aibn Accident Investigation Board Norway

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REPORT ROAD 2015/03

REPORT ON RUN-OFF-THE-ROAD ACCIDENT INVOLVING A COACH ON THE E6 ROAD BY TRONES IN NAMSSKOGAN MUNICIPALITY ON 29 JULY 2014

The Accident Investigation Board has compiled this report for the sole purpose of improving road transport safety. The object of any investigation is to identify faults or discrepancies which may endanger road transport safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for road transport safety shall be avoided.

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

Photos: AIBN

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REPORT ON ROAD TRAFFIC ACCIDENT

Date and time:	At 11:55 on 29 July 2014
Scene of the accident:	Lindmoen, north of Trones in Namsskogan municipality
Road no, main section (hp), km:	European Road No 6 (E6), hp 30, km 13,960
Type of accident:	Run-off-the-road accident
Vehicle:	Coach, VDL BOVA Futura 365 PR
Type of transport:	Passenger transport

NOTIFICATION OF THE ACCIDENT

The officer on duty at the Accident Investigation Board Norway's (AIBN) Road Department was notified of the accident a few minutes after it occurred. Based on the information that was available about the scope of the injuries/damage, four representatives of the AIBN were dispatched and they arrived at the scene of the accident at 17:31 on the same day.

SUMMARY

In the morning on Tuesday 29 July 2014, a Swiss-registered tour coach was travelling south on the E6 road from Mo i Rana. There were 16 Swiss tourists and a German driver on board. The driver also served as a guide and tour leader on the trip.

When the coach passed by Brekkvasselv, the travelling pattern changed somewhat. Witnesses have described that the coach was not moving with the same directional stability as it had previously done. After travelling for approximately 5–10 minutes with reduced directional stability, the coach veered off to the left, crossed the opposite lane and ran into the ditch on the left side of the road. The coach tipped over to the left in the roadside terrain before it hit a boulder and resumed an upright position. It came to a halt standing on its wheels in the ditch. Four passengers died in the accident, and three of them were not wearing the two-point seat belts that were installed in the coach.

The accident, in which four people died, is the eighth and most serious of the run-off-the-road accidents involving a coach that the AIBN has investigated. The driver has stated to the AIBN that he has no memory of the accident or of anything that happened during a period of about two hours prior to the accident. The investigation has focused on clarifying the sequence of events in connection with the accident, but there is nonetheless uncertainty about why the coach ran off the road. The AIBN cannot say for certain what affected the driver in this accident. In the AIBN's opinion, several factors point to fatigue, and that the driver possibly fell asleep and/or became distracted/inattentive.

The investigation of this road traffic accident has identified learning points for several of those involved (public authorities, coach manufacturers, coach companies, coach drivers and passengers) that can help to improve road safety. The AIBN believes that there are several possibilities of

improving safety by means of technical systems in vehicles, physical barriers on the road and organisational barriers that support the driver.

The AIBN has chosen not to submit any safety recommendations, but refers to the results of the investigation and points out that everyone mentioned above can use the learning points identified in this investigation to help to improve road safety.

1. FACTUAL INFORMATION

1.1 Sequence of events

In the morning on Tuesday 29 July 2014, a Swiss-registered tour coach was travelling south on the E6 road from Mo i Rana. There were 16 Swiss tourists and a German driver on board. Both the passengers and the driver had stayed overnight at a hotel in Mo i Rana, and it was day 10 of a 14-day long trip, according to the schedule drawn up by the coach company. The coach was driving south along the E6 road heading for Trondheim, a journey of about 470 km.

The group stopped by the tourist attraction Laksforsen at approximately 09:45, and continued south after a 35-minute break at 10:20.

When the coach passed Brekkvasselv at around 11:45–11:50, i.e. about 1.5 hours after leaving Laksforsen, the coach's travelling pattern changed somewhat. Several witnesses who drove behind the coach described to the police and the AIBN that the coach was not moving with the same directional stability as it had previously done (see also section 1.7.1.3). After the coach passed Lindmoen at approximately 11:55, it continued onto a stretch of road with newly laid asphalt.

Figure 1 shows the route from Mo i Rana to the place where the accident occurred.

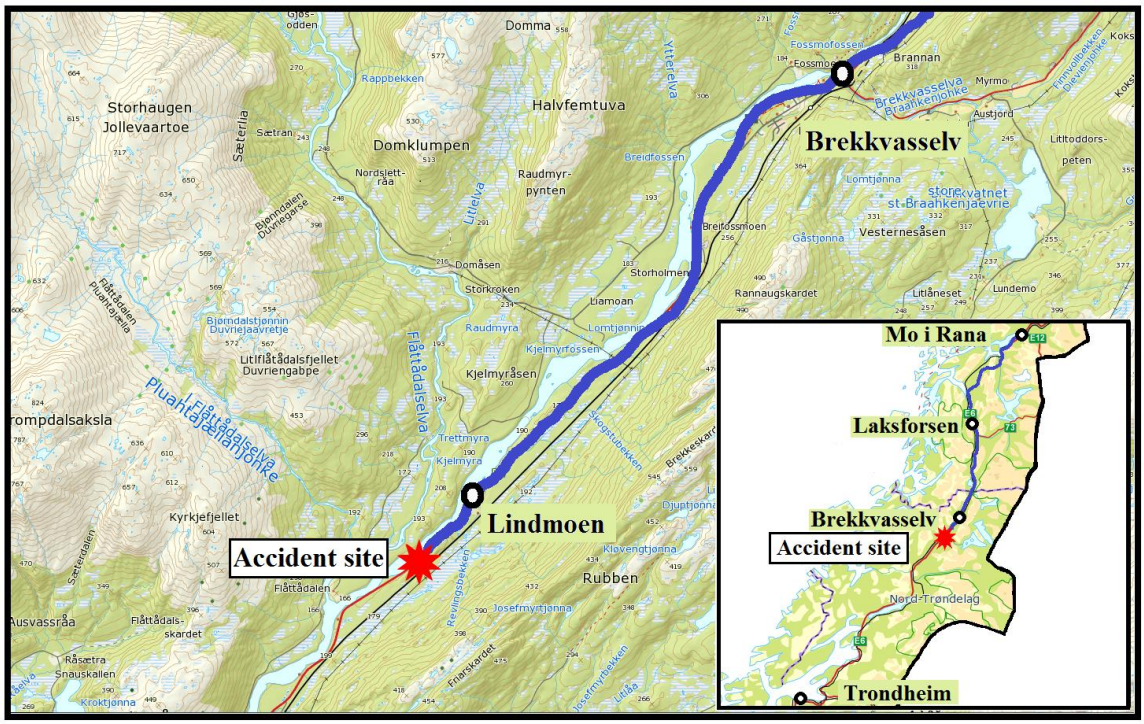

Figure 1: Map showing the route from Mo i Rana to the scene of the accident. The map also shows Trondheim, which was the destination for the day. Source: The Norwegian Mapping Authority, Geovekst and Municipality

After it had been driven for approximately 20 seconds along the stretch of road with newly laid asphalt, the coach veered off to the left, crossed the opposite lane and ran into the ditch on the left side of the road in the coach's direction of travel. The coach tipped over to the left in the roadside terrain before it hit a boulder and resumed an upright position. It came to a halt standing on its wheels in the ditch, less than 50 metres from

where it first ran off the road. The coach left tyre marks on the road shoulder and in the ditch all the way to its final position.

Figure 2 shows the coach in its final position.

Figure 2: Final position of the coach. Photo: AIBN

1.2 Injuries to persons

The accident involved a total of 17 persons (one driver and 16 passengers). Table 1 shows personal injuries resulting from the accident.

Table 1: Injuries to persons

Injuries	Driver	Passengers	Total
Dead		4	4
Serious			
Minor	1	10	11
Uninjured		2	2
Total	1	16	17

1.3 Survival aspects

1.3.1 Safety equipment on board the coach

Two-point seat belts were installed on all passenger seats. The driver's seat was equipped with a three-point seat belt.

There were information brochures on board the coach that focused on safety, which, among other things, instructed the passengers to use the seat belts. At the start of the journey in Switzerland/Germany, the passengers watched a video with information about use of the seat belts. Several passengers have also stated to the police that the driver regularly reminded them to wear seat belts, but that he had not done so when they started driving on the day of the accident.

1.3.2 Use of seat belts, survival space and injuries

Survival space was preserved for all the seats after the accident. The space around the driver's seat was slightly reduced by dented vehicle body parts.

The driver and the 12 passengers who survived the accident all wore seat belts. Only one of the four passengers who died in the accident wore a seat belt:

- Two of those who died and did not wear a seat belt were ejected from the coach. They were declared dead on arrival by medical personnel.

- One of those who died and did not wear a seat belt was thrown towards the front of the coach. The person was declared dead on arrival.

- The person who died despite wearing a two-point seat belt suffered head injuries in an impact with a window bar on the left side of the coach. The person died the following day in hospital.

Figure 3 shows which seats were occupied, use of seat belts, the degree of injury and the direction in which the accident caused the passengers to move.

There was a coffee machine next to the rear door of the coach. After the accident, it was found in the seat in front of its original position. The investigation found that the coffee machine was not adequately secured, so that it came loose during the accident.

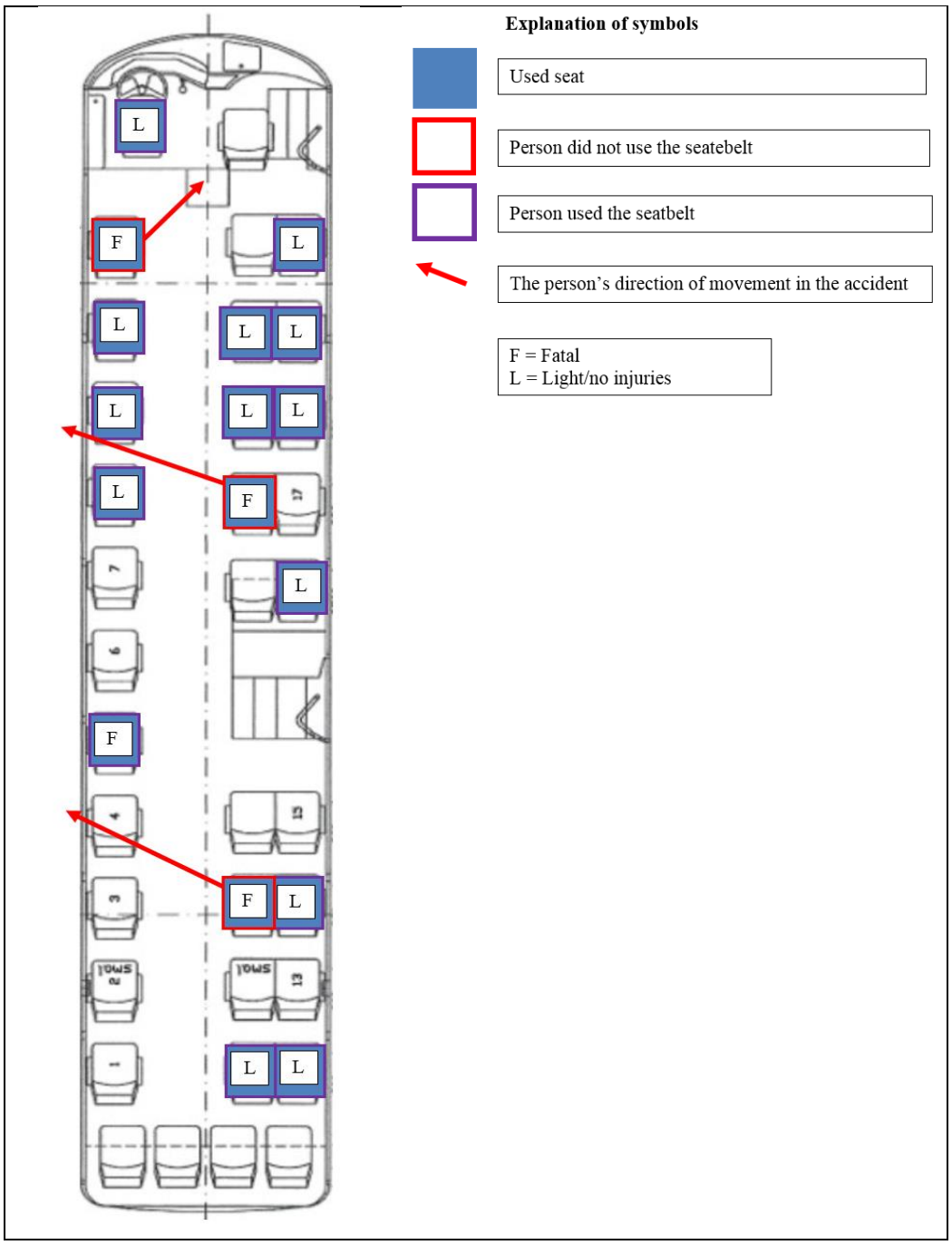

Figure 3: Overview of where people were seated in the coach, use of seat belts and, where applicable, the direction in which the accident caused them to move. The figure also shows the degree of injury, which is in accordance with Table 1. The categories 'minor injuries' and 'uninjured' have been combined into one category (L – Light/no injuries). The seats of those who died are marked with the letter F. Drawing: VDL. Illustration: AIBN

1.4 Health and rescue

1.4.1 Notification of the emergency services and arrival at the scene of the accident

The Emergency Medical Communication Centre (AMK) was notified when it received calls about the accident at 11:55. AMK issued a triple alert notification to the fire service and the police at 11:57.

The first emergency service unit on site was an ambulance that arrived at 12:15. The first fire and rescue unit arrived at 12:22. The first police patrol unit arrived at 12:35, approximately 37 minutes after the police had been notified. At 13:12 and 13:15, respectively, a SeaKing rescue helicopter and an ambulance helicopter arrived. The notification and arrival times of the different resources that contributed during the operational phase are presented in Table 2.

Table 2: Notification and arrival times of the different resources. For the police, ambulance and fire and rescue services, the time shown is the time of arrival of the first unit (vehicle).

Unit	Time of notification	Time of arrival at the scene of the accident
Ambulance	11:57	12:15
Fire and rescue service	11:57	12:22
Police	11:57	12:35
SeaKing	12:07	13:12
Ambulance helicopter	12:01	13:15

1.4.2 Rescue resources at the scene of the accident

The medical resources at the scene of the accident consisted of seven ambulances, one SeaKing rescue helicopter and one ambulance helicopter. The district medical officer on duty also arrived on the scene.

The fire and rescue resources at the scene of the accident consisted of two call-out units with a combined crew of 12. A rescue car with a crew of five from a neighbouring district was also present.

In an early phase, the police resources at the scene of the accident consisted of ten police officers and about five patrol cars. The police's operational commander arrived at the scene of the accident at approximately 13:00, and a forensic technician also participated during this phase.

A recovery vehicle for heavy vehicles was sent for, and it was waiting at the scene of the accident when the AIBN's representatives arrived.

1.4.3 On-scene assessment of injuries

Table 3 shows the result of the on-scene assessment by medical personnel of the severity of injuries sustained by patients (prioritisation).

Table 3: On-scene emergency medical assessment of the severity of injuries

Injuries	Driver	Passengers	Total
Dead		3	3
Critical		1	1
Urgent	1		1
Can wait		12	12
Total	1	16	17

1.4.4 Evacuation of injured people

The passengers who had only sustained minor injuries walked out of the coach themselves or were assisted by other road users, and subsequently also by the arriving medical personnel.

The passenger who was defined as critically injured was transferred to St. Olav's Hospital in Trondheim by the ambulance helicopter, which left the scene of the accident at 13:35.

The driver of the coach was evacuated by ambulance at 13:52 and transferred to Namsos Hospital.

Four of the 12 passengers who were defined as patients who 'can wait' (see Table 3) were evacuated from the scene of the accident by ambulance. The remaining eight were evacuated from the scene of the accident by helicopter (SeaKing) at 14:11. They were also brought to Namsos Hospital, approximately 100 kilometres by road from the scene of the accident.

1.4.5 Guidelines for time use in connection with emergency medical response

The following guidelines for time use apply to emergency medical response at the scene of an accident:

- The Prehospital Trauma Life Support (PHTLS[1]) Interdisciplinary Emergency Service Cooperation (TAS) Norwegian Air Ambulance course 2, and several different health authorities' Medical Operations Manuals (MOM) describe the ideal on-scene time as being 10 minutes for seriously injured.

- Advanced Trauma Life Support (ATLS[2]), PHTLS and trauma manuals describe the 'golden hour', meaning that that seriously injured people should be brought to a hospital with adequate expertise within one hour.

Because the time spent in connection with the rescue work exceeded that stipulated in the recommended guidelines, the AIBN requested an assessment of this by Oslo University Hospital and its traffic medicine experts. The assessment concluded that the time spent probably had no effect on the degree of severity of the injuries for the people involved in the accident.

As mentioned in the bullet points above, critically injured people shall be evacuated from the scene of the accident within a short time if possible. The AIBN has noted that the evacuation was not begun by ambulance on the grounds that air transport was heading to the scene.

[1] PHTLS is a course offered in Norway to all prehospital medical personnel, especially ambulance services. Courses for prehospital medical personnel – doctors, interns and nurses who accompany ambulances or have other emergency medical tasks at the scene of an accident, in accident and emergency units etc. http://www.norskluftambulanse.no/kursene/

[2] ATLS is a course for surgeons, orthopaedics, anaesthesiologist, general practitioners working in sparsely populated areas, radiologists and other doctors treating severely injured patients. http://www.norskluftambulanse.no/kursene/

1.5 Damage to vehicle

The coach sustained extensive damage to the front and to the left side as a result of the collision with the roadside terrain. All the windows on the left side of the coach were broken and several of the window bars were bent inwards and backwards. Rocks were found in the driver and passenger spaces. Figure 4 and 5 show the damage to the front and to the left side of the coach. In addition, the rear axle of the coach broke in the accident.

Figure 4: Damage to the front. Photo: AIBN

Figure 5: Damage along the left side of the coach. Photo: AIBN

1.6 The scene of the accident

The AIBN investigated the accident site the same day that the accident occurred. The coach had not been moved and was in its final position during the investigation. Registrations were also made at the accident site by representatives of the police and the Norwegian Public Roads Administration's (NPRA) accident team. The AIBN has gained access to this information.

The point where the coach ran off the road was at the end of a relatively straight stretch of road. At the coach's final position (E6, hp 30, approx. km 13,960), the road curved slightly to the right.

The distance from where the newly laid asphalt started (seen in the coach's direction of travel) to where the coach ran off the road was less than 400 metres.

A crash barrier had been erected on the right side of the road (in the direction of travel), where the road ran alongside a river. No marks were found on the crash barrier and no scratches were found on the coach that could stem from the crash barrier.

The asphalt surfacing at the accident site had been laid recently, and there were no edge markings or centreline at the accident site.

Figure 6 shows the accident site with the coach in its final position seen from above.

No skid marks from the coach were found on the asphalt surfacing on the final stretch of road where the coach travelled with its wheels still on the road. The coach left tyre marks in the gravel outside the edge of the asphalt on the left side of the road in the direction of

travel, which indicates that the wheels were rolling. The tyre marks did not follow the edge of the asphalt, but continued at a slight leftward angle in the direction of travel. In Figure 9, the tyre marks are marked with a red circle.

Very close to where the coach ran off the road, there was a rock cutting (see Figure 9) that the coach stayed clear of. Between the rock cutting and the final position of the coach, the roadside terrain consisted of heather, low plants and some rocks. Figure 7, 8 and 9 illustrate the condition of the roadside terrain where the coach tipped over to the side. The coach hit a large boulder that was pushed in front of the coach as it tipped over to the left. This boulder ended up in front of the coach in its final position (see Figure 7).

The AIBN measured the inclination from the road to the bottom of the ditch to be about 34°–38° behind the coach in its final position. The height from the road to the bottom of the ditch was approximately 1.2 metres.

Figure 6: Aerial view of the accident site with the coach in its final position at the centre of the photo. The white stuff along the road is gravel, not road marks. Photo: AIBN

Figure 7: The accident site with the coach in its final position. The boulder that was pushed in front of the coach is just visible in front of the coach (red arrow). Photo: AIBN

Figure 8: Road shoulder and ditch with the coach in its final position. Also shows the assumed initial location of the boulder that was pushed in front of the coach (red circle). Photo: AIBN

Figure 9: The coach in its final position and tyre marks from the rear left wheel pair in the ditch (red circle). The boulder cutting that the coach stayed clear of can also be seen on the left-hand side of the photo. Photo: AIBN

1.7 Road users

1.7.1 The coach driver

1.7.1.1 *General information*

The AIBN has carried out two interviews with the driver (at Namsos Hospital the day after the accident and over the phone in February 2015). In both interviews, the driver stated that he does not remember anything from the accident or from a period of approximately two hours before the accident. The driver also made a statement to the police, and the following description is based on information that emerged in the interviews and statements.

The driver was a German national and was 60 years old at the time of the accident. He had a driving licence in categories BE, CE, DE and ML. Categories CE (tractor-trailer vehicle combination) and DE (bus with trailer) were acquired in 1990. After this, he worked as a bus driver for 13–14 years. Then, he worked as a heavy vehicle driving instructor for seven years.

The driver had been employed by Eurobus since March 2013. He had not previously driven a bus in Norway.

The driver started the trip in Germany July 20, 2014, and drove through Sweden to Finland. In Stockholm and Helsinki there were used local guides and the driver only filled the role as bus driver. The bus trip proceeded through Finland to Honningsvaag in northern Norway, where a hired driver drove the bus and the passengers to Nordkapp and back to Honningsvaag, while the first driver rested. The first driver then drove the bus from Honningsvaag via Lofoten, ferry to Bodø and Mo i Rana where the trip started day of the accident.

1.7.1.2 *Work, sleep and rest*

The driver's work, sleep and rest periods on the day of the accident and during the week before the accident were in accordance with the requirements in the applicable regulations (see section 1.14.4). The AIBN has no detailed information about the driver's sleep pattern during the period before the accident. The driver has explained that he got up at 5:15 on the day of the accident. He has also explained that he is used to waking up at this hour and that he was well rested on the day of the accident.

Based on data from the coach's tachograph, the driver had working days of approximately 9–11 hours before the accident, including breaks. The AIBN does not know what the driver ate or drank during the break at Laksforsen. According to the schedule prepared by the coach company, the group were to eat lunch at a restaurant in Trones.

Table 4 shows the driver's activities, based on data from the tachograph, on the day before the accident and on the day of the accident.

Table 4: The driver's activities from starting up on the day before the accident and until the time of the accident on the following day.

Date	At (approx.)	Activity
28 July	07:00	Started driving/work
	10:00	Break (approx. 4 h break on the ferry was recorded)
	14:00	Driving/work
	16:30	Break (45 minutes recorded)
	17:15	Driving/work
	19:00	End of working day
29 July 2014	08:00	Started driving from Mo i Rana
	09:45	Break at Laksforsen (35 minutes)
	10:20	Driving
	11:55	Time of accident

1.7.1.3 *Driver's behaviour*

The AIBN conducted an interview with a witness who was a passenger on the coach. The witness was not asleep at the time of the accident and was seated in a position that afforded a partial view of the driver's seat. The AIBN has also collected the written documentation from the police's interviews with the passengers on the coach. In addition, the AIBN has conducted interviews with three witnesses (two of them in the same car) who were driving behind the coach before the accident.

Information from the AIBN's and the police's interviews taken together shows that, for approximately 5–10 minutes before the accident, the coach was not moving with the same directional stability as it had done previously on the same day. In connection with this, the witnesses who were driving behind the coach described that the bus did lateral movements just before the accident, but their descriptions of the movements just before the coach ran off the road differ somewhat. The following quotes are taken from these three witnesses' statements to the police and describe their experience of the coach's movements during the phase when it ran off the road:

> *To the witness, it appeared as if the coach moved as when someone is dozing off.*

The witness was puzzled by the fact that the coach headed straight across the road without pause, and that the driver did not attempt to correct its course or get it back on the road, but drove straight into the ditch.

He noticed that the coach suddenly started to lean heavily to the right. Then, the coach was steered to the left into the opposite lane and into the ditch next to the opposite lane.

One of the passengers states that the driver seemed to have a cold, because he was eating lozenges and blowing his nose several times while driving. The AIBN found a box of lozenges by the driver's seat after the accident. The driver has given information that he did not suffer from a cold.

During the trip, some of the passengers also reflected on whether the driver might be tired and/or exhausted, although he did not say anything to that effect. The AIBN's general impression is that the driver was perceived as a skilful, calm chauffeur and tour guide.

1.7.1.4 *Mobile phone use*

The AIBN has obtained information about the driver's mobile phone use. He used his mobile phone at 05:42 on the day of the accident, this was before the driving commenced at 08:00. There is no evidence to suggest that the driver used his mobile phone immediately before the accident or during driving on the day of the accident.

1.7.2 Passengers on the coach

There were a total of 16 Swiss passengers on board the coach. They were all calm and many of them were asleep just before the accident. The AIBN's investigation has not found that the passengers in any way disturbed or influenced the driver just before the accident.

1.8 Medical conditions

Various samples/tests and assessments of the driver were conducted at Namsos Hospital after the accident, both the same afternoon and the day after. Blood samples were taken at 14:43 on the day of the accident. They were processed without finding any traces of drugs or alcohol, or other medical conditions that could have contributed to the accident.

The AIBN's further investigations, with assistance from Oslo University Hospital and its traffic medicine experts, have not found anything about the driver's medical condition that can explain the accident with any certainty. This is consistent with Namsos Hospital's conclusion.

No post mortem examinations were carried out of the deceased passengers, and their exact cause of death is therefore unknown.

1.9 Vehicle

The coach was a two-axle VDL Bova, Futura 365PR 4x2, 2010 model. The coach's odometer reading at the time of the accident was 451,790 km. The most recent periodic roadworthiness test (EU inspection) prior to the accident was carried out on 29 January 2014. The coach was equipped with a stabilisation system. The bus was also equipped

with a microphone for communication with passengers. This microphone could be operated hands-free.

Figure 10 shows the driver's work station on board the coach.

Figure 10: The driver's work station on the coach. The display on the right had GPS and a rear view camera. Photo: The police

No faults or deficiencies that may have contributed to the accident were found in connection with the technical examination of the coach that was carried out by the AIBN in cooperation with the NPRA and the police.

1.10 Weather/ driving conditions

At the time of the accident, the sun was high in the sky, a light north-northeasterly breeze was blowing and the temperature was approximately 22°C. The road with newly laid asphalt was bare and dry.

1.11 Road and traffic conditions

1.11.1 General information

European Road No 6 (E6) in Norway is one of the main roads between Svinesund and Kirkenes. It is 2,630 km long and is part of the European TEN-T[3] road network.

The NPRA has stated that the annual average daily traffic (AADT[4]) was 1,340 vehicles per day on the section of road where the accident happened, and that heavy goods vehicles accounted for 26%.

[3] The trans-European transport network.
[4] The total number of vehicles passing the section in the course of a year, divided by 365.

The NPRA Central Region had not carried out a traffic safety inspection (TS inspection) on this section of the road. It has stated that one of the reasons for this is that the accident cost on this section has not been sufficiently high for it to be given priority under the guidelines issued by the NPRA Directorate of Public Roads.

According to information from the NPRA's public road map service, there have been no serious traffic accidents here.

The speed limit at the accident site was 80 km/h.

1.11.2 Road design and signage

The width of the asphalt road at the accident side was about 6.5 metres, and the asphalt was relatively newly laid.

Subbus (quarry waste)/gravel had been laid outside the asphalt edge on the left side of the road in the coach's direction of travel. It did not appear to have been compressed.

A crash barrier had been erected on the right side of the road, where the road ran alongside a river. There was a distance of approximately 30 cm between the asphalt edge and the crash barrier, and no subbus/gravel had been laid outside the asphalt edge. The height difference between the top of the newly laid asphalt and the shoulder between the roadway and the crash barrier was measured to be 13 cm.

Approximately 100 metres before the stretch of road with newly laid asphalt, a warning sign[5] had been erected, no 116 'Slippery road surface' (see Figure 11), with a sub-sign underneath (no 804) stating that the warning sign applied for 0.2–2.5 km.

Figure 11: Warning sign 116 Slippery road surface. Source: www.vegvesen.no

According to the NPRA, a levelling course of asphalt had been laid about one month before the accident occurred. A wearing course was scheduled to be laid at the accident site approximately one week after the accident occurred. Marking of the road was planned after the wearing course had been laid. There were no plans for rumble strips at the accident site.

[5] Warning signs are used when a danger/risk can be difficult to perceive in time, or when it is significantly greater than can be expected based on the traffic conditions, road design or surroundings. Most warning signs consist of a black symbol on a white background within a red triangle. Temporary warning signs used in connection with road works have a yellow background (see http://www.vegvesen.no/Trafikkinformasjon/Lover+og+regler/Trafikkskilt/Fareskilt).

1.11.3 Asphalt surfacing and friction

1.11.3.1 *Friction measurement*

Friction measurements were carried out at the accident site after the accident. A friction tester of the type RoAr5 was used, with a fixed slip of 18% and a measuring speed of 60 km/h. A series of measurements without a water film were carried out in both directions. Two series of measurements with a 0.5 mm thick water film were also carried out in both directions.

The measurements showed that the accident site had a friction coefficient (μ) on a dry surface[6] of approximately 0.8. The measurements with a water film gave a friction coefficient (μ) of approximately 0.6. The NPRA's friction requirement is μ=0.4 on wet roads.

1.11.3.2 *Core samples*

The day after the accident, the AIBN ordered drill cores to be taken from the asphalt where the accident happened. Drill cores were taken from two sections just before where the bus ran of the road, with approximately 30 meters in-between.

Four 15 cm and two 10 cm cores were taken per section/point (above), amounting to a total of 12 cores. Four 15 cm and four 10 cm cores were sent to Veiteknisk Institutt[7] in Høvik. The remaining cores (4 x 15 cm) were stored for possible subsequent analysis.

Veiteknisk Institutt carried out analyses of bonding agent content, grain size, density measurements and a visual assessment of the core samples. The samples were in accordance with the requirements set for asphalt surfacing.

1.11.3.3 *Texture (nature of the surface)*

Friction is also affected by the micro and macro texture of the surface. The AIBN therefore took samples of the asphalt surfacing's texture on the day of the accident. Samples were taken in a cross-section of the road where the tyre marks in the gravel started on the left shoulder (see Figure 9). The texture was found to be functional and visually homogeneous as newly laid asphalt shall be according to the NPRA's (2014) handbook no N200 (see 1.14.1.2).

1.12 Technical registration systems

The AIBN has retrieved speed data from the coach's digital tachograph.

There may be some uncertainty attached to the speed information stored on the tachograph. According to the company Fartsskriver AS, such speed records normally have an uncertainty margin of +\- 6 km/h.

The data retrieved show that the coach kept a speed of between 82 km/h and 84 km/h during the final five seconds before the accident. The speed varied during the final 25

[6] The friction coefficient μ is defined as the ratio between the force of friction and the normal force applied by a vehicle. $\mu=Ft/Fn$, where Ft is the tangential force at contact and Fn is the normal applied force.
[7] Veiteknisk Institutt is a competence centre for R&D, quality control and documentation of asphalt. See http://www.asfaltteknisk.no/Om_ATI/198.

seconds before the point at which the accident occurred, which indicates that cruise control was not used during this period.

Calculations of the coach's acceleration/retardation based on data and recordings taken every 0.25 seconds indicate that the brakes were not used in the final five seconds before the coach ran off the road.

1.13 Tests and research

1.13.1 Simulation of accident

The AIBN has used the engineering firm Ingeniørfirmaet Rekon DA to carry out analyses and simulations using the computer program Scan-crash. In the simulation, the angle of the tyre marks on the shoulder (gravel) was used to indicate the coach's movements before it ran off the road. Because no skid marks from the coach were found on the asphalt from when the whole coach was still on the road, some uncertainty is attached to the results of the simulations. The following conclusions related to the sequence of events can be drawn from Ingeniørfirmaet Rekon DA's report:

- The tachograph records show that the coach's brakes were not engaged during the final five seconds before it ran off the road.

- It can be excluded that the driver made a sudden manoeuvre to the left prior to the accident.

1.14 Relevant rules and regulations

1.14.1 Road requirements

1.14.1.1 *Laws and regulations*

The Act of 21 June 1963 No 23 relating to roads (the Road Act) with subsequent amendments provides legal authority for regulations, guidelines and standards for the construction of public roads.

The Regulations of 28 October 2011 on safety management of the road infrastructure (the Road Safety Regulations) define requirements for safety management of the road network, including for road safety impact assessments, road safety audits, safety ranking of the road network and safety inspections.

The regulations apply to roads in the trans-European road network in Norway (the TEN-T road network), whether they are in the planning phase, the design phase, under construction or in use.

1.14.1.2 *Road standards*

Legal authority for road standards is found in Section 3(2) of the Regulations of 29 March 2007 No 363 on the construction of public roads. The standards are requirements documents. Guidelines are provided as auxiliary documents supporting the standards. They contain detailed technical material over and above what is included in the standards.

The NPRA's (2014) handbook no N200 Road Construction states the following about the texture and homogeneity of newly laid asphalt:

The asphalt surfacing shall be functionally and visually homogeneous to prevent differences in, for example, friction or resistance. The finished surfacing shall be free of cracks, holes, open or greasy patches.

1.14.2 Requirements relating to vehicles, and the approval and use of vehicles

The Regulations of 4 October 1994 No 918 relating to technical requirements for and approval of vehicles, parts and equipment (the Motor Vehicle Regulations) define technical requirements for motor vehicles and trailers in Norway. The regulations were replaced by the Regulations of 5 July 2012 No 817 relating to approval of vehicles and vehicle trailers (the Approval Regulations), and the new regulations contain requirements for, among other things, a lane departure warning system[8] for coaches in category M3. EU Regulation 661/2009 sets requirements for lane departure warning system for new types of buses (buses with new type approval number) from 1 November 2013. From 1 November 2015 is type approvals without lane departure warning system no longer valid for registration of new buses. The lane departure warning system shall alert the driver of a vehicle if the vehicle is about to depart from the lane unintentionally. The purpose is to prevent traffic accidents. The requirement is based on optical detection of edge markings and is assumed to be a contribution to the improvement of road safety in Norway.

The coach in question was approved according to Swiss regulations. The AIBN is aware that requirement for lane departure warning system in these kind of buses are now implemented in Switzerland. The involved bus was however an older model that did not have such a system.

The Regulations of 25 January 1990 No 92 relating to the use of vehicles apply to both foreign and Norwegian motor vehicles used in Norway.

1.14.3 Requirements of the driver

The Act of 18 June 1965 No 4 relating to road traffic (the Road Traffic Act) and the Regulations of 21 March 1986 No 747 relating to vehicular and pedestrian traffic (the Traffic Rules) contain guidelines for all motor vehicle traffic on Norwegian roads. Among other things, they contain requirements for speed and the driver's attentiveness.

1.14.4 Requirements relating to work, driving and rest periods

The applicable driving and rest provisions (the Regulations of 2 July 2007 No 877 relating to driving and rest periods for road transport in the EEA (the Regulations relating to Driving and Rest Periods in the EEA)) contain detailed rules about work time regulation, recording systems and sanctions for violation of the rules.

The Regulations of 10 June 2005 No 543 relating to working hours for drivers and others in the road transport sector (Regulations on Working Hours in the Road Transport Sector) have been adopted pursuant to Section 21 of the Road Traffic Act and Section 10-12 of the Working Environment Act.

[8]. https://www.regjeringen.no/nb/sub/eos-notatbasen/notatene/2012/mai/kjorefeltvarsler-lane-departure-warning/id686844/

1.15 Authorities, organisations and leadership

1.15.1 The Norwegian Public Roads Administration (NPRA)

The NPRA is an administrative agency that reports to the Ministry of Transport and Communications. The agency is organised with two administrative levels: the Directorate of Public Roads and five regional offices. The NPRA is the administration of roads classified as national roads, and manages the county road network for the county administration. The agency is responsible for planning, construction, operation and maintenance of the national road and county road networks, and for approval and supervisory activities relating to vehicles and motorists/road users. The NPRA also prepares rules and guidelines for road design, operation and maintenance, road traffic, road user training and vehicles.

1.15.2 Eurobus[9]

Eurobus is a Swiss coach company that offers various types of coach transport throughout Europe. The coach company's drivers are trained internally and are required to undergo a medical check.

According to the information received by the AIBN, the whole trip was planned in detail and day by day as regards route, breaks, meals and accommodation.

Eurobus has arranged and conducted the same journey over 100 times before. Based on these previous voyages, the travel program has been continuously revised and adjusted. The company also conducts several health promoting measures. Among other activities mandatory training for drivers with a focus on nutrition and exercise are organized.

Eurobus have a hotline service that the drivers can contact when needed if they have questions or problems with the bus, guests, hotels or other.

1.16 Previous AIBN reports

1.16.1 Roadside terrain

The AIBN has previously issued reports and safety recommendations concerning, among other things, unforgiving roadside terrain.

The following safety recommendation was issued in the report Road 2010/01 (SHT 2010b), concerning a coach that ran off the RV 72 road at Garnes in Verdal on 24 November 2007:

> *Safety recommendation ROAD No 2010/03T*
>
> *In this accident, and in the accident discussed in Report Road 2009/03, vehicles ran into boulders in the roadside terrain. The accidents show that an unfavourable roadside terrain has an adverse impact on the scope of injuries/damage once the accident occurs and the vehicle runs off the roadway. The AIBN recommends that the NPRA introduce procedures for improving the roadside terrain at safety-critical and accident-prone points of the road network.*

[9] http://www.eurobus.ch/ueber-uns/busreisen-vom-spezialisten/

1.16.2 Use of seat belts

During the period 2005–2014, the AIBN investigated several coach accidents in which the failure to use or incorrect use of seat belts has been a contributory cause of the scope of injuries/damage. These have been summed up in the report Road 2014/05 (SHT 2014a), which concerns a run-off-the-road coach accident on the RV 4 road in Oslo in which two people died.

1.16.3 Rescue operations

In connection with a head-on collision on the E16 road in Flåm, Report Road 2010/04 (SHT 2010a), the AIBN discussed and analysed the time spent on rescue work at the scene of the accident.

Report Road 2010/01 (SHT 2010b) discusses the medical check after an accident.

1.17 Implemented measures

1.17.1 The coach manufacturer

Shortly after the accident, the AIBN forwarded information to the coach manufacturer concerning the coffee machine that had become dislodged from its position in the driver and passenger space in the coach. The manufacturer has subsequently conducted an internal investigation. The investigation showed that the coffee machine had neither been installed by the coach manufacturer nor by the customer, but by the supplier in Switzerland. The coach manufacturer has contacted its dealer in Switzerland and ensured that corrective action is being taken to prevent the recurrence of similar incidents.

1.17.2 The Norwegian Public Roads Administration (NPRA)

The NPRA conducted a traffic safety (TS) inspection and UG (accident group in NPRA) inspection of the accident site 31 July 2014. The boulder that the bus hit was still lying in the ditch but was removed immediately.

2. ANALYSIS

2.1 Introduction

The accident, in which four people died, is the eighth and most serious of the run-off-the-road accidents involving a coach that the AIBN has investigated. Furthermore, this is a very serious accident involving a foreign-registered coach on the Norwegian road network, which means that the investigation may also be of interest internationally. That was why the AIBN decided to investigate the accident.

The investigation has focused on clarifying the sequence of events in connection with the accident, but there is nonetheless uncertainty about why the coach ran off the road. The AIBN will consider the findings that can help explain the sequence of events in section 2.2. The most probable driver-related factors that may have contributed to the coach running off the road are discussed in section 2.3, while the road design and the asphalt surfacing are considered in section 2.4.

We then go on to discuss the factors that contributed to the scope of injuries/damage. In section 2.5, we discuss the importance of the roadside terrain.

In several of the coach accidents investigated by the AIBN, the failure to use seat belts stands out as a prominent factor. The present accident is yet another example of the critical role that the use of seat belts plays in reducing the scope of injuries and saving lives. This is discussed in section 2.6.

The injured passengers stayed at the scene of the accident for a relatively long time. The on-scene time for several of the emergency medical service units was longer than the prescribed ideal time in various guidelines. This is discussed in section 2.7, though the AIBN has no information to indicate that the long on-scene time had any adverse impact on the injuries that were sustained.

Section 2.8 addresses framework conditions and various safety barriers relating to coach transport. The AIBN believes that there are several possibilities of improving safety by means of technical systems in vehicles, physical barriers on the road and organisational barriers that support the driver.

2.2 Assessment of the sequence of events

The AIBN’s explanation of the sequence of events in connection with the accident is based on tyre marks from the coach on the road shoulder and in the ditch, data from the coach’s tachograph and witness statements from passengers on the coach and from motorists who drove behind the coach.

Witness observations indicate that, for a period of time before the accident occurred, the coach displayed a lack of directional stability. It is difficult to determine the exact length of this period, however, though it probably lasted some five to ten minutes before the accident occurred. Since the coach has been found to be free of technical faults, the AIBN considers that the directional instability of the coach during this period is best explained by driver-related factors. These factors may be related to the driver’s state of health, level of fatigue and possibly falling asleep and/or becoming distracted/inattentive. This is discussed in more detail in section 2.3.

After travelling for about 20 seconds on a relatively straight stretch of road on which new asphalt had recently been laid, the coach ran off the left side of the road after crossing the opposite lane. This finding alone might suggests that, when the coach ran off the road, it had something to do with the newly laid asphalt. The results of the analysis of the condition of the asphalt and the reduced directional stability of the coach even before it reached the newly asphalted stretch of road, indicates however that the condition of the road did not play such an important role in causing the coach to run off. This is discussed in more detail in section 2.4.

Data from the tachometer show that the coach was travelling at a speed of just under 70 km/h through the curve at the start of the newly asphalted stretch. The speed then increased to just over the speed limit of 80 km/h. This finding indicates that the coach driver was aware of the road's speed limit and adjusted the speed accordingly as well as to the local infrastructure.

Ingeniørfirmaet Rekon DA simulated the accident based on tyre marks and measurements at the accident site. The results suggest that the driver is unlikely to have made any clear, active manoeuvre towards the left immediately before running off the road.

The angle and direction of the tyre marks in the gravel give no indication that the driver tried to avoid the situation during the phase when the coach left the asphalted part of the road. The tyre marks and tachometer data also indicate that the brakes were not engaged before the coach left the edge of the asphalt. In the AIBN's opinion, this suggests that the driver may not have been fully conscious and/or focused on the driving when the coach ran off the roadway.

2.3 Possible driver-related factors

The AIBN has spent a great deal of resources on trying to find out what happened in the driver's seat and outside the coach just before and while the coach was running off the road. The information was obtained at the accident site, from the examination of the coach and from witnesses. The AIBN has also commissioned a simulation of the accident and involved traffic medicine experts from Oslo University Hospital. Furthermore, the AIBN has reviewed research material to find possible explanations of driver-related factors that may have contributed to the sequence of events described in section 2.2.

2.3.1 Health/illness

The investigation did not find any factors relating to the driver's medical condition that can explain the accident with any certainty. Nonetheless, medical factors cannot be completely ruled out.

2.3.2 Fatigue

The AIBN has not succeeded in its attempt to determine the driver's sleep pattern prior to the accident. The information available to the AIBN indicates, however, that the driver had been awake since 05:15 on the day of the accident. The accident occurred at 11:55, after about 6.5 hours of being awake and about 1.5 hours after a 35-minute break.

The section of road before reaching the point where the accident occurred can be described as relatively monotonous. Several passengers stated that they felt tired on the trip and some of them had fallen asleep when the accident occurred. It is therefore natural

to raise the question of whether the driver may have been tired and fallen asleep. Analyzed facts in the investigation can neither rule out nor confirm this.

Jackson et al. (2011) have demonstrated that there is a correlation between too little sleep, even for one night, and a reduced ability to drive. Drivers are also not always aware of momentary micro-naps and lapses, and healthy drivers who have not had enough sleep often find it difficult to predict when they are likely to fall asleep (Herrmann et al. 2010). Food and liquid intake can also have an effect on drowsiness. The investigation has been unable to obtain details about the driver's food and liquid intake during the trip.

Moreover, as a group, drivers are not very good at assessing how sleepy they are (Garbarino et al. 2014), and they are often not aware of the typical signs of sleepiness. Such signs may be: rapid blinking, blinks of more than the normal duration, head nodding, difficulties keeping one's eyes open and in focus, impaired memory and daydreaming. Wider lateral movements in one's own traffic lane and running off the road are likewise described as signs of fatigue. Both lateral movements and running off the road are important elements of this accident. This research in the context of the events shows that fatigue may be an explanation, but the investigation has not demonstrated this surely.

2.3.3 Distraction and/or inattentiveness

In addition to fatigue/falling asleep, the sequence of events can be explained by distraction and/or inattentiveness. This is also uncertain. The investigation has shown that the coach displayed reduced directional stability for a period of time prior to the accident.

Stutts et al. (2005) refer to the existence of a correlation between distraction and drifting from one side of the lane to the other or into the opposite lane. According to Garbarino et al. (2014), inattentiveness is identified as one of the most frequently occurring single cause of road traffic accidents. A not uncommon distraction is eating and drinking (including preparations for eating and drinking). Some lozenges were found by the driver's seat when the coach was examined after the accident, though this cannot be identified as a certain cause of the driver's possible inattentiveness.

The AIBN has also assessed the driver's work station in the coach with a view to possible distractions. The dashboard had a GPS display. In the AIBN's opinion, the route to Trones (planned lunch stop) was easy and not very complex, and there are no information that indicates that the attention of the driver was focused on the display in this connection.

Nor has it emerged that the driver communicated with passengers in the period just before the accident, and AIBN therefore considers this potential distraction factor absent.

The AIBN has also investigated the driver's mobile phone use. It has been documented that, on the day of the accident and immediately prior to the accident, the driver's mobile phone was not in use while the coach was in motion.

2.3.4 Summary of possible driver-related factors

The AIBN's analysis in this connection is based on three observed driving episodes. Lack of directional stability in the coach's own lane, veering into the opposite lane and running

off the road. Movements of this nature are generally characteristic of driving behaviour influenced by distraction, inattentiveness and fatigue.

The investigation has not identified what factors can be said with certainty to have affected the driver in connection with this accident, but the investigation in connection with the mentioned research at this field, shows that driver fatigue and possibly falling asleep, and/or distraction/inattentiveness possibly can explain the accident.

2.4 Road design and asphalt surfacing

The accident occurred after the coach had been driven for approximately 20 seconds along a newly asphalted stretch of road without road markings. The AIBN initiated several investigations with a view to determining the condition of the asphalt surfacing and roadway surface in order to identify possible deviations from the condition that one would expect (see section 1.11.3). The core samples of the newly laid asphalt showed that its composition met the given requirements for asphalt surfacing. The friction was also good; it more than fulfilled the NPRA's standard requirements. The AIBN also took its own texture samples, which were found to be in accordance with the NPRA's requirements for texture and homogeneity. Based on records and observations at the accident site, core samples and texture samples, the AIBN has found that the condition of the asphalt was in accordance with applicable requirements and had the characteristics that can be expected of newly laid asphalt.

The shoulder on the right side of the road in the coach's direction of travel had not been filled up with gravel, but a crash barrier had been erected where the road ran alongside the river. The AIBN sees an elevated asphalt edge as a potential element of risk for all types of vehicles. However, there were no marks in the roadway, on the road shoulder or on the crash barrier to indicate that the coach had run off the asphalt edge on the right side of the road, and then turned sharply back and veered off to the opposite side. This is also supported by the fact that no scratch marks were found on the right side of the coach from the crash barrier on the right side of the road.

The coach displayed reduced directional stability even before it entered the newly asphalted stretch of road, and there is nothing to indicate that the coach skidded or came outside the asphalt edge on the right side of the road. Roadway friction was also good. Based on the above, the AIBN considers the design and condition of the road to have been clearly visible and predictable, and that they contributed very little to the coach running off the road.

2.5 The roadside terrain and scope of injuries/damage

The coach sustained extensive damage to the front and to the left side as a result of the collision with the roadside terrain. In the AIBN's opinion, the roadside terrain had an impact on the scope of the injuries/damage, and the accident has demonstrated the importance of having what is known as forgiving roadside terrain. In this context, this means a roadside terrain designed to give a more even retardation and minimise damage to the vehicle body in the event of a run-off-the-road accident. In this connection, it is particularly important to take into account that coaches hit the roadside terrain higher up in the cutting when running off the road or overturning. The passengers are seated higher up and can therefore come very close to protruding elements in the roadside terrain.

The AIBN believes that, in the present accident, the roadside terrain with its relatively deep ditch was one reason why the coach was unable to stay on its wheels and tipped over towards the left in the roadside terrain, before it hit a relatively large boulder and resumed an upright position. Two of the people who died were ejected from the coach as it tipped. Several of the coach's window bars were bent inwards and backwards in the collision with the terrain, and rocks came into the passenger space. One passenger, who was secured with a two-point seat belt, sustained serious head injuries from the impact of the window bars. Based on the above, the AIBN is of the opinion that a more favourably designed ditch, and a more even and forgiving roadside terrain, could have helped the coach to stay upright and reduced the scope of the injuries/damage.

Because of low accident figures for this stretch of road, it was not prioritised for TS inspection by the NPRA before the accident happened. However, the TS inspection 31 July 2014 after the accident led to the immediate removal of the boulder that the bus hit.

Based on the present and previous investigations in which the roadside terrain has been demonstrated to increase the scope of injuries/damage, the AIBN would like to emphasise the importance of giving priority to improving the roadside terrain as an important measure in relation to the zero accident philosophy.

2.6 Use of seat belts and the scope of injuries/damage

In the AIBN's investigations of accidents during the period 2005–2014, it is repeatedly demonstrated that there is a correlation between the failure to use seat belts and the scope of injuries. This accident is yet another example of how bus passengers' use of seat belts is essential to survival should an accident occur.

The driver and 13 passengers wore seat belts. This means that 82% of the people in the coach wore seat belts when the accident occurred. The AIBN considers this percentage to be high compared with known average figures for the use of seat belts in coaches. The AIBN believes that the high percentage who wore seat belts may have to do with the fact that the coach company had procedures in place whereby the driver reminded the passengers to wear seat belts.

Despite the driver's efforts to remind the passengers to wear seat belts, there were three people who did not wear seat belts. They died in the accident. Two of them were ejected from the coach, and one was thrown towards the front of the coach. In the AIBN's opinion, all three would probably have remained in their seats had they worn the installed two-point seat belts at the time of the accident. This would probably have prevented fatal injuries.

The fourth passenger who died was wearing the installed two-point seat belt. However, the passenger died as a consequence of suffering head injuries from the impact of a window bar on the left side of the coach. The AIBN believes that this person's injuries would probably have been less severe if a three-point seat belt had been worn with a chest strap across the person's left shoulder. While a two-point seat belt is primarily intended to retain people in their seats, a three-point seat belt would have been able to keep the upper body in place in the seat.

As a consequence of AIBN Report Road 2010/04 (2010a), both the NPRA and NHO Transport (the Confederation of Norwegian Enterprise's transport section) have initiated information campaigns promoting and raising people's awareness about the use of safety

belts in coaches. Nonetheless, the AIBN does not consider it likely that public awareness campaigns[10] alone will be sufficient to increase the use of seat belts to the desired level. Based on the present and previous investigations, the AIBN is of the opinion that technical alerting systems for passenger seats, combined with reminders issued by the driver, could contribute significantly to getting more coach passengers to wear seat belts.

2.7 On-scene time

Various guidelines on emergency medical response (see section 1.4.5) describe the ideal time use for on-scene emergency medical response (on-scene time) as being ten minutes, and the 'golden hour' from the incident until surgical treatment is administered is considered as very important. The on-scene time for several of the emergency medical service units was longer than prescribed time in various guidelines.

The on-scene time for the patients in this accident was 1 hour and 40 minutes for those who were critically injured, 2 hours for the coach driver who, at the scene of the accident, was defined as in need of 'urgent' attention, and more than 2 hours for the remaining passengers. This deviates a bit from to the 'golden hour' and what is described as the ideal time on scene. The time use had to do with the distance to hospital and that the response was slightly delayed (by less than 20 minutes) as a consequence of a concurrency conflict.

Nevertheless, the AIBN has no information to suggest that the scope of the injuries suffered by those involved in the accident was adversely affected by the time use in connection with the on-scene response effort. Medical assessments have shown that the head injuries sustained by the patient who was critically injured were so severe that there was little chance of survival.

The AIBN would still like to stress the importance of correct on-scene prioritisation of those who are injured and of seeking to minimise the on-scene time, including for patients with light injuries. Similar factors has previously been commented on by the AIBN in Report Road 2010/04 (SHT 2010a) and in Report Road 2010/01 (SHT 2010b).

2.8 Framework conditions and barriers for coach transport

Regardless of why the coach ran off the road, the investigation found that neither the vehicle nor the road had any barriers[11] in place that could have helped or alerted the driver, or helped to stop the coach before it ran off the road. The AIBN would also like to point out that good framework conditions and organisational barriers are important in order to maintain a good level of safety on long coach journeys.

2.8.1 Technical barriers in the coach

The coach was not equipped with intelligent driver support systems that could intervene or issue alerts and prevent the coach from leaving the traffic lane and roadway. Newer coaches (from 2013) are required to have lane departure warning system (see section 1.14.2). If the road had been marked the AIBN's opinion is that such an aid could

[10] Quote from AIBN (2012) Report Road 2012/01 p. 20: The average effect on seat belt use of seat belt campaigns is 25% (+18; +31).

[11] Technical, operational or organisational measures that separately or together could have prevented or stopped the sequence of events in question, or limited the consequences of the accident.

potentially have contributed to preventing this accident, given that the driver had been able to gain control of the vehicle soon enough. Early marking of newly asphalted stretches of road is therefore also important for the active safety systems in vehicles to work.

Previously, in AIBN Report Road 2014/01 (2014b) on an express bus that ran off the E6 road at Dombås, the AIBN has discussed systems that are capable of recognising signs of fatigue and of alerting or correcting the driver. The systems are increasingly used in private cars and heavy vehicles. In the AIBN's opinion, there is a need to campaign for the use of such preventive systems in coaches, particularly those travelling over long distances. According to the import agent for the coach involved in the accident, such additional equipment was not available for coaches manufactured in the year in question.

2.8.2 Physical barriers on the road

The road was without barriers that could potentially have helped to stop the coach on its way as it veered into the opposite lane and left the road. Road design (road width), traffic volume and accident statistics for this particular stretch of road do not warrant the erection of a median crash barrier. Nor have there been any plans to install rumble strips. Such strips would have been able to alert the driver to the fact that the vehicle was about to depart from its lane. Rumble strips have proved to be an effective means of preventing run-off-the-road accidents (Høye et al. 2012:303).

According to the NPRA, run-off-the-road and head-on collisions represent 70% of all fatal accidents on Norwegian roads. The stretch where the accident occurred is part of the TEN-T road network and, as such, it comes under the scope of the Road Safety Regulations. In the AIBN's opinion, the NPRA should, in its follow-up of the safety of the TEN-T network, give high priority to the establishment of barriers that can prevent vehicles from leaving their traffic lane and/or reduce the consequences of vehicles running off the road.

2.8.3 Organisational barriers

The driver's work, driving and rest periods were in accordance with regulatory requirements. The trip had been planned by the coach company so that the driver would be replaced by a hired driver on the trip from Honningsvåg to Nordkapp and back. A detailed day-by-day plan had also been drawn up of the route, which included breaks, meals and accommodation. This is an indication that the driver worked under predictable framework conditions and with support functions available.

At the same time, the driver acted as chauffeur, guide and tour leader on the trip. The AIBN considers that these may have been demanding functions to fill for a driver who was unfamiliar with Norway. On that basis and having regard to the fact that the driver had been on a working trip for two weeks with relatively long working days, the AIBN cannot exclude the possibility that he may have been slightly affected by tiredness and fatigue. In turn, this may have contributed to reducing the driver's ability to function at the time of the accident, as mentioned in section 2.3.

In the AIBN's opinion, coach companies should look into the possibility of establishing more organisational barriers in order to support the drivers and contribute to reducing the number of fatigue-related accidents. In order to ensure safety in connection with long coach journeys, the coach companies can a) raise the drivers' awareness of possible signs

of fatigue,[12] b) draw up trip plans that give the drivers a real possibility to take breaks regardless of the defined time schedule if they experience signs of tiredness or fatigue, and c) arrange the working conditions so that the drivers can be relieved if they feel unfit to continue the journey (for example, two drivers who share the driving or the possibility of calling in a stand-in).

3. CONCLUSION

3.1 Sequence of events

a) The coach displayed a lack of directional stability in its own lane for between some five and ten minutes before the accident occurred.

b) After travelling for approximately 20 seconds along a relatively straight, newly asphalted stretch of road, the coach veered into the opposite lane and ran into the ditch on the left side of the road.

c) The coach tipped over to the left in the roadside terrain before it hit a boulder and resumed an upright position, coming to a halt after approximately 50 metres.

3.2 Operational and technical factors

d) The condition of the asphalt was in accordance with applicable requirements, and the surface friction was good.

e) The speed of the coach was adapted to the local infrastructure and the speed limit of 80 km/h.

f) There is nothing to indicate that the coach skidded or moved outside the asphalt edge on the right side of the road before it veered to the left.

g) It is unlikely that the driver made any active manoeuvre to the left immediately prior to the accident.

h) Seen together, the tyre marks and tachometer data suggest that the driver was not fully conscious and/or focused on the driving when the accident occurred.

3.3 Survival aspects

a) The accident is yet another example of the critical role that the use of seat belts plays in saving lives. The driver and 13 passengers wore seat belts.

b) The three passengers who did not wear their seat belts were ejected from their seats and died instantly. Had they used the two-point seat belts in the coach, they would probably have been retained in their seats and their injuries would most likely not have been fatal.

[12] Section 2.3.2 contains references to research showing that drivers are often not aware of signs of fatigue.

c) The fourth passenger who died, who was wearing a two-point seat belt, would probably have been less severely injured had a three-point seat belt with a chest strap across the left shoulder been installed in the coach.

d) Time use in connection with the on-scene response effort probably had no effect on the injuries sustained as a consequence of the accident.

e) The roadside terrain had an impact on the scope of the injuries/damage. A more favourably designed ditch, and a more even and forgiving roadside terrain, could have helped the coach to stay upright and further reduced the scope of the injuries/damage despite the failure to use seat belts.

3.4 Contributory causes

a) The AIBN cannot identify with any certainty the exact factors that affected the driver in this accident, but it is of the opinion that several factors point to fatigue and that the driver possibly fell asleep and/or was distracted/inattentive.

b) The relatively high percentage who wore seat belts (82%) may have to do with the fact that the coach company had procedures in place whereby the driver reminded the passengers to wear seat belts.

c) The driver functioned as chauffeur, guide and tour leader, and he had been on a working trip for two weeks of relatively long working days. The AIBN cannot exclude that the driver may have been slightly affected by tiredness and fatigue, and that this, in turn, may have affected the driver's ability to function at the time of the accident.

3.5 Other investigation results

a) The investigation did not find any factors relating to the driver's medical condition that can explain the accident with any certainty, though medical factors cannot be completely excluded.

b) The road was without barriers that could potentially have helped to stop the coach on its way as it veered into the opposite lane and left the road.

c) The coach was not equipped with intelligent driver support systems, such as lane departure warning system based on optical detection of road edge markings that could intervene or issue alerts and prevent the coach from leaving the traffic lane and roadway.

d) Optical detection of edge markings is conditional on the road being marked.

e) Technical alerting systems for passenger seats, combined with reminders issued by the driver, can contribute significantly to getting more coach passengers to wear seat belts.

f) The design and condition of the road was clearly visible and predictable and contributed very little to the coach running off the road.

g) Improving the roadside terrain stands out as an important measure in relation to the zero accident philosophy.

h) The driver worked under predictable framework conditions, and the driver's work, driving and rest periods were in accordance with regulatory requirements.

i) Coach companies should look into the possibility of establishing more organisational barriers in order to support the drivers and contribute to reducing the number of fatigue-related accidents.

4. SAFETY RECOMMENDATIONS

The investigation of this road traffic accident has identified learning points for several of those involved (public authorities, coach manufacturers, coach companies, coach drivers and passengers) that can help to improve road safety. The AIBN believes that there are several possibilities of improving safety by means of technical driver support systems in vehicles, physical barriers on the road and organisational barriers that support the driver.

The AIBN has chosen not to submit any safety recommendations, but refers to the results of the investigation and points out that everyone mentioned above can use the learning points identified in this investigation to help to improve road safety.

Accident Investigation Board Norway

Lillestrøm, 28 July 2015

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