the situation with the special coefficient of friction related to the speed and also to the brake operation (pressure reduction of the main pipe). As a result, up to a double brake distance in service braking can be normal at low braking speeds and it is not related to winter only and may help to avoid flats in the wheels. However, this behaviour is considered in the operating guidelines also since years.

UIC tests in Finland in 2019 aimed to improve operating rules gave mixed results. Regular conditioning braking kept the wheel and the brake block interface free of ice. Yet, frequent conditioning led to ice built-up in the bogie that in effect caused a complete blocking of the brake rigging resulting in complete loss of brake performance. The rigging was totally clogged in less than 1,000 km of running and after that ice and snow had to be melted from the wagons in order to use them.

One part of the test tried to simulate the situation of driving uphill and braking downhill. The result was that conditioning may not be possible in uphill-downhill gradient profiles. For example, the driver cannot condition the brakes in uphill because the locomotive does not have enough power to pull the train up the hill with brakes on. Similar problems can occur in networks that have more level gradients when the trains get longer and are in full load. In downhill, the brake efficiency has been so poor in some cases that the train has not reduced any speed until the gradient has levelled, even though conditioning has been made. Based on the Nordic experiences conditioning cannot solve this problem. This was a special situation caused by a total locked brake rigging. In consequence, no application force at the brake blocks was generated. In result, the brake force was near zero.

The test were made (because there was no practical alternative because VR was the only operator who was able to perform tests for UIC in that winter) with a type of very covered bogies, which are not representative for usual used bogies in Europe but are common ones in Finland.

After the test, it was found out that the efficiency of the brake rigging of the test wagons was very low (much lower than they should be in official tests and in operation either). This situation must be considered in interpreting the results.

Tests in Sweden were performed on winter 2019-2020 between Boden and Haparanda funded by NSA SE. The preliminary results of these tests are validated by the Chalmers Technology University of Göteborg. However, peers review from UIC and FEMFM is expected when the definitive report is available. Preliminary results showed the following results summarised by NSA SE for different types of LL composite brake blocks:

- IB 116* (organic)
  - 22 % average increase of braking distance and large variation
  - Braking distance seems to be dependent on air temperature
  - Considerable massing of ice and snow around brake equipment in the bogie
- C952-1 (sintered)
  - No increase in braking distance
  - Braking distance seems to be independent of temperature and grade of snow fly-off

However, weather conditions for winter testing were poor. The winter 2019-2020 was somewhat shorter and had less time of snowing than the others. December 2019 and January 2020 have been substantially warmer than the three years prior, with a lowest temperature of -8.6 °C. Analysis of snow drift in combination with lower temperatures show that the winter 2019-2020 had almost same total number of days with possibility for snow drift as previous years. However, occasions for possible snow drift at temperatures below -10 °C are substantially lower than for the three other winters (1,220 as compared to 1,720, 2,858 and 2,672 occasions). Looking at the coldest temperature range, colder than -20 °C, the differences are even more pronounced (129 as compared to 322, 735 and 1,053 occasions). The meteorological data were extracted from the weather stations near test sites in Boden - Haparanda region.

Based on these test results, NSA SE concluded that LL composite brake blocks work under the following conditions:

- Light winter conditions (temperatures down to -10 °C and at limited amount of drifting snow)
- Wagons are properly maintained (efficiency of the brake system should be high - about 90 %)
- Continuous de-icing of wagon (de-icing every two to three weeks)
- Braking is performed every 15th minute to standstill with full service brake[3]

Brake force comparative testing will be evaluated in order to learn if there are major difference in the braking performance behaviour of composite brake blocks compared to cast-iron brake blocks to improve the instructions to the drivers. Continued analysis of relationships that can explain differences in braking distances.

It is foreseen to continue testing in Sweden. Future tests will focus on alleviated operating conditions, severe winter conditions with substantial amounts of snow whirling for C952-1/IB 116* and lower temperatures for organic blocks (-15 °C to -40 °C) and testing of the automatic conditioning device (LAW-B).

9.1.8. Preliminary conclusions

The only conclusion at this stage is that the occurrences related to winter performance happened in Finland, Norway and Sweden and not in other Member States.

A complex interplay of, among other factors, meteorological conditions (temperature, snow and humidity), type of composite brake block, type of bogie, loading conditions, other brake equipment and required braking performance and specific operating conditions jeopardises the performance of composite brake blocks in the countries mentioned above during winter.

In the date of publication of this report, further testing is foreseen in order to provide additional insight regarding this preliminary conclusion. This testing should include new composite brake block types currently under development, additional technical solutions reinforcing composite brake blocks such as LAW-B and operational procedures.

9.2. Unique situation in Sweden

Sweden has a unique combination of safety issues (as explained in chapter 9.1 of this report) and other aspects that together will lead to different direct and indirect effects (as explained in this section).

The brake performance of composite brake blocks has been shown to be reduced under certain winter conditions. This is problematic as stopping distances are not respected and many SPADs have been reported concerning trains with wagons with composite brake blocks. SPADs may even further be increased as more and more wagons are being equipped with composite brake blocks and entering into Sweden. Up until winter 2020 only a limited amount of wagons with composite brake blocks have been circulated on the Swedish network according to the railway undertakings and these have mostly been running in mixed trains, i.e. trains consisting of wagons with both composite brake blocks and cast-iron brake blocks. It is widely believed that

[3] UIC rules do not impose regular braking to standstill. UIC stated that braking to a standstill was performed between Boden and Haparanda but this was due to the fact, that these were the regular braking points in the test.

the cast-iron braked wagons in the trains have covered for the loss of the brake performance of the wagons equipped with composite brake blocks. The incidents reported have basically been with trains with wagons equipped with only composite brake blocks.

The main reasons NSA SE have reported an increase in SPADs due to poor brake performance of composite brake blocks in winter conditions and no other national safety authorities are partly due to:

- Differing safety related engineering rules for signalling (see chapter 9.2.1 of this report)
- Characteristics of the Swedish network (see chapter 9.2.2 of this report)
- Lower brake performance of freight wagons fitted for networks with longer braking distances than those required on the Swedish network. Most networks require a brake weight of just 62 t compared to the brake weight of 72 t used by wagons, which are mainly operated on the Swedish network) (see chapter 9.2.2 of this report)
- Dependency of wagons mainly used in other Member States to maintain traffic to and from Sweden (see chapter 9.2.3 of this report)
- Distribution of wagons throughout Sweden (see chapter 9.2.3 of this report)
- Longer and harsher winter conditions prevailing in Sweden (see chapter 9.2.5 of this report)

Finally, winter testing performed in Finland and Sweden have shown that the brake performance of composite brake blocks is, to various degrees, considerably lower in winter conditions, especially in the case of organic LL composite brake blocks. LL composite brake blocks have longer braking distances depending on lower temperature and snowdrift. Sintered LL composite brake blocks performed much better in temperatures down to -10 °C and moderate snowdrift (see chapter 9.2.5 of this report). However, according to UIC it is too early to draw such conclusions for organic LL composite brake blocks.

NSA SE considers that the safety limit is thus compromised when operating freight wagons fitted with composite brake blocks in winter conditions unless strong operational measures are taken, which have economic consequences (see chapter 11 of this report). The reason for that is the increased risk of SPADs. NSA SE is preparing a dedicated risk analysis, which should be taken into account in future revisions of this report.

9.2.1. Safety related engineering principles for signalling

The main engineering principle of the signalling system in Sweden is that the protection distance is located beyond the end of a route, i.e. signal in red. The protection distance may be used by a train, which overrun the end of the route. The protection distance must therefore be free.

Thus, in Sweden when the safety limit is lowered or even exceeded in the case of brake performance with composite brake blocks the train will pass a signal in danger; while the protection distance in other countries is before the signal and so most likely being the reason for no SPADs are officially recorded.

9.2.2. Characteristics of the Swedish network the source of operational issues

Signalling distances in Sweden are generally shorter than elsewhere in Europe. That combined with a topography which is rather hilly together with single track lines (9,000 km of 14,000 km) and mixed traffic leads to a braking duty which is 2 - 3 times higher in Sweden than compared to e.g. Germany.

Therefore, normal operation in Sweden require that Swedish registered wagons (4-axle wagons) have a higher brake performance (brake weight 72 t) than the European equivalents (brake weight 62 t) in order to allow 100 km/h operation of the trains - see Figure 1. This leads to further increased risk of SPADs as wagons with lower braking weight than Swedish registered wagons are used in the single wagon load system on the Swedish network (see chapter 9.2.4 of this report).

Figure 1: Load spectra. Source: EuropeTrain: Braking Questions, Synthesis paper on the EuropeTrain operation with LL brake blocks – Final Report – Management Summary – UIC B 126/RP 43 (February 2013), http://europetrain.uic.org/IMG/pdf/b126_rp43_managementsummary.pdf

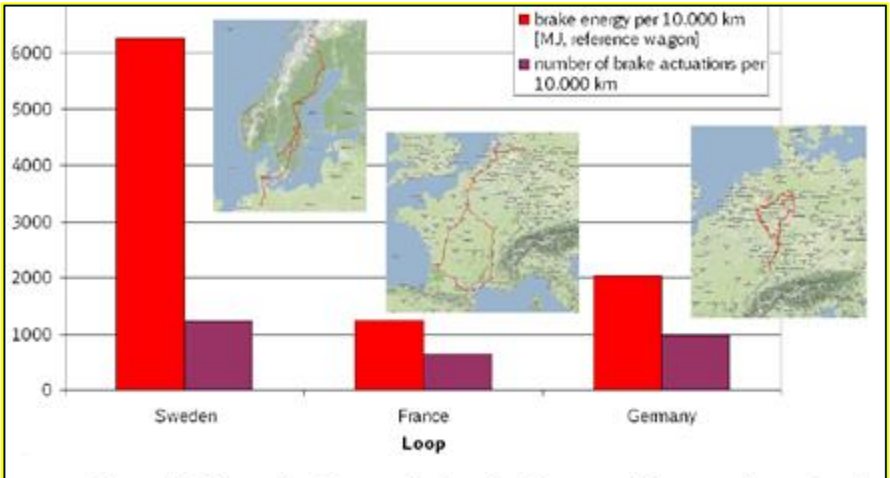


Figure 1: Different load spectra in Sweden, France and Germany (exemplary)

Furthermore, the Swedish network consists of mainly single-track lines. A single-track railway is a railway where trains traveling in both directions share the same track. A single track has many operational and safety disadvantages. For example, a single-track line that takes 15 minutes to travel through would have capacity for only two trains per hour in each direction. By contrast, a double track with signal boxes four minutes apart can allow up to 15 trains per hour in each direction, provided all the trains travel at the same speed.

Other disadvantages include the propagation of delays, since one delayed train on a single track will also delay any train waiting for it to pass thus accumulating the negative effects of running slower trains on the single-track line.

This lower operating speed, in turn, would lead to substantial losses of operational capacity in the Swedish rail system; also for passenger trains. Freight trains will simply consume more of the available infrastructure capacity. In general terms longer travelling time leads also to heightened risk for delays.

These lower operating speeds and subsequent lower capacity on the infrastructure lead to a more vulnerable rail system to operative disturbances resulting in a more rigid rail system without flexibility and less room to manoeuvre. In effect one can predict further delays and longer rerouting patches. Effects that are extremely difficult to estimate and undoes what the infrastructure manager has under a long time striven to achieve.

9.2.3. The geographical distribution of wagons

Sweden is dependent on wagons from Europe in order to maintain traffic loads internally and in traffic to and from Sweden. As can be seen from *Figure 2* one out of five wagons will travel all the way up to the northern parts of Sweden.

The map below depicts the distribution of all wagons passing the Öresundsbro-link to/from Denmark during the year 2017 (= wagons with international destination or coming from international destinations).

The original map holds information on all lines in Sweden with letter indication of the name of the station and number indication of the actual line, e.g. Blg which translates to the town of Borlänge.

The added coloured lines are the main freight corridors in Sweden.

The yellow marked percentage figures, for example 84 %, means that the stated percentage of the wagons travelling over the Öresundsbro-link to and from Sweden also have passed the indicative spots marked with yellow figures on the map.

A small share of the freight wagons use ferries from the continent.

Main freight corridors in Sweden:

Southern main line

Freight corridor through Bergslagen

West coast main line

Begslagen line

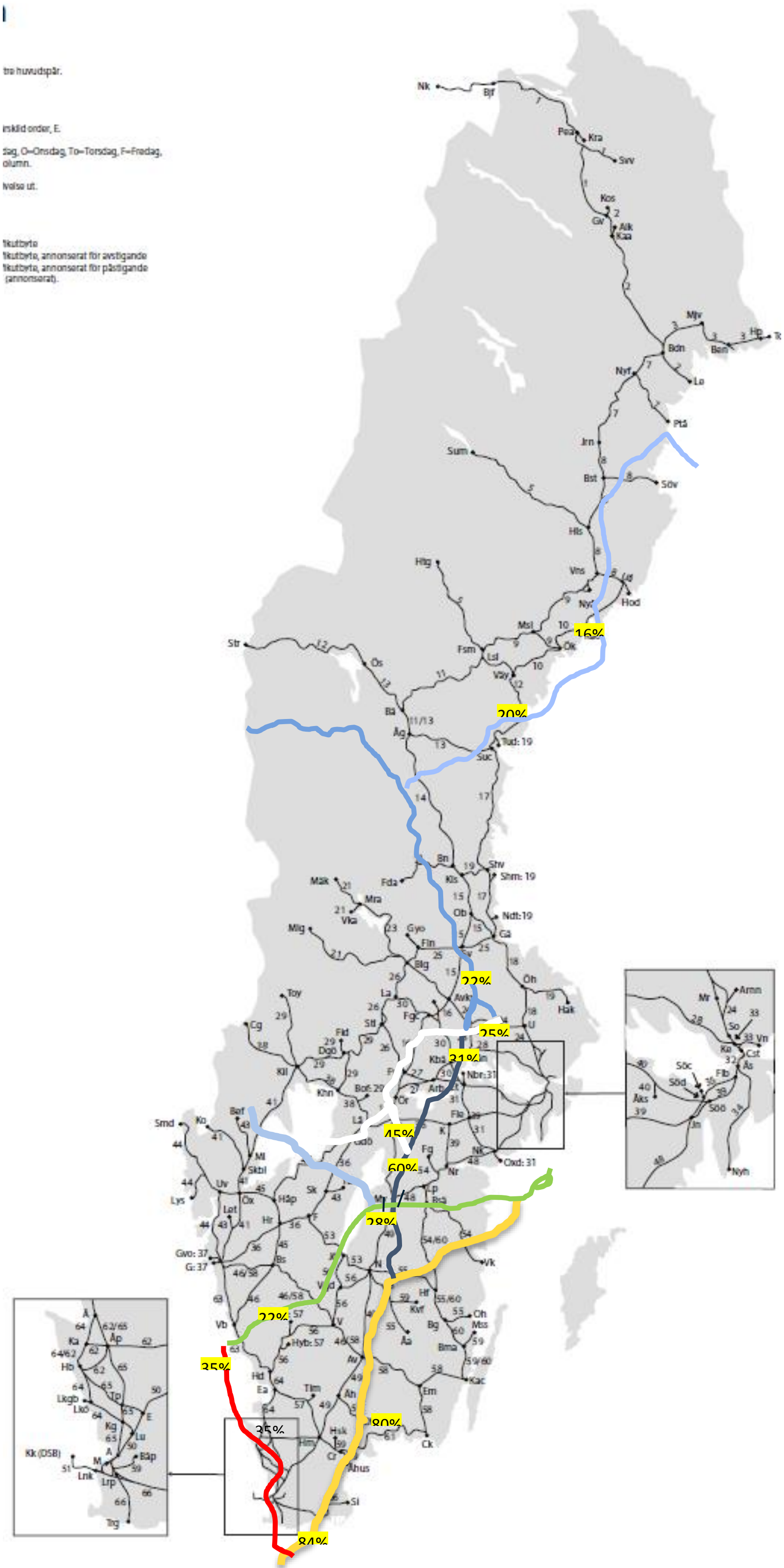
Värmland line

Northern main line

Main line through Upper Norrland

Wester

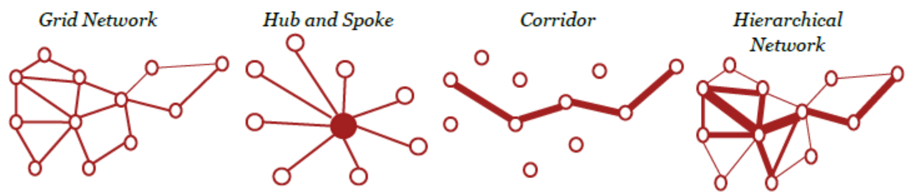
Figure 2: Geographical distribution of international wagons in Sweden



9.2.4. Single wagon load system

The single wagon load system in Sweden is a hierarchical hub-and-spoke network. One of the reasons that there is so many wagons mainly operated on other Member States in the freight trains in Sweden is because of the single wagon load system.

Hub-and-spoke is a supply layout characterized by one principal node (the hub) and the remaining minor nodes all connected to the former through direct links (spokes) but not directly among each other and hierarchical network is a more complex layout, where both hub-and-spoke and corridors are combined on a grid network thus introducing so a hierarchy of rail transport supply in terms of frequency and capacity.



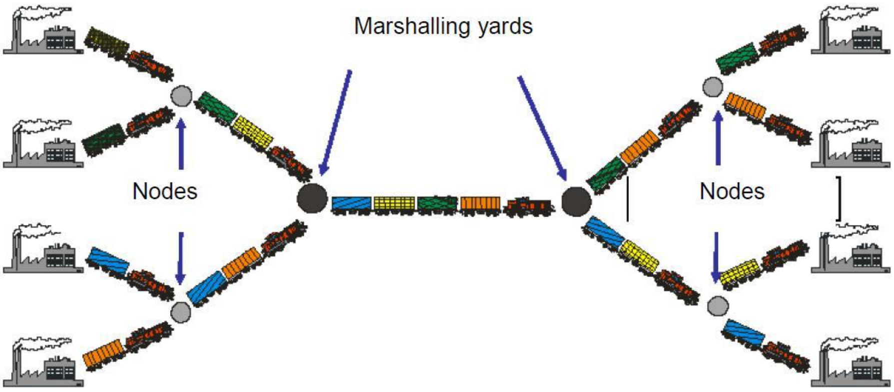
The hub-and-spoke is the prevailing current system for the single wagon load traffic. The chief characteristic of the hub-and-spoke design is that all loading units pass through the hub terminal, and it must thus handle an extensive throughput. It is, therefore, of great importance that the hub terminal has a large capacity. It also has to be extremely reliable, since the whole system is affected if the hub terminal breaks down. The design implies comparatively large detours, and for covering a large area overnight the hub terminal must allow short train stops. The load plan and exchange technology must offer accessibility to any loading unit, and if all trains combined at the hub are not accessible simultaneously, there is a great need for intermediate storage.

In some western European Union Member States, single wagon load services are no longer offered by the incumbent rail freight operators: Italy, Spain, United Kingdom, partly France where SNCF reduced by 2/3 its single wagon load business.

In the central Europe, DB, SNCB, ÖBB, CFL made the choice to continue single wagon load services and propose new organisation and operating processes.

The Swedish system is special since it is a hybrid system which comprises some 20 - 30 % trainload product where blocks of typically 10 - 15 wagons a day are produced in capacitated wagonload trains. Also, intermodal volumes are produced in the single wagon load system. All orders are reserved and an ETA (estimated time arrival) is produced based on capacity bookings on individual trains. Especially all foreign (import/export) traffic, but also most domestic traffic is depending heavily on the national wagonload system such as ports, intermodal terminals and the largest Swedish industries.

In the Eastern Europe, single wagon load is still at least 20 % (or more) of the business of ČD Cargo, PKP Cargo, CFR Marfa but its future is uncertain, especially with State-owned rail freight companies offered for privatization as in Poland and Romania.



9.2.5. *Statistics and duration of winter*

Primarily, the problem of lowered brake performance is caused by harsh winter conditions with snow covering the ground; conditions prevailing in Sweden for up to 5 months a year. Snow and ice builds up on the brake equipment and causes the loss of brake performance, especially when it is snowing and it is cold, which is the case in Sweden. For long durations of time it is extremely cold, -10 °C to -30 °C, in large parts of Sweden combined with a snowfall which all adds up to problems for the braking of trains accentuated by the implementation of composite brake blocks.

The main differences between continental European and Swedish environmental conditions is probably that in Sweden the wagons will hardly ever be subject to defrosting which is highly likely in continental Europe. Trains travel between colder and warmer areas which is not the case in Sweden. The cold and the snow cover prevails in a geographically large part of Sweden during the whole winter period, which means that the wagons never defrost and snow and ice keeps building up. See Annex 5 for more information on average duration of winter, snow cover and impacted areas of Sweden.

Other effects of operation of trains with wagons fitted with composite brake blocks compared to those fitted with cast-iron brake blocks are considered in the impact analysis.

9.3. Unique situation in Finland

9.3.1. *Isolated Network in Finland*

The Finnish track gauge is 1,524 mm, which effectively makes of Finland an isolated network.

This is duly taken into account in the assumptions of the impact assessment (see chapter 11 of this report).

9.3.2. *Winter in Finland*

For big part of Finland, thermal winter is the longest part of the year. Northern Finland winter is about seven months and in the southern island of Åland only about three months.

Southern and Western Finland: Length of winter is usually more than four months, it is a real winter, but there are also longer warmer periods (temperature is on both sides of zero Celsius).

Eastern and Northern Finland: Length of winter is 5-7 months, occasionally short warmer periods (temperature is on both sides of zero Celsius).

Relevant facts and figures of winter in Finland are provided in Annex 6.

9.4. Unique situation in Norway

9.4.1. *Geographical and topographic particularities for Norway*

Landscape in Norway is hilly with high mountains and deep valleys. The climatic changes between the western (coastal) parts and eastern parts (inland) are significant.

The average elevation is 460 m above sea level, and 32 % of the mainland is located above the forest line in an alpine climate. Norway has some of the longest continuous ascents and descents on railway lines in Europe with nominal gradients up to 27 ‰ - see Annex 7.

All the main railway tracks cross the mountain chain with high elevation, e.g. the line between Oslo and Bergen which is at its highest 1,237 m above sea level.

9.4.2. Climate

Winter months are typically characterised by low average temperatures, abundant snow and high risk for avalanches. Generally, western Norway has a marine climate with cool summers, mild winters and humid all year round. Eastern Norway, sheltered by the mountains, has an inland climate with warm summers, cold winters and dry all year-round climate type. The country is one of Europe's most mountainous countries, with large areas dominated by the Scandinavian mountains.

Winter period is 5 months in south and 6 months in middle of the country.

Temperature during the winter vary from -4 °C to -18 °C in south to -10 °C to -25 °C in middle, inland region.

Snow in the lowlands, like the Oslo-area, an average of 50 cm is normal, while at an altitude of no more than 300 m above sea level the snow increases to an average of 100 cm, and in altitudes over 800-1000 m above sea level the snow can reach 180 - 250 cm - see Annex 9.

9.4.3. Particularities for train operation due to poor brake performance, in addition to the ones described in reports after test of composite brake blocks in Finland and Sweden

9.4.3.1. Conditioning braking

Conditioning braking is used in Norway where and when it is possible.

However, it is not possible to do this when travelling uphill due to the risk of speed/traction capability loss and as a consequence the train eventually stops. As most of the railway lines are single track such a stop leads to track blocking for a considerable period of time. Consequently, a train can run for shorter periods or over 1 hour depending on the route, without possibility to exercise conditioning braking until arriving at the highest level for the route in case and starting the descent on the other side of the mountain with extreme reduced brake capability. Tests in Finland during winter 2018 have simulated such a situation and the result evidenced considerably increased braking distance - see the report VRTe/K10/05/18/1215.

9.4.3.2. De-icing

De-icing and anti-icing treatment facility for freight wagons is located at Alnabru in the Oslo-area. During winter season snow and ice can, after only some hours of train running, cover large parts of the bogies including brake rigging.

Freight trains staring from or around Oslo and with destination west, north or south in the country will not have the possibility to de-ice or chemical treat the wagons until they are returning to Oslo-area.

In many cases a roundtrip from Oslo will last for 2 days or more with no possibility to de-ice the wagons during this time period.

9.4.3.3. Tunnels

Due to the topographical characteristics in Norway there are a significant number of tunnels, both short and long. Annex 8 displays selected tunnels with a length of over 2,000 m. A train running through a tunnel encounters a change of temperature from outside in a range -10 °C to -20 °C to 6 °C inside the tunnel. Consequently, while the train is inside the tunnel any accumulated ice and snow will begin to melt partially and then freeze again when the train runs out of the tunnel. The process considerable worsens the ice/snow load accumulation on brake components and performance of composite brake blocks.

9.4.4. Risk reducing measures at operational level when operating trains with composite brake blocks

Summarized by the Norwegian operator CargoNet AS (CN).

Reduced brake capability for trains with composite brake blocks and cast-iron brake blocks in mixed configuration has for some years been a known risk and has been monitored and handled through various measures. The risk is significant and operational requirements are implemented for test of braking and deceleration control, both before departure and in traffic, in order to detect a lower brake capability. Before departure from a terminal, brake tests are mandatory, the driver assesses the results and decides on the minimum brake performance allowed for a specific route. In extreme situations, entire trains equipped with composite brake blocks brake blocks are cancelled.

After repeatedly having experienced brake failure with composite brake blocks in harsh winter conditions, CN had to implement mandatory use of additional brake wagons with cast-iron brake blocks on trains with a high proportion of composite brake blocks in order to avoid cancelling/delaying the train. Not always changing of train formation is readily achievable and postponing the transport is the only alternative until brake wagons are available. Consequently, trains are delayed for shorter or longer periods, and when weather conditions allow, the transport is resumed, often at reduced speed.

CN reports that sometimes trains had to be rescued back to a nearby terminal/station in order to couple extra brake wagons with cast-iron brake blocks.

From January 2018, CN implemented marking of wagons with composite brake blocks in train wagon lists both in Norway and Sweden. This in order to facilitate overview of train composition in mixed train configurations, as well as setting a limitation for the percentage of number of axles with composite brake blocks in trains.

9.4.5. Long term test in commercial traffic for LL sintered composite brake blocks

Generally, the use of brakes on freight trains is more intense in Norway compared with the rest of the European Union due to the special geographical and topographical conditions.

The test[4] initiated by CN consisted of a freight train in commercial traffic, equipped with sintered LL composite brake block type C952 on half of the wheelsets and standard cast-iron brake blocks on the others. The test was carried out through a period of 3 years. During the test period, 14 of the wheelsets equipped with LL C952 had to be replaced due to wheel thread damages, against 6 of the wheelsets with cast-iron brake blocks. After 3 years the LL C952 were worn out and the test stopped. The test has been started with new wagons new brake blocks, and with new wheels in material ER7, profile P8.

The test emphasized practical challenges when running trains with composite brake blocks, hereunder:

- Significant and unpredictable reduction in braking capacity in winter conditions
- Higher wheel thread wear and wheel thread damages
- Thermal capacity challenges when running downhill on constant braking for a longer period

10. What must be achieved?

All freight wagons, existing and new, within the Union rail system with an area of use encompassing Nordic countries must achieve adequate brake performance in all meteorological conditions, loading conditions, and operating conditions and meet the noise requirements as set out in Regulation (EU) No 1304/2014.

[4] The test carried out by CN was a test in ordinary commercial traffic with the aim to gain experience in use of trains with mixed configuration, composite brake blocks and cast-iron brake blocks, during winter and summer. CN does not have a typical report with findings. CN's conclusions are in form of an ascertainment and are summarized as in the NSA NO's description.

11. Impact Assessment

All scenarios described below apply for 2024, when the revised NOI TSI will be in force. An increasing number of freight wagons have already been retrofitted with composite brake blocks (mostly LL blocks) in Europe due to the following reasons:

- Legal instruments
  - Existing noise bans in Switzerland or planned noise bans in Germany
  - NOI TSI requirements for new wagons favour the use of composite brake blocks
- Financial instruments
  - The direct funding of K composite brake block retrofitting in Switzerland
  - The NDTAC schemes based on EU legislation in Austria, Germany and the Netherlands
  - EU subsidies for retrofitting to composite brake blocks (Connecting Europe Facility)

The impacts of the baseline scenario in the Nordic countries have been evaluated only for the Member State Sweden, because most international single wagon traffic passes through Sweden. There is international rail traffic in Norway too, however to a much lower extent than in Sweden. For Finland, no international single wagon traffic arriving from other European Member States is considered. For this reason, Finland is not concerned by the currently imposed (and future) noise bans in other EU Member States or Norway.

In the following the baseline scenario analyses the economic impacts resulting from the problem of a reduced of brake performance of composite brake blocks under winter conditions. These impacts are derived from mitigation measures in terms of speed reductions. The following options represent potential solutions in order to get rid of the mitigation measures of the baseline scenario (speed reductions). However these solutions will cause a cost impact for the rail stakeholders as well, which is different from the cost impact in the baseline scenario. A cost comparison between baseline scenario and potential options will identify the best options.

In all options, it is assumed that wagons equipped with composite brake blocks can still move all around Europe. However, measures and adaptations as described in the baseline scenario have to be applied under the scope and meteorological conditions covered by this report.

11.1. Baseline/Reference Scenario (effects of the legislation in force)

In winter conditions there is an increased risk of reduced brake performance when the wagons are fitted with composite brake blocks instead of traditional cast-iron brake blocks (see chapter 9.1.8 of this report). Railway undertakings therefore apply operative rules in order to avoid incidents or even accidents.

The mitigation measure for a lower brake performance of the train is a maximum operative speed for this train. The lower maximum speed negatively effects the transport time and consequently line capacity causing an increase in rail transport costs and subsequently a modal shift from rail to other modes like road and sea.[5]

In the following analysis the main assumption is that railway undertakings implement an operative rule or restriction on freight trains with wagons equipped with composite brake blocks so that these trains only may run at maximum operative speed of 80 km/h instead of running at 100 km/h[6]. Alternatively, the railway undertaking might condition the brakes every 15 minutes. However this would lead to a lower average speed as well which would be consistent with the above assumption (80 km/h). This reduction is a very conservative assumption by the Swedish railway sector, as a higher speed reduction could be necessary (based on current experience with the reduced brake performance). This speed reduction is not needed in the whole year, but

[5] For the model shift impact, no increase in transport costs of other modes due to winter conditions is considered, which could reduce the calculated modal shift from rail to other transport modes.

[6] In Sweden, see regulation TDOK 2015:0309 TTJ - the driver has to adapt speed in case of brake performance loss.

maybe under some special winter condition. It will cause a significant reduction of average speeds of other trains as well.[7]

Trafikverket used the model SAMGODS[8] which simulates the whole transport network and all transport modes in Sweden, in order to calculate the overall effect on the Swedish freight transport system. In this model, such reduction of the maximum speed only applies for freight trains and for the complete Swedish network[9], however passenger trains are not directly impacted by the speed reduction but indirectly impacted by the reduced line capacity. This represents a worst case.

The model is limited in the way that there is no distinction between wagons used nationally and wagons used internationally. This limitation, however, has no real impact on the outcome of the results. A sensitivity analysis, where only single wagon load runs at lower maximum allowed speed, verified the results of the main calculation.[10]

The model is restricted that it can only apply such speed reduction for the whole year. The theoretical winter timetable would last from 1st November to 30th April. This would mean that more than half[11] of the freight would be transported during the winter time and that the cost impact would be at least more than half of the estimated costs in table 1 (see below[12]). However according to Swedish RUs, the real cost impact is still about 100 % of the estimated costs in table 1 due to the following reasons: The most inefficient timetable plan (in this case the winter timetable with lower speed) is the basis for the determination of resources in terms of locos, wagons and staff for a specific regular transport of goods. The adaptation of the production and transportation chain during summer and winter period would involves huge investments.[13]

The effect resulting only from the reduction of maximum speed for freight traffic is a modal shift from rail to road and sea transport modes of 4 billion tonne kilometres per year which represents a 15 % decrease of rail transport.

[7] Due to passenger trains operating at up to 200 km/h on many of the same lines, the large disparity between fast passenger trains and slow freight trains running at down to 70 - 80 km/h forces the freight trains to frequently go into a siding and wait for passenger trains to pass, which further decreases the freight train average speeds and extends their transit times, while the lower speed also consume line capacity. Also on single track or with construction work the line capacity will be lowered when the slower trains will not reach the next siding and have to wait for meeting trains for a longer time.

[8] The national model for freight transportation in Sweden, REPORT Representation of the Swedish transport and logistics system in Samgods v. 1.1. (Trafikverket, VTI 2016) - link: https://www.vti.se/sv/Publikationer/Publikation/representation-of-the-swedish-transport-and-logist_1034226

[9] Logistically, trains in Sweden run south-north and vice-versa so may at any given point in time and place be affected by unpredictable winter conditions affecting the brake performance negatively.

[10] Calculation in the Swedish application of UIC-406 method, Magnus Backman, Trafikverket. Transport costs are for international rail freight (single wagon) are significantly (300 %) higher compared to transport costs for national rail freight traffic.

[11] It has to be considered that during the long Swedish summer break there are a reduced number of freight transports.

[12] In addition to this cost impact as specified in *Table 2*, the costs referred to in chapters 11.1.2 to 11.1.6 of this report have to be taken into account too.

[13] For more explanation, see also chapter 11.1.2 of this report.

The total impact on the socioeconomic costs are calculated by Trafikverket using data and results from the simulation models "Bansek2"[14] and "SAMGODS".[15]

Table 2. Socioeconomic costs due to 80 km/h

Socioeconomic effects		*MSEK (per year)*	*MEUR (per year)*
Effect on railway undertakings (Tickets, cost for vehicles, track access charges etc.)		-595	-54
Effect on passengers (Traveling times, delays etc.) Note: Modal shift impacts (passengers could take alternatives) are visible under budget effects and external effects.		-675	-61
Effect on freight customers (Transport costs) Note: Modal shift impacts (freight customers could take alternatives) are visible under budget effects and external effects.		-1,895	-172
Budget effects (Fuel taxes, track access etc.)	Passengers	+35	+3
	Freight	+392	+36
External effects (CO_2, NOx, noise, accidents etc. due to modal shift)	Passengers	-64	-6
	Freight	-506	-46

Total Impact	-3,307	-300
Contribution of impacts to impacted stakeholders		
Passenger	-1,299	-118
Freight	-2,008	-182

The effect on passenger railway undertakings is basically a loss of revenue and changes in vehicle costs and track access charges etc. The effect on passengers is due to increase in traveling times and cost of delays etc. while the effect on transport buyers is the real cost of the transport. The budgetary effects on freight are due to fuel taxes and track access charges etc. The external effects due to the modal shift are depending on increase of emissions of CO_2, NOx, Noise and costs due to accidents, etc.

The transport volumes that are shifted from rail to other modes (due to capacity losses in rail sector) lead to a decrease of the total cost for rail transports, however the volume transferred from rail to road and sea

[14] BANSEK 2 is a model to analyse measures in the rail system. används för analyser av infrastrukturåtgärder och banavgifter inom järnvägssystemet. - link: https://www.trafikverket.se/tjanster/system-och-verktyg/Prognos--och-analysverktyg/bansek-2/

[15] Samhällsekonomiska effekter och förändrade utsläpp av luftföroreningar och CO2 till följd av ny reglering av järnvägsbuller, Lena Wieweg, Trafikverket, 2018.

leads to a transport cost increase that largely outweighs this cost reduction for rail transports, taking into account the total transport cost for all modes in the model.

There are the negative impacts, which were not taken into account in the calculated socio-economic costs as presented in the table above, which are explained in chapter 11.1.2 of this report.

11.1.1. Optimisation of operational procedures for composite brake blocks

According to UIC, the proposed operational mitigation scenarios (e.g. speed reduction to 80 km/h) could be further optimised. However this requires further investigation of tests of composite brake blocks under winter conditions. For this reason, it cannot yet be estimated, to what extent the socio economic impacts as presented in *Table 2* can be affected.

11.1.2. Effects for industry and BNP

The Swedish export industry is located far away from their main markets and are dependent on safe, reliable and affordable transportation in order to maintain competitiveness. A large part of these products being exported are heavy goods and products for which the cost of transportation makes up a large part of the value of the product, e.g. forestry and mining products. In addition these products are not suitable for transport by other modes than rail.

Some industries in Sweden, like paper mill factories, use freight wagons as a rolling inventory. Train arrivals and departures are integrated into the work flow at the production facility. Finished goods are hot-loaded into a buffer of empty wagons, while for the incoming wood trains the locomotive, blocking a track in the node, waits while the timber wagons are discharged.

An increase of the time for turnaround of the wagons would lead to further wagons needed in the integrated system and would require increased capacity in the shunting yard at the industries. In the long run, these kind of huge investments may be shunned by the industries.

Furthermore, a change of the timetable mid-season to accommodate for poor brake performance of composite brake blocks in winter conditions would require huge adjustments of the production at the factories; adjustments that probably would not be acceptable.

Overall, these secondary effects would lead to a modal shift from rail to other available transport modes, e.g. road.

Konjunkturinstitutet, the National Institute of Economic Research, estimated that the production costs for rail transports would increase by 30 % for the rail freight customers and as a consequence the negative effect on national gross production is a reduction of about 0.23 % for the whole Swedish industry which equals 16,000 MSEK/1,450 MEUR (per year), which is much higher than the calculations in *Table 2*.

11.1.3. Collapse of single wagon load traffic

Trafikverket estimated that the speed reduction to 80 km/h combined with longer running cycles for trains in the single wagon load system will probably lead to a quickly deteriorating number of single wagon load-connections that could result in a collapse of the complete single wagon load system in Sweden. This could be considered as a worst case scenario, if no solution can be found to mitigate the problems of a reduced break performance, as described in the baseline scenario. NSA SE estimates that the effect resulting from such a collapse would be a modal shift from rail to road and sea transport modes of 8 billion tonne kilometres per year, which is about twice than the modal shift in the baseline scenario[16]. The external costs resulting

[16] According to an EC study from 2015 about the single wagon traffic - link: https://ec.europa.eu/transport/sites/transport/files/2015-07-swl-final-report.pdf, the single wagon load traffic load in Sweden was 5.5 bn tkm in 2012.

from this modal shift are 170 MEUR/year.[17] The single wagon load transport is already under extreme pressure due to price competition from road transport and low margins in the industry. The collapse of the single wagon load in Sweden would likely negatively impact (as a chain reaction) this transport mode in other European countries (e.g. Norway, Germany) due to the reduced transport volume and increased transport costs. The total single wagon load traffic volume in the European Union is 75 billion tonne kilometres per year[18]. This transport volume would be shifted to other transport modes in case of a collapse. UIC doubts that the consequences of the baseline scenario would result in such a worst case, without specific justifications.

11.1.4. Non-sufficient capacity for shunting

If the brake performance of a train is still insufficient to operate at lower speeds (e.g. 80 km/h as used in the model by Trafikverket, see above), railway undertakings would need to build trains with a certain proportion of freight wagons with cast-iron brake blocks in marshalling and shunting yards in order to form an appropriate train.

The increased operational costs of shunting in sufficient number of freight wagons with cast-iron brake blocks in the trains are estimated by Green Cargo to 275 SEK/25 EUR per ranked freight wagon. Assuming 1 million impacted train runs per year for Sweden, the costs are 275 MSEK/25 MEUR per year.

In addition the existing shunting capacity of the yards has to be increased:

The Swedish railway undertakings estimated that capacity at shunting yards needs to be increased in Malmö and Hallsberg requiring additional infrastructure investments.

Trafikverket estimates the cost of upgrading a shunting yard to be approximately 2,000 MSEK/180 MEUR; thus the total cost for the necessary upgrading[19] would then be 4,000 MSEK/360 MEUR and would require at last 10 years in planning and effectuating the increase.

There are secondary positive effects on shunt capacity due to the general reduction of maximum speed, however these are marginal and do not play any role compared to the primary effects (due to insufficient number of freight wagons with cast-iron brake blocks).

11.1.5. Fleet management

Railway undertakings would in fact be expected to keep a fleet of cast-iron braked wagons obviously causing increased shunting and administrative costs. This management of a double fleet of wagons decreases the optimal usage of the wagons (more wagons running longer routes empty) and increases operational complexity due to the management of double fleets (wagon handling, shunting, wagon management - right wagon at the right place at the right time.). The Swedish rail sector estimated an additional cost impact of 200 MSEK/18 MEUR per year.

11.1.6. Increase in maintenance costs

As the resulting brake performance is provided by a reduced number of brakes, the maintenance costs of these brakes will increase especially during winter conditions. In the impact assessment for the limited revision the additional life-cycle cost to 0.022 EUR/wagon km. The Swedish transport sector estimated the impact to be about 0.033 EUR/wagon km due to higher brake load. Assuming 20 wagons per train and 36,000 train km/year, the total cost would be 20 - 30 MEUR per year for the Swedish Rail Sector.

[17] See Handbook on the external costs of transport Version 2019 - 1.1, Table 73, values for 2016 - link: https://ec.europa.eu/transport/sites/transport/files/studies/internalisation-handbook-isbn-978-92-79-96917-1.pdf

[18] See footnote 17 - The total single wagon load traffic in the European Union was 75 bn tkm in 2012.

[19] The assumption is that two major shunting yards in Sweden need to be upgraded.

11.2. Option 1: Specific wagon fleet with disc brakes

Instead of brake blocks a freight wagon could be equipped with disc brakes which offer a similar reduced noise level as composite brake blocks, however they are less impacted by the winter conditions, as reported by UIP during the task force. If there would be a sufficient number of international wagons with disc brakes operating to Sweden, the problem and the economic consequences of the baseline scenario could be completely mitigated. Green Cargo operates 66 freight wagons fitted with disc brakes which make up 4 freight trains. Winter operation 2019 – 2020 with these wagons showed no problems. However, bigger return of experience of disc brakes in freight wagons in Nordic winter conditions is needed as this winter has been extraordinarily mild. It might be, that operational rules and de-icing will be needed for disc braked freight wagons, too.[20]

A new freight wagon with disc brakes is about 10 % more expensive than one equipped with composite brake blocks. The increased costs are estimated in the range of 10 - 14 kEUR/wagon by the Swedish railway sector.

As the cost to retrofit an existing wagon with disc brakes is almost as high as a new freight wagon with disc brakes this alternative is not feasible and will therefore not further investigated.

Conservative estimate for impacted wagon fleet

There are 629,000 freight wagons in Europe and the single wagon load represents 27 % of the transport work in Europe and 2/3 of the wagon load is of an international nature.

The ERA CBA for the NOI TSI revision[21] assumes a 12 % reduction of the wagon fleet until year 2026 due to efficiency gains. With the assumption that freight wagons in the singe wagon load system perform the same transport work per wagon as the wagons in the full train load the number of wagons in the European singe wagon load system is:

$$629\ 000\ x\ \frac{27}{100}\ x\ \frac{2}{3}\ x\ (1 - 12\ \%) = 100{,}000\ wagons$$

In order to mitigate the negative effects of operational measures in the baseline scenario, a minimum of 100,000 wagons needs to be equipped with disc brakes. A wagon in the international single wagon load system could be sent to Sweden at any given point in time, see chapter 9.2.4 of this report for an explanation on how the single wagon load system functions. This represents a conservative estimate because it assumes that every wagon in Europe used for single wagon load transport would to be used in Sweden as well.

Best Case Estimate for impacted wagon fleet

The number of impacted wagons was already estimated inside the revised NOI TSI. It is 17,500 - see Commission Implementing Regulation (EU) 2019/774, recital 10). This is considered as a best case by the Swedish rail sector. Other task force members asked for more substantiation of this figure.[22]

It is estimated, though, that the maintenance costs of wheels will be considerably lower and operative speed may be increased when equipping freight wagons with disc brakes. Thus allowing for achieving the target of more freight to rail.

[20] De-icing is currently used in passenger trains fitted with disc brakes, mostly due to comfort reasons.
[21] See ERA Impact assessment 006REC1072.
[22] The more realistic estimate can be derived from the necessary amount of freight wagons for the international freight volume from Sweden to other countries via Denmark. It does not depend on the number of registered wagons in a country. From ERA side, such estimates can only be provided by international freight forwarders.

Fleet Renewal

The fleet renewal rate in the ERA CBA for the NOI TSI revision was estimated with 2 %. This is a very optimistic view as the reported renewal rate currently reported by the railway sector is only approximately 1 %.

Based on a renewal fleet of 2 %, approximately 50,000 new wagons from 2020 - 2024 would be part of the European fleet. This number is between the conservative estimate and the best case estimate and could be sufficient to cover the international freight transport to Sweden or Nordic Countries.

However further incentives have to be made available to investors to reach 2 % renewal rate.

Incentives

Two incentives are necessary to push investments into disc braked wagons:

- Differential costs between disc braked wagons and composite brake block braked wagons have to be compensated. For the further evaluation, 10 kEUR/wagon are considered.
- To push the renewal of the fleet, the residual value of the existing wagons has to be compensated. For the further evaluation, 10 kEUR/wagon are taken into account too, considering a lifetime of 20 years of a wagon and investment costs of 100 kEUR/wagon, this equals a residual lifetime of 2 years for a wagon.

In total, this sums up to an incentive of 20 kEUR/new wagon. This incentive is necessary only for wagons procured until 2024 when the ban for noisy freight wagons will be in force.

The following table calculates the total or yearly (until 2024) incentives necessary based on the assumed wagon fleet:

	Wagon Fleet Best Case 17,500 *(Assumption in revised Noise TSI)*	*Wagon Fleet 2 % 50,000* *(Total Renewal until 2024)*	*Wagon Fleet 100,000* *(Conservative Estimate)*
Total incentives	350 MEUR (3,400 MSEK)	1,000 MEUR (9,650 MSEK)	2,000 MEUR (19,300 SEK)
Incentives per year (from 2021 until -24)	88 MEUR (850 SEK)	250 MEUR (2,400 MSEK)	500 MEUR (4,800 MSEK)

The yearly costs for the incentives for the 2 % renewal scenario are still lower than the baseline impact. In addition these costs apply for a limited period of 4 years until the noise ban is in force. It is assumed that afterwards, no additional measures are required. This assumption is based on current experience with disc brakes in the Nordic countries.

11.3. Option 2: Fitting all freight locomotives to be operated in Nordic countries with ‘winter brakes’ or locomotive mounted automatic de-icing device

This brake function consists of automatic light brake applications without traction cut-off in order to regularly clean the layer of snow and ice between the wheel and the brake block. The idea of the function of de-icing of the brake equipment of the wagon is that this will ensure the correct brake performance of the composite brake block. In addition, as it is automatically applied, the traction effort is not cut while conditioning the wagon brake equipment. Furthermore, the driver will not be responsible for applying the conditioning braking therefore adding a layer of safety, a technical barrier, to the system.

This requires a modification (additional brake panel) in the freight locomotives only. No modification is needed on the freight wagons.

The automatic brake de-icing device consists of pneumatic valves mounted on a brake panel which in turn is mounted in the locomotive on the main brake pipe.

The device will at set time intervals reduce the air pressure of the main brake pipe and so realise a brake effort of the wagon brake systems; i.e. apply brake pressure of the composite brake block on the wheel in effect realising an automatic conditioning or de-icing of the brake equipment.

The device, however, is today not a standard product and exists only in a prototype version for conventional rail freight wagons.

Based on the tests in Finland in 2019 (draft report UIC B126/DT450), the use of this kind of device in closed bogie configurations which are the most usual in Finland may in certain winter conditions:

- Cause significant snow and ice build-up in the bogie
- Brake rigging gets stuck
- Braking performance decreases significantly or could be lost completely.

However, the full function of the device is planned to be tested during winter testing in 2020/2021.

The following cost figures represent a first rough estimate:

- NSA SE estimates that around 200 freight locomotives in Sweden need to be equipped with such device
- The cost of implementing such device is estimated with 0.5 MSEK/45 kEUR per locomotive type

This would lead to total costs of 100 MSEK/9 MEUR to mitigate the problem of the baseline scenario and represents the best scenario from a strictly economic point of view.

However several issues remain to be solved – these mainly concern the fitting of the device in the locomotive and the full function of the device. In modern locomotives the traction cut-off is realised by software so in order to implement the device in such a locomotive requires software modifications while for older types a software modification is not necessary.

Furthermore, the issue of locked brakes due to continuous operation of brake cylinder must be investigated with field tests over a lengthy period to gain experience of the function of the device.

Finally, the effect of the continuous braking function being applied on a heavy freight train running in an uphill (length and gradient) needs to be investigated.

The technical feasibility of this option is considered to be weak, especially considering the fact that a standardised and tested product needs to be available before 2024. However this option can be combined with any other proposed option mitigating the problem.

11.4. Option 3: Composite brake blocks tailored for Nordic countries

The main idea is to retrofit all existing freight wagons and install in new freight wagons within the Union rail system with an area of use encompassing Nordic countries with ‘silent’ brake blocks that achieve adequate brake performance in all weather conditions.

There are no developments expected so far tailored for Nordic countries.

The time to develop a new brake block, including the required testing, is estimated by some block manufacturers to seven years and several million euros in development costs.

The sintered brake blocks might potentially represent such tailored brake blocks.

The technical feasibility of this option is considered to be very weak. However this option can be combined with any other proposed option mitigating the problem.

11.5. Option 4: Exemption of wagons from the NOI TSI regulation

The solution is based on the assumption that a number of wagons are thought to be exempted from the requirements of the revised NOI TSI and may still travel on all quieter routes of the rail system within the European Union.

The negative impact is an increase in noise costs in all other European Member States, where the wagons will operate.

For the evaluation, an exemption of[23] 17,500 wagons from the noise ban is considered. Applying the ERA noise cost model used for the CBA of the revised NOI TSI, this would result in an averaged dB reduction from 4.3 dB (no additional exemptions from the NOI TSI) to 4 dB[24]. The negative impact yields in an increase in noise costs **of approximately 70 MEUR/year** for whole EU railway network.

The cost impact is a recurrent cost impact. For this reason, this option can only be seen as a transitionary measure for a limited timespan.

11.6. Preferred option and further conclusions

At current stage options 1 and 4 represent a technical feasible[25] and economic useful options. These 2 options complement each other. A temporary exclusion of freight wagons for a specific time window according to option 4 would allow sufficient time to create a specific pool of silent wagons which could operate in Sweden under winter conditions as well (option 1).

Concerning the option 4, some aspects require further clarification, e.g. how many wagons are needed for international transport to Nordic countries, what are the criteria that wagons get an exemption? How is this going to be controlled and enforced? If option 4 is immediately applied for a period until 2025, then no change of EU legislation is necessary.

However as some important information such as results from a risk analysis and from tests in harder winter conditions is currently not yet available, it is impossible to draw final conclusions.

Current operational measures might be further optimised, such that the economic impact of the baseline might be reduced.

Option 2 could be a working solution if more test and development time would be available.

For the option 3, sinter blocks could be a working solution, if demonstrated in future test campaigns under stronger winter conditions.

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[23] Some specific freight wagon types (including types as specified in the specific cases) are already exempted from the application of the NOI TSI.

[24] For the calculation, the following assumption was taken: This wagons fleet is distributed equally over the whole European Union and the additional noise costs are calculated over the whole European Union. Most likely, the wagons will be distributed only in certain European countries (CH, DE, DK, NL, NO, SE) - leading to a higher ratio of noisy wagons compared to silent wagons in these countries and higher noise costs in these countries. In this case only the additional noise costs in the concerned countries have to be taken into account. It is assumed that in both approaches the total additional noise costs are at similar level.

[25] The operational measures as described in the baseline scenario can be considered as somehow 'feasible' as well however they are undesirable and unbalanced within the EU Member States. The objective of this impact assessment is therefore to find solutions to mitigate these operational measures, with a lower cost impact than the impact described in the baseline scenario.

Annex 1 Definitions and abbreviations

Table 3: Definitions

Definition	*Description*
CH	Switzerland
DE	Germany
DK	Denmark
EUR	Euro
FI	Finland
NL	The Netherlands
NO	Norway
PL	Poland
SE	Sweden
SEK	Swedish Crown

Table 4: Abbreviations

Abbreviation	*Description*
ASTOC	Association of Swedish Train Operating Companies
CER	Community of European Railway and Infrastructure Companies
EIM	European Rail Infrastructure Managers
ERA	European Union Agency for Railways
FEMFM	Federation of European Manufacturers of Friction Materials
IM	Infrastructure manager
LAW-B	Locomotive mounted automatic de-icing device
LKAB	Luossavaara-Kiirunavaara Aktiebolag
NDTAC	Noise differentiated track access charges
NOI TSI	Technical specification for interoperability relating to the ‘rolling stock — noise’ subsystem of the rail system in the Union
NSA	National Safety Authority

Table 4: Abbreviations

Abbreviation	*Description*
SPAD	Signal Passed at Danger
UIC	International Union of Railways
UIP	International Union of Wagon Keepers
UNIFE	Association of the European Rail Industry
WAG TSI	Technical specification for interoperability relating to the 'rolling stock — freight wagons' subsystem of the entire European Union's rail system

Annex 2 Reference documents

Table 5: Reference documents

N°	*Title*	*Reference*	*Version*
[1]	Swedish Tests of Block Brake Performance in Winter Conditions		30/09/2018
[2]	Test report Composite brake block winter tests at low speeds	VRTe/K 10/05/18/1215	11/07/2018

Annex 3 Reference legislation

Table 6: Reference legislation

N°	*Title*	*Reference*	*Version*
[1]	Regulation (EU) 2016/796 of the European Parliament and of the Council on the European Union Agency for Railways and repealing Regulation (EC) No 881/2004	2016/796	
[2]	Directive (EU) 2016/797 of the European Parliament and of the Council on the interoperability of the rail system within the European Union	2016/797	

Table 6: Reference legislation

N°	Title	Reference	Version
[3]	Commission Regulation (EU) No 1304/2014 on the technical specification for interoperability relating to the subsystem 'rolling stock — noise' amending Decision 2008/232/EC and repealing Decision 2011/229/EU	1304/2014	
[4]	Commission Implementing Regulation (EU) 2019/774 of 16 May 2019 amending Regulation (EU) No 1304/2014 as regards application of the technical specification for interoperability relating to the subsystem 'rolling stock — noise' to the existing freight wagons	2019/774	
[5]	Commission Decision 2011/229/EU concerning the technical specifications of interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system	2011/229/EU	
[6]	Commission Decision 2006/66/EC concerning the technical specification for interoperability relating to the subsystem 'rolling stock — noise' of the trans-European conventional rail system	2006/66/EC	

Annex 4 Technical description of train protection system assisted brake testing

At departure the brake equipment must be checked. It is a very time consuming activity to determine if the brakes are applied or not when the brake equipment is completely covered with ice and snow. Very low probability to be able to run the train when doing the 'pre-departure' check of the brake performance. Composite brake blocks generally display a very poor brake performance at departure and at low speed winter time.

It is not advisable to place the responsibility to the driver to act as barrier to brake failure (e.g. by demanding the driver to constantly condition the brake equipment).

The automatic train protection system in Sweden, ATC2, is capable of validating the brake performance of the friction brakes of the train. The driver is obliged to perform a check soon after departure, if weather conditions deteriorate further or when the driver considers that the brake performance may have been affected adversely. The theoretical brake performance of the train is the input in the ATC2-system. This theoretical value is validated by the system when the driver effectuates a R1/R2 check. The driver firstly brakes with 1 bar pressure reduction (R1); should the system return a lower than expected value another brake with 1.5 bar reduction (R2) is effectuated. The return value after the R2-test is the new brake performance of the train. This value is fed into the ATC2-system.

The maximum allowed speed of the train may have to be reduced in cases where a lower value has been fed into the system; 100 km/h to 80 or 70 km/h depending on the brake performance.

In case the brake percentage is now 60 % or less the train must be stopped and the brakes are to be checked. The train may not be moved again until brakes have been rectified.

Annex 5 Winter in Sweden - Facts and figures

Figure 3: Snow cover in Sweden 18th March 2018 - [Source: SMHI - Swedish Meteorological and Hydrological Institute]

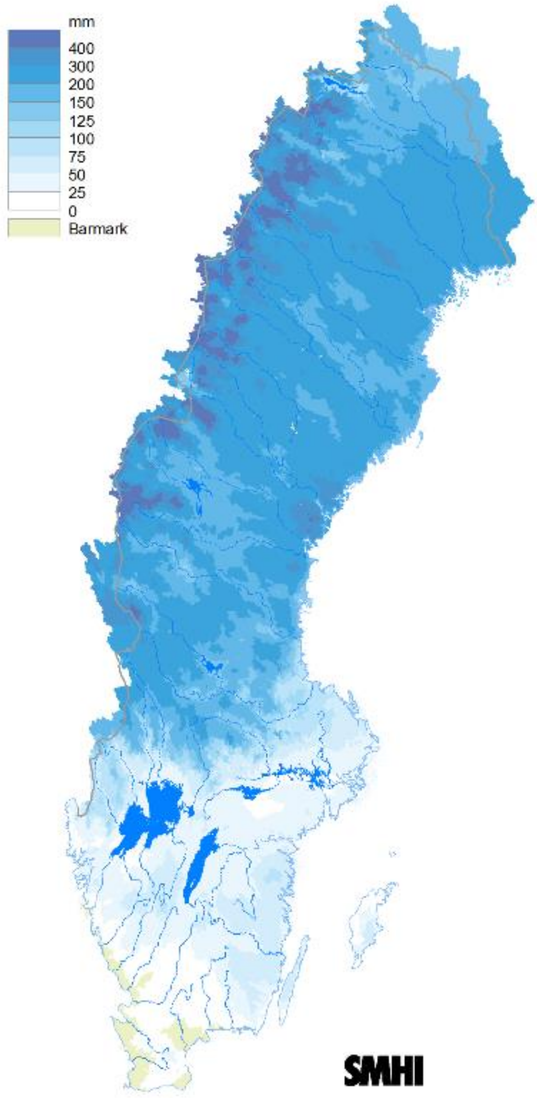
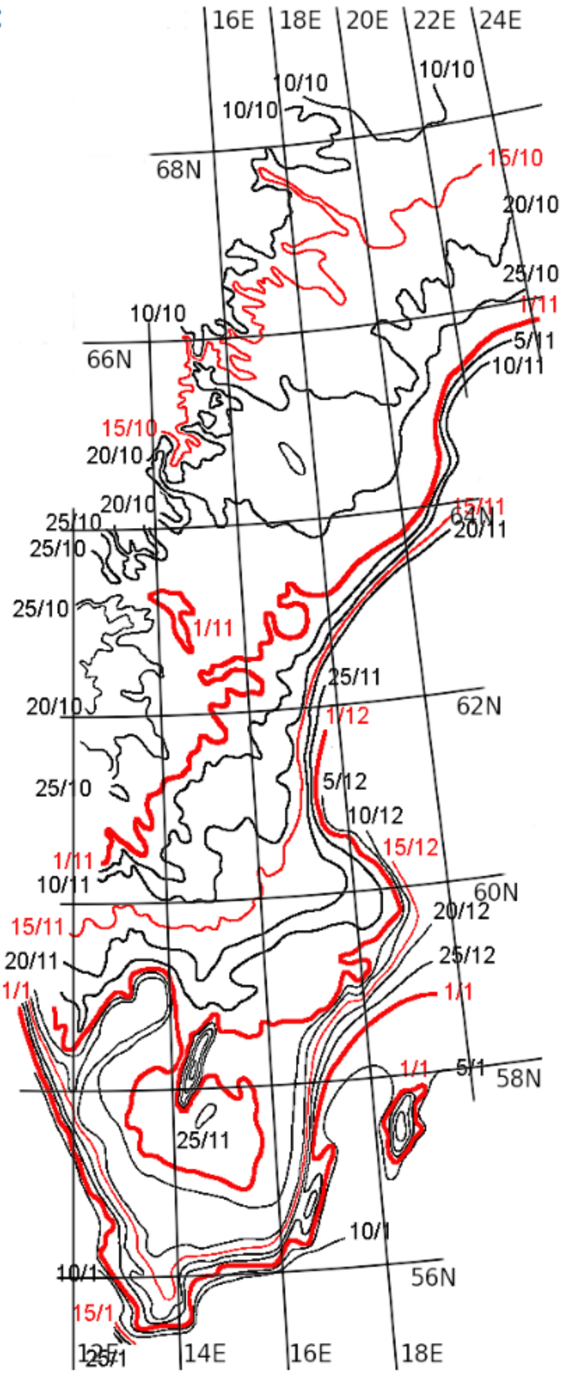
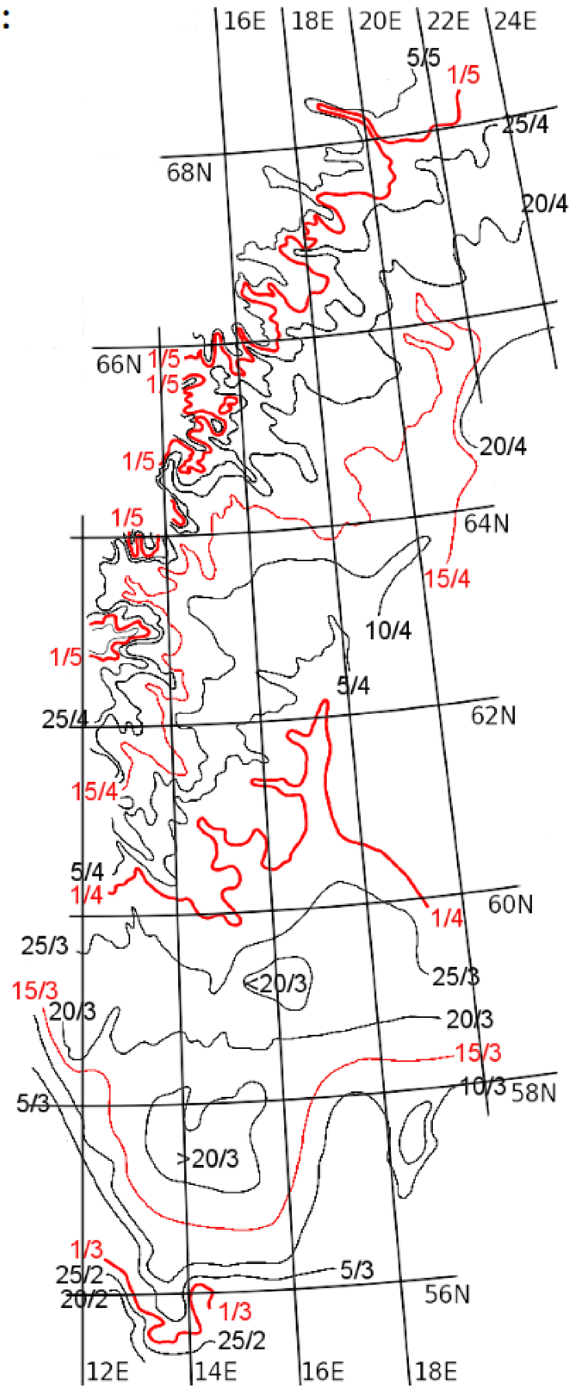


Figure 4: Winters coming - Definition: Average daily temperature below 0 °C - [Source: SMHI]

Figure 5: Spring arrives - Definition: Average daily temperature above 0 °C - [Source: SMHI]





Winter period - First snow and ground covered in snow - 2017/2018 *(potentially snowfall → flying snow → poor braking performance of composite brake blocks)* *(ground covered with snow (as long as temperature not above 0 ℃) → flying snow → poor braking performance of composite brake blocks)*				
Skåne	10/1	1/3	Winter	~2 months
	22/11	5/4	Snowfall	~5 months
	4/2	5/4	Ground covered	~2 months

South region incl. Mjölby	20/11	20/3	Winter	~4 months
	11/11	8/4	Snowfall	~4,5 months
	12/12 15/1 2/2	24/12 26/1 8/4	Ground covered	~3,5 months
West region incl. Göteborg, Charlottenberg	20/11	25/3	Winter	~4 months
	19/11	7/4	Snowfall	~5,5 months
	12/12 15/1 2/2	24/12 26/1 7/4	Ground covered	~3 months
East region incl. Hallsberg, Stockholm	15/11	25/3	Winter	~4,5 months
	12/11	10/4	Snowfall	~5 months
	12/12 15/1 30/1	24/12 26/1 10/4	Ground covered	4 months
Central region incl. Borläng/Gävle - Östersund/Långsele	1/11	5/4	Winter	~5 months
	31/10	7/5	Snowfall	~6 months
	12/11	7/5	Ground covered	~6 months
North region	10/10	5/5	Winter	~7 months
	22/10	20/5	Snowfall	~7 months
	31/10	20/5	Ground covered	~7 months

Annex 6 Winter in Finland - Facts and figures

Figure 6: Length of winter during 1981-2010. Top left, average starting date of thermal winter. Top right, average starting time of thermal spring. Bottom, average length of thermal winter in days - [Source: FMI - Finnish Meteorological Institute]

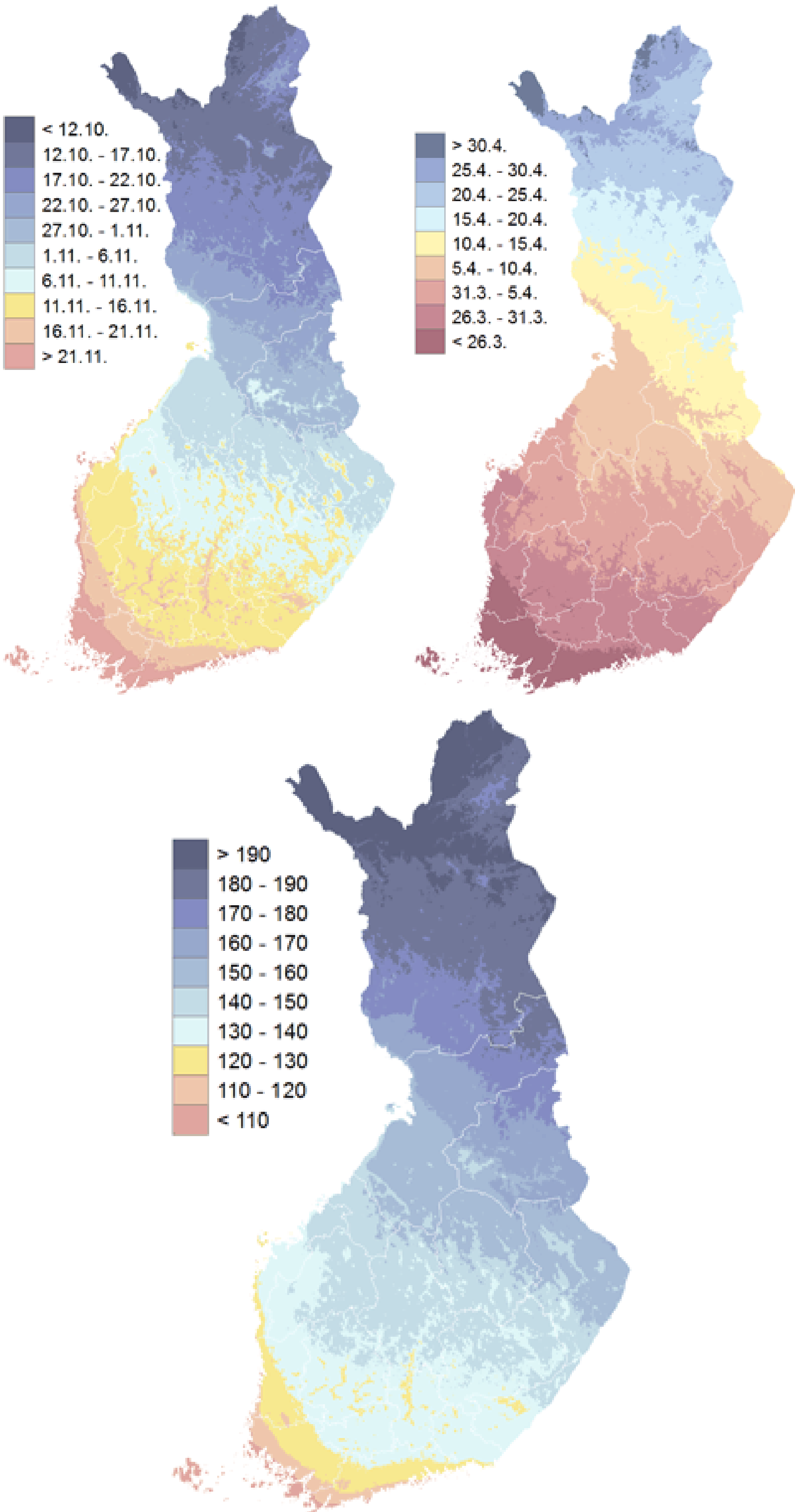
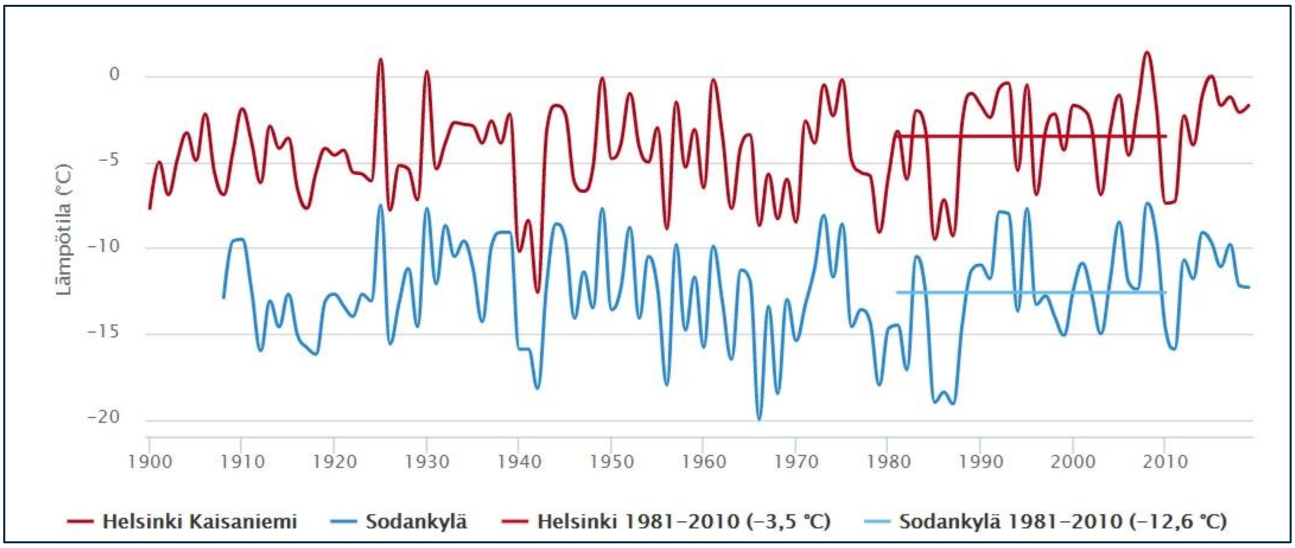
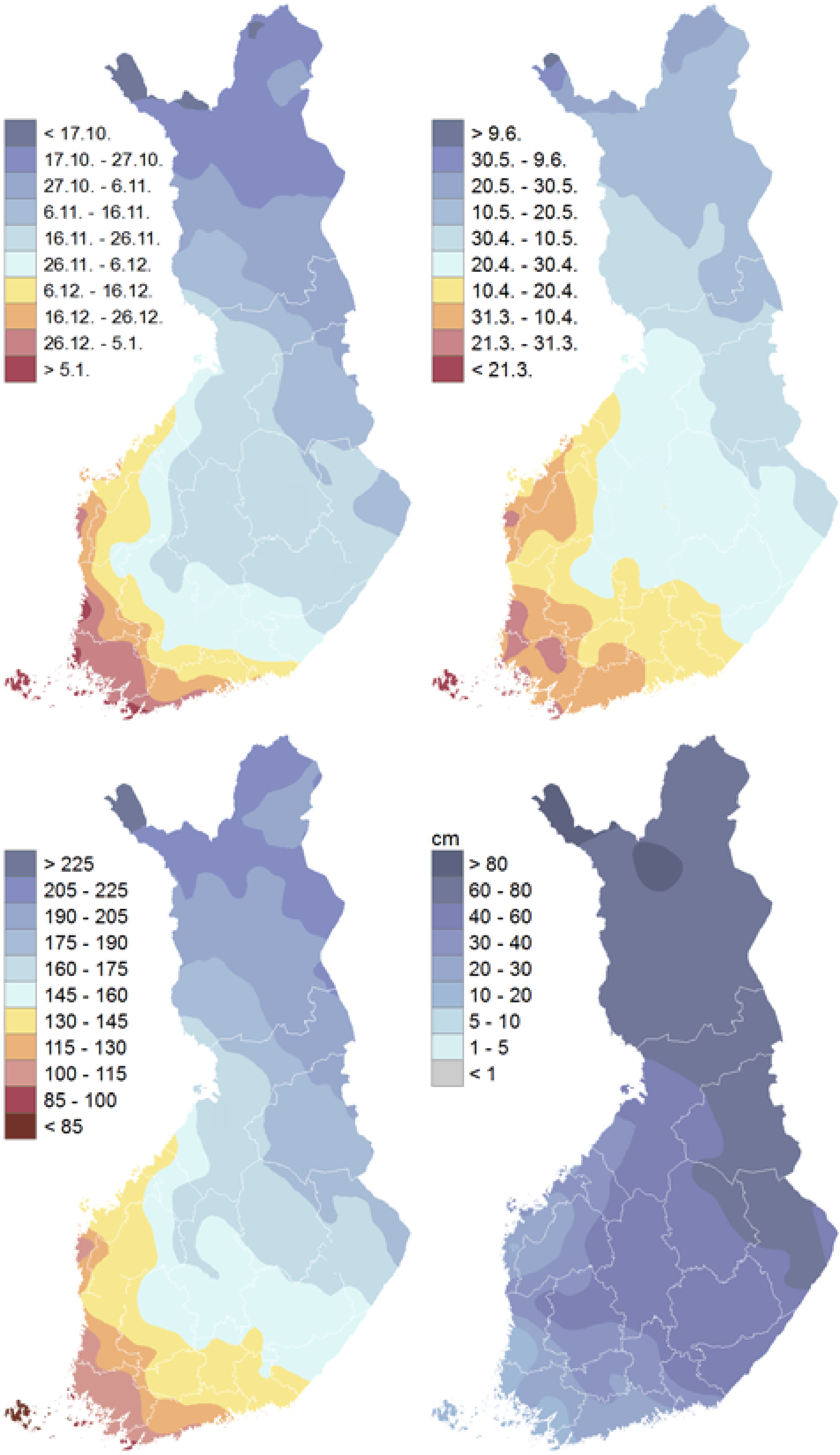


Figure 7: Winter in South and North of Finland. Average temperatures during winters (Dec-Feb) in Helsinki (1900-2018) and Sodankylä (1908-2018) - [Source: FMI]

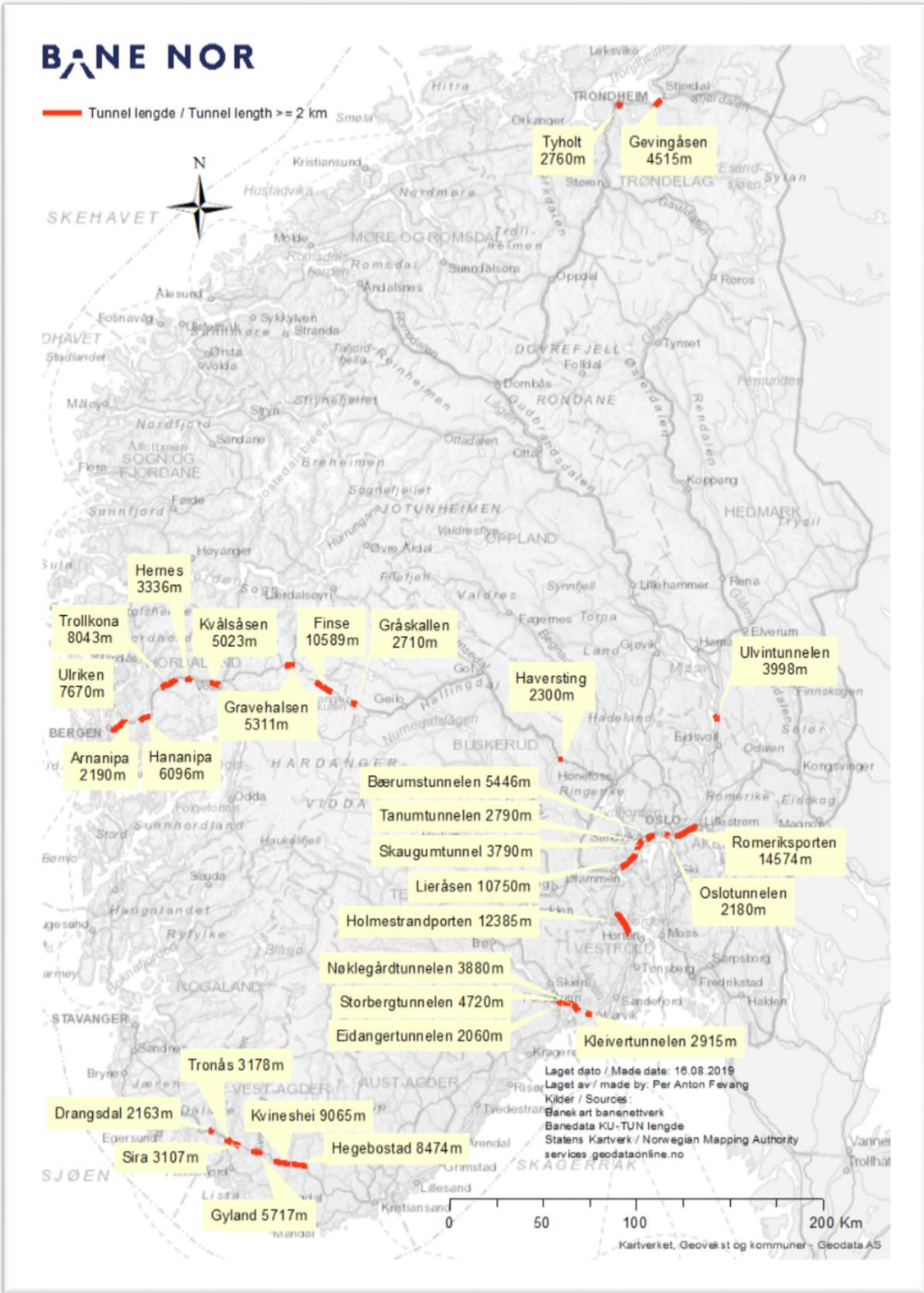


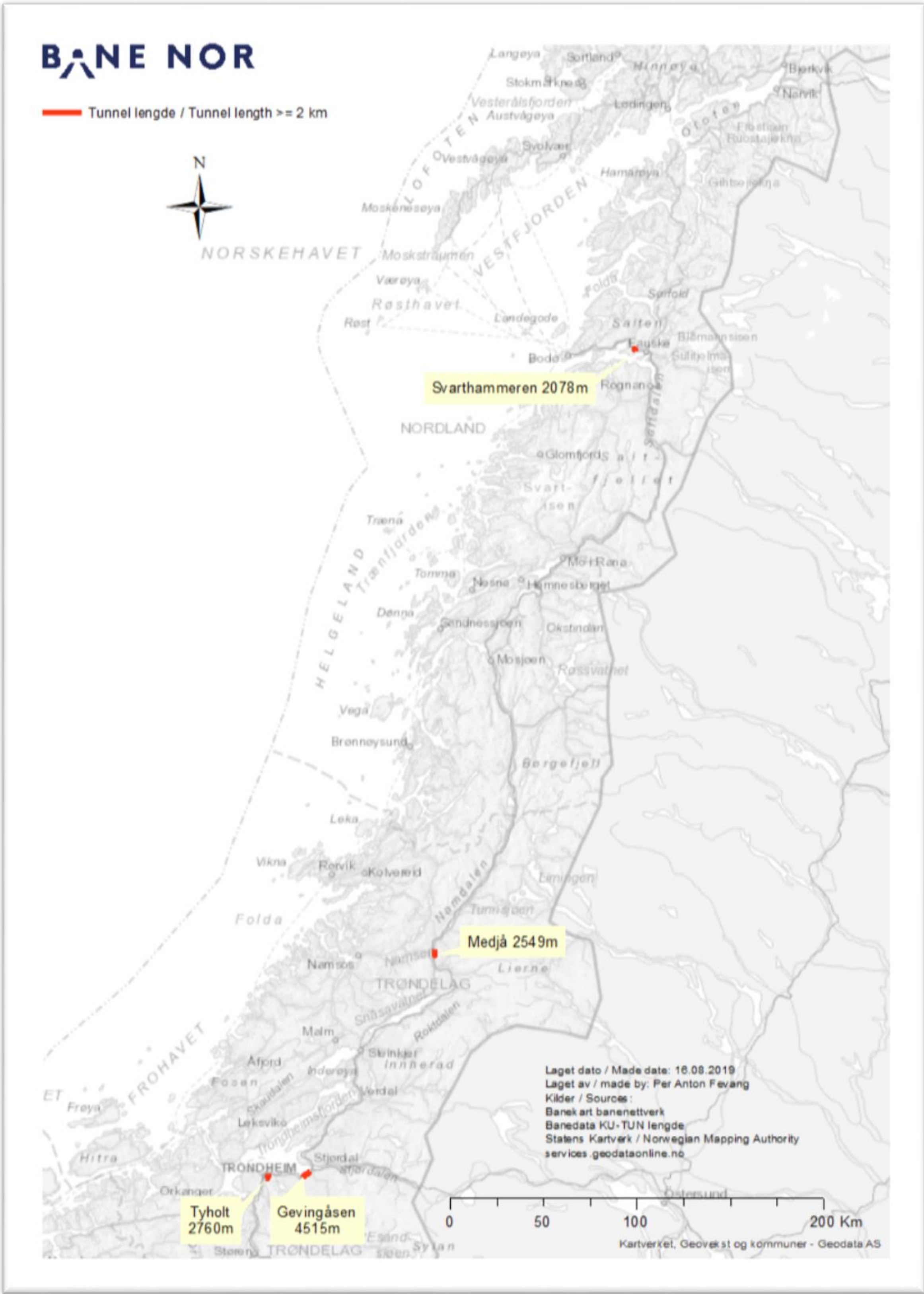
Arrival of snow cover varies from winter to winter, but *Figure 8* gives indication of periods of permanent snow cover and depth of snow:

Figure 8: Average snow during 1980-2010. Top left, arrival of permanent snow cover. Top right, leaving of permanent snow cover. Bottom left, average length of period of permanent snow cover. Bottom right, average depth of snow on 15th March - [Source: FMI]

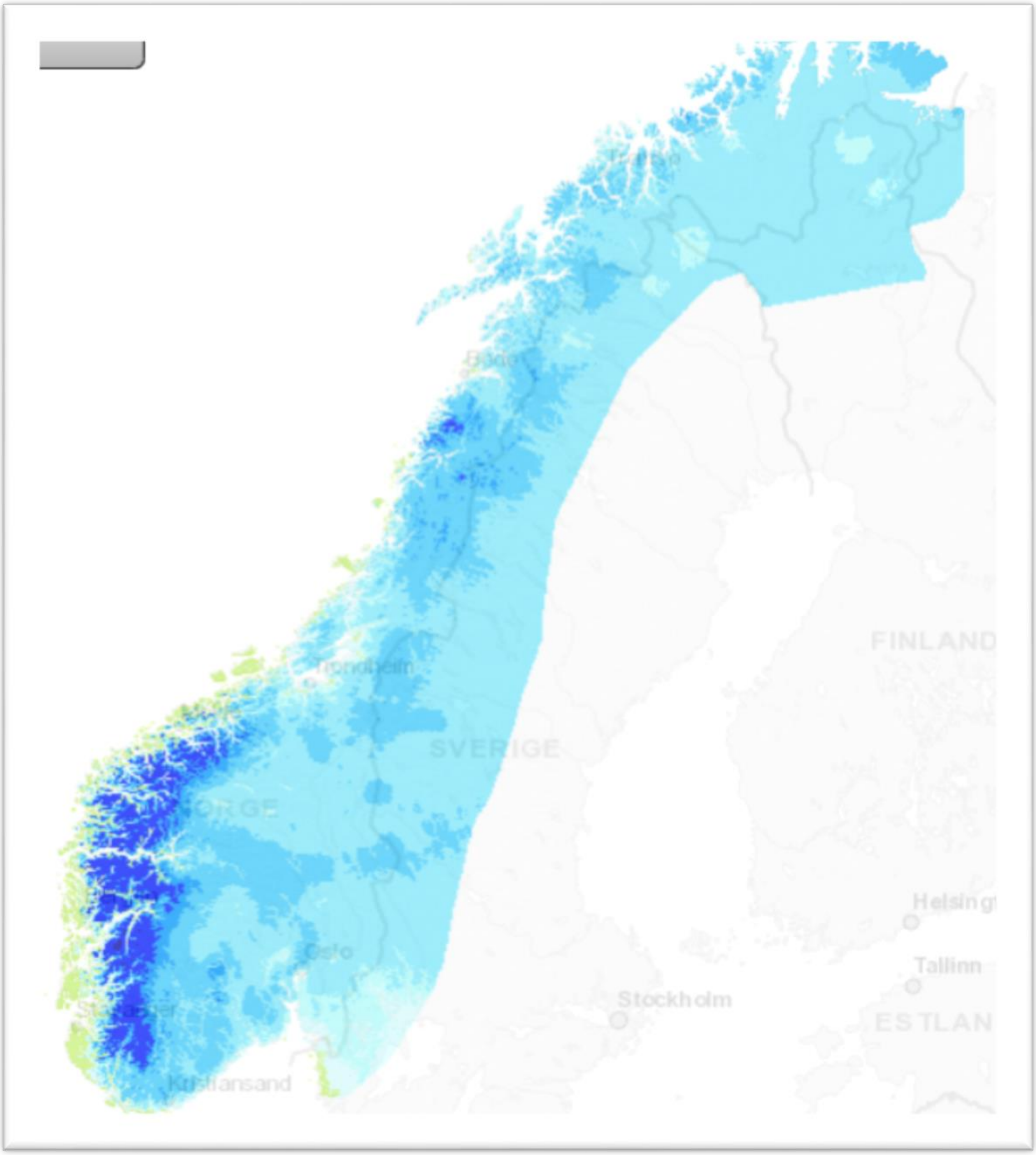


Annex 8 Tunnels in Norway with length longer than 2 km

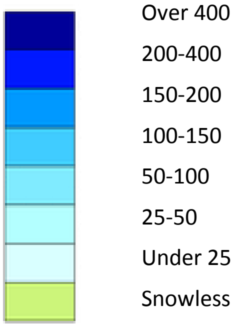



BANE NOR
Tunnel lengde / Tunnel length >= 2 km
N
NORSKEHAVET
Svarthammeren 2078m
NORDLAND
Medjå 2549m
TRØNDELAG
Tyholt 2760m
Gevingåsen 4515m
TRONDHEIM
Laget dato / Made date: 16.08.2019
Laget av / made by: Per Anton Fevang
Kilder / Sources:
Banekart banenettverk
Banedata KU-TUN lengde
Statens Kartverk / Norwegian Mapping Authority
services.geodataonline.no
0
50
100
200 Km
Kartverket, Geovekst og kommuner - Geodata AS

Annex 9 Average snow depth in Norway (2018)



Average snow depth in cm:


Over 400
200-400
150-200
100-150
50-100
25-50
Under 25
Snowless

Annex 10 Safety alerts

SAFETY ALERT

SYSTEM/ EQUIPMENT	Composite brake blocks in winter conditions
SAFETY ISSUE DESCRIPTION	Finnish operator VR Group Ltd has noticed that composite brake blocks aren't working properly especially in severe winter conditions. Braking performance has diminished and the braking/stopping distances have become longer, in some cases even dangerously. Partial loss of braking performance is not systematic but more sudden and unpredictable in nature.
CIRCUMSTANSES *(e.g. special weather conditions)*	Snps and Snpss wagons are used to transport timber. Wagons are equipped with brake blocks C333 in K16 bogie assembly. Wagons have been in use for about eight years. During this period wagons have had issues with braking, most severe issue being lack of braking power in certain winter conditions. The braking power issue has recently worsened when these wagons have been used to form whole trains. Previously the trains had also older wagons with cast iron brake blocks in them. Almost all of the occurrences have been reported in wintertime in the northernmost part of Finland.
REASON FOR ISSUE	Heat dissipation from the block seems not to be sufficient to melt the ice and snow between the block and wheel. Due to lower friction coefficient of the block, the braking force applied to block is lower which also makes it more difficult to remove ice and snow from between the block and wheel.
LIST OF SUPPORTING DOCUMENTS *(e.g. PHOTOS, LINKS)*	ANNEX 1. VR presentation "Winter conditions and composite brake blocks"
LINKED WITH OCCURRENCE NOTIFIED TO ERA DATABASE?	Choose an item. **OCCURRENCE DATE** Click here to enter a date.
	LINK TO ERA NOTIFICATION Click here to enter text.

ISSUER

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Safety Information System

Safety problems with composite brake blocks

The Swedish NSA, Transportstyrelsen, has got information from the Swedish railway undertaking Green Cargo (the largest Swedish freight company) about three reported incidents in winter conditions concerning trains with wagons using composite brake blocks.

1. The first incident was an unpermitted passing of a STOP-signal outside Gävle. The train had a speed of 18 km/h and braking was applied 200 m before the signal. No retardation was obtained and the train passed the signal with 20 m, after emergency braking. The train consisted of 100 % wagons equipped with composite brake blocks of type C810.

2. The second incident was a train that reported poor braking performance after a retardation check. The same driver was driving the train both in loaded condition and in empty condition. In loaded condition the brake performance was 10 % below the calculated value. In empty condition the brake performance was 18 % below the calculated value. The train consisted of 100 % wagons equipped with composite brake blocks of type C810.

3. The third incident occurred between Boden and Haparanda in northern Sweden on the 3rd of February 2017. The weather was -2˚C with whirling snow. The train consisted of eight wagons. Two of the wagons had four axles and composite brake blocks (C810). These wagons were placed first and last in the train. The other six wagons had two axles and cast iron brake blocks. The “composite wagons” were heavy and loaded with dangerous goods. The weight of the composite wagons was 42% of the total weight of the wagons and had 41% of the total brake weight of the wagons.

   The driver braked every 15 minutes but still experienced that the train's braking capability was decreased during the journey. When the train came to Haparanda the wagons were checked. The cast iron blocks had no build-

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up of ice and snow but the composite blocks had. It was possible to move the last wagon without having the brakes released - the wagon appeared to be unbraked.

Green Cargo has concluded that the reason that the train could finish the journey probably was thanks to the wagons with cast iron blocks having enough braking capacity for the whole train. Green Cargo sees a severe risk in having a wagon loaded with dangerous goods as the last wagon in the train when the wagon could lose its braking capability in winter conditions due to composite brake blocks.

Besides these three incidents the drivers at Green Cargo have reported about experienced operational risks in winter conditions with trains consisting of wagons equipped with 100 % composite brake blocks, but without leading to incidents.

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