Norwegian Safety Investigation Authority

Issued August 2022

REPORT ROAD 2022/06

Accident involving a passenger car and an HGV driver on the E18 road near Arendal on 29 May 2020

The Norwegian Safety Investigation Authority (NSIA) has produced this report exclusively for the purpose of improving road safety.

The object of the NSIA's investigations is to clarify the sequence of events and causal factors, elucidate matters deemed to be important to the prevention of accidents and serious incidents, and to issue safety recommendations if relevant. It is not the NSIA's task to apportion blame or liability under criminal or civil law.

This report should not be used for purposes other than preventive road safety work.

ISSN 1894-5902 (digital version)
Photo: The police

This report has been translated into English and published by the NSIA to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report for reference.

INDEX

Report on road traffic accident

Table 1: Data relating to the incident

Date:	29 May 2020
Time:	11:19
Location:	Just north of the Torsbuås tunnel in Arendal municipality, Agder county
Road no, main section, km:	E18, S16D1, m2590
Type of accident:	Vehicle-pedestrian collision
Vehicle/road user:	A: Passenger car B: Driver of heavy goods vehicle (tractor unit and semi-trailer)
Type of transport operation:	A: Private transport B: Goods transport

Notification of the accident

The Norwegian Safety Investigation Authority (NSIA) was not notified of the accident on the E18 road (see figure 1), but became aware of it through the media. The NSIA obtained further information from the police and decided to initiate a safety investigation into the accident.

Figure 1: The E18 road near Arendal. The red star indicates the accident site. Map: Road map, NPRA Illustration: NSIA

Summary

On Friday 29 May 2020 at about 11:00, a heavy goods vehicle (HGV) consisting of a tractor unit and a semi-trailer was driving north on the E18 road towards the Torsbuås tunnel near Arendal. The vehicle was carrying roof tiles and the driver was alone in the vehicle. The driver was notified that the lashings at the rear of the semi-trailer had come loose. He stopped the vehicle on the hard shoulder of the E18 road, 181 metres northeast of the tunnel exit. Despite the driver having utilised the entire available width of the road shoulder, the vehicle was partly in the right lane. The driver exited the vehicle to secure the lashing at the rear of the semi-trailer. This resulted in him standing in the roadway to the left of the vehicle.

At the same time, a passenger car was northbound on E18. The passenger car was in the right lane when exiting the Torsbuås tunnel. As the passenger car passed the HGV, the driver heard a loud bang, and the car's windscreen cracked. The driver braked and stopped on the hard shoulder. When approaching the HGV, he saw a lifeless person in the roadway, to the left of the HGV, in the right lane.

The HGV driver did not notify the Traffic Control Centre (TCC) or anyone else after stopping outside the Torsbuås tunnel. Nor did any other road users report the stationary vehicle, and the TCC did not have access to CCTV or any other detection devices on the section of the E18 road in question. Consequently, the driver of the passenger car was not notified of the situation.

The investigation has shown that the passenger car driver’s situational awareness in the moments before the accident was that an HGV had been abandoned on the hard shoulder, and that there was room to pass it in the right lane. The HGV driver was in the vehicle’s shadow, and close to the flatbed. From a distance, it may have been difficult for the passenger car driver to see that there was a person beside the HGV.

The investigation has also shown that the passenger car's adaptive cruise control and autosteer function were activated at the time of the accident. These driver support systems were not designed to identify conflicts with people in the road or to apply emergency braking or avoidance manoeuvres automatically in this type of situation. NSIA is of the opinion that the driver might have been less involved in the driving process due to a combination of the use of the passenger car’s driver support systems and the road design.

The section of road where the accident occurred was opened for traffic on 2 July 2019. During the planning phase, Nye Veier requested permission to reduce the shoulder width from 3.0 metres to 2.0 metres, with proposed mitigating measures. The Norwegian Public Roads Administration (NPRA) approved this solution, assuming that Nye Veier would implement the proposed mitigating measures on the section of road in question. However, Nye Veier chose not to establish incident detection or extra emergency lay-bys on this section of road.

In light of the road users' situational awareness immediately before the accident, NSIA's view is that insufficient hard shoulder width and the lack of emergency lay-bys, combined with the absence of notification, were the most important contributing factors to the accident. NSIA is also of the opinion that the road safety was not sufficiently addressed by the NPRA's deviation management and Nye Veier's construction of this section of road.

A study of narrow four-lane motorways with a 110 km/h speed limit and an annual average daily traffic (AADT) of 6,000–20,000 vehicles/day was initiated by the Ministry of Transport and conducted by the NPRA. The study and the recommendation of the NPRA concluded, among other things, that motorways with an AADT of 12,000–20,000 vehicles/day can be designed as narrow four-lane motorways. The investigation has shown that several expert communities were highly critical of the content of the NPRA's studies. Several sources commented that the proposal to reduce the hard shoulder width was in conflict with Vision Zero – no fatalities or serious injuries on the road.

The process resulted in the road design norm N100[1] being amended to allow the hard shoulder width of four-lane motorways, with an AADT of < 20,000 vehicles/day and a speed limit of 110 km/h, to be reduced without the need for this to be processed as a deviation if mitigating measures aimed at ensuring that accident frequency and accident costs do not increase are implemented. The term 'mitigating measures' is not defined in N100. There is no requirement for the client/road manager to document the mitigating measures and their desired risk-reducing effects.

Scientific articles and data show a clear link between hard shoulder width and the number of traffic accidents, and a wider hard shoulder leads to fewer accidents. In light of this, the NSIA takes a critical view of allowing the hard shoulder width to be reduced in N100. In order to reduce the number of road traffic fatalities and serious injuries, Vision Zero has to be the basis for investments in the road network, including expert feedback and political decisions. In NSIA's view, sufficient importance has not been attached to Vision Zero when the Ministry of Transport tasked the NPRA with conducting a study of narrow four-lane motorways, or in the content of the NPRA's study and accompanying recommendation. NSIA is of the opinion that the accident represents a case of conflicting goals, where financial aspects have been given priority over traffic safety.

The NSIA submits five safety recommendations addressed to organisations and authorities following this investigation. The NSIA would also like to highlight the following learning points for road users:

- In hazardous situations, such as vehicles stopped along a motorway, notify the Traffic Control Centre (VTS) by calling 175.
- When you observe a vehicle stopped along a motorway, increase your safety margins by passing in the left lane if possible.
- Even if you are using your car's driver support systems, it is your responsibility to be alert, drive safely and be in control of your vehicle at all times.

[1] The legal authority for the road design norm N100 Veg- og gateutforming ('Road and street design' - in Norwegian only) (2021) is found in the Ministry of Transport's regulations pertaining to Act No 23 of 21 June 1963 relating to roads (the Road Act) Section 13.

About the investigation

Purpose and method

The NSIA decided to investigate the accident due to its severity. It was also a factor that the accident occurred on a new section of the E18 road that had a narrower cross-section than normal. The purpose of the investigation has been to clarify the sequence of events and the circumstances that resulted in the HGV driver being hit by the passenger car and dying. The NSIA has also looked at areas with a potential for improving safety and considered what can be done to improve safety and prevent the recurrence of similar incidents in the future.

The accident and the circumstances surrounding it have been investigated and analysed in line with the NSIA's framework and analysis process for systematic safety investigations (the NSIA method[2]).

Sources of information

The NSIA's investigation is largely based on the following sources:

- Elevation data from the Norwegian Mapping Authority
- The Norwegian Public Roads Administration's National Road Database (NVDB)
- Meteorological data
- Technical vehicle data from Tesla
- Simulation of the sequence of events in PC-Crash, a software tool that creates simulations of motor vehicle accidents
- Interviews and meetings with the parties involved: the driver of the passenger car, Nye Veier and the Directorate of Public Roads
- Photos and documents from the police
- Information from Oslo University Hospital
- The Norwegian Public Roads Administration's accident analysis report
- Documentation from the Directorate of Public Roads
- Documentation from the Ministry of Transport
- National Transport Plan (NTP) 2022–2023
- Manual N100 Veg- og gateutforming ('Road and street design' – in Norwegian only)

The investigation report

The first part of the report, 'Factual information', describes the sequence of events, related data and information gathered in connection with the accident, as well as the NSIA's investigation and findings.

The second part, the 'Analysis' part, contains the NSIA's assessment of the sequence of events and contributing causes based on factual information and completed investigations/examinations. Circumstances and factors found to be of little relevance to explaining and understanding the accident are not discussed in depth.

The final part of the report contains the NSIA's conclusions and safety recommendations.

[2] *See https://www.nsia.no/About-us/Methodology.*

1. Factual information

1. Factual information

1.1 Sequence of events

On Friday 29 May 2020 at about 11:00, an HGV consisting of a tractor unit and a semi-trailer was heading north on the E18 road near Arendal. The vehicle was carrying roof tiles and the driver was alone in the vehicle.

About 9 km south of the accident site, at Nedenes, the driver of a passenger car driving behind the HGV saw that the lashings at the rear of the semi-trailer had come loose. The driver called their husband, who was a colleague of the driver of the HGV in question. At 11:15, he called the HGV driver to inform him of the loose lashings. The HGV driver replied that he was at Harebakken (about 1.5 km south of the accident site), and that he would pull over to check the cargo lashings.

The driver of a camper van driving behind the HGV also noticed the loose lashing hanging down on the right-hand side of the vehicle. The camper van driver signalled repeatedly using both lights and sound to make the HGV driver aware of the loose lashing. The camper van driver saw the HGV slow down and pull over onto the hard shoulder outside the Torsbuås tunnel.

Once the HGV had come to a halt, the driver exited the vehicle. The driver had activated the yellow flashing lights above the driver's cab and at the back of the semi-trailer. No warning triangle had been deployed. According to the police, the driver was seen on foot in front of the HGV and later seen carrying a cargo lashing near the rear of the vehicle.

At the same time, a passenger car was heading north on E18 towards the Torsbuås tunnel. The driver has stated that he activated the adaptive cruise control and autosteer after entering the E18 road near Stoa, about 4 km south of the accident site. The driver has stated that he used to relax a little mentally when entering this section of the E18.

The passenger car was in the right lane when exiting the Torsbuås tunnel. The driver noticed an HGV standing on the hard shoulder outside the tunnel. As he saw no signs of activity in the area around the HGV, nor any warning lights on the vehicle or a warning triangle in the road, he interpreted the situation as a vehicle abandoned on the hard shoulder. He did not consider this remarkable. At the time, the driver's assessment of the situation was that there would not be any road users near the abandoned vehicle.

The driver of the passenger car has also stated that in situations such as this, he would normally move into the left-hand lane to pass the vehicle parked on the hard shoulder at a greater distance. He does not remember why he did not change lanes on this occasion, but assumed that there may have been vehicles in the left-hand lane that made it difficult to do so.

As the passenger car passed the HGV, the driver heard a loud bang, and the car's windscreen cracked. The driver braked and pulled over on the hard shoulder on the right side of the road. When he approached the HGV, he saw a lifeless person in the roadway to the left of the semi-trailer, in the right lane. Several other motorists also stopped in the roadway, and life-saving first aid was administered while the emergency services were notified. The driver was pronounced dead when health personnel arrived at the scene.

1.2 Survival aspects

1.2.1 NOTIFICATION AND RESCUE WORK

A police patrol happened to be heading north on the E18 road when the accident occurred and arrived at the scene at 11:25. The patrol notified the police operations centre of the accident and assisted in the rescue work until the ambulance arrived.

1.2.2 PERSONAL PROTECTIVE EQUIPMENT

The HGV driver was wearing a yellow high-visibility vest with two reflective stripes around the waist and reflective stripes on the shoulders (see figure 2). The vest was torn along the seam in the right side.

He was also wearing a pair of black work trousers of the brand 'Blåkläder' (see figure 3).

Figure 2: High-visibility vest similar to the one worn by the HGV driver. Source: YOU Odense high-visibility vest

Figure 3: Work trousers similar to the pair worn by the HGV driver. Source: Blåkläder

1.3 Personal injuries

The HGV driver died instantly from extensive injuries to the chest and neck. He also sustained a fracture in the right shin, which is described in the post-mortem report as consistent with impact from the passenger car's bumper. The post-mortem report also states that his injuries are consistent with him standing up at the time of the impact and being hit in the right-hand side by the passenger car.

The driver of the passenger car suffered no physical injuries in the accident.

1.4 Damage to vehicles and cargo

1.4.1 PASSENGER CAR

The passenger car sustained damage to the right side as a result of colliding with the HGV driver (see figure 4). The passenger car had damage to the front, windscreen, A pillar and roof. The wing mirror was also broken.

Figure 4: Damage to the right side of the passenger car. Photo: The police

Technical examinations of the passenger car found bright yellow textile traces in the cracks in the windscreen (see figure 5) and on the bottom apron below the bumper (see figure 6).

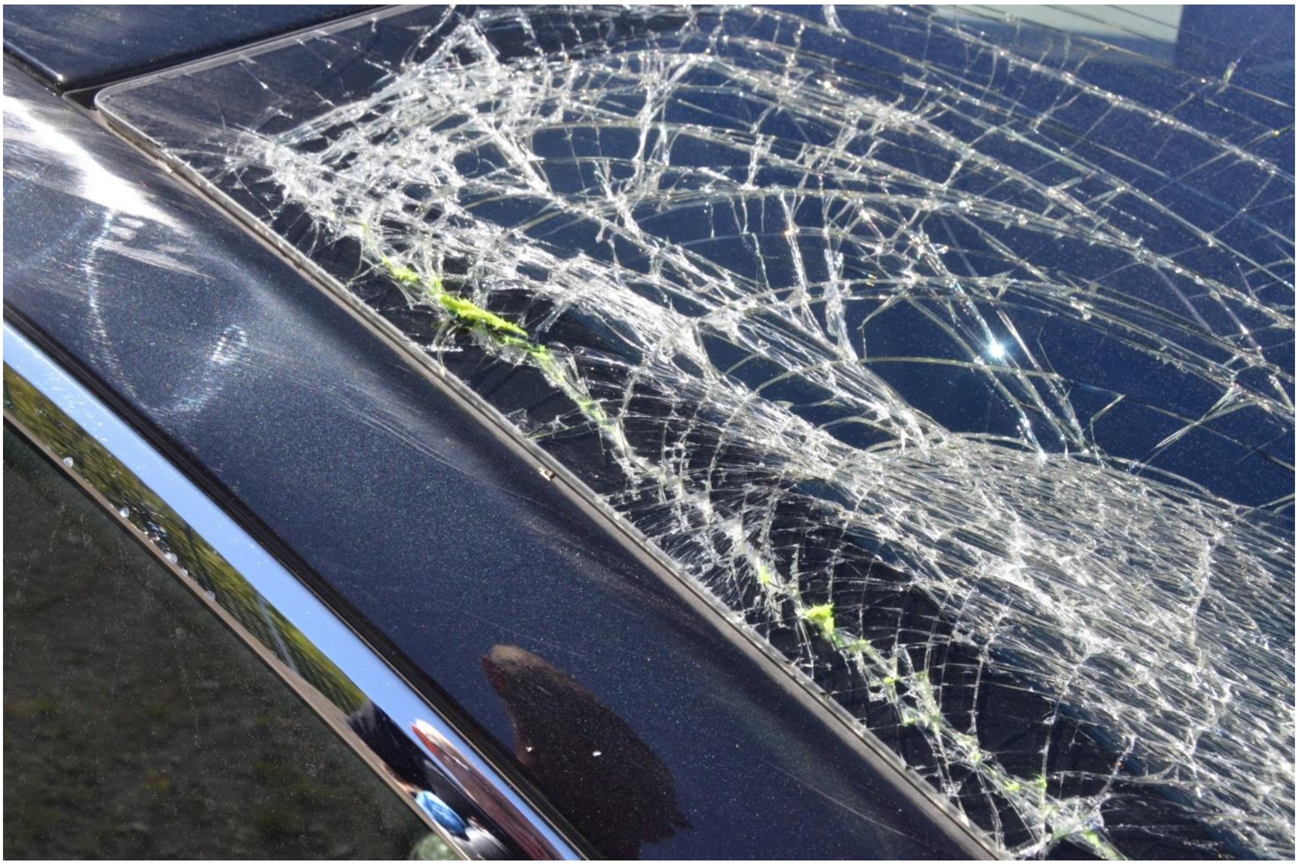
Figure 5: Yellow textile traces in the windscreen. Photo: The police


Figure 6: Lower part of the bumper and apron. The arrow indicates where traces of yellow textile were found. Photo: The police

1.4.2 HEAVY GOODS VEHICLE

The semi-trailer was carrying pallets of roof tiles wrapped in plastic. The packaging on the second, third and fourth rearmost pallets on the left-hand side of the flatbed sustained some damage in the collision between the passenger car and the HGV driver (see figure 7). Several of the tiles in the fourth pallet from the rear were broken, and pieces of broken tiles were found in the roadway from the pallet and forward in the passenger car's direction of travel. A structure on top of the semi-trailer had also shifted forward.

Figure 7: Damage to the cargo and packaging, and textile fibres found on the fender behind the left wheel on the semi-trailer's middle axle. Photo: The police. Illustration: NSIA

1.5 The accident site

1.5.1 LOCATION

The accident happened in the northbound lane of the E18 road near Arendal, about 1.5 km north-east of Harebakken. The accident site is located on a straight stretch of road 181 metres north-east of the Torsbuås tunnel exit (see figure 8).

Figure 8: Overview photo and drone photo of the accident site. Map: © Norwegian Mapping Authority. Photo: The police. Illustration: NSIA

1.5.2 MARKS REGISTERED AT THE ACCIDENT SITE

The accident site was examined, but no marks left by the passenger car were found on the roadway.

The police took the following measurements at the accident site, among others:

- Traces of blood were found on the left-hand side of the flatbed, behind the third and second axles from the rear of the semi-trailer.
- Objects belonging to the HGV driver were found on the roadway in an area of the northbound lane between 2.2 and 4.15 metres from the rear end of the HGV.
- The driver was lying on the roadway in the right northbound lane 7.25 metres from the rear end of the HGV (measured in relation to the centre line of the body).
- Parts from the passenger car were found on the roadway in the northbound lane approx. 10–12 metres from the rear end of the HGV.
- The passenger car's front number plate was located on the roadway in the right northbound lane 30.15 metres from the rear end of the HGV.

1.5.3 FINAL POSITIONS

The police measured the distance between the rear end of the HGV and the passenger car to be 87 metres.

The HGV was parked on the hard shoulder of the right lane, more or less parallel with the road markings (see figure 9 and figure 10). The left-side tyres of the HGV were partly in the right lane of the road. The police measured the outer edges of the tyres to be approx. 15–16 cm into the right lane. The tractor unit's front and rear axles were measured to extend approx. 13 cm and 23 cm, respectively, into the right lane. The tyres on the right side of the HGV were partly outside the tarmacked surface of the hard shoulder.

Figure 9: The HGV's position on the roadway. Photo: The police

Figure 10: The HGV’s position in relation to the white edge line. Photo: The police

The passenger car was on the hard shoulder of the right lane, outside the road markings (see figure 11).

Figure 11: The passenger car's position in the roadway. Photo: The police

1.6 Weather and road surface conditions

At the time of the accident, the weather was dry and sunny with good visibility, and the road surface was dry and bare. The air temperature was approx. 17°C. According to PC-Crash and Sun Surveyor, the sun was 47.1° above the horizon and 135.6° south-west in the sky when the accident occurred at 11:19.

Figure 12 and figure 13 show the shadow conditions and the extent of the shadows cast on the roadway by the HGV approx. 50 minutes after the accident. The police took these photos between 12:08 and 12:10. According to PC-Crash and Sun Surveyor, the sun was then 50.9° above the horizon and 152.3° south-southwest in the sky.

Figure 12: Extent of the shadows cast on the roadway by the HGV between 12:08 and 12:10. The photo was taken from the northbound lane looking north. Photo: The police

Figure 13: Extent of the shadows cast on the roadway by the HGV between 12:08 and 12:10. The photo was taken from the northbound lane looking south. Photo: The police

1.7 Road users

1.7.1 THE DRIVER OF THE HEAVY GOODS VEHICLE

The HGV driver was 51 years old at the time of the accident. He held a driving licence valid for vehicle categories B, C and CE, as well as valid professional driver qualifications for goods transport. The driver was a professional driver employed by Myrvang Transport DA, for which he had worked for about 30 years. The HGV driver had driven the section of road where the accident occurred several times before.

1.7.2 THE DRIVER OF THE PASSENGER CAR

The driver was 42 years old at the time of the accident. He held a driving licence for categories B and C. The driver had owned the passenger car for nearly two years and driven more than 100,000 km in it at the time of the accident. He has stated that he had good general knowledge of and confidence in the driver support systems. The driver estimated that he drives about 50,000–60,000 kilometres a year.

According to his own estimate, he had slept for about eight hours the night before the accident. He felt awake and alert before the accident, and he had eaten shortly before. The driver is not sure whether he was wearing sunglasses immediately before the accident.

1.8 Medical and health information

1.8.1 THE PASSENGER CAR DRIVER'S VISION

At the request of the NSIA, the driver of the passenger car had his eyesight tested by an optometrist after the accident. The results from the tests were assessed by a specialist at Oslo University Hospital health trust's Department of Ophthalmology. The specialist assessment was that the results of the tests gave no indications that the driver's vision was impaired at the time of the accident, and that the driver met the formal eyesight requirements for holding a driving licence even without glasses.

1.9 Vehicles

1.9.1 PASSENGER CAR

1.9.1.1 Technical data

Table 2: Technical data for the passenger car, including safety and convenience systems.

Make and model:	Tesla, Model S, 85D, 2015
Most recent periodic roadworthiness test:	12 April 2019
Unladen weight and maximum authorised mass:	2,109 kg and 2,640 kg
Length and width:	4.97 metres and 1.964 metres
Safety systems:	Automatic emergency braking, forward collision warning, obstacle-aware acceleration, blind spot collision warning, side collision assist, lane assist, lane departure avoidance, emergency lane departure avoidance and auto high beam
Convenience systems:	Speed assist, traffic-aware cruise control, autosteer, auto lane change, autopark and summon
Cameras and sensors:	Front cameras, front radar (range approx. 160 metres), 12 ultrasonic sensors (range approx. 5 metres) and rear view camera

Automatic emergency braking, forward collision warning, traffic-aware cruise control and autosteer are described in more detail in Table 3.

Table 3: A selection of safety and convenience systems. Source: Tesla Model S owner's manual

Safety systems	Automatic Emergency Braking	The forward-facing cameras and radar sensor are designed to determine the distance from an object travelling in front of the Model S. When a frontal collision is considered unavoidable, Automatic Emergency Braking is designed to apply the brakes to reduce the severity of the impact. If the vehicle is travelling at a speed of 56 km/h or faster, the brakes will disengage after the Automatic Emergency Braking has reduced the vehicle's speed by 50 km/h. Automatic Emergency Braking operates only when driving between approximately 10 km/h and 150 km/h.
Safety systems	Forward Collision Warning	The forward-facing cameras and radar sensor monitor the area in front of the Model S for the presence of an object such as a vehicle, motorcycle, bicycle or pedestrian. If a collision is considered likely unless the driver takes immediate corrective action, Forward Collision Warning is designed to sound a chime and highlight the vehicle in front in red on the touchscreen.
Convenience systems	Traffic-Aware Cruise Control	Traffic-Aware Cruise Control uses the forward-facing cameras and the radar sensor to determine whether there is a vehicle in front of you in the same lane. If the area in front of Model S is clear, Traffic-Aware Cruise Control maintains a set driving speed. When a vehicle is detected, Traffic-Aware Cruise Control is designed to slow down Model S as needed to maintain a selected time-based distance from the vehicle in front, up to the set speed. Traffic-Aware Cruise Control is designed for your driving comfort and convenience and is not a collision warning or avoidance system. Although Traffic-Aware Cruise Control is capable of detecting pedestrians and cyclists, never depend on Traffic-Aware Cruise Control to adequately slow down Model S.
Convenience systems	Autosteer	Autosteer builds upon Traffic-Aware Cruise Control, keeping Model S in its driving lane when cruising at a set speed. Using the vehicle's camera(s), radar sensor and ultrasonic sensors, Autosteer detects lane markings and the presence of vehicles and objects to steer Model S. In most cases, Autosteer attempts to centre Model S in the driving lane. If the sensors detect an obstacle, however, Autosteer can steer Model S in a driving lane that deviates from the centre of the lane. Autosteer is not designed to, and will not, steer Model S around objects partially or completely in a driving lane.

1.9.1.2 Technical investigations

The NPRA carried out technical examinations of the vehicle after the accident. No faults or defects were found that may have contributed to the accident.

1.9.2.1 Technical data

Table 4: Technical data regarding the HGV.

Type:	Tractor unit (triple-axle Volvo FH16) / Semi-trailer (triple-axle HRD)
Model:	2014 / 2018
Most recent periodic roadworthiness test:	2 January 2020 / 25 March 2020
Maximum authorised mass:	31,500 kg / 50,900 kg
Permissible gross train weight:	60,000 kg
Length and width:	7.20 metres and 2.55 metres / 13 metres and 2.55 metres

1.9.2.2 Cargo and how it was secured

The semi-trailer was mostly carrying pallets of roof tiles wrapped in plastic (see figure 14). The pallets were stacked in two rows next to each other with a central third row on top. The rearmost row of pallets consisted of seven pallets of plastic-wrapped cargo stacked three wide and two high. The final pallet was placed on top of two other pallets at the centre of the flatbed.

Figure 14: The HGV consisted of a tractor unit and a semi-trailer. The rearmost ratchet strap is hanging loose, and the HGV driver was in the process of securing it when the accident happened. Photo: The police

The pallets were secured by transverse ratchet straps in top-over lashing using web lashings (see figure 15). The ratchet strap ends were secured by being placed either inside the pallets or in compartments under the flatbed. The ratchet straps were all tightened from the left side of the HGV, with the exception of the rearmost one that was hanging loose, which the HGV driver was securing when the accident happened. That ratchet strap was tightened from the right side of the semi-trailer.

Figure 15: Location and securing of pallets on the semi-trailer. Photo: The police

1.10 Technical registration systems

1.10.1 PASSENGER CAR

A selection of data downloaded from the passenger car is presented in table 5 and figure 16.

Table 5: Excerpt of information from the car's logging system. Source: Tesla

Logged time[3]	Information from the passenger car's logging system
11:16:58	The driver activated the adaptive cruise control and autosteer functions. The car was travelling at a speed of approx. 80 km/h.
11:17:49	The driver increased the speed to approx. 99 km/h.
11:18:08	The autosteer function was deactivated because the steering wheel was turned. The adaptive cruise control remained active.
11:18:17	The driver re-activated the autosteer function.
11:18:50	The speed had been reduced from approx. 99 km/h to approx. 96 km/h, and the wheel had been turned 13.6° to the left in the past second.
11:18:50	The autosteer function was interrupted.
11:18:50	Traction control and electronic stability control were activated.
11:18:51	Traffic-aware cruise control was deactivated.
11:18:51	The park assist system indicated a fault in a parking sensor located in front of the right front wheel.
11:18:51	The driver pressed the brake pedal.
11:18:57	The vehicle stopped.

1.10.2 HEAVY GOODS VEHICLE

Tachograph data[4] downloaded from the heavy goods vehicle show that the vehicle was travelling at a speed of approx. 90 km/h before it began to slow down (see figure 17). This was while the HGV was inside the Torsbuås tunnel, approx. 450 metres from its final position. It took the HGV approx. 24 seconds to travel from the tunnel exit to the place on the E18 road where it stopped.

[3] The original log recorded times as British summer time (BS, UTC +1), but the times shown here are converted into Norwegian summer time (CEST – Central European Summer Time, UTC +2). The original log shows times to a thousandth of a second, but they have been rounded to the nearest whole second to make the data easier to read.
[4] The tachograph has a potential error margin of approximately ± 6 km/h.

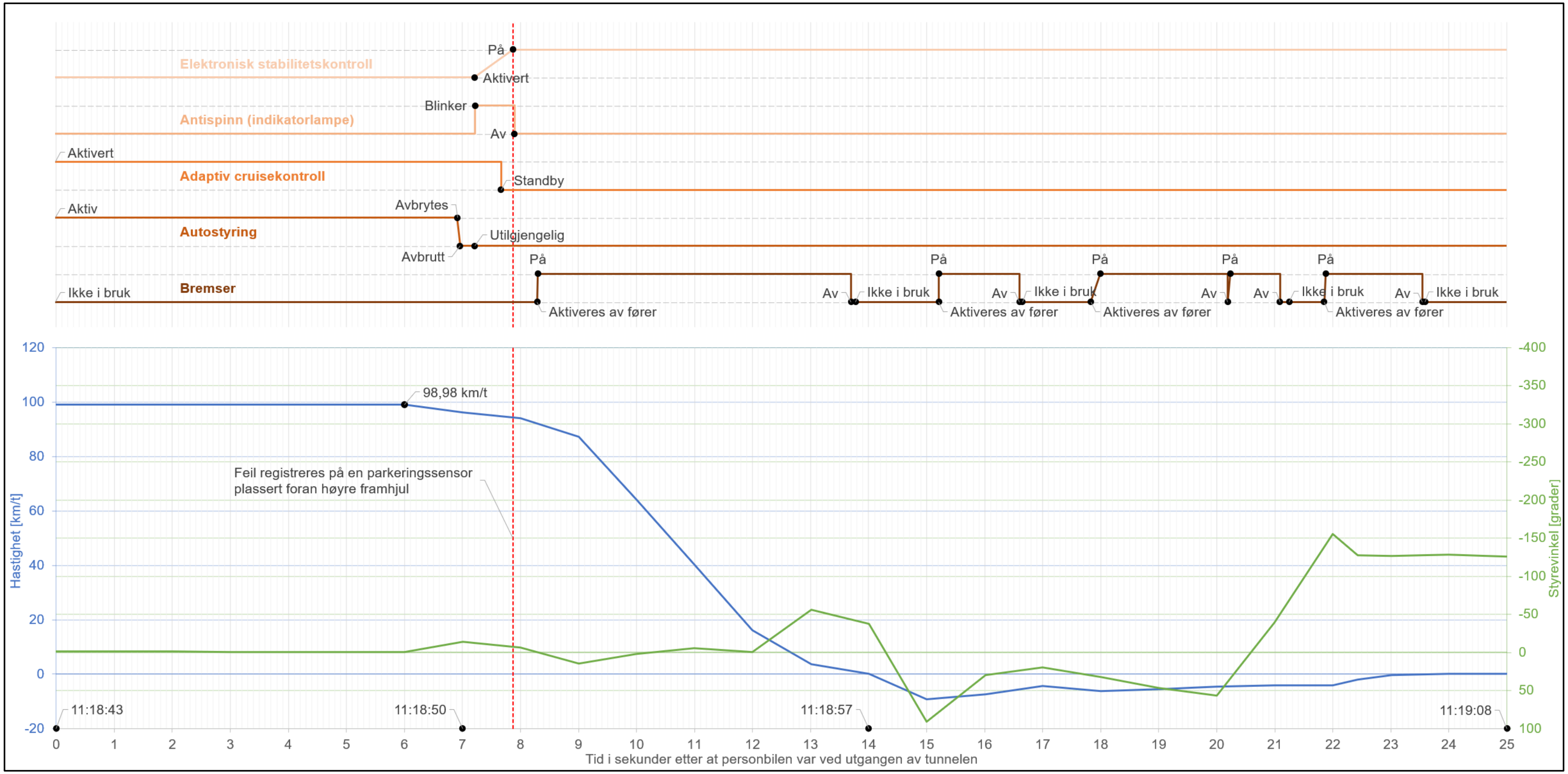

Figure 16: The passenger car's speed, steering angle and brake use, the function state of its stability system, traction control and cruise control after the passenger car exited the tunnel,[5] and the time when a fault in one of its parking sensors was registered. Source: Tesla. Illustration: NSIA

[5] *The NSIA has calculated the approximate time when the passenger car exited the tunnel based on the speeds recorded for the vehicle.*

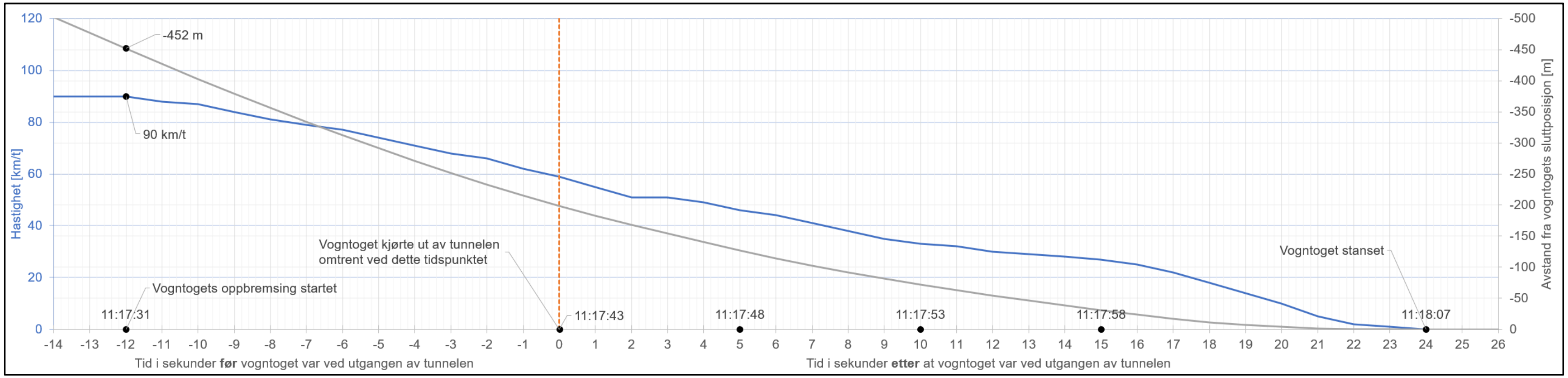

Figure 17: The HGV's speed and calculated distance from its final position before and after exiting the Torsbuås tunnel.[6] Source: NPRA. Illustration: NSIA

[6] The NSIA has calculated the approximate time when the HGV exited the tunnel based on the speeds recorded for the vehicle.

1.11 Road and infrastructure

1.11.1 GENERAL INFORMATION

The new 22-km section of the E18 road between Tvedestrand and Arendal was opened for traffic on 2 July 2019. The section was planned and built by Nye Veier AS, the company that is also responsible for the operation and maintenance of this part of the E18 road.

The section north of Longum was dimensioned for an annual average daily traffic (AADT[7]) of 13,400 vehicles/day[8] and has a speed limit of 110 km/h (see figure 18). The section had an AADT of 8,915 vehicles/day in 2020.

The section south of Longum, which is where the accident happened, was dimensioned for an AADT of more than 20,000 vehicles/day and has a speed limit of 110 km/h (see figure 18). The section had an annual average daily traffic AADT of 10,279 vehicles/day in 2020.

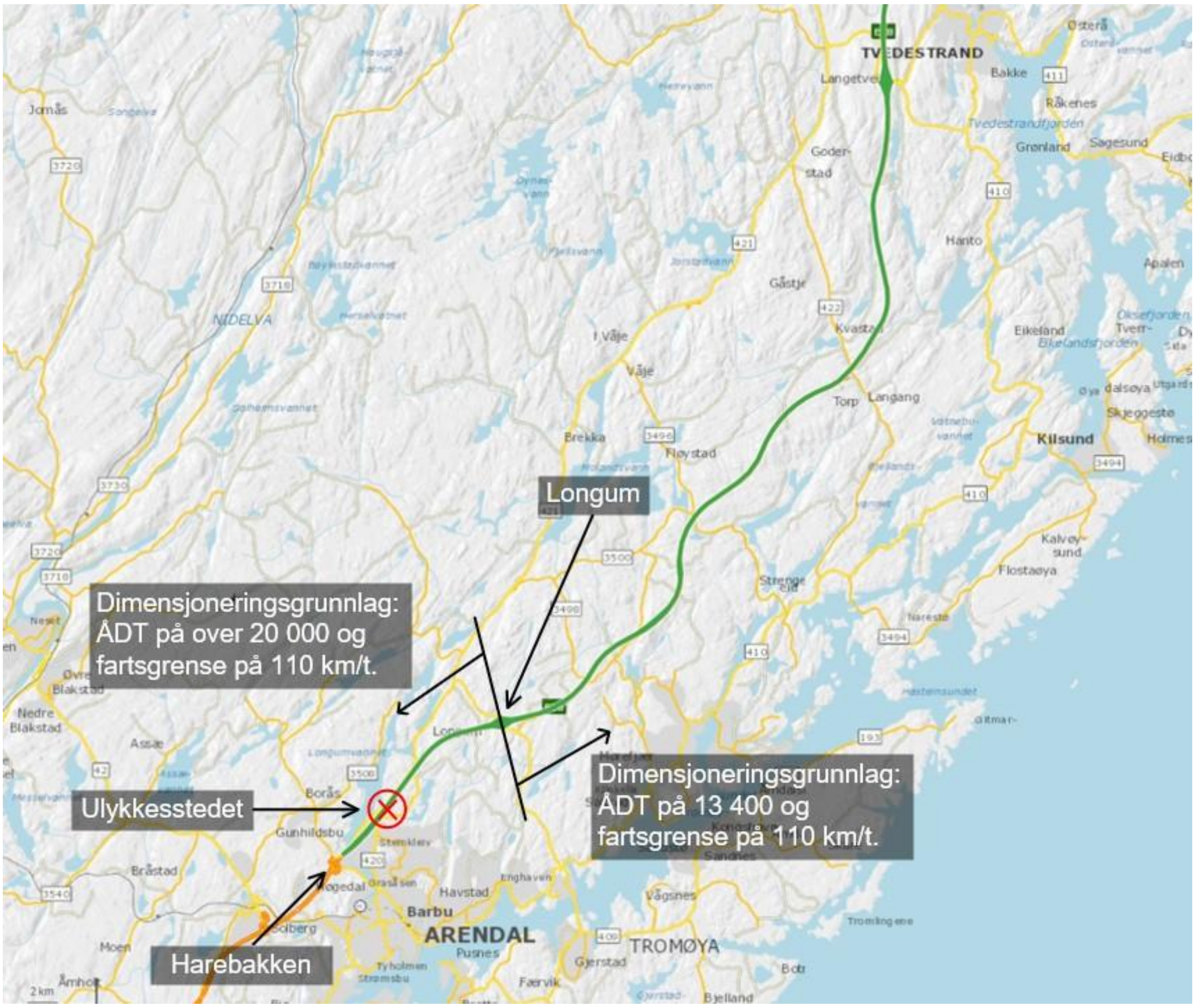

Figure 18: Overview map with basis for dimensioning. The new part of the E18 road is shown in green. Map: Vegkart.no. Illustration: NSIA

[7] Annual average daily traffic (AADT) – average daily traffic through the year, total for both directions.
[8] When planning and developing the road network, land use and road functions must be considered in relation to a time horizon of 20 years from the opening.

The speed limit on the E18 road is 80 km/h up to a point just before the entrance to the Torsbuås tunnel when travelling north. The road changes from one to two lanes at the same point. At the time of the accident, remotely controlled variable speed limit signs were placed here, and the speed limit was set to 110 km/h (see figure 19). Such variable speed limit signs were also installed just before the accident site, about 70 metres south of the rear end of the HGV. These signs were also set to 110km/h at the time of the accident.

Figure 19: The portal of the Torsbuås tunnel with electronic speed limit signs, view when travelling north. Photo: Google Maps

1.11.2 ROAD DESIGN

At the accident site, there are two northbound lanes and one southbound lane. In the southbound direction, the road narrows from two to one lanes just north of the accident site. In the area where the HGV stopped, there is a tarmacked service passage between the northbound and southbound lanes (see figure 20).

On the section where the accident occurred, there is a straight stretch of about 2.4 km from the Torsbuås tunnel's exit to the first bend north of the tunnel. The upward slope from the tunnel to the final position of the passenger car is approx. 1%, and the cross slope is approx. 3% (to the right viewed from the direction of travel).[9]

The police measured the distance from the centre of the road's edge line to the edge of the tarmac of the hard shoulder to be approx. 1.9 metres. The width of both lanes was measured to be approx. 3.55 metres measured from the centre of the lines. Both the yellow centre line and the edge line were approx. 30 cm wide, while the line separating the lanes was approx. 15 cm wide (see figure 21). The width of the lanes between the road marking lines was approx. 3.33 metres.

[9] *Source: Norwegian Mapping Authority (www.hoydedata.no).*

Figure 20: Overview photo of the section of road where the accident occurred. Photo: NPRA

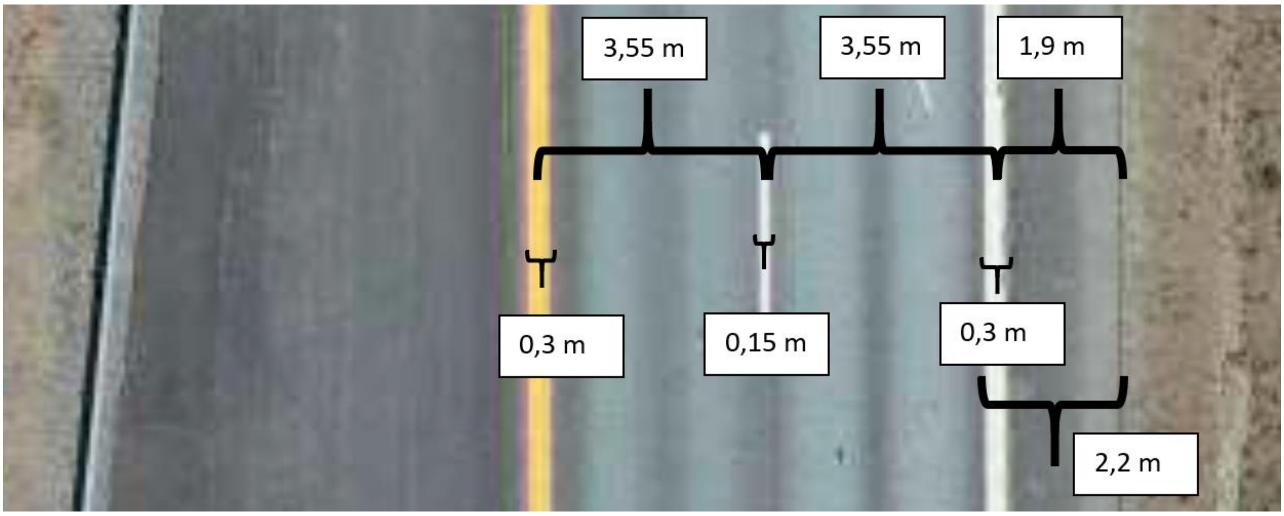

Figure 21: Northbound lane with measured distances. Source: The police. Illustration: NSIA

figure 22 illustrates measurements including the distance from the edge to the wheels of the HGV to the white edge line.

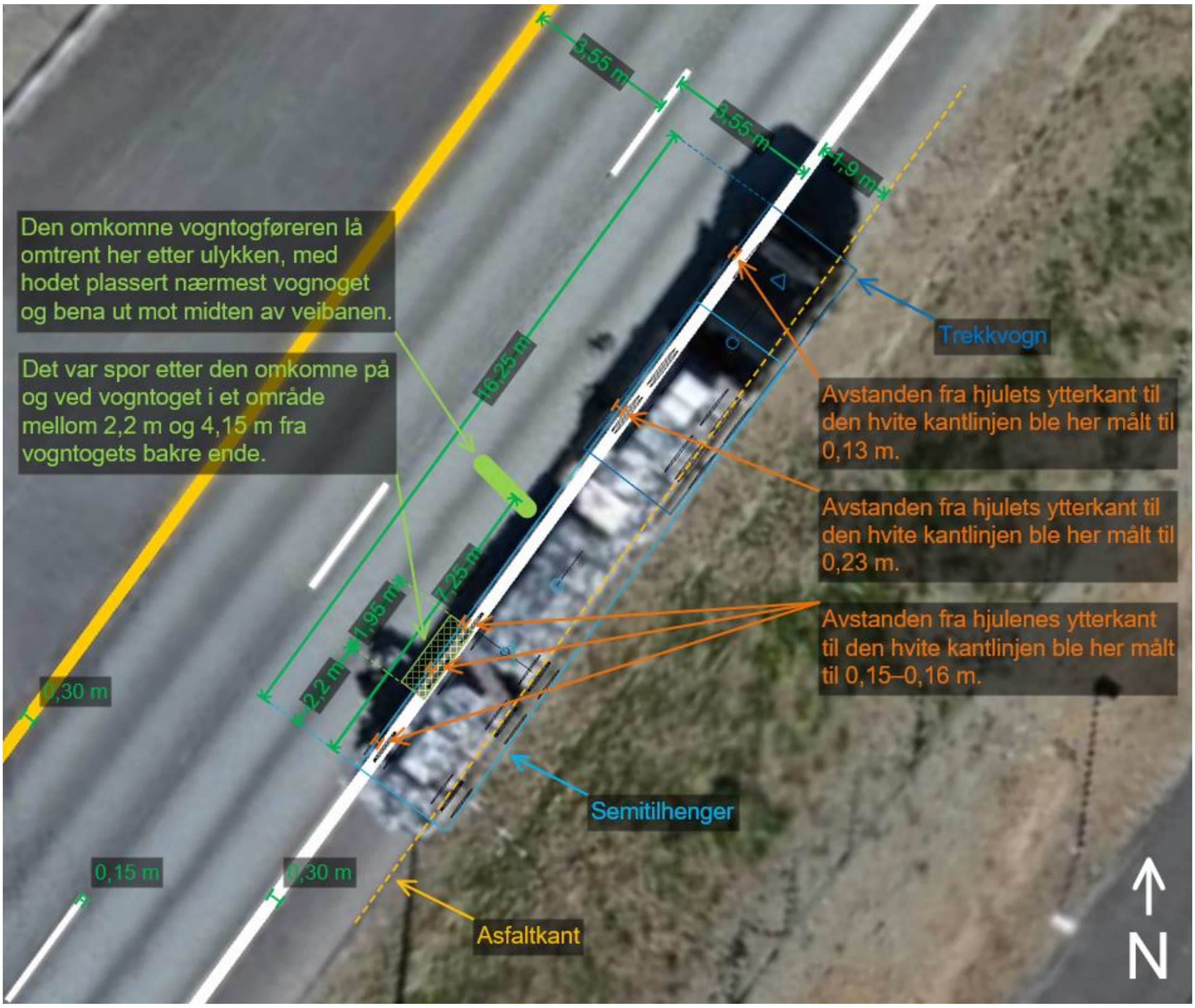

Figure 22: Drone photo of the accident site with various measurements.[10] *Photo and data: The police. Illustration: NSIA*

1.11.3 LAY-BYS

There is an emergency lay-by inside the Torsbuås tunnel, approx. 600 metres south of the accident site. There is another emergency lay-by approx. 2,500 metres north of the accident site (by Longumkrysset junction). There are also two short lay-bys that are not signposted between the accident site and Longumkrysset junction (approx. 400 metres and approx. 1,900 metres, respectively, north of the accident site).

[10] The outlines of the tractor unit and semi-trailer were drawn up using PC-Crash based on the measurements given for the HGV. The outlines are placed across the longitudinal direction of the road in accordance with the police's measurements of the distance between the outer edges of tyres on the left side of the HGV and the edge line of the road. The longitudinal placement of the outlines of the tractor unit and semi-trailer on the road is partly based on the police's measurements of the distance between the rear end of the semi-trailer and a nearby lamp post. However, it has been somewhat challenging to represent this distance accurately using the photographic documentation available, so the longitudinal placement of the outlines is also partly based on professional judgement. The road markings have been digitally enhanced to clarify the location of the HGV's wheels at the time of the accident.

1.11.4 VISIBILITY

Figure 23 and figure 24 show the visibility from the exit of the Torsbuås tunnel, when travelling north, at a distance of 181 and 54 metres, respectively, from the HGV's final position.

Figure 23: Visibility from the tunnel portal, 181 metres from the HGV. Photo: The police

Figure 24: Visibility from the tunnel portal, 54 metres from the HGV. Photo: The police

1.11.5 TRAFFIC MONITORING, TRAFFIC INFORMATION AND TRAFFIC MANAGEMENT

The stretch of road between Harebakken and the accident site is equipped with variable speed limit signs controlled by the Traffic Control Centre (TCC). There are no cameras or other detectors on this section of road other than a fixed camera covering the mechanical road barrier at the southern end of the Torsbuås tunnel. Nor does this section, including the Torsbuås tunnel, have lane signals.

In the event of planned or unforeseen incidents on the road network, TCC operators can reduce the speed limit or close a road completely in areas equipped with barriers. The TCC operators have told the NSIA that incidents that require them to reduce the speed using the variable speed limit signs are not uncommon on the section of road in question. There is no way for the TCC to close individual lanes, as lane signals have not been installed on the section in question.

The variable speed limit signs were set to 110 km/h at the time of the accident. The TCC operators have stated that, in such a situation, they would normally have reduced the speed if they had been made aware that the HGV had stopped outside the Torsbuås tunnel.

The HGV driver did not notify the TCC when he stopped outside the Torsbuås tunnel. Nor did other road users notify the TCC of the situation, and the operators were therefore unaware that the HGV was stationary at the roadside north of the tunnel. Moreover, the accident took place shortly after the HGV had pulled over.

1.11.6 ROAD DESIGN REQUIREMENTS

The zoning plan for the E18 road section between Tvedestrand and Arendal (dated 22 January 2014) stated that the E18 was to be planned in accordance with Manual 017 *Veg- og gateutforming* ('Road and street design') (2013 edition).

On 14 January 2015, the Directorate of Public Roads published circular NA 2015/2 *Fartsgrenser og motorveger – Ny dimensjoneringsklasse for motorveg med fartsgrense 110 km/t* ('Speed limits and motorways – New design class for motorways with a speed limit of 110 km/h' – in Norwegian only). This circular prescribed standard category H8 for roads with an AADT of between 12,000 and 20,000 vehicles/day, and category H9 for AADT ≥ 20,000 vehicles/day (see figure 25 and figure 26).

The guidelines set out in this circular replaced the previous requirements set out in the manual in questions, whose name had now been changed to Manual N100 *Veg- og gateutforming* ('Road and street design') (2014).

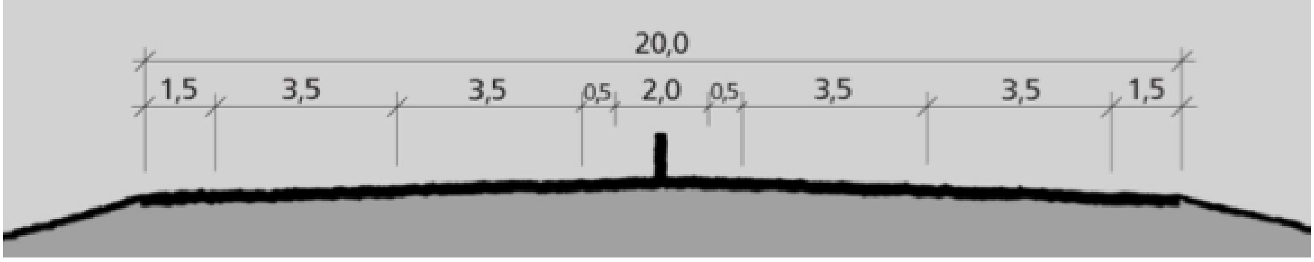

Figure 25: Cross section for AADT 12,000–20,000 vehicles/day with a speed limit of 110 km/h. Source: NA circular 2015/2, Norwegian Public Roads Administration

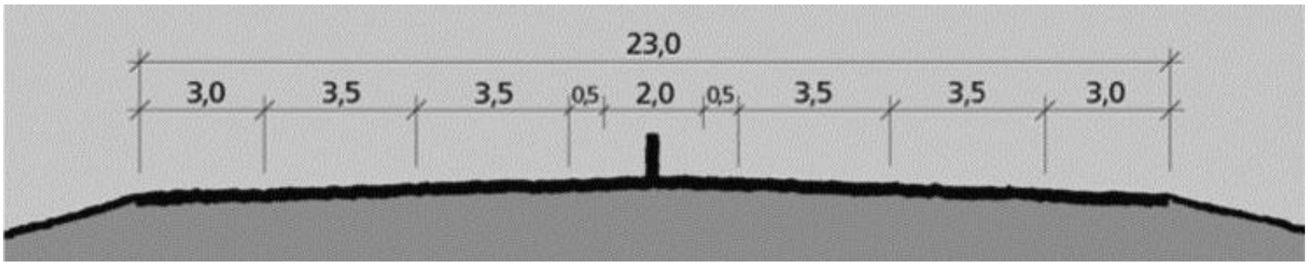

Figure 26: Cross section for AADT > 20,000 vehicles/day with a speed limit of 110 km/h. Source: NA circular 2015/2, Norwegian Public Roads Administration

The AADT estimated for the section of road where the accident occurred was just over 20,000 vehicles/day, and the road should have been dimensioned in accordance with the requirements illustrated in figure 26, which indicate a hard shoulder width of 3.0 metres.

When Nye Veier planned the stretch of road where the accident occurred, the road design requirements could only be deviated from by application and with the approval of the NPRA.

1.11.7 NYE VEIER'S APPLICATION FOR DEVIATION AND THE DIRECTORATE OF PUBLIC ROAD'S CONSIDERATION OF THE APPLICATION

1.11.7.1 General information

In connection with the planning of the section of road in question in 2016, Nye Veier applied for two deviations from the standard conditions. One of the applications concerned the speed limit of 110 km/h, and the other concerned reduction of the hard shoulder width from 3.0 to 2.0 metres.

Both applications were considered by the Directorate of Public Roads, the Norwegian Public Roads Administration.

1.11.7.2 Risk analysis pertaining to the application for deviation

Nye Veier hired the consultancy company COWI AS to carry out a risk analysis in connection with the possible decision to use a road profile with a width of 20 metres (see figure 25), despite the fact that the AADT was projected to exceed 20,000 vehicles/day by 2040.

The analysis considered the risk of hard shoulders with a width of 1.5 metres instead of 3.0 metres, with was the standard requirement. The analysis defined a total of 13 incidents and assessed the risk based on these incidents. Figure 27 shows the assessment from the risk analysis of one of the 13 incidents identified; 'Lorry breakdown'.

The overall conclusion from the risk analysis was that a hard shoulder width of 1.5 metres would entail the greatest risk and that mitigating measures should be considered. The mitigating measures outlined in the analysis were incident detection, more emergency lay-bys, a wider road shoulder (2.0 metres) or reducing the use of crash barriers (creating 1:4 slopes). The risk analysis also concluded that some mitigating measures should be considered for the section of road in question if the hard shoulder width was 3.0 metres.

The risk analysis did not specifically consider a hard shoulder width of 2.0 metres, but instead described it as a mitigating measure, as described above.

7.1 Havari lastebil

En lastebil stanser i vegen (motorfeil, etc.) og blir stående i skulderen. Da lastebilen er bredere enn 1,5 m er en del av denne ute i kjørebanen. Følgende typer ulykker kan skje:

- En fører oppdager ikke at lastebilen er stanset og kjører inn i denne (påkjøring bakfra).
- En fører oppdager lastebilen og utfører unnamanøver, men treffer et annet kjøretøy i venstre kjørefelt (fletteulykke).
- En fører oppdager lastebilen og utfører unnamanøver, men treffer rekkverk i midten (påkjøring av rekkverk).
- Fører går ut av kjøretøy og blir truffet i kjørebanen (påkjøring av fotgjenger).
- Passasjer må gå ut i kjørebanen da døren på høyre side ikke kan åpnes pga. rekkverk (påkjøring av fotgjenger).
- Fører venter på skulder og treffes av annet kjøretøy som kjører inn på skulder (påkjøring av fotgjenger).
- Kjøretøy til eller fra skulder påkjøres (fletteulykke).

HAZID-matrise for denne uønskede hendelsen vises nedenfor:

Tabell 7-1 Risikomatrise. Uønsket hendelse 1. Havari lastebil.

Gjelder	1,5 m skulder/3,0 m skulder		
Konsekvens / Hyppighet	Lettere skadd	Hardt skadd	Drept
Svært ofte (minst 1 gang pr år)			
Ofte (1 gang hvert 2. - 10. år)			
Sjelden (1 gang hvert 10. - 30. år)	1,5		
Svært sjelden (sjeldnere enn hvert 30. år)	3,0	1,5/3,0	1,5

Tegnforklaring	Mulig tiltak
Tiltak nødvendig	a) Hendelsesdetektering.
Tiltak skal vurderes	b) Flere havarilommer.
Tiltak bør vurderes	c) Bredere skulder.
Tiltak ikke nødvendig	d) Mindre rekkverk. Se *Tabell 6-1*.

Figure 27: Detailed assessment of one of the 13 undesirable incidents identified for the section of road in question, with a hard shoulder width of 1.5 metres and 3.0 metres, respectively, taken from the risk analysis. Source: Cowi/Nye Veier

1.11.7.3 Nye Veier AS's application for deviation

The application for permission to deviate from the standard hard shoulder width was dated 4 July 2016. In the application, Nye Veier stated that they wanted to reduce the width of the hard shoulder from the standard 3.0 metres to 2.0 metres. They also stated that a reduction from 3.0 metres to 2–2.75 metres would result in cost savings in the order of NOK 10–15 million (2014).

In the application, Nye Veier referred to the risk assessment described and the possible mitigating measures proposed therein:

A. *Incident detection. Deemed inexpedient for this section in isolation. This measure must be considered for longer continuous sections in combination with other measures to monitor and regulate traffic.*

B. *More emergency lay-bys. No lay-bys are shown in the zoning plan. Two new emergency lay-bys must be added to reach an average of one emergency lay-by per kilometre in each direction of travel.*

C. *Increasing the hard shoulder width from 1.5 to 2.0 metres, unless crash barriers are in place, as described in the Swedish road design norm.*

D. *Less use of crash barriers. Reducing the length of sections with crash barriers by creating 1:4 slopes if possible.*

If the proposed solution is implemented with mitigating measures b), c) and d), the standard of this section of the E18 road will be at least as safe as the adopted solution.

1.11.7.4 The Directorate of Public Roads' consideration and granting of the application for deviation

The Directorate of Public Roads granted Nye Veier's application. The NPRA has informed the NSIA that the deviation was approved based on the four mitigating measures described in the application. In its approval, the Directorate of Public Roads commented on the fact that they understood the application to be motivated by considerations of costs saving.

The following is quoted from the approval:

> *The Directorate of Public Roads takes a positive view of new motorway design solutions being tested. Moreover, the section of road in question is short and its AADT just exceeds 20,000, which makes it a borderline case in terms of hard shoulder width. Based on the above, the Directorate of Public Roads approves the solution. This approval is not to be interpreted as a general deviation applicable to other Nye Veier projects.*

The Directorate of Public Roads also commented that it would have liked to see more detailed and better documented grounds for the professional judgement exercised during the risk assessment. The Directorate also commented that the risk assessment was of limited use, as it had not been assessed in relation to quantitative and qualitative data to substantiate the probability and consequence of the different hazards.

The Directorate described the mitigating measures proposed as interesting, but had little faith in establishing more emergency lay-bys. However, the Directorate did recommend that Nye Veier should consider measures to automatically direct traffic to another lane in connection with incidents. Furthermore, the Directorate stated that it hoped and recommended that evaluations be carried out of the reduced hard shoulder width, as such evaluations could provide important contributions to the revision of road design norms. The Directorate also stated that it would be considering a hard shoulder width of 2.0 metres for motorways already in the next version of Manual N100.

1.11.8 INCIDENTS REGISTERED ON THE SECTION OF ROAD IN QUESTION

According to Nye Veier, a total of 111 incidents defined as stopped vehicles were registered on the E18 road between Arendal and Tvedestrand from September 2019 to October 2020. These are incidents that required breakdown recovery and entailed a risk of people in the road.

In this connection, Nye Veier has informed the NSIA that reduced speed limit using variable speed limit signs is usually implemented as a mitigating measure in connection with such incidents. Nye Veier has also stated that reducing the speed limit is deemed to improve road traffic safety and reduce the risk of road traffic accidents and consequential accidents.

1.12 Authority, organisation and management

1.12.1 NYE VEIER

Nye Veier was established in 2015, and is a wholly state-owned limited liability company organised under the Ministry of Transport. The company is charged with planning, building, operating and maintaining parts of the Norwegian national road network.

Nye Veier has described the object of the company as follows:[11]

> *Nye Veier AS is planning, building, operating and maintaining traffic-safe main roads in Norway. Our roads reduce travel time, connect living and labour market regions, and ensure fewer killed and severely injured in traffic.*
>
> *(...)*
>
> *The Storting established Nye Veier because it wanted a lean, efficient and specialised client organisation capable of carrying out comprehensive planning and development in a quicker and more cost-effective manner than has previously been the case in Norwegian road construction projects. Nye Veier has been given a remit to build motorways in a new manner and contribute to innovation in the sector to arrive at better solutions.*

Nye Veier took over responsibility for the development and operation of many sections of motorway in Norway, including the E18 section between Tvedestrand and Arendal, with effect from 1 January 2016.

1.12.2 THE NORWEGIAN PUBLIC ROADS ADMINISTRATION

The NPRA is an administrative agency under the authority of the Ministry of Transport. It is charged with developing and facilitating a comprehensive, forward-looking transport system for the whole country. The NPRA has sector responsibility for following up national functions for the entire road transport system.

The NPRA is the road authority for national roads. The agency is also responsible for studies and land use planning for roads that Nye Veier AS has been assigned responsibility for. The NPRA is charged with administering legislation that falls within the Ministry of Transport's remit and the NPRA's areas of responsibility. The NPRA exercises regulatory and administrative functions under the Road Act, the Road Traffic Act, the Professional Transport Act, the ITS[12] Act and the Act relating to testing of self-driving vehicles, with pertaining regulations.

The NPRA also adopts norms for public roads (national, county and municipal roads). Moreover, the NPRA has regulatory functions under other legislation, for example the Planning and Building Act. The Directorate of Public Roads is a part of the NPRA that has been authorised to consider and grant applications for deviation from road norms (authority to deviate).

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[11] *Source: www.nyeveier.no.*
[12] *Intelligent transport systems.*

1.13 Framework conditions

1.13.1 VISION ZERO

Vision Zero is the vision of no road traffic fatalities or serious injuries. The NPRA describes it as follows:

> *The Storting adopted Vision Zero in 2002. Vision Zero is the vision of no road traffic fatalities or serious injuries.*
>
> *The National Transport Plan 2018–2029 (Report No 33 to the Storting 2016–2017) set a goal for the period in terms of fatalities and serious injuries figures. The ambition is no more than 350 fatalities and serious injuries in 2030.*
>
> *Norwegian authorities and organisations have engaged in long-term, targeted traffic safety work since 1970, and the efforts have paid off. The number of fatalities per year has been reduced from 560 in 1970 to about 100 in recent years.*
>
> *This positive development is the result of close, positive cooperation between important parties, including the Ministry of Transport, the Norwegian Public Roads Administration, the police, the Norwegian Directorate of Health, the Norwegian Directorate for Education and Training, municipal and county authorities, the Norwegian Council for road traffic safety (Trygg Trafikk) and many other organisations.*
>
> *Vision Zero highlights the fact that it is morally and ethically unacceptable that people are killed or seriously injured in road traffic accidents. Furthermore, the accidents entail an unacceptable cost of the traffic system, despite the benefits that road traffic brings.*
>
> *Vision Zero is thus both an ethical ideal and a guideline for continued road traffic safety work in Norway. Among other things, this means that the transport system, means of transport and regulatory framework that governs behaviour shall be designed in such a manner as to encourage safe behaviour among road users and, as far as possible, help to prevent human errors from resulting in serious injury or death.*

1.13.2 NATIONAL TRANSPORT PLAN 2022–2033

The National Transport Plan (NTP) presents the Government's transport policy and describes the goal and principles underlying it. The purpose of the NTP is to describe how work towards the policy objective for the transport sector – to achieve an efficient, environmentally friendly and safe transport system by 2050 – is to be organised over the coming twelve years.

The NTP sets the framework for development of the transport system and services during the twelve-year period, with a particular emphasis on priorities for the first six years. The NTP is revised every four years and submitted as a report to the Storting before each general election. The current plan applies to the period 2022–2033.

Figure 28 (Figure 28) describes the five policy objectives developed in connection with NTP 2022–2033 to provide direction for the use of resources during the period covered by the plan. These objectives are:

- More value for money
- Efficient use of new technologies
- Contribute to Norway's fulfilment of its climate and environmental goals
- Vision Zero for road traffic fatalities and serious injuries
- Make travelling easier and increase the competitiveness of business and industry

Figure 28: The five policy objectives for the transport sector as defined in NTP 2022–2033. Source: www.regjeringen.no

1.14 New motorway speed limits and standards

1.14.1 INTRODUCTION

The Ministry of Transport sent two letters dated 13 June 2018 and 26 March 2019 in which the NPRA was asked to prepare reports on different widths for narrow four-lane motorways with a speed limit of 110 km/h and on speed limits for new and existing motorways (110 km/h or 120 km/h).

Figure 29 illustrates this process with an emphasis on the consideration of different widths for narrow four-lane motorways. Some of the main elements of the process are described in more detail in the following sections of this report.

Figure 29: Main elements of the process. Illustration: NSIA

1.14.2 REPORTS ON NARROW FOUR-LANE MOTORWAYS AND A SPEED LIMIT OF 120 KM/H

The NPRA prepared two reports in which the factors described in the Ministry of Transport's letters of 2018 and 2019 were discussed.

The following is quoted from the report on narrow four-lane roads and standards for roads with an AADT of 6,000–20,000 *(Utredning av smal 4-felts veg og standarder på veger med ÅDT 6 000–20 000* – in Norwegian only):

A comparison of a two- or three-lane road (speed limit 90 km/h) and a narrow four-lane road (speed limit 110 km/h) shows that the investment and accident costs will be lower for the two- or three-lane road. The four-lane alternative will have lower time costs.(..) The overall conclusion for all projects is that a four-lane road with a speed limit of 110 km/h will have lower net benefit (lower profitability) than a two- or three-lane road with a speed limit of 90 km/h.

(...)

A comparison has been made between a narrow four-lane road (20 metres) and a standard four-lane solution (23 metres) with an AADT of 12,000–20,000. The speed limit on both roads was 110 km/h. A road width of 23 metres will require higher investment, operating and maintenance costs and take up more land, but the accident costs will be lower than for the narrower four-lane road. (…) A calculated example shows that the two four-lane alternatives are virtually identical in terms of socio-economic profitability.

(…)

The difference between a narrow four-lane road with a width of 20 metres and the standard 23-metre solution is that the width of the hard shoulder is reduced from 2.75 metres to 1.5 metres. Many scientific articles based on literature studies and collected data show a clear link between hard shoulder width and the number of accidents. The wider the hard shoulder, the fewer accidents. An increase from 1.5 to 2.75 metres will reduce the number of accidents by approx. 15%.

(…)

Socio-economic calculations relating to the two alternative four-lane solutions were conducted for the section of the E6 road between Ulsberg and Vindåsliene. The calculations show negative net benefit for both alternatives, with only marginal differences between them. The savings in investment, operating and maintenance costs that can be made by reducing the width from 23 to 20 metres are offset by the higher accident costs.

The conclusion of the report and the NPRA's recommendation was that motorways with an AADT of 6,000–12,000 vehicles/day should be designed as two- or three-lane roads with a speed limit of 90 km/h. The NPRA also submitted the following recommendation to the Ministry of Transport:

Our recommendation is that roads with an AADT of 12,000–20,000 be designed as narrow four-lane roads. Socio-economic calculations show only minor differences between the two alternatives, but the narrower profile entails lower investment costs and requires less land. Despite entailing somewhat higher accident costs, the most cost-efficient alternative is recommended. The cost savings can be better spent on road networks where the risk of accidents is higher.

In its report on a speed limit of 120 km/h on motorways *(Utredning av 120 km/t som fartsgrense på motorveger* – in Norwegian only), the NPRA considered what impact such a speed limit would have on the achievement of the objectives set out in the National Transport Plan (NTP) 2018–2029. The following is quoted from the report's section on traffic safety:

The goal of no more than 350 fatalities and serious injuries in 2030 is ambitious, but achievable. In the Norwegian Public Road Administration's opinion, increasing the speed limit to 120 km/h would push development in the wrong direction, and this measure is not consistent with the National Transport Plan's transport safety goal.

The report also discussed mitigating measures:

> *The results already presented in the present report show that a speed limit of 120 km/h will result in more fatalities and serious injuries than a speed limit of 110 km/h (calculated at portfolio level). The Norwegian Public Roads Administration has a particular responsibility for traffic safety, and we therefore present some mitigating measures that can be implemented to prevent the number of fatalities and serious injuries from increasing if the speed limit is increased.*

The report on narrow four-lane roads and road standards did not include a similar assessment of how the introduction of narrow four-lane motorways would affect the attainment of NTP goals.

1.14.3 CONSULTATION SUBMISSION TO THE NPRA'S REPORTS

The two reports prepared by the NRPA based on the letters from the Ministry of Transport underwent public consultation from 24 October 2019 to 10 February 2020. A total of 35 consultation submission were received. Below is a selection of quotations from the consultation submissions, most of which concern the report on narrow four-lane motorways:

Oslo Police District

In particular, we take a sceptical view of the use of a hard shoulder width of 1 metre in combination with a lane width of 3.25 metres. If an HGV that is 2.5 metres wide stops, it will, even if it is on the hard shoulder, occupy much of the nearest ordinary lane. That will leave only 1.75 metres of the lane for other vehicles. A VW Golf, for example, is 1.79 metres wide. A certain distance will always be required for it even to be possible to pass another vehicle. Higher speeds will require more space. This challenge will therefore spread to the next lane. Overall, the situation will entail an increased risk of vehicles colliding with each other or with pedestrians, as well as a risk of panic braking when motorists find themselves in a position that feels cramped.

Rusfri Trafikk

In 2019, 110 people were killed on Norwegian roads. The figure for 2018 was 108. This shows that we are probably still 'best in the world', but, to quote traffic safety scientist Rune Elvik: 'No one is a world champion forever'. He points out that, when things are going well, people relax. Sooner or later, there will be a setback, and the number of traffic fatalities will increase again. We consider this consultation round to be an example of precisely this phenomenon. Vision Zero gives us something to aim for. At the same time, it gives us a clear direction for our efforts and a clear basis for prioritising. It requires long-term, systematic and targeted work by all parties that influence the safety of the road network. In our opinion, the proposals now distributed for consultation represent a step in the wrong direction and are not in accordance with Vision Zero's ethical foundation that road traffic fatalities and serious injuries are unacceptable.

The Norwegian Council for Road Traffic Safety (Trygg Trafikk)

The main reasons why narrow hard shoulders cannot fill all the necessary and important functions required for a high-speed road is that they do not provide:

• Room for emergency stop of vehicles (breakdown, illness)

• Room for avoidance manoeuvres on the right side

• Safety margin for regaining control after being inattentive/falling asleep

• Room for emergency service vehicles in case of congestion

• Room for the police to pull over vehicles for traffic rule violations (speeding/driving under the influence of alcohol or drugs) (not roadside checks)

• Room to reduce the perception of 'narrow road', which has a speed-reducing effect (...) particularly when the crash barrier is very close to the roadway

As a matter of principle, Trygg Trafikk objects to what we perceive as a failure to emphasise Vision Zero in the Ministry of Transport's instructions to the Norwegian Public Roads Administration of 26 March 2019, which formed the basis for this consultation round. In its letter, the Ministry requested an assessment of what it would take to increase the speed limit from 110 to 120 km/h on existing and new motorways, as well as introduce narrow four-lane roads as a standard for roads with an annual average daily traffic (AADT) of 6,000–20,000, based on a cost-benefit assessment in socio-economic analyses. This commission has of course influenced the Norwegian Public Roads Administration's delivery, which consequently does not focus much on Vision Zero in its assessments and recommendations.

Both analyses predict that the proposals under review will result in an increase in the number of accidents. Several of the proposals (e.g. increasing the speed limit from 110 to 120 km/h on motorways) are 'rejected' because they are not deemed socio-economically profitable. But one proposal, namely narrow motorways with a speed limit of 110 km/h in the AADT range 12,000–20,000, is recommended despite the fact that it is predicted to cause the number of fatalities and serious injuries to increase by approx. 15%. Reference is made to how this alternative entails lower investment costs and requires less land, although the socio-economic calculations show only minor differences between this proposal and the current standard.

As far as Trygg Trafikk is aware, this is the first time that the road authorities have recommended measures that are socio-economically profitable at the expense of an increase in the number of fatalities and serious injuries. Traditionally, traffic safety has been ensured through various investments that have helped to reduce the number of fatalities and serious injuries. In our opinion, one should not look for an 'optimum' number of fatalities and serious injuries by weighing accident costs against savings in terms of time and investment costs.

Of course we agree that society must make sensible use of its resources. However, we want to warn against basing political decisions that concern life and health solely on socio-economic analyses. We believe that these analyses should be used for their intended purpose, namely to make cost-benefit comparisons between alternative measures. Vision Zero must also be a factor, and a very weighty one, in all decisions.

Trygg Trafikk is of the view that decisions regarding speed limits and changes to the width of motorways should be based on goal achievement in terms of a reduction of the number of fatalities and severe injuries rather than traffic flow. We therefore object as a matter of principle to the planning and implementation of measures on Norwegian roads that we know will lead to more fatalities and serious injuries. This will not be in accordance with the ethical dimension of Vision Zero.

Institute of Transport Economics (TØI)

The Norwegian Council for Road Traffic Safety (Trygg Trafikk) commissioned TØI to produce a scientific discussion of the conclusions of the NPRA's reports. The discussion was to emphasise the traffic safety consequences of the different solutions.

Socio-economic analyses show minor differences between narrow and ordinary four-lane roads in terms of socio-economic profitability. A narrow four-lane road is assumed to have an accident risk 15% higher than an ordinary four-lane road. Studies mentioned in the Handbook of Road Safety Measures indicate that increasing the width of the hard shoulder will reduce the number of accidents resulting in personal injury by 17%.

The Norwegian Public Roads Administration has assumed that the accident risk on narrow four-lane roads is 15% higher than on ordinary four-lane roads. This is a reasonable, if possibly somewhat conservative, estimate. The results quoted in the Handbook of Road Safety Measures suggest that a 20% higher risk would be a reasonable assumption.

The Norwegian Public Roads Administration recommend that new roads with an annual average daily traffic of 12,000–20,000 should be built as narrow four-lane roads with a speed limit of 110 km/h. The grounds given for this recommendation is that there is not much difference between an ordinary and a narrow four-lane road in terms of socio-economic profitability, and that narrow four-lane roads are cheaper to build than ordinary ones, so that one can either: (1) build more kilometres of four-lane road within a certain budget, or (2) use the funds saved on other traffic safety measures on higher-risk roads.

In principle, both of these arguments are correct. The reason we say 'in principle' is that experience shows that different road construction projects are rarely viewed in relation to each other and that they are rarely or never compared with cheaper measures. Vision Zero means both that traffic safety should be improved in the cheapest possible manner and that the best possible solution should be chosen.

Another principle of Vision Zero is that the best solution should always be chosen. By 'the best solution' is meant the one that results in the lowest number of fatalities or serious injuries. In the choice between a narrow and an ordinary four-lane road, the ordinary one is the best solution because it is safer. Since socio-economic analyses show only minor differences between narrow and ordinary four-lane roads, such analyses are no argument in favour of choosing the narrow four-lane road.

We fear that the argument that money saved can be spent on other traffic safety measures will remain purely hypothetical unless a formal regime is established to ensure that traffic safety measures are considered every time a narrow four-lane road is planned.

1.14.4 THE NPRA'S FINAL REPLY TO THE MINISTRY OF TRANSPORT

On 29 May 2020, the NPRA sent a letter to the Ministry of Transport in which reference was made to the letters of 13 June 2018 and 26 March 2019. The letter states that, based on the letters from the Ministry of Transport, two studies were conducted that looked at speed limits on new and existing motorways (110 km/h and 120 km/h) and different widths for narrow four-lane motorways with a speed limit of 110 km/h, among other things. The two reports, as well as the consultation submissions, were enclosed with the NPRA's letter to the Ministry.

The letter contained the NPRA's assessment of the elements studied following the public consultation process held in connection with the reports.

In its letter, the NPRA requests that the Ministry of Transport conclude on the elements so that road design norm N100 *Veg- og gateutforming* can be completed.

The following is quoted from the chapter on how wide a narrow four-lane road should be *(Kva breidde bør ein smal firefeltsveg ha?)*:

In accordance with the assignment from the Ministry, the Directorate of Public Roads has considered how wide a 'narrow' four-lane motorway with a speed limit of 110 km/h should be within a range from 19.0 to 20.5 metres.

The current N100 requires four-lane motorway with a speed limit of 110 km/h to be built with a normal profile of 23 metres in width. (…)

On assignment from the Directorate of Public Roads, the Danish consultancy company Trafitec has estimated that a hard shoulder width of 2.75 metres will result in 15% fewer traffic accidents compared with a width of 1.5 metres. In order to keep reducing the number of traffic fatalities and serious injuries, it will be necessary to focus more on how unusual road traffic accidents can be prevented. One example of such an accident type is accidents in connection with vehicles stopping on the hard shoulder of a motorway. They are relatively rare, but when they do happen, their outcome is often fatal. Sufficiently wide shoulders are an important measure to reduce the probability of such accidents.

At the same time, it is logical to conclude that the correlation between shoulder width and risk is weaker when there is less traffic on the road. The reason for this is that less traffic entails a lower risk of a vehicle needing to stop on the hard shoulder, while it will also be easier for other road users to use the left lane when passing a stationary vehicle.

Sufficient shoulder width is also important to ensure good passability for emergency service vehicles when both ordinary lanes are blocked by traffic jams. Moreover, sufficient shoulder width is an important health and safety factor for the police when they need to pull vehicles over on the hard shoulder.

Road width also has a bearing on construction costs, and it is important that roads are not built wider than necessary. It is estimated that reducing the cross-section of a motorway by one metre will save about NOK 5,100 per metre of road. Local circumstances will nonetheless have a bearing on the savings that can be achieved by reducing the road width in individual projects.

Nye Veier AS and the NPRA's construction division believe that more importance should be attached to socio-economic profitability when defining requirements in road design norms. In its consultation statement, Nye Veier AS suggested reducing the shoulder width to 1.5 metres on roads with an AADT of < 25,000 (total width 19.0 metres).

The Directorate of Public Road's expert opinion is that, with an AADT of < 20,000, the shoulder width can be reduced from 2.75 to 2.0 metres provided that mitigating measures are implemented to maintain traffic safety. If crash barriers are installed along the hard shoulder, that could make it difficult for light vehicles to move completely out of the road. Hard shoulders with crash barriers should therefore have a width of 2.75 metres.

In cases where the AADT is < 12.000, it should be allowed to reduce the shoulder width from 2.0 to 1.5 metres, provided that mitigating measures are implemented to maintain traffic safety.

Measures can be implemented to mitigate the negative impacts of a reduced shoulder width. Such measures could be automatic incident detection, reduced speed limit in connection with incidents, and regulating traffic in different lanes. This should be seen in conjunction with the discussion above on mitigating measures for the speed limit 120 km/h.

There is significant uncertainty regarding what impact the vehicles of the future will have on road design. Some believe that the required road width will be reduced in future, while others believe that it will increase. For example, it is possible that vehicles will become wider than today. It has also been said that the vehicles of the future will experience more emergency stops because stopping is the autonomous vehicles' response to technical faults. If this proves to be the case, it will be useful to have a wide road shoulder. On the other hand, communication between vehicles on roads and between vehicles and road equipment is an example of future technology that will reduce the need for a wide shoulder, because vehicles will take account of incidents in the roadway. Digital signs will also push developments in this direction.

The following is quoted from the letter's chapter on whether the speed limit for motorways should be 110 or 120 km/h (*Fartsgrense 110 eller 120 km/t på motorveg?)*:

> *As commissioned by the Ministry, the Directorate of Public Roads has considered whether new motorways designed in accordance with current design class H3 should have a speed limit of 120 km/h rather than 110 km/h. It is also considered in the report whether existing motorways with a current speed limit of 110 km/h should have their speed limit increased to 120 km/h when their road geometry indicates that this is a possibility.*
>
> *In the same way as increased speed limits on two-lane and three-lane roads, a higher speed limit on these roads will have a positive impact on passability for passenger cars and help to reduce (time-related) costs for road users.*
>
> *However, a higher speed limit will have a negative impact on traffic safety. Generally speaking, speed is an important risk factor. If a speed limit of 120 km/h was to be introduced on all new motorways and the best sections of existing motorways, the report estimates that this would result in just under four more fatalities and serious injuries per year. As stated in the report, mitigating measures can be introduced to compensate for the fact that a speed limit of 120 km/h will lower traffic safety.*
>
> *In a socio-economic analysis, such mitigating measures will help to reduce accident costs. At the same time, they will increase the costs associated with other components of the analysis, such as development costs. Use of mitigating measures can therefore reduce the net benefit compared with a corresponding situation without such measures.*
>
> *Cost-benefit analyses show that the net benefit of increasing the speed limit to 120 km/h on existing motorways is higher compared with keeping the speed limit of 110 km/h. The increase is just under NOK 4 million per kilometre. Non-monetised impacts will not change much when the speed limit increases, so a higher speed limit may be socio-economically profitable overall.*
>
> *The studies show that, if the speed limit for new motorways was to be increased to 120 km/h, the net benefit would be negative compared with 110 km/h. The reduction in net benefit amounts to just over NOK 7 million per kilometre. The non-monetised impacts will also be better with a speed limit of 110 km/h. This is because a higher speed limit requires straighter road alignment, which makes it more difficult to adapt to the terrain and environmental values. All things considered, it will not be socio-economically profitable to increase the speed limit to 120 km/h.*
>
> *The study report explains why the analyses yield different results for existing and new motorways. To put it briefly, only roads that satisfy certain geometrical design requirements are candidates for a speed limit of 120 km/h.*
>
> *The Directorate of Public Roads specifies that only light vehicles will benefit from a higher speed limit on roads where the current speed limit is 110 km/h. This is because most heavy vehicles are subject to a special speed limit of 80 or 90 km/h, and their travel time will thus not change with the speed limit.*
>
> *Nineteen of the consultation submissions received expressed a wish for the speed limit for motorways to remain at 110 km/h. Six consultation submissions advocated the introduction of a higher speed limit. Three consultation submission expressed the opinion that the speed limit on motorways should be reduced. Six of the consultation submissions did not comment on the matter.*

1.14.5 REVISED ROAD DESIGN NORM N100 *VEG- OG GATEUTFORMING* (2021)

The legal authority for road design norm N100 *Veg- og gateutforming* ('Road and street design' – in Norwegian only) (2021) is found in Section 13 of the Ministry of Transport's Regulations pertaining to Act No 23 of 21 June 1963 relating to roads (the Road Act). The road design norm describes requirements relating to street and road design. These requirements apply to all public roads in Norway.

The applicable road design requirements for national main roads (H3) with an AADT of more than 12,000 vehicles/day and a speed limit of 110 km/h[13] are described in figure 30.

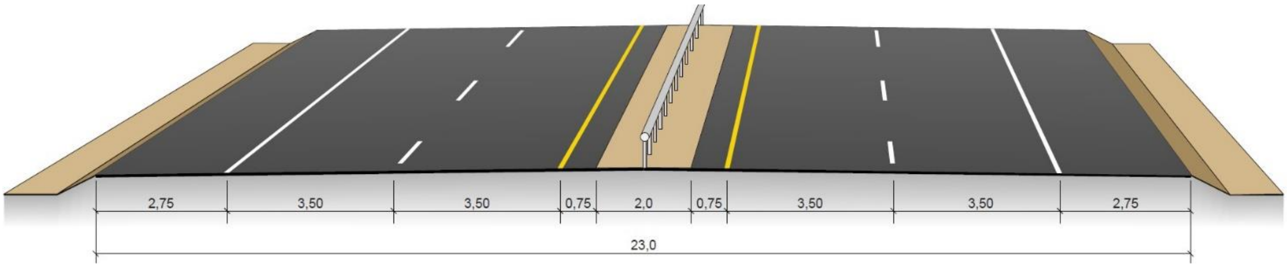


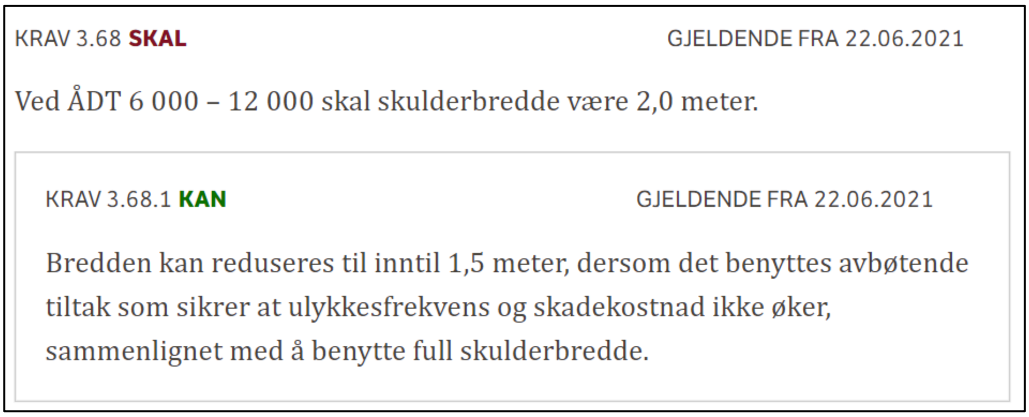
Figure 30: Standard profile, H3, for national main roads with an AADT of more than 12,000 vehicles/day. Source: Road design norm N100 Veg- og gateutforming (2021), NRPA

For roads with an AADT of 12,000–20,000 vehicles/day, the width of the hard shoulder may be reduced to as little as 2.0 metres, provided that mitigating measures are implemented (see figure 31). At an AADT of 6,000–12,000 vehicles/day, the shoulder width can be reduced to as little as 1.5 metres (see figure 32).

KRAV 3.67 **KAN** GJELDENDE FRA 22.06.2021

Ved ÅDT 12 000 – 20 000 kan skulderbredden reduseres til inntil 2,0 meter, dersom det benyttes avbøtende tiltak som sikrer at ulykkesfrekvens og skadekostnad ikke øker, sammenlignet med å benytte full skulderbredde.

Figure 31: Hard shoulder width requirements for H3 roads with an AADT of 12,000–20,000 vehicles/day. Source: Road design norm N100 Veg- og gateutforming (2021), NRPA



KRAV 3.68 **SKAL** GJELDENDE FRA 22.06.2021

Ved ÅDT 6 000 – 12 000 skal skulderbredde være 2,0 meter.

KRAV 3.68.1 **KAN** GJELDENDE FRA 22.06.2021

Bredden kan reduseres til inntil 1,5 meter, dersom det benyttes avbøtende tiltak som sikrer at ulykkesfrekvens og skadekostnad ikke øker, sammenlignet med å benytte full skulderbredde.

Figure 32: Hard shoulder width requirements for H3 roads with an AADT of 6,000–12,000 vehicles/day. Source: Road design norm N100 Veg- og gateutforming (2021), NRPA

It is up to the construction client/road manager to decide which mitigating measures to implement. They are also responsible for ensuring that the accident frequency and injury costs do not increase

For AADTs in excess of 20,000 vehicles/day, the road design norm stipulates a hard shoulder width of 2.75 metres.

[13] *This design class can also be used with an AADT of 6,000–12,000 vehicles/day if project-specific socio-economic analyses indicate that this is sensible.*

1.15 Implemented measures

So far, no measures have been implemented following the accident.

2. Analysis

2. Analysis

2.1 Introduction

This chapter begins with an assessment of the sequence of events leading up to the collision, provided in section 2.2. The assessment discusses the choices and actions of the HGV driver, the collision between the HGV driver and the passenger car, and the passenger car driver's situational awareness.

The further analysis of the accident is based on the principle that the NSIA's investigations are intended to contribute to safety at an overarching level that can give rise to lasting improvements to systems, designs and work processes. For this purpose, traffic management and monitoring are discussed in section 2.3. Factors relating to the approval and construction of the section of road where the accident happened are discussed in section 2.4.

Finally, section 2.5 discusses the fact that the revised road design norm N100 (*Veg- og gateutforming*) allows for narrow four-lane motorways. The objectives of the National Transport Plan and Vision Zero are discussed in section 2.6.

2.2 Analysis of the sequence of events

2.2.1 THE HGV DRIVER'S CHOICES AND ACTIONS

The investigation has found that the HGV driver received a phone call telling him that there was a problem with the cargo lashings on the semi-trailer. In the Torsbuås tunnel, this impression was reinforced when the driver of a camper van used both lights and sound to signal that something was wrong.

The driver chose to pull over on the hard shoulder on a straight section of the E18 road about 180 metres after exiting the Torsbuås tunnel. Calculations show that it took the HGV about 20 seconds to cover the distance from the tunnel portal to the vehicle's final position. The driver did not notify the Traffic Control Centre by calling 175, nor had he notified anyone else that he had stopped on the side of the road. The driver still chose to exit the vehicle to secure the lashings. He was wearing personal protective clothing and had activated yellow flashing lights above the driver's cab and at the back of the semi-trailer. He had not deployed a warning triangle.

It is the NSIA's opinion that, considering the information the HGV driver was in possession of, namely that the lashings had come loose and that immediate action was required, he acted correctly when he chose to stop his vehicle on the side of the road. The NSIA is also of the opinion that the driver's choice to stop some distance away from the tunnel portal made the vehicle more visible and gave other motorists more scope of action as they exited the tunnel. In the area where the HGV stopped, there was also a tarmacked service passage between the northbound and southbound lanes that would give other vehicles more room to pass the HGV.

On exiting the vehicle, the driver probably first walked in front of the HGV and then along its right side. The NSIA believes that the driver made a conscious decision to fasten the rear ratchet strap on the right side of the vehicle so that he only had to fasten the hook on the strap on the vehicle's left side. This resulted in him standing in the roadway in the right lane for a short time.

However, it is the NSIA view that the HGV driver took a considerable risk when he chose to exit the vehicle to secure the cargo lashings, considering the following:

- The hard shoulder was so narrow that the vehicle was partly in the right lane of the road.
- Incoming traffic was not notified.
- When securing the lashings, the driver stood in the right land of the road for a short time.

The NSIA submits one safety recommendation to the Norwegian Truck Owners Association on this matter.

2.2.2 THE COLLISION BETWEEN THE HGV DRIVER AND THE PASSENGER CAR

The investigation has shown that the HGV driver was hit by the passenger car while standing in the right lane near the rear end of the vehicle where a cargo lashing had come loose. The post-mortem report concluded that the HGV driver was standing when the car hit him.

The damage to the passenger car indicates that the part that hit the HGV driver was the far right side of the front; the headlight and the front of the right wing. Findings indicate that the HGV driver was in the process of securing the cargo lashings at the time of the accident, and that he was standing in the shadow cast by his own vehicle when the car hit him. The damage to the passenger car also shows that the deceased was thrown partly over and along the side of the passenger car in the collision. It is likely that the deceased also hit a structure on top of the semi-trailer, as it had shifted forward.

2.2.3 THE PASSENGER CAR DRIVER'S SITUATIONAL AWARENESS

2.2.3.1 Introduction

The analysis aimed at assessing the driver of the passenger car's situational awareness before the accident is based on the NSIA's investigation model for human functioning in connection with accidents (see Appendix A). The NSIA has also considered the accident in relation to the research described in Appendix B, which studied automation and use of driver support systems.

2.2.3.2 The driver saw the HGV, but did not change lanes

The driver of the passenger car has stated that he saw the HGV parked on the hard shoulder, but that he did not see a person nearby. He therefore concluded that the vehicle was abandoned. The driver cannot remember why he did not move into the left lane to pass the HGV, but believes that there may have been vehicles in the left lane that made it difficult to do so. According to the driver's understanding of the situation, there was enough room to pass the HGV in the right lane. His situational awareness and prediction therefore indicated that it would be safe to pass the HGV in the right lane of the E18 road.

However, the NSIA is of the opinion that the driver's decision not to change lanes when passing the HGV entailed a significant risk considering the following:

- The hard shoulder was so narrow that the HGV was partly in the right lane of the road.
- There should not be any road users in the roadway on a high-speed road, but at the same time, it is natural to assume that there could be a person near a stationary vehicle.
- The passenger car was travelling at a speed of approx. 100 km/h and did not slow down when passing the HGV.

2.2.3.3 The passenger car driver did not see the HGV driver

The following factors are potential explanations why the driver of the passenger car did not see the HGV driver:

- The passenger car driver's belief that the HGV was an abandoned vehicle may have contributed to him deciding to turn his attention to the next natural step of the driving process, i.e. to look past the HGV in the direction of travel to be ready to perceive the next potential situation on the motorway. If this was the case, that would constitute natural driving behaviour, as driving at high speed requires the driver to update his situational awareness frequently.
- The driver's attention may have shifted to considering whether it would be possible to change to the left lane to increase the distance between his own vehicle and the HGV. That would require the driver to check one or two mirrors to check whether other vehicles were approaching in the left lane, glance over his left shoulder, and consider the speeds and relative positions of his own and other vehicles. This task would require the driver to take his eyes and attention off the HGV during that time, and he would therefore not have spotted the HGV driver.
- The post-mortem report shows that the HGV driver was hit on his right side. This means that he was facing the semi-trailer, which would have made him a smaller object in the passenger car driver's field of vision than he would have been had he been facing or had his back turned to the passenger car. Moreover, the HGV driver was standing in the vehicle's shadow, and close to the flatbed. It is also likely that he was standing relatively still while attaching the hook on the lashing. It is possible that his movements were too small to be detected by the passenger car driver at the distance in question. It may therefore have been difficult for the driver of the passenger car to see that there was a person standing next to the HGV.
- The passenger car driver is not sure whether he was wearing sunglasses immediately before the accident. If he was, that would have made it even more difficult for him to spot the HGV driver.

Taken together, the location of the HGV driver, the shadows along the semi-trailer and the driver's small body movements may have contributed to him not being very visible to the passenger car driver at the distance in question. In addition, the passenger car driver's belief that the HGV was an abandoned vehicle may have contributed to him turning his attention to the next natural step of the driving process.

2.2.3.4 The passenger car's driver support systems and their use

The investigation has shown that the passenger car driver activated the adaptive cruise control and autosteer functions at approx. 11:17. The autosteer function was then deactivated approx. 1 minute and 50 seconds later. The traction control and electronic stability control were activated at the same time, and the traffic-aware cruise control was deactivated. Also, the park assist system indicated a fault in a parking sensor located in front of the passenger car's right front wheel. The NSIA considers this to support the assumption that the collision with the HGV driver happened at approx. 11:19.

At that time, the passenger car's adaptive cruise control and autosteer functions were active. Cruise control is not a collision warning or avoidance system, and the autosteer function is not designed to steer the passenger car around objects partially or completely in the driving lane.

The passenger car driver's understanding of the driver support systems was that they would keep the car in the right lane and keep the distance to any other vehicles in front of him in the same lane. The driver support systems were not designed to identify conflicts with people in the road or to apply automatic emergency braking or avoidance manoeuvres in this type of situation. The driver support systems therefore did not help the passenger car driver to identify the HGV driver.

The NSIA is of the opinion that the driver may have been less involved in the driving process due to a combination of the use of the passenger car's driver support systems and the road design. The driver has stated that he used to relax a little mentally when entering this section of the E18 road. The NSIA can see how the road design may encourage a more relaxed driving style, but at the same time points out that the high speed requires drivers to be particularly attentive.

2.2.4 SUMMARY

The investigation has shown that the HGV driver did not notify the Traffic Control Centre by calling 175, nor had he notified anyone else that he had stopped on the side of the road. The driver still chose to exit the HGV to secure the lashings on the vehicle's left side. He was then standing in the roadway.

The investigation has also shown that the passenger car driver's situational awareness in the moments before the accident was that a vehicle had been abandoned on the hard shoulder, and that there was room to pass it in the right lane. The HGV driver was standing in the vehicle's shadow, and close to the flatbed. From a distance, it may have been difficult for the passenger car driver to see that there was a person standing next to the HGV.

The investigation has also shown that the passenger car's adaptive cruise control and autosteer were activated at the time of the accident. These driver support systems were not designed to identify conflicts with people in the road or to apply automatic emergency braking or avoidance manoeuvres in this type of situation. The driver of the passenger car was aware of this. However, the NSIA's view is that the driver may have been less involved in the driving process due to a combination of the use of the passenger car's driver support systems and the road design.

To summarise, the NSIA would like to point out the following learning points for road users based on the investigation in question:

- In hazardous situations, such as vehicles stopped along a motorway, notify the Traffic Control Centre (VTS) by calling 175.
- When you observe a stationary vehicle on the side of a motorway, increase your safety margins by passing in the left lane if possible.
- Even if you are using your car's driver support systems, it is your responsibility to be alert, drive safely and be in control of your vehicle at all times.

2.3 Traffic monitoring, notification and management

The HGV driver did not notify the Traffic Control Centre (TCC) or anyone else after stopping outside the Torsbuås tunnel. Nor did any other road users report the stationary vehicle, and the TCC did not have access to CCTV or any other detection devices on the section of the E18 road in question. Consequently, the driver of the passenger car was not notified of the situation on the northern side of the Torsbuås tunnel.

TTC operators have told the NSIA that situations involving vehicles stopping on the side of the road are fairly common on this section of the E18 road, and that they would normally have lowered the speed limit on the section had they been made aware of the situation.

The NSIA's understanding is that road owners and road authorities consider traffic management and notification, for example by lowering the speed limit or closing lanes in connection with incidents, to constitute a mitigating measure. However, the present investigation has shown that, in light of the situation that arose, the variable speed limits on this section of road have not been a sufficient mitigating measure to compensate for the narrow hard shoulder. In the absence of monitoring, the TTC had no possibility of detecting the incident and consequently no possibility to intervene in the situation by lowering the speed limit.

Although the collision occurred relatively soon after the HGV had stopped on the side of the road, the NSIA believes that this accident illustrates the vulnerability of the road geometry. The NSIA is also of the opinion that this accident shows that, in the absence of adequate traffic monitoring and detection functions, variable speed limits are not a sufficient mitigating measure to maintain traffic safety on this section of road.

2.4 Approval and construction of the section of road

The investigation has shown that the hard shoulder was not sufficiently wide and that the HGV was therefore partly in the right lane after stopping, despite the driver having utilised the entire width of the road shoulder.

Nye Veier applied for permission to reduce the width of the hard shoulder from 3.0 metres (standard width) to 2.0 metres for the section of road in question. The shoulder width applied for was in accordance with the recommendations of a risk analysis prepared in connection with the application. The risk analysis proposed mitigating measures based on potential safety problems identified in connection with a narrower hard shoulder. The measures were incident detection, more emergency lay-bys, a road shoulder width of 2.0 metres and reducing the use of crash barriers (creating 1:4 slopes).

The investigation has found that the NPRA entity that considered the application took a critical view of the risk analysis enclosed with the application. Among other things, they questioned the lack of quantitative and qualitative data to substantiate probabilities and consequences in the risk assessment. The NPRA was also uncertain about how useful it would be to establish more emergency lay-bys. Nye Veier considered it inexpedient to install incident detection only on the section of road in question, but the Directorate of Public Roads recommended that Nye Veier consider measures to automatically direct traffic into one lane in the event of an incident. Other than this, the NPRA took a positive view of new motorway design solutions being tested.

The NSIA's understanding of the NPRA's approval is that no explicit requirements were stipulated for mitigating measures to be implemented when the solution with a reduced hard shoulder width was approved. However, the NPRA has informed the NSIA that it approved the solution in the expectation that the mitigating measures described would be implemented on the section of road in question.

When the section was built with a hard shoulder width of 2.0 metres, Nye Veier chose not to equip it with incident detection. Nor were more emergency lay-bys established. The investigation has shown that the HGV driver was forced to stop on the hard shoulder as there was no emergency lay-by outside the tunnel and the next opportunity to stop was about 2.5 km further north.

The NSIA agrees with the NPRA that the risk analysis on which the application was based was not adequate for the solution in question. However, the NSIA takes a critical view of the fact that the NPRA did not request a new and more comprehensive risk assessment when it considered the application. The NSIA also considers that explicit requirements should have been set and that the approval should have been conditional on Nye Veier implementing mitigating measures.

In light of the road users' perception of the situation immediately before the accident, the NSIA's view is that an insufficient shoulder width and the absence of emergency lay-bys and notification were the most important contributing factors to the accident. The NSIA is also of the opinion that the road safety was not sufficiently addressed by the NPRA's deviation management and Nye Veier's construction of this section of road.

The NSIA submits one safety recommendation to Nye Veier on this point.

2.5 Road design norm N100 allows for narrow four-lane motorways

It is the NSIA's opinion that the narrow shoulder and absence of mitigating measures on the section of road in question were important contributing factors to this accident.

The revised version of N100 allows for the width of the hard shoulder of four-lane motorways with an AADT of < 20,000 vehicles/day and a speed limit of 110 km/h to be reduced without this having to be processed as a deviation. However, mitigating measures are required to ensure that the accident frequency and injury costs do not increase compared with a road with full shoulder width. No definition of 'mitigating measures' is provided, nor does the road design norm describe what the mitigating measures may consist of. It is also not described how it should be assessed that the measures *'ensure that the accident frequency and injury costs do not increase'.* No requirement is stipulated for the construction client/road manager to document the mitigating measures and their desired risk-reducing effects.

N100 initially describes traffic safety as a shared prerequisite and premise for street and road design. In the NSIA's opinion, this accident demonstrates that the possibility of reducing the hard shoulder width provided for in N100 does not sufficiently attend to traffic safety on narrow four-lane motorways with a speed limit of 110 km/h. The NSIA considers that N100 should be revised to include a requirement for mitigating measures and their risk-reducing effects to be documented.

The NSIA is also of the opinion that N100 must require the construction client/road manager to give grounds for their choice of mitigating measures and describe their expected risk-reducing effect, as well as any remaining consequences of the measures. In light of the above, the client/road manager should also be required to define clear goals for what the proposed mitigating measures are intended to achieve.

The NSIA also considers that a technical guide for mitigating measures on planned narrow four-lane motorways should be prepared that the client/road manager can use and base their assessment and planning of this type of road designs on. Follow-up and control of the mitigating measures and their risk-reducing effects should also be facilitated. The NSIA considers this to be particularly important considering the fact that N100 no longer requires deviation processing by the NPRA to reduce the road shoulder width.

The NSIA submits two safety recommendations to the NPRA and one to the Directorate of Public Roads on this point.

2.6 National Transport Plan objectives and Vision Zero

A study of narrow four-lane motorways with a 110 km/h speed limit and an AADT of 6,000–20,000 vehicles/day was initiated by the Ministry of Transport and conducted by the NPRA.

The report states that a comparison between a two- or three-lane road (speed limit 90 km/h) and a narrow four-lane road (speed limit 110 km/h) with an AADT of 6,000–12,000 vehicles/day shows that the investment and accident costs will be lower for the two- or three-lane road. It goes on to state that a comparison between a narrow four-lane road (20 metres) and a standard four-lane solution (23 metres) with an AADT of 12,000–20,000 vehicles/day and a speed limit of 110 km/h shows marginal differences in socio-economic terms between the two road widths, as the investment, operating and maintenance costs that can be saved by reducing the width will be offset by an increase in accident costs.

The study concluded and the NPRA recommended that motorways with an AADT of 6,000–12,000 vehicles/day should be designed as two- or three-lane roads with a speed limit of 90 km/h, and that motorways with an AADT of 12,000–20,000 vehicles/day can be designed as narrow four-lane motorways.

The recommendation continues:

> *Our recommendation is that roads with an AADT of 12,000–20,000 be designed as narrow four-lane roads. Socio-economic calculations show only minor differences between the two alternatives, but the narrower profile entails lower investment costs and requires less land. Despite entailing somewhat higher accident costs, the most cost-efficient alternative is recommended. The cost savings can be better spent on road networks where the risk of accidents is higher.*

The final letter from the NPRA to the Ministry of Transport emphasised that Nye Veier and the NPRA's construction division believe that more importance should be attached to socio-economic profitability when defining requirements in road design norms. It was also emphasised that the Directorate of Public Roads' expert opinion was that the width of the hard shoulder could be reduced from 2.75 to 2.0 metres on roads with an AADT of < 20,000, provided that mitigating measures are implemented to maintain traffic safety.

However, the letter does not mention that documentation should be required for the mitigating measures or their expected risk-reducing effects. The letter goes on to state that measures can be implemented to mitigate the negative impacts of reduced shoulder width, for example in the form of automatic incident detection, a lower speed limit in connection with incidents, and traffic regulation in different lanes. The letter also emphasises the significant uncertainty regarding what impact the vehicles of the future will have on road design. In that connection, it is also emphasised that some believe that the required road width will be reduced in future, while others believe the opposite will be the case.

The process resulted in N100 allowing for the width of the hard shoulder to be reduced. The investigation has shown that a number of expert communities commented on this aspect during the consultation process, and that several of them were highly critical of the content of the NPRA's reports. Several sources commented that the proposal to reduce the hard shoulder width was in conflict with Vision Zero for road traffic fatalities and serious injuries. The Norwegian Council for Road Traffic Safety (Trygg Trafikk) objected to the failure to emphasise Vision Zero in the Ministry of Transport's instructions to the NPRA. Trygg Trafikk also commented that, as far as the organisation is aware, this is the first time that the road authorities recommended measures that are socio-economically profitable at the expense of an increase in the number of fatalities and serious injuries.

In that connection, the investigation has also shown that the NPRA's study of 120 km/h as a speed limit for motorways considered how such a speed limit would affect the achievement of the NTP's objectives. The report pointed out that the NPRA has a particular responsibility for traffic safety and presented examples of mitigating measures that can be implemented to prevent the number of fatalities and serious injuries from increasing if the speed limit is increased. The investigation has found that the NPRA's study of narrow four-lane motorways did not include a corresponding assessment of the impact on the achievement of the NTP's objectives. The NSIA considers this unfortunate and finds that the study has not adequately assessed and emphasised the traffic safety consequences of this solution.

The NSIA is also of the view that the NPRA's report on narrow four-lane motorways is based on a cost-efficiency principle whereby the savings in investment costs from building narrower four-lane motorways can be used to upgrade and improve other parts of the road network where the risk of accidents is higher. The report shows that the overall benefit to society can be optimised in this way. The NSIA is not aware of any framework that would ensure that funds saved by planning and building narrow four-lane motorways can be used for traffic safety measures on other roads with a higher accident risk. In light of this, the NSIA agrees with the Institute of Transport Economics (TØI) that the argument seems to be purely hypothetical until such a framework is established.

Scientific articles and data show a clear link between hard shoulder width and the number of traffic accidents, and that a wider hard shoulder leads to fewer accidents. In light of this, the NSIA takes a critical view of N100 allowing the hard shoulder width to be reduced. The NSIA supports the expert input to the process that this is not in line with Vision Zero.

In order to reduce the number of road traffic fatalities and serious injuries, Vision Zero must form the basis for investments in the road network, including expert feedback and political decisions. In the NSIA's view, sufficient importance has not been attached to Vision Zero when the Ministry of Transport tasked the NPRA with conducting a study of narrow four-lane motorways, or in the content of the NPRA's study and accompanying recommendation. The NSIA is of the opinion that the accident represents a case of conflicting goals, where financial aspects have been given priority over traffic safety. This is opposed to a systems approach, which requires a safety culture where safety is paramount in road system investment decisions.[14]

[14] https://safety.fhwa.dot.gov/zerodeaths/zero_deaths_vision.cfm.

3. Conclusion

3. Conclusion

3.1 Main conclusion

In light of the road users' perception of the situation immediately before the accident, the NSIA's view is that an insufficient shoulder width and the absence of emergency lay-bys and notification were the most important contributing factors to the accident. NSIA is also of the opinion that road safety was not sufficiently addressed by the NPRA's deviation management and Nye Veier's construction of this section of road.

Scientific articles and data show a clear link between hard shoulder width and the number of traffic accidents, and a wider hard shoulder leads to fewer accidents. In light of this, the NSIA takes a critical view of N100 allowing the hard shoulder width to be reduced. In order to reduce the number of road traffic fatalities and serious injuries, Vision Zero must form the basis for investments in the road network, including expert feedback and political decisions. In the NSIA's view, sufficient importance has not been attached to Vision Zero when the Ministry of Transport tasked the NPRA with conducting a study of narrow four-lane motorways, or in the content of the NPRA's study and accompanying recommendation. The NSIA is of the opinion that the accident represents a case of conflicting goals, where financial aspects have been given priority over traffic safety.

3.2 Investigation results

3.2.1 SEQUENCE OF EVENTS, OPERATIONAL AND TECHNICAL FACTORS

A. The vehicle was carrying roof tiles and the driver was alone in the vehicle. The driver was notified that one of the lashings on the vehicle had come loose.

B. The driver stopped the vehicle on the hard shoulder of the E18 road, 181 metres north-east of the tunnel exit.

C. Despite the driver having utilised the entire available width of the road shoulder, the vehicle was partly in the right lane.

D. The driver exited the vehicle to secure the lashing at the rear of the semi-trailer. This resulted in him standing in the roadway to the left of the vehicle for a short time.

E. The passenger car was in the right lane when exiting the Torsbuås tunnel at a speed of approx. 100 km/h. The speed limit on this section of road was 110 km/h.

F. The HGV driver did not notify the Traffic Control Centre (TCC) or anyone else after stopping outside the Torsbuås tunnel. Nor did any other road users report the stationary vehicle, and the TCC did not have access to CCTV or any other detection devices on the section of the E18 road in question.

G. The passenger car driver's situational awareness in the moments before the accident was that an HGV had been abandoned on the hard shoulder, and that there was room to pass it in the right lane.

H. The HGV driver was standing in the vehicle's shadow, and close to the flatbed. From a distance, it may have been difficult for the passenger car driver to see that there was a person standing next to the HGV.

I. The passenger car's adaptive cruise control system and autosteer function were activated at the time of the accident.

J. The driver support systems were not designed to identify conflicts with people in the road or to apply automatic emergency braking or avoidance manoeuvres in this type of situation.

K. The driver was less involved in the driving process due to a combination of the use of the passenger car's driver support systems and the road design.

3.2.2 ORGANISATIONAL AND SYSTEMIC FACTORS

A. During the planning phase, Nye Veier requested permission to reduce the shoulder width on this section of road from 3.0 metres to 2.0 metres.

B. The NPRA was critical of the risk analysis enclosed with the application, but took a positive view of new motorway design solutions being tested.

C. The NPRA approved the solution with a narrower shoulder width in the expectation that Nye Veier would implement the proposed mitigating measures on the section of road in question.

D. Nye Veier chose not to establish incident detection or extra emergency lay-bys on this section of road.

E. A study of narrow four-lane motorways with a speed limit of 110 km/h and an AADT of 6,000–20,000 vehicles/day was initiated by the Ministry of Transport and conducted by the NPRA.

F. The conclusion of the study and the NPRA's recommendation was that motorways with an AADT of 12,000–20,000 vehicles/day can be designed as narrow four-lane motorways.

G. Several expert communities were highly critical of the content of the NPRA's reports. Several sources commented that the proposal to reduce the hard shoulder width was in conflict with Vision Zero for road traffic fatalities and serious injuries.

H. The revised version of N100 allows for the width of the hard shoulder of four-lane motorways with an AADT of < 20,000 vehicles/day and a speed limit of 110 km/h to be reduced without this having to be processed as a deviation. However, mitigating measures are required to ensure that the accident frequency and injury costs do not increase compared with a road with full shoulder width.

I. The term 'mitigating measures' is not defined in N100. There is no requirement for the client/road manager to document the mitigating measures and their desired risk-reducing effects.

4. Safety recommendations

4. Safety recommendations

The Norwegian Safety Investigation Authority submits the following five safety recommendations for the purpose of improving road safety.[15]

The NSIA would also like to highlight the following learning points for road users:

- In hazardous situations, such as vehicles stopped along a motorway, notify the Traffic Control Centre (VTS) by calling 175.
- When you observe a stationary vehicle on the side of a motorway, increase your safety margins by passing in the left lane if possible.
- Even if you are using your car's driver support systems, it is your responsibility to be alert, drive safely and be in control of your vehicle at all times.

Safety recommendation Road No 2022/13T

The accident on 29 May 2020 occurred when the driver of a heavy gods vehicle (HGV) was hit by a passenger car on the E18 road near Arendal. The driver of the HGV died. The investigation has shown that the hard shoulder was not sufficiently wide to allow the whole HGV to be placed outside the roadway, and that it was therefore still partly in the right lane after stopping. The driver did not notify the Traffic Control Centre (TCC) by calling 175, nor had he notified anyone else that he had stopped on the side of the road. The driver still chose to exit the HGV to secure the lashings on the vehicle's left side, and he was standing in the roadway.

The Norwegian Safety Investigation Authority recommends that the Norwegian Truck Owners Association (NFL) prepare an information campaign aimed at professional drivers, focusing on notifying the TCC when stopping on high-speed motorways where it is not possible for the vehicle to leave the roadway completely.

[15] The investigation report is submitted to the Ministry of Transport, which will take the necessary steps to ensure that due consideration is given to the safety recommendations, cf. the Regulations of 30 June 2005 No 793 on Public Investigation and Notification of Traffic Accidents etc. Section 14.

Safety recommendation Road No 2022/14T

The accident on 29 May 2020 occurred when the driver of a heavy gods vehicle (HGV) was hit by a passenger car on the E18 road near Arendal. The driver of the HGV died. The investigation has shown that the hard shoulder was not sufficiently wide to allow the whole HGV to be placed outside the roadway, and that it was therefore still partly in the right lane after stopping. The Norwegian Public Roads Administration approved the reduced hard shoulder width, assuming that Nye Veier would implement the proposed mitigating measures on the section of road in question. However, Nye Veier chose not to establish incident detection or extra emergency lay-bys on this section of road.

The Norwegian Safety Investigation Authority recommends that Nye Veier AS implement mitigating measures to address road safety on the E18 road section between Tvedestrand and Arendal.

Safety recommendation Road No 2022/15T

The accident on 29 May 2020 occurred when the driver of a heavy gods vehicle (HGV) was hit by a passenger car on the E18 road near Arendal. The driver of the HGV died. The investigation has shown that the hard shoulder was not sufficiently wide to allow the whole HGV to be placed outside the roadway, and that it was therefore still partly in the right lane after stopping. The section of road where the accident occurred was built with a reduced hard shoulder width. The road design standard N100 allows for reducing the hard shoulder width of narrow four-lane motorways, provided that mitigating measures are implemented, without requiring this to be processed as a deviation. There is no requirement for the client/road manager to document the mitigating measures and their risk-reducing effects.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration amend the requirements regarding the reduction of the hard shoulder width in the road design norm N100, Road and street design, to include a requirement for documentation of the mitigating measures and their risk-reducing effects if narrow four-lane motorways are allowed.

Safety recommendation Road No 2022/16T

The accident on 29 May 2020 occurred when the driver of a heavy gods vehicle (HGV) was hit by a passenger car on the E18 road near Arendal. The driver of the HGV died. The investigation has shown that the hard shoulder was not sufficiently wide to allow the whole HGV to be placed outside the roadway, and that it was therefore still partly in the right lane after stopping. The section of road where the accident occurred was built with a reduced hard shoulder width. The road design standard N100 allows for reducing the hard shoulder width of narrow four-lane motorways, provided that mitigating measures are implemented, without requiring this to be processed as a deviation. The road design norm N100 also does not define mitigating measures, nor does it describe the nature of such mitigating measures.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration prepare a technical guide for mitigating measures for planned narrow four-lane motorways.

Safety recommendation Road No 2022/17T

The accident on 29 May 2020 occurred when the driver of a heavy gods vehicle (HGV) was hit by a passenger car on the E18 road near Arendal. The driver of the HGV died. The investigation has shown that the hard shoulder was not sufficiently wide to allow the whole HGV to be placed outside the roadway, and that it was therefore still partly in the right lane after stopping. The section of road where the accident occurred was built with a reduced hard shoulder width. The road design standard N100 allows for reducing the hard shoulder width of narrow four-lane motorways, provided that mitigating measures are implemented, without requiring this to be processed as a deviation.

The Norwegian Safety Investigation Authority recommends that the Road Supervisory Authority, within its remit, work to ensure that the accident frequency and accident costs do not increase on planned narrow four-lane motorways, as stated in road design norm N100, Road and street design.

Norwegian Safety Investigation Authority
Lillestrøm, 10 August 2022

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Appendices

Appendix A Investigation model for human functioning in connection with accidents

In this investigation, the NSIA has applied an investigation model based on research into situational awareness (Endsley, 2012). The research shows that, in situations where great demands are placed on a person to function in a demanding, potentially dangerous and time-critical situation, people follow a certain pattern when they try to find the best way to resolve the situation.

The person collects sensory information about the situation, for example weather conditions and infrastructure. Visual input is usually particularly important in identifying key aspects of the situation.

Situational awareness is created when the person combines the different pieces of information to form a comprehensive picture and forms an understanding of the here-and-now situation. This understanding enables the person to predict what is likely to happen in the immediate future. In combination with previous experience and other knowledge, this forms the basis for the person's decisions and actions in the situation in question.

The actions that a person chooses to perform or not perform can have a favourable or adverse effect on the situation, or no effect at all. In the course or a given period, for example the sequence of events in connection with an accident, the person will continue to go through this loop until the situation has been resolved.

Many different factors will have a bearing on how a person functions in this process. The NSIA groups such factors into four main categories: local operational factors, local technical factors, individual factors, and organisation factors including framework conditions. Figure 33 shows the NSIA's investigation model for human factors, which for our purposes means how people function before and during an accident situation.

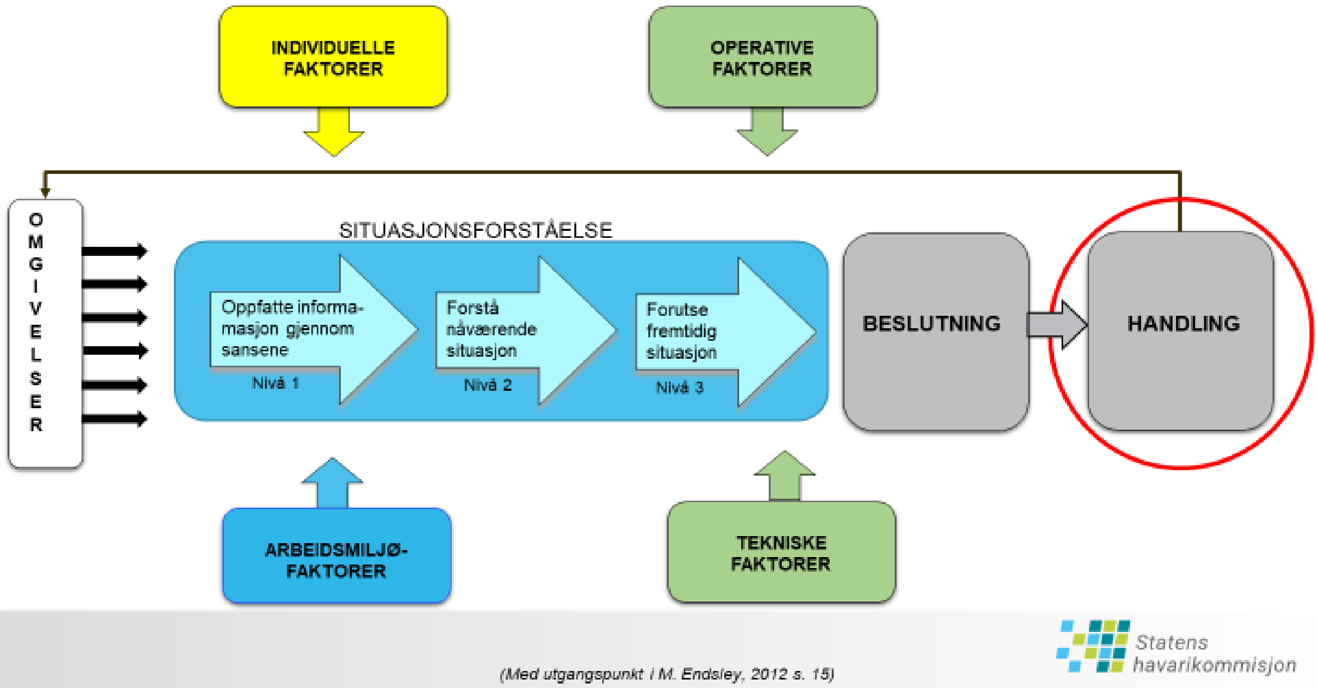

Figure 33: The NSIA's investigation model for human factors (HF). Illustration: The NSIA based on M. Endsley (2012, p. 15). The box 'Action' is circled in red because it is usually the explanations for and

consequences of people's actions that constitute the HF element's most important contribution to the NSIA's safety investigations.

A systematic investigation of the situational awareness and actions of important parties will often yield important contributions to understanding what happened in an accident and why it happened, which forms the core of the NSIA's remit. The model is used to the extent it is useful to an investigation, which means that not all groups of factors or individual factors will be brought up in all investigations.

As applied to the road traffic sector, the model means that a well-functioning driver will go through the dynamic situational awareness process as often as the situation requires and for as long as the driver is driving. This is referred to as the driving process in the present report.

According to Endsley (2017), this process includes the ability to perceive and interpret information from the traffic situation and to make sensible assessments regarding how the information is relevant to the person's goals (for example when it is necessary to change lanes to be able to exit a motorway). The driving process also includes the ability to anticipate future events to make proactive decisions (for example slowing down your own car when you see the brake lights on the car in front).

Appendix B Relevant research

This appendix describes relevant research on automation and use of driver support systems (DSSs).

Insufficient situational awareness

According to Endsley, two of the most common causes of traffic accidents are failure to adequately monitor the road and inattention – examples of situations where the driver's situational awareness during the driving process has been inadequate. One form of inattention is to engage in secondary tasks.[16] De Winter et al. (2014) found an increase of 261% in secondary tasks performed when drivers used DSSs for automated driving.

A lot of research has gone into finding out how the introduction of driver support systems such as automatic braking and steering affect the driving process. It has long been known that systems that partly take over and automate parts of the driving process tend to distance the driver from the process (Wickens & Kessel, 1979; Young, 1969) because they reduce the driver's situational awareness (Endsley & Kiris, 1995). So far, recent research and development do not seem to have succeeded in finding satisfactory solutions to this challenge.

The paradox of automation

Research on settings in which people monitor automated processes has identified a paradox: The more automated a human-machine system that performs a work process becomes, and the more reliable this automation is, the less likely it is that the human will identify the need for manual intervention soon enough and be able to intervene in a sufficiently quick and effective manner. Victor et al. (2018) call this a catch-22 situation *'whereby automation may prevent crashes, but crashes may occur because of automation'* (p. 1095).

Endsley (2017) sums up the past 30 years of research by stating that a driver's ability to intervene and take over manual control from an automated system when needed depends on the driver's situational awareness of key information about the surrounding environment. Endsley points to three main factors that are important to the situational awareness of drivers when DSSs are activated:

1. Attention and trust
2. Involvement and workload
3. Mental model

Each of the main factors are briefly discussed below.

1. Attention and trust

The situational awareness of a driver is directly affected by how much attention he or she is paying to information of relevance to the driving process; the less attention to such information, the poorer the driver's situational awareness in the traffic situation.

[16] Secondary tasks are activities that are not necessary to the driving process, for example regulating the temperature in the compartment or checking activity on your mobile phone.

At the same time, studies have shown that, when the driver support systems' automation becomes more reliable and robust, the drivers trust the systems more. This will then increasingly lead the drivers to shift their attention to secondary tasks such as daydreaming, using the vehicle's various technologies, talking to passengers or others, sending text messages, eating, checking their appearance in the mirror etc. (see e.g. Hergeth et al., 2016). Such distractions lower a driver's situational awareness, and thus also his or her ability to interrupt the automatic driving when a DSS encounters a hazardous situation that it has not been designed to deal with in a safe manner.

2. Involvement and workload

Even drivers who are vigilant and pay attention to the traffic situation may become significantly less involved in the driving process when they use automated functions. They begin to think and behave in a manner more akin to a passenger than an active driver. This lowers their situational awareness and delays their reaction to dangerous situations in traffic.

According to Mosier and Skitka (1996), the use of automatic aids can contribute to operators making decisions that are not based on an assessment of all available information. Instead, the user of the automated aid makes decisions that are strongly influenced by the instructions and advice of the automatic aid, a phenomenon referred to as 'automation bias'. This could increase the risk of accidents, for example in situations when the user fails to identify a hazard because an automatic aid did not identify it. Empiric support for this has been found e.g. by Manzey et al. (2012), who also used the term 'complacency' to describe this. In this context, it is understood to mean *'a state of uncritical self-satisfaction with the situation and one's own functioning'.*

Factors such as reduced involvement in the driving process, automation bias and complacency can reduce the driver's situational awareness and ability to avert hazardous situations by taking over control from the driver support system.

3. Mental model

A driver's situational awareness will also be greatly influenced by how familiar the driver is with how the driver support system functions. This applies both to how precise an understanding the driver has of what the different functions do and to what extent the driver understands how the system actually functions as a whole. The driver's mental model of a DSS is primarily developed through practical use of the system, and is based on the information the system provides on the displays in the car and the vehicle's behaviour in traffic.

Mental models of DSSs create a set of expectations that drivers use to assess the traffic situation and anticipate how the system will act. The DSSs thus become part of the driving process.

As the driver support systems become more advanced and capable of a certain level of machine learning, meaning that they will change over time, this development will make it more difficult for drivers to gain and maintain an accurate mental model of the system. It will also make it more difficult for the driver to anticipate the vehicle's behaviour in different traffic situations.

If the driver does not have a sufficiently precise understanding or mental model of how a DSS works, the expectations of what the vehicle is capable of will also be imprecise. This reduces the driver's situational awareness and thereby also the ability to intervene in an appropriate manner at the appropriate time when the situation so requires.