Norwegian Safety Investigation Authority

Issued July 2025

REPORT ROAD 2025/02

Head-on collision between a passenger car and a heavy goods vehicle on the Rv 7 road in Flå on 21 May 2024

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.

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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.

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Photo: Norwegian Public Roads Administration

Legal authority for the NSIA's activities is found in Section 44 of the Act of 18 June 1965 No 4 relating to road traffic (the Road Traffic Act); cf. Section 2 of the Regulations of 30 June 2005 No 793 on Public Investigation and Notification of Traffic Accidents etc.

Table of Contents

Notification of the accident

Table 1: Event data

Date:	21 May 2024
Time:	16:18
Accident location:	Flå centre, Flå municipality, Hallingdal
Road system reference:	[RV7 K S6D1 m9046]
Type of accident:	Head-on collision
Vehicle type:	Heavy goods vehicle, passenger car

The Norwegian Safety Investigation Authority (NSIA) was alerted by the police operations centre at 17:00 on 21 May 2024 about an accident between a heavy goods vehicle and a passenger car, see Figure 1. The NSIA initiated dialogue with the police and the Norwegian Public Roads Administration to secure relevant documentation. The NSIA secured the passenger car for further technical investigations. Based on the preliminary findings, the NSIA decided to initiate a safety investigation of the accident.

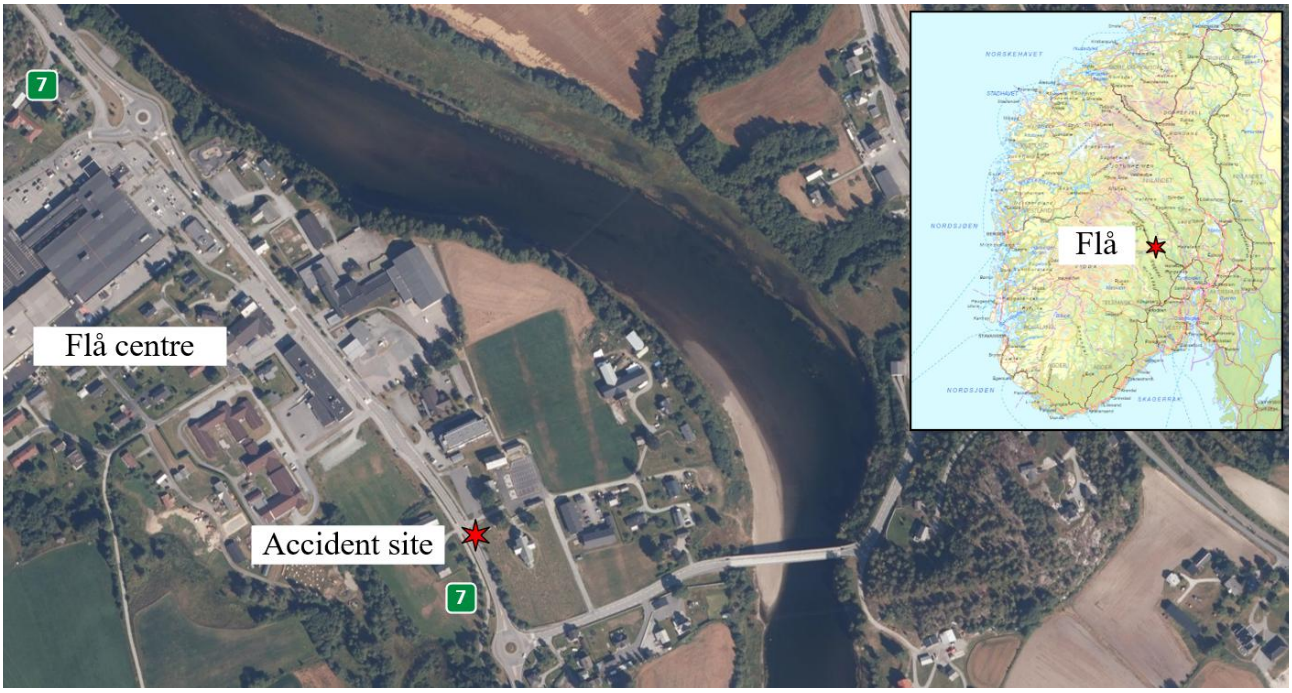


Figure 1: The accident site on the Rv 7 road in Flå centre in Flå municipality. Map: © norgeskart.no. Illustration: NSIA

Summary

The head-on collision on 21 May 2024 on the Rv 7 road in the centre of Flå occurred when a passenger car crossed over into the opposite lane at a speed of approximately 60 km/h and collided with a heavy goods vehicle. A family of five were in the passenger car, a Tesla Model S 85D 2014 model, who were travelling south through Hallingdal. The speed limit through the centre of Flå was 40 km/h.

The driver of the passenger car did not notice the gentle curvature of the roadway for a short time just before the collision. The HGV driver had seen the passenger car and slowed down before the collision. This reduced the forces of the collision considerably. Despite this, two of the people in the rear seat of the passenger car sustained critical injuries and the other people in the car sustained minor injuries.

The NSIA decided to initiate a safety investigation of the accident based on the major difference in the severity of the injuries sustained by the occupants of the passenger car. The investigation has mapped the sequence of events inside the passenger car, as well as the car's construction and safety systems that had a bearing on the severity of the injuries in the accident.

Everyone in the car was wearing a seat belt. The car was properly packed, and no heavy items were loose or entered the vehicle body from the boot. The total weight in the boot was approximately 67 kg. The booster seats used by two of the children were suitable for the children's age and size. The serious injuries sustained by an adult and one of the children of the rear seat can be explained by the incorrect use and adjustment of seat belts, combined with fewer supplemental restraint systems (airbag, seat belt pretensioner and force limiter), and the rear seat-back collapsing in the collision. Active seat belts and airbags helped to limit the injuries of the occupants of the front seats.

The NSIA finds that the passenger car passed the requirements set out in the regulations for both belt anchorage and rear seat strength. The requirements, however, do not show how rear seat strength, luggage and seat belts should work together. The NSIA believes that the dynamic forces in the accident were within what the vehicle's design should be able to withstand in terms of the mass of luggage and occupant weight.

The NSIA performed static tensile tests on a reference car to see how much load the rear seat-back could withstand when tensioned longitudinally, and whether it was possible to find out what caused the rear seat-back to collapse. The tests showed that with sufficient distortion, lateral forces occurred in the locking mechanism, which significantly reduced the strength of the connection in the rear seat-back. The rear seat-back collapsed at a load equivalent to around 1,000 kg in one of the tests. Based on this, the NSIA calculated that the rear seat-back could withstand less than 30 kg of pressing load when the rear seat-back simultaneously secured a light adult person, like the conditions in the accident.

The NSIA believes that regulations must change to improve safety for rear seat passengers, but this is a process that requires international agreement. A first step towards changing the regulations may be to raise the issue in The European New Car Assessment Programme (Euro NCAP). Tesla should also take a closer look at the car model's design for ensuring the safety of rear seat occupants. The NSIA moreover encourages car manufacturers to develop tests to ensure that their design solutions improve the safety of occupants of different sizes sitting in all positions.

The investigation also provides several learning points for road users about securing occupants and luggage in passenger cars. Also see the NSIA's previously published information video on the correct adjustment of seat belts.

The NSIA submits one safety recommendation to the Norwegian Public Roads Administration and one safety recommendation to Tesla Norway as a result of this investigation.

About the investigation

Purpose and method

The NSIA decided to initiate a safety investigation of this accident based on the major difference in the severity of the injuries sustained by the occupants of the passenger car. All the seats had physical survival space, and everything that had been placed in the boot was still there after the collision. The rear seat-back striker was torn off after the collision. This provided the basis for investigating the sequence of events inside the car, the car's design and safety systems.

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[1]).

Sources of information

- Investigations of the accident scene and involved vehicles, including tachograph data from the truck and the passenger car's airbag module (ACM).
- Investigations and tests performed on a similar passenger car for reference.
- Interviews and meetings with involved parties.
- Photos and documents from the police, the Norwegian Public Roads Administration and a photojournalist who was at the accident scene.
- Information from the Norwegian Public Roads Administration, Flå Municipality, Tesla, Scania, Oslo University Hospital (OUS).
- Map services: Road maps, the Norwegian Mapping Authority (kystinfo.no, norgeibilder.no).
- Crash tests: Database data from tests conducted by NHTSA and IIHS.

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, 'Analysis', contains the NSIA's assessment of the sequence of events and contributory factors based on factual information and completed investigations and examinations. Circumstances and factors found to be of little relevance to explaining and understanding the accident will not be discussed in detail.

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

NSIA – Norwegian Safety Investigation Authority. See https://www.nsia.no/About-us/Methodology

1. Factual information

1. Factual information

1.1 Sequence of events

At 16:18 on Tuesday 21 May 2024, a passenger car carrying a family of five and a dog, was on its way south on the Rv 7 road in Hallingdal through Flå centre. An adult driver and a child sat in the front, and in the back an adult sat in the middle rear seat with a child on each side. The dog lay on blanket on the right side of the boot. The luggage was placed on the left side of the boot, close to the rear seat-back, with the heaviest items placed lowest. The rear seat-back was designed as a 60/40 split[2]. The 60-part was on the left side and the middle rear seat passenger's seat belt was mounted on this seat-back.

The road through the centre of Flå is straight and, in the southbound direction, there is a gentle bend to the right just before Flå church. The driver of the car has said that he may have observed the oncoming heavy goods vehicle as he drove south through the centre of Flå, while looking for a place to stop. Just before the exit to Flå church, the driver looked in the rear-view mirror and briefly turned his attention to the other occupants inside the car. The next thing the driver heard was the HGV honking its horn. He managed to hit the brakes and attempted to swing to the right just before the collision occurred.

The driver of the HGV, who was in the opposite lane, has described that as he drove north towards Flå centre, a car approached that appeared to be preparing to turn into a car park a little further ahead of him. The car was then level with a red barn further ahead on the opposite side of the road, see Figure 2. The HGV driver slowed down to allow space and time for a possible exit, but noticed that the passenger car continued straight ahead and into his lane. The HGV's automatic emergency braking system activated, the driver honked his horn and braked hard before the collision.

A full head-on collision then occurred between the passenger car and the HGV. The 60-part of the rear seat-back in the passenger car collapsed in this collision.

Figure 2: Final positions of the vehicles, road alignment in the passenger car's travel direction and the position of the red barn by the side of the road. Photo: Norwegian Public Roads Administration

[2] A 60/40 rear seat-back is split with one part covering 60% of the rear seat-back and the other 40%.

1.2 Survival aspects

1.2.1 THE RESCUE WORK

After the collision, medical personnel quickly arrived at the accident site. The Helseekspressen patient transport service was driving behind the HGV, and had medical personnel on board. The medical personnel quickly established an overview of the accident site. The fire service was the first emergency service at the scene, and an ambulance arrived about 15 minutes later. Three air ambulances were called out, two of which landed at the accident site.

Figure 3: Rescue work in process, where the Helseekspressen patient transport service, two ambulances and two air ambulances had arrived at the accident site. Photo: Tangen foto

Everyone involved was conscious after the collision. The three children got out of the car on their own, but the driver and middle passenger in the rear seat had a great deal of pain. The condition of one of the children also started deteriorating.

The passengers in the middle and right rear seats were deemed to have sustained critical injuries. The two patients were transported by air ambulance at 17:10, and arrived at Ullevål University Hospital (OUS) at 17:40, approximately 1 hour and 20 minutes after the collision. The other three occupants of the car were taken by ambulance either via Ringerike Hospital or directly to Ullevål OUS.

1.2.2 SURVIVAL SPACE AND INTERIOR SAFETY EQUIPMENT

All the seats in the passenger car had physical survival space after the collision. Everyone in the car was wearing a seat belt and no heavy items were loose in the vehicle body. All airbags and seat belt pretensioners in the car activated at an early stage.

Table 2: Installed safety features and activation command. Source: Tesla, (Event 1) EDR report

Device	Status	Deployment Command Time (ms)
Driver Front Airbag Stage 1	Deployment Commanded	9
Driver Front Airbag Stage 2	Deployment Commanded	14
Driver Knee Airbag	Not Configured	
Driver Retractor Pretensioner	Deployment Commanded	9
Driver Lap Pretensioner	Deployment Commanded	9
Driver Side Seat Airbag	Deployment Not Commanded	
Passenger Front Airbag Stage 1	Deployment Commanded	9
Passenger Front Airbag Stage 2	Deployment Commanded	14
Passenger Knee Airbag	Not Configured	
Front Right Passenger Retractor Pretensioner	Deployment Commanded	9
Front Right Passenger Lap Pretensioner	Deployment Commanded	9
Passenger Side Seat Airbag	Deployment Not Commanded	
Left Side Curtain Airbag	Deployment Commanded	9
Right Side Curtain Airbag	Deployment Commanded	9
HV Battery Disconnect	Deployment Commanded	9

The striker of the 60-part of the rear seat-back was torn off, but no luggage from the boot moved into the vehicle body. Figure 4 illustrates the location of the various elements in the car, which safety equipment was activated and the severity of the injuries sustained by the different occupants of the car after the collision.

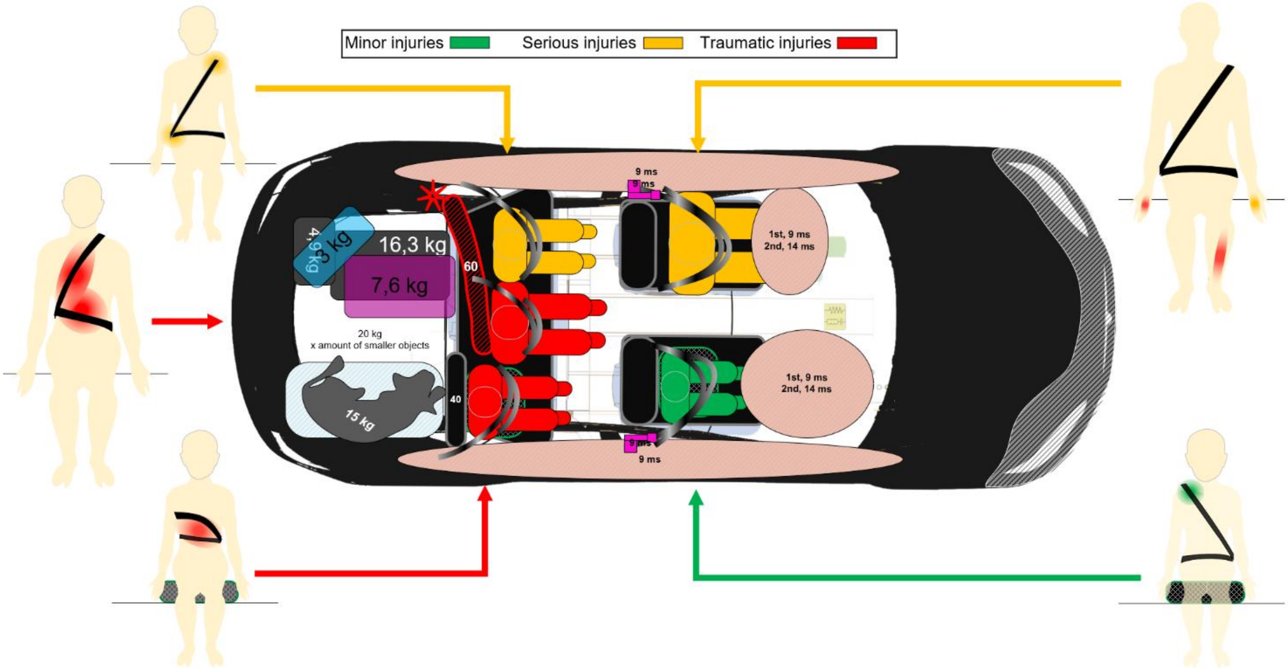


Figure 4: Deployed safety equipment, torn-off rear seat-back, luggage and seat belt positions in the collision are shown. Illustration by the NSIA

The NSIA has investigated in more detail the collapse of the rear seat-back, and has conducted tensile tests on a reference car of the same model and year, see section 1.11.3.

1.3 Personal injuries

1.3.1 DESCRIPTION OF INJURIES

A total of six people were involved, the HGV driver in the heavy goods vehicle and five people in the car. The dog was in the boot and sustained several critical fractures as a result of the collision, and was later put down by a vet. The HGV driver did not sustain any physical injuries after the accident.

After prehospital treatment and transport, the injuries were assessed at the trauma centre at Ullevål OUS or Ringerike Hospital, respectively. Everyone in the passenger car was transferred to Ullevål OUS over the course of the day.

Table 3: Location and description of injuries[3] sustained by the occupants of the passenger car. Source: OUS

Seat	Gender, age	Cuts, injuries (ICD coding)
Driver	Man, 45–50 years Normal weight/height	Closed fracture of left lower leg and right hand, superficial injuries across the pelvis.
Right front seat passenger	Child, 8–10 years Normal weight/height	Contusion of thorax and abrasions caused by the seat belt and airbag.
Left rear seat passenger	Child, 10–12 years Normal weight/height	Superficial injuries across the pelvis, fracture of the anterior right edge of the pelvis, minor left-sided pneumothorax and abrasion over the left collarbone.
Middle rear seat passenger	Woman, 40–45 years 55 kg[4], normal height	Multiple right-sided rib fractures and fracture of the sternum, right-sided pneumothorax, unstable fracture of lumbar vertebra, and transverse process fractures. Tearing of the abdominal wall musculature on the left side, small and large intestine injuries, injury of liver, laceration of abdominal aorta.
Right rear seat passenger	Child, 8–10 years Normal weight/height	Abrasions at an angle across the chest and across the abdomen. Injury of liver, spleen and pancreas. Fracture of lumbar vertebra and transverse process fractures.

1.3.2 TREATMENT OF INJURIES

Everyone in the car had superficial injuries consistent with wearing a seat belt in the collision. Apart from the driver and middle rear seat passenger, the injuries of the other passengers were subject to treatment without the need for surgery.

The driver was operated on in the orthopaedic department for a fracture of the left lower leg and a fracture of a metacarpal bone in the right hand.

The middle rear seat passenger was operated on immediately after arrival at the trauma centre at OUS. This passenger had life threatening injuries, and rapid treatment was vital. Extensive abdominal injuries, including intestinal damage, damage to the artery, and fractures in the lumbar spine, resulted in the passenger being placed in an induced coma and undergoing several operations in the days following the accident.

1.4 Damage to vehicles

1.4.1 GENERAL INFORMATION

Both the front of the tractor unit and the passenger car suffered extensive deformation as a result of the collision. The bonnet of the passenger car penetrated some way into the front of the tractor

[3] *Those involved have consented to a detailed description of the injuries.*
[4] *Her weight is provided because this passenger's seat belt was attached to the rear seat-back.*

unit, which was fitted with frontal protection. As a result of the collision, the chassis of the tractor unit was bent, and it sustained damage to the fifth wheel, among other things.

Figure 5: Deformation of the tractor unit and passenger car after the collision. Photo: Tangen foto

1.4.2 PASSENGER CAR

The damage to the passenger car was primarily in the front crumple zone. The car bumper was deformed rearwards and the outer edges on both sides folded back outside the chassis frame.

Figure 6: Passenger car after collision seen from above and crumple zone in front seen from below. Photo: NSIA

All the luggage in the boot of the car was still there after the collision. The striker of the 60-part of the rear seat-back was torn off and lodged in the rear seat-back latch, see red circles in Figure 7 and Figure 8.

Figure 7: Luggage in the boot after the collision behind the loose rear seat-back. Photo: Norwegian Public Roads Administration

Figure 8: Torn-off striker that lodged in the lock of the rear seat-back (60-part). Photo: Norwegian Public Roads Administration

Two booster seats were in use in the car. Both were designed with relatively low lap belt routing. Both had signs of routing wear on the right side, which was most evident in the booster seat in the right front seat, where a belt pretensioner for the lap belt was also activated.

Figure 9: Booster seat right rear seat. Photo: NSIA

Figure 10: Booster seat right front seat. Photo: NSIA

1.5 Accident site and collation of evidence

An illustration of the accident site with collated evidence is shown in Figure 11. Photos from the accident site showed no evidence of debris under or behind the front wheels of the tractor unit, indicating that the HGV was stationary when the collision occurred. There were skid marks from the semi-trailer's dual wheels approximately 6.8 metres behind the HGV, and under the front wheels up to its final position. The NSIA has illustrated where the vehicles may have been five seconds before the collision, based on distance/time calculations in section 1.11.1. The red barn and the car park described by the HGV driver are also marked in the figure.

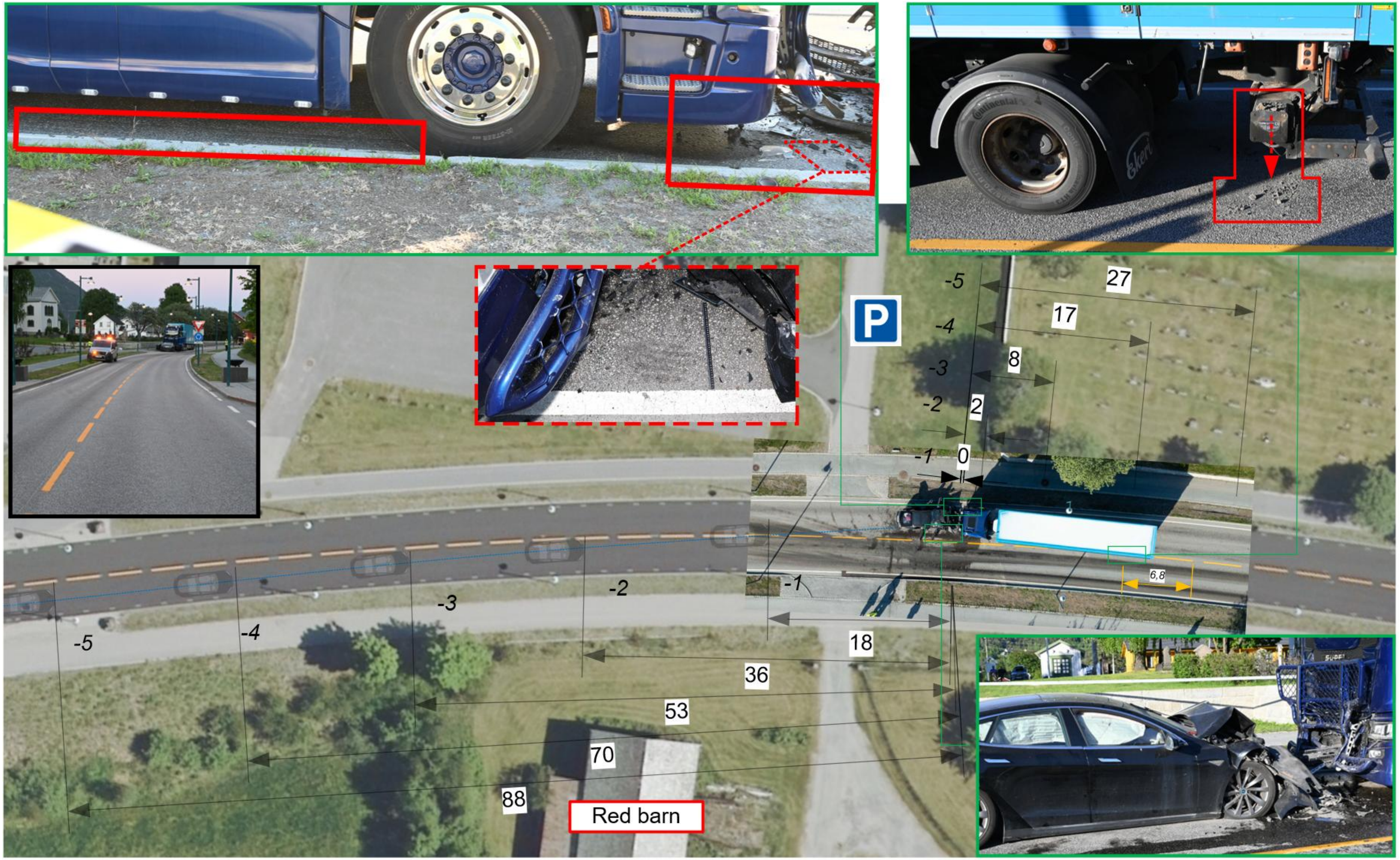


Figure 11: Illustration of the accident site and external damage to vehicles, the front of the passenger car and the HGV's distance in time five seconds before the collision (section 1.11.1). Debris and traces in the roadway are highlighted in red. Drone: Tangen foto, aerial photo: © norgeibilder.no (Hallingdal 2020), photo: Norwegian Public Roads Administration, Police, illustration: NSIA

1.6 Weather and driving conditions

The weather was fine and sunny, and the asphalt was clear and dry at the time of the accident. The sun conditions did not indicate a likelihood of dazzling.

1.7 Road users

The driver of the car was a man in his late 40s. Blood samples were collected from the driver and there was no evidence of alcohol or other substances that might have impaired the driver's competence prior to the accident.

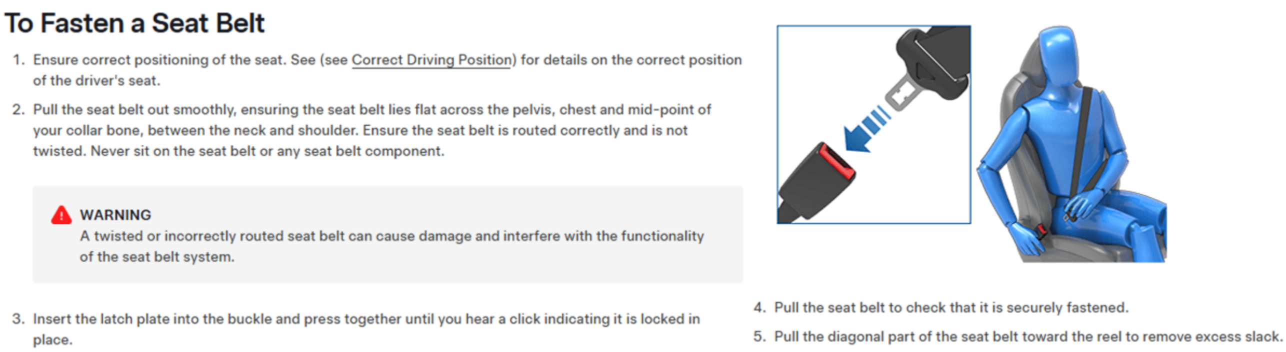
The driver of the HGV was in his late 20s.

1.8 Vehicles

1.8.1 PASSENGER CAR

1.8.1.1 Passive safety systems

The passenger car was an electric Tesla Model S 85D, first registered on 17 December 2014. In the Euro NCAP tests, this car received five stars when it was new. It came with several standard Supplemental Restraint Systems (SRS) described in Table 2, but was not equipped with a driver's knee airbag in Europe. The owner's manual describes the following about fastening the seat belt:



To Fasten a Seat Belt

1. Ensure correct positioning of the seat. See (see Correct Driving Position) for details on the correct position of the driver's seat.
2. Pull the seat belt out smoothly, ensuring the seat belt lies flat across the pelvis, chest and mid-point of your collar bone, between the neck and shoulder. Ensure the seat belt is routed correctly and is not twisted. Never sit on the seat belt or any seat belt component.

WARNING
A twisted or incorrectly routed seat belt can cause damage and interfere with the functionality of the seat belt system.

3. Insert the latch plate into the buckle and press together until you hear a click indicating it is locked in place.
4. Pull the seat belt to check that it is securely fastened.
5. Pull the diagonal part of the seat belt toward the reel to remove excess slack.

Figure 12: Fastening the seat belt, points 1–5. Source: Tesla Model S 2012–2020 owner's manual

The Tesla Model S 2012–2020 owner's manual describes the following under 'Checking the passenger front airbag': *'When a child is seated in the front passenger seat (even when the child is seated in a child restraint system or booster seat), you must disable the passenger front airbag to prevent it from injuring the child if a collision occurs*.'

The boot of this car model does not have hooks for securing luggage with straps, or wire mesh or netting to separate the boot from the vehicle body.

1.8.1.2 Installed driver assistance features

The owner's manual describes driver assistance systems that are or may be installed, and the limitations of these systems. The NSIA has retrieved a sample of these in Table 4, which describes different speed corridors. A radar was installed in the front of the car and a first-generation autopilot (mono camera) in the windscreen. At the time of production of this vehicle, automatic emergency braking systems were not a regulatory requirement for passenger cars in Europe.

Table 4: Selected driver assistance features described in the owner's manual. Source: Tesla

Driver assistance feature	Active at speeds
Active Cruise Control	30–140 km/h
Autosteer	30–140 km/h
Navigate on autopilot	30–140 km/h
Lane assist	48–140 km/h
Lane departure avoidance	64–145 km/h
Automatic emergency braking	5–200 km/h

1.8.1.3 Condition, service and periodic roadworthiness tests

Investigations carried out after the accident indicate that the vehicle has undergone regular maintenance and was in good technical condition. The last services performed on the car were twice in February 2024, and most recently on 13 May 2024, just over a week before the accident. The 12-volt battery was replaced during the last service.

However, the car did not undergo a periodic roadworthiness test (PKK) by the deadline of 28 February 2018, and an approved test was not submitted by 2 May 2018. The car was inspected on 7 May 2018, where it received three deficiencies with code 2, which means that the vehicle inspection would not be approved until the defect has been rectified. The driver has stated that he had the deficiencies rectified at a workshop, but did not receive any further letters or messages from the Norwegian Public Roads Administration. An approved follow-up inspection was never recorded in the Norwegian Public Roads Administration's records, and the car has been registered with a ban on use since then.

Notification from the Norwegian Public Roads Administration (NPRA) that a defect will result in a prohibition on use is provided in a letter entitled '*Notification that vehicle [reg. no.] may be deregistered' (Varsel om at kjøretøy [reg.nr.] kan bli avskiltet)*, which describes the risk of number plates being removed on site in the event of an inspection and that a fee will have to be paid to get the number plates back. This letter from the NPRA is to be regarded as advance notification of a decision, pursuant to section 16 of the Public Administration Act. Further follow-up from the NPRA stops there, and they do not have a system for following up and confirming that an owner has understood the decision, or the advance notification.

The NSIA has asked the NPRA about this issue and it received the following response:

> *In principle, we [the Norwegian Public Roads Administration] currently have letters that are distributed as notification that a prohibition on use is to be imposed on the vehicle, for various reasons. At present, these letters are not followed up by a reminder to the vehicle owner if nothing more happens to the vehicle. In cases where a prohibition on use is imposed and the vehicle owner fails to take action, a reminder could be sent to the owner after some time. This would mean in the above case that a reminder would be sent that the roadworthiness test deadline had passed, and that the vehicle should not be used and the owner would have to deregister the vehicle. This could help the owner in certain cases, not least in situations where the owner believes that everything is in order.*

1.8.1.4 Total weight passenger car

The registered kerb weight of the vehicle was 2,100 kg, and the maximum permitted weight was 2,590 kg.

The NSIA weighed all the luggage a few days after the accident. In the front luggage compartment (frunk) there was approximately 30 kg of luggage. The boot primarily contained four items; a suit in a suit bag, two soft suitcases and a backpack (3.0 kg, 7.6 kg and 16.3 kg, 4.9 kg), as well as various unsorted items, including a charging cable, totalling 20 kg. The heaviest suitcase was placed lowest and close to the seat-back. The total weight of all luggage was approximately 52 kg. In addition, the dog weighed approximately 15 kg and was placed on a dog blanket behind the right rear seat-back (40-part).

Figure 13: : Luggage virtually untouched until weighed. The dog was on the right side on a dog blanket. Photo: NSIA

The total weight in the boot was approximately 67 kg. The estimated total weight with luggage in the frunk and in the boot, and all occupants was approximately 2,445 kg. This was within the permitted total weight by approximately 145 kg.

1.8.2 HEAVY GOODS VEHICLE

The heavy goods vehicle consisted of a Scania S 660 tractor unit, first registered on 25 March 2024. The tractor unit was approved with frontal protection (a ‘bull bar’) at the front. The tractor unit was equipped with Automatic Emergency Braking system (AEB), after the requirements in UN ECE R 131. The tractor unit was connected to an Ekeri semi-trailer, first registered on 22 September 2017. The semi-trailer was loaded with 4.5 tonnes of pallet cargo, and 41 tonnes in total. This was within permitted total weight.

1.9 Technical registration systems

1.9.1 TACHOGRAPH DATA, FAULTS AND FLEET MANAGEMENT FROM THE TRACTOR UNIT

The tachograph, which detects speed via rotation from the drive shaft, was downloaded by the NPRA after the accident. The tachograph has its own externally calibrated clock, different from the tractor's internal clock and the fleet management GPS.

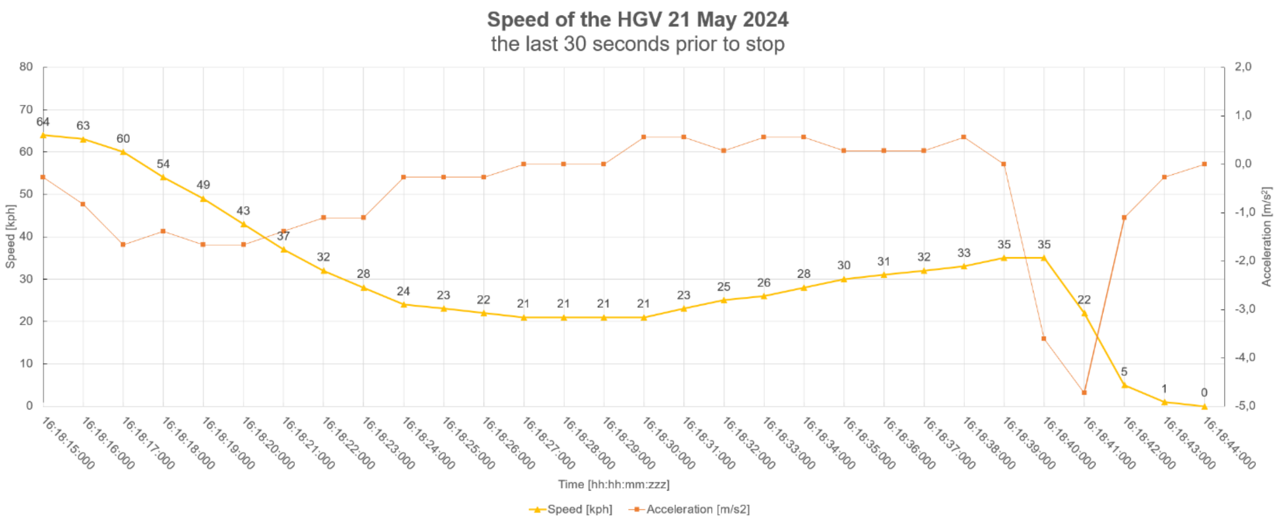


Figure 14: Speed of the HGV's tachograph the last 30 seconds prior to stop on 21 May 2024. Source: NSIA

Fault recorded in the tractor truck that could be related to the impact, was a circuit-break in the fan speed sensor and solenoid valve recorded at 14:18:39 (UTC[5]). The fleet management recorded a last speed before impact of 25 km/h at 16:18:34, and then 0 km/h at 16:18:46. The timestamps between the systems cannot be considered synchronous.

1.9.2 EDR REPORT FROM THE PASSENGER CAR

An 'Event Data Recorder report' (EDR report) was created in the passenger car in the collision, and this was downloaded after the accident. The report describes a driving data set saved every ½-second five seconds before the incident, as well as sensor data during the incident with a high sampling rate over 300 ms. The report also describes the safety equipment available and what was activated when. Vehicle Speed is calculated and reported by the average of the four wheel speed signals.

Table 5: Stored vehicle information five seconds before the head-on collision (Event 1). Source: Tesla, Event data (Event 1) EDR report

Time (sec)	Vehicle Speed (kph)	Accelerator Pedal %	Rear Motor Speed (rpm)	Service Brake	Steering Wheel Angle (deg)	Stability Control	ABS Activity
-5.0	62	22	4600	Off	8.4	On	Off
-4.5	63	22	4700	Off	8.4	On	Off
-4.0	63	22	4700	Off	8.4	On	Off
-3.5	63	22	4700	Off	4.2	On	Off
-3.0	63	22	4700	Off	4.2	On	Off
-2.5	63	22	4700	Off	4.2	On	Off
-2.0	64	22	4700	Off	4.2	On	Off
-1.5	64	22	4700	Off	4.2	On	Off
-1.0	64	22	4700	Off	4.2	On	Off
-0.5	64	0	4700	Off	8.4	On	Off
0.0	64	0	4700	On	84.0	On	Off

Longitudinal acceleration (g) in the head-on collision over time was logged with a resolution rate of 2 ms, shown in Figure 15. The data were also saved as a table (shown in Appendix A).

[5] *Local time = UTC + 2 hr*

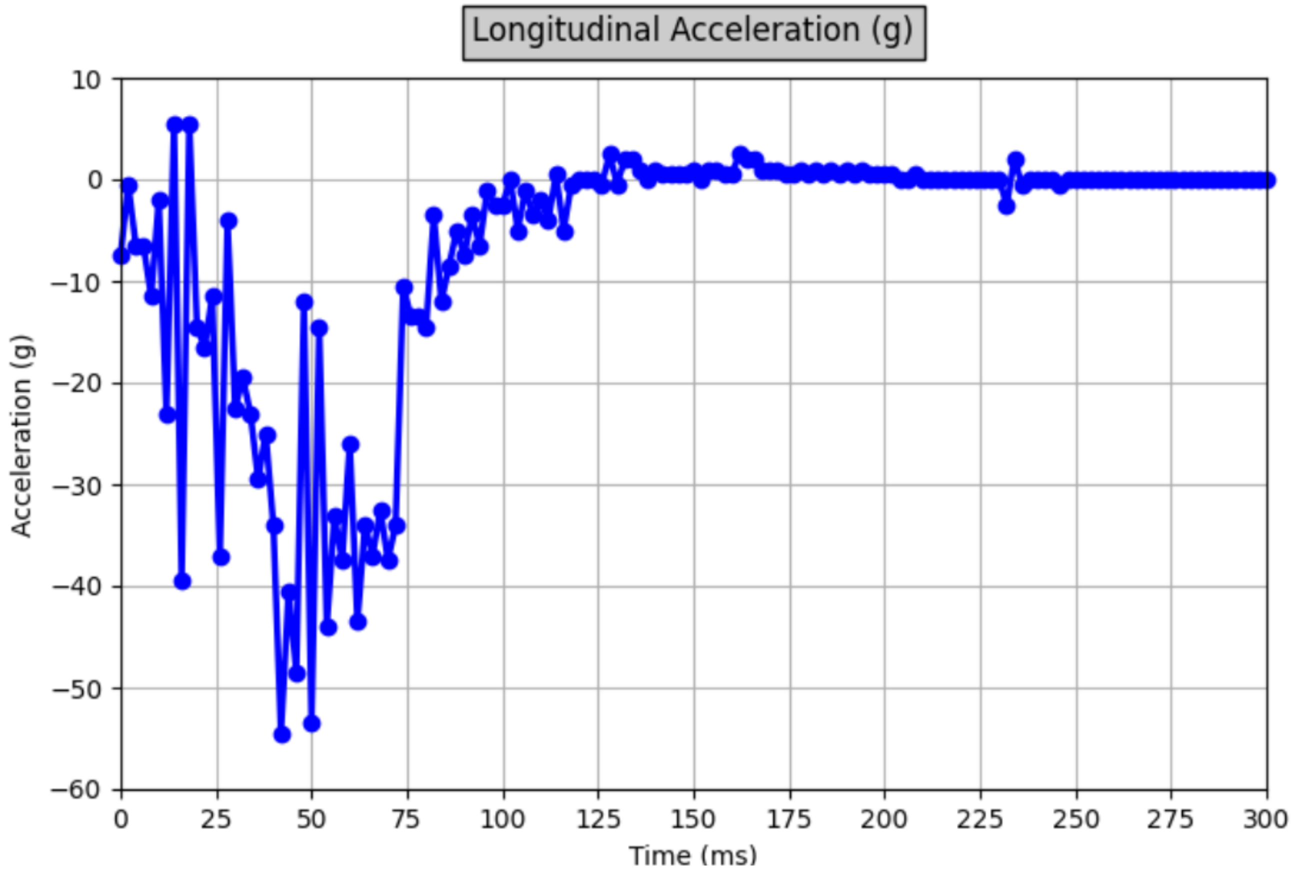


Figure 15: Longitudinal acceleration (g) of the passenger car in the collision. The highest g recorded was -54.5 g. Source: Tesla, (Event 1) EDR report

Acceleration data are used to calculate Delta-V (ΔV), and is the acceleration integrated over the time it is applied, or the area under an acceleration curve. It is common to describe Delta-V in km/h and it is shown in Figure 16.

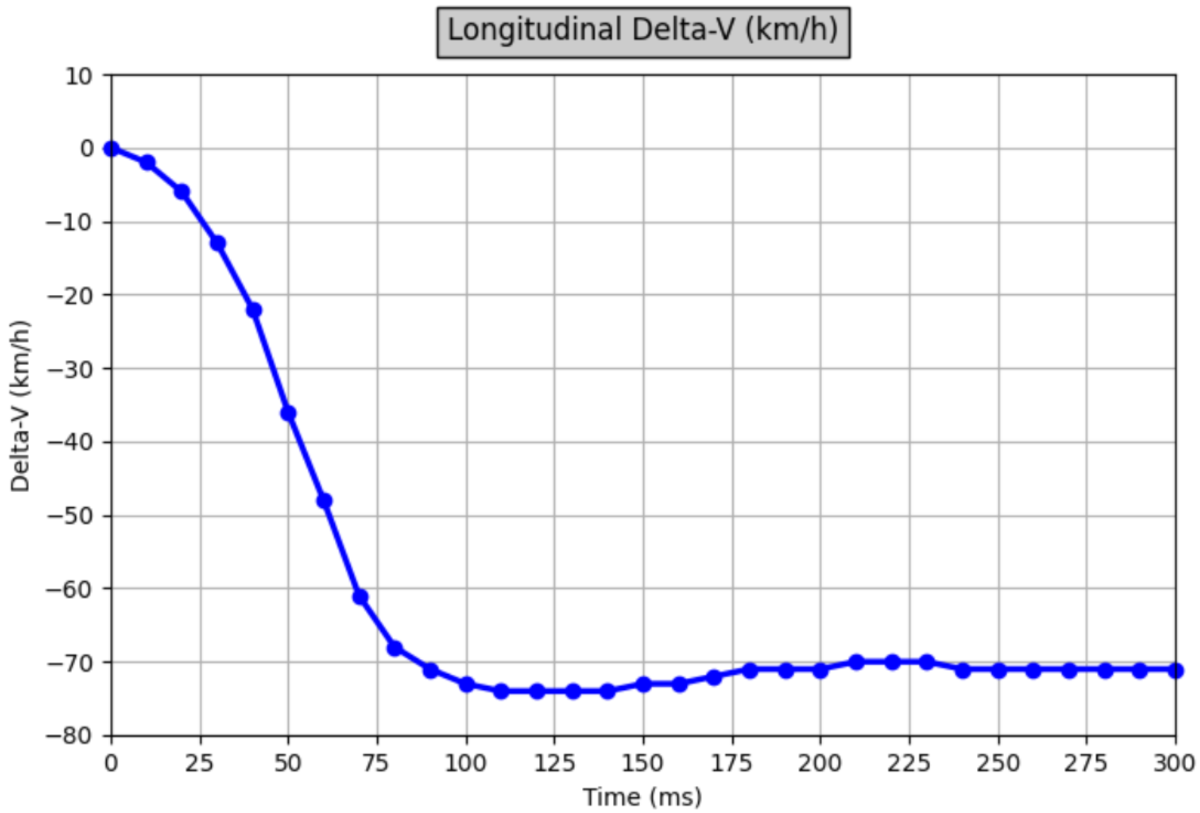


Figure 16: Longitudinal ΔV (km/h) of the passenger car in the collision. Source: Tesla, (Event 1) EDR report

Delta-V is also summarised in Table 6 below, which also describes the seat belt status of both driver and front seat passenger. Delta-V is a measure of collision forces during a collision, and should not be mistaken with the mechanical change in velocity before and after a collision between multiple vehicles, see chapter 1.14.2

Table 6: EDR report summary om the head-on collision including maximum Delta-V. Source: Tesla, (Event 1) EDR report

Data Element	Value
Maximum Delta-V, Longitudinal (km/h)	-75
Time To Maximum Delta-V, Longitudinal (ms)	127.0
Maximum Delta-V, Lateral (km/h)	-5
Time To Maximum Delta-V, Lateral (ms)	80.0
Time To Maximum Delta-V, Resultant (ms)	127.0
Ignition Cycle At Event	20148
Airbag Warning Lamp Status	Off
Driver Safety Belt status	Buckled
Passenger Safety Belt status	Buckled
Occupant Classification Status In Front Passenger Seat	Not Available
Driver Seat Position	Rearward
Passenger Airbag Suppression Switch Status	On
Complete File Recorded	Yes

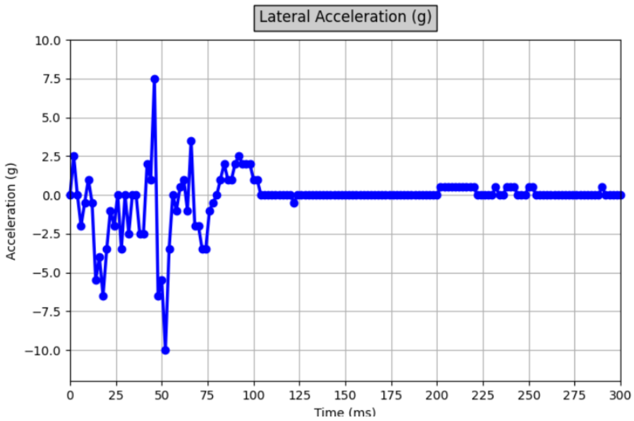


Figure 17: Lateral acceleration (g) of the passenger car in the collision. Source: Tesla, EDR report

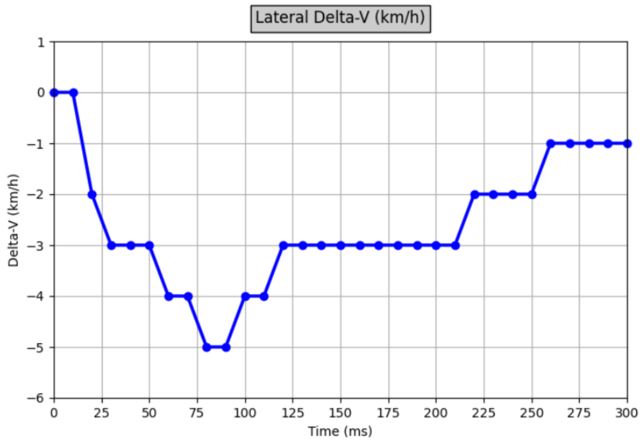


Figure 18: Lateral ΔV (km/h) of the passenger car in the collision. Source: Tesla, EDR report

Acceleration data from the EDR report show that there was both longitudinal and lateral deceleration in the collision, of which the longitudinal acceleration was greatest.

1.9.3 LOG DATA FROM THE PASSENGER CAR

The NSIA also obtained log data from the car's systems and has attached the status of relevant systems in addition to logged speed, etc. one minute before the recorded collision. There is no indication that the log data is not synchronous with data from the airbag module (EDR) or other systems in the passenger car.

- Automatic emergency braking was standby from 15:17.
    - *Automatic Emergency Braking State: 'AEB_CAN_STATE_STANDBY, 1.0' [13:17:38 UTC[6]]*
- Autopilot was available at 16:18, but not activated before the accident.
    - *Autopilot State: 'AVAILABLE, 2.0' [14:18:10 UTC]*

[6] *Local time = UTC + 2 hr*

- A frontal collision was detected at 16:18:42 on collision.
    - *Frontal Collision Detected: 'CRASH, 1.0' [14:18:42 UTC]*
- No warning indicator registered until after the accident.
    - *Warning Indicator status: 'WARNING_LAMP_ON, 1.0' [14:18:43 UTC]*

Log data about the passenger car's speed, steering angle and accelerator pedal one minute before the recorded collision is compiled in Figure 19.

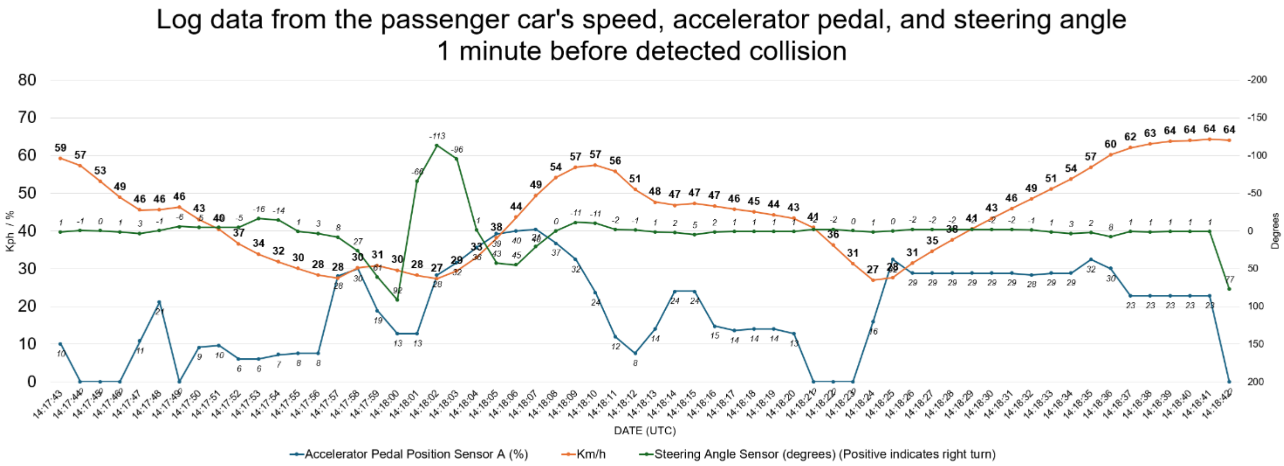


Figure 19: Log data about the passenger car's speed, steering angle and accelerator pedal one minute before the recorded collision. Source: Tesla

1.10 Road and infrastructure

1.10.1 GENERAL INFORMATION

The Rv 7 road through Flå (Sentrumsvegen) is approximately 600 metres long. Sentrumsvegen road starts and ends with a roundabout at each end of the centre of Flå. From the northernmost roundabout, the road is straight for around 400 metres, before it curves the last 200 metres to the right southwards towards the southernmost roundabout with a curve radius of 376 metres.

The road has a total width of eight metres and asphalt was last laid on 10 June 2020. The speed limit is 40 km/h and there are paths for pedestrians and cyclists on both sides of the road. There are three pedestrian crossings along the road. The pedestrian crossings are marked and signposted. No measures had been implemented to reduce speed at the time of the accident.

Figure 20: Sentrumsvegen road with pedestrian crossings, at the time of the accident. Source: [Norwegian Public Roads Administration](), photos of road taken on 25 June 2024.

1.10.2 SIGNAGE DECISION CONCERNING RAISED PEDESTRIAN CROSSINGS, SPEED REDUCTION MEASURES

At the time of the accident, a signage decision had already been made, which entailed modifying the pedestrian crossings in the centre of Flå. This process started on 20 January 2023 following a complaint from the parents' council (FAU) at Flå school. Between 14 and 27 February 2023, a temporary traffic counter was set up in the 40 zone in Flå centre. The speed of 95,937 vehicles was logged during this period, see Figure 21. The annual average daily traffic (AADT) was 7,379.

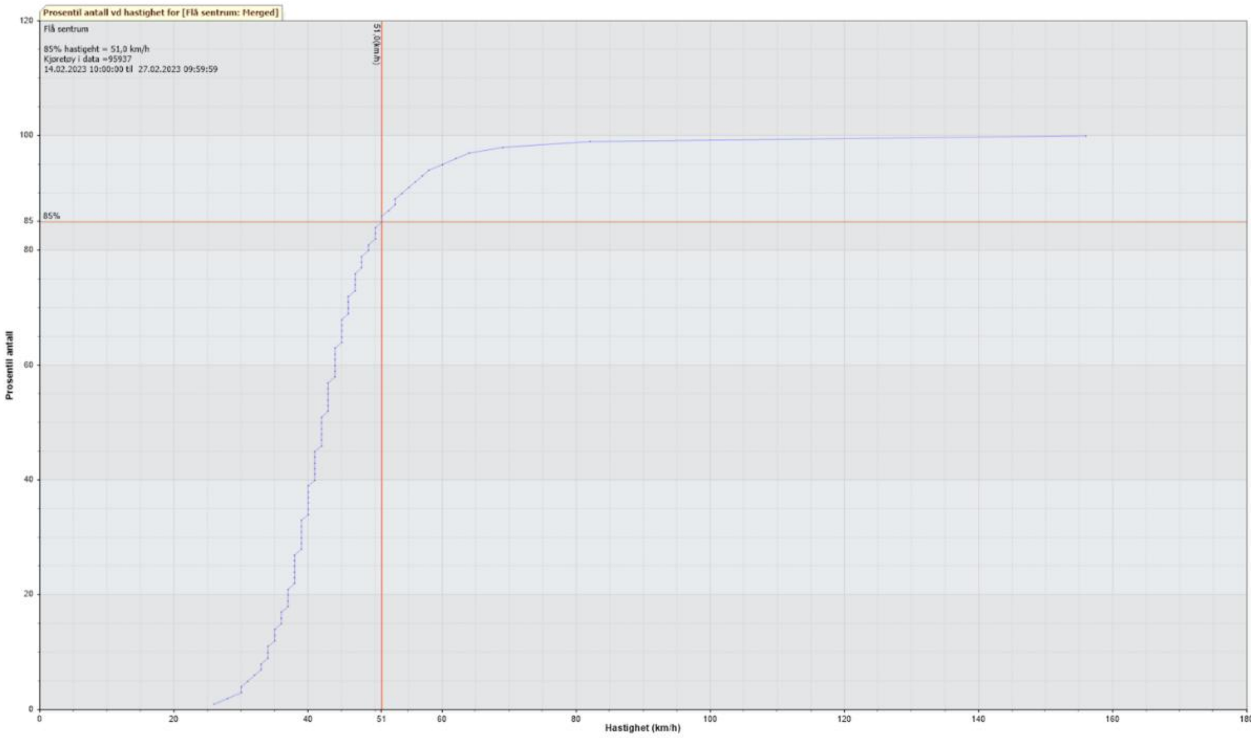


Figure 21: Graph of the number of vehicles and registered speeds in the period 14–27 February 2023 Graph: Norwegian Public Roads Administration

Figure 21 shows that the average speed was 43.68 km/h. The 85 percentile (15%) of all vehicles travelled at a speed of more than 51 km/h. The figure also showed that the 95 percentile (5%) of all vehicles had a recorded speed of more than 60 km/h.

On 28 April 2023, the NPRA distributed a new signage decision for consultation with a consultation deadline of 12 May 2023 (15 days). The signage decision included raising the speed limit to 50 km/h in the southern part of Sentrumsveien road, and two raised pedestrian crossings in the 40 km/h zone. The consultation submission from Flå municipality, dated 8 May 2023, did not support a higher speed limit.

The submission from the NPRA on 28 February 2024, supported retaining the 40 zone. It also described[7]:

> *Speed reduction measures will be implemented immediately along the road, and warning signs related to the measure will be erected.*
>
> *The weather and driving conditions are currently such that installing the measure now will be at the expense of quality. The Norwegian Public Roads Administration therefore recommends waiting until spring to install the speed bumps.*

The decision to raise and modify the pedestrian crossings through Flå centre was approved on 29 February 2024. Raised pedestrian crossings were built in early September of 2024.

Figure 22: Established speed bumps along the central road in Flå city center, 2–3 September 2024 Photo: Norwegian Public Roads Administration

1.11 Special investigations

1.11.1 DISTANCE/TIME CALCULATIONS

The NSIA has used downloaded speed data from the collision to calculate the distance back in time before the collision, and from when both vehicles entered the 40-zone in Flå. In Figure 23 and Figure 24 the individual roundabouts and the location of the traffic counter, as described in chapter 1.10.2, are marked.

[7] *'Consultation submission on signage plan for Flå centre' - reference: 23/76094-4*

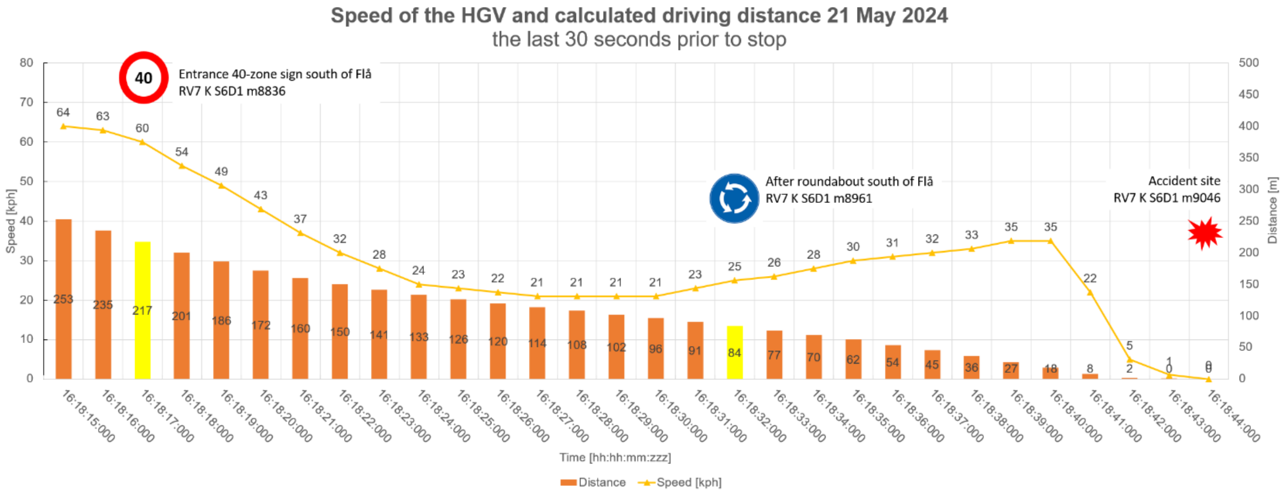


Figure 23: The HGV tachograph speed and calculated driving distance of the prior to stop. Graph: NSIA

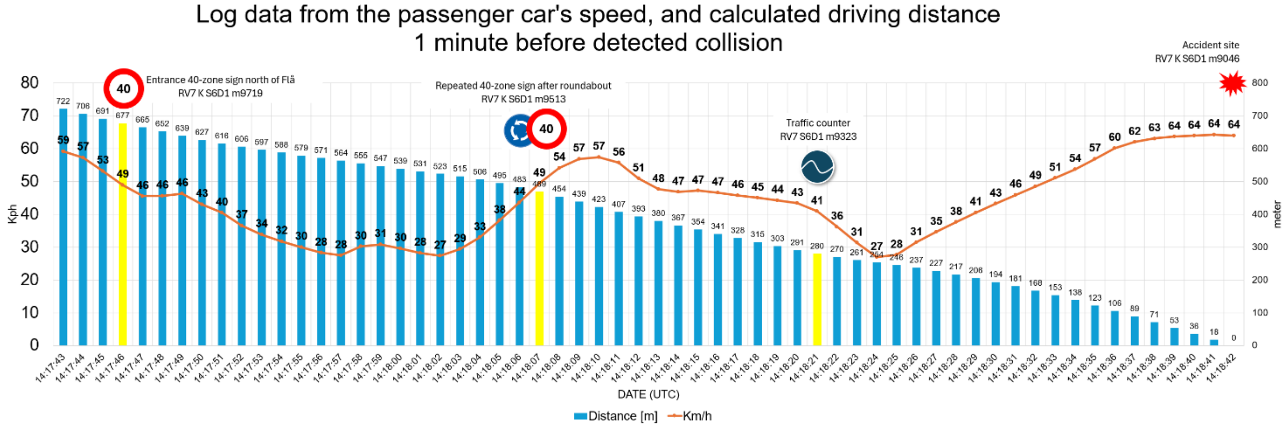


Figure 24: Log data from the passenger car's speed, and calculated driving distance 1 minute before detected collision. Graph: NSIA

1.11.2 EXAMINATION OF THE REAR SEAT-BACK STRIKER (60-PART)

The NSIA was given access to a 2014 Tesla Model S reference car[8] to conduct investigations and compare it with the torn-off striker point in the 60-part of the rear seat-back in the accident car, see green and red circles in Figure 25.

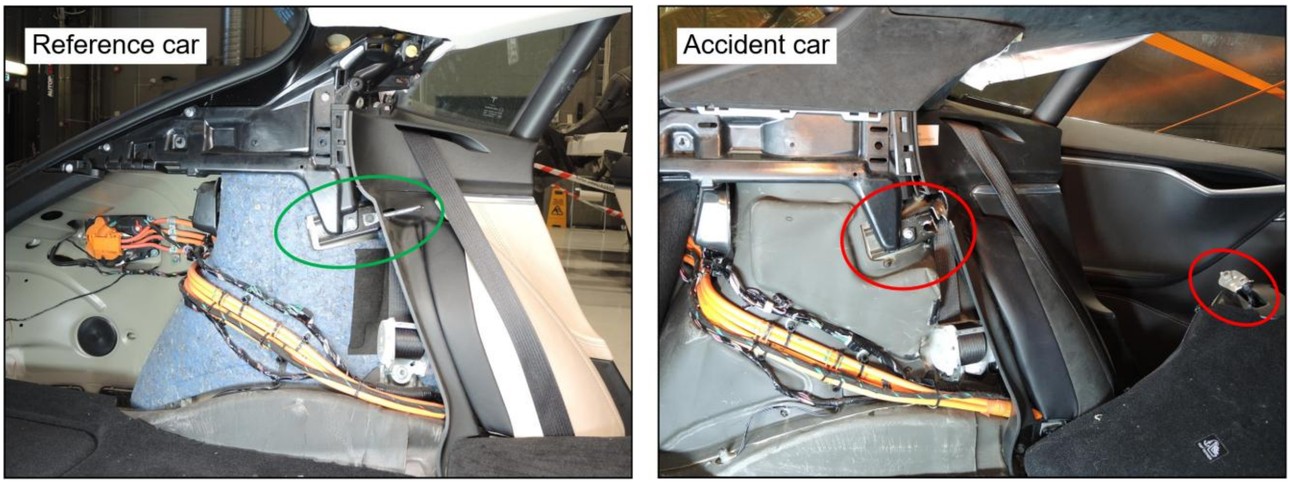


Figure 25: Examination of the striker in the reference car and the torn-off striker in the accident car. Photo: NSIA

The entire rear seat-back connection to the car body consisted of four elements; a latch mounted in the rear seat-back, which was locked to a striker loop attached to a bracket, the striker, and finally the anchorage of the striker to the rear left wheel arch, shown in Figure 26.

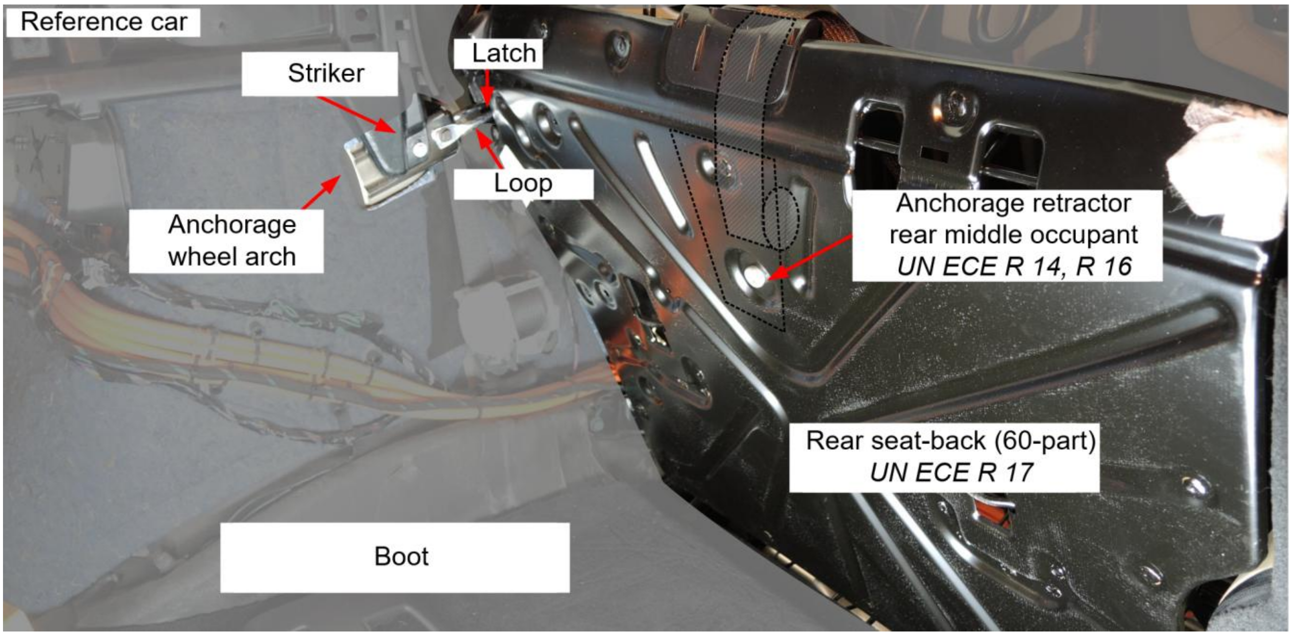


Figure 26: All elements that made up the anchorage of the rear seat-back to the car body (back of the seat-back). Photo: NSIA

[8] *First registered on 15 May 2014, seven months before the accident car.*

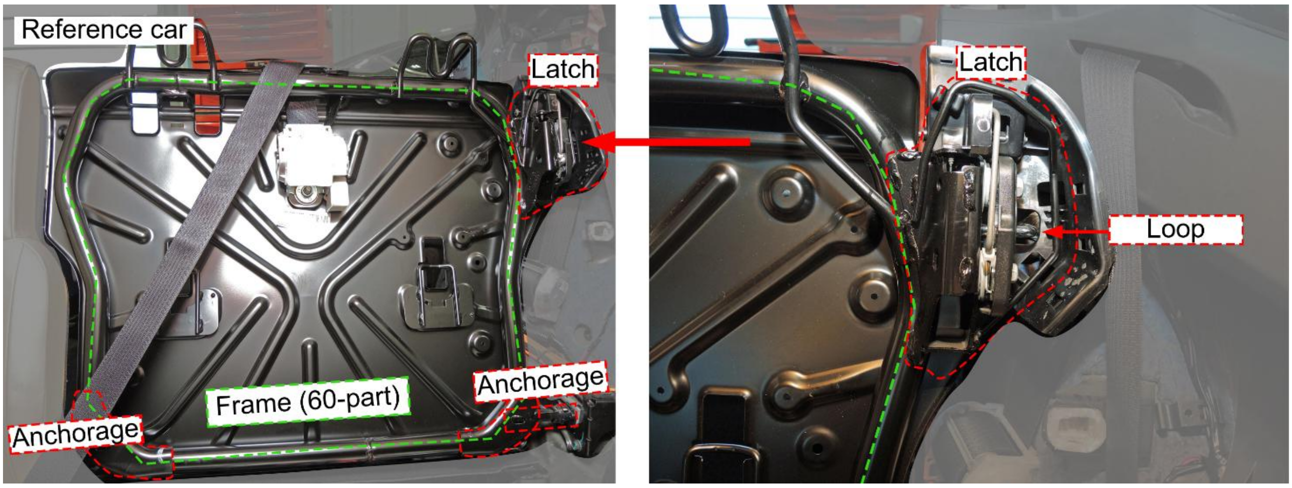


Figure 27: Front of rear seat-back 60-part with frame, anchors and lock welded to the outside of the frame. Photo: NSIA

The rear seat was documented in phases as covers were removed. The reference car and the accident car had slightly different designs, where the accident car's striker anchorage to the wheel arch was reinforced by four bolts.

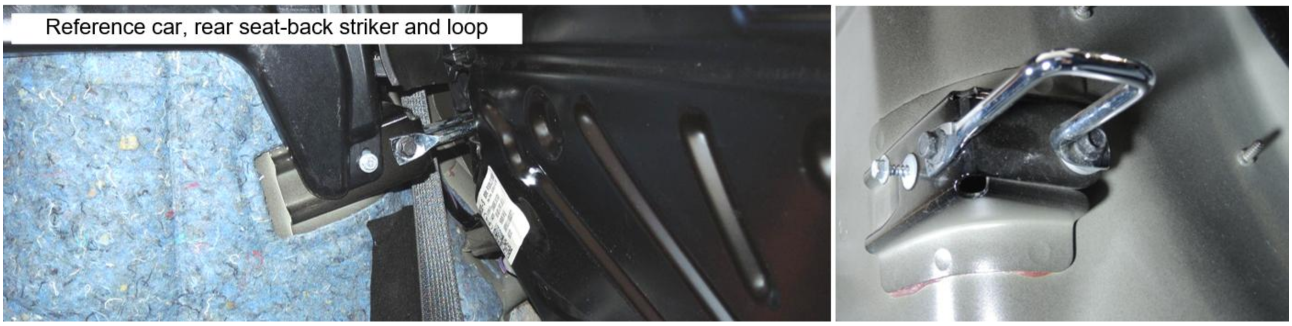


Figure 28: The striker with bracket and striker loop facing the rear seat-back latch (without reinforcement bolts). Photo: NSIA

The bracket that constituted the striker was a 2 mm thick aluminium plate, which was bent and folded into a shape adapted to the wheel arch. The striker had a loop, which was screwed to it with two bolts, one in a longitudinal direction through two aluminium layers and one lateral bolt through one aluminium layer in the striker. This striker loop locked the 60-part of the rear seat-back.

The torn-off striker from the accident car is shown in Figure 29.

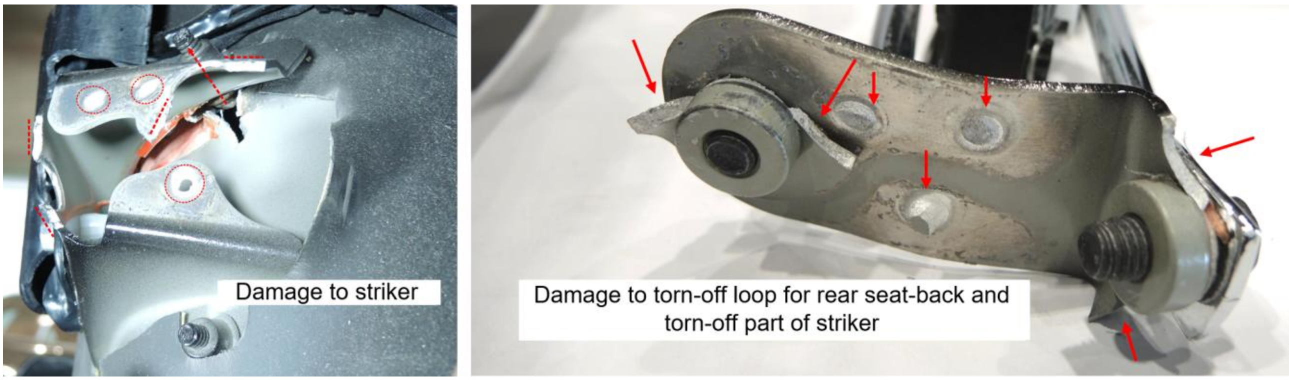


Figure 29: Striker in the accident car, torn-off bracket and torn-off striker loop. Photo: NSIA

The anchorage bracket was glued and spot-welded to the wheel arch at six points, with an additional four bolts from a retrofit. The anchorage was visible from the outside of the wheel arch beside the shock tower, where one of the bolts was also torn out of the wheel arch, see red markings in Figure 30

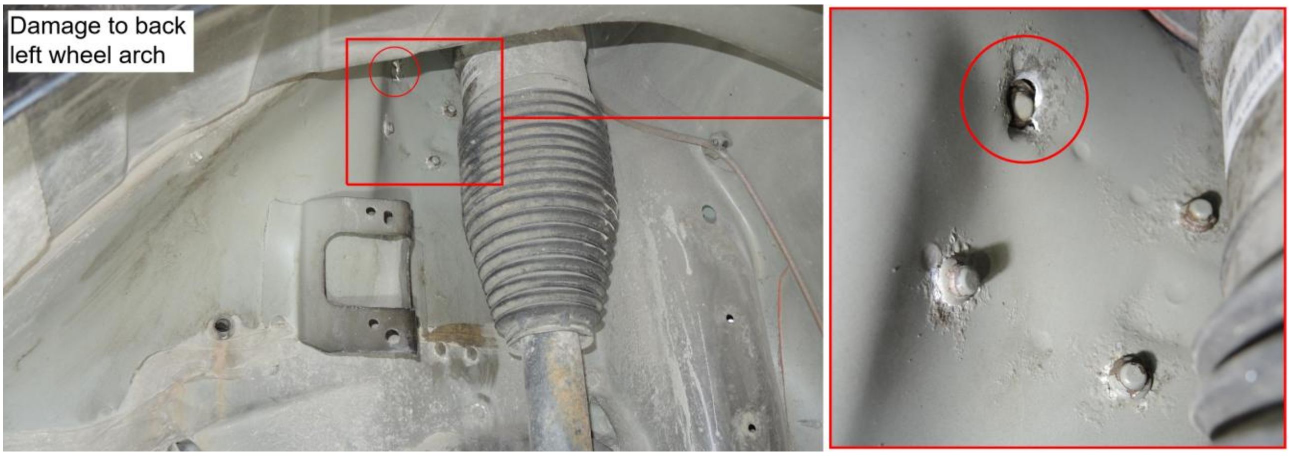


Figure 30: The accident car's striker and anchorage seen from the left wheel arch beside the shock tower. Photo: NSIA

One of the four reinforcement bolts anchoring the striker was torn out of the wheel arch and the loop was torn out of the striker.

Comparison of the torn-off parts indicated that one of the reinforcement bolts and the anchorage of the striker to the wheel arch gave way first, see Figure 31 This was the theory, but tensile tests aimed to confirm which part of the structure gave way first.

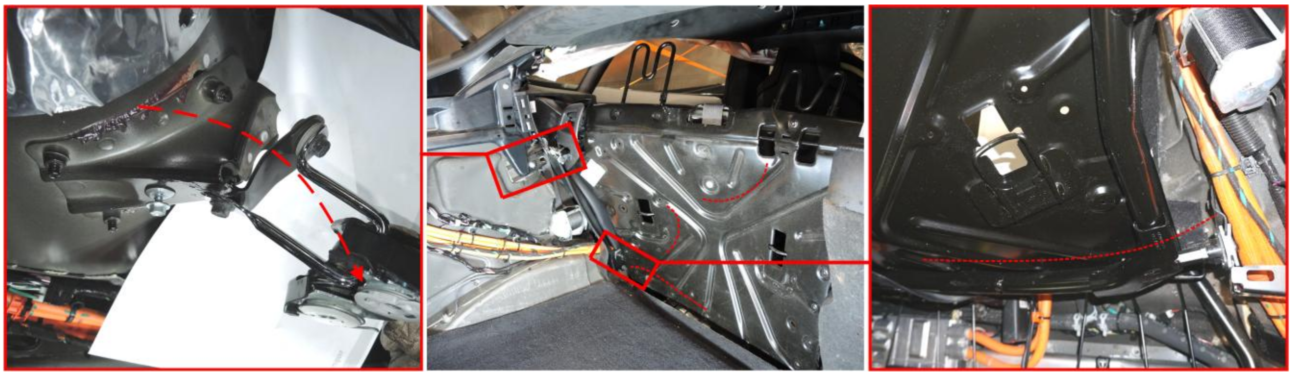


Figure 31: Examination of the torn-off striker for the rear seat-back's 60-part, and deformation of the anchorage of the rear-seat back. Photo and illustration: NSIA

1.11.3 TENSILE TEST OF REAR SEAT-BACK AND ANCHORAGE

1.11.3.1 Test setup and results

The NSIA performed quasi-static tensile tests on the 60-part section of the rear seat back in the reference car. The purpose of the tensile tests was to see how much load the rear seat could withstand when pulled longitudinally, and whether it was possible to find out what caused the rear seat-back to tear off.

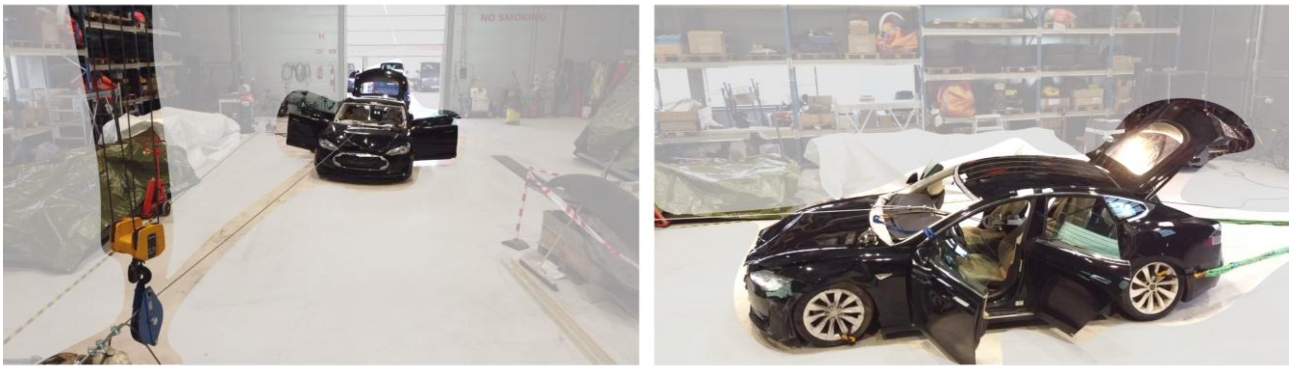
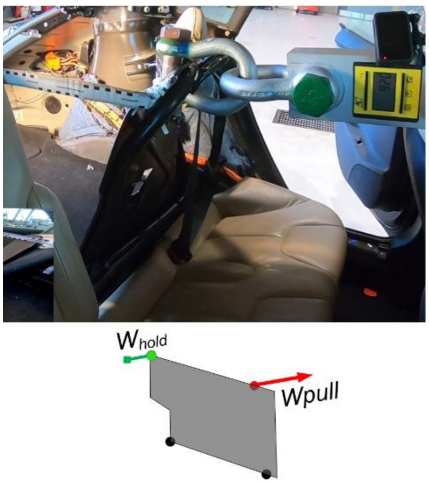


Figure 32: Setup for tensile tests with pull-cable, load cell and counterhold in the reference car. Photo: NSIA

The first test (#1) was an indirect tensile test on the rear seat-back via the middle shoulder belt in the rear seat. As the lower part of the shoulder belt was fastened to the floor, the load on the back of the seat was reduced in relation to the total load on the shoulder belt. The second test (#2) involved direct longitudinal tension at the top of the rear seat-back near the shoulder belt routing. The third and final test (#3) involved direct longitudinal tension on the striker itself.

Table 7: Overview of tensile tests and results. Source: NSIA

Test #1	Test #2	Test #3
		
Shoulder belt tensile test, indirect rear seat-back (60-part) **Result:** The shoulder belt tore after 20 s, at 1,660 kg (16.3 kN) ~ 20 cm displacement of the rear seat-back.	Tensile test directly on rear seat-back (60-part) **Result:** The striker broke after 17 s, at 920 kg (9.0 kN) ~ 35 cm displacement of the rear seat-back.	Tensile test directly on the striker (40-part). **Result:** No breakage after 30 s, at 1,480 kg (14.5 kN). Test terminated.

1.11.3.2 Summary of tensile tests

In test #1, the shoulder belt broke at approx. 1,660 kg. The shoulder belt was fastened to the floor and at the top of the seat-back so that the longitudinal forces on the seat-back itself were decomposed. The rear seat-back twisted forwards approx. 20 cm. The latch in the rear seat-back came near the corner of the striker loop, but did not make contact. The shoulder belt broke due to displacement of the counter-hold attached to the lap belt in the test setup, before reaching the limits of the belt's own tensile strength.

Figure 33: Test #1 distortion just before the shoulder belt broke at 1,660 kg. Source: NSIA

Figure 34: Test #2 distortion and contact between latch and striker loop at 740 kg. Source: NSIA

In test #2 with direct tension on the rear seat-back, the seat-back was subject to a greater load than in the first test. The rear seat-back twisted and the latch came into contact with the corner of the striker loop, at around 740 kg.

The contact between these two elements resulted in lateral tension on the striker. As a result, the striker connection to the wheel arch broke off, before the entire striker broke off after a short time at approx. 920 kg, see Figure 35.

Figure 35: Sequence from test #2. Distortion of the rear seat-back as a result of tension led to the latch in the rear seat-back coming near the corner of the striker loop. There was lateral tension on the striker via the loop and the rear seat-back's striker to the wheel arch was torn clean off. Screenshot: NSIA

Figure 36: Torn-off striker and loop left hanging in the rear seat-back. Photo: NSIA

Figure 37: Torn-off striker beside the wheel arch. Photo: NSIA

Test #3 involved direct longitudinal tension on the striker loop of the rear seat-back's 40-part, as the other one was torn off. The test was terminated at 1,480 kg without breakage. The test showed that the striker and loop could withstand at least 500 kg more sheer longitudinal tension than tension applied by the distortion of a rear seat-back.

The NSIA shared the results of the tensile tests with Tesla in mid-March 2025.

1.12 Authority, organisation and management

1.12.1 NORWEGIAN PUBLIC ROADS ADMINISTRATION

The Norwegian Public Roads Administration (NPRA) is subordinate to the Ministry of Transport and consists of six specialist divisions and a directorate. The NPRA is responsible for the planning, construction, operation and maintenance of national roads, and for approval and supervisory activities relating to vehicles and road users. The NPRA also prepares regulations and guidelines for road design, operation and maintenance, road traffic, road user training and vehicles.

1.12.2 UNECE WP.29 HARMONISATION OF VEHICLE REGULATIONS

The Norwegian Public Roads Administration provides experts to represent Norway in the UNECE World Forum for Harmonisation of Vehicle Regulations (WP.29). WP.29 consists of six working groups that each have their own specialist areas, which prepare proposals for harmonised regulations. The GRSP working group is developing proposals for regulations on passive safety. GRSP consists of more than 80 experts from over 60 member countries plus international special interest organisations representing industry and consumers.

1.12.3 EURO NCAP

Euro NCAP (New Car Assessment Programme) is a non-state organisation that carries out crash tests on new passenger cars coming onto the market in Europe. All passenger cars are awarded points for the tests, there is special recognition for innovation, and the final evaluation is expressed as a star score where the maximum is five stars. The Norwegian Public Roads Administration joined the board of Euro NCAP (European New Car Assessment Programme) in October 2022.

1.12.4 NHTSA

The National Highway Traffic Safety Administration (NHTSA) is an American federal agency that reports to the Department of Transportation. NHTSA was established in 1970 and is responsible for the New Car Assessment Program (NCAP) in the US, a road safety programme established in 1979 to encourage car manufacturers to make safer cars and consumers to buy them.

1.12.5 IIHS

The Insurance Institute for Highway Safety and Highway Loss Data Institute (IIHS) is an American non-profit organisation. Established in 1959, IIHS is known for its safety assessments of vehicles in various simulated traffic situations. Assessments include the effectiveness of the vehicle's structural integrity and safety systems during a collision, as well as improvements to such elements.

1.12.6 TESLA

Tesla, Inc. is an American automotive, software, robotics and energy company. Tesla designs, manufactures and sells battery electric vehicles.

1.12.7 SCANIA

Scania is a Swedish company that manufactures trucks, buses, diesel engines for heavy vehicles and small marine engines.

1.13 Rules and regulations

1.13.1 CRASH TESTS AND SAFETY EQUIPMENT

1.13.1.1 Introduction

Seat belt requirements are regulated by the UN ECE R14, R16 and R94 regulations, among others. The strength of split rear seats is regulated through UN ECE R17. The UN ECE R14 and R16 regulations set strength requirements for seat belt anchorage, the seat belt itself and its integrity.

UN ECE R17 sets strength requirements for, among other things, rear seat-back protection against displacement of luggage in the boot. The strength requirements are based on a split rear seat-back having to withstand deformation from a certain amount of luggage. This test is approved if the deformation of the rear seat-back is less than a specified limit.

The regulations have been implemented in Norwegian law pursuant to Section 1-4 of the Motor Vehicle Regulations[9], where, among other things, Regulation (EU) No. 2018/858 has been made into Norwegian law.

1.13.1.2 UN ECE R14 safety-belt anchorage strength

In UN ECE R14, revision 7 sets minimum requirements for safety belt anchorage. The general test requirement for seat belt anchorage (6.3) is that the test load must be applied as quickly as possible, within 60 seconds, while manufacturers may require maximum load within 4 seconds, where the anchorage must withstand maximum load for a minimum of 0.2 seconds. For three-point belts, the load must be 1,350 daN ± 20 daN (1,376 kg) in the mechanism that pulls on the shoulder belt, or between the upper belt anchorage and the opposite lower belt anchorage of the same belt[10].

Annex 7 of the regulation provides for an option to conduct a dynamic seat-belt anchorage test via the crash test described in UN ECE R 16, Annex 8. This is a sled test, where the sled must have a deceleration over time within a given corridor to be approved. This is shown below:

---

[9] Regulations of 28 June 2022 on the approval of cars and car trailers (the motor vehicle regulations).
[10] This load requirement is halved for vehicles other than passenger cars over 3,500 kg.

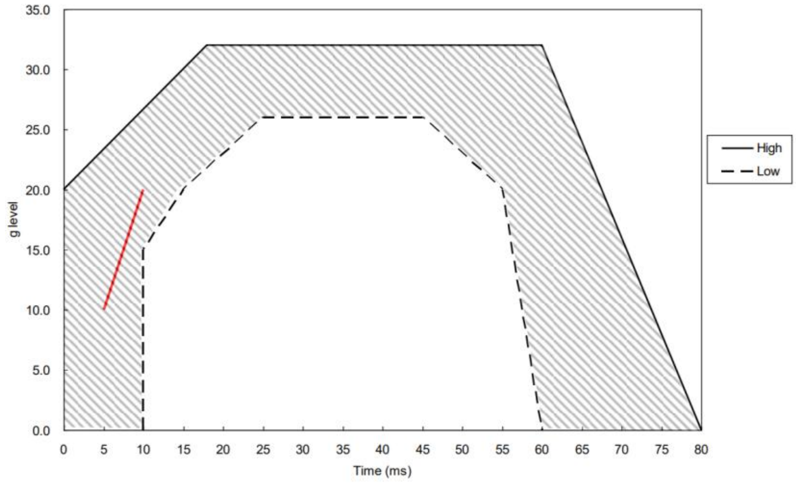


Figure 38: Description of the corridor of g-forces in the sled test in UN ECE R 16, Annex 8. Source: [UN ECE](#)

1.13.1.3 UN ECE R17 protection against displacement of luggage in the boot

[UN ECE R17, Annex 9](#) describes a test where rear seat-backs must protect occupants against the displacement of loose luggage. This test is conducted without occupants in the rear seat. This is also a sled test, where two 18 kg blocks are placed 20 cm from a split rear seat-back, and where the sled stops in a simulated head-on collision at 50 km/h. For this test to be approved, the seat-back must not be bent more than 15 cm in front of the R-point of the seat. The sled test must have a deceleration over time within a given corridor to be approved.

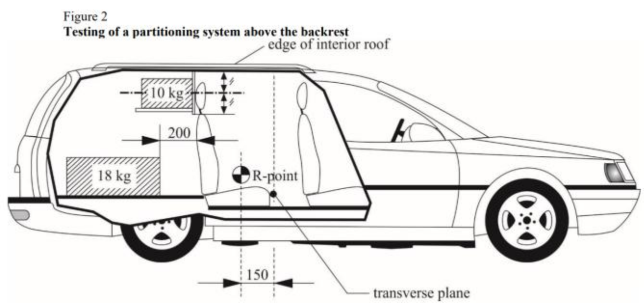


Figure 39: Luggage configuration in the sled test with two 18 kg blocks, 20 cm from the rear seat-back at 50 km/h. Source: UN ECE R 17, Annex 9

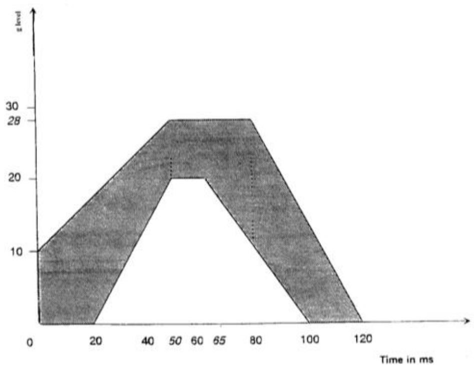


Figure 40: Description of corridor for g-forces for the sled test. Source: UN ECE R 17, Annex 9

1.13.2 SPEED REDUCTION MEASURES

Speed reduction measures are used in residential areas, city streets, towns, villages and at intersections in built-up areas (at schools, shops, etc.). Such measures are implemented '*primarily to make walking and cycling safer and more attractive'.* This is described in the Norwegian Public Roads Administration's Handbook V128 'Speed reduction measures[11]' (in Norwegian only):

> *Speed reduction measures are needed when more than 15% drive 5 km/h faster than the speed limit on the section of road.*

[11] https://www.vegvesen.no/globalassets/fag/handboker/hb-v128-fartsdempende-tiltak.pdf

1.14 Additional information

1.14.1 REINFORCEMENT OF LEFT REAR SEAT-BACK STRIKER, TESLA MODEL S, 2013

Tesla issued a recall in June 2013 for 2013 Model S cars in the US and Canada[12]. The recall was due to a possible defect in the welding points on the left rear seat striker. The defect, which could arise during production, could result in the seat back not staying in the upright position during a collision. To rectify the problem, four bolts were retrofitted to the striker bracket of the left rear seat. The reinforcement was implemented before the car was introduced in Europe.

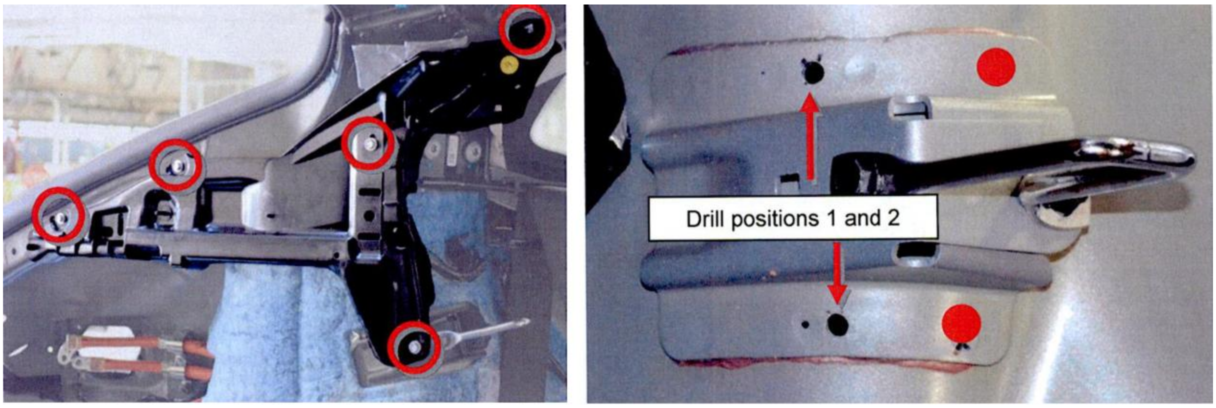


Figure 41: Removal of the cover over the striker loop for the left rear seat and reinforcement drill holes. Source: Tesla

1.14.2 FRONTAL IMPACT TESTS WITH TESLA MODEL S

1.14.2.1 NCAP full frontal impact test 2013

On 5 August 2013[13], NHTSA performed a New Car Assessment Programme (NCAP) crash test on the same model involved in the accident. The crash test was performed at a speed of 56.3 km/h where the entire front of the car hit an immovable wall. The Delta V in this test was measured at 63.5 km/h[14].

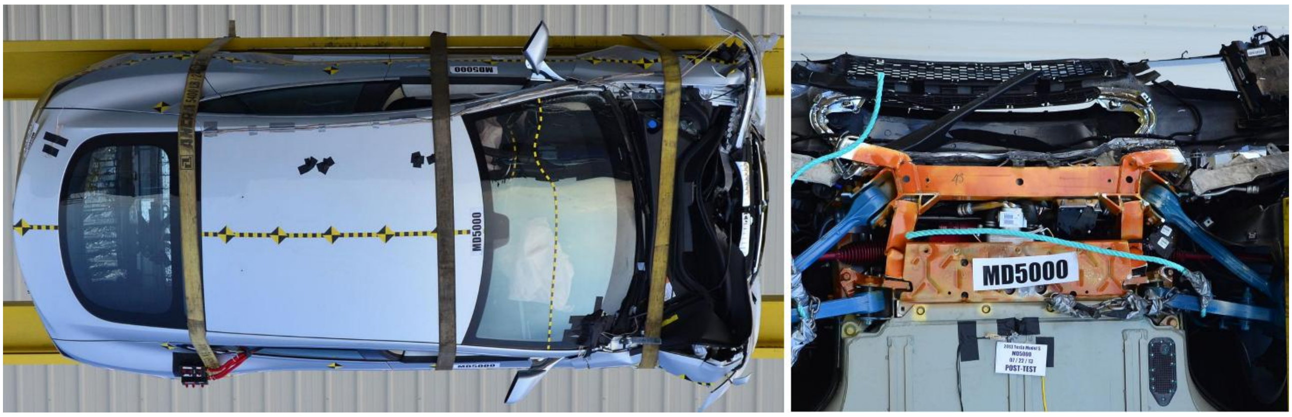


Figure 42: After NCAP frontal barrier impact test, MD5000. Source: NHTSA

[12] https://www.nhtsa.gov/?nhtsaId=13V249000, *Recall bulletin; Remedy Instructions and TSBRCRIT-13V249-9944*

[13] *NHTSA, 2013 TESLA MODEL S Technical Report, v08308R001.pdf*

[14] *The difference between the impact speed and Delta-V does not describe the wall's inherent speed at the moment of impact. Delta-V represents how the impact forces act on the car, including through deformation and suspension. Delta-V varies from car to car, even in identical crash tests.*

Data that were recorded but not included in the report have been downloaded from the research database of this test[15]. This includes measurement data from accelerometers mounted in various locations. The NSIA has extracted data from the accelerometer from the left rear sill and the load cell at the top of the front passenger's shoulder belt for further analysis, see Appendix A.

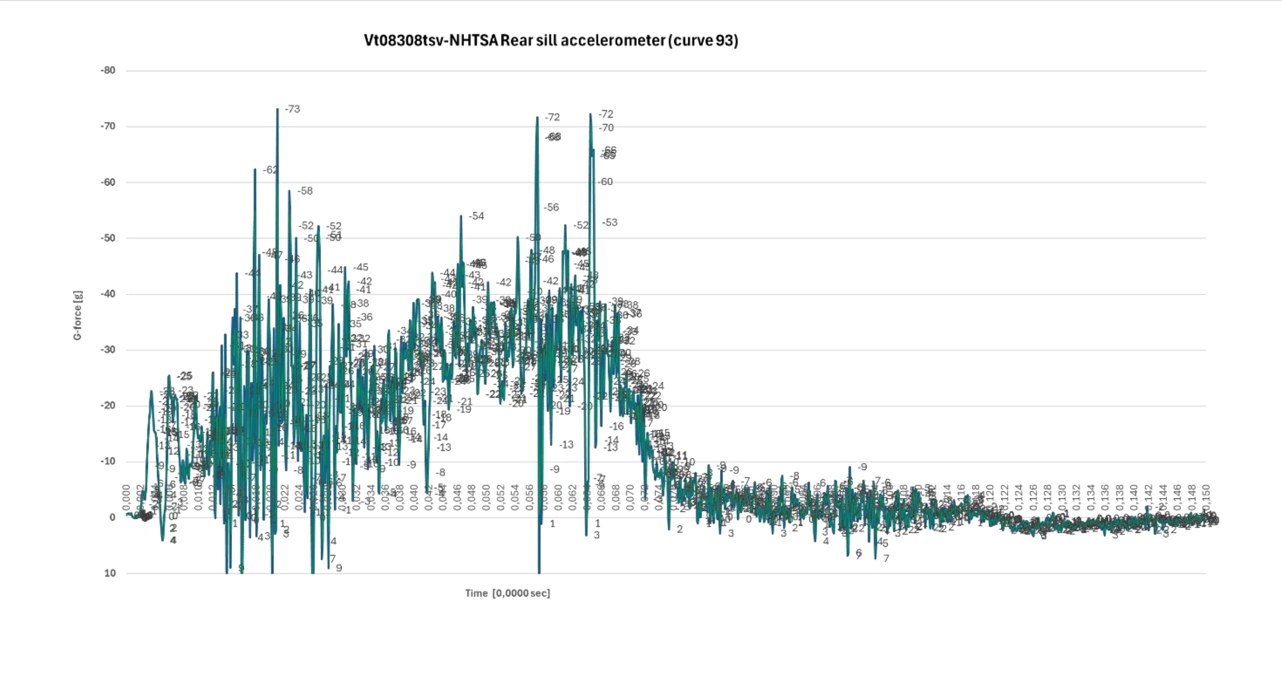


Figure 43: Accelerometer from the rear left sill up to 150 milliseconds. Source: NHTSA, [Test Number 8308, Curve 93]

The NSIA has adapted the graph for comparison with data from the accident. High-speed images from the test are provided below, up to 160 milliseconds. The biggest g-forces on the vehicle were at around 80 milliseconds.

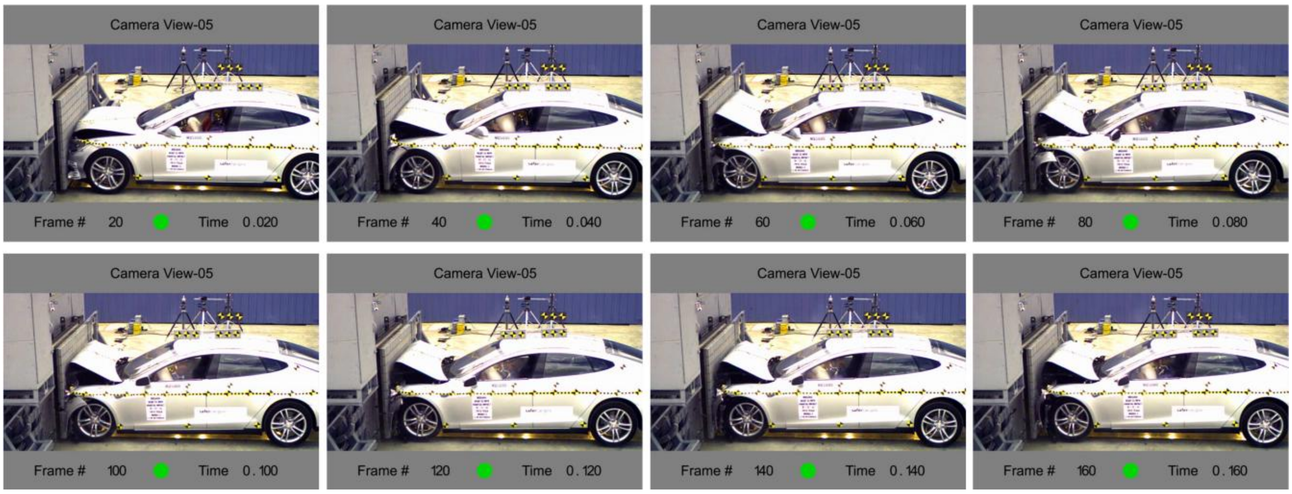


Figure 44: NHTSA NCAP test 160 milliseconds. Video: NHTSA, [Test Number 8308, Camera 5.]

1.14.2.2 IIHS moderate overlap frontal impact test Tesla Model S 2016

The Insurance Institute for Highway Safety (IIHS) conducted a frontal impact test with a Tesla model S in 2016. This test is a frontal impact test where a car is driven at a speed of 64.4 km/h with 40% overlap against a deformable barrier with a shock absorber. Delta-V in this test was 70 km/h.

[15] https://www.nhtsa.gov/research-data/research-testing-databases#/vehicle/8308

Figure 45: Tesla model S 2016 during crash test with moderate overlap at 64.4 km/h. Source: IIHS, CEF1611, FLO03_WIDE

IIHS has a website for its tests where test results can be downloaded[16] by logged-in users. The NSIA downloaded data from the acceleration sensors in the test with moderate overlap, and used this as a basis for comparison in the analysis. The graph is available in Appendix A.

1.14.3 PREVIOUS NSIA INVESTIGATIONS

1.14.3.1 Reports on interior car safety

The NSIA has investigated interior safety in passenger cars several times in the past. The thematic report on safety in cars (2012/01) and the report on a head-on collision between a passenger car and a passenger van on the E6 road at Slettnes in Storfjord, Troms on 24 September 2017 (2019/01) described the critical importance of the correct use of seat belts and securing luggage to survive and reducing the severity of the injuries caused by a collision. The findings revealed, among other things, that wearing a seat belt was not only sufficient, but that the correct use and adjustment of seat belts was decisive in relation to the severity of injuries.

As a result of these reports, the NSIA (formerly AIBN) issued five safety recommendations on the topic of correct belt use and securing luggage. The following safety recommendation is particularly relevant to this accident:

> ***Safety recommendation ROAD No 2019/02T***
>
> *The investigation of the head-on collision on the E6 road in Storfjord on 24 September 2017 has shown that the injuries sustained by one of the passengers in the car were aggravated by incorrect use of the seat belt. In the AIBN's experience, there is still insufficient knowledge about the importance of both drivers and passengers using their seat belts correctly. The AIBN therefore finds that there is a potential for reducing the number of traffic fatalities and serious injuries by intensifying efforts to inform the public about the correct adjustment and use of seat belts.*
>
> *The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration, in collaboration with relevant partner organisations, intensify its work to improve road users' knowledge about and understanding of the importance of using safety equipment in cars correctly.*

The safety recommendation (ROAD 2019/02T) was closed by the Ministry of Transport on 31 May 2022 based on the following grounds from the Norwegian Public Roads Administration (extract):

> *The Norwegian Public Roads Administration's road safety campaigns have played a key role for years in increasing road users' knowledge and thus encouraging safer behaviour in traffic. The NPRA's campaign strategy is guided by the Vision Zero initiative. This means that we pick a few topics in areas where we see a significant number of fatalities and serious injuries. This gives each campaign topic heft and substance.*

[16] https://techdata.iihs.org/secure/filegroup.aspx?3059 *Sensor curve data 4010VEHC0000__ACXD was then used.*

Seat belt use has been a focus area for campaigns over the past two decades. Over the past five years, most attention has been focused on the use of seat belts in buses. The percentage of people wearing seat belts in buses is significantly lower than in cars. Based on our information, a relatively small proportion of those who lose their lives in traffic have worn a seat belt incorrectly. We also have little information about the reasons for any incorrect use of belts. If the NPRA was to intensify its work '... to increase road users' knowledge and understanding of the importance of the correct use of safety equipment in cars', our road safety campaigns would be a relevant instrument. Given our campaign strategy of focusing on a few topics, this would mean that another campaign topic would have to be cancelled. The NPRA believes that this would be the wrong priority in road safety work.

Buses are still an area with low seat belt use, and we see great potential for bringing about change using campaigns as a tool. In the event of a bus accident, the potential for injury is also considerable if passengers are not wearing seat belts. It has therefore been decided to continue the use of seat belts in buses as a campaign topic for 2022. However, the NPRA has also produced films and other material on the correct use of seat belts as part of its work on seat belt use. Some of these materials are still in use. The fact that the NPRA believes this topic is not the right choice for a main campaign does not mean we will not continue our efforts in this area. It may be relevant to refer to 'correct use' in PR/press material or social media posts in connection with other types of seat belt campaigns. In this connection, the NPRA will also consider using materials and films prepared by the NSIA.

1.14.3.2 Report on a head-on collision between a passenger car and a van on the E39 at Austefjorden, Volda, Møre og Romsdal on 20 October 2019 (2020/07)

In this head-on collision, a passenger sitting in the middle rear seat was killed, and the minimum rear seat strength requirements were specifically investigated by the NSIA. The passenger was secured by a three-point belt to a split rear seat-back and the total weight of luggage in the boot was 65 kg. A safety recommendation was submitted to the Norwegian Public Roads Administration as a result of the investigation:

Safety recommendation ROAD No 2020/10T

In the frontal collision in Volda on 20 October 2019, two people sitting in the back seat of the station wagon died and one person was seriously injured, while the people in the front seats of both cars survived the accident with only minor injuries. The investigation of the high-energy accident that occurred at around 70–80 km/h, has shown that the passive safety systems in the estate car were constructed differently, and that the safety in the middle rear seat was directly linked to how a split rear seat manages to withstand the load from passenger and luggage placed in the boot. In this case, unsecured but well-placed luggage contributed to large deformations on the rear seat back. The NSIA has assessed UN-ECE R17 (Annex 9) and the test requirements for the strength of rear seat-backs in the light of this accident, and believes that the test requirements do not adequately safeguard the safety of passengers in the middle rear seat.

The Norwegian Safety Investigation Authority recommends the Norwegian Public Roads Administration to make an assessment with the aim to improve the regulations for the safety of rear seat passengers and inform UN's Working Party on Passive Safety (GRSP) about this accident and the findings of the investigation.

The safety recommendation (ROAD 2020/10T) was closed by the Ministry of Transport on 22 May 2022 based on the following grounds from the Norwegian Public Roads Administration:

The Norwegian Public Roads Administration first presented the NSIA report at the GRSP meeting in May 2021. Subsequently, based on the report, we have proposed an amendment *to UN regulation no. 17. The proposal was presented to GRSP at the meeting in December 2021: (Proposal in document)*

The proposal was supported by, among others, the Netherlands and consumer organisations, while industry and some member states wanted more accident data to be collected before the proposal was given further consideration. The Norwegian Public Roads Administration will appeal to member states to request more data on this issue, while at the same time conferring with the Dutch authorities on alternative arguments and further progress. The proposal is still under consideration by GRVA (UN ECE), where, among other things, we will collect accident data from other countries. The Norwegian Public Roads Administration is also discussing further progress with the Netherlands. It may therefore take some time before the work in GRVA is finalised.

2. Analysis

2. Analysis

2.1 Introduction

Head-on collisions between light and heavy vehicles are some of the most serious accidents that occur on the roads. Depending on the speed level, large forces will be at play in situations like these, and the accidents can result in serious injuries to the occupants of the light vehicle due to the difference in momentum, kinetic energy and compatibility between the vehicles.

In this case, the forces in the accident were survivable and within the level the vehicle was designed to withstand. The NSIA nevertheless decided to initiate a safety investigation of the accident based on the major difference in the severity of the injuries sustained by the occupants of the passenger car. The investigation has mapped the sequence of events inside the passenger car, as well as the car’s construction and safety systems that had a bearing on the severity of the injuries in the accident. The investigation has also revealed other findings of general importance to road safety, which are not related to the causal factors of the accident.

The analysis consists of the following parts:

- Section 2.2 discusses the sequence of events in the accident.
- Section 2.3 discusses the crash protection of the passenger car, and the occupants’ injury location and severity.
- Section 2.4 discusses the collision in the accident compared with minimum requirements and tests.
- Section 2.5 discusses the car’s rear seat-back, design and strength, and requirements of and tests for rear occupant protection.
- Section 2.6 discusses other findings in the investigation that did not contribute to the accident and the severity of the injuries.

2.2 Sequence of events

Evidence at the scene of the accident showed that there was no debris under the HGV that came from the passenger car. Gravel from the semi-trailer had also fallen straight down. This indicates that the HGV was able to stop and was stationary just before the collision. The HGV driver had thought that the car was about to turn off the road in front of him, and the HGV was therefore already in a braking phase before the collision.

The car was driving on a virtually straight road through the centre of Flå. However, the road has a gentle bend to the right just before Flå church, but the driver did not adjust the steering wheel to the bend. The car’s speed and modest steering angle before the collision, together with its final position, indicate that the car was heading towards the centre line just before it passed the red barn, approximately 30 metres before the exit to Flå church.

The driver explained that he had seen the oncoming HGV. However, his attention had briefly turned to inside the car, and he failed to notice the gentle curvature of the road for the last 30 metres, approximately 1.5 seconds before the collision. This led to the car sliding slowly into the opposite lane. The car was also travelling at a relatively high speed compared with the speed limit for the area, which also meant that the driver had less time to react to deviations. Based on the injuries sustained by the driver, he may have had both hands on the steering wheel in an avoidance manoeuvre to the right and one foot on the brake pedal in the collision.

The average speed of traffic on this section of road had previously been measured as too high, without immediate measures being implemented to reduce speed. This is discussed further in section 2.6.1.

The HGV driver interpreted the traffic situation as an oncoming turnoff situation and reduced his speed. The NSIA believes that this was an observant and fortunate interpretation that enabled the HGV driver to stop the HGV just before the collision. This action significantly reduced the force of the collision.

Both vehicles were equipped with automatic emergency braking (AEB) systems, but only the tractor unit's system activated. Data from the passenger car, indicates that the AEB and the windscreen-camera have been available. However, the systems did not issue warnings or activate. The situation immediately before the collision indicates that there were no obstacles to radar reflection between the front of the HGV and the passenger car’s radar. If the automatic emergency braking system had been activated, this could also have helped to significantly reduce the forces of the collision. The NSIA cannot explain why none of these driver assistance systems neither issued warnings or were activated.

2.3 Crash protection in the passenger car, location and scope of injuries

2.3.1 INTRODUCTION

When one or more occupants of the same car sustain minor injuries after a collision, the energy level is likely to have been in a range where everyone could have sustained minor injuries. In this accident, there was a major difference in the severity of the injuries between the occupants of the front seats and those in the rear seats of the same car. Everyone in the car was wearing a seat belt and no heavy items were loose in the vehicle body or entered the vehicle body from the boot. The booster seats used by two of the children were suitable for the children’s age and size.

The following section discusses the passenger car’s general level of safety, as well as interior crash protection and the safety equipment available in the different areas of the car.

2.3.2 SAFETY LEVEL OF THE CAR

The passenger car was a Tesla Model S (2014), which was built to high crash protection safety standards and had five stars in Euro NCAP. This car model has evolved in terms of safety over time, with models after 2021 including belt pretensioners with force limiters in the outer rear seats and more side airbags.

The NSIA is of the opinion that the car involved in the accident still had a relatively high level of safety, even though it was manufactured more than 10 years ago. Double belt pretensioners in the front seats, like this car had, are not standard in many newer models.

2.3.3 INTERIOR CRASH PROTECTION AND SAFETY EQUIPMENT

2.3.3.1 Crash protection in the front seats (row 1)

The driver suffered fractures in his left lower leg and right hand. This car was not equipped with a knee airbag in the driver’s seat, but the fracture is attributed to a direct impact from the brake pedal in the footwell. The fracture in one hand and fissure fracture in the other are linked to the fact that the driver’s hands were most likely on the steering wheel.

The front seat occupant, who was sitting on a booster seat, sustained abrasions from the front airbag and seat belt, but only sustained minor injuries. The owner's manual describes that the front airbag should be deactivated if a child is sitting on the right front seat, but it does not describe when a child is big enough for this airbag not to be deactivated. The NSIA is of the opinion that the front airbag in this case helped to reduce the severity of the injuries and that owner's manuals should specifically describe when a child is big enough to sit in the right front seat without disconnecting the front airbag.

In summary, the NSIA believes that both occupants of the front seats benefited from the available safety equipment, as well as correctly positioned seat belts with activated double belt pretensioners, front airbags and side airbags.

2.3.3.2 Crash protection in the rear seats (row 2)

The right rear seat occupant sustained critical injuries. The occupant had injuries consistent with both the shoulder belt and lap belt lying across the abdomen and lower chest. The upper body may have rotated over the shoulder belt in the collision. The injuries are consistent with the seat belt possibly having been under one arm at the time of the collision and that the lap belt was above the top of the hip.

This is not uncommon for young passengers. The occupant probably had the seat belt on correctly when the journey started, and the shoulder belt probably came under their arm at a later stage. Both booster seats and high-back booster seats are recommended for this age group. A booster seat provides a greater degree of freedom, than a high-back booster seat with a routing track, with respect to moving out of a favourable belt position. At the same time, the NSIA recognises that there is great variety in the design of rear seats among car manufacturers. The seats can have fixed or adjustable backs, fixed or removable neck cushions and different locations for shoulder belt anchorages. This means that a high-back booster seat may be impractical when all the seats in the rear seat are to be used.

The left rear seat occupant was severely impacted by a correctly positioned seat belt. The shoulder section of the seat belt was anchored to the C-pillar and positioned at an angle just above the corner of the rear seat-back. When the rear seat-back's striker broke, the seat belt may have further tightened around the occupant as a result of pressure from the rear seat-back. This additional tightening of the seat belt may explain the fracture of the top of the occupant's hip in the area covered by the seat belt. The NSIA is of the opinion that pressure from the torn-off rear seat-back resulted in extra tightening of a seat belt without a force limiter, and contributed to the severity of the injuries sustained.

The middle rear seat occupant sustained critical injuries from both the shoulder part of the seat belt on the right side of the torso, and from the lap section of the seat belt across the abdomen. The occupant has indicated that the seat belt was not initially tightened at the hip and that the seating position was relaxed. See Figure 46 and Figure 47 for the correct positioning of the lap section of the seat belt.

Figure 46: Incorrect positioning of the lap section of the seat belt. Illustration: NSIA

Figure 47: Correct positioning of the lap section of the seat belt. Illustration: NSIA

The middle seat belt was anchored to the rear seat-back, which collapsed over the occupant in the collision. The shoulder section of the seat belt continued to restrain the occupant, while their weight pulled the rear seat-back down towards their back. The rear seat-back probably came loose as a result of the compressive force of the luggage in combination with tensile forces from the shoulder belt. The NSIA is of the opinion that the torn-off rear seat-back contributed to the severity of the injuries. This is discussed further in section 2.5.

2.3.4 SUMMARY OF CRASH PROTECTION

The most serious and critical injuries sustained by the occupants of the rear seat can be related to the use of seat belts, combined with fewer supplemental restraint systems (airbag, seat belt pretensioner and force limiter), and the collapse of the rear seat-back. Active belts and front airbags helped to limit the injuries of the occupants of the front seats.

In 2019, the Norwegian Safety Investigation Authority submitted a safety recommendation (2019/02T) to the Norwegian Public Roads Administration to *'intensify its work to improve road users' knowledge about and understanding of the importance of using safety equipment in cars correctly*'. In 2020, the NSIA, in collaboration with the Department of Traumatology at Ullevål Hospital, published an information video on the correct adjustment of seat belts. The Norwegian Public Roads Administration has run several seat belt campaigns in recent decades, but has not followed this safety advice up with a major campaign on correct seat belt use. One of the latest initiatives launched by the Norwegian Public Roads Administration is an e-learning course on improving road safety, which includes the correct adjustment of seat belts and securing luggage.

The trauma department at Ullevål OUS has informed the NSIA that they have not seen a reduction in seat belt injuries in recent years as a result of incorrectly adjusted seat belts on patients who have been in head-on collisions. Passenger car owner's manuals describe the correct adjustment of seat belts, but the NSIA is unsure how many people read and familiarise themselves with them. The NSIA thus believes that we still need good ways of communicating and increasing road users' knowledge of the importance of correct use and tightening of seat belts.

This investigation has shown that the vehicle's structural design parameters affect the severity of the injuries in an accident. In this case, the luggage was well placed in the boot of the car and the total weight on the rear seat-back was not disproportionately large. Despite this, the rear seat-back striker was torn off. This is discussed further in sections 2.4 and 2.5.

Research on head-on collisions with regard to rear seat occupants shows that safety developments for rear seats has lagged behind safety developments for front seats (Edwards, 2023). The research the NSIA has looked at focuses exclusively on rear seat occupants sitting in the outer seats and not in the middle rear seat. The research findings show that the geometric design of rear seats may contribute to increased submarining and that belt pretensioners with force limiters do not necessarily compensate for this to a sufficient degree (Guettler, 2023). Car manufacturers have generally not established front airbags for rear seat occupants either.

2.4 The collision in the accident compared with minimum requirements and crash tests.

The NSIA has compared acceleration data from the collision in the accident (black line) with test requirement corridors from UN ECE R 16 and UN ECE R 17 (shaded differently in grey), the full frontal NCAP crash test performed by NHTSA (green line), and the moderate overlap crash test performed by IIHS (yellow line), shown in Figure 48.

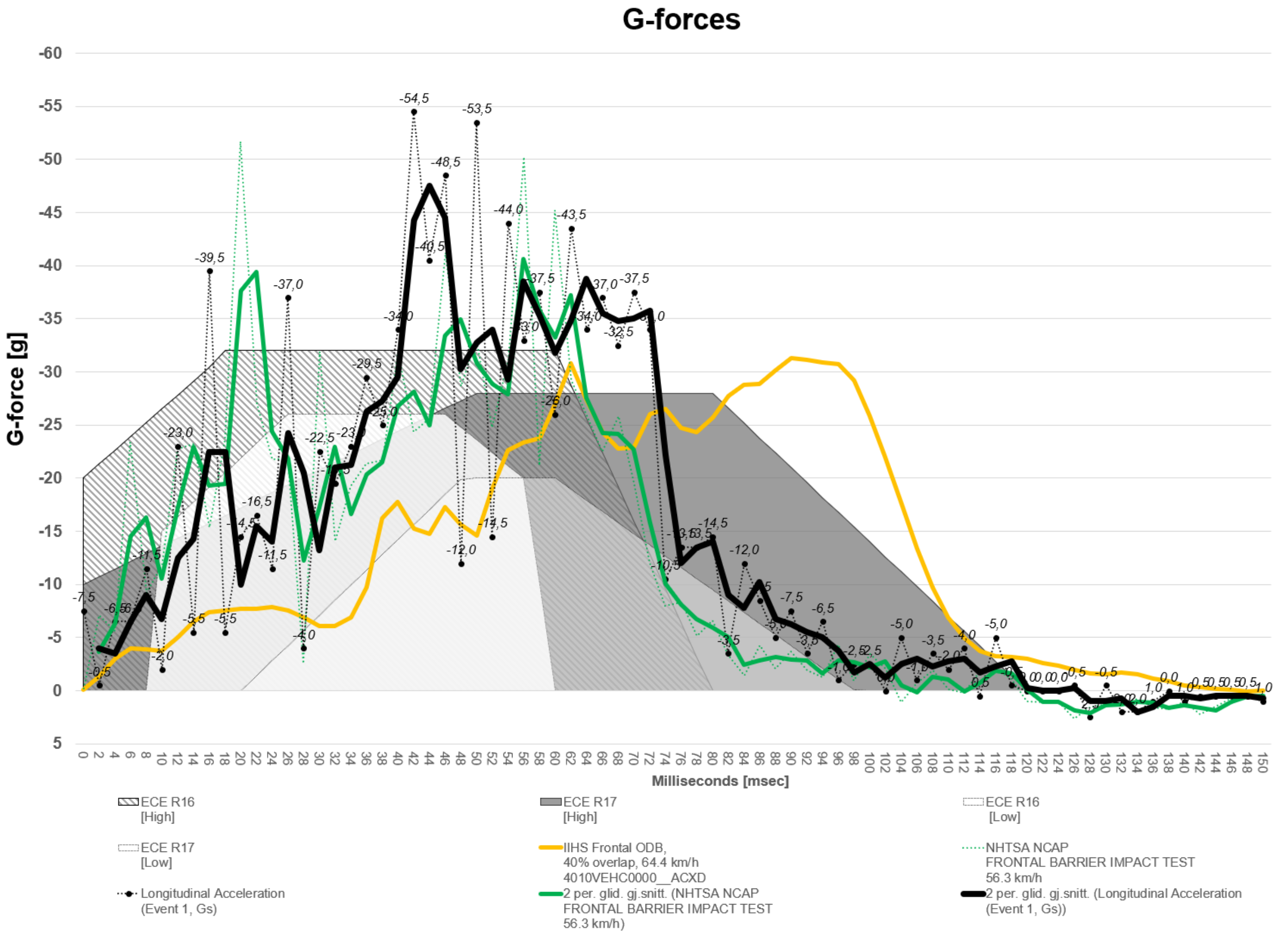


Figure 48: Comparison of g-forces over time from the car's EDR report, NCAP and IIHS crash test of the same model, shoulder belt load on crash-test dummy in the NCAP test and test corridors in UN ECE R16 and 17 in the background. Source: Tesla, NHTSA, UN ECE, IIHS. Collation: NSIA

A comparison between the NHTSA test and the collision in the accident shows relatively similar values[17], despite the different collision speeds. The fact that the values are relatively similar can be explained by the fact that, in the NHTSA test, the car collides with an immovable wall, while in the accident in question, the car collided with the front of an HGV that absorbed the impact at the front. Both the crash in the accident and the NHTSA test have values that are both above and below the UN ECE test corridors at different times. The collation also shows that the collision was more high-energy than the IIHS test, which simulates a frontal collision with an oncoming car. Both the

[17] The NHTSA test recorded and stored values 10 times per millisecond, while the EDR report stored values every other millisecond. The NSIA has reduced the NHTSA test frequency by 20 for the sake of comparison.

NHTSA and IIHS tests are considered demanding tests with high, but survivable, acceleration values. The tests require a high degree of vehicle deformation and integrity and SRS systems that work together in time. None of these tests have been carried out with regard to passenger safety in the rear seat (row 2) or unsecured luggage in the boot.

The UN ECE R 16 has a peak acceleration in the test corridor of -32 G at 42 milliseconds, and the acceleration can be -30 G on average at 60 milliseconds. The UN ECE R 17 rear seat strength corridor has a lower peak acceleration, -28 G at 30 milliseconds, and the test corridor itself is 40 milliseconds longer.

Figure 49 shows a comparison of the Delta-V curve calculated on the basis of the values in Figure 48. Delta-V in the UN ECE R 16 test corridor is in the 40–75 km/h range. The collision in the accident and the NHTSA test have values that are at the very top of the corridor, but achieve a maximum Delta-V over time more slowly than UN ECE R 16.

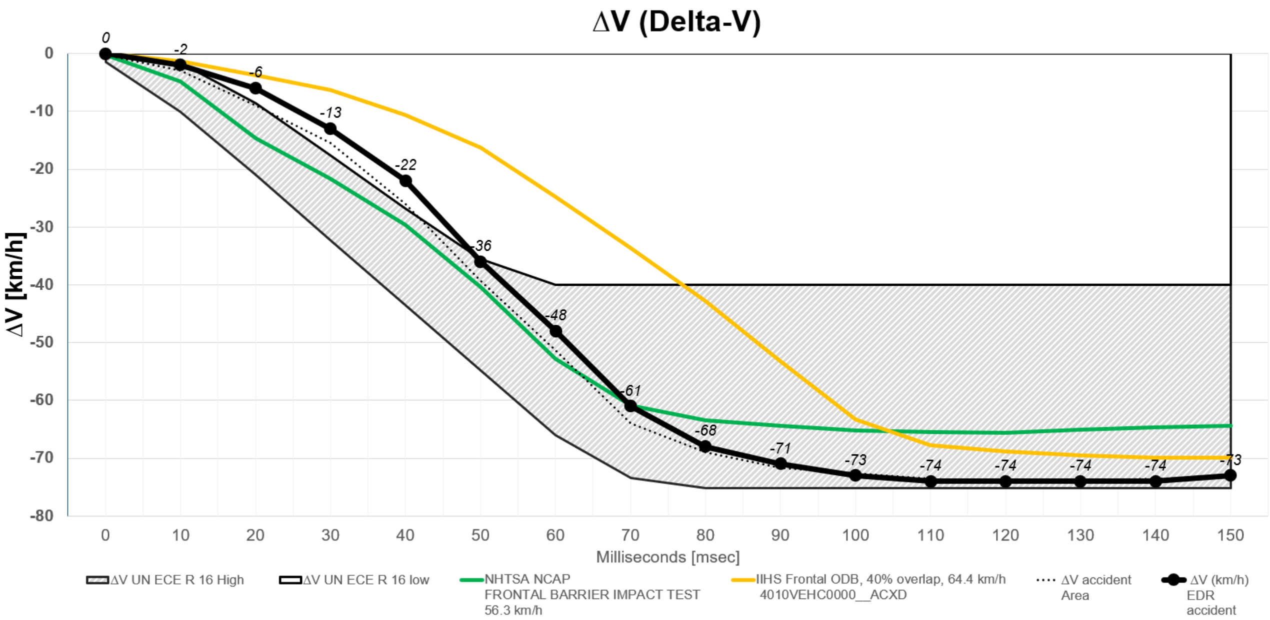


Figure 49: Comparison of the build-up of ΔV between the collision, NHTSA and IIHS test and UN ECE R16. Source: Tesla, NHTSA, IIHS and UN ECE. Collation: NSIA

Based on Figure 48, the NSIA is of the opinion that the acceleration in the collision in the accident is comparable to the NHTSA test. Nor does the collision in the accident deviate significantly from the minimum requirements of UN ECE R 16, even though it is at the top of the corridor. This indicates that the forces involved in the accident were great, but still within the level the vehicles should be able to withstand in terms of safety.

2.5 Accident car rear seat-back, design and strength

2.5.1 THE LOAD RATIO BETWEEN THE TENSION IN THE SEAT BELT AND THE WEIGHT OF LUGGAGE ON THE REAR SEAT-BACK

The tensile tests carried out by the NSIA showed that when the frame of the rear seat-back was distorted enough, the locking mechanism of the rear seat-back came near the corner of the striker loop. The tests showed that the strength of the striker was reduced as a result of this distortion, compared to the strength it had when only subjected to tension along the longitudinal axis.

In the accident, there was approximately 67 kg in the boot, but only 30 kg of luggage behind the 60-part of the rear seat-back. The luggage was placed close to the seat back with the heaviest items at the bottom. There were no hooks in the boot to secure this luggage with straps.

Research into the human body’s ability to withstand acceleration has shown that it can withstand 40 G steadily for up to 50 milliseconds without major injury, if correctly secured (Shanahan, 2004)[18]. The accelerations in collisions often have a waveform and follow what is known as a Eiband curve with build-up, a plateau and reduction of acceleration. The NSIA has chosen to look at an average of an acceleration plateau over 50 milliseconds, where the acceleration from luggage and the tensile force from a shoulder belt simultaneously work on the rear seat-back in the collision, see Figure 50.

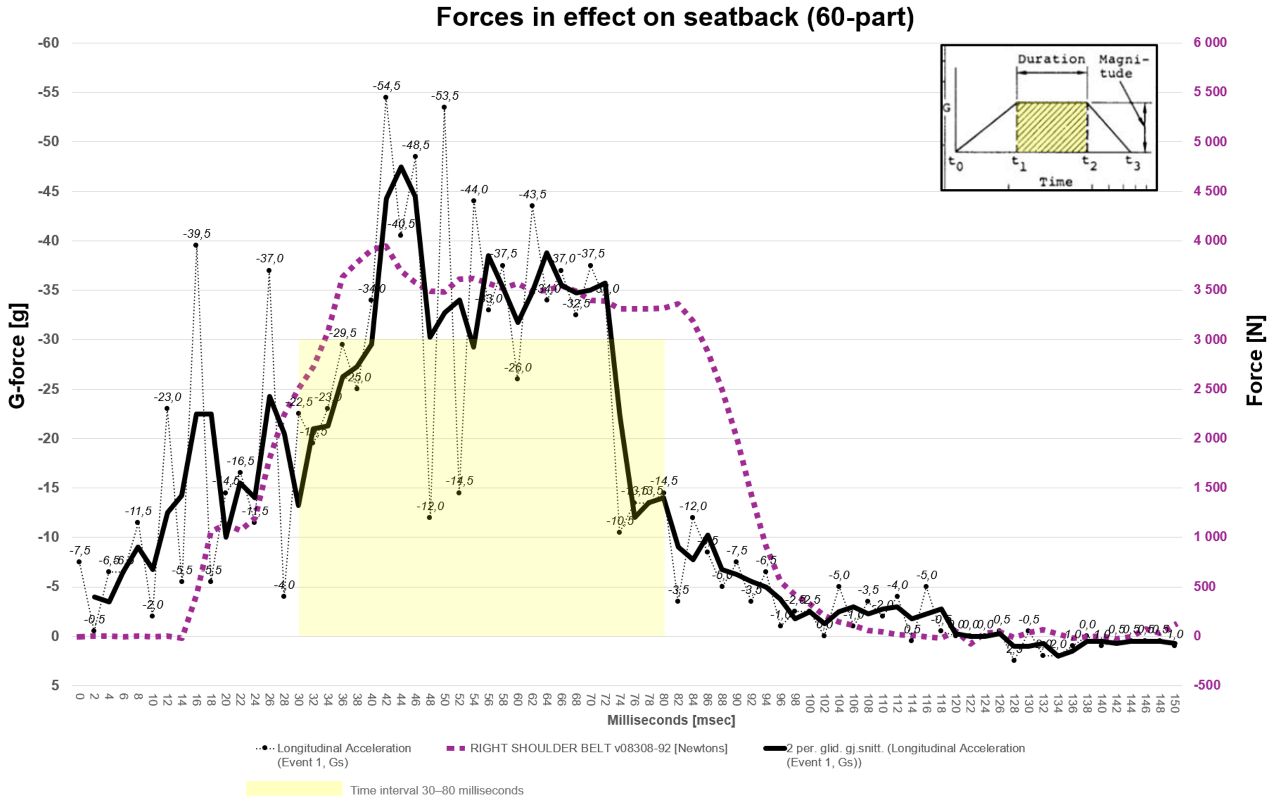


Figure 50: Average acceleration from luggage and tensile force from the right shoulder belt in the NHTSA NCAP test over 50 milliseconds. Source: Tesla, NHTSA. Collation: NSIA

The EDR report has recorded that in the period 30–80 milliseconds, the average acceleration in the passenger car was -30 G. The average force on the shoulder belt from the corresponding NHTSA test from the crash-test dummy on the right side was 3,450 N. The NSIA considers these values to be representative of the load on the shoulder belt from the middle occupant of the rear seat in the accident, due to weight similarity with the test dummy in the NHTSA test.

This makes it possible to calculate how much load effectively affected the seat belt anchorage over 50 milliseconds and whether a critical load on the rear seat-back is reached during this period. Although the rear seat-back in test #2 broke off at 920 kg, the strength may have been reduced as a result of test #1. The NSIA has therefore assessed that the critical load for distortion of the rear back-seat is reached in the range 1,000–1,200 kg. An example from a calculation with a critical load of 1,200 kg is shown below.

[18] ‘Human Tolerance and Crash Survivability’, DF Shanahan, graph from this publication is in Appendix A.

$$F_{seatback\ (60-part,1\ 200kg)} = F_{shoulderbelt} + F_{luggage}$$

$$\rightarrow F_{luggage} = F_{seatback\ (60-part,1\ 200kg)} - F_{shoulderbelt}$$

$$F_{luggage} = 11\ 772\ N - 3\ 450\ N$$

$$\rightarrow m_{luggage} = \frac{11\ 772\ N - 3\ 450\ N}{30\ g}$$

$$m_{luggage} = \frac{8\ 3220\ N}{30g}$$

$$m_{luggage} = 28\ kg$$

Although the calculation is subject to many reservations, it shows a probable load interaction between the seat belt loading from a person and pushing from luggage on the rear seat-back. If the critical load on the rear seat-back was 1,000 kg, the luggage mass would be reduced to 21 kg.

Other tests with test dummies in the rear seat with a similar weight show that forces in a shoulder belt without belt pretensioner or force limiter can reach 6–8 kN (Edwards, 2023). If this were to be applied, the luggage mass would be further reduced to 13–19 kg based on the same assumptions.

The NSIA assumes that the passenger car passed the requirements in the regulations for both belt anchorage and rear seat strength. The requirements, however, do not show how rear seat strength, luggage and seat belts should work together.

The tests showed that with sufficient distortion, lateral forces occurred in the locking mechanism, which significantly reduced the strength of the connection in the rear seat-back. The rear seat-back collapsed at a load equivalent to around 1,000 kg. These forces led to distortion of the rear seat-back, which in turn led to the latch in the rear seat-back lodging in the corner of the loop. The NSIA believes that the further effect of these two elements meeting in the corner was that the striker was subject to lateral tension and broke off in the wheel arch.

The calculations above shows that the rear seat-back could withstand less than 30 kg of pressing load when the rear seat-back simultaneously secured a light adult person, like the conditions in the accident. The NSIA is aware that rear seats can collapse in high-energy head-on collisions where pressure from luggage is a contributing factor. This was a high-energy collision, but the NSIA believes that the dynamic forces in the accident were within what the vehicle's design should be able to withstand in terms of the mass of luggage and occupant weight.

The NSIA makes one safety recommendation to Tesla related to this issue.

2.5.2 REQUIREMENTS AND TESTS RELATING TO THE PROTECTION AND RESTRAINT OF REAR SEAT OCCUPANTS

Minimum safety requirements in head-on collisions are described in the regulations as individual requirements for each component. In the event of a head-on collision, for example, the minimum requirements of individual elements must work together and not conflict with each other. However, the strength of rear seat-backs (UN ECE R 17) and simultaneous securing of the middle occupant's seat belt anchorage (UN ECE R 14) are not addressed in the regulations.

In most cars, rear seat-backs have a dual function and the automotive industry has several different design solutions for this. A rear seat-back should provide good seat belt protection for the middle seat, while also having the strength to withstand luggage in a head-on collision.

The NSIA has previously investigated this issue and issued a safety recommendation to the Norwegian Public Roads Administration to work on developing regulations for the safety of rear seat occupants (NSIA report 2020/07). However, any change to the regulations is a time-consuming process that requires international agreement.

The NSIA believes that better consumer tests or extra assessments could be a step towards a possible amendment to the regulations and to raising awareness about the safety of rear seat occupants. In order to accommodate safety developments in this area, assessment points could be established in the 'SAFETY EQUIPMENT' chapter of the Euro NCAP reports that could describe whether there are locking mechanisms for split rear seat-backs and load securing concepts for luggage, e.g. wire mesh or netting and load restraint hooks.

The Norwegian Safety Investigation Authority submits one safety recommendation to the Norwegian Public Roads Administration to propose that Euro NCAP expand the safety assessment of passenger cars to include factors relevant to the safety of rear seat occupants. The Norwegian Safety Investigation Authority moreover encourages car manufacturers to develop tests to ensure that their design solutions improve the safety of occupants of different sizes sitting in all positions.

2.6 Other findings

2.6.1 SPEED MEASUREMENTS AND SPEED REDUCTION MEASURES IN FLÅ CENTRE

Safety margins will always be higher at lower speed levels, including compliance with the speed limit. This applies to both the driver's ability to detect and correct deviations, as well as the utilisation of the vehicle's passive safety systems. Furthermore, the investigation demonstrates the importance of road authorities identifying places where many road users, for various reasons, do not comply with the stipulated speed limit.

In February 2023, a traffic counter was set up in the 40 km/h zone in Flå centre, which showed that half of all vehicles drove slightly above the speed limit and that 15% drove 11 km/h above the 40 km/h speed limit. Approximately 1 in 20 vehicles (5%) drove at a speed of 60 km/h or higher. With a daily traffic volume of 7,379 vehicles, this means that more than 350 vehicles a day drove at speeds of over 60 km/h through Flå centre.

The registered speed of the car in question was above the speed limit in the collision. At the place where the traffic counter was installed, the NSIA calculated the speed of the car to be 41 km/h, which was on average compared with other vehicles driving through Flå centre.

The process concerning a new signage decision and approval of a new signage plan took a relatively long time, with the Norwegian Public Roads Administration taking over nine months to respond to the comments from Flå municipality. Speed reduction measures were not implemented immediately in the period after 28 February 2024, and speed bumps were not established in Flå centre until autumn 2024. The NSIA is of the opinion that the final measure is a good safety measure with a view to reducing the average speed in 40 km/h zones.

2.6.2 EXERCISE OF AUTHORITY TO IMPOSE A PROHIBITION ON USE

The passenger car concerned had been driven with a prohibition on use since 2018 due to failure to report a rectified defect. It is important to stress that the prohibition on use had no bearing on the accident, and that the car had no technical faults or defects at the time of the accident.

The NSIA has been informed that letters concerning tests or notices of prohibition on use are neither confirmed in the Norwegian Public Roads Administration's systems nor followed up. The

NSIA believes that the investigation has shown that the owner intended to comply with the regulations, and in practice maintained the car in accordance with this intention.

The NSIA is of the opinion that the problem shows a shortcoming in the authorities' ability to ensure that vehicles with serious faults and defects do not continue to be used. If the car in question had been stopped for inspection, it could have been deregistered, not because of its condition, but because of inadequate follow-up. The NSIA supports the proposal from the Norwegian Public Roads Administration that it may be expedient to send a reminder concerning prohibition on use after a certain period of time, but makes no safety recommendation in this area.

3. Conclusion

3. Conclusion

3.1 Main conclusion

The head-on collision occurred when a passenger car crossed over into the opposite lane at a speed of approximately 60 km/h and collided with a heavy goods vehicle. The driver of the passenger car did not notice the gentle curvature of the roadway for a short time just before the collision. The HGV driver had seen the passenger car and slowed down before the collision. This reduced the forces of the collision considerably. Despite this, two of the people in the rear seat of the passenger car sustained critical injuries and the other people in the car sustained minor injuries.

Everyone in the car was wearing a seat belt. The car was properly packed, and no heavy items were loose or entered the vehicle body from the boot. The total weight in the boot was approximately 67 kg. The booster seats used by two of the children were suitable for the children’s age and size. The serious injuries sustained by an adult and one of the children of the rear seat can be explained by the incorrect use and adjustment of seat belts, combined with fewer supplemental restraint systems (airbag, seat belt pretensioner and force limiter), and the rear seat-back collapsing in the collision. Active belts and airbags helped to limit the injuries of the occupants of the front seats.

The NSIA finds that the passenger car passed the requirements set out in the regulations for both belt anchorage and rear seat strength. The requirements, however, do not show how rear seat strength, luggage and seat belts should work together. The NSIA believes that the dynamic forces in the accident were within what the vehicle's design should be able to withstand in terms of the mass of luggage and occupant weight.

The NSIA performed static tensile tests on a reference car to see how much load the rear seat-back could withstand when tensioned longitudinally, and whether it was possible to find out what caused the rear seat-back to collapse. The tests showed that with sufficient distortion, lateral forces occurred in the locking mechanism, which significantly reduced the strength of the connection in the rear seat-back. The rear seat-back collapsed at a load equivalent to around 1,000 kg in one of the tests. Based on this, the NSIA calculated that the rear seat-back could withstand less than 30 kg of pressing load when the rear seat-back simultaneously secured a light adult person, like the conditions in the accident.

The NSIA believes that regulations must change to improve safety for rear seat passengers, but this is a process that requires international agreement. A first step towards changing the regulations may be to raise the issue in The European New Car Assessment Programme (Euro NCAP). Tesla should also take a closer look at the car model’s design for ensuring the safety of rear seat occupants. The NSIA moreover encourages car manufacturers to develop tests to ensure that their design solutions improve the safety of occupants of different sizes sitting in all positions.

The investigation also provides several learning points for road users about securing occupants and luggage in passenger cars. Also see the NSIA’s previously published information video on the correct adjustment of seat belts.

3.2 Other findings

The investigation has also revealed two other findings of general importance to road safety, which are not related to the causal factors of the accident:

A. The average speed of traffic on the section of road had been measured as too high in February 2023, without immediate measures being implemented to reduce speed. Speed bumps were not established in Flå centre until autumn 2024.

B. The passenger car had no technical faults or defects, but had nevertheless been banned from use since 2018 due to failure to report a rectified defect. This must be seen in conjunction with the Norwegian Public Roads Administration not having a system for following up prohibitions on use.

4. Safety recommendations and learning points

4. Safety recommendations and learning points

The Norwegian Safety Investigation Authority submits the following safety recommendations[19] for the purpose of improving road safety:

Safety recommendation ROAD No 2025/08T

The head-on collision on 21 May 2024 between a heavy goods vehicle and a passenger car occurred when the passenger car crossed over into the opposite lane at a speed of approximately 60 km/h. There were five people in the passenger car, where two of those in the rear seat sustained critical injuries and the other occupants of the car sustained minor injuries.

The NSIA finds that the passenger car passed the requirements set out in the regulations for both belt anchorage and rear seat strength. The requirements, however, do not show how rear seat strength, luggage and seat belts should work together. In this accident, the rear seat-back was subjected to tensile forces from luggage and loading from an adult occupant fastened in the middle rear seat. This led to distortion of the rear seat-back, which in turn led to the striker in the wheel arch being torn off. The NSIA is of the opinion that the forces in the accident were within the level the vehicle should be designed to withstand in terms of luggage mass and occupant weight.

The Norwegian Safety Investigation Authority recommends that Tesla Norway investigate whether the safety of rear seat occupants in the car model (Tesla Model S) can be improved with regard to the design and anchorage of the rear seat-back and the securing of luggage in the boot.

[19] The investigation report is submitted to the Ministry of Transport, which will take necessary measures to ensure that due consideration is given to the safety recommendations, cf. Regulations of 30 June 2005 No 793 on Public Investigation and Notification of Traffic Accidents etc Section 14. The Road Supervisory Authority is responsible for following up all safety recommendations for roads on behalf of the Ministry of Transport. This means, among other things, maintaining an overview of the follow-up of all the NSIA's safety recommendations in the road sector and recommending closure to the Ministry of Transport when a safety recommendation is considered satisfactorily followed up.

Safety recommendation ROAD No 2025/09T

The head-on collision on 21 May 2024 between a heavy goods vehicle and a passenger car occurred when the passenger car crossed over into the opposite lane at a speed of approximately 60 km/h. There were five people in the passenger car, where two of those in the rear seat sustained critical injuries and the other occupants of the car sustained minor injuries.

The NSIA finds that the passenger car passed the requirements set out in the regulations for both belt anchorage and rear seat strength. The requirements, however, do not show how rear seat strength, luggage and seat belts should work together. In this accident, the rear seat-back was subjected to tensile forces from luggage and loading from an adult occupant fastened in the middle rear seat. This led to distortion of the rear seat-back, which in turn led to the striker in the wheel arch being torn off. The NSIA is of the opinion that the forces in the accident were within the level the vehicle should be designed to withstand in terms of luggage mass and occupant weight. A first step towards changing the regulations to better safeguard the safety of rear seat occupants may be to raise the issue in Euro NCAP.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration propose to Euro NCAP to expand the safety assessment of passenger cars to include factors relevant to the safety of rear seat occupants. For example, whether locking mechanisms for split rear seat-backs and luggage securing systems, such as wire mesh or netting and hooks for straps are available.

Learning points on securing occupants and luggage in passenger cars

Correct use and adjustment of seat belts

- Adjust the shoulder belt to the height of the occupant where possible and adjust the seat back to the upright position (normal position). See the NSIA's previously published information video on the correct adjustment of seat belts.
- In the normal position try to ensure that
    - the shoulder belt lies naturally diagonally from the hip over the middle of the chest and collarbone of the opposite shoulder
    - the lap belt is as low and close to the body as possible, under the top of the hip and tighten by pulling on the shoulder belt
- Securing older children:
    - Use a high-back booster seat as long as physically possible.
    - Booster seats are preferable to not using such seats.
        - Ensure that the lap belt is under the belt routing in the booster seat, never above.

Securing luggage in the boot

- Install protective wire mesh or netting between the boot and the vehicle body if available and appropriate.
- Avoid loading luggage above the height of the rear seat-back.
- Use straps to secure luggage where appropriate and use load restraint hooks in the boot if possible.
- Place luggage close to the back of the rear seat-back with the heaviest at the bottom and the lightest at the top.
- Consider whether using a roof box or trailer is possible or appropriate if the car is full and there is a large amount of luggage.

Norwegian Safety Investigation Authority
Lillestrøm, 2 July 2025

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Appendices

Appendix A Technical background information

Acceleration data from IIHS moderate overlap front test Tesla Model S 2016, CEF1611

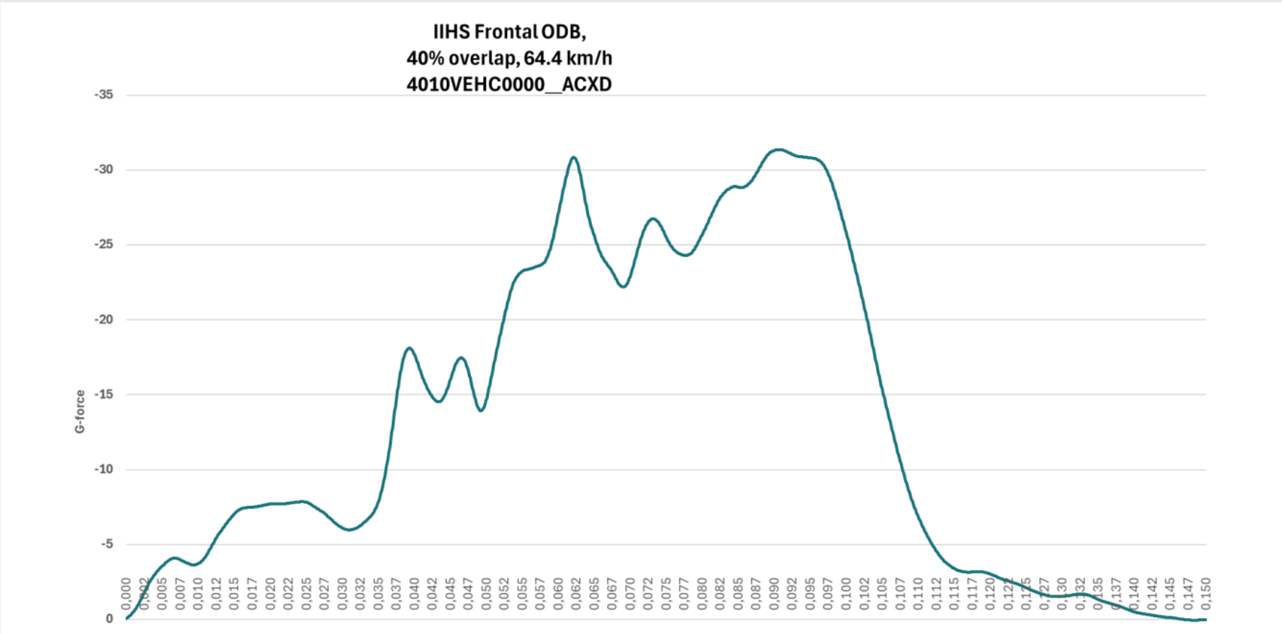

Figure 51: Acceleration data from the Insurance Institute for Highway Safety Crashworthiness Evaluation 2016 Tesla Model S (CEF1611) Moderate Overlap Front Test. Source: IIHS

Force distribution over time on the shoulder belt of the driver and front seat passenger in the NHTSA NCAP test

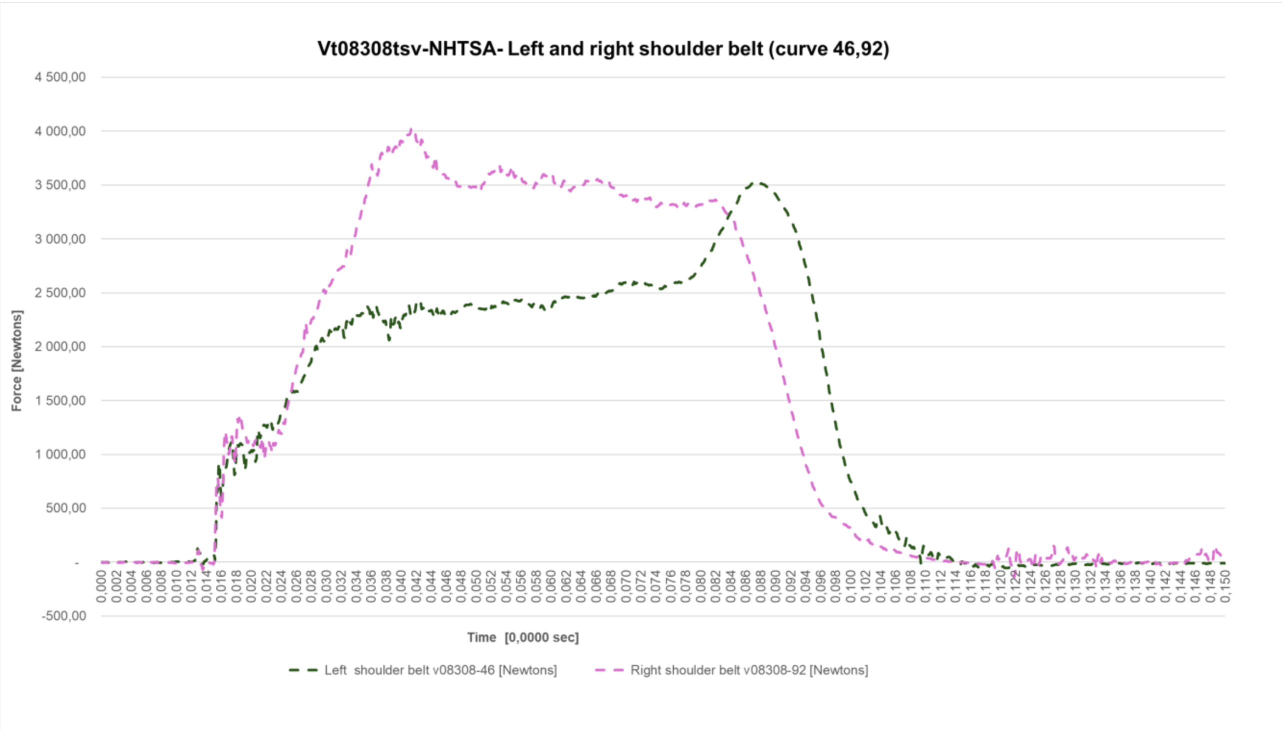

Figure 52: Shoulder belt force on the driver dummy (77.7 kg) and front passenger dummy (50 kg). The belt pretensioner, force limiter and airbag affect the forces on the shoulder belt. Source: NHTSA, [Test Number 8308, Curve 46 and 92]

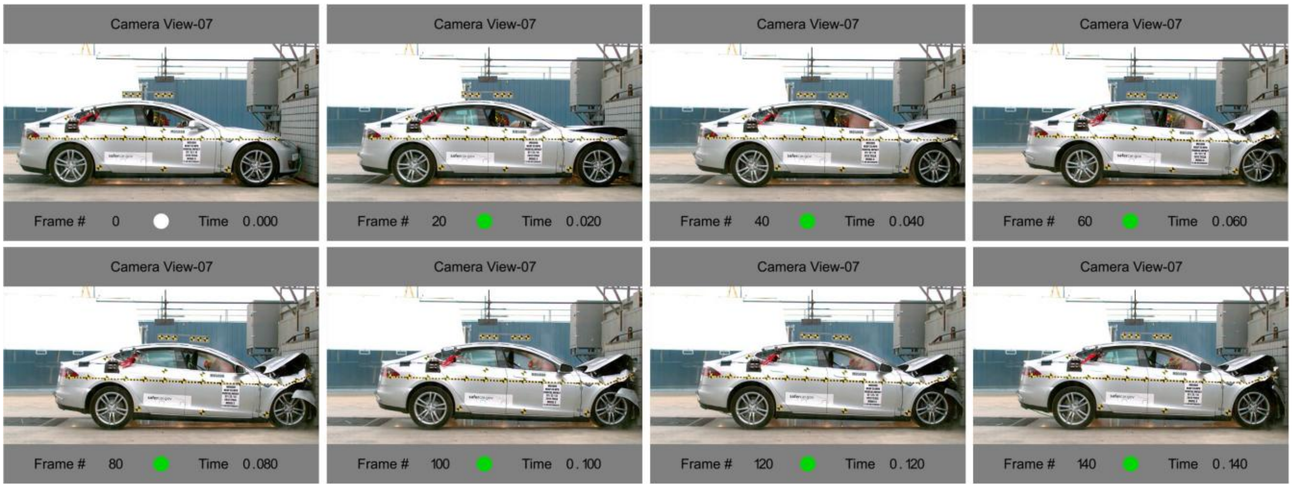

Figure 53: Activation front airbags in the test, 20 ms resolution. Source: NHTSA, [Test Number 8308, Camera 7]

Longitudinal acceleration and calculated Delta-V from the EDR report of the passenger car in the accident

Longitudinal Acceleration Values (Event 1)

Time (ms)	Acceleration (g)	Time (ms)	Acceleration (g)	Time (ms)	Acceleration (g)	Time (ms)	Acceleration (g)
0	-7.5	88	-5.0	176	0.5	264	0.0
2	-0.5	90	-7.5	178	1.0	266	0.0
4	-6.5	92	-3.5	180	0.5	268	0.0
6	-6.5	94	-6.5	182	1.0	270	0.0
8	-11.5	96	-1.0	184	0.5	272	0.0
10	-2.0	98	-2.5	186	1.0	274	0.0
12	-23.0	100	-2.5	188	0.5	276	0.0
14	5.5	102	0.0	190	1.0	278	0.0
16	-39.5	104	-5.0	192	0.5	280	0.0
18	5.5	106	-1.0	194	1.0	282	0.0
20	-14.5	108	-3.5	196	0.5	284	0.0
22	-16.5	110	-2.0	198	0.5	286	0.0
24	-11.5	112	-4.0	200	0.5	288	0.0
26	-37.0	114	0.5	202	0.5	290	0.0
28	-4.0	116	-5.0	204	0.0	292	0.0
30	-22.5	118	-0.5	206	0.0	294	0.0
32	-19.5	120	0.0	208	0.5	296	0.0
34	-23.0	122	0.0	210	0.0	298	0.0
36	-29.5	124	0.0	212	0.0	300	0.0
38	-25.0	126	-0.5	214	0.0		
40	-34.0	128	2.5	216	0.0		
42	-54.5	130	-0.5	218	0.0		
44	-40.5	132	2.0	220	0.0		
46	-48.5	134	2.0	222	0.0		
48	-12.0	136	1.0	224	0.0		
50	-53.5	138	0.0	226	0.0		
52	-14.5	140	1.0	228	0.0		
54	-44.0	142	0.5	230	0.0		
56	-33.0	144	0.5	232	-2.5		
58	-37.5	146	0.5	234	2.0		
60	-26.0	148	0.5	236	-0.5		
62	-43.5	150	1.0	238	0.0		
64	-34.0	152	0.0	240	0.0		
66	-37.0	154	1.0	242	0.0		
68	-32.5	156	1.0	244	0.0		
70	-37.5	158	0.5	246	-0.5		
72	-34.0	160	0.5	248	0.0		
74	-10.5	162	2.5	250	0.0		
76	-13.5	164	2.0	252	0.0		
78	-13.5	166	2.0	254	0.0		
80	-14.5	168	1.0	256	0.0		
82	-3.5	170	1.0	258	0.0		
84	-12.0	172	1.0	260	0.0		
86	-8.5	174	0.5	262	0.0		

Figure 54: Longitudinal acceleration (Event 1) from the EDR report of the accident car. Source: Tesla

Time (ms)	Delta-V (km/h)	Time (ms)	Delta-V (km/h)	Time (ms)	Delta-V (km/h)
0	0	140	-74	280	-71
10	-2	150	-73	290	-71
20	-6	160	-73	300	-71
30	-13	170	-72		
40	-22	180	-71		
50	-36	190	-71		
60	-48	200	-71		
70	-61	210	-70		
80	-68	220	-70		
90	-71	230	-70		
100	-73	240	-71		
110	-74	250	-71		
120	-74	260	-71		
130	-74	270	-71		

Figure 55: Longitudinal Delta-V (Event 1) from the EDR report of the accident car. Source: Tesla

Eiband curve for uniform acceleration:

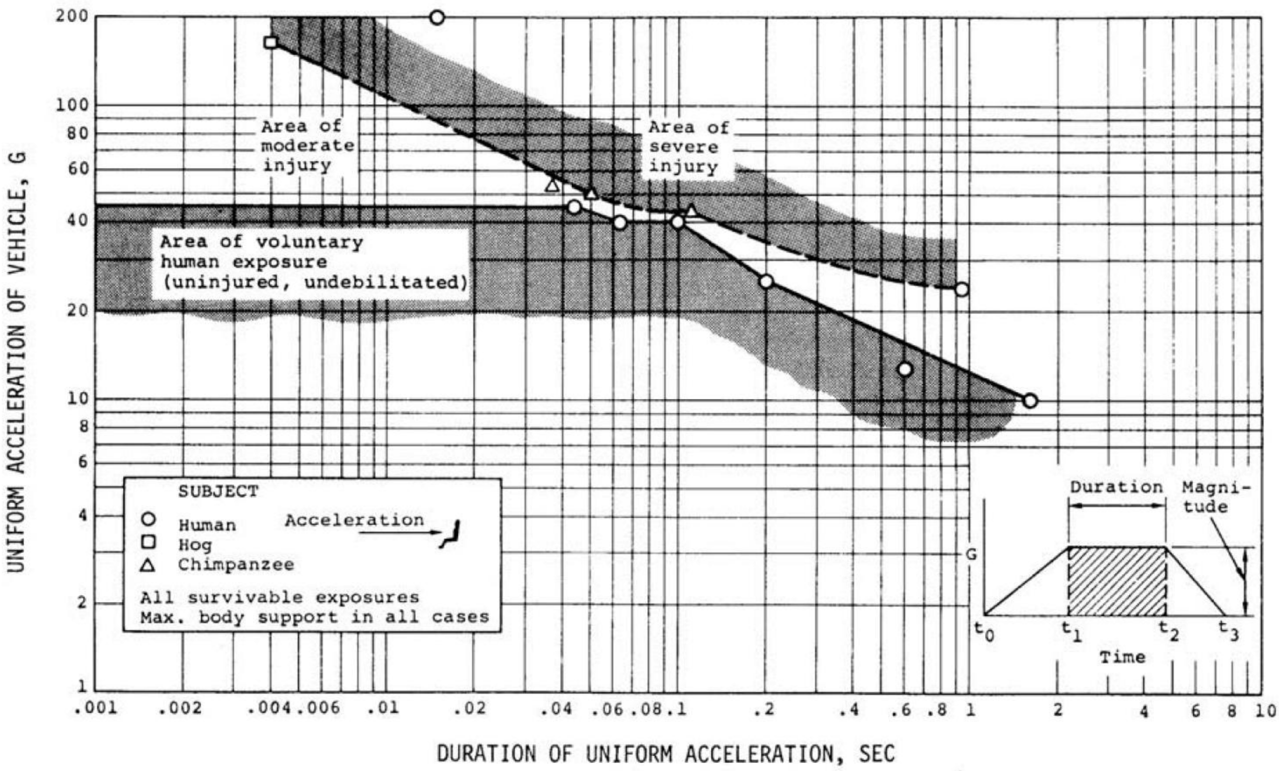

Figure 56: 'Human Tolerance and Crash Survivability, figure 6, Eiband Curve for -$G_{x'}$, (Shanahan, 2004).

Basis for the graphs in Figure 48, Figure 49, Figure 50:

Note:

- **‘NHTSA NCAP FRONTAL BARRIER IMPACT TEST 56.3 km/h’** and ‘**ΔV NHTSA NCAP Vt08308tsv**’ are an average of:
    - ‘93-Vt08308tsv-NHTSA rear sill accelerometer (0,2,4… milliseconds)’ and ‘93-Vt08308tsv-NHTSA rear sill accelerometer (1,3,5 milliseconds)’.

Time (ms)	Longitudinal Acceleration (Event 1, Gs)	m/s²	Area (2nd ms)	ΔV Longitudinal Acceleration (Event 1)	ECE R17 [Low]	m/s2	Area (2nd ms)	ΔV r17-low Area	ECE R17 [High]	m/s2	Area (2nd ms)	ΔV r17-High Area
B		=C4*9,81	=(D4+D5)	=SUMMER(E$4:E5)/1000*3,6								
0	-7,5	-73,6	-78,5	-0,3	0,0	0,0	0,0	0,0	-10,0	-98,1	-203,3	-0,7
2	-0,5	-4,9	-68,7	-0,5	0,0	0,0	0,0	0,0	-10,7	-105,2	-217,4	-1,5
4	-6,5	-63,8	-127,5	-1,0	0,0	0,0	0,0	0,0	-11,4	-112,2	-231,5	-2,3
6	-6,5	-63,8	-176,6	-1,6	0,0	0,0	0,0	0,0	-12,2	-119,3	-245,6	-3,2
8	-11,5	-112,8	-132,4	-2,1	0,0	0,0	0,0	0,0	-12,9	-126,4	-259,8	-4,2
10	-2,0	-19,6	-245,3	-3,0	0,0	0,0	0,0	0,0	-13,6	-133,4	-273,9	-5,2
12	-23,0	-225,6	-279,6	-4,0	0,0	0,0	0,0	0,0	-14,3	-140,5	-288,0	-6,2
14	-5,5	-54,0	-441,5	-5,6	0,0	0,0	0,0	0,0	-15,0	-147,5	-302,1	-7,3
16	-39,5	-387,5	-441,5	-7,2	0,0	0,0	0,0	0,0	-15,8	-154,6	-316,3	-8,4
18	-5,5	-54,0	-196,2	-7,9	0,0	0,0	0,0	0,0	-16,5	-161,7	-330,4	-9,6
20	-14,5	-142,2	-304,1	-9,0	0,0	0,0	-13,9	-0,1	-17,2	-168,7	-344,5	-10,8
22	-16,5	-161,9	-274,7	-10,0	-1,4	-13,9	-41,8	-0,2	-17,9	-175,8	-358,7	-12,1
24	-11,5	-112,8	-475,8	-11,7	-2,8	-27,9	-69,7	-0,5	-18,6	-182,9	-372,8	-13,5
26	-37,0	-363,0	-402,2	-13,1	-4,3	-41,8	-97,5	-0,8	-19,4	-189,9	-386,9	-14,9
28	-4,0	-39,2	-260,0	-14,1	-5,7	-55,7	-125,4	-1,3	-20,1	-197,0	-401,0	-16,3
30	-22,5	-220,7	-412,0	-15,5	-7,1	-69,7	-153,2	-1,8	-20,8	-204,0	-415,2	-17,8
32	-19,5	-191,3	-416,9	-17,0	-8,5	-83,6	-181,1	-2,5	-21,5	-211,1	-429,3	-19,4
34	-23,0	-225,6	-515,0	-18,9	-9,9	-97,5	-209,0	-3,2	-22,2	-218,2	-443,4	-21,0
36	-29,5	-289,4	-534,6	-20,8	-11,4	-111,4	-236,8	-4,1	-23,0	-225,2	-457,5	-22,6
38	-25,0	-245,3	-578,8	-22,9	-12,8	-125,4	-264,7	-5,0	-23,7	-232,3	-471,7	-24,3
40	-34,0	-333,5	-868,2	-26,0	-14,2	-139,3	-292,5	-6,1	-24,4	-239,4	-485,8	-26,0
42	-54,5	-534,6	-932,0	-29,4	-15,6	-153,2	-320,4	-7,2	-25,1	-246,4	-499,9	-27,8
44	-40,5	-397,3	-873,1	-32,5	-17,0	-167,2	-348,3	-8,5	-25,8	-253,5	-514,0	-29,7
46	-48,5	-475,8	-593,5	-34,7	-18,5	-181,1	-376,1	-9,8	-26,6	-260,6	-528,2	-31,6
48	-12,0	-117,7	-642,6	-37,0	-19,9	-195,0	-391,2	-11,2	-27,3	-267,6	-542,3	-33,6
50	-53,5	-524,8	-667,1	-39,4	-20,0	-196,2	-392,4	-12,7	-28,0	-274,7	-549,4	-35,5
52	-14,5	-142,2	-573,9	-41,4	-20,0	-196,2	-392,4	-14,1	-28,0	-274,7	-549,4	-37,5
54	-44,0	-431,6	-755,4	-44,2	-20,0	-196,2	-392,4	-15,5	-28,0	-274,7	-549,4	-39,5
56	-33,0	-323,7	-691,6	-46,7	-20,0	-196,2	-392,4	-16,9	-28,0	-274,7	-549,4	-41,5
58	-37,5	-367,9	-622,9	-48,9	-20,0	-196,2	-392,4	-18,3	-28,0	-274,7	-549,4	-43,4
60	-26,0	-255,1	-681,8	-51,3	-20,0	-196,2	-382,1	-19,7	-28,0	-274,7	-549,4	-45,4
62	-43,5	-426,7	-760,3	-54,1	-19,0	-185,9	-361,5	-21,0	-28,0	-274,7	-549,4	-47,4
64	-34,0	-333,5	-696,5	-56,6	-17,9	-175,6	-340,9	-22,2	-28,0	-274,7	-549,4	-49,4
66	-37,0	-363,0	-681,8	-59,0	-16,9	-165,3	-320,3	-23,4	-28,0	-274,7	-549,4	-51,3
68	-32,5	-318,8	-686,7	-61,5	-15,8	-155,0	-299,7	-24,4	-28,0	-274,7	-549,4	-53,3
70	-37,5	-367,9	-701,4	-64,0	-14,8	-144,7	-279,1	-25,4	-28,0	-274,7	-549,4	-55,3
72	-34,0	-333,5	-436,5	-65,6	-13,7	-134,4	-258,5	-26,4	-28,0	-274,7	-549,4	-57,3
74	-10,5	-103,0	-235,4	-66,5	-12,7	-124,1	-237,9	-27,2	-28,0	-274,7	-549,4	-59,3
76	-13,5	-132,4	-264,9	-67,4	-11,6	-113,8	-217,3	-28,0	-28,0	-274,7	-549,4	-61,2
78	-13,5	-132,4	-274,7	-68,4	-10,6	-103,5	-196,7	-28,7	-28,0	-274,7	-549,4	-63,2
80	-14,5	-142,2	-176,6	-69,0	-9,5	-93,2	-176,1	-29,4	-28,0	-274,7	-535,6	-65,1
82	-3,5	-34,3	-152,1	-69,6	-8,5	-82,9	-155,5	-29,9	-26,6	-260,9	-508,2	-67,0
84	-12,0	-117,7	-201,1	-70,3	-7,4	-72,6	-134,9	-30,4	-25,2	-247,2	-480,7	-68,7
86	-8,5	-83,4	-132,4	-70,8	-6,4	-62,3	-114,3	-30,8	-23,8	-233,5	-453,2	-70,3
88	-5,0	-49,1	-122,6	-71,2	-5,3	-52,0	-93,7	-31,1	-22,4	-219,7	-425,8	-71,9
90	-7,5	-74	-107,9	-71,6	-4,3	-41,7	-73,1	-31,4	-21,0	-206,0	-398,3	-73,3
92	-3,5	-34,3	-98,1	-72,0	-3,2	-31,4	-52,5	-31,6	-19,6	-192,3	-370,8	-74,6
94	-6,5	-63,8	-73,6	-72,2	-2,2	-21,1	-31,9	-31,7	-18,2	-178,5	-343,4	-75,9
96	-1,0	-9,8	-34,3	-72,4	-1,1	-10,8	-11,3	-31,8	-16,8	-164,8	-315,9	-77,0
98	-2,5	-24,5	-49,1	-72,5	-0,1	-0,5	-0,5	-31,8	-15,4	-151,1	-288,4	-78,0
100	-2,5	-24,5	-24,5	-72,6	0,0	0,0	0,0	-31,8	-14,0	-137,3	-260,9	-79,0
102	0,0	0,0	-49,1	-72,8	0,0	0,0	0,0	-31,8	-12,6	-123,6	-233,5	-79,8
104	-5,0	-49,1	-58,9	-73,0	0,0	0,0	0,0	-31,8	-11,2	-109,9	-206,0	-80,6
106	-1,0	-9,8	-44,1	-73,2	0,0	0,0	0,0	-31,8	-9,8	-96,1	-178,5	-81,2
108	-3,5	-34,3	-54,0	-73,4	0,0	0,0	0,0	-31,8	-8,4	-82,4	-151,1	-81,8
110	-2,0	-19,6	-58,9	-73,6	0,0	0,0	0,0	-31,8	-7,0	-68,7	-123,6	-82,2
112	-4,0	-39,2	-34,3	-73,7	0,0	0,0	0,0	-31,8	-5,6	-54,9	-96,1	-82,5
114	0,5	4,9	-44,1	-73,9	0,0	0,0	0,0	-31,8	-4,2	-41,2	-68,7	-82,8
116	-5,0	-49,1	-54,0	-74,1	0,0	0,0	0,0	-31,8	-2,8	-27,5	-41,2	-82,9
118	-0,5	-4,9	-4,9	-74,1	0,0	0,0	0,0	-31,8	-1,4	-13,7	-13,7	-83,0
120	0,0	0,0	0,0	-74,1	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
122	0,0	0,0	0,0	-74,1	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
124	0,0	0,0	-4,9	-74,1	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
126	-0,5	-4,9	19,6	-74,0	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
128	2,5	24,5	19,6	-74,0	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
130	-0,5	-4,9	14,7	-73,9	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
132	2,0	19,6	39,2	-73,8	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
134	2,0	19,6	29,4	-73,7	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
136	1,0	9,8	9,8	-73,6	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
138	0,0	0,0	9,8	-73,6	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
140	1,0	9,8	14,7	-73,5	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
142	0,5	4,9	9,8	-73,5	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
144	0,5	4,9	9,8	-73,5	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
146	0,5	4,9	9,8	-73,4	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
148	0,5	4,9	14,7	-73,4	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0
150	1,0	9,8	9,8	-73,3	0,0	0,0	0,0	-31,8	0,0	0,0	0,0	-83,0

Time (ms)	ECE R16 [Low]	m/s2	Area (2nd ms)	ΔV r16-low Area	ECE R16 [High]	m/s2	Area (2nd ms)	ΔV r16-High Area
0	0,0	0,0	0,0	0,0	-20,0	-196,2	-405,2	-1,5
2	0,0	0,0	0,0	0,0	-21,3	-209,0	-430,7	-3,0
4	0,0	0,0	0,0	0,0	-22,6	-221,7	-456,2	-4,7
6	0,0	0,0	0,0	0,0	-23,9	-234,5	-481,7	-6,4
8	0,0	0,0	-147,2	-0,5	-25,2	-247,2	-507,2	-8,2
10	-15,0	-147,2	-307,8	-1,6	-26,5	-260,0	-532,7	-10,1
12	-16,4	-160,6	-334,8	-2,8	-27,8	-272,7	-558,2	-12,1
14	-17,8	-174,1	-361,7	-4,1	-29,1	-285,5	-583,7	-14,2
16	-19,1	-187,6	-388,7	-5,5	-30,4	-298,2	-612,1	-16,4
18	-20,5	-201,1	-415,7	-7,0	-32,0	-313,9	-627,8	-18,7
20	-21,9	-214,6	-442,7	-8,6	-32,0	-313,9	-627,8	-21,0
22	-23,3	-228,1	-469,7	-10,3	-32,0	-313,9	-627,8	-23,2
24	-24,6	-241,6	-496,6	-12,1	-32,0	-313,9	-627,8	-25,5
26	-26,0	-255,1	-510,1	-13,9	-32,0	-313,9	-627,8	-27,7
28	-26,0	-255,1	-510,1	-15,8	-32,0	-313,9	-627,8	-30,0
30	-26,0	-255,1	-510,1	-17,6	-32,0	-313,9	-627,8	-32,3
32	-26,0	-255,1	-510,1	-19,5	-32,0	-313,9	-627,8	-34,5
34	-26,0	-255,1	-510,1	-21,3	-32,0	-313,9	-627,8	-36,8
36	-26,0	-255,1	-510,1	-23,1	-32,0	-313,9	-627,8	-39,0
38	-26,0	-255,1	-510,1	-25,0	-32,0	-313,9	-627,8	-41,3
40	-26,0	-255,1	-510,1	-26,8	-32,0	-313,9	-627,8	-43,6
42	-26,0	-255,1	-510,1	-28,6	-32,0	-313,9	-627,8	-45,8
44	-26,0	-255,1	-510,1	-30,5	-32,0	-313,9	-627,8	-48,1
46	-26,0	-255,1	-498,3	-32,3	-32,0	-313,9	-627,8	-50,3
48	-24,8	-243,3	-474,8	-34,0	-32,0	-313,9	-627,8	-52,6
50	-23,6	-231,5	-451,3	-35,6	-32,0	-313,9	-627,8	-54,9
52	-22,4	-219,7	-427,7	-37,1	-32,0	-313,9	-627,8	-57,1
54	-21,2	-208,0	-404,2	-38,6	-32,0	-313,9	-627,8	-59,4
56	-20,0	-196,2	-294,3	-39,7	-32,0	-313,9	-627,8	-61,6
58	-10,0	-98,1	-98,1	-40,0	-32,0	-313,9	-627,8	-63,9
60	0,0	0,0	0,0	-40,0	-32,0	-313,9	-596,4	-66,1
62	0,0	0,0	0,0	-40,0	-28,8	-282,5	-533,7	-68,0
64	0,0	0,0	0,0	-40,0	-25,6	-251,1	-470,9	-69,7
66	0,0	0,0	0,0	-40,0	-22,4	-219,7	-408,1	-71,1
68	0,0	0,0	0,0	-40,0	-19,2	-188,4	-345,3	-72,4
70	0,0	0,0	0,0	-40,0	-16,0	-157,0	-282,5	-73,4
72	0,0	0,0	0,0	-40,0	-12,8	-125,6	-219,7	-74,2
74	0,0	0,0	0,0	-40,0	-9,6	-94,2	-157,0	-74,8
76	0,0	0,0	0,0	-40,0	-6,4	-62,8	-94,2	-75,1
78	0,0	0,0	0,0	-40,0	-3,2	-31,4	-31,4	-75,2
80	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
82	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
84	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
86	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
88	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
90	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
92	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
94	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
96	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
98	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
100	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
102	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
104	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
106	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
108	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
110	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
112	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
114	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
116	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
118	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
120	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
122	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
124	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
126	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
128	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
130	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
132	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
134	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
136	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
138	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
140	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
142	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
144	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
146	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
148	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2
150	0,0	0,0	0,0	-40,0	0,0	0,0	0,0	-75,2

Time (ms)	93-Vt08308tsv-NHTSA rear sill accelerometer (0,2,4... milliseconds)	m/s2	Area (2nd ms)	ΔV Accumulated Area	NHTSA NCAP FRONTAL BARRIER IMPACT TEST 56.3 km/h	93-Vt08308tsv-NHTSA rear sill accelerometer (1,3,5 milliseconds)	m/s2	Area (2nd ms)	ΔV Accumulated Area	ΔV NHTSA NCAP Vt08308tsv	RIGHT SHOULDER BELT v08308-92 [Newtons]	IIHS Frontal ODB, 40% overlap, 64.4 km/h 4010VEHC0000__ACXD	m/s2	Area (2nd ms)	ΔV Accumulated Area
	Y			AB	'=(Y5+AD5)/2	AD			AG	=(AB4+AG4)/2					
0	-0,4	-4,4	-16,8	-0,1	-0,2	0,0	-0,4	-126,9	-0,5	-0,3	-2,3	-0,1	-0,5	-13,1	0,0
2	-1,3	-12,4	-162,6	-0,6	-7,1	-12,9	-126,5	-86,9	-0,8	-0,7	-0,6	-1,3	-12,6	-42,3	-0,2
4	-15,3	-150,2	-400,0	-2,1	-5,6	4,0	39,6	-169,8	-1,4	-1,7	-0,6	-3,0	-29,7	-68,7	-0,4
6	-25,5	-249,9	-339,2	-3,3	-23,4	-21,3	-209,4	-301,1	-2,5	-2,9	-2,9	-4,0	-39,0	-77,0	-0,7
8	-9,1	-89,3	-228,6	-4,1	-9,2	-9,3	-91,7	-185,4	-3,1	-3,6	0,6	-3,9	-38,0	-74,4	-1,0
10	-14,2	-139,3	-391,2	-5,5	-11,9	-9,6	-93,7	-287,9	-4,2	-4,9	-4,6	-3,7	-36,5	-85,5	-1,3
12	-25,7	-251,9	-410,4	-7,0	-22,7	-19,8	-194,2	-491,7	-5,9	-6,5	2,9	-5,0	-49,0	-112,4	-1,7
14	-16,2	-158,6	-170,2	-7,6	-23,2	-30,3	-297,5	-587,8	-8,1	-7,8	-22,1	-6,5	-63,3	-135,9	-2,2
16	-1,2	-11,6	-285,1	-8,7	-15,4	-29,6	-290,3	-480,1	-9,8	-9,2	430,3	-7,4	-72,5	-146,3	-2,7
18	-27,9	-273,5	-569,4	-10,7	-23,6	-19,3	-189,8	-907,8	-13,1	-11,9	1052,7	-7,5	-73,8	-149,3	-3,3
20	-30,2	-295,9	-561,0	-12,7	-51,7	-73,2	-718,0	-984,2	-16,6	-14,7	1136,3	-7,7	-75,6	-151,3	-3,8
22	-27,0	-265,1	-511,3	-14,6	-27,1	-27,1	-266,3	-446,5	-18,2	-16,4	1070,1	-7,7	-75,7	-152,6	-4,4
24	-25,1	-246,3	-400,4	-16,0	-21,7	-18,4	-180,2	-455,3	-19,8	-17,9	1194,9	-7,8	-76,9	-151,2	-4,9
26	-15,7	-154,2	-190,6	-16,7	-21,9	-28,0	-275,1	-289,1	-20,9	-18,8	1787,8	-7,6	-74,3	-141,8	-5,4
28	-3,7	-36,4	-309,5	-17,8	-2,6	-1,4	-14,0	-366,4	-22,2	-20,0	2240,1	-6,9	-67,5	-127,5	-5,9
30	-27,8	-273,1	-367,6	-19,1	-31,9	-35,9	-352,4	-533,8	-24,1	-21,6	2508,9	-6,1	-60,0	-119,9	-6,3
32	-9,6	-94,5	-341,2	-20,4	-14,1	-18,5	-181,4	-312,3	-25,2	-22,8	2728,4	-6,1	-59,8	-127,6	-6,8
34	-25,1	-246,7	-418,8	-21,9	-19,2	-13,3	-130,9	-378,4	-26,6	-24,2	3066,9	-6,9	-67,8	-163,3	-7,3
36	-17,6	-172,2	-309,9	-23,0	-21,4	-25,2	-247,5	-534,6	-28,5	-25,8	3633,6	-9,7	-95,5	-254,3	-8,3
38	-14,0	-137,7	-474,9	-24,7	-21,7	-29,3	-287,1	-576,6	-30,6	-27,7	3781,1	-16,2	-158,8	-332,7	-9,5
40	-34,4	-337,2	-460,9	-26,4	-31,9	-29,5	-289,5	-643,9	-32,9	-29,6	3910,6	-17,7	-174,0	-323,8	-10,6
42	-12,6	-123,7	-362,8	-27,7	-24,4	-36,1	-354,4	-616,7	-35,1	-31,4	3943,1	-15,3	-149,8	-294,5	-11,7
44	-24,4	-239,1	-665,5	-30,1	-25,6	-26,7	-262,3	-645,5	-37,5	-33,8	3697,5	-14,7	-144,7	-313,8	-12,8
46	-43,5	-426,5	-735,6	-32,7	-41,3	-39,1	-383,2	-636,3	-39,8	-36,2	3573,8	-17,2	-169,1	-322,9	-14,0
48	-31,5	-309,1	-582,2	-34,8	-28,7	-25,8	-253,1	-627,9	-42,0	-38,4	3488,5	-15,7	-153,8	-297,1	-15,0
50	-27,8	-273,1	-473,7	-36,5	-33,0	-38,2	-374,8	-659,9	-44,4	-40,5	3482,1	-14,6	-143,2	-330,4	-16,2
52	-20,4	-200,6	-579,8	-38,6	-24,8	-29,1	-285,1	-515,3	-46,3	-42,4	3611,6	-19,1	-187,2	-409,5	-17,7
54	-38,7	-379,2	-696,3	-41,1	-31,1	-23,5	-230,2	-898,2	-49,5	-45,3	3615,0	-22,7	-222,3	-451,8	-19,3
56	-32,3	-317,1	-605,4	-43,3	-50,2	-68,1	-667,9	-796,4	-52,4	-47,8	3565,7	-23,4	-229,5	-462,9	-21,0
58	-29,4	-288,3	-661,1	-45,7	-21,2	-13,1	-128,5	-642,3	-54,7	-50,2	3521,0	-23,8	-233,5	-498,5	-22,8
60	-38,0	-372,8	-658,3	-48,0	-45,2	-52,4	-513,7	-801,2	-57,6	-52,8	3572,1	-27,0	-265,1	-567,3	-24,8
62	-29,1	-285,5	-275,9	-49,0	-29,2	-29,3	-287,5	-806,1	-60,5	-54,7	3489,6	-30,8	-302,2	-571,1	-26,9
64	1,0	9,6	-151,4	-49,6	-25,9	-52,9	-518,5	-799,6	-63,3	-56,4	3500,1	-27,4	-268,9	-507,6	-28,7
66	-16,4	-161,0	-490,5	-51,3	-22,5	-28,7	-281,1	-458,9	-65,0	-58,2	3547,7	-24,3	-238,7	-462,1	-30,4
68	-33,6	-329,5	-531,8	-53,2	-25,9	-18,1	-177,8	-358,0	-66,3	-59,8	3487,3	-22,8	-223,4	-448,0	-32,0
70	-20,6	-202,2	-323,5	-54,4	-19,5	-18,4	-180,2	-295,9	-67,3	-60,9	3399,6	-22,9	-224,6	-480,3	-33,7
72	-12,4	-121,3	-193,0	-55,1	-12,1	-11,8	-115,7	-201,0	-68,1	-61,6	3388,0	-26,1	-255,7	-515,5	-35,6
74	-7,3	-71,7	-162,6	-55,7	-8,0	-8,7	-85,3	-157,4	-68,6	-62,2	3309,0	-26,5	-259,8	-502,5	-37,4
76	-9,3	-90,9	-127,3	-56,1	-8,3	-7,3	-72,1	-137,3	-69,1	-62,6	3314,9	-24,7	-242,8	-481,4	-39,1
78	-3,7	-36,4	-80,1	-56,4	-5,2	-6,7	-65,3	-152,2	-69,7	-63,1	3311,4	-24,3	-238,6	-490,5	-40,9
80	-4,4	-43,6	-60,5	-56,7	-6,7	-8,9	-86,9	-136,9	-70,2	-63,4	3318,3	-25,7	-251,9	-523,9	-42,8
82	-1,7	-16,8	-47,3	-56,8	-3,4	-5,1	-50,1	-47,7	-70,3	-63,6	3364,8	-27,7	-272,0	-554,7	-44,8
84	-3,1	-30,4	-83,7	-57,1	-1,4	0,2	2,4	-27,6	-70,4	-63,8	3188,3	-28,8	-282,7	-566,3	-46,8
86	-5,4	-53,3	-46,4	-57,3	-4,2	-3,1	-30,0	-76,9	-70,7	-64,0	2886,3	-28,9	-283,5	-579,4	-48,9
88	0,7	6,8	-4,4	-57,3	-2,0	-4,8	-46,8	-108,9	-71,1	-64,2	2484,5	-30,2	-295,9	-603,0	-51,1
90	-1,1	-11,2	-20,4	-57,4	-3,7	-6,3	-62,1	-90,1	-71,4	-64,4	1992,7	-31,3	-307,1	-612,9	-53,3
92	-0,9	-9,2	-14,4	-57,4	-1,9	-2,9	-28,0	-48,1	-71,6	-64,5	1436,5	-31,2	-305,8	-608,7	-55,5
94	-0,5	-5,2	-46,8	-57,6	-1,3	-2,0	-20,0	-63,3	-71,8	-64,7	912,8	-30,9	-302,9	-604,1	-57,6
96	-4,2	-41,6	-31,6	-57,7	-4,3	-4,4	-43,2	-72,5	-72,1	-64,9	551,0	-30,7	-301,2	-587,3	-59,8
98	1,0	10,0	-42,8	-57,9	-1,0	-3,0	-29,2	-44,8	-72,2	-65,1	416,3	-29,2	-286,1	-539,9	-61,7
100	-5,4	-52,9	-50,5	-58,1	-3,5	-1,6	-15,6	-58,5	-72,5	-65,3	328,6	-25,9	-253,7	-469,3	-63,4
102	0,2	2,4	47,7	-57,9	-2,1	-4,4	-42,8	-66,9	-72,7	-65,3	210,8	-22,0	-215,6	-388,3	-64,8
104	4,6	45,2	46,0	-57,7	1,1	-2,4	-24,0	-38,4	-72,8	-65,3	144,6	-17,6	-172,7	-304,3	-65,9
106	0,1	0,8	-30,8	-57,8	-0,7	-1,5	-14,4	-20,8	-72,9	-65,4	108,0	-13,4	-131,7	-227,3	-66,7
108	-3,2	-31,6	-51,3	-58,0	-1,9	-0,7	-6,4	10,8	-72,9	-65,4	62,1	-9,7	-95,6	-163,2	-67,3
110	-2,0	-19,6	-18,0	-58,1	-0,1	1,8	17,2	20,0	-72,8	-65,4	41,2	-6,9	-67,6	-116,5	-67,7
112	0,2	1,6	-0,8	-58,1	0,2	0,3	2,8	-28,4	-72,9	-65,5	19,2	-5,0	-48,9	-85,5	-68,0
114	-0,2	-2,4	-27,6	-58,2	-1,7	-3,2	-31,2	-47,3	-73,1	-65,6	8,1	-3,7	-36,7	-68,2	-68,3
116	-2,6	-25,2	-32,8	-58,3	-2,1	-1,6	-16,0	-30,4	-73,2	-65,7	-5,8	-3,2	-31,5	-62,8	-68,5
118	-0,8	-7,6	6,8	-58,3	-1,1	-1,5	-14,4	-9,6	-73,2	-65,7	-20,3	-3,2	-31,2	-61,0	-68,7
120	1,5	14,4	20,8	-58,2	1,0	0,5	4,8	19,6	-73,1	-65,7	52,8	-3,0	-29,8	-55,7	-68,9
122	0,7	6,4	21,6	-58,1	1,1	1,5	14,8	20,4	-73,1	-65,6	-73,7	-2,6	-25,9	-48,7	-69,1
124	1,6	15,2	47,7	-57,9	1,1	0,6	5,6	24,0	-73,0	-65,5	27,9	-2,3	-22,8	-41,6	-69,2
126	3,3	32,4	42,4	-57,8	2,6	1,9	18,4	39,2	-72,8	-65,3	47,0	-1,9	-18,8	-34,4	-69,4
128	1,0	10,0	26,4	-57,7	1,6	2,1	20,8	28,8	-72,7	-65,2	-14,5	-1,6	-15,6	-30,8	-69,5
130	1,7	16,4	28,8	-57,6	1,2	0,8	8,0	22,0	-72,7	-65,1	38,3	-1,5	-15,2	-31,6	-69,6
132	1,3	12,4	26,0	-57,5	1,3	1,4	14,0	15,6	-72,6	-65,1	63,9	-1,7	-16,4	-31,7	-69,7
134	1,4	13,6	31,2	-57,4	0,8	0,2	1,6	14,4	-72,6	-65,0	25,0	-1,6	-15,3	-26,7	-69,8
136	1,8	17,6	30,4	-57,3	1,6	1,3	12,8	34,0	-72,4	-64,9	-20,9	-1,2	-11,4	-20,0	-69,9
138	1,3	12,8	26,4	-57,2	1,7	2,2	21,2	27,6	-72,3	-64,8	-4,6	-0,9	-8,6	-13,5	-69,9
140	1,4	13,6	35,6	-57,1	1,0	0,7	6,4	27,2	-72,2	-64,6	2,3	-0,5	-5,0	-8,1	-69,9
142	2,2	22,0	42,8	-56,9	2,2	2,1	20,8	28,8	-72,1	-64,5	-27,3	-0,3	-3,2	-4,8	-70,0
144	2,1	20,8	35,6	-56,8	1,5	0,8	8,0	6,8	-72,1	-64,4	-2,9	-0,2	-1,6	-2,3	-70,0
146	1,5	14,8	14,0	-56,7	0,7	-0,1	-1,2	9,2	-72,1	-64,4	74,9	-0,1	-0,6	-0,2	-70,0
148	-0,1	-0,8	4,0	-56,7	0,5	1,1	10,4	14,0	-72,0	-64,4	30,8	0,0	0,5	0,6	-70,0
150	0,5	4,8	0,8	-56,7	0,4	0,4	3,6	2,8	-72,0	-64,4	116,1	0,0	0,1	0,1	-70,0