Accident
Investigation Board
Norway

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REPORT ON RAILWAY ACCIDENT WITH FREIGHT CAR SET THAT ROLLED UNCONTROLLEDLY FROM ALNABRU TO SYDHAVNA ON 24 MARCH 2010

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

Photos: AIBN and Ruter As

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REPORT ON RAILWAY ACCIDENT

Train number:	Freight car set for trains 5806–5807
Train data:	Weight 435.5 tonnes Length 458.4 metres
Rolling stock involved:	Special freight cars for containers, semi-trailers and swap bodies
Registration:	Norwegian
Owner:	CargoNet AS
User:	CargoNet AS
Crew:	None
Passengers:	None
Accident site:	Port of Oslo, Sydhavna
Time of accident:	Wednesday, 24 March, at approximately 13:13:15

NOTIFICATION OF THE ACCIDENT

The Accident Investigation Board Norway (AIBN) was notified of the accident by the Norwegian National Rail Administration (NNRA) at 13.15 and by CargoNet AS some time afterwards. Three members of the AIBN travelled to Sydhavna. Later that day another three people were sent for, to assist with the preliminary investigation, which continued at Alnabru throughout that afternoon. Loenga and Alnabru yards were closed after the accident. All the relevant communications logs and signal logs were secured. The technical investigations were undertaken jointly by the police and the NNRA. An additional three people joined the AIBN's investigating group on the following day.

The parties concerned were informed by letter of 29 March 2010 that the AIBN was launching a safety inquiry into the accident.

SUMMARY

On Wednesday, 24 March 2010, a freight car set consisting of empty container freight cars rolled uncontrolledly from Alnabru shunting yard, down to Loenga and into the sea at Sydhavna in the Port of Oslo. The AIBN has carried out a safety inquiry into the accident and is submitting a total of seven safety recommendations based on this.

The accident was triggered by a misunderstanding between the local traffic controller and the shunter about which shunting route to set, and the result was that the freight car set started rolling from an arrival track (A track) at Alnabru. When the shunter added an extra freight car to the freight car set, the local traffic controller was convinced that the freight car set was being shunted for loading.

The result of this was that the local traffic controller released the mechanical brake that held the freight car set in place on the A track. The shunter had not intended to move the freight car set and had uncoupled the shunting engine.

There were no shared mental models, standard phrases or readback-hearback systems in place to prevent misunderstandings of communication between the local traffic controller and shunting personnel at Alnabru. Furthermore, two provisions which could potentially have stopped that particular chain of events were 'dormant' and not known to the operating personnel.

When it became clear that the freight car set had started rolling and was not coupled to a locomotive, it had already moved to track G4. It was not possible to stop the freight car set by setting a diversion route before it left Alnabru. Nor were there any barriers on the freight train track between Alnabru and Loenga/Sydhavna which could stop the freight car set in a controlled way. The accident reflects a breach of the ‘no single point of failure’ principle which dictates that railway operations shall be planned, organised and performed in such a way that a single failure does not lead to loss of human life or serious personal injury.

In the AIBN's view, the basic premise that allowed the accident to happen was the fact that Alnabru was being used in a manner for which it was not originally intended. This was a consequence of structural changes and increased rail freight traffic, combined with a lack of remodelling and development work on the infrastructure to reflect this development.

A focus on efficiency and productivity on worn-out, outdated infrastructure, and an insufficient focus on updating safe work practices had reduced safety margins. Political priorities and the NNRA's own prioritising of freight traffic had played their part in this lack of alteration or development.

The investigation showed that both the NNRA and CargoNet AS have consistently failed to handle safety-critical information in a systematic way. There was not enough of a culture of reporting incidents, governing documents were inadequately distributed and implemented, risk assessments were fragmented and inadequate, and the system for collecting and handling safety-critical information from the operational parts of the organisations was deficient. The result of this was that, until the time of the accident, the NNRA and CargoNet AS were both unaware that Alnabru had fundamental faults and deficiencies in terms of operational and technical safety barriers.

The NNRA had not adequately followed up its responsibilities as Principal Enterprise for infrastructure management, for instance through carrying our overall risk assessments. In a complex system like Alnabru, it is especially important that all the organisations involved work together to set up barriers against single failures. This does not seem to have been properly addressed. Alnabru lacked an overall safety management system which would pick up the risks that were a consequence of the many changes that had taken place over time.

The AIBN's investigation has shown that Alnabru does not seem to have been sufficiently 'seen' by the Norwegian Railway Authority (NRA). Even if the responsibility for safety lies with the railway undertakings, the AIBN would nevertheless like to see the supervisory authority playing a more proactive role in overseeing how the undertakings address this responsibility. This is particularly important as regards control of the risk of major accidents in complex areas.

1. INFORMATION ABOUT THE ACCIDENT

1.1 Chain of events

The description contained in the following was compiled by the AIBN on the basis of interviews with those involved, a review of log sheets, CCTV recordings, track usage schedules and observations. The stated speeds are primarily estimates, based on logged passing times and video recordings of the runaway freight cars insofar as these have been available.

On Wednesday, 24 March, the Alnabru central control tower was manned by a local traffic controller, who operated the main control centre, an assistant local traffic controller, who operated the slip control centre, and a trainee who had just begun his training at Alnabru. According to the local traffic controller, the trainee was not involved in the chain of events in question or the events that took place before the freight car set broke loose and started to roll. At the time of the incident, the assistant local traffic controller had finished his tasks, and it was a quiet period at Alnabru shunting yard. The local traffic controller had agreed that the assistant local traffic controller could leave for the day, even though his shift was not over according to the official duty schedule. At this point in time, the local traffic controller was thus operating the slip control centre, including the yard's brake systems, on his own.

The freight car set that broke loose arrived at Alnabru on 24 March 2010 at about 03:10 as train 5806. On arrival, the locomotive was uncoupled and the freight car set was shunted to the freight terminal for unloading at about 03:20. At about 04:20 the freight cars had been fully unloaded and the freight car set was shunted to track A5 at Alnabru shunting yard for parking, and the track's mechanical brake was used to hold it in place. The parking brake was not engaged on any of the freight cars. According to CargoNet AS's shunting schedule, the freight car set was to be shunted back to the freight terminal for loading at about 18:00 on the same day.

The last freight car was shunted into the freight car set just before 13.00 to prepare the freight car set for collection later in the afternoon, thereby making things easier for the next shunting team. Using the shunting channel, the shunter radioed the local traffic controller in the central control tower at Alnabru and requested a shunting route from track R47 to track A5 North. The shunting engine drove up to Alnabru North, and on receiving the signal, shunted the freight car into the freight car set at the north end. When the freight car had been coupled to the freight car set and the shunting engine had been uncoupled from the freight car, the shunter returned to the shunting engine. The shunter radioed the local traffic controller over the shunting channel and asked how far train 5800 had come. Receiving that train for unloading was to be the shunting team's next task. The shunter was told that the train was just arriving at Alnabru and was being driven onto a G track. Train 5800 passed the main approach signal for Alnabru at about 13:01.

According to the shunter and the driver of the shunting engine, who overheard the conversation, the shunter asked the local traffic controller via the shunting channel for a shunting route from track A5 North to a G track. The purpose of this shunting route was to unhook the locomotive from train 5800 and then couple the shunting engine to the same train so that it could be shunted to the freight terminal for unloading. The local traffic controller was convinced that the freight car set on track A5 was ready for loading when the extra freight car had been shunted in. The local traffic controller therefore thought that the shunting engine was coupled to the freight car set and that the shunting engine would pull the freight car set down to a G track. The local traffic controller said that he first asked the shunter to pull back behind the dwarf signal in the G track, so that a train route could be set from the container terminal to the Grefsen–Alna line for outbound train 5507, which was delayed because it had been used for snow clearance.

The local traffic controller first went to the main control centre and set the signals for a route south from track A5 to the G tracks that would bypass the access brake. The local traffic controller then went to the slip control centre and released the mechanical brake. The mechanical brake was released between 13:01 and 13:02. The local traffic controller then returned to his position at the main signal control centre and set signals to track G4 using the Ebilock system.

According to the shunter, they waited for the 'permission to commence shunting' signal for between two and three minutes before deciding to call the local traffic controller to remind him / her. The shunter then noticed that the freight car set had started moving down through the A track, and called the local traffic controller to inform him that the shunting engine was not connected to the freight car set.

Once it became clear that the freight cars were moving and were not coupled to a locomotive, the local traffic controller attempted to stop them by using the lowering brakes. The local traffic controller also tried to set a train route to the G2 / G3 tracks from where the freight cars could be diverted to buffer stops T1 / T2. The attempt was unsuccessful and the freight car set continued downwards through track G4. Tracks G4 and G5 were not equipped with diversion points or buffer stops. The freight car set passed the main departure signal at Alnabru at13:07:07 at a speed of approximately 25 km/h.

When the local traffic controller at Alnabru became aware that it was not possible to stop the freight cars, the traffic controller on the Hovedbanen line, whose place of work is the traffic control centre at Oslo Central Station (Oslo S), was informed of the situation. The Hovedbanen traffic controller informed the shift foreman and the traffic controller at Oslo S. The Hovedbanen traffic controller also checked that the freight cars would not be able to enter the Hovedbanen track at Brobekk, Bryn or Kværner. Information was then obtained about the load status of the freight cars.

The freight cars travelled along the freight track from Alnabru down towards Bryn station. The freight car set had an estimated speed of about 60 km/h as it passed the main approach signal at Bryn station. The freight cars passed the main departure signal at Bryn station at 13:10:30 at a speed of approximately 70 km/h.

The Oslo S traffic controller phoned the local traffic controller at Loenga and informed him of the situation. They discussed possible train routes and alternative methods of stopping the freight car set. They discussed whether to direct the freight cars to the Østfoldbanen line, down towards Sydhavna, to tracks 7 or 8 at Loenga, or to track 10 at Loenga where they could be derailed. The latter option was chosen and the route was prepared to send the freight cars 'along the wall' onto track 10. On approaching Loenga station, the speed of the freight car set was estimated to be approximately 120 km/h.

The freight cars were deliberately not sent onto tracks 7 or 8, because two workers were carrying out repair work on some freight cars that were parked there. There was insufficient time to locate and warn these people. The option of sending the freight cars onto the Østfoldbanen was also considered. A local train was occupying the track between Bekkelaget and Nordstrand stations. The local train was called and instructed to proceed towards Ski station.

At 13:12:40, the freight car set continued along track 10 without derailing. It is estimated that its speed had increased to approximately 125 km/h. A derailer is installed at the south end of track 10 and it was expected that this, combined with the track's layout and curvature, would derail the freight cars and bring them to a halt. Instead, the derailer was sheared off and was later found 250–300 metres further down the track. The freight cars ran through the derailer at 13:12:54 and passed Loenga station at 13:13:00, and then continued along the Port of Oslo's track system towards Sydhavna.

At Kongshavn at 13:13:15, one of the two-axled container wagons (freight car no. 8) in the freight car set derailed at a set of points. It pulled the freight cars behind it along so that these also derailed, overturned and came to a stop. This caused a great deal of damage to the track, to a building close to the track and to motor vehicles along the road.

The front section of the freight car set (seven freight cars, 194 tonnes, 207 m) continued past the pump station for the jet fuel train and on towards Bekkelagskaia. One person walking close to the track was hit by the freight cars and died.

The freight cars continued through a buffer stop at the end of the track, across a parking area, through the access gate to the container terminal and into the gate building[1].This occurred at approximately 13:15:25. Freight cars 2 and 3 went over the edge of the quayside, across a tug boat and ended up in the harbour basin, while the rest of the freight cars stopped on the quayside. Two people inside the building died, and four others were injured. The freight cars damaged the gate building so badly that it collapsed, and they also caused extensive damage to motor vehicles and infrastructure.

[1]The Reception building at the entry and exit points to/from the container terminal

1.2 Scene of the accident

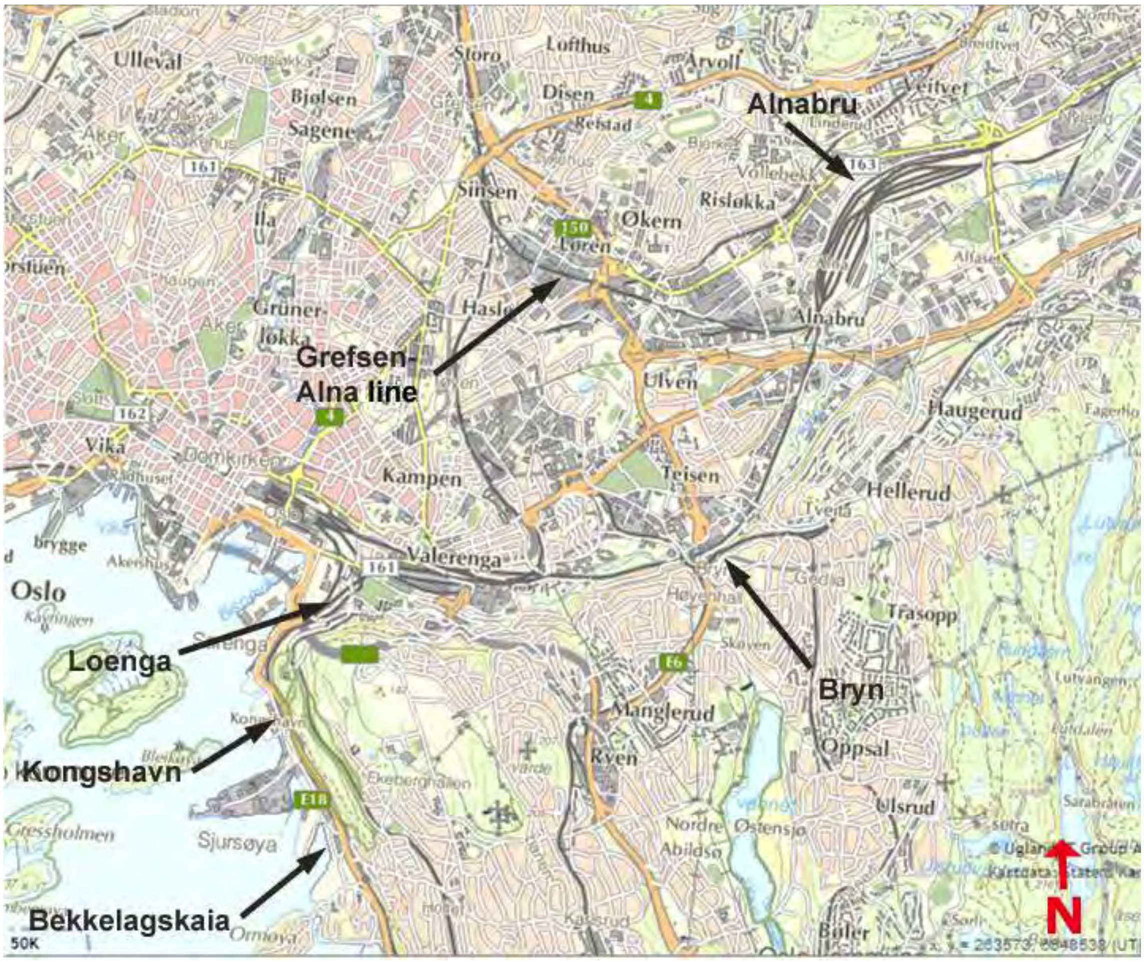

Figure 1: Map of the section travelled by the freight car set.

The freight cars broke loose at the northern part of Alnabru shunting yard, rolled through Alnabru freight terminal and out onto the Loenga-Alnabru freight line. The freight car set continued via Bryn station all the way down to Loenga station and then out into the Sydhavna area of the Port of Oslo. The rear section of the freight car set derailed at Kongshavn beside sheds 7476. The front part of the freight car set passed through the Sjursøya junction and continued onto Bekkelagskaia and towards the container terminal, where the freight cars hit the gate building. The freight cars rolled a total distance of more than 9 km.

Figure 2: Photo of Kongshavn where freight car 8 and the freight cars behind it derailed.

Figure 3: Photo of container terminal at Bekkelagskaia.

1.3 Notification and rescue efforts

- The NNRA used the 110 emergency number to alert Oslo Fire and Rescue Services at 13:12. This alert reported *'runaway freight cars that can potentially end up on the quay at Sjursøya/Ormsundkaia.'* The traffic controller requested the emergency operator to initiate a triple-alert to the various emergency services.

- The Emergency Medical Communication Centre (AMK) was first alerted by a member of the public at the scene at 13:14.

- At 13:25 Oslo Police Department was alerted by AMK.

- At 13:25 the first ambulance arrived on the scene.

- At 13:25 the first unit from Oslo Fire and Rescue Services passed the site of the first incident (at Kongshavn) and continued to the site of the second incident (at Bekkelagskaia).

- The first police unit was on the scene at 13:26.

- Oslo Havn KF was not notified of the incident until the freight cars had entered the port area.

1.4 Injuries

1.4.1 Personal injuries:

Table 1: Personal injuries:

Injuries	Crew:	Passengers:	Others
Died			3
Serious			3
Minor			1
None			

All three people defined as seriously injured survived the incident.

1.4.2 Damage to rolling stock involved

All the freight cars were damaged so badly that they had to be scrapped.

1.4.3 Details of damage to infrastructure and roads

Among other things, the infrastructural damage meant that Oslo Havn KF's tracks at Kongshavn and Bekkelagskaia had to be repaired.

1.4.4 Other damage:

The gate building at Bekkelagskaia was completely destroyed and the port area had to be cleared. One wall of a warehouse building that abutted the bridge at Sjursøya and two bollards were destroyed.

Several motor vehicles and a tug-boat were also damaged, and the Port of Oslo and Alnabru shunting yard were closed for a period after the incident. The AIBN has not obtained a full overview of this damage.

1.5 Personnel involved

The local traffic controller at Alnabru was 41 years of age. He/she was an employee of the NNRA and had served as a local traffic controller since 1993. He/she had started in the Norwegian State Railways (NSB) in 1986. In addition to holding the position of local traffic controller, he/she also worked as an instructor.

The local traffic controller at Loenga was 40 years of age. He/she had been an employee of the NNRA since 1993.

The traffic controller at Oslo S was 51 years of age. He/she had been an employee of the NNRA since 1993.

The Hovedbanen traffic controller was 46 years of age. He/she had been an employee of the NNRA since 1996.

The shift foreman at the traffic control centre was 59 years of age. He/she had been an employee of the NNRA since 1989.

The shunter was 53 years of age. He/she had been employed by CargoNet AS since 2002 and had served in a corresponding position since 1986.

The shunting engine driver was 35 years of age. He/she had been an employee of CargoNet AS since 2008.

1.6 Rolling stock involved

The freight car set consisted of 11 six-axled special freight cars for containers, swap bodies and semi-trailers and five two-axled special freight cars for containers. There were a total of 16 empty freight cars weighing a total of 435.5 tonnes, and the freight car set was 458 metres long. The freight cars were owned by CargoNet AS and were registered in Norway.

No technical faults or defects of any relevance to the incident were found in the rolling stock involved.

Figure 4: Two-axled container freight car.

Figure 5: 6-axled container freight car.

1.7 Infrastructure and roads

The NNRA is the infrastructure manager for Alnabru central shunting yard, including the Central Control Tower, and the freight line to Loenga with the Loenga yard.

CargoNet AS operates terminal services in the container terminal, which includes shunting and preparing freight car sets and freight cars between the container terminal and the shunting yard. The shunting yard and parts of the container terminal are also used by railway undertakings other than CargoNet AS.

1.7.1 Alnabru

The railway facilities at Alnabru consist of Alnabru central shunting yard (Alnabru S) and Alnabru freight terminal (Alnabru G). Alnabru S is a sorting machine for freight cars in which freight trains are broken up and made up, while Alnabru G consists of the tracks on which the freight cars are loaded and unloaded.

Alnabru S consists of an arrival yard with a group of six arrival tracks (A tracks), five of which are equipped with a mechanical brake and a lowering brake. There are 36 directional tracks (R tracks) divided into five (4+1) groups. The main part of the terminal is located at Alfaset, and has four groups of loading tracks with pertaining loading areas. There are tracks connecting Alnabru S and Alnabru G, namely tracks G2–G5. The highest permitted speed at Alnabru S is 40 km/h. The area is electrified and there are overhead contact wires as far as the loading tracks at Alnabru G.

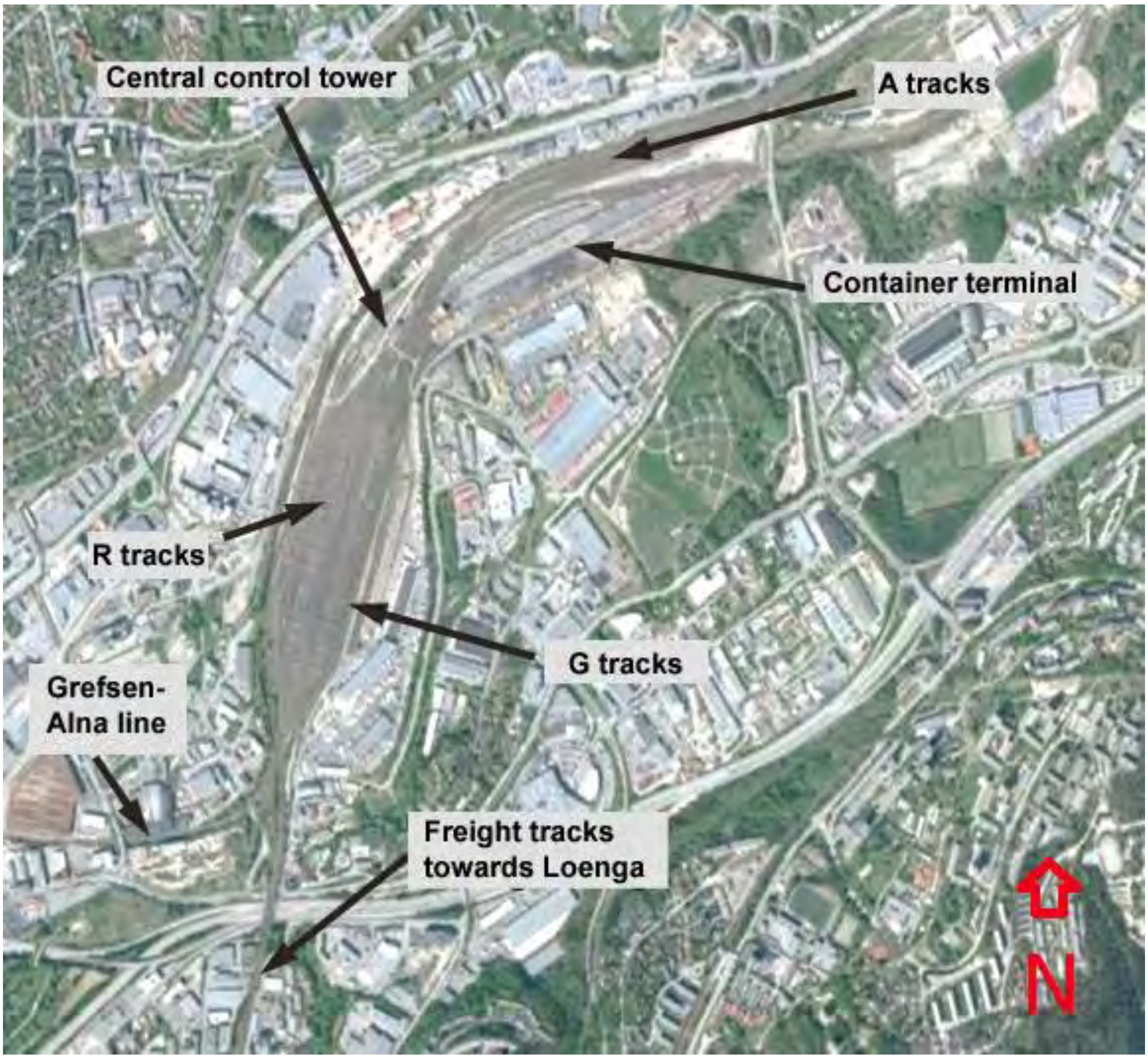

Figure 6: Aerial view of Alnabru.

1.7.2 Loenga – Alnabru freight line

The Loenga–Alnabru freight line is a single-track stretch running parallel to Hovedbanen from the north end of Loenga, via Bryn to Brobekk. The stretch is electrified. The height difference from Alnabru north down to Sydhavna is over 100 metres. The steepest gradient on the stretch is 25‰, between Bryn and Loenga. The highest permitted speed between Alnabru and Loenga is 60 km/h.

1.7.3 Loenga shunting yard

Loenga yard has 10 tracks. The yard has connections to Østfoldbanen, Lodalen train formation yard, Oslo S and the Sydhavna track. The highest speed permitted at Loenga is 40 km/h. The yard is electrified.

1.7.4 Port of Oslo, Sydhavna

The track system at Sydhavna belongs to Oslo Havn KF. The traffic on the track system moves at low speeds (maximum 40 km/h). The track system starts about 2 km south of Loenga and branches into a number of tracks. The points are operated manually. The track system is not electrified.

1.7.5 Ongoing infrastructure work

There were diversions due to snow clearance on the Grefsen–Alna line. This meant that outbound train 5507 to Bergen and an uncoupled locomotive were held back at the freight terminal.

1.8 Traffic control

1.8.1 Alnabru

Traffic at Alnabru S and G is controlled from the Central Control Tower at Alnabru S by a local traffic controller employed by the NNRA. The yard is equipped with dwarf signals and main signals. The shunting yard's braking systems are controlled from the slip control centre, normally by an assistant local traffic controller employed by the NNRA. The slip control centre is co-located with the Central Control Tower.

1.8.2 Loenga

Traffic at Loenga is controlled from the control centre at Loenga by a local traffic controller employed by the NNRA. The yard is equipped with dwarf signals and main signals.

1.8.3 Loenga – Alnabru freight line

Traffic on the freight track between Loenga and Alnabru is controlled by an Oslo S traffic controller, located in the traffic control centre at Oslo S. The freight track has a partial remote traffic control (DATC) system installed.

1.8.4 Østfoldbanen

Traffic on the Østfoldbanen line is controlled by an Østfoldbanen traffic controller at Oslo S. Østfoldbanen has a centralised traffic control (CTC) system, and the Oslo S–Ski section is equipped with partial automatic traffic control (DATC).

1.8.5 Port of Oslo, Sydhavna

Rail traffic to, from and within Sydhavna is controlled by the local traffic controller at Loenga. Oslo Havn KF controls access to the line.

1.9 Weather

The nearest weather stations at Alna in Groruddalen and Blindern showed temperatures of approximately +2 °C between 12:00 and 14:00 on 24 March 2010. Relative humidity was 85% and there was a light breeze. The wind direction at Alna was north-easterly. It was more variable at Blindern. It was completely overcast but dry.

2. INVESTIGATIONS CARRIED OUT

2.1 The investigation – process, methods and limitations

Please refer to Annex C, which describes the AIBN's investigation process and methods.

Among other things, the AIBN has used sequential timed events plotting (STEP) in its investigation, in order to establish the chain of events. The STEP diagram provides a broader base from which to identify potential safety problems and causal factors that affected the course of the accident. The AIBN has also conducted a barrier analysis to uncover weaknesses and failings in existing barriers, and to find out if any barriers were missing which could potentially have stopped the chain of events.

A preliminary report was published on 3 May 2010 which describes the chain of events, the structure and use of Alnabru shunting yard, and preliminarily identified safety problems.

In our further investigation and causal analysis we have chosen to focus on determining and assessing the structures, cultures and interactions of the organisations involved, the status of their risk assessments and safety management, their monitoring by supervisory authorities and the history, restructuring and remodelling of Alnabru, as well as on reviewing technical systems and operational work practices at Alnabru.

The investigation has involved the following:

- Technical investigations and inspections of infrastructure, brake and signalling systems at Alnabru, Loenga and the Port of Oslo.
- Test drives on the freight line.
- Examination of logs, photos and video recordings.
- Inspection of the traffic control centre at Oslo S.

- Examination of system documentation pertaining to the signalling and track systems.

- Interviews with railway personnel involved and other witnesses.

- Examination of relevant documentation received from the police.

- Examination of the emergency services' logs, notifications and rescue work related to the accident. The AIBN has been assisted in this work by Oslo University Hospital at Ullevål.

- Semi-structured interviews with operating personnel, management and support staff in the NNRA and CargoNet AS (a total of approximately 40 people).

- Meetings with the Oslo Havn KF and examination of relevant documentation regarding Sydhavna.

- Reviewing Det Norske Veritas' (DNV) report on the safety culture in the NNRA, including a meeting with DNV.

- Examination of various documents from the NNRA and CargoNet AS: safety management system, procedures and instructions, minutes of meetings, risk assessments and Synergi records.

- Examination of various documents from the NRA and the Norwegian Labour Inspection Authority (NLIA) including audits, applications, notices and permits.

- Meetings with organisations involved.

2.2 Railway infrastructure – design, conditions and use

2.2.1 Alnabru S

Alnabru central shunting yard (Alnabru S) is designed to serve rail traffic in accordance with the freight car loading system, whereby individual freight cars or groups of freight cars are loaded in loading bays and subsequently allocated to trains, and are then reallocated to new loading bays or new trains.

2.2.1.1 *Theoretical track plan*

Alnabru S consists of an arrival yard of six arrival tracks (A tracks), five of which are equipped with a mechanical brake and a lowering brake, and 36 directional tracks (R tracks) divided into five (4+1) groups. The freight cars are moved from the A tracks over the 'hump' and through various distribution points to their respective R tracks. The arrival yard is on a gradient (hump yard) so that the freight cars can roll from the A tracks over the 'hump' by force of gravity. As the freight cars roll over the hump, they accelerate and the distance between them widens, so that the distribution points can be switched between the passing of each freight car or group of freight cars.

At the southern end of the freight terminal, the R tracks converge via a points zone and are connected to two extension tracks, T1 and T2, which each end in a buffer stop. Tracks G2–G5 (the G tracks) connect Alnabru S and Alnabru G. There are tracks from the south end connected to the Loenga–Alnabru freight line and the Grefsen–Alna line towards Grefsen Station on the Gjøvikbanen line.

No technical faults were found in the track layout when this was inspected after the accident.

Please see the schematic track plan in Appendix B of this report.

2.2.1.2 *Brakes*

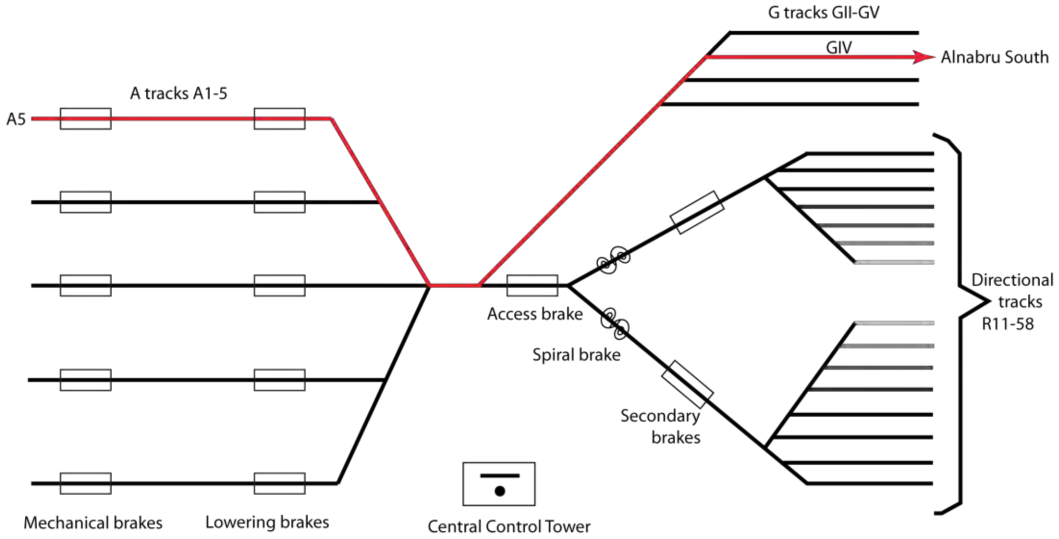

Figure 7: Plan showing the locations of the various brake systems at Alnabru S. The red line shows the freight cars' exit route from track A5.

In order to control the rail cars, the shunting yard has several sets of brakes. The first brake on the arrival tracks (A1–A5) is the mechanical brake, the function of which is to keep parked / unused freight car sets stationary until sorting can commence. Just after the mechanical brake there is a lowering brake on each A track. The purpose of the lowering brake is to enable controlled lowering of a freight car set from its braked position on an A track to the hump. There is an access brake just before the 'hump'. The purpose of this brake is to finely adjust the speed of the freight cars before they roll over the hump. A second function of the brake is to ensure that there is sufficient slack in the couplings for them to be thrown off if the freight car set is to be broken up.

Figure 8: The mechanical brake is a beam brake that pinches against the freight car wheels.

In the final part of the hump and in the distribution zone, ASEA spiral brakes are installed to limit the speed of the most easy-running freight cars. At the bottom of the incline there are four secondary brakes, the purpose of which is to reduce the speed of the freight cars before they run onto the R tracks. The R tracks are also equipped with ASEA spiral brakes, which reduce the speed of the rail cars to an acceptable follow-on speed (< 2 m/s).

When the brake systems were inspected after the accident, they were found to be in good working order.

2.2.1.3 *Theoretical use*

Incoming freight trains intended for sorting in the shunting yard are driven along the access tracks to one of the A tracks. They are held stationary there by the mechanical brake, and the train's own brakes are released. The train's locomotive is uncoupled and can leave the arrival yard along the access tracks. Shunting crews bleed the air to release the brakes on the freight cars, disconnect the air hoses and slacken the couplings where the freight car set is to be broken up (in accordance with a list that has been prepared in advance). The freight car set is then ready for slipping. When other conditions are right, the freight car set is lowered towards the hump by means of the lowering brake. The lowering brake is used to regulate the speed and ensure slack in the couplings. One person stands on the 'ball' and throws off the couplings where the freight car set is to be broken up. The freight cars / freight car sets accelerate along the hump and are switched to their respective R tracks while being controlled by the secondary brakes and ASEA spiral brakes. Once on the R tracks, the freight cars are slowed down to an acceptable follow-on speed. Ideally, the freight cars on an R track should end up next to each other when slipping is completed.

When the incoming freight car sets have been slipped, they are placed next to each other on the R tracks and coupled together. Alternatively, freight car sets can be shunted from one R track to another using a shunting engine and the track extensions at the south or north ends of the R tracks. The end product is a 'group-shunted' train. Locomotives are coupled to the new freight car sets on the R tracks, the trains' brakes are tested and documented, and the trains can then leave Alnabru S.

2.2.2 Alnabru G

Alnabru container terminal (Alnabru G) is designed to serve rail traffic based on the shuttle train principle. This means that whole freight car sets shuttle between major terminals. Whole freight car sets are loaded and unloaded without being broken up. Changes to the composition of the freight car sets are, as a rule, the result of maintenance or repair work on individual freight cars.

2.2.2.1 *Theoretical track plan*

The main part of the container terminal is located at Alfaset, and has four yards of loading tracks with pertaining loading areas. The tracks are throughgoing; in the north via the Grorud track, which is connected to the Hovedbanen line at Grorud; and, in the south, via tracks connected to tracks G2–G5. There is also a throughgoing track that connects tracks G2–G5 with the Grorud track. Overhead contact wires have been installed as far as the end of most of the loading tracks in both the south and north.

2.2.2.2 *Brakes*

This part of the terminal has no separate braking systems. The loading tracks are horizontal and the freight car sets are secured by engaging the parking brakes / braking shoes on the freight cars at the south end of the loading tracks.

2.2.2.3 *Theoretical use*

Arriving trains are directed onto tracks G2–G5. A shunting engine is coupled to the train and the train's locomotive is uncoupled. The shunting engine pulls or pushes the freight car set onto the relevant loading track, where it is secured by means of the parking brake / braking shoes. The freight car set is unloaded by container forklift trucks or container cranes. The empty freight car set is normally shunted out of the terminal tracks and parked at Alnabru S to make room for the next trains arriving.

The empty freight cars are inspected and replaced as required, before the freight car set is reloaded with a new cargo. When loading is completed, the locomotive is coupled to the train, the load is checked and the brakes tested. The train can then leave the terminal via either the Grorud track (to the north) or tracks G2–G5 (to the south and west).

2.2.3 <u>Interlocking systems at Alnabru</u>

2.2.3.1 *Central Control Tower*

The Central Control Tower is the centre from which all the various types of interlocking systems at Alnabru are controlled.

Figure 9: Alnabru Central Control Tower.

The Central Control Tower is the workplace containing all the control panels at Alnabru, and is geographically situated in the middle of the yard area.
It contains several types of interlocking systems and is primarily operated using the following main systems: the main control system (NSI-63), an Ebilock 850 system and a slip control system.

The north and south control systems are both part of the main control system.

2.2.3.2 *Main control system NSI-63*

The main control system is an NSI-63 relay interlocking system which is one of several interlocking systems at Alnabru. This was commissioned at the same time as the slip control system in 1970. This interlocking system controls trains entering and leaving the Hovedbanen line from/to either end of the Alnabru freight terminal in consultation with the Hovedbanen traffic controller, as well as the Loenga–Alnabru freight track and the Grefsen–Alna line to the south. The system also sets shunting routes at Alnabru, interfacing with the Ebilock system. The interlocking system is equipped with three relay rooms; one central room (middle), one at Alnabru South and one at Alnabru North, but in interlocking terms, it should be regarded as one system. The track circuits consist of conventional track circuit relays, and the points are operated by Siemens single-phase point machines.

The local traffic controller faces away from the tracks and operates the control panel.

<u>Middle control system</u>
The middle control system controls the middle part of the shunting yard. The middle

control system interfaces with Ebilock 850, the slip control system and the south and north control systems. It is operated from the control panel in the Central Control Tower. The middle control system is independent of the track brake system.

South control system

The south control system interfaces with Brobekk and Grefsen stations, with the Ebilock interlocking system and with the middle control system via track G1 and the R tracks. The system is operated from a control panel in the Central Control Tower, but can also be operated locally from a separate control panel at Alnabru South.

For parts of the train operations (Alnabru S), the local traffic controller does not have electronic control or indication of point settings, track or point circuits, or the protection of train and shunting routes. These are controlled by the shunting crew from a control panel where they queue the trains for departure, depending on which directional track the points are set from.

North signal control system

The north signal control system reaches up to the middle of the A tracks and up to the middle of tracks G11 and G12, and interfaces with Ebilock 850. All the functions in the north signal control system are controlled from the Central Control Tower, but can also be operated locally from a separate signal control panel at Alnabru North.

2.2.3.3 *Westinghouse-type slip control system*

The slip control system is made up of the slip controls and track braking systems (mechanical brakes, lowering brakes, access brakes, spiral brakes and secondary brakes). The slip control system is released for operation from the main signal control centre.

The local traffic controller faces the tracks and operates the slip signal control system.

The slip signal control system was commissioned in 1970 when Alnabru shunting yard was built. The system was originally an older type of electronic system constructed using wolve technology. This required daily adjustments and maintenance. Between 1987 and 1989, the system was converted to a programmable logic controller (PLC) system, which requires less adjustment and maintenance than the original system. The track circuits are electronic and the point machines are pneumatic.

2.2.3.4 *Ebilock 850*

Ebilock 850 is a first-generation computer control system produced by EB Signal (now Bombardier). This system was commissioned in the early 1990s when the container terminal was built. The system controls a secured area in the container terminal as far as bypass tracks G2–G5 on the east side of the yard. The track circuits are electronic, and the points are operated by Siemens three-phase point machines.

In the Central Control Tower, the monitors are situated to the right of the control panel for the main control centre, and the local traffic controller operates the system with the tracks set out on his right-hand side.

The system uses an LM Ericsson Man 900 control system. The latter logs traffic instructions that are sent, but does not log indications.

2.2.4 Loenga – Alnabru freight line

The Loenga – Alnabru freight line has tracks that connect with Hovedbanen at Kværner, Bryn and Brobekk. The normal point setting is towards the freight track. Points 113A/113B at Brobekk station between the freight tracks and Hovedbanen automatically return to their normal setting when a train route to or from Hovedbanen is released.

2.2.5 Loenga

Loenga yard has 10 tracks. Entry from Bryn is via two tracks. (Hovedbanen freight track and Gjøvikbanen freight track). Tracks 1 to 3 connect with the Østfoldbanen and Sydhavna/the Port of Oslo. Tracks 7 to 10 connect with Sydhavna/the Port of Oslo. Tracks 4 and 5 are buffer stops which are entered from the north. Track 6 is a buffer stop which is entered from the south.

2.2.6 Sydhavna track area

The track layout within the Sydhavna area is extensive, but manually operated. The track system is designed for limited speeds. The track system starts approximately 2 km from Loenga and covers the area to the south, branching into a number of tracks.

Access to the tracks is granted by Oslo Havn KF. At present, only CargoNet AS has access to the tracks, for operation of the jet fuel train. The jet fuel train is loaded twice a day. No other freight trains operate on the port tracks.

The condition of the tracks played no part in the incident.

The photos show the roundabout at the Sjursøya junction which the freight car set went right through, on its way down towards Bekkelagskaia. There is a great deal of road traffic to and from the freight facilities in the area.

Figure 10: View from above of the roundabout at Sjursøya junction.

Figure 11: Roundabout at Sjursøya junction viewed from the south.

Activities south of Sjursøya include Gardermoen airport's jet fuel train's fuelling operations. The freight car set followed the last train route that had been used. It therefore ran through the loading track for the jet fuel train; which was at Gardermoen at the time.

2.3 Condition and functionality of the technical systems

2.3.1 Inspection of the mechanical brake, lowering brake and track system

The AIBN and representatives from the police inspected the mechanical brake and lowering brake on track A5 at Alnabru S on 24 March 2010. Following the inspection and documentation of their condition, a simple function test was performed by engaging and releasing the brakes. These inspections did not uncover anything to suggest technical failure in the brakes. Nor were there any marks indicating that the freight cars had 'climbed' out of' the lowering brake.

The condition and position of the points en route from track A5 via track G4 to the last set of points at the southern end of Alnabru were inspected. The findings were compared with logged information and descriptions provided by the personnel involved. One set of points was found to have been sheared off (no. 693). This was considered to be a natural consequence of the incident and the train routes that had been set at the time of the accident. No abnormal conditions were found to exist on the other tracks or in the remaining points, which were positioned in accordance with the incident and the known train movements.

The mechanical brakes were also tested the day after the accident, by applying them to a 'test train' with a corresponding number of freight cars. The train's brakes were then released and it was noted that the train did not move despite the fact that the locomotive was pulling gently on the freight cars. A shunting route to track G4, corresponding to that on the day of the accident, was set and the mechanical brake was released. The train started to roll by virtue of its own weight, its speed was observed and the train was video-recorded until it was braked before the exit from Alnabru. The test train's freight cars were uncoupled from the locomotive, and the locomotive drove the freight train route from Alnabru to Loenga and back while the section was video-recorded.

The AIBN carried out a function test of Ebilock 850, which verified that the interface between the operator and the technical system was functioning. Ebilock 850 appears to have been functioning satisfactorily on the day of the accident.

2.3.2 Inspection of actual barriers against runaway freight cars and the possibilities of stopping them

This section provides an overview of the technical or manual barriers in the infrastructure which the AIBN has identified as being designed to prevent freight cars from rolling uncontrolled without brakes, to regain control of such freight cars, or to limit the damage that they can cause. The investigation is limited to the stretch of track from track A5 at Alnabru S to the accident site in the Port of Oslo.

2.3.2.1 *Mechanical brake on track A5*

The mechanical brake on track A5 is designed to hold freight car sets weighing up to 1,000 tonnes while these are being prepared for slipping. In order to release the brake, two push-buttons in the slip signal control centre must be activated. It is a precondition that the freight car set is stationary before the mechanical brake is engaged. The brake is spring-loaded. It is released by means of compressed air and engaged when the compressed air is released.

2.3.2.2 *Lowering brake on track A5*

The lowering brake on track A5 is located just below the mechanical brake. Normally, this brake is used to regulate the speed of freight car sets being lowered towards the access brakes. The braking effect is achieved by means of compressed air. The braking effect can be regulated in steps. The brake can be engaged while the freight car set is in motion and can stop a freight car set, provided that a sufficient part of the freight car set is located in or above the brake and that it does not exceed a certain speed.

2.3.2.3 *Points 125*

At the exit from track A5, points 125 can be set to one of two routes: a) freight cars can be directed towards the access brake, or b) freight cars can be directed around the access brakes towards tracks G2–G5. Points 125 are controlled via the interlocking system and are normally set towards the access brakes unless a train route is set through these points towards the G tracks. In the latter situation, any runaway freight cars would roll onto the directional tracks, collide with any freight cars standing in their way and finally be caught by the end buffers (T1 / T2) at the southern end of the shunting yard. The normal setting of the points to the south is that they are pulsed towards secure tracks T1/T2.

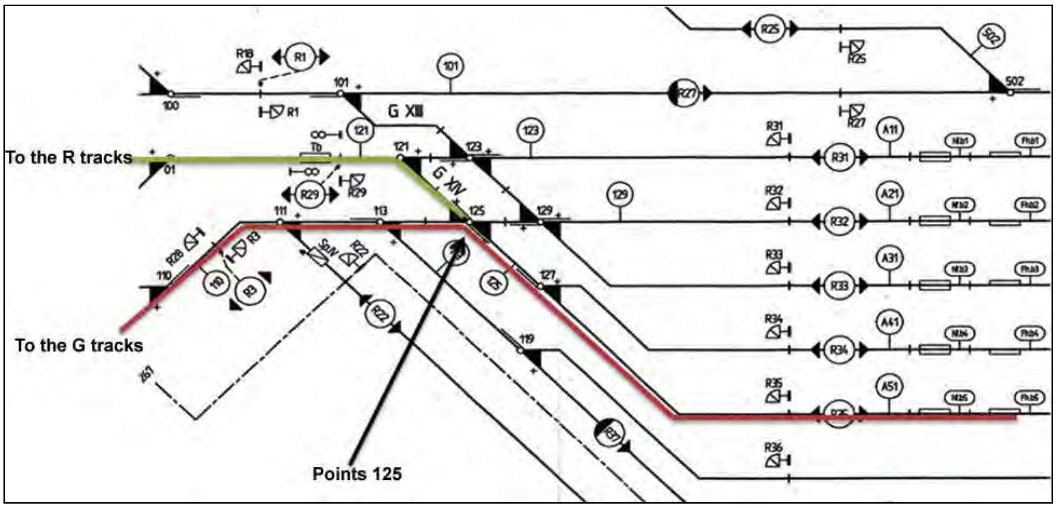

Figure 12: Section of schematic track plan. Possible train routes from track A5 through points 125. The red line shows the route that was taken by the freight cars.

2.3.2.4 *Tracks G2–G5*

Tracks G2–G5 meet at the southern end of Alnabru from where they run straight into the freight track between Alnabru and Loenga. There was no diversion point or extension buffer leading away from this track group in the south. In the southern part of track G2, there is a track connection from track G2 to track R47, and, before that, there is a track connection from track G3 to track G2. The AIBN has been informed that there is no function installed that would automatically set the points for these connections towards track R47. There were no connections for tracks G4 and G5. Even though the control system for choosing train routes through this track system has some prioritisation rules, these can be overridden by the local traffic controller according to the specific use he/she wants to make of the tracks. This means that the choice of train routes that can be set from track A5 to the end of the track group is not permanently blocked in any way. Thus the possibility of regaining control of runaway freight cars by leading them onto track

R47 was limited to freight cars that run through track G2 and G3, provided that the situation was noticed in time for it to be possible to set the points towards R47 via the track connections.

2.3.2.5 *Brobekk*

Just after departure from Alnabru South there are some track connections between the freight track and the Hovedbanen line. These connections simply allow for transfer of trains between the Hovedbanen tracks and the Alnabru tracks. However, there are no facilities for stopping or derailing runaway freight cars here. The same applies to the stretch of track between Brobekk and Bryn.

2.3.2.6 *Bryn to Loenga section*

At Bryn station we also find track connections that make it possible to transfer to the Hovedbanen line. However, there are no facilities for stopping or derailing runaway rail cars here either.

Between Bryn and Kværner, the track passes through both cut and fill sections. There are no facilities for stopping or derailing runaway freight cars.

At Kværner there is a connection to Gjøvikbanen and onwards to Hovedbanen. However, there are no facilities for stopping or derailing rail cars here either. The same applies to the stretch of track between Kværner and Loenga.

2.3.2.7 *Loenga*

At Loenga, there is a track system with a total of ten tracks. The tracks converge in the southern end and lead either to Østfoldbanen or to Oslo Havn KF's track system. There are no facilities for stopping or derailing high-speed runaway freight cars here either. A derailer was mounted on track 10 which connects to the Port of Oslo. This type of derailer was designed for maximum speeds of around 50 km/h.

2.3.2.8 *Port of Oslo's track system*

The points are manual and the track system has no barriers against runaway rail cars approaching from Loenga at high speed. The train route normally remains the one that was set for the most recent shunting movement. That is either for the most recently departed freight cars or freight cars that are still within the area. In the case of the runaway freight car set, it ran all the way to Bekkelagskaia, where the track had been terminated by being overlaid with tarmac, and a buffer stop had been installed. This type of buffer is not designed to stop the kind of energy represented by the runaway freight car set.

2.3.3 Investigation of alternative train routes

Figure 13 illustrates the section travelled by the runaway freight car set, in addition to the alternative train routes which could have been available in the Asker, Bryn, Kværner and Loenga areas.

The traffic controller is not able to release main train routes instantly, but is able to set all signals to stop and then release train routes with a 90 second delay, and finally set the points to a different setting if the track circuit is unoccupied.

In a test carried out during an inspection the AIBN conducted at Loenga yard in September 2010, it took 50 seconds to release an existing train route from this signal control centre in order to be able to set a new one.

An overview of alternative train routes can also be found in Annex A.

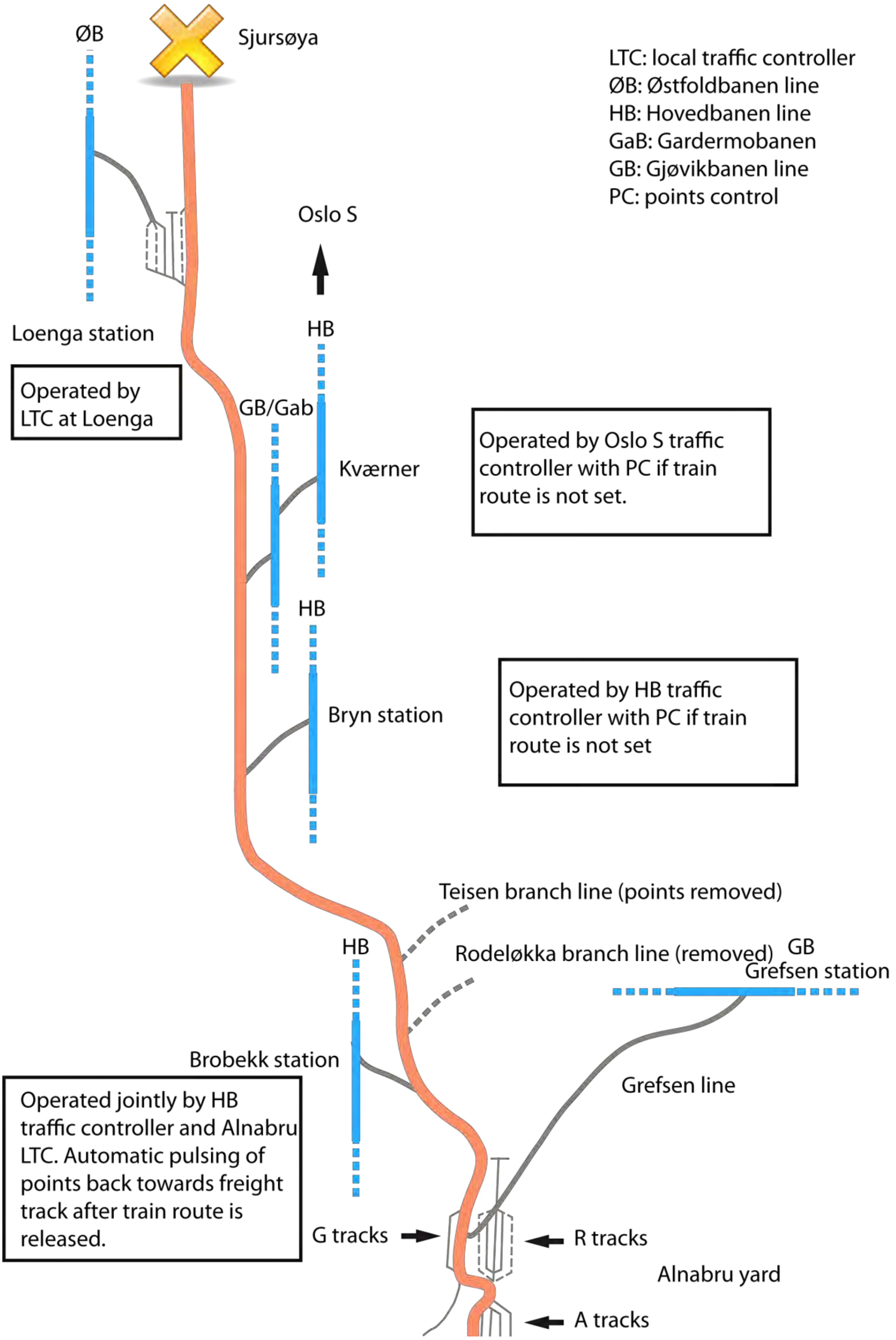

Figure 13: Plan of track connections between Loenga and Alnabru.

2.4 Traffic control and communication

2.4.1 Traffic control at Alnabru

Traffic at Alnabru is controlled by a local traffic controller. The local traffic controller is responsible for monitoring and ensuring safe operation of inbound and outbound train traffic and safe shunting operations at Alnabru. Traffic management is performed in accordance with the timetable established for the duration of a timetable period. Prior to the accident, the timetable was last updated on 13 December 2009.

There is constant communication between the traffic controllers at Oslo S Traffic Control Centre and the local traffic controllers regarding train movements and ongoing and imminent traffic operations. The local traffic controller at Alnabru sets outbound train routes to Hovedbanen, but it is the Hovedbanen traffic controller who sets the relevant main departure signals from Alnabru. The Alnabru local traffic controller is also responsible for controlling traffic on the Grefsen–Alna line, in consultation with the Grefsen local traffic controller.

The local traffic controller is the shunting coordinator and continuously coordinates shunting between the various undertakings. The Central Control Tower is also manned by an assistant local traffic controller who operates the slip signal control system.

2.4.2 Shunting operations and track usage

At the time of the accident, only CargoNet AS had its own shunting engines at Alnabru. CargoNet AS usually had two shunting engines with crews led by two shunters, one for each shunting team.

According to the NNRA, CargoLink AS, who operated freight trains to two destinations from Alnabru (Trondheim and Åndalsnes), shunted with a locomotive at Alnabru. No other rail companies were involved in any shunting operations at Alnabru at the time of the accident.

CargoNet AS has prepared a track usage schedule for the various loading tracks (C tracks) available to the company at Alnabru. The R tracks, where empty freight car sets are parked between operations, are shared between the railway undertakings.

The CargoNet AS shunting teams are responsible for shunting the undertaking’s rolling stock within the yard area in accordance with the established track usage schedule and shunting orders issued by the team leader. The shunting order describes shunting movements which are planned for that day. Changes to the shunting schedule are relatively common. The local traffic controller does not receive the railway undertakings' shunting orders or track usage schedules.

The AIBN has been informed that the demand for parking space for freight car sets can sometimes exceed the capacity of the R tracks. As a consequence of this, CargoNet AS has gradually started using the A tracks at Alnabru for parking and storage of freight car sets. CargoNet AS has informed the AIBN that the freight car set involved in the accident was parked on an A track every night.

2.4.3 Communication

Communication regarding train movements (issuing of orders, messages etc.) between the local traffic controller, traffic controller and the trains takes place over a GSM Railway (GSM-R) telephone.

Communication between the local traffic controller and the shunter takes place via a dedicated channel on the shunting radio[2]. Before shunting begins, the shunter calls the local traffic controller and requests a shunting route. Communication between the local traffic controller and the shunter via shunting radio is not saved.

Communication between shunter and shunting engine driver takes place via the shunting radio. The shunting engine driver uses the GSM-R telephone when he announces to the local traffic controller that he wishes to enter Alnabru.

It is clear from the interviews with the personnel involved that, from a technical point of view, communication over the shunting radio worked as intended at the time of the accident.

The requirements of the Train Operation Regulations regarding communications during shunting are summarised in section 2.15.1.

2.5 Recordings

2.5.1 Recording speed sensors and data logs

The freight track between Alnabru and Loenga is equipped with DATC. Freight car sets do not have ATC equipment installed, since they are not intended to operate on free lines without being coupled to a locomotive.

2.5.2 Balises and detectors

No recordings from balises or detectors have been used in this investigation.

2.5.3 Other recordings

Information has been used from those CCTV cameras at various places along the route which captured the movements of the freight car set. The data has been used to verify the speed and passing time of the freight car set at various places along the route.

2.5.4 Accident timeline

Feil! Fant ikke referansekilden. contains an overview of what the AIBN has been able to ascertain about the timing of the chain of events. The following sources have been used:

- Ebicos 900 traffic control log Alnabru
- CTC logs (Hovedbanen and Oslo S)
- GSM-R log

[2] The GSM-R system has not yet been developed for use during shunting.

- Video recordings from the Schenker AS CCTV cameras

- Video recordings from the partial reconstruction on the day after the accident

- Interviews with the personnel involved

CTC logs, GSM-R logs and Schenker AS video recordings have synchronised timing and indicate times in whole seconds. The Alnabru traffic control log indicates times in whole minutes, i.e. it does not show seconds. In addition, the minute figures cannot be confirmed as synchronised with the CTC log. The traffic control log's time indications are therefore uncertain in relation to those of the CTC log.

The rolling speed of the test train on track G4 was measured to about 40 km/h on the locomotive's speedometer, while the speed of the runaway freight car set was measured to be approximately 25 km/h in the same place using Schenker AS's video recordings. Two conditions could explain this difference. The test train's freight cars and traction engine were 'motioned' before they were let loose, and they could therefore have had a lower rolling resistance from the start, or else the attempt to stop the freight car set with the lowering brake could have reduced the freight car set's speed.

The following statements must be considered:

- Train 5800 was on its way into Alnabru when the shunter requested a shunting route from track A5 north to a G track.

- The local traffic controller set the shunting route from track A5 southwards to the G tracks, bypassing the access brake, released the mechanical brake and then set the shunting route to track G4.

The timing of several important events could not be ascertained, since conversations that took place over the shunting radio system were not logged. Results from the test train run, combined with observations from Schenker AS's video recordings indicate that the mechanical brake was released between 13:01 and 13:02. This means that there is between two and four minutes' difference between the traffic control log and the CTC log.

The results of the test train run show that the time from when the test train began to roll until:

- it could no longer be diverted to another G track was approximately two minutes and seven seconds.

- the last freight car had passed the lowering brake was approximately two minutes and five seconds.

The runaway freight car set took much longer than the test train. However, it was not possible to calculate this additional time based on the observations available.

Table 2: Accident timeline The times noted in the traffic control log deviate from other sources.

Time				
Start	End	**Event**	**Source:**	**Comments**
03:10:00		Freight car set arrives Alnabru as train 5806	CargoNet AS	
03:20:00		Freight car set to C terminal for unloading	CargoNet AS	
04:20:00		Freight car set shunted to A5 for parking	CargoNet AS	
		Shunter requests shunting route from R47 to A5 north	Conversation	
		Local traffic controller sets shunting route from R47 to A5 north	Conversation	
12:57:00		Local traffic controller sets train route from signal 601 to signal 617	Traffic control log	Train route for 5800 to G5
		Shunter requests shunting route from A5 north to a G track	Conversation	
		Local traffic controller sets a southward shunting route from A5 north towards the G tracks	Conversation	
13:01:00		Train 5800 passes Alnabru main approach signal	Estimated	Schenker CCTV camera shows 13:04:10 as the last freight car moves onto G5
13:01 – 13:02		Local traffic controller releases mechanical brake	Estimated	
12:59:00		Local traffic controller sets shunting route from signal 670 to signal 686 (shunting route to G4)	Traffic control log	Deviating time in traffic control log
		Shunter notices rolling freight cars and notifies local traffic controller	Conversation	
		Local traffic controller engages lowering brake	Conversation	
13:07:00		Local traffic controller sets train route from signal 670 to signal 700	Traffic control log	
13:07:07		Freight car set passes main departure signal M at Alnabru	CTC log	Schenker's CCTV camera shows 13:07:11
13:07:48	13:08:45	Telephone conversation between Hovedbanen traffic controller and Alnabru local traffic controller	GSM-R log	Alnabru local traffic controller informs the traffic controller
13:09:36	13:13:34	Telephone conversation between Oslo S traffic controller and Loenga local traffic controller	GSM-R log	Discuss possible train routes

Time				
Start	End	**Event**	**Source:**	**Comments**
13:09:47		Freight car set passes Bryn main approach signal	CTC log	
13:10:58		Freight car set passes Bryn main departure signal	CTC log	
13:12:00		Traffic controller alerts 110 and requests triple alert	CTC log	
13:12:40		Freight car set enters Loenga track 10	CTC log	
13:12:54		Freight car set breaks derailer in track 10	CTC log	
13:13:00		Freight car set leaves Loenga	CTC log	
13:13:15		First derailment at Kongshavn	Estimated	
13:13:25		Freight car set hits gate building	Estimated	
13:15:18	13:16:46	Telephone conversation between Hovedbanen traffic controller and Alnabru local traffic controller	GSM-R log	
13:23:59	13:24:51	Telephone conversation between Oslo S traffic controller and Loenga local traffic controller	GSM-R log	

2.6 Documentation of operational conditions

2.6.1 Personnel working hours and shifts

The shifts indicated are in accordance with the working hours provisions.

Table 3: Shifts of local traffic controllers at Alnabru

Date: 22.03.2010	Date: 23.04.2010	Date: 24.03.2010
Shift 1350 – 2140	Shift Time off	Shift 06:50 – 14:00

Table 4: Shifts of shunters at Alnabru

Date: 22.03.2010	Date: 23.03.2010	Date: 24.03.2010
Shift 06:00–14:00	Shift 1400–2200	Shift 06:00–14:00

Table 5: Shifts of shunting engine drivers at Alnabru

Date: 22.03.2010	Date: 23.03.2010	Date: 24.03.2010
Shift start: 21:00 –	Shift end: 03:30	Shift 06:50–15:45

Table 6: Shifts of local traffic controllers at Loenga

Date: 22.03.2010	Date: 23.03.2010	Date: 24.03.2010
Shift 13:50–21:40	Shift 13:50–21:40	Shift 06:50–14:00

Table 7: Shifts of traffic controllers at Oslo S

Date: 21–22.03.2010	Date: 22–23.03.2010	Date: 24.03.2010
Shift 22:00–06:40	Shift 22:00–06:40	Shift 06:30–14:10

Table 8: Shifts of traffic controllers on Hovedbanen

Date: 21–22.03.2010	Date: 23.03.2010	Date: 24.03.2010
Shift 22:00–06:40	Shift Time off	Shift 06:30–14:10

Table 9: Supervisor shifts, traffic control centre

Date: 22.03.2010	Date: 23.03.2010	Date: 24.03.2010
Shift Time off	Shift 06:30–14:10	Shift 06:30–14:10

2.6.2 Medical and personal circumstances

All the personnel involved had undergone medical examinations at the prescribed times. There were no exemptions or provisos of any kind. No other circumstances with a bearing on the incident were discovered.

The staff had no concurrent duties or tasks which influenced the incident in any way.

2.6.3 Workplace layout and operation

The Alnabru interlocking system is described in section 2.2.3. The slip control system, NSI 63 and Ebilock 850 are operated by the local traffic controller and the assistant local traffic controller. Instructions dated 15 June 2008 for the assistant local traffic controller at Alnabru describe that the assistant local traffic controller's duties include operating the slip control system and assisting and relieving the operator of the main control centre (NSI 63 and Ebilock 850). When operating the slip control system, the operator sits with a view of the tracks to the front and side (see Figure 17). The control panel for the brakes is to the left (see Figure 16).

No separate instructions have been prepared for the local traffic controllers at Alnabru, but the NNRA has stated that one of the local traffic controller's duties is to operate the main control centre. When operating the NSI 63 system, the operator sits with his/her back to the slip control system and the tracks (see Figure 14). The Ebilock 850 monitors are arranged in a semicircle to the right of the NSI 63 system. When operating the Ebilock system, the operator has the NSI 63 system behind and on his/her left-hand side, and the tracks on his/her right-hand side (see Figure 15).

Figure 14: NSI 63 control panel.

Figure 15: Ebilock 850 monitors and operator's work station.

Figure 16: Control panel for brakes.

Figure 17: Work station for Westinghouse slip control system The control panel for the brakes to the left.

The AIBN has been informed that at times the interlocking system can be operated by only one local traffic controller, but that this is an exception, during parts of weekends and public holidays.

The NNRA carried out a change analysis of the local traffic controller's work situation at Alnabru freight terminal in 2006, and chapter 2.13.3.5 of this refers to the challenges caused by the design and location of the system that the local traffic controller has to use for his/her work:

> *The yard's interlocking system is composed of several types of systems and is showing signs of wear and tear.*
>
> *The local traffic controller has to physically move between the different work stations / control systems in order to carry out the various operations.*
>
> *It is hard to get an overview of the traffic situation.*
>
> *The work stations face away from and do not have a view of the station facilities. (This does not apply to the slip control system).*

The change analysis' description of the general traffic pattern and situation for the local traffic controllers is based on:

The traffic pattern is complicated because different trains often arrive and depart at the same time and have different destinations.

Simultaneous shunting movements.

Freight cars being 'slipped'.

Locomotives being parked/moved.

Track maintenance machinery etc. being deployed/moved.

Alnabru freight terminal operates with five different boundaries

There are diverse forms of train operations.

The change analysis identified a number of risks/ one-off incidents inherent in the interface between traffic control and train operations, which can be related to the design of the work stations, including the following:

The local traffic controller and pointsman misunderstand each other and the wrong track is laid.

The local traffic controller misinterprets a situation when he/she does not have electronic indication of the freight cars' location (except within the spiral braking zone), and could thereby send freight cars onto occupied tracks.

It is impossible for the local traffic controller to have a continuous overview when he/she has to move between different screens. The local traffic controller is therefore slower, and cannot become aware of situations in time to avert incidents (...) it is possible for the local traffic controller to misunderstand the indications on the various screens.

At present, different kinds of traffic movements take place at the same time. These are being indicated continually on the different screens and this means that the local traffic controller's job can easily become stressful, as he/she continually has to move between the screens. It is thus easy to overlook important factors.

The change analysis resulted in the decision to increase manpower, so that there would always be two local traffic controllers in the Central Control Tower at Alnabru.

2.6.4 Other information

The traffic control room in the Central Control Tower is not secured with access control.

2.7 Rescue operations

2.7.1 Ambulance and health resources

2.7.1.1 *Organisation*

At 13:25 the first of the rescue service units arrived on the scene. This was in the form of the medical response team leader and one ambulance. Six ambulances and the medical response team leader were in place within the first 12 minutes. In the course of the next 8 minutes, a total of 15 ambulances and three helicopters arrived on the scene. The three critical casualties were evacuated to Ullevål Hospital, while the less seriously injured were taken to the emergency outpatients' ward (Oslo legevakt). At 13:57, most of the ambulances had been demobilised from the scene of the accident. Two ambulances were retained in case more casualties were discovered.

Several hospitals in the Oslo area announced a medical disaster situation, despite the fact that this was quickly reported to be unnecessary.

2.7.1.2 *On-scene time*

The principle of the ideal on-scene time[3] was not achieved for one of the patients in this incident. The AIBN has not investigated whether this had any medical impact on the patient.

2.7.2 Fire and rescue services

At 13:25 the first unit from Oslo Fire and Rescue Services passed the first injury scene (at Kongshavn) and drove on to the second injury scene (at Bekkelagskaia). Five units from Oslo Fire and Rescue Services arrived at the second injury scene within the first 15 minutes. Oslo Fire and Rescue Services were present on the scene with a total of 11 units comprising 29 crew members.

2.7.3 Police

The first police unit arrived on the scene at 13:26. They reported that there were two injury scenes, and only one casualty at the first injury scene. At 13:31 a mobile command centre had been set up close to the injury scene by the incident commander.

All the police incident commanders were at a meeting at Police Headquarters when the incident occurred. This meant that the police had better than normal access to operational and command personnel. The police had ample resources in place within the first 15 minutes.

2.8 The Norwegian National Rail Administration (NNRA)

2.8.1 General

In 1996, the former NSB was split into a traffic division (NSB BA) and an infrastructure division under the Norwegian National Rail Administration (NNRA). NSB BA has operational responsibility for rolling stock and for passenger and freight traffic. The state administrative agency NNRA became responsible for railway infrastructure, including systems and equipment, infrastructure operation and traffic control. The NNRA reports directly to the Norwegian Ministry of Transport and Communications.

The NNRA's core processes include: (1) planning, designing and building infrastructure, (2) operating and maintaining infrastructure, (3) capacity allocation, (4) operational traffic control. The NNRA is responsible for providing the Norwegian public with a safe railway network, and for coordinating this work with the railway undertakings. The NNRA regulates access to its tracks via an access contract with the various railway undertakings.

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[3] Please see the following references regarding guidelines for ideal on-scene time:
Prehospital Trauma Life Support (PHTLS) Interdisciplinary Emergency Service Cooperation (TAS) Norwegian Air Ambulance course 2, and several health authorities' Medical Operations Manuals (MOM) describe the ideal on-scene time as 10 minutes. Advanced Trauma Life Support (ATLS), PHTLS and trauma manuals describe the 'golden hour': the time from injury to surgical intervention should not exceed one hour.

In 2010, the NNRA focused on the following safety factors (ref. NNRA presentation of May 2010):

- *the National Rail Administration has a vision of zero fatalities as a result of railway activities.*
- *the number of incidents resulting in serious harm to people, the environment or equipment shall be reduced by at least 20% by the end of 2013*
- *analysing risks and learning from undesirable incidents are two key elements in the National Rail Administration's safety management programme.*
- *The National Rail Administration has engaged Det Norske Veritas to monitor the work initiated to further reinforce the organisation's safety culture.*

2.8.2 Organisation at the time of the accident

The NNRA consists of three divisions: Infrastructure Management, Infrastructure Construction and Traffic Management. There are safety support entities at several levels in the NNRA's organisation (see Figure 18).

The NNRA's Traffic Management Division is responsible for traffic management. The Director of Traffic has overall responsibility for the Traffic Management Division, which consists of staff entities (including Safety and Quality) and line entities (Stations and Public Areas, Timetables, Customer and Traffic Information, Traffic area East, Traffic area West and Traffic area North). The respective traffic areas are managed by traffic managers. Within each traffic area there are train operation managers responsible for their respective traffic control centres, and area managers responsible for local traffic control in their respective geographic areas, including manned stations.

Oslo Local Traffic Control (including Alnabru and Loenga) and Oslo Traffic Control Centre are part of Traffic East. At the time of the accident, Oslo's area manager for local traffic control had personnel responsibility and line manager responsibility for all local traffic controllers in the Oslo area (a total of 62 employees), including the 23 local traffic controllers at Alnabru and Loenga. The office of Oslo's area manager for local traffic control was in the NNRA's premises at Oslo S.

The local traffic controllers at Alnabru and Loenga had team leaders. The team leaders had no personnel responsibility, and their position could be compared with that of a foreman in the industrial sector. The team leader's office was in the Central Control Tower at Alnabru. After the accident, the NNRA also established a line manager position for Alnabru, with personnel responsibility for the local traffic controllers.

The Director of Infrastructure has overall responsibility for the Infrastructure Management division, which consists of staff entities (including Safety and Quality), and line entities (Maskinsentralen, Bane Energi, Bane Nett, Bane øst, Bane nord and Bane sør/vest). Deputy infrastructure directors run the regional entities which again are split into infrastructure districts managed by permanent way superintendents.

Alnabru is part of the Østfold and Kongsvinger lines, and comes under the jurisdiction of the Eastern Region. The discipline area for infrastructure includes a supervisor with responsibility for the Alnabru section. The supervisor has an office in the Central Control

Tower at Alnabru. Correspondingly, supervisors have been appointed for Alnabru in the discipline areas Energy and Signalling/Telecommunications.

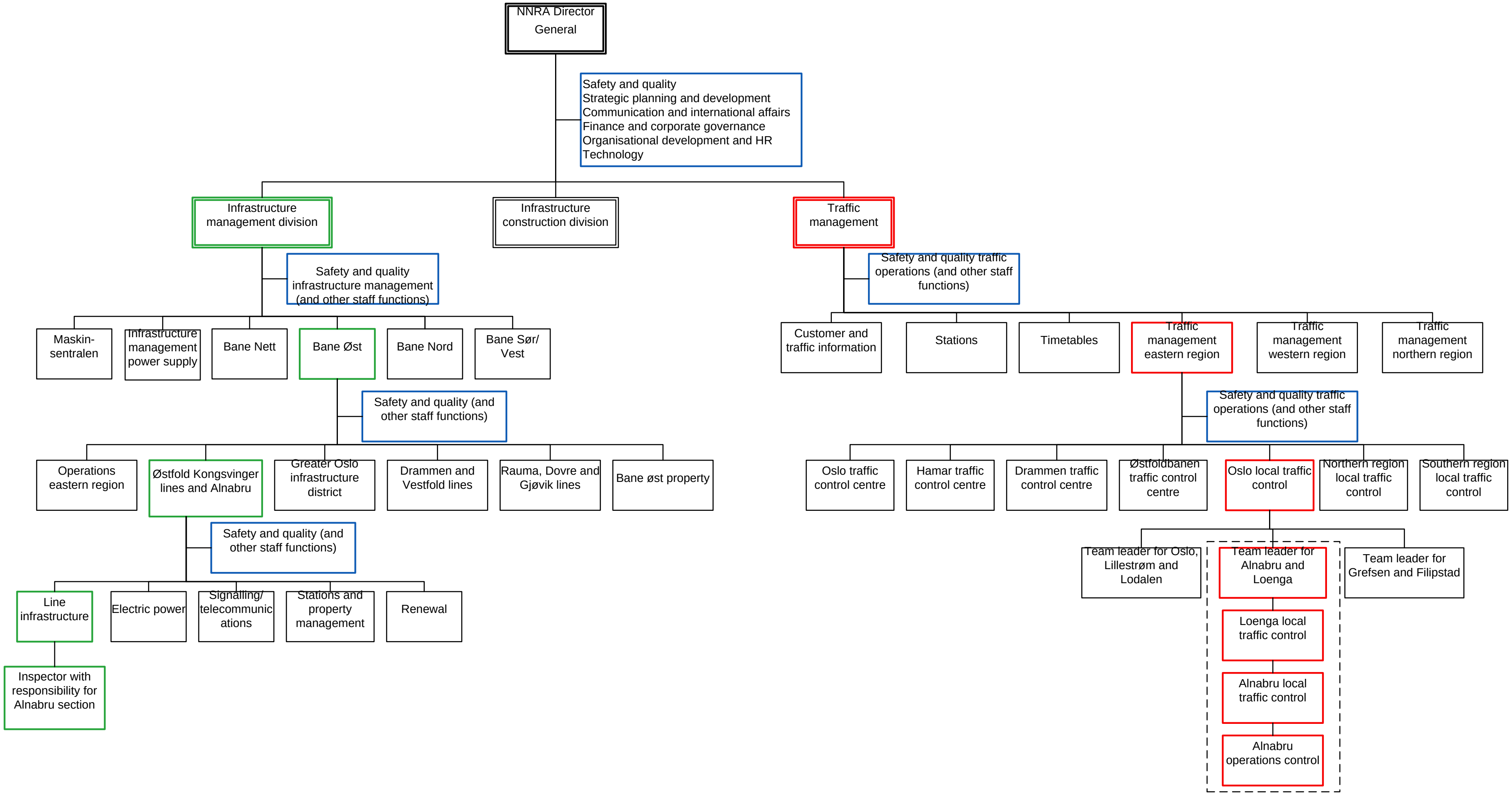


Figure 18: Organisation chart for the NNRA showing the position of Alnabru and the safety support organisation.

2.8.3 Safety Management

The NNRA's Safety Manual describes the NNRA's safety management and is a part of the NNRA's management system. The Safety Manual describes the NNRA's safety policy and overall safety goals, provides tools and describes how to comply with the relevant safety-related legislation.

The Safety Manual (most recent revision before the accident of 4 March 2010) is a comprehensive document totalling 116 pages and contains the following chapters: Introduction, Acts and Regulations, Terms and definitions, Safety management in the National Rail Administration, Organisation and responsibility, Risk acceptance criteria, Risk analysis method, Emergency response, the National Rail Administration's Accident Commission, Learning from undesirable incidents.

Relevant excerpts and quotations from the Safety Manual are given here:

2.8.3.1 *Safety philosophy and safety targets*

> *In order to meet the overall target (*the zero vision*), and still be able to choose those solutions which give the best safety results from a general perspective, the following sub-goals are defined:*
>
> - *Changes or modifications to the system or rolling stock must help to maintain or raise the level of safety; see the chapter Risk acceptance criteria.*
> - *The work on developing and implementing risk-reduction measures must be ongoing, even if the requirements for an acceptable level of risk have been satisfied; see the chapter Risk acceptance criteria.*
>
> *Changes to infrastructure, traffic management or work processes may in certain instances result in an isolated reduction of the safety level. These changes must be approved by the Director of Safety.*

2.8.3.2 *Safety Management*

> *The NNRA's risk-based safety management is based on assessing the safety consequences of changes. Safety assessments must also be used as a starting point for decisions and prioritisations.*

2.8.3.3 *Line manager's responsibility*

> *Safety is the line manager's responsibility.*
>
> *The line management is responsible for ensuring that all employees have been fully trained in the skills they need to carry out their work safely and responsibly.*
>
> *The line management receives professional safety support in its safety management work at various levels of the organisation.*
>
> *All line managers are responsible for ensuring that safety analyses and assessments are used as a basis for any decisions, and for any potential actions and changes that have a safety implication.*
>
> *All employees have a duty to raise the alarm if there is any threat to safety.*

2.8.3.4 *Organisation of safety support*

> *The Safety Director is charged with systematically monitoring the safety management system on behalf of the Director General of the NNRA, to ensure that the safety management system works, and that a defined level of safety is achieved at all levels of the organisation.*
>
> *The NNRA's Safety and Quality department's particular responsibility is to put in place and develop a framework for safety work. The Infrastructure and Traffic Management safety organisation supports the line managers in the two divisions.*

2.8.3.5 *Risk analysis method*

This chapter of the Safety Manual discusses in broad terms the process of performing risk analyses in the NNRA. It does not specify how frequent risk analyses should be, or what specific circumstances or scope of change would require a risk analysis to be initiated.

It appears that a risk analysis is initiated when the NNRA needs support for its decisions. Emphasis is given to the group's overall skills and quality assurance of the analysis. In the analysis phase, risk identification is carried out so as to find out what could go wrong in the system, and identify operational and technical barriers, and any potential single failures. Risks which are obviously negligible do not need to be analysed further.

The NNRA has defined seven top incidents: Derailment, train-to-train collision, train-to-object collision, fire, passenger injured on platform, people injured at level crossings, people injured on or beside tracks. Frequency and consequence categories are stipulated for each risk, using statistics available from accidents and near-misses. The NNRA's primary sources of statistics are Synergi and BaneData. The risk is assessed in relation to the NNRA's acceptance criteria. The acceptance criteria must be complied with at all times, and actions to reduce the risk shall always be considered.

The risk analysis is documented in a report. The report must be clear with respect to the conclusions, stipulations and assumptions used in the assessment, recommended measures and a follow-up plan. If there is any disagreement regarding the conclusion(s), this must be described in the report. A risk log shall be used to document how the decision, stipulations and measures are addressed, by clearly indicating responsibilities, deadlines and how these are followed up.

2.8.3.6 *Learning from undesirable incidents*

This chapter in the Safety Manual describes the NNRA's requirements for reporting, handling and following up undesirable incidents.

Synergi is the NNRA's data tool for registering, following up, correcting and reporting undesirable incidents. Synergi is used to document how logged cases are handled and how actions and investigations are followed up. Synergi data forms the basis for accident statistics, indicators, trends and reports.

The NNRA's Safety and Quality department's Quality section owns the Synergi system. The NNRA's various entities are specifically charged with responsibility for ensuring that the Synergi reports they receive are registered and handled. The NNRA has established fixed locations for registering Synergi reports. These locations will also provide feedback to the persons who report in each case (if they provide their name and e-mail address). It is the line manager's duty to then pass on to his colleagues the status of cases that were registered in his/her entity. In addition, registered cases shall be regularly examined in a regional forum.

2.8.4 Internal audits and supervisory activities

The NNRA carries out internal audits to ensure that governing documents are being complied with. The following is a quote from the NNRA's 2010 audit programme:

> *'Carrying out planned audits (compliance audits) of compliance with, and existence and knowledge of procedures within particular risk areas is a priority and, based on the findings of previous audits and inspections, the NNRA has pledged to the Norwegian Railway Inspectorate that it will carry out compliance audits using the management system and applicable regulations as audit criteria. The focus of the compliance audits are matters related to safety management, and areas of particular significance for safety. Any of the NNRA's areas of activity that are of particular significance to safety shall be covered by compliance audits.*
>
> *Compliance audits are essential to the task of promoting a good culture of safety and accuracy.'*

The audits / supervisory activities will be carried out by the safety support organisation. The central audit plan will be prepared on the basis of input from the traffic managers and district permanent way superintendents. Operational inspections / random checks in the Traffic Management division will be included in the central audit programme.

The AIBN has received the NNRA's 2009 and 2010 audit programmes. The audit programmes state audit area, objective, scope and planned time of implementation. The audit areas and subjects are based on assessments of risk and other material factors. The eastern traffic area (Trafikk Øst) was included in the programmes for both years. However, the AIBN has been informed that, until the time of the accident, Alnabru had not been included in the central audits. Nor had the line management requested any extra inspections of the operations at Alnabru.

Quality control playbacks of conversations between traffic controllers and drivers were not performed in 2009 and 2010 for reasons of personal privacy protection, but the AIBN has been informed that the NNRA is working on new guidelines for this.

2.8.5 Notification plan and hierarchy in case of accidents and incidents

When the accident happened, the NNRA initiated actions based on the authority's emergency response manual and emergency response plan. The traffic controller was notified by the Alnabru local traffic controller, who initiated notification in accordance with the notification list in the emergency response plan.

2.8.6 DNV – Survey of the safety culture in the NNRA

2.8.6.1 *Background*

On 3 April 2008, the NRA rejected the NNRA's application for a safety certificate as a consequence of inadequate safety management. Nevertheless, on 26 June 2009, the NRA adopted a resolution granting the NNRA a safety certificate for a duration of three years. The NRA's resolution made it clear that renewal of this certificate in 2012 would depend on the quality and results of the NNRA's process of improving its safety management and safety culture.

The NNRA therefore engaged Det Norske Veritas (DNV) to assist with the work of reinforcing and improving its safety culture. DNV's task is to evaluate and document the effects of the measures put in place by the NNRA as part of this ongoing improvement project. The AIBN has reviewed the survey of the NNRA's safety culture conducted by DNV as the first part of its assignment for the NNRA.

2.8.6.2 *Results*

DNV's survey of the safety culture consisted of questionnaires (a total of 2282 respondents) and interviews (a total of 102 interviews), and was conducted during the spring of 2010 (March–June).

DNV has summed up its work in 21 conclusions which identify areas the NNRA should focus on to make *'safe systems even safer'*. The following is taken from the report's summary section:

> *The NNRA comes across as an organisation in which managers and employees seem genuinely concerned about safety, and in which safety is regarded as an important part of the day-to-day work of the organisation. Among other things, this is demonstrated by how well conflicting goals are handled. For instance, there is no doubt that safety takes priority if there is a conflict between safe train operation and punctuality or regularity. This is a good starting point for further work on improving the safety culture.*
>
> *However, the report also paints a picture of an organisation with a potential for improvement in the main areas surveyed by DNV. The most important examples are:*
>
> *Organisational learning*
>
> *The NNRA has a potential for improvement in its understanding of, attitudes to and practical use of reporting tools as a basis for organisational learning and continual improvement.*
>
> *Compliance*
>
> *The National Rail Authority has a potential for improvement in its compliance with rules and procedures. At present, it is largely the degree to which rules are perceived to be safety-critical that determines compliance. This creates a basis for inconsistent practice.*
>
> *Working together*
>
> *The NNRA faces a challenging task in getting its divisions and units to work together. The organisation also has a potential for improvement in the work of clarifying roles and responsibilities. Furthermore, the organisation does not seem to fully understand that the challenge of working together can also have an effect on safety.*
>
> *DNV also considers that the NNRA could develop the organisation's understanding of the concept of safety. This would involve establishing an understanding that the existence of technical systems and procedures does not*

mean that safety can be taken for granted; safety is dynamic and must be continually established and improved.

DNV considers that the NNRA must take general trends in the organisation's culture into account in its effort to reinforce the safety culture. The NNRA comes across as an organisation that is facing challenges relating to working together to achieve overall goals. The task of improving the safety culture is a demanding one. It is therefore important that the NNRA manages to establish a common understanding that improving the safety culture is essential so that all parts of the organisation can work towards this goal together.

The AIBN has had access to the results of the safety culture survey conducted in the organisational entity Oslo Local Traffic Control, which includes Alnabru. The results from this entity do not differ significantly from those of the division to which it belongs (Traffic Management East) or the NNRA as a whole. The survey did not include collaboration between the NNRA and other organisations.

2.8.7 Meetings – structure and participation

2.8.7.1 *Staff meetings*

The local traffic controllers attend monthly staff meetings. In addition to this, there is employee participation in the line organisation, i.e. matters are raised with the team leaders, who pass them on to the person with personnel responsibility (area manager).

2.8.7.2 *Bipartite council*

As a government agency, the NNRA is bound by the Basic Agreement between the Confederation of Norwegian Enterprise (NHO) and the trade unions, and has established a bipartite council. The employee and management representatives have regular meetings for information, discussion and negotiation purposes.

2.8.7.3 *Working environment committee (WEC)*

Alnabru is represented on the joint working environment committee (WEC) for Traffic East and Infrastructure Management East. Through documentation and interviews, the AIBN has learnt that the committee holds meetings four times a year. The meetings have focused on the areas that are relevant to that forum, such as sickness leave, use of overtime, reported injuries, undesirable incidents, reports from safety rounds, noise and other physical conditions, the manpower situation and training plans.

Working environment surveys are submitted to the WEC when they have been reviewed.

The corporate health service submits an annual report on the working environment to the WEC, which is discussed in this forum. Current representatives receive information from the central working environment committee (CWEC).

The local traffic controllers and other Alnabru employees did not have a local safety representative. Following the accident, the NNRA has made arrangements for a local safety representative at Alnabru.

Chief safety representatives also participate in other forums and hearings on matters affecting the working environment, including proposals for restructuring.

2.9 CargoNet AS

2.9.1 General

When NSB was split in 1996, the freight traffic operations section became a separate entity (NSB Gods). In 2002, the freight traffic section became a limited company with the name of CargoNet AS.

At the time of the accident, the CargoNet AS group was a partially owned subsidiary of NSB AS in Norway, which owned 55% of the shares, with the Swedish railway company Green Cargo AB owning 45% of the shares (CargoNet AS has been wholly owned by NSB AS since 30 November 2010). CargoNet AS runs all the Norwegian operations, while the wholly owned subsidiary CargoNet AB is responsible for operations at terminals in Sweden. CargoNet AS is responsible for train operations.

Cargo Net AS's head office is in Oslo. According to the company's website, it had a turnover of approximately NOK 1.511 billion and employed approximately 929 staff in 2009.

CargoNet AS is Scandinavia's largest railway undertaking transporting containers, swap bodies and trailers. CargoNet AS carries freight in a network of 22 container terminals in Norway and Sweden, and between Scandinavia and the continent. The company's vision is: '*The world becomes a bit better when the cargo is on track.*' In 2008 the company was running about 100 trains every day, fully laden with mixed cargo and consignments. One train replaces about 24 lorries.

At the time of the accident, 24 CargoNet AS trains were operating in or out of Alnabru daily. Bring, Norway Post, Schenker, Tollpost and DHL represent 75% of its customers. Sixty per cent of the units are 25 foot swap bodies, 25% are semi-trailers, 10% are 40–45 foot containers, and 5% are sea containers. CargoNet AS also operates the jet fuel train service with 380 trains annually.

2.9.2 Organisation at the time of the accident

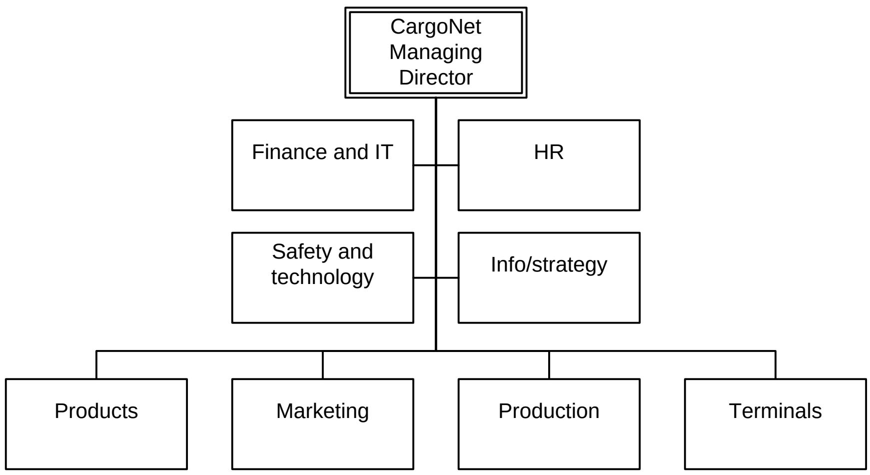


Figure 19: Organisation chart for the Cargo Net AS group.

The terminals director, who reports directly to the managing director, is responsible for all terminals owned / used by CargoNet AS, including Alnabru. The organisational entity

Safety and Technology is a staff entity covering the areas of technology, quality and traffic safety, and reports directly to the managing director.

Each terminal is in turn managed by a terminal manager. At Alnabru, team leaders coordinated terminal logistics (train movements, loading/unloading, shunting).

CargoNet AS had 120 employees at Alnabru distributed as follows: delivery and arrival checks (20 staff), train handling preparation/ shunting (45 staff) and loading/unloading trucks/cranes/ terminal tractors (45 staff).

CargoNet AS's organisation at Alnabru terminal:

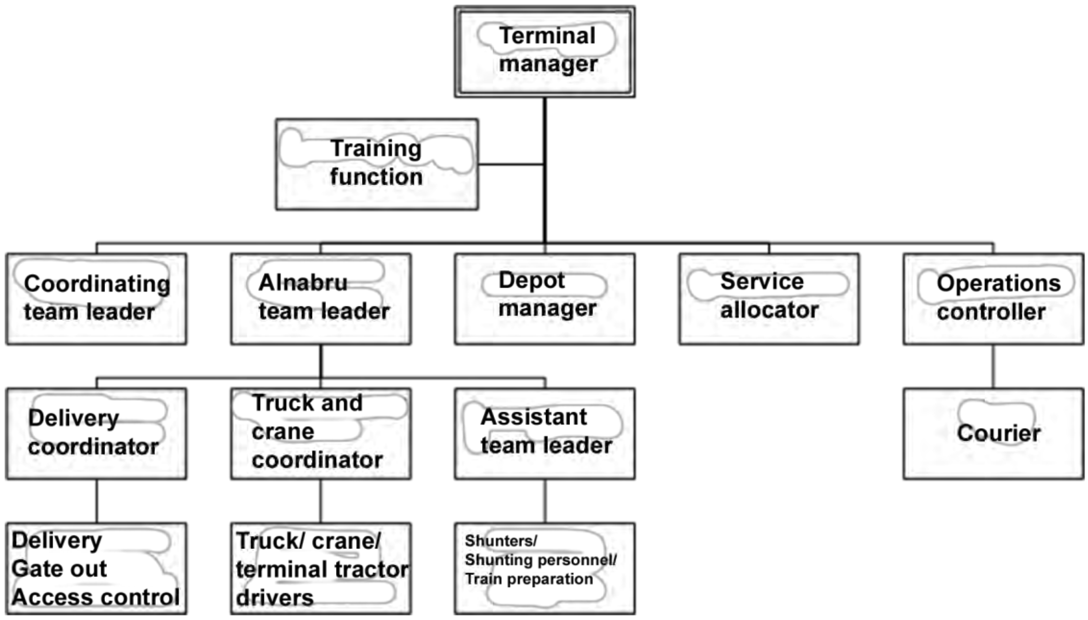


Figure 20: Organisation chart for Cargo Net AS at Alnabru.

2.9.3 Safety management

Chapter 5 in CargoNet AS's overriding management system describes traffic safety management. The document is 18 pages long and includes the following chapters: Purpose; Area of validity; Responsibility and authority; Definitions; Traffic safety document structure; Acts and Regulations in Norway and Sweden; Safety policy and principles; Continual safety work in CargoNet AS; Reporting; Investigation and notification of undesirable incidents; Emergency response; Traffic safety programme; Traffic safety follow-up plan; Handing of nonconformities; Audits; supervisory activities; Inspections and safety rounds; Audit history; Approval.

Relevant excerpts and quotations from the traffic safety management system are presented below (most recent revision dated 12 January 2010):

2.9.3.1 *Responsibility and authority (page 2)*

Traffic safety is a line responsibility, with the managing director bearing ultimate responsibility. Each line manager is responsible for traffic safety in his/her area of operation.

2.9.3.2 *Safety policy (page 6)*

The activities of CargoNet AS shall not lead to loss of human life or cause serious personal injuries.

The work of avoiding injuries to people and damage to materials or the environment shall be systematic and continuous.

2.9.3.3 *Principles of safety management (page 6)*

Safety Management in CargoNet AS is based on the following principles: safety must be prioritised, safety is everyone's responsibility, all work processes must be carried out in accordance with rules and regulations, analyses must be performed to maintain an overview of the risk picture, and appropriate action must be taken.

2.9.3.4 *Overall acceptance criteria (page 9)*

Changes or new activities must not result in an increased risk, at least not beyond what is acceptable in relation to the change in activity level or production volume.

If accidents or serious damage could arise as a result of a single failure, then an extra barrier or other measure must be introduced, if possible, preferably of a technical/structural kind that reduces the likelihood of an accident, or other measures.

2.9.3.5 *Risk identification and analysis (page 10)*

Performing risk analyses involves systematically examining the activity, or a limited part of it, in order to identify the various risks that could be involved in the activity. The results of this work make it possible to give priority to necessary measures to keep risk at an acceptable level. All measures that emerge as a result of these analyses are transferred to a traffic safety follow-up plan (TSFUP).

2.9.3.6 *Overall risk picture (page 12)*

CargoNet AS shall prepare an overall risk picture for its activities, which shall provide an overview of the level of risk associated with train operations and shunting. The risk picture shall be put together from data collected from undesirable incidents and analyses of factors affecting risk.

2.9.3.7 *Risk picture for terminals and workshops (page 13)*

CargoNet AS will prepare risk pictures of its activities at terminals and workshops. Risk pictures showing details of each geographical area will be prepared, based on reports and local knowledge. The risk picture will be regularly updated and will assist in the task of setting traffic safety priorities. The risk picture for each terminal will include the following main themes:

- *Circumstances affecting traffic safety*
- *Changes of an operational or organisational nature*
- *Procurements or hire of rolling stock, equipment or personnel*
- *Maintenance programmes and upgrades to rolling stock*

2.9.3.8 *Internal reporting (page 15)*

> *Everybody in CargoNet AS shall use the same system to report undesirable incidents. Undesirable incidents shall be logged and followed up. There shall be a specific procedure describing how this must be done.*

2.9.3.9 *Traffic safety follow-up plan (page 17)*

> *The traffic safety follow up plan (TSFUP) is used to follow up specific safety-related activities and measures The plan should be continuously updated, and in this way will become a 'live picture' of all ongoing and planned risk-reduction activities and measures.*

2.9.4 Internal audits and checks

The following is taken from CargoNet AS's traffic safety management system (page 18):

> *The traffic safety management system shall be regularly audited, reviewed and examined in order to ensure that it works as intended.*

CargoNet AS has advised that one of the focus areas of its system audits is to ensure that any significant changes made to current regulations and instructions, including any changes to section descriptions, have been implemented. However, a system audit does not involve a systematic review of individual documents unless they have been revised. CargoNet AS had therefore not conducted any detailed review of all the provisions in the section description that covered Alnabru at the time of the accident.

The AIBN has been informed that the last audit of Alnabru before the accident was carried out on 5 and 6 March 2007, and that the last inspection was on 18 August 2009.

CargoNet AS has stated that the organisation is concerned about its consequence management and that disciplinary measures have been taken as a result of deliberate breaches of the safety provisions. At the same time, CargoNet has also made it clear to the AIBN that it is accepted that people make mistakes.

2.9.5 Notification plan and hierarchy in case of accidents and incidents

When the accident happened, CargoNet AS initiated notification and actions in accordance with the company's emergency response plan.

2.9.6 Meetings – structure and participation

Management meetings take place at the terminal every Monday. The managers also have an extended meeting with the safety representatives and employee representatives every six months.

The company also has task managers to attend to operational issues. The Alnabru operations controller at Alnabru is central to the working relationship with the NNRA, both in connection with safety rounds and for preparing track usage schedules. Preparing these track usage schedules is essential, because the NNRA changes its timetables. CargoNet AS's shunters are also involved in the process, to ensure a practical approach.

A total of six safety meetings and four staff meetings are held annually, as well as annual performance appraisals and development discussions and planning discussions.

CargoNet AS has a local working environment committee (WEC) at Alnabru and a central working environment committee (CWEC) at the group level. Meetings are held quarterly in each forum, and agenda items are sickness leave, injury monitoring etc.

2.10 Oslo Havn KF

2.10.1 General

The Port of Oslo is Norway's biggest public freight and passenger port. It is managed by Oslo Havn KF (HAV) – a municipal enterprise with its own board. The enterprise's main aims are to ensure efficient and expedient port operations. The NRA has granted HAV a permanent mandate to operate Oslo's port railway system. HAV is thus the infrastructure manager for the railway tracks in the Sydhavna area.

2.10.2 Development of Sydhavna

In 2008, Oslo City Council decided to establish Sydhavna as Oslo's permanent cargo port. All container traffic is therefore being moved there. The Sjursøya area is one part of Sydhavna. HAV has plans to redevelop the port railway system in Sydhavna in several phases. In 2014 and 2015 it is aiming to build new tracks and a fuelling plant for the jet fuel train after building a new access route to Sydhavna at Kongshavn. It will then be possible to redevelop the tracks at Søndre Bekkelagskai.

2.10.3 Safety Management

Oslo Havn KF has prepared an operations manual for railway tracks (dated 15 November 2004). This contains the basis for its application to the NRA for a permanent mandate to operate railway tracks. The operations manual contains the safety case, safety plan, operations and maintenance procedures, hazard identification and hazard log, rough analyses – shunting movements at the Port of Oslo and drawings.

2.10.4 Notification plan and hierarchy in case of accidents and incidents

The notification procedures for the Port of Oslo are set out in HAV’s operations manual. The notification procedures described there are operationally effective and functional. The procedure *Notification and reporting of railway accidents* describes how to notify, report and follow up railway incidents and accidents on the railway tracks owned by HAV. It does not describe how the NNRA's traffic management or local traffic controllers should notify HAV should that become necessary.

In close cooperation with the police, fire and ambulance services and the NNRA, HAV has prepared an emergency response plan, to limit the scale of any damage in the event of an accident, and to prevent accidents. The emergency response plan applies generally to all accidents, and does not mention railway accidents in particular, but according to the operations manual, it was to be updated on this point (which had not been done at the time of the accident).

HAV has informed the AIBN that if there are any circumstances that could have a negative effect on safety (for instance track work, a fault in the road barrier system at

Sjursøya junction, tracks closed etc.), the Sydhavna district notifies the Loenga local traffic controller and the traffic operator. If there are any factors regarding traffic operations that are not in accordance with the track access contract/agreement, these must be raised directly with the traffic operator, who must be kept informed of these factors.

In a meeting with the AIBN, HAV mentioned that the NNRA needs to have better procedures in place regarding local traffic controller's notification of HAV. However, HAV also feels that it is impossible to make allowances for the recurrence of a similar scenario. It is neither possible nor practical to establish an escape/evacuation plan for the area. The Port of Oslo is an industrial area where loading and unloading takes place on a large scale and involves many parties. Something could potentially happen across the entire area, which is why no fixed escape routes have been established. It has been pointed out that if the accident had happened at 07:00 for example, 25 to 30 trailers would have been waiting outside the gate building, and then there would have been considerably more casualties.

2.11 Interaction between the organisations

The NNRA is the infrastructure manager, and in accordance with section 4–3, final paragraph of the Safety Regulations, must take into account how the various railway undertaking' activities affect the network. The NNRA is also the Principal Enterprise for activities at Alnabru, in accordance with chapter 2 of the Working Environment Act. The Principal Enterprise is responsible for coordinating the health, safety and environment work of the various enterprises.

2.11.1 NNRA and CargoNet AS

The following formal forums have been set up for contact and coordination purposes between the NNRA and CargoNet AS.

SCQ (safety, coordination and quality) meetings: these are held monthly for each traffic control area, and the NNRA, NSB, the Airport Express Train and CargoNet are expected to attend. Alnabru is part of the Oslo traffic control area. The agenda is described in the NNRA's management system. The AIBN has examined documentation from some of the 2008–2009 SCQ meetings and found that CargoNet AS has repeatedly drawn attention to the lack of space at Alnabru. The challenges involved in snow clearance were also a recurring subject. On this point, the minutes refer to specific measures, where the parties concerned were involved in the process.

The AIBN has been informed that during periods of heavy snow, there are daily meetings between the team leader for the local traffic controllers at Alnabru and CargoNet AS, in order to get on top of the situation.

Alnabru operational meetings: these are held monthly and are attended by the team leader for the local traffic controllers at Alnabru and a representative of CargoNet AS terminal management staff (operations controller).

Coordinated safety rounds at Alnabru are carried out annually and involve participants from the NNRA (Infrastructure Management and Traffic) and CargoNet AS (safety representative and terminal management). Main subjects: safety conditions, hazards, day-to-day safety, physical conditions.

The report from the previous safety round is discussed and local safety rounds are incorporated. A field inspection is also carried out, to see what has been implemented.

S circulars are prepared and distributed by the NNRA to all the users of the infrastructure.

CargoNet AS must notify the NNRA directly, through traffic controllers or local traffic controllers, if there are any circumstances affecting traffic safety that require immediate action. The NNRA must be notified via Synergi of any undesirable incidents on its infrastructure.

Safety coordination meeting, a forum at the heads of safety level.

At the time of the accident, Alnabru did not have a common arena for the HSE organisations of the NNRA, CargoNet AS and other parties.

2.11.2 NNRA and (HAV)

The Sydhavna district is in daily operational contact with the NNRA's local traffic controllers regarding operations at the port. HAV has informed the AIBN that they feel that they had good dialogue with the NNRA, both before and after the accident. HAV and the NNRA also keep each other mutually informed of each other's plans, and there has been a need for regular contact, particularly regarding the Sydhavna redevelopment plans.

2.12 Structural changes and growth in freight traffic by rail

2.12.1 Structural changes

During the latter half of the 1980s and throughout the 1990s, there was a structural change in freight traffic by rail. Traffic schemes switched from conventional freight wagon loads to shuttle trains with unit loads (containers, swap bodies and eventually semi-trailers). At the same time, the transport of timber and wood chips was separated from the wagon loads system and transferred to separate 'system trains'.

These structural changes led to a decline in the use of Alnabru S for breaking up trains, sorting wagons and making up new trains. Today, these activities are relatively rare. However, there is now a greater demand for parking space for freight car sets. The tracks at Alnabru S are mainly used for parking rolling stock between assignments or rolling stock awaiting maintenance.

2.12.2 Freight strategy – moving freight from road to rail

In recent years, the Ministry of Transport and Communications has been aiming to increase the amount of freight transported by rail. For example, the budget proposal for the 2007 fiscal year (*Den kongelige proposisjon om statsbudsjettet for budsjettåret 2007* – in Norwegian only) states that one of the government's goals is to considerably improve the operation of freight and passenger traffic. The government also proposes considerable increases to the railway's freight capacity for the year 2009.

The 2010–2019 National Transport Plan (NTP) states that the aim is to have almost doubled the railway's freight capacity by the end of the plan period. Alnabru is singled out as the major terminal project for that period.

Section 11.1 of the 2010–2019 NTP states that the government's main goal regarding transport safety is to maintain a continued high level of safety in air, rail and sea transport. This is emphasised further in section 11.3, Railway safety, where it is stated that the goal is to maintain and further improve the high level of safety during the plan period.

Over 12 million tonnes of freight were transported by rail in 2008, and a little less in 2009. The political goal is to switch more freight from road to rail. As part of its work towards the 2009–2010 NTP, the NNRA prepared a freight strategy in 2007 which aimed to double the volume of freight transported by rail by 2020 and triple it by 2040. The strategy describes the infrastructural and organisational measures that are necessary to enable continued growth in rail freight transport. Measures shall also be taken with the aim of achieving a punctuality target of 90% of all traffic. The strategy's background information describes developments in freight traffic:

- Significant growth of transport volumes.
- A steadily increasing containerisation of freight transport. Combined transport constituting about 85% of freight transport by rail, measured in number of tonnes, and about 90% measured in tonne-km.
- Freight increasingly being directed to major hubs and heavy transport corridors. A trend in rail transport towards fewer combined terminals handling ever increasing volumes of freight.
- Increasing challenges for road transport (regulations regarding rest breaks and driving hours, shortage of drivers)
- Focus on safe and environmentally friendly transport.

It describes how developments have brought capacity problems, particularly in the terminals, but also on the sections between the terminals. Most combined transport goes between the major Norwegian cities, with Oslo (Alnabru) as the transport hub.

The plan is to spend approximate NOK 3.7 billion on an expansion in capacity during the 2010–2019 decade. Terminal expansion and extra passing loops will be priorities. The freight strategy's first phase will be to prioritise the heaviest trafficked freight sections and, in this connection, the plan describes that measures will be taken to increase Alnabru's capacity.

The NNRA announced the following on its website on 7 December 2010:

> *The changeover to the new timetable period on Sunday 12 December will be accompanied by an increase in the number of freight trains. There are now a total of 14 train companies on Norwegian lines, and ten of them are operating freight traffic. The capacity of several sections is now increasing as a result of competition on the lines.*

The same announcement contained an account of which freight train companies are operating in Norway, and which routes the various companies are to operate.

2.12.3 Reconstruction and remodelling plans for Alnabru

Please refer to Appendix F, which describes the history and timeline for remodelling Alnabru.

While the shunting yard was completed in the early 1970s, the main part of the container terminal was built in the first half of the 1990s. Some completion work and minor changes were also carried out during the latter part of the 1990s.

Over the past ten years, plans have been drawn up for major remodelling and development of the facilities at Alnabru, designed to increase its capacity and adapt the facilities to the structural changes that have taken place. At the time of the accident, the reconstruction works had not yet started.

Several plans have been drawn up for the reconstruction of Alnabru. The first plan for major reconstruction works was prepared in 2001. The second plan was prepared in 2006, in 2008 and resulted in an expansion of the loading and unloading capacity, as well as in the capacity for handling incoming and outgoing freight transport. According to the NNRA, this reconstruction is to be regarded as an interim solution, until major reconstruction works can be carried out.

In 2007, the NNRA prepared a new master plan for Alnabru. The plan resulted in a cost estimate that formed the basis of the 2009 budget. After this master plan had been approved, the NNRA adopted the freight strategy that changed the conditions at the terminal. When work on the detail plan commenced, the master plan was assessed for quality assurance. The quality assurance assessment involved running simulations of the operational concept. The conclusion was that the measures described in the plan would not result in the expected capacity expansion, which had been their main purpose. The technical condition of some major elements of the terminal's technical railway infrastructure was shown to be extremely poor. It was pointed out that modification of the existing signalling system was deemed to be impractical. Critical bottlenecks in the recommended track plan were also mentioned. It was pointed out that further capacity expansion at the terminal would not be possible, based on the available track plan, and the need for parking tracks and buffer tracks was mentioned.

In spring 2010, the NNRA presented a new study on redeveloping Alnabru terminal which complied with the freight strategy and would also enable the development work to be phased. It proposes four construction phases, with the need for the remaining phases being assessed on completion of each phase. The first construction phase includes several measures which would have the combined effect of improving operations at Alnabru. During this first phase, it is proposed to upgrade the technical railway infrastructure, including with a new software-based signalling system. It is also proposed to include a new operations system to manage the terminal's logistics.

When the master plan for the first construction phase was being drawn up, a risk analysis of the track plan, signalling system and train and shunting movements was performed. The most important question to which the analysis was to provide answers was whether the proposed design of Alnabru would make it possible for train and shunting movements to be carried out safely. The analyses are qualitative and the risk levels have not been estimated. The risk analysis concluded that it would be possible to build the terminal so that the risk level would be acceptable, but this would involve measures beyond what would be considered normal for shunting areas. The reason for this is that there are conditions at Alnabru that increase the level of risk compared with other shunting areas. Further analyses are recommended in order to ascertain the actual scale of measures that would need to be implemented. It is envisaged that these analyses would quantify risks and compare them with acceptance criteria, and that all measures identified would be assessed against the NNRA's defined cost-benefit factors.

In a memo dated 6 September 2010 from the NNRA to the Ministry of Transport and Communications, it is stated that the completion time for this kind of remodelling project is long and extremely complicated. The NNRA has estimated a 6-8-year construction period for the first construction phase, with start-up of commissioning approximately one year prior to completion of the work, which it expects could be completed in 2021. The project is described as a complicated open-air site with a number of different functions to be developed and expanded in a densely built-up central area. An external company has carried out a third-party evaluation of the study, and describes the project as the NNRA's most complicated project in the time ahead.

The NNRA goes on to say that if the first construction phase is postponed or abandoned, then it must begin extensive planning and design work relating to the existing infrastructure.

This is because some major elements of the terminal's technical railway infrastructure are in extremely poor condition.

A large number of the components have reached or almost reached the end of their technical service life. It emphasises that a renewal plan for Alnabru involves maintaining current capacity, while renewing technical installations as necessary. It estimates that this renewal procedure would take 12 years.

2.13 Risk picture for Alnabru

2.13.1 Similar corresponding incidents

In 1938 some freight cars broke loose from the old Alnabru yard and derailed at Loenga. Geita bridge was damaged and collapsed.

In 1981, a freight car set broke loose from the mechanical brake at Alnabru S, rolled along the freight track and caught up with an uncoupled locomotive at Bryn before all the items of rolling stock derailed at Loenga. The material damage was extensive. Automatic pulsing of points 125 towards the R tracks was introduced after this incident.

17. On 17 March 2006, because of a build-up of snow and ice, a freight car set broke loose from the mechanical brake at Alnabru S and collided with a shunting engine after only 50 m, causing only minor material damage. The following quotation is taken from the AIBN's report on the incident (see RW Report No 6/2006).

The AIBN has been informed that, because of previous incidents, unless other shunting routes have been set and interlocked, the points below the mechanical brake on the A tracks are automatically set so that rolling stock which accidentally starts moving is guided down into the access brake and southwards onto the R track. Rolling stock which breaks loose on the A tracks cannot therefore get out of the yard and onto the main tracks.

2.13.2 Synergi reports for Alnabru

The NRA states that a total of about 1900 incidents at Alnabru have been reported to its Synergi database. The bulk of these concern stowing and securing, and only two of the incidents are of any relevance to the accident.

2.13.2.1 *The NNRA*

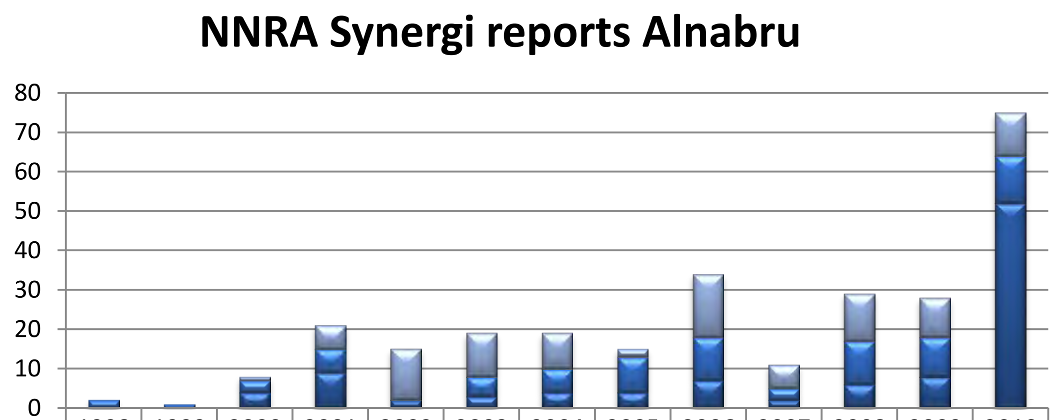
The NNRA states that about 14,000 incidents are reported annually in Synergi, of which approximately 8,000 to 9,000 concern the operation of infrastructure, and 2,000 of the infrastructure incidents are in the Oslo region.

A total of 248 incidents were reported to the NNRA's Synergi database between 1998 and 9 November 2010. The reported incidents were mainly undesirable incidents of derailments, collisions and people on the tracks.

In 2004, two instances of damage from collisions between moving rolling stock were reported. One was a collision of rolling stock being shunted on the R track, and the other was an unbraked freight car which rolled into a rail tractor in Alnabru's shunting area.

In 2006, the incident of 17 March was reported. There are no other Synergi reports regarding runaway rolling stock or lack of barriers at Alnabru.

Figure 21 shows that there were considerably more incidents reported in Synergi for Alnabru in 2010. This increase occurred after the accident. There was no increase in the number of reported near misses or injuries in 2010, but there were more reports regarding conditions. For example, after the accident in March 2010, there were more reports in Synergi regarding the working environment for local traffic controllers. The local traffic controllers' line manager has stated that they were not accustomed to reporting any working environment problems in Synergi, and that if they had any of those kinds of problems, they were handled through the performance appraisal and development discussions.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Skade			1	6	13	11	9	2	16	6	12	10	11
Tilløp	2	1	3	6		5	6	9	11	3	11	10	12
Tilstand			4	9	2	3	4	4	7	2	6	8	52

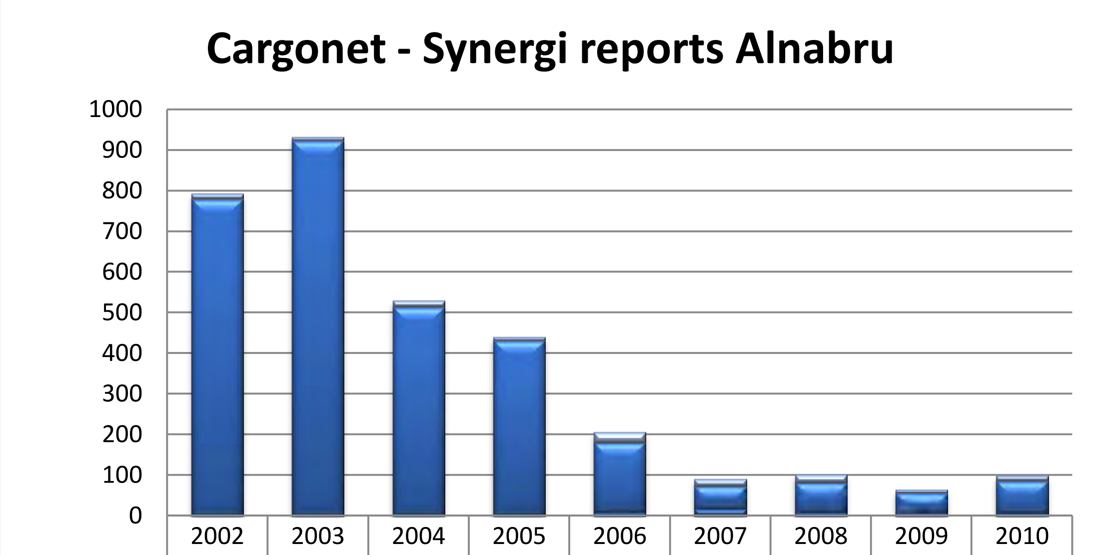
Figure 21: Synergi reports for Alnabru, NNRA 1998-2010. (Skade = injury/loss, Tilløp = Near misses, TIstand = conditions).

2.13.2.2 *CargoNet AS*

The AIBN has received a summary of Synergi reports from CargoNet AS's organisation at Alnabru for the period from CargoNet AS’s formation in 2002 until 2010.

Figure 22 shows a considerable reduction in the reporting of near-misses in Synergi. CargoNet AS has stated that the reduction is mainly due to the fact that near-misses that are detected during pre-departure inspections and rectified before departure are no longer reported in Synergi.

Under accidents (equivalent to NNRA's damage category), derailments at yards or terminals are the most frequently reported, followed by (non-rail) vehicle collisions, collisions with fixed installations, falls or jumps from train or shunting stock and crush injuries. Of all the undesirable incidents, the most frequently reported are collisions with fixed installations (signals, masts, buffer stops etc.), followed by falling loads or dropped objects.



	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ulykke	13	9	16	9	26	18	21	8	13
Tilløp	779	923	513	430	170	55	71	48	79
Tilstand	1		1	1	10	18	10	8	7

Figure 22: Synergi reports of all undesirable incidents for CargoNet AS Alnabru 2002-2010. (Ulykke = Accident, Tilløp = Near misses, Tilstand = Condidions).

2.13.3 Available risk assessments related to Alnabru and the hazard of runaway freight cars

The following section examines all available risk assessments related to Alnabru shunting yard and the Alnabru to Sydhavna stretch.

2.13.3.1 *Establishing the risk picture in NSB Gods for Alnabru – Safetec, 2000*

The report "*Etablering av risikobilde i NSB Gods. Risikobilde for Region 5 – Alnabru* 'Establishing the risk picture in NSB Gods. Risk picture for Region 5 – Alnabru' – in Norwegian only) was prepared by Safetec in 2000 for NSB Gods. A risk assessment of railway and workshop operations and operational hazards was performed.

This identified three incidents with an unacceptably high risk level, one of which concerned shunting at Alnabru: *'Collision with stationary freight car and shunter who falls under freight car.'* The risk of a number of incidents is stated as being in the 'assessment range' (ref. the ALARP principle). The report shows that the risk for shunting personnel is generally high. It assesses that incidents with the potential for 'catastrophic' consequences are often related to brake failure and freight cars that have broken loose and are moving towards the main track and brake line. The following excerpt is taken from the description about freight cars breaking loose:

> *Hazard / incident: Freight cars breaking loose*
>
> *Subject for assessment: NSB Gods / Reg 5 / Grefsen line / shunting*
>
> ***General***
>
> *Description: Freight cars breaking loose after being temporarily parked during shunting*

Comments: Reliability is required from the people in the system. Safety is based on education, training and diligence

Causes

Description: Failure/lack of brakes, missing brake shoes (only relevant for TLP). Freight cars getting onto main line

Existing barriers: Procedures for parking freight cars

Consequence:

Description: Collision with train on main line

Existing barriers:

Risk description:

*Probability: 1-Sj***: > 100 years*

Consequence class:

Third person 5 - Catastrophic

The report does not go into more details about barriers or measures that could reduce the risk or consequences of such an incident.

2.13.3.2 *Risk analysis for Alnabru shunting yard – NNRA, 2001*

The report *Risikoanalyse av arbeidsforhold ved skifteoperasjon Alnabru Skiftestasjon (*'Risk analysis of working conditions during shunting operations at Alnabru shunting yard' – in Norwegian only) was prepared in 2001 by NNRA Region East, involving representatives from NSB Gods. The risk analysis was performed on the orders of the NLIA after a serious work accident at Alnabru shunting yard on 18 April 2001.

The analysis was conducted by the safety engineer, HSE manager, quality advisor and a traffic controller from the NNRA, together with the operations managers, operations coordinator and a shunting engine driver from NSB Gods.

The analysis identified one hazard (hazard no 11) which could be relevant to the accident of 24 March 2010:

Subject of analysis: Freight cars leave the 'hump', slipping to slipping train route.

Undesirable incident: Brakes not engaged for freight car which rolls onto the main track at Alnabru South.

Location: Alnabru shunting yard, slipping area after hump.

Chain of events: The freight cars leave the hump, but access brakes or secondary brakes are not engaged, so that, in a worst case scenario, they could get out onto the main track at Alnabru South.

The description shows that the basis for hazard identification was ordinary slipping of freight cars to the directional tracks. Activities such as parking freight car sets in the A tracks, shunting in additional freight cars while the freight car set was parked in an A track and reversing freight car sets around the access brakes do not appear to have been included in the basis for the analysis.

The report shows that the analysis team was divided in its view of whether or not this was a realistic incident and priority was therefore not given to identifying appropriate measures. The report concluded with the following:

> *The risk of this kind of incident is so low that the analysis does not see any need for measures, beyond verifying that there are routines / procedures in place to ensure that braking systems are maintained and that the traffic controller does not forget to apply the secondary brake.*

2.13.3.3 *Section analysis for Hovedbanen – DNV, 2001*

The report "*Risikoanalyse av banestrekninger hovedbanen med Oslo S"* ('Risk analysis for main line sections, including Oslo S' – in Norwegian only) was prepared in 2001 for the NNRA by DNV. The report assesses and documents the risks associated with train traffic at Oslo S and the Oslo S–Lillestrøm section of Hovedbanen, based on the rolling stock trafficking the section. A hazard identification was carried out, which looked at possible undesirable incidents that could result in the injury or death of train personnel, passengers or third parties. The section analysis identified one general hazard of relevance to the accident, point 4.3.4 of the report, *Collision with runaway rolling stock:*

> *Rolling stock that accidentally breaks loose and rolls away without personnel on board and without functioning brakes represents a particular hazard since neither the interlocking system nor the ATC system can prevent a collision between such rolling stock and other trains. When freight cars or rolling stock are parked, the parking brakes must be engaged and the rolling stock must otherwise be secured so that it cannot roll towards train tracks. They can be secured by means of a derailer or run-off points, or by natural topographical conditions. It seems that the biggest risk of rolling stock breaking loose may be caused by unauthorised parking of rolling stock during maintenance operations.*
>
> *Runaway rolling stock from Hovedbanen or Gjøvikbanen could end up at Oslo S or even pass through it. Should runaway rolling stock approach Oslo S, the prescribed procedure is to direct it into the tunnel, where it will eventually come to a stop at the lowest point of the tunnel.*
>
> *At Lillestrøm station, runaway rolling stock could run into the station from Hovedbanen in the south.*

This report does not discuss Alnabru in any detail.

2.13.3.4 *Risk analysis for Alnabru – NNRA, 2004*

The NNRA carried out a risk analysis for Alnabru in 2004, with representatives from CargoNet AS. However, the report was not completed and only the draft document is available. The analysis identified several hazards and measures that are relevant to this accident, and we therefore present some excerpts from this analysis. Please note however that the report is not final.

The analysis was conducted by the safety engineer, emergency response section manager, Alnabru team leader, technical manager for signalling, section manager for advice on traffic safety, traffic operations safety advisor and head of safety and quality from the NNRA together with CargoNet AS's safety manager and operations manager.

The report describes the changes that have taken place at Alnabru between 2001 and 2004. The changes are mainly related to increased shunting using shunting locomotives and less slipping. As a consequence of this, the workload of NNRA personnel in the main control centre has increased. The workload of CargoNet AS's personnel has also increased, but the tasks are less physically strenuous. The report also describes that:

> *The safety culture has improved, in that there is more of a focus on, and more frequent, safety analyses and investigations of incidents; personnel are more involved, and more undesirable incidents and near-misses are being reported.*

The risk analysis identified that risk has generally increased at Alnabru shunting yard during the last few years, and identified one hazard in the red risk area (people injured at level crossing).

The risk analysis did not identify the hazard of freight cars breaking loose from A tracks toward G tracks. However, it did identify the following hazards related to shunting locomotives in and out of trains at the south end of the yard.

Breaking loose at the south end. It is described that there are procedures in place to avoid slipping operations being carried out while locomotives are being shunted in or out at the south end, and that the instructions should be reviewed and improved, and it should be verified that the procedures are in accordance with the instructions.

Breaking loose from slip towards main line. It is described that measures have been taken to ensure that the points automatically switch away from the main line (towards the shunting yard).

Leaving stationary stock on unoccupied lines (G2, G3, G4 and G5) – trains breaking loose towards freight track (brake failure). It is described that this type of incident has not occurred, and that it is no different from other types of parking[4] on unoccupied lines, and that current parking provisions must be observed. Consequently, no measures were identified in relation to this.

The analysis also identified operational measures related to the hazards *'points set to wrong track for shunting'* and *'communications failure between shunting locomotive driver, shunter, signaller and traffic control system operator'* which are relevant to this investigation:

- Standard phrases stipulated in governing documents (e.g. operations manual and shunting instructions).
- Procedures for Alnabru clarifying who is responsible for what during the shunting process (in relation to shunting instructions and draft of new shunting instructions).
- Review of guidelines and procedures with regard to responsibilities and duties.

[4] The report uses the terms 'leaving' (up to 40 mins unsupervised) and 'parking' (parking for an unspecified period in a secure area).

- Review of communication and wording during shunting (in relation to draft of new shunting instructions).

2.13.3.5 *Change analysis Alnabru yard – NNRA, 2006*

In 2006, the NNRA Traffic Management Eastern Region prepared the report *Endringsanalyse Togekspeditørs arbeidssituasjon ved Alnabru stasjon* ('Change analysis of local traffic controllers' work situation at Alnabru yard' – in Norwegian only). The background for the analysis was that the local traffic controllers' workstations at Alnabru were to be changed as a consequence of the remodelling of tracks and signalling systems in connection with the construction of the new container terminal, so as to handle the increase in traffic at Alnabru.

The analysis was conducted by the section manager/safety advisor for the NNRA's Traffic Management Eastern Region and the area manager for Oslo Local Traffic Control. The conclusion of the analysis was that the following requirements from the NNRA's Traffic Management Eastern Region would have to be implemented to prevent the risk level at Alnabru yard from increasing as a consequence of the new container terminal:

> *Installation of centrally controlled points at Alnabru South.*
>
> *Installation of a screen-based traffic control system with train number indication for local traffic controllers.*
>
> *This will improve safety from an overall point of view by eliminating the hazards of inadequate and incorrect communication which can arise in the current situation.*

The above-mentioned measures were not implemented. The AIBN has been informed that, as a compensatory measure, Alnabru was given necessary authorisation to employ another local traffic controller, which meant that the control centre would be manned by two local traffic controllers. There had previously been two local traffic controllers in the control centre, but a quiet spell with less freight being transported by rail had resulted in one of the positions being removed. Over time, the workload for the local traffic controllers at Alnabru had increased, and this change analysis of the work situation at Alnabru formed the basis for the decision to increase the number of staff in the traffic control centre.

2.13.3.6 *Updating the risk picture at Alnabru – CargoNet AS, 2008*

In order to ensure that CargoNet AS has an overview of the risk picture at the terminal and branch lines, a risk picture of the terminal areas has been prepared, which should be updated annually. The AIBN has examined the report *Oppdatering av risikobilde. Terminalområde Alnabru* ('Updating the risk picture. Alnabru terminal area' – in Norwegian only) dated October 2008. The aim of the analysis is to update the risk picture after analysing how new activities or changes in operations affect the risk of accidents at the terminal. The study includes all activities at the Alnabru terminal, i.e. shunting, slipping, loading and unloading.

The analysis was conducted by the terminal manager, safety representative for shunting, safety representative for handling and delivery, safety advisor and representatives of the corporate health service.

The report describes the changes at Alnabru since the risk picture was last updated in September 2007. It describes that the terminal is very busy and operates round the clock, and that at times there is a shortage of space at the terminal. The form of operations has changed radically since January 2008, which saw the introduction of a loading and unloading window with a total train turnaround time of four hours. This indicates that there are several simultaneous arrivals in the morning and several simultaneous departures in the evening. A consequence of this form of operations has been a 30% increase in shunting. The report goes on to describe the changes and reconstruction work that was to be take place at the terminal in 2008, with new C tracks, and the remodelling or extension of tracks and loading areas.

The report describes that shunting is generally considered to be a high-risk activity. This is because of hazards such as knocks, impact and crush injuries when connecting or disconnecting couplers, or falling while boarding or alighting. The report states:

> *Barriers against these incidents include the caution exercised by the shunting personnel, whose education, training and experience help to ensure that a single-point failure does not lead to an undesirable incident.*

It goes on to identify an incident of relevance to the accident, which involves personnel risk in the yellow zone:

> *FA 00239 Collision between train or shunting stock and rolling stock in connection with shunting. Freight cars getting onto main line*
>
> *The freight car set could break loose due to brake failure... A parking error could result in the cars breaking loose. There is a downhill gradient from the A tracks to the R tracks. A collision could only occur if the points were set incorrectly. More than a single-point failure would have to occur for the incident to happen.*

According to CargoNet AS, the possibility that a freight car set could get out onto the main line via a G track was not considered in this connection. The incident was not followed up by any measures in CargoNet AS's traffic safety follow-up plan (TSFUP).

2.13.3.7 *Safety assessment of several parties on public tracks and loading areas – Terminal operations – DNV, 2010*

The NNRA has commissioned DNV to assess the safety consequences of allowing multiple parties to carry out loading and unloading services on public tracks and in public loading areas. The report was completed on 25 March 2010. DNV has carried out a qualitative safety assessment of the problems, limited to personnel safety. As requested by the NNRA, DNV has made its assessment on an independent basis and has not held any work meetings or interviews with any representatives from the companies involved. DNV has used Synergi reports and other documentation in the assessment, and has carried out an inspection of the Alnabru terminal.

The following is taken from the report's conclusion:

> *In principle, DNV cannot see that it will constitute any substantial change relating to the safety of personnel working on public tracks and in loading areas if multiple parties are allowed to operate these.*
>
> ...

> *However, the assessment presupposes that all the parties have the equipment and skills necessary to enable them to carry out their activities in a responsible manner, and that the parties have agreed on rules and procedures for these activities.*
>
> ...
>
> *If the NNRA decides that more operators should be permitted to carry out loading and unloading services on public tracks and loading areas, then the NNRA must itself take over the management of these activities in order to ensure that all operators work under the same conditions. This will require the planning and introduction of measures that are not currently in place.*

Some of CargoNet AS's comments on the framework for DNV's safety assessment (presented in a meeting with the NNRA on 10 May 2010) are given here:

- *No systematic hazard identification was carried out, nor interviews or quality assurance consultations with personnel experienced in terminal operations.*
- *The choice of scenario (personnel safety) as the basis on which to decide whether the risk level would be affected by the changes is not representative of the problems involved.*
- *The system description contains errors, e.g. the map of Brattøra.*
- *The basic data is incomplete and is only used to a limited degree.*
- *CargoNet AS was not asked to provide any form of data, risk picture or analyses.*

CargoNet AS felt that the safety assessment contained factual errors and limitations, and therefore requested another detailed and methodical risk analysis.

2.13.4 Risk assessments for the Sydhavna area – Oslo Havn KF

HAV has carried out risk assessments of the Sydhavna area and its railway operations as part of its Sydhavna development work and its notification to the NRA, and in connection with its application to the NRA for a permanent mandate to operate railway tracks.

In meetings with the AIBN, HAV's representatives have described the accident scenario as being almost impossible for an ordinary, reasoning person to foresee, and that they had never thought that anything like that could happen. HAV has identified a potential risk picture of a train set coming at a low speed from Loenga. Sydhavna is also described as not being wide enough for more tracks to be laid alongside the existing ones, and as having too little space to stop a runaway train set. HAV has informed the AIBN that it was aware of the lack of space at Alnabru, but that this was not significant for the safety of the port.

2.13.4.1 *Risk analysis for Sydhavna*

As part of the Sydhavna development and the notification to the NRA, Norconsult has prepared the report *Risikovurdering – alternative løsninger for nytt havnespor, Sydhavna* ('Risk assessment – alternative options for new port tracks, Sydhavna' – in Norwegian only), dated 9 March 2007. The risk assessment was used to help decide which track system to choose and to assess the need for risk-reduction measures. The risk assessment methodically identified factors and properties of the track systems which could affect the risk situation, in relation to which each track system was assessed. The risk assessment did not identify any dangers relevant to the accident.

The risk assessment also refers to two other documents:

2003: *Grovanalyse - skiftebevegelser på Oslo Havn* ('Rough analysis – shunting movements at Port of Oslo' – in Norwegian only).

1997: *Risikoanalyse for fylle- og lossestasjonene for jetfuel på Gardermobanen* ('Risk assessment for Gardermobanen jetfuel fuelling and unloading plants' – in Norwegian only). Undertaken by Scandpower for Oslo Lufthavns Tankanlegg (OLT). HAV has informed the AIBN that this risk analysis focused on emissions and collisions with people/objects, not collisions between train sets. It was prescribed that points towards the loading track must be switched manually to the bypass track when the jet fuel train is in the filling station. Runaway freight cars were not a subject of the analysis.

2.13.4.2 *Rough analysis – shunting movements at the Port of Oslo:*

The rough analysis is a risk assessment carried out by a working group consisting of representatives from HAV, CargoNet AS, Banepartner and the NNRA's Eastern Region (report dated 18 November 2003). The rough analysis for Sydhavna identifies the hazard *'parked/stationary rolling stock breaking loose.'* It goes on to describe the following:

Not aware of any such incidents, but it could theoretically happen. Extremely low probability in the port area.

The incident is assigned consequence category C and frequency category 5. That puts it inside the green zone: minor incident, low risk potential.

2.14 Supervision by regulatory bodies

This describes the roles of the NNRA and NLIA in relation to the railway undertakings and infrastructure managers that were involved in the accident

2.14.1 Norwegian Railway Authority (NRA)

2.14.1.1 *General*

When NSB was split into a traffic division (NSB BA) and an infrastructure division (NNRA), the Norwegian Railway Authority (NRA) was established on 1 October 1996 as an independent agency under the Ministry of Transport and Communications. The roles of each were not sufficiently clarified at this time, and the NRRA still had a number of monitoring duties. The NRRA was not defined as an object of supervision until February 1998 and the NRA carried out the first audit of the NRRA in autumn of the same year.

The NRA is the supervisory authority for railway activities, including tramways and underground railway systems, in Norway. The activities of the NRA are financed over the ordinary national budget. The NRA shall actively promote safe and expedient railways in line with the overall objectives of Norwegian transport policy.
The NRA shall carry out inspections to ensure that the rail operators comply with the conditions and requirements that govern the activity as provided for in railway legislation. The NRA will also monitor the market to ensure competition on equal terms

and ensure that passengers' rights are looked after. The NRA is also responsible for drawing up regulations, approving rolling stock and infrastructure and awarding safety authorisation, licences and safety certificates.

The NRA conducts risk-based supervision. According to the NRA, this means that it is the objects of supervision (railway enterprises) that are responsible for carrying out their activities in a safe and responsible manner and in line with current legislation. The railway enterprises must carry out risk assessments and conduct the necessary analyses to establish current levels of risk and must also have systems in place to monitor risk.

The task of the NRA do not include those areas of authority which belong to other public control and supervisory bodies, including the police, the Directorate for Civil Protection and Emergency Planning and the Norwegian Labour Inspection Authority.

2.14.1.2 *Permission to use infrastructure*

Sections 12-8, 12-9, 12-10 of the Regulations relating to requirements for railway enterprises on the national rail network (the Safety Regulation) states that before any infrastructure is commissioned, the NRA must grant permission for use of the infrastructure. If the infrastructure is subsequently changed, the NRA must assess whether the nature of the change necessitates a renewal of the permission to use the infrastructure or the modified part of it.

Notification of planned projects must include a risk analysis and a safety plan. An application for permission to use infrastructure must include documentation of risk exposure and risk control. The NRA makes it clear that they check every application that it receives against the regulatory requirements.

2.14.1.3 *Supervisory activities*

The NRA's 2010 supervisory strategy states that a risk-based approach means that the authority chooses to make it a priority to follow up undesirable incidents with a major accident potential individually, while other incidents are normally followed up by assessing trends and statistics.

The NRA compiles statistics based on incidents and accidents reported by the railway enterprises. The NRA emphasises that it is the railway enterprises' responsibility to process and analyse incidents and accidents (see sections 8-2 and 8-3 of the Safety Regulation).

The NRA carried out over 10 inspections of CargoNet AS as a whole, and about 40 of the NRRA as a whole, between 2002 and the date of the accident. This number includes every kind of inspection of these enterprises, and also deals with topics that are not directly relevant to the accident.

2.14.1.4 *Inspection of the railway systems at Alnabru*

The railway systems at Alnabru have been continually adapted and adjusted over a period of many years. The systems have gradually been transformed from a conventional wagon loading terminal to a container terminal, handling a continually increasing volume of freight. In order to get a picture of developments and of the safety status, the AIBN asked the NRA for access to all available documents pertaining to the railway systems at Alnabru.

When the AIBN examined these on 13 October 2010, it discovered that every notification and application relating to changes in infrastructure was accompanied by a risk analysis. The risk analyses only dealt with the specific change in each case, and did not show how the change would affect the total level of risk at Alnabru. The documentation shows that, prior to the notified changes, there was no analysis for the terminal as a whole showing the overall safety level at Alnabru. The NNRA emphasised that an assessment of the overall safety level at Alnabru after the changes was to be carried out as part of the ongoing planning work for Alnabru as a whole.

2.14.2 Norwegian Labour Inspection Authority (NLIA)

2.14.2.1 *General*

The NLIA is a government agency under the Ministry of Labour. The agency administers the Working Environment Act and its regulations, and carries out inspections to ensure that enterprises comply with the regulatory requirements. It does this, among other things, through unannounced inspections, verifications, investigation of work accidents, internal control audits, coordinated supervision with other agencies, market control, campaigns and projects. The NLIA has recourse to sanctions like orders, coercive fines, closing down operations, and can also report an enterprise to the police for serious or repeated breaches of the provisions of the Working Environment Act. The NLIA has supervisory responsibility for approximately 180,000 enterprises in the private and public sectors, and 60,000 agricultural entities.

2.14.2.2 *Supervisory activities in relation to CargoNet AS at Alnabru before the accident*

The agency has carried out three inspections relating to work accidents, but these have not concerned shunting. CargoNet As has also applied for and received truck and crane drivers' licences for EEA citizens.

2.14.2.3 *Supervisory activities in relation to the NNRA at Alnabru before the accident*

The NLIA had not carried out any supervisory activities in relation to the NNRA at Alnabru before the accident. The NNRA in Oslo has been inspected twice by the NLIA in recent years, but neither of these inspections were of any relevance to the accident.

2.14.2.4 *Supervisory activities in relation to the NNRA at Alnabru after the accident*

Following the accident, the NLIA exercised supervision in relation to the NNRA when Alnabru shunting yard was inspected in May 2010. The subject of the supervisory activity were the general working conditions for local traffic controllers in the Central Control Tower at Alnabru, including whether or not they had received sufficient training, whether the NNRA had obtained sufficient information about their work situation, and whether the enterprise had systems in place to detect, remedy and prevent that employees were exposed to unfortunate physical or mental strains.

The supervisory activity took the form of two meetings in which management, the chief safety representative and safety representatives were present; an inspection of Alnabru shunting station; and observation of the work situation in the control tower, where the

NLIA interviewed three local traffic controllers. The NLIA has also examined documentation and information relating to training, risk identification and the NNRA's nonconformity system (Synergi).

The following quotations illustrate the NLIA's main impressions and findings:

> *Positive conditions:*
>
> *The inspection has revealed a number of positive conditions. Documentation that we have received shows that the NNRA conducts annual safety rounds at Alnabru shunting yard. The documentation also shows that the enterprise is collaborating with other employers with regard to health, safety and environmental conditions at Alnabru shunting yard by also conducting coordinated safety rounds with them. We have also learned that the NNRA's working environment committee held four meetings in 2009 in accordance with section 10 of the Regulations on safety representatives and working environment committees.*
>
> *Railway legislation sets specific requirements for training employees whose duties will be related to train operations. The NNRA appears to have good systems in place for training local traffic controllers. The NLIA has not examined the quality of the training in detail, but we have noted that the enterprises not only have a training programme for new recruits, but also an in-service training programme.*
>
> *Findings:*
>
> *As well as the above-mentioned positive conditions, the NLIA has found conditions that we deem to be breaches of the Working Environment Act. Our investigations have found that the workload of the local traffic controllers in the Central Control Tower at Alnabru can at times be too high, and that the NNRA has not obtained enough information about its employees' work situations. The NLIA has also discovered that the NNRA does not have good enough systems in place to identify, remedy and prevent breaches of requirements set out in or pursuant to the Working Environment Act.*

The NLIA considered that there was a breach of section 4-1(1) of the Working Environment Act, which provides for a fully satisfactory working environment, and that section 4-1(2) relating to the organisation and arrangement of work had also been breached. This had to do with the local traffic controllers' high workload. The NLIA also considered that there were breaches of the Working Environment Act section 3-1(2)(c), cf. the Internal Control Regulations section 5, second paragraph subparagraph 6. This had to do with the lack of information about the local traffic controllers' work situation. The NLIA also found breaches of the Working Environment Act section 3-1(2)(e), cf. the Internal Control Regulations section 5, second paragraph subparagraph 7. This had to do with the inadequacies of the systems to detect, remedy and prevent breaches of requirements set out in or pursuant to the Working Environment Act.

On the basis of these breaches, the NNRA was notified of the following order:

> 1) *The NNRA must examine the work situation of its employees in the Central Control Tower at Alnabru, and use this as a basis for assessing risks and implementing measures to reduce the risk factors relating to workload, work duties, working hours arrangements and work performance, so that the local traffic controllers are not exposed to adverse physical or mental strain and so that considerations of safety are properly addressed.*

While it is making its assessment, the enterprise must implement temporary measures to ensure a fully satisfactory working environment for the local traffic controllers.

The working environment committee must consider the order before reporting back to the NLIA.

2) The NNRA must review and make necessary changes to procedures and routines so as to identify, remedy and prevent any breaches of requirements set out in or pursuant to the Working Environment Act.

The working environment committee must consider the order before reporting back to the NLIA.

2.15 Acts and regulations

2.15.1 The Railways Act and its Regulations

The overarching regulatory framework for railway operation is laid down in Act of 11 June 1993 No 100 relating to the establishment and operation of railways, including tramways, underground railways and suburban railways etc. (the Railways Act) and pertaining laws and regulations. Sections and regulatory requirements that are relevant to this accident are cited below:

Section 6 of the Railways Act requires:

Whoever intends to operate infrastructure or rail transport services must be authorised to do so by the ministry. Operation of infrastructure includes responsibility for rail traffic control, unless the ministry authorises the transfer of such responsibility to others.

2.15.1.1 *Licensing Regulations – Railway Regulations*

At the time of the accident, Regulations of 16 December 2005 no 1490 on licensing, safety certification and access to the national railway network, and on safety authorisation to operate railway infrastructure (the Licensing Regulations) applied. These regulations was repealed with effect from 1 January 2011, and replaced by Regulation of 10 December 2010 No 1568 on railway operations on the national railway network (the Railway Regulations).

The NNRA has safety authorisation and CargoNet AS has a licence and safety certificate.

2.15.1.2 *The Safety Regulation*

Section 4-3 of Regulation of 19 December 2005 No 1621 on requirements for railway enterprises on the national rail network (the Safety Regulation) describes the requirements for the safety management system.

The safety management system must be adapted to the enterprise and the enterprise's activities and must cover all aspects of its operations, including the use of contractors. Furthermore, due consideration shall be given to any risk that might arise from the activities of other railway enterprises and third parties.

The railway enterprise shall have internal rules to ensure safe operation and fulfil the requirements laid down in or pursuant to the Norwegian Railways Act.

An infrastructure manager's safety management system must take account of the effects of activities carried out by different railway undertakings on the rail network and include measures to enable all railway undertakings to operate in compliance with the requirements and conditions of their safety certificates.

Sections 5-1, 5-2, 5-3 and 5-4 of the Safety Regulation describe the requirements for acceptance criteria, risk analyses, following up and updating risk analyses:

The railway enterprise shall update the risk analyses whenever there are changes to the premises or limitations that, individually or in aggregate, will affect the analysis results and whenever any other new knowledge that may affect the results becomes available.

The Safety Regulation describes the requirements for barriers, including the 'no single point of failure' principle:

Section 3-3 Barriers:

The railway enterprise shall have barriers that reduce the probability of faults and escalation of danger and accident situations. The barriers must restrict the potential scope of damage and inconvenience. If a number of barriers are required, these must be sufficiently independent of each other.

Operations must be planned, organised and implemented with a view to ensuring that no single fault will ever lead to loss of human life or serious personal injury.

The established barriers and their functions must be known throughout the organisation.

2.15.1.3 *The Train Operation Regulations*

Regulation No 240 of 29 February 2008 on train operations on the national railway network (the Train Operation Regulations), Section 2-7 first paragraph describes the requirements for readback in communication concerning train operations and shunting:

Verbal orders, permissions and notifications regarding train operations, shunting and works on the line must not be considered to be received until the whole wording or essential content has been repeated by the person receiving the order, permission or notification. The same applies to signals that are communicated verbally.

The following is taken from comments on the Train Operation Regulations regarding receipt of orders, permissions, notifications and signals:

The provision shall ensure that verbal communications, described in the Regulation as orders, permissions and notifications, are understood correctly by being repeated by the person receiving the communication.

(...)

The term 'permission' is used in the Regulations to describe those instances when drivers, shunters or safety supervisors must have approval from traffic controllers or local traffic controllers before an activity can be commenced, for example *permission to shunt, permission to start working on the tracks, or permission to pass a main signal that cannot indicate line clear.*

The Regulations use the term 'notification' here to describe messages about changed conditions or information that it is important to understand correctly.

Chapter 3 of the Train Operation Regulations describes requirements for shunting: The relevant sections are cited below:

Section 3-1 shunting:

3. The infrastructure manager shall establish detailed provisions for shunting as described in section 2, including for simultaneous shunting operations conducted in one and the same area, and any requirements as to who is to be designated shunter. The infrastructure manager shall provide descriptions for use and operation, and descriptions of technical barriers between trains and shunting stock etc.

4. The railway enterprise shall establish detailed provisions for shunting the type of rolling stock that is in use, including use of shunting movements, responsibilities and duties of personnel involved in shunting, control of rolling stock and use of brakes.

Section 3-7 Shunting in stations:

When shunting takes place in stations, it must be ensured that the shunting stock cannot enter a route that has been set for a train.

Section 3-4 Supervision of shunting:

1. Shunting shall be supervised by a shunter. The shunter shall ensure that safety is addressed during shunting.

Section 3-13 Signalling and control of shunting route:

4. Shunting stock that could potentially roll down an incline and out onto the line must have a handbrake or effective air brakes applied to whichever freight car or manned traction engine is closest to the incline.

Section 3-16 Stationary shunting stock:

1. Shunting stock may be left stationary on a train track or main track (stationary). Shunting personnel must supervise the braking procedure at the end closest to the incline.

2. The shunting stock must be secured by handbrakes, parking brakes and/or brake shoes before the traction engine is uncoupled, in such a way that the shunting stock cannot start moving. Shunting stock without traction engines must not be left stationary on gradients exceeding 18%.

3. The shunting stock may nevertheless be left unsupervised for up to 40 minutes if the shunting stock is an air-braked train set or part of such a train set, and if its air brakes have a braking capacity of at least 40%. In such cases, the air brake must be engaged by opening a shunt valve and keeping it in the open position.

Section 3-17 Parking of shunting stock:

1. Shunting stock to be left for an unspecified period (parked) shall be placed behind derailers, run-off points or in a secured shunting area.

2. Shunting stock that is parked shall be secured by handbrakes, parking brakes and/or brake shoes in such a way that the shunting stock cannot break loose and start moving.

Section 3-30 faults in infrastructure or rolling stock:

Shunting personnel shall immediately inform the traffic controller or local traffic controller if any faults are discovered in infrastructure, trains or shunting stock that may have a bearing on safety.

2.15.2 The Working Environment Act and pertaining regulations

The employer is responsible for ensuring a proper working environment in accordance with the regulations set out in the act relating to working environment, working hours and employment protection etc. (Working Environment Act) and its Regulations. The employer's and employees' duties are set out in Section 2 of the Working Environment Act.

Section 2-2 (2) of the Working Environment Act refers specifically to the responsibility of a principal undertaking to coordinate health, environment and safety work.

According to Section 2-3 of the same Act, the employee – the individual worker – has a duty to cooperate. This cooperation includes notifying the employer if employees become aware of faults or defects that could endanger human life or health, and they themselves are unable to remedy the fault or defect.

The work on health, environment and safety shall be systematic and ongoing. Section 3-1 of the Working Environment Act requires that the employer shall ensure that systematic health, safety and environment work is carried out at all levels of the undertaking.

2.15.2.1 *Regulations on work in control rooms*

Regulations of 20 April 1995 No 385 regarding work in control rooms covers the planning, location, design of and changes to rooms that are fitted out and equipped for control and monitoring of automatic systems (control rooms) and how work in control rooms is organised and performed. Chapter 2 Section 6 describes that the employer is required to base all planning and organisation of work in control rooms on analyses of processes, systems and work duties in order to meet the requirements for a fully satisfactory working environment and safety of operations and maintenance.

2.15.3 The enterprises' regulations and internal procedures

Railway enterprises that traffic the national rail network are also obliged to follow Traffic Rules for the NNRA's Network (TJN). The individual enterprise must also have examined its own activities and established comprehensive provisions to ensure the safety of its own activities. Temporary and permanent changes to the traffic rules are notified by the NNRA in S circulars. There are also local procedures and special provisions for individual stations and route areas.

The following procedures and provisions are relevant to the accident:

2.15.3.1 *Procedure for releasing the mechanical brakes*

The instructions for the slip control centre at Alnabru relating to track brakes describe the conditions for bypassing the access brakes when reversing a train coupled to a locomotive at the northern end (sub-system 7, section 1.1.2 Conditions for releasing the mechanical brakes). The instructions are not dated. They state:

1. *A shunting train route is set from the relevant A track towards the relevant access brake. The dwarf signal displays signal 46*
2. *The access brake is set to braking pressure 2*
3. *The mechanical brake and lowering brake are opened*
4. *The shunting route towards the access brake is released*
5. *When it has been checked that the locomotive is in control of the shunting stock, shunting route R31-R35 can be set to bypass the access brake*

The AIBN has been informed that the local traffic controller became aware of this procedure for the first time when he/she was being questioned by the police after the accident.

We are informed by the NNRA that this procedure is being revised as a result of the accident.

2.15.3.2 *Special provisions for Alnabru station*

Of the relevant provisions in 'Section description for the National Rail Administration's railway network, Part 3 Special provisions for Network Area East' dated 28 February 2010, we refer to Section 3.4.2 Use of mechanical brakes to hold trains in place on arrival tracks.

In the case of trains left on the access tracks for more than four hours, the hand brakes shall be engaged.

The parking brakes had not been engaged on any of the freight cars while they were parked in track A5. The AIBN has been informed that the traffic controller became aware of this procedure (in the following called the ‘four-hour rule’) for the first time when he/she was being questioned by the police after the accident.

The NRA has informed the AIBN that the four-hour rule is not in accordance with the regulatory requirements given in the second paragraph of Section 3-17 of the Train Operation Regulations.

The NNRA has stated that the four-hour rule was removed when the Section Handbook was revised with effect from 12 December 2010, because the track brake system at Alnabru was taken out of use after the accident (S circular 067-2010). The AIBN has also been informed that before any reopening of the track brake system, the track brakes' usage concept, including this provision, will be reviewed.

2.15.3.3 *S circulars*

S circular 013-2010 of 23 February 2010 describes exceptions from the Train Operation Regulations regarding the presence of a local traffic controller on a platform during the arrival and departure of a train, shunting without verbal permission from a local traffic controller and local traffic controllers' use of an open channel on the shunting radio.

2.15.4 Competence requirements for personnel

2.15.4.1 *Drivers*

Drivers of traction vehicles must be trained in accordance with Regulations of 7 February 2005 No 113 on requirements for the competence and certification of operators of traction vehicles on the national rail network. Drivers must have undergone type training for the relevant rolling stock, have sufficient knowledge of the section, be trained in internal procedures and have passed an approved safety test. Locomotive personnel are regularly tested on safety provisions, electrical safety, fire and emergency response.

2.15.4.2 *Shunting personnel*

Shunting personnel must be trained in accordance with Regulations of 18 December 2002 No 1679 on training of personnel with work duties of importance to railway traffic safety, including tramways, underground railways and suburban railways etc. (the Training Regulations). The personnel receive training as terminal workers, and this includes training in shunting and brake testing. The training lasts about three and a half months and is partly theoretical and partly practical. To serve at Alnabru, an additional one month's service (20 service trips) is required, in order to get to know the yard. The shunting personnel regularly have to attend refresher courses and tests on safety provisions, in order to have their approval renewed. The personnel will usually have served about two years before they can work as shunters.

2.15.4.3 *Local traffic controllers*

Local traffic controllers and assistant local traffic controllers must have completed their local traffic controller's training in accordance with the Training Regulations. This training takes about nine months and includes training in traffic safety rules and a basic course in a simple control centre (double track system). The personnel are then trained in the traffic control centre at the station in which they will serve. This training takes about eight to nine months at Alnabru. The local traffic controllers regularly have to attend refresher courses and tests on safety provisions, in order to have their approval renewed. Local traffic controllers employed at Alnabru alternate between serving as local traffic controllers and assistant local traffic controllers.

2.15.4.4 *Traffic controllers*

A traffic controller must be a trained local traffic controller, have completed the traffic controllers' course and have taken the written traffic controllers' examination. When a traffic controller starts in a new position, he/she is then trained on the respective remote controlled systems which he/she will operate, and must then take a practical test in these systems. Traffic controllers must sit an exam on the safety provisions every three years. They must pass this exam to have their approval renewed. The traffic controllers participate in an annual two-day traffic controllers' conference, at which one day is allocated to reviewing changes in the train operation provisions, and/or a particular regulatory issue.

2.16 Relevant theory

In this investigation, the AIBN has emphasised the collaboration between the NNRA and CargoNet AS organisations, and the interaction between the operating personnel at Alnabru. The AIBN has therefore examined relevant theories and research relating to communication and decision-making.

2.16.1 Communication

In a linear communication model, a message is expected to be transferred from sender to receiver without any particular problems.

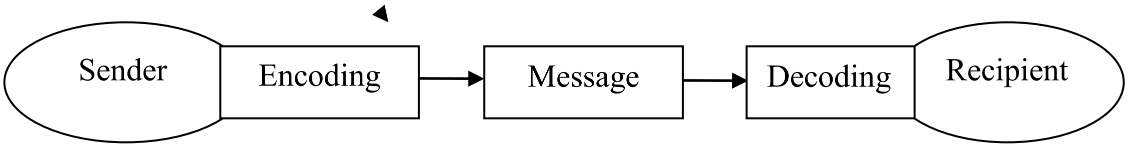


Figure 23: Linear communication model (adapted from Adler et al, 1983).

In this model, communicating is regarded as more or less the same as informing, the focus being on sending a message, while not knowing much about how the message will be understood by the recipient. This is only possible in interactive communication, where both parties are senders and recipients at the same time.

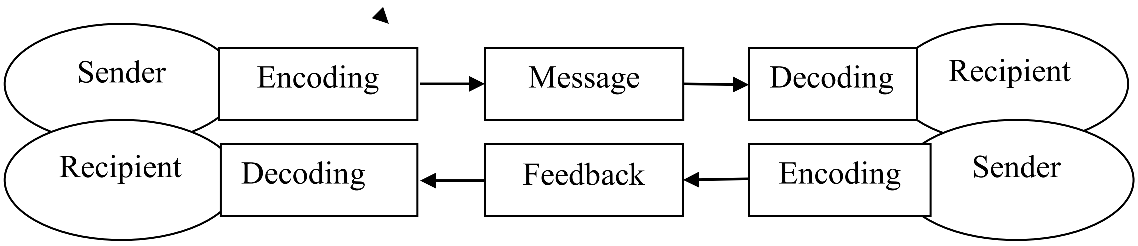


Figure 24: Interactive communication model (adapted from Adler et al, 1983).

Aviation research has focused on two communication factors in particular which can improve a crew's efficiency (Orasanu in Johnston, McDonald and Ray, 1997). These two factors are explicit communication (i.e. what is said) and effective communication (i.e. how it is communicated or verbally imparted). Explicit communication is about communicating clearly, so that the recipient of a message does not need to know what the sender of the message knows or is thinking, and does not need to interpret what the sender is trying to impart. This means that unambiguous words and phrases must be used as far as possible. Effective communication is about being brief and only imparting what is necessary, so that the recipient does not need to use too much cognitive capacity to understand what is being said.

People have a limited capacity for processing information, but are constantly receiving large volumes of sensory stimuli (information data). In order to handle this volume of sensory stimuli, the individual reorganises selected parts of this volume into meaningful units. When the recipient receives a message, he/she will perceive what is said, interpret the content so that it becomes meaningful, and then act. The perception and interpretation of the content is affected by mental models or 'schemata' that the person has created, among other things based on previous experience and knowledge. These 'schemata' create expectations, which again affect what the individual focuses on in his/her perception, and thereby also his/her understanding. You could therefore say that the process of perception is a circular process (Brun and Kobbeltvedt in Eid and Johnson, 2005).

Ambiguous and ineffective communication requires the recipient of a message to use more cognitive capacity to understand what is being imparted. This cognitive process of extracting something meaningful from ambiguous communication and long sentences containing a lot of information increases the risk of gaps in understanding being filled by the recipient's previous experiences, knowledge and expectations. The result of this can easily be that the content of the message being communicated is interpreted in a different way than the sender of the message intended. This is most likely to happen when the recipient does not check his/her interpretation or understanding of the message with the sender. It can also easily cause different recipients of the same message to be able to interpret and understand the message in different ways, based on differences in experience, expectations, knowledge etc. Orasanu (1997) specifies the importance of shared mental models to ensure a maximum of shared knowledge and understanding of each other’s duties, roles and procedures so as to reduce the probability of misunderstandings. Some of this has been integrated into the training of aviation crews and air traffic controllers.

It is a well-known phenomenon from research into cross-cultural communication that communicating across cultural boundaries increases the probability of misunderstandings (for example, see Brinkmann and Eriksen, 1996). The reason for this is that the references needed to understand a statement are often culture-dependent. Things that appear obvious to members of one group can seem less intelligible to someone who is not a member of that group and consequently does not have the references to be able to understand the more implicit part of the communication.

Readback is defined in ICAO Annex 10 Aeronautical Telecommunications Volume II Communication Procedures including those with PANS status (sixth edition dated October 2001) as a recipient repeating a message or appropriate part of a message back to the sender of the message in order to get confirmation that it has been received correctly. Readback requires the sender of the original message to listen to the recipient repeating it in order to ensure that the recipient has grasped the content of the message. Readback is used to reduce the probability of misunderstandings between the sender of a message and its recipient. Not using readback increases the probability that a recipient will not grasp all or parts of a message they receive and will mishear or guess at what was said. A recipient's expectation of what the sender of a message may have wanted to impart may result in the recipient acting according to what they expected to hear and not what was actually imparted. A recipient's expectations can be created from the recipient's previous experience or routines. A redundancy is created in the communication between air traffic controllers and pilots through what is known as the communications loop (Flight Operations Briefing Notes – Airbus). The communication loop includes both the repeated message (readback) and hearback by the original sender of the message. Hearback is when the sender of the message verifies (confirms or corrects) the recipient's confirmation of the message and thereby closes the communication loop. The aviation industry has defined which radio messages need to be confirmed by readback, i.e. repeated (for example, see ICAO Annex 10 Vol. II).

That expectations affect perception and communication is a common phenomenon, and can have a negative effect on the confirmation of information by readback and hearback

(Hawkins, 1993, p 163). This can result in a person hearing what they expect or want to hear, instead of what is said.

The combination of expectations and non-standardised phraseology can easily result in dangerous situations. (Hawkins, 1993, p163). Expectations of something or someone in a situation can have an effect on what is perceived in a communication between two people and can also replace information, which is not then released by the working memory and is therefore not remembered by the recipient of the information. If information in the working memory is not processed, it will be replaced by the stream of new incoming information needing to be processed. Readback and hearback to confirm information is not enough to guarantee that misunderstandings will be detected. The disciplined use of standard phraseology with a focus on critical words is also needed.

2.16.2 Decision making

The decision-making process can be divided into two types. The classical decision-making process and the naturalistic decision-making process (Strauch, 2004). The classical decision-making process is suitable for relatively static environments, while the naturalistic process is used in more dynamic environments.

In the classical decision-making process, a situation is evaluated as it arises, possible alternatives are identified, the alternatives are assessed for cost versus benefit, and the alternative is chosen that offers the most benefit for the lowest cost. This process is used when the decision-maker has plenty of time to assess the situation and the possible alternatives. This decision-making process can result in poor decisions, because the alternatives have been poorly assessed, not all the alternatives have been identified or examined, or the cost of each alternative has not been evaluated well enough.

In the naturalistic decision-making process, also referred to as intuitive decision-making, the decision-maker uses his/her experience to assess the situation. A decision-maker's previous experience governs how the situation is perceived, which then determines which decision is made. The decision-maker uses his/her experience to identify a situation's typical characteristics and typical ways of responding. Naturalistic decision-making in dynamic situations requires less time than the classical decision-making process. The naturalistic decision-making process is less cognitively demanding and more efficient. However, there is a danger that the decision-maker in a dynamic situation will focus on the most prominent signals and not the most informative. If the subject of focus is incorrect, this can result in poor decisions.

Strauch (2004) points out that it can be difficult to differentiate between the quality of a decision-making process and the quality of a decision. A poor decision is not necessarily the product of a poor decision-making process. Decisions made in a dynamic environment are demanding, because critical information can change during the decision-making process and be missed by the decision maker. A decision is thus no better than the information it is based on. Brun and Kobbeltvedt (2005) explain that inexperienced people like to follow rules when making decisions, but that experienced people or experts use more intuition. Kaempf and Klein (1997) describe how experienced people seldom compare alternative options when making decisions. Klein used this premise as a basis for a model called the Recognition-Primed Decision model (RPD).

The recognition-primed decision model falls within the naturalistic decision-making approach. RPD contains two components: assessing the situation and evaluating the options. The model emphasises that the decision-maker recognises the dynamics of the situation, and this enables him/her to assess and then act accordingly. A simplified version of RPD describes how the decision-maker recognises the purpose of the action, relevant elements of the situation, what can be expected and what a typical action might be. In the complex version we see elements of what is known as mental simulation of a situation, which the decision-maker uses to make a mental evaluation of possible actions and imagine or visualise the possible effects of these actions.

Brun and Kobbeltvedt (2005) refer to Klein (1998) who points out that 'expertise is learning how to perceive,' i.e. experienced professionals have a greater capacity and speed in identifying the important elements and contexts of a situation.

Cognitive short-cuts in decision-making (heuristics or rules of thumb) which enable decision-makers to draw conclusions and make decisions without analysing in depth, testing or thoroughly weighing up are essential in many contexts. Short-cuts like these are essential because of people's limited capacity to process large volumes of data. However, they can increase the risk of a decision-maker misunderstanding situations because of deficiencies in the mental schemata. People's cognitive shortcuts are often a major reason why they misjudge the information they are looking for and which they use as a basis for a decision. This can easily lead to distortions in the way information is interpreted, or to information being filtered away if it does not correspond to the decision-maker's mental schemata and therefore affect the basis on which decisions are made.

Previous experience, knowledge and expectations can result in different interpretations of a situation and different decisions from person to person. An example of a shortcut that can result in misjudgements and poor decisions is accessibility, i.e. a person judges a situation based on the information that is easily accessible from memory. Another shortcut is representativeness, where a person judges a situation based on what seems to be most normal. Decision traps or decision biases common in decision-making include the confirming bias of evidence, which is a way of saying that people tend to seek confirmation of what they have understood. Another trap is overconfidence among experienced people. This is people’s tendency to be more certain of their own assessment than they have reason to be.

2.17 Other information

'Technical Specification for Interoperability - Subsystem: Operation and traffic management” (TSI OPE[5]) are European rules for railways prepared by the European Railway Agency (ERA). Annex C pp. 106-116 'Safety related communications methodology', describes the principles for a common European standard for communication. The main document also contains several references to communication, including point 4.2.1.2 on page 16 and section 4.6 regarding competence. This is a document that has been ratified by the EU and which Norway is bound by through the EEA Agreement, but which has not yet been implemented in Norway. The AIBN has been informed that the document will be implemented by the NNRA when it undertakes a major review of the regulations.

[5] http://ec.europa.eu/transport/rail/interoperability/doc/ope-tsi-en-annex.pdf.

According to the NNRA, it will be extremely important in the work of preparing a new standard for safety communication, which will be in accordance with a future EU standard for railway communication. For example, it would not make sense to develop a new standard for communication while shunting, if at a later date new, different standards would be introduced that would apply to the entire railway network. The NNRA will therefore coordinate the work of a new standard for communication with the NRA so that it will be in accordance with a future regulatory requirement.

3. ANALYSIS

3.1 Introduction

The analysis aims to study and understand how and why the safety problems, including operational nonconformities and the absence/inadequacy of barriers, were allowed to occur or were present in the chain of events. However, the AIBN is unable to identify specific relationships/causalities in every case, between factors at the various system levels. Irrespective of this, they are important components in a description of the complex organisational conditions and the general conditions that impacted safety at the time of the accident. By focusing on organisational conditions and the framework conditions for safety, the AIBN intends to identify every opportunity to learn about and improve railway safety.

For a description of the AIBN’s investigative process and methodology, see Annex C. Annex G contains a summary of the AIBN's analysis in the form of an event, cause and barrier diagram.

In section 3.2 , the AIBN will review the chain of events and highlight the immediate safety problems that were identified through the STEP analysis. This analysis will in turn serve as the basis for the barrier analysis in section 3.3, where we will review the barriers that could potentially have stopped the chain of events. Section 0 will then look at other potential consequences/scenarios of the accident and analyse survival aspects, including notification and rescue.

The further causal analysis is divided into six parts: 0 Work practice and operational conditions, 3.6 Safety management, 3.6.5.3 Cultural aspects, 3.8 Collaboration internally and between organisations, **Feil! Fant ikke referansekilden.** Factors relating to history and development and **Feil! Fant ikke referansekilden.** Supervisory authority.

Interviews with informants from the NNRA and CargoNet AS were an important part of the AIBN’s investigation and causal analysis of the accident. We have included quotes from these interviews to illustrate the various topics that were covered. These quotes must be regarded as examples of characteristic features rather than isolated individual viewpoints.

3.2 Event analysis

3.2.1 Assumptions underlying the analysis

No recording is available of the conversation between the local traffic controller and the shunter; hence the AIBN has no technical evidence of what was said (the exact wording) in the communication over the shunting channel. The AIBN therefore asks you to take note of the fact that the analysis of the incident is based on an analysis of what the personnel involved told the AIBN and stated when interviewed by the police, combined with the AIBN's investigations relating to the condition and functions of the technical systems at Alnabru.

On Wednesday 24 March 2010, a trainee local traffic controller was being trained at Alnabru S. The trainee was in his/her first week of training, and was answering the telephone and operating the main control centre. According to the local traffic controller, the trainee was not involved in the chain of events in question or in the events that took place before the freight car set started to roll. The AIBN sees no reason to doubt this and has based its further analysis on the assumption that this was so.

3.2.2 The chain of events before the freight cars left Alnabru

The freight car set that started rolling had been parked for intermediate storage on track A5 at approximately 04.20 on the day of the accident, pending reloading. The freight car set had been secured using the track's mechanical brake. In the AIBN's opinion, the use of an A track for parking was not in accordance with the original plan for track usage at Alnabru shunting yard (see section 0).

The parking brakes had not been engaged on any of the freight cars in the freight car set while it was parked in track A5. This is not in conformity with *Særbestemmelser for Ruteområde øst* ('Special provisions for route area East' - in Norwegian only) which require the use of additional brakes when parking in an A track for more than four hours (the 'four-hour rule'). The further analysis in section 0 considers whether this could also constitute a nonconformity with the second paragraph of Section 3-17 of the Norwegian Train Operation Regulations.

According to CargoNet AS's track usage schedule for the applicable timetable, the freight car set was to be shunted back to the container terminal for loading at 18.00. However, the local traffic controllers neither have a copy of the track usage schedule nor an overview of where the various freight car sets are parked. All that the local traffic controllers have is the overview of incoming and outgoing trains provided by the timetable.
When the shunter ordered a shunting route from track R47 to track A5 North, the local traffic controller was convinced that the purpose was to shunt an additional freight car into the freight car set and then shunt the freight car set onto a loading track for loading. However, the shunter did not intend to move the freight car set, but only to add another freight car so as to prepare the freight car set for collection and prepare the work of the next shunting team. There is considerable traffic at Alnabru in the afternoons. In the AIBN's opinion, adjusting the length of the freight car set on an A track was not in accordance with the intended use of the arrival tracks, and was conducive to increasing the possibility of misunderstandings.

In the AIBN's opinion, a misunderstanding arose between the shunter and the local traffic controller concerning what shunting route to set. The local traffic controller understood the situation to be one in which the shunting engine was coupled to the freight car set and the latter was to be pushed down along the G track under the control of the shunting engine. The fact that the shunter used the wording 'A5 North' in his request could, from the local traffic controller's point of view, mean that the locomotive was at the north end of the freight car set and not necessarily that the shunting route was to be set in a northerly direction. In the opinion of the AIBN, when the shunter asked for a shunting route from track A5 North to the G track, it was therefore only natural for the local traffic controller to release the mechanical brake and set the shunting route from A5 South to G4.

The AIBN understands that the wording of requests for shunting routes from A tracks to G tracks varies (see section 0). The use of a shunting engine to both pull and push freight cars is also common practice. According to the information received by the AIBN, the communication did not contain any direct indication that the shunting locomotive was detached from or connected to the freight car set when the shunting route was ordered. Fixed wording and readback-hearback was not used in the communication between the local traffic controller and the shunter. The failure to read back messages is deemed by the AIBN to be not in conformity with the first paragraph of Section 2-7 of the Norwegian Train Operation Regulations.

The local traffic controller chose to set the shunting route to track G4 for the freight car set, since train 5800 was arriving at Alnabru using the southern part of track G5 and track G3 was intended for outbound train 5507 which was destined for Bergen. The shunter's next task was to shunt train 5800 to the unloading position. The local traffic controller believed that the shunter would push the whole freight car set down along the side of track G5 in order to hook the locomotive onto train 5800.

The local traffic controller asked the shunter to pull back behind the dwarf signal in the G track so that a train route could be set from the container terminal via the Grefsen-Alna line for outbound train 5507. The AIBN considers that this information was not sufficient for the shunter to be able to understand that a misunderstanding had occurred, since the request would have been the same had it simply been a matter of moving the shunting engine down to the G track.

When the mechanical brake was released, the local traffic controller was not familiar with the instructions on how to push a train that was coupled to a locomotive at the north end back from an arrival track to a G track (bypassing the access brakes). The local traffic controller did not take sufficient steps to make sure that the shunting engine was in control of the freight car set (see section 3.3.2.3).

The assistant local traffic controller had left for the day. At this point in time, it was therefore the local traffic controller who was operating the slip signal control centre, including the station's brake systems. After releasing the mechanical brake, the local traffic controller moved back to the main control centre. The AIBN believes that the capacity of the Central Control Tower was reduced since it was no longer manned by two approved local traffic controllers, particularly since the local traffic controller who was left behind would necessarily have to devote some of his attention to the trainee. This is analysed in section 0.

When the shunter saw the freight car set moving, he/she called the local traffic controller and notified that the freight cars were rolling. The local traffic controller tried to stop the freight cars using the lowering brakes. However, the situation had not been noticed in time for these brakes to be able to stop the freight car set.

It is worth noting that if the local traffic controller had seen the trains moving at an earlier point in time, this would, in the AIBN's view, have been in accordance with his expectations, since the freight car set had been allocated a shunting route from track A5 and down to the G track.

The runaway freight cars were also discovered too late to enable diversion to the buffer stops T1/T2 via tracks G2/G3. There were no diverging train routes or run-off points for tracks G4/G5. The freight car set was therefore able to leave Alnabru by following the freight train track in the direction of Loenga.

3.2.3 The chain of events after the freight cars left Alnabru

When the local traffic controller saw that the freight cars did not stop in track G4, he/she informed the Hovedbanen traffic controller about the runaway freight cars. Once the freight cars had entered the freight train track from Loenga to Alnabru, it was important to prevent them from ending up at Oslo S. The Hovebanen traffic controller ensured that the freight car set would follow the freight train track and not enter the Hovedbanen track at Brobekk, Bryn or Kværner. The shift foreman and Oslo S traffic controller were then informed of the incident.

The Oslo S traffic controller contacted the local traffic controller at Loenga and, after considering the matter, they agreed to run the freight car set onto Gjøvikbanen's freight train track and down along the 'wall' onto track 10.

In this situation, the freight cars could also have been sent onto Østfoldbanen , but the AIBN considers that this would not have been a good choice. According to the AIBN's calculations, the freight cars would have rolled past Ljan station, stopped and then rolled back in an uncontrolled manner towards Oslo S or Loenga. In addition, a local train was travelling between Ekeberg and Nordstrand. If some of the freight cars had derailed when running onto the track of the Østfoldbanen, they could have pulled the overhead contact wire system with them. The local train would then have stopped and the freight car set would have caught up with it.

If the freight car set had been assigned another train route towards Loenga, this could have caused a derailment in the upper part of the track system. This could have caused damage to one or more bridges across Loenga. Geita bridge has previously been damaged by derailed rolling stock, which caused it to collapse. Nor was it a natural choice to send the freight cars towards track 7 or 8, where two persons were carrying out maintenance work on some parked freight cars. There was no time to locate and notify these two persons so that they could move to a safe place.

The route that was chosen – towards Loenga and continuing onto track 10 – was, in the AIBN's view, a reasonable choice in the given situation. Track 10 curves sharply left at Geita bridge and there is also a derailer installed at the southern end of the track. All these factors indicated that the freight car set would derail at this point and eventually come to a halt. However, the empty freight cars had a very low centre of gravity and hence good running properties, which caused them to stay on the track.

There was in actual fact no possibility of derailing the freight car set along the freight train track or adjacent sections. The freight cars passed through the Gjøvikbanen freight train track and track 10 without derailing (see section 0).

When the freight train set had left Loenga, it continued through an area of heavy traffic. The rearmost freight cars derailed in the points at Kongshavn. The remaining seven cars in the freight car set continued through the roundabout at the Sjursøya junction which is very busy with heavy vehicles, including road tankers. They then continued along the railway track towards Bekkelagskaia before they finally collided with the gate building in the container terminal.

The time of the accident was favourable in this case: among other things the jet fuel train was parked at Gardermoen and there was moderate traffic in the port area.

3.3 Barrier analysis

3.3.1 Introduction

In the following section, the AIBN will carry out an analysis of the barriers that could potentially have stopped the chain of events and could thus have prevented the freight cars from ending up in the sea at Port of Oslo’s Sydhavna. In the AIBN’s opinion, the Alnabru shunting yard had fundamental faults and defects relating to operational and technical safety barriers against runaway rolling stock.

3.3.2 Barriers before the freight cars left Alnabru

3.3.2.1 *Mechanical brake and lowering brake*

When the mechanical brake and lowering brake were tested following the accident, they worked as intended. The mechanical brake was intentionally released by the local traffic controller as a consequence of the misunderstanding that arose about which shunting route was being set.

There was an attempt to use the lowering brake when most of, if not all, the freight cars in the set had passed through the brake. The lowering brake is an active/dependent barrier, i.e. it requires that any runaway rolling stock is noticed by the operator at an early enough stage. By their very nature, misunderstandings often take time to detect and, keeping this in mind, the lowering brake is not an adequate barrier. On the basis of the AIBN’s test operation using a test train, it appears that, to some extent, the lowering brake may have had some braking effect on the rearmost freight cars (see section **Feil! Fant ikke referansekilden.**).

3.3.2.2 *Parking brake*

The investigation has revealed that none of the freight cars in the train set had engaged the parking brake. Pursuant to the second paragraph of Section 3-17 of the Norwegian Train Operation Regulations, when parking a set of freight cars, they shall be secured by engaging the hand brake, parking brake or brake shoes so that they cannot start to roll. In this context, the AIBN is not sure about the status of the mechanical brake in the A track. The mechanical brake secures the rolling stock against movement; however, there is a difference between this brake and the freight car’s parking brake in that that it can be released by a person who does not have any direct supervisory function in relation to the freight car set. The AIBN understands that the NRA does not consider the use of a mechanical brake to be sufficient when rolling stock is parked on an A track.

Since the set of freight cars was parked in track A5 at approximately 04.20 and there were no plans to move it to a loading track until approximately 17.30, the requirement that the parking brakes should be engaged to secure the set of freight cars (the four-hour rule) cannot have been observed when it was parked on track A5 during the night before the accident. There are several reasons why this provision did not constitute an effective barrier at the time of the accident (see section 0).

The AIBN considers that, had the parking brake been used, it would have contributed to reducing the speed of the freight car set on entering the G track and it would perhaps have brought them to a complete halt before they left Alnabru (depending on how many freight cars had the brakes applied). This assessment applies to this isolated case in which the shunter did not intend to move the freight train set. If the previous shift had applied the parking brakes, the shunter would not have released them.

3.3.2.3 *Procedure for releasing the mechanical brake*

The instructions for the slip control centre at Alnabru shunting yard lists the conditions that must be present before the mechanical brake is released. Section b3 describes the conditions on which a train that is coupled to a locomotive at the north end can be pushed from the arrival track past the access brake.

According to the procedure the local traffic controller must ensure that the locomotive is in control of the freight cars before setting a train route towards an area in which the tracks have no independent barriers to prevent the freight cars from rolling away from Alnabru. The fact that the set of freight cars rolled towards the G tracks suggests that the mechanical brake was released and that the shunting route towards the G tracks, which bypassed the access brakes, was set without the local traffic controller having ascertained whether the locomotive was in control of the freight cars. It the procedure had been complied with, the consequences would have been manageable as the freight car set would either have ended up on one of the R tracks, the various brake systems installed in the tracks could have been used, or they would have been stopped by other freight cars or ended up on one of the T tracks.

However, there are several reasons why this procedure did not constitute an effective barrier at the time of the accident (see section 3.5.7.2).

3.3.2.4 *Barriers to prevent misunderstanding of safety-critical information*

No procedures have been established at Alnabru for use of fixed wording and readback-hearback in connection with shunting. These are operational barriers that could potentially have prevented/clarified the misunderstanding between the local traffic controller and the shunter. This is discussed in section 0.

In the AIBN's opinion, section 2-7 first paragraph of the Norwegian Train Operation Regulations with supplementary comments contains a clear requirement for readback of safety-critical information, including during shunting. The AIBN therefore deems that the failure to establish a procedure for readback in connection with shunting in A tracks constitutes non-compliance with the Norwegian Train Operation Regulations.

3.3.2.5 *Requirements for staffing of the Central Control Tower*

According to the duty schedule, two local traffic controllers were meant to be present in the Central Control Tower at Alnabru at the time of the accident (one local traffic controller manning the main traffic control centre and one assistant traffic controller manning the slip signal control centre). The assistant local traffic controller had left for the day and this meant that the other traffic controller had to operate all the safety systems in the Central Control Tower.

In the AIBN's view the staffing requirements provide for a redundancy in the Central Control Tower which did not exist at the time of the accident. The impact of this barrier breach on the accident is analysed in connection with the local traffic controller's work situation in section 0.

3.3.2.6 *Run-off points at Alnabru*

No run-off points had been installed at the end of the G tracks. Tracks G2 and G3 have possible set of run-off points at the south end, but these are manual (not automatically reset to the safe position). The local traffic controller can set the train route to track G3 or G2 and from there into R47 where end buffers are installed on tracks T1 and T2, but this depends on the freight cars being noticed in time before they the shunting sections are occupied. This is therefore not an adequate barrier against runaway rolling stock. If the train route is set to tracks G4 or G5, these tracks have no run-off points or other form of barrier. All train routes leaving these tracks at the southern end lead to the Loenga-Alnabru freight train track or to the Hovedbanen track at Brobekk.

3.3.3 Barriers after the freight cars left Alnabru

3.3.3.1 *The Alnabru-Loenga freight train track*

The AIBN's review shows that no arrangements were in place that would have enabled controlled diversion, run-off, derailing or halting of runaway freight cars after they had left Alnabru. As shown by the incident analysis, there are options to steer the freight cars onto the Hovedbanen track and towards Oslo S at Brobekk, Bryn and Kværner and onto Østfoldbanen at Loenga. However, these tracks also lack arrangements that would make it possible to gain control in a situation with runaway freight cars. An attempt at derailing the freight cars at Loenga by driving them through a curve and across a derailer failed since the speed at that point far exceeded the capacity of the derailer, i.e. 50 km/h.

It is clear from the layout and allocated use of the area between Alnabru and Loenga that a scenario with runaway freight cars was never taken into consideration.

3.3.3.2 *Loenga - Sydhavna*

No barriers have been established at Sydhavna that would stop runaway freight cars that were rolling at great speed. In the AIBN's opinion, any runaway freight cars from Alnabru must be stopped before or, at the latest, when they reach Loenga. The AIBN understands that there may be a design challenge involved in stopping runway cars from Alnabru at Sydhavna. However, the AIBN has been informed that the possibility of storing rolling stock at Loenga is being considered, on the basis that there is not enough parking space at Alnabru. This means that freight cars could conceivably roll from Loenga to Sydhavna. The speed of any freight cars from Loenga will be less than 40 km/t, and they should therefore be manageable using simple types of barriers between Sydhavna and Loenga.

3.4 Impact analysis and analysis of survival aspects

3.4.1 Introduction

The rearmost cars in the runway freight car set derailed at Kongshavn, while the remaining seven continued to the end of the track, cut through the track’s buffer stops, ran across a car park and into the gate building in the Port of Oslo's container terminal, whereupon the building collapsed. Three persons died, three were seriously injured and one person suffered minor injuries. There was extensive damage to buildings, infrastructure, motor vehicles and freight cars.

3.4.2 Potential consequences/scenarios

3.4.2.1 *Runaway freight cars on Hovedbanen/Østfoldbanen*

In the AIBN’s view, the freight cars could have caused considerably more damage had they ended up on the Hovedbanen or Østfoldbanen. Barriers to stop runaway freight cars are not in place on these lines either.

Runaway freight cars can end up on Hovedbanen if an incoming or outgoing train route has been set to/from Alnabru via Brobekk. The same applies if a train runs onto the freight train track at Bryn station or Kværner. If rolling stock starts to roll uncontrolledly along the freight train track, it will follow the train routes that have been set.

It is not possible for the traffic controller to release any main train routes instantly, but it is possible for the traffic controller to set all signals to the stop position and then release the train routes with a delay (90 seconds) before finally switching the points to a different position, provided that the track circuit is unoccupied. However, as mentioned above, there are no run-off points in use on Hovedbanen between Alnabru and Oslo S or on the Loenga-Alnabru freight train track.

3.4.2.2 *The jet fuel train*

When the accident took place, the jet fuel train was standing at Gardermoen. Had the jet fuel train been standing at the filling station, the outcome would have depended on whether or not the manual points between the loading track and the bypass track were set to the bypass track. Had it not been set to that position, the freight cars would have collided with the jet fuel train. This could have led to fire and explosion and subsequent spread of pollutants.

3.4.3 Notification and rescue efforts

3.4.3.1 *Notification of the emergency services*

Based on the logs, it seems that a triple alert in very hectic situations of this kind is not the optimum solution. Based on experience, triple alerts between the emergency services work for 'everyday' emergencies. In the present incident, the AIBN believes that, if Oslo’s fire and rescue services agency had issued a triple alert at the time of receiving notification from the NNRA, there is a possibility that rescue units would have been hit by the freight cars, since response personnel would have already arrived or been approaching the scene when the incident occurred. The AIBN thinks that guidelines should be introduced for handling messages in cases of 'runaway rolling stock.' This applies specifically to trains, trams, busses, trailers etc. When one of the emergency services is notified of an incident of the type described above, response personnel must not be dispatched to a potential incident site but, if applicable, receive advance notification so that they can be ready to respond.

3.4.3.2 *Notification of Oslo Havn KF*

Oslo Havn KF was notified of the accident at the time when it occurred. No procedures had been established by the NNRA for notifying the Port of Oslo. There were procedures for notification of gas leakages and similar, but this type of incident had not been considered in when drawing up of notification plans. It is also uncertain where and how evacuation should be carried out in connection with runaway freight cars and no evacuation plans have been established for this event. There is uncertainty about the route that the freight cars will follow and about where and when they should be derailed, if at all. As demonstrated by the damage at Kongshavn and the container terminal, the forces that are let loose are enormous. Where to evacuate to in such situations is uncertain.

The AIBN finds that if notification of what was about to happen had reached Sydhavna, a much greater number of people could have been exposed in that they would have been present outside in the route taken by the freight cars or next to the container building that collapsed.

3.4.3.3 *Rescue work*

Access to necessary rescue resources of the right type was good. The rescue work posed several challenges that were dealt with in a professional and satisfactory manner. The Oslo region's access to health resources is formidable and major incidents can be dealt with within a short time interval.

The police were adequately in control of both the operative action and the response effort. The command centre (CC) was organised as a 'mobile' CC in proximity to the incident site. In recent years, this form of CC organisation has proved to be efficient in terms of maintaining an overview, and in terms of organisation and communication. The incident commanders did a good job which enabled them to maintain a full overview of all necessary actions at all times.

3.5 Work practice and operational conditions

3.5.1 Introduction

In this section, we will analyse work practice at Alnabru and the operational conditions around the accident. This largely concerns operational collaboration between local traffic controllers and shunters. The AIBN will seek to explain how the misunderstanding could occur and why the misunderstanding was not discovered until it was too late. In this connection it is also relevant to review the status of and practice relating to compliance with governing documents which could potentially have prevented the sequence of events. At the same time, the established work practice of using the A tracks was in many ways a precondition for several of the other conditions that contributed to the accident.

3.5.2 The misunderstanding between the local traffic controller and the shunter

3.5.2.1 *Explicit and effective communication*

In order to reduce the likelihood of misunderstandings between operating personnel, it is important that both parties communicate clearly (explicit communication) so that the information does not have to be interpreted by the recipient. If the recipient has to interpret the information, there is a basis for possible misinterpretation and misunderstandings between the parties. It is also important that the parties express themselves concisely so that they only communicate necessary information (effective communication).

The application of these principles to communication between a local traffic controller and a shunter essentially means that when the shunter requests a shunting route, it is important that the request is expressed clearly and concisely. It must not be left to the local traffic controller to interpret what is said and then act on the basis of his/her own interpretation. The order must be unambiguous and refer to a single specific shunting route only, i.e. it must not be possible to interpret the request as referring to any shunting route other than the one to be followed by the shunter. It must be understood in the same manner, regardless of who is the local traffic controller and who is the shunter. It is also important that the communication between the local traffic controller and the shunter does not contain too much information so that the amount of information does not exceed the cognitive capacity of the recipient and disrupt their understanding of what is being said.

3.5.2.2 *Lack of fixed phrases*

The AIBN's interviews with shunting personnel and managers in CargoNet AS suggest that they believe that shunters are always very clear in their communication with the local traffic controllers. It is also stated that, on the whole, CargoNet AS's shunters are clear and precise in their communication with the local traffic controllers. CargoNet AS perceives the misunderstanding as a misinterpretation on the part of the local traffic controller and not as a manifestation of ambiguous or unclear communication on the part of the shunter. This is illustrated by the following quote:

> *What was ordered could not be misunderstood.*
>
> *When you issue an order, you are quite clear about what it means. What you say then cannot be misunderstood. This is the very thing on which the whole culture is based.*

The local traffic controllers who were interviewed by the AIBN said that all local traffic controllers could have understood the request and acted in the same manner as the local traffic controller in question:

> *I also had that thought. It could have happened to anybody* [any local traffic controllers].

Chapter 3 of the Norwegian Train Operation Regulations, in which shunting requirements are described, contains no requirements for the use of fixed phrases in the communication between shunters and local traffic controllers. Based on interviews with local traffic controllers and shunters, the AIBN is also under the impression that the use of fixed phrases is not part of their communication practice:

> *'We do not have any fixed phrases, so this varies according to the individual with whom you are talking.*
>
> *You could say that the wording that is used may have something to do with it, that it was not communicated clearly enough that we are now moving … a freight car.'*

In the AIBN's opinion this has given rise to unfortunate individual variations in the communication relating to shunting, which can form the basis for misunderstandings.

As far as communication in connection with releasing the mechanical brake is concerned, the AIBN is under the impression that some shunters specifically ask the local traffic controllers to release the mechanical brake while others only say that they are ready to proceed. The shunter involved said that if the purpose had been to move the freight car set, he/she would have asked the local traffic controller to release the mechanical brake. The local traffic controller involved explained that there were no fixed phrases relating to shunting or the slip control centre. When shunting personnel have run shunting engines up an A track in order to collect freight cars, it is common practice for them to say when they are ready, and the mechanical brake can then be released. Whether a release of the brake is ordered specifically, varies from shunter to shunter.

This confirms that the wording varies from one shunter to the next.

In the AIBN's opinion, this variation can give rise to misunderstandings between local traffic controllers and shunters in as much as local traffic controllers cannot assume that the mechanical brake should not be released except on the request of a shunter.

3.5.2.3 *Lack of readback and hearback*

When interviewed by the AIBN, both local traffic controllers and shunters emphasise the importance of asking when one does not understand or hear what is being said in a communication. Until the time of the accident, it was not common practice to read back shunters' requests.

It is clear from the interviews that there have previously been misunderstandings between shunters and local traffic controllers, and that most people see readbacks as something that could reduce the likelihood of misunderstandings. Readback, i.e. that the recipient reads back the message to ensure that it is correctly understood, is practised to some extent, but it depends on the person and it is only used when the recipient is in doubt. The following quote illustrates the view of the local traffic controllers:

> *'I don't think I am very good about doing it, but if I am uncertain about what they have said, I ask again… I think it is very important that I have understood the message correctly.'*

The shunters say the same thing:

> '[Readback]*... It depends on who is there.'*
>
> *'There are not many in the traffic control centre who read back what we say. And we do not actually read back much either.'*

The AIBN finds that the shunting personnel's and local traffic controllers' practice of only asking when they were uncertain as to whether they had understood the message, was clearly inadequate. It is only a safeguard in those cases when the recipient is in doubt about what he/she has heard. It does not cover those cases when the recipient is certain as to what he/she heard. The AIBN believes that readback should be used in all safety-critical communication, including communication about shunting routes from the A tracks at Alnabru.

It is important to point out that the AIBN does not believe that readback alone can ensure correct understanding. Hearback (in which the sender listens carefully to the recipient's readback of the information) is also an important part of the communication loop to reduce the likelihood of misunderstandings. Hearback means that the sender of a request can consider whether there are any discrepancies between what was requested and what was understood by the recipient. This corresponds to an interactive communication model (see Figure 24) in which both parties are senders and recipients at the same time.

The AIBN is not under the impression that the introduction of requirements for hearback or the use of fixed phrases has been considered in connection with shunting, in order to reduce the likelihood of misunderstandings.

3.5.2.4 *Mutual mental models and expectations*

The importance of mutual knowledge and understanding of each other's tasks, roles and procedures in order to reduce the likelihood of misunderstandings has been highlighted in technical literature. This was also mentioned in our interviews with shunters and local traffic controllers:

> *'You obviously get to understand things once you've worked here for a few years.'*
>
> *There is a slight difference, according to whether they are familiar with shunting or have only worked in the traffic control centre, since, in the former case, they are familiar with our routines … set up a signal and know that the train is headed there.'*

Only a few local traffic controllers have worked in shunting, while no shunters have worked as local traffic controllers. This does not provide a sufficient basis for shared knowledge and a mutual understanding of each other's tasks, roles and procedures. The AIBN cannot see that there has been any emphasis on establishing mutual mental models to ensure unambiguous and effective communication between shunters and local traffic controllers.

The lack of mutual mental models, on top of the variation in the communication between local traffic controllers and shunters in the absence of fixed phrases, will give rise to misunderstandings. This is because local traffic controllers will be likely to understand what is being communicated on the basis of previous experience and expectations. Such experience will also vary from one local traffic controller to the next.

The local traffic controllers' mental model of how shunting from A tracks is handled will affect the decisions they make. The local traffic controller does not necessarily have the same mental model as the shunter. Hence, what is obvious to a shunter is not necessarily obvious to a local traffic controller.

The AIBN believes that it is important that experience and the local traffic controllers' expectations do not form the basis for their understanding of what is being communicated by the shunters; rather, clearly defined mutual mental models must be established to ensure a mutual understanding.

Information obtained from governing documents, from the surroundings and from the shunters forms the basis for the local traffic controllers' decisions. In addition, expectations of something or someone can also influence a local traffic controller's decision in a given situation. Among other things, such expectations may be based on previous experience of similar situations and available information. What experience does the local traffic controller have of shunting in A tracks? Is it usually carried out from the north or the south end of the freight car set? How often does shunting in the A tracks take place? If this is an infrequent occurrence, the local traffic controller could base his/her handling of a shunter's request for a shunting route on available information from the last time he/she received such a request from a shunter. If it is a frequent occurrence, it may involve a routine response.

The AIBN is not clear about how often freight cars are shunted into a freight car set on an A track at the northern end, neither in this case nor for freight car sets in general. The shunting movements at Alnabru were not documented or logged. The shunter who was involved in the accident told the AIBN that the operation of shunting in a freight car at the north end of a freight car set in the A tracks was something that the shunter seldom did. In this particular situation, the freight car was added to make the work easier for the next shunting team.

Through its interviews with local traffic controllers and shunters, the AIBN has formed the impression that there is no unequivocal answer to the question of how often cars are shunted in on the A tracks. The shunters believe that it is not uncommon for cars to be shunted into a freight car set on an A track:

> *'Shunting in at the north end is not uncommon.*
>
> *Shunting has been going on all the time and several times in the A tracks, so that is not abnormal in any way.'*

The local traffic controllers, on the other hand, believed that this was generally a relatively infrequent occurrence:

> *'I don't think that it is such a common thing, that they carry on and shunt out cars and shunt them back in again there. As far as I know, I have probably been involved in such operations, but not many times.'*

The local traffic controller is not in possession of CargoNet AS' track usage schedule or shunting schedule, and irrespective, it was not uncommon to make changes to the planned usage of the freight car sets. This means that the local traffic controller has no basis for ascertaining whether or not a freight car set is to be moved, unless explicitly informed by the shunter. The accident took place after a harsh winter with many delays and changes, and cars were often removed for maintenance or repair.

It is clear from the interviews that the two groups' views of the situation that lead up to the accident vary relatively widely. The local traffic controller concerned stated that when the shunter added a car at the northern end of the freight car set, he/she considered that the shunting operation had been completed and that the freight car set was complete and ready to be parked for loading. The shunters feel that it was evident from the shunting movements up to the A tracks, that the freight cars that were parked there were not to be moved with the freight car set to the G track. Such a movement is described as 'illogical', since the shunting operation would have involved more moves. We have also been informed by CargoNet AS that the freight car set in question was parked on the A track every night and that the freight car set was not normally moved at this time of day.

However, local traffic controllers may not have the same intuitive understanding of what, to the shunters, appear to be 'logical' shunting movements. The gap in understanding between the local traffic controllers and the shunters may be a source of misunderstanding and clearly demonstrates the absence of mutual mental models in this area on which they can base their understanding and their decisions.

3.5.2.5 *Summary*

The AIBN believes that the use of fixed phrases, particularly for safety critical communication, is essential to establishing mutual references and mutual mental models for local traffic controllers and shunters. The AIBN believes that a combination of fixed phrases for safety-critical communication relating to shunting, readback and hearback of critical and appropriate parts of messages will largely reduce the likelihood of misunderstandings between local traffic controllers and shunters. The AIBN cannot see that the NNRA and CargoNet AS have analysed shunting communication with a view to defining safety-critical information and coordination. Fixed phrases can only be introduced after a proper review of the terminology, so that the use of terms and concepts precludes any ambiguity with respect to understanding and interpretation. The introduction of fixed phrases and fixed words which will be read back will result in efficient communication. Readback combined with hearback will allow the initial sender of the information to verify the recipient's confirmation of the information.

The AIBN is aware that any new standard for communication about shunting should be coordinated with the work on national regulatory requirements that follow from the future EU standard for communication on interoperable railway networks (TSI OPE Annex C).

3.5.3 The local traffic controllers' working situation and overview

The AIBN has considered whether the local traffic controller's working situation and the ergonomic design of his/her workplace could have influenced the situation in question.

Immediately before the freight car set was shunted and while the shunting operation was in progress, the local traffic controller dealt with inbound train 5800 arriving at Alnabru in track G5 and outbound train 5507 that was leaving via the Grefsen-Alna line. The local traffic controller was in contact with the safety supervisor on the Grefsen-Alna line so that the line could be opened for crossing train 5507 and an uncoupled locomotive. The local traffic controller was also in contact with the local traffic controller at Grefsen to check if train 5507 could go to Grefsen. This communication with the trains took place via the GSM-R telephone which is placed next to the operator station for the Ebilock 850 control centre.

For the inbound train, the local traffic controller set the train route to track G5. The train routes for the two trains were set using the control panel next to the Ebilock 850 control centre. The local traffic controller used the same control panel to set the shunting route for the shunter who was shunting the freight car set on A5. There was radio communication with the shunter via the shunting channel.

The local traffic controller has to move to the slip control centre on the opposite side in order to release the mechanical brake. When the traffic control systems are operated by the local traffic controller and assistant local traffic controller together, there is less need to move between the control centres, since the slip control centre is being operated by the assistant local traffic controller. When all the traffic control systems in the Central Control Tower are operated by the local traffic controller alone, as in the present case, this requires more movement between the control centres.

In the AIBN's view, the ergonomic conditions under which the local traffic controllers work in the Central Control Tower have not been adapted to the current activity structure and activity level at Alnabru, particularly when it is operated by only one traffic controller. Having to operate the various control systems, which all have a different design and are located in different places in the room, and having to deal with various communication tools (radio and telephone) can contribute to reducing the local traffic controller's overview of what is happening.

In its follow-up of the accident, the NLIA found that, in the case of the local traffic controllers at Alnabru, the working environment provisions had been breached and the inspection authority notified of an order to rectify the conditions (see section **Feil! Fant ikke referansekilden.**). The AIBN believes that the HSE conditions have affected the local traffic controllers' work practice at Alnabru. The AIBN also believes that the ergonomic design of the Central Control Tower had a negative impact on the local traffic controller's overview of the situation in question.

The traffic companies' track usage schedules and shunting orders are not available to the local traffic controllers. The shunting order provides a rough overview of the tasks planned for the shunters on each shift. The local traffic controllers have the timetable for Alnabru which provides an overview of all inbound and outbound trains. From conversations with the shunters and local traffic controllers it is evident that the schedule according to which the shunters are working is constantly being changed.

It is doubtful that an overview of the shunting order would have made any difference in preventing the accident on account of the constant changes that take place in the course of a day. The shunter wanted to ease the work of the subsequent shift by shunting a new freight car into the freight car set earlier than planned, so that it was ready for shunting to the terminal. The AIBN believes that it is doubtful that the local traffic controller would be able to keep track of all the changes from the planned shunting movements.

The AIBN believes that having to supervise trainee personnel will necessarily reduce a local traffic controller's capacity for information processing. In combination with the ergonomic conditions in the Central Control Tower and the absence of barriers relating to communication (fixed phrases, readback and hearback), this may have constituted unfortunate circumstances on the day of the accident.

3.5.4 Operational coordination between local traffic controllers and shunters

Our informants in both the NNRA and CargoNet AS describe the operational collaboration between the local traffic controllers and shunters as good with relatively few conflicts. The local traffic controllers mention that they have common interests with

CargoNet AS as regards operations at Alnabru, and that it is their function to ensure that the shunting team is able to do its job. This means that the task of the local traffic controllers is to set the signals on the orders of CargoNet AS. The local traffic controllers believe they do not need any further information about CargoNet AS's scheduled shunting movements on any particular day.

When interviewed, both the local traffic controllers and shunting personnel showed an inadequate understanding of each other's tasks and the pressure they experience at work. The shunters stress that they have to work outside in the snow and the cold, and they believe that the local traffic controllers, from their warm workplace in the tower, have a good overview of all the activities and operations that are going on in the yard. In general, the shunters feel that the local traffic controllers have no need for further information or a better overview of the shunting operations, while at the same time stressing that the best local traffic controllers are those with shunting experience. Some local traffic controllers describe certain shunters and locomotive drivers as very insistent and say that they sometimes feel pressurised by the railway undertakings to keep the traffic moving.

There are clear cultural divisions between the two groups. Both parties are clear about whom they refer to as 'us' and 'them':

> *'But you obviously meet informally and probably over a coffee or during lunch, don't you? Not with the Rail Administration. Not with the Rail Administration? No, no! They stay down that way* (laughter).
>
> *We don't have joint meetings like we used to do in the old days – we were all one company then, weren't we?'*

This type of dividing line between the groups is not unnatural, given that the two groups have different tasks, different skills and a different workplace. However, interaction between the local traffic controllers and the shifters is essential to the safety as well as the efficiency of traffic operations at Alnabru. Since there is little contact between the local traffic controllers and the shunters except by radio in connection with shunting operations, they lack the basis for knowing anything about each other's working situation and reference framework for communication.

It therefore seems that each group needs to adjust its expectations of the other if they are to establish mutual mental models and a common terminology. Shunting personnel could gain more insight into the complexity of the local traffic controllers' day-to-day operations, and the local traffic controllers could gain a better understanding of the additional burdens experienced by the shunters, particularly as a result of the yard's shortage of space, the space taken up by freight cars for repair and problems of snow in the winter.

3.5.5 <u>Other factors</u>

The AIBN would like to comment on one set of circumstances that had no impact on the accident in question. The AIBN has been informed by local traffic controllers of several cases in which other railway personnel have climbed up into the Central Control Tower and exerted pressure in order to get the all-clear signal to leave Alnabru. In the AIBN's opinion, the Central Control Tower must be seen as a control centre to which unauthorised personnel should not have access, and the NNRA should secure the area accordingly.

3.5.6 Use of A tracks

The AIBN's investigations show that a form of operation had developed at Alnabru, which included extensive use of the arrival tracks ('A tracks') for intermediate storage of freight train sets between loading operations.

In the AIBN's opinion, the use of A tracks as parking tracks was not in accordance with the original plan for track usage**Feil! Bokmerkenavn er ikke angitt.**. The A tracks were designed and built for use as arrival tracks on which freight car sets are broken up/slipped and the freight cars prepared for shunting into new freight car sets. There has been a considerable decline in this type of transportation (by freight car loads) in recent years, which currently consists mainly of uniform freight cars, block trains and container trains. This means that the freight car sets are largely permanent with the exception of some simple adjustments to their length at either end or replacement of freight cars being repaired. In addition, there has been a steep increase in rail freight via Alnabru.

Together, the above factors have increased the demand for parking space for freight car sets after unloading and until they are reloaded, and the capacity of the directional tracks ('R tracks') for storage and parking have sometimes been used to bursting point. As a consequence of this, the A tracks at Alnabru have gradually been taken into use for parking and storage.

It is clear from the interviews that the freight car set that was involved in the accident was parked in an A track every night. The AIBN understands that this had become established practice regardless of whether or not there was room on the directional tracks. The interviews made it clear that there was storage room for the freight car set in question on the day of the accident. From the shunters' point of view, it is easier to conduct shunting operations when the entire freight car set is parked in an A-track, since they involve fewer shunting movements and shorter running distances.

The staff that were interviewed by the AIBN refer to there having been too few local traffic controllers and too much pressure at work in relation to the changes that have taken place at Alnabru. The AIBN is under the impression that the shunters may also have been under some indirect pressure to increase efficiency, which caused them to make adjustments to reduce the workload and hours worked, for example by using the A tracks for parking and by adjusting freight car sets in this position. At the same time, the AIBN would like to stress that both the local traffic controllers and the shunters believe that there is sufficient tolerance in both organisations for them to feel able to stop the work if they find themselves in a situation where they feel that there is a threat to safety.

Local working practice adaptations of this type are described in the safety literature by Rasmussen (1997) and Snook (2000), among others. This is analysed in more detail in section 0.

3.5.7 Status of and compliance with governing documents

Procedures are prepared in order to standardise the way in which work operations are carried out and to communicate a ‘best practice’ of the best way in which work should be carried out, based on experience. Procedures are developed with a view to improving general safety, but which may be perceived as laborious in certain situations, in that it takes longer to complete a work operation.

Two nonconformities in relation to governing documents have caused the AIBN to investigate the operating personnel's familiarity with and understanding of the procedures, as well as the availability and suitability of the procedures. The first nonconformity concerns the provision that a train that is left standing for more than four hours on the arrival track shall be secured with parking brakes In this case the parking brake had not been engaged on any of the freight cars that made up the set that was parked on the A track. In the AIBN’s view, engaging the parking brakes (depending on the number of parking brakes that were engaged) could have prevented the freight car set from rolling out of Alnabru shunting yard. The second nonconformity concerned the procedure for releasing the mechanical brake: a shunting route to the G track was set without the local traffic controller having ensured that the shunting engine had control of the freight car set. If the steps of the procedure had been followed, the freight car set would have been prevented from entering track G4 or G5.

3.5.7.1 *The provision that a train that is left standing on an A track for more than four hours shall be secured with parking brakes*

Nobody that the AIBN spoke with in CargoNet AS, whether operating personnel, management or staff with support functions, knew of the four-hour rule before it was presented after the accident. The rule had not been implemented in CargoNet AS’s procedures or in the training of shunting personnel, and it had therefore never been complied by CargoNet AS. None of the people that the AIBN spoke with in CargoNet AS knew about the background to the four-hour rule or why it existed, and several of them felt that the rule was illogical since, in principle, the mechanical brake is supposed to be able to hold the permitted train weight for an indefinite period. Several people mentioned that parking brakes were only used in the A tracks for parking heavy freight car sets and train sets (of more than 1,200 tonnes, particularly ‘Swedish trains’):

> *’I came here in 2000,(...) and heard nothing about it. And if it exceeds a certain number of tonnes, we went up and turned some screws. (...) But something must be fundamentally wrong, since nobody knew about it.*
>
> *I believe this is a dormant rule for both CargoNet AS and the NNRA.’*

Several people in CargoNet AS believe that if this provision is to be observed in practice, the NNRA should also be responsible for notifying the operator that the parking brakes must be engaged if the freight cars were left standing for more than four hours.

Some of the local traffic controllers stated that they were familiar with the provision and that they had relied on the operators to secure the freight cars accordingly. Other local traffic controllers only knew that the shunting personnel engaged the parking brakes in the case of heavy freight car sets, but not that this was practised in any other cases:

> *'But then we don't ask about it either* [whether the parking brakes are engaged] *since we have joint safety regulations which everybody must observe… meaning that this whole operation is based on trust.*
>
> *Yes, it had to do with the tonnage. But was otherwise not done. Even if the train was left standing for more than four hours, we didn't do it.'*

The AIBN finds it surprising that nobody with whom it has spoken in the NNRA is able to explain the background to the four-hour rule or the reason for its existence. The provision has never been subjected to any audit or evaluation. One of the informants assumed that it was meant as a safety precaution in the event of loss of air. However, this does not tally with the fact that the mechanical brake is a spring-loaded brake that is released using compressed air and engaged when the compressed air is released. Another informant thought that the four-hour rule was introduced as the infrastructure owner's guarantee of how long the mechanical brake would hold the rolling stock in place, while at the same time stating that, in principle, the brake should hold indefinitely. The AIBN notes that there is much uncertainty about this provision.

The AIBN believes that the provision may have its origin in the rhythm at which the rail terminal used to operate. In the days of handling freight car loads, the freight cars were not usually parked for as long as four hours. If the cars were not sorted and slipped within four hours, they would be left there for a long time and hence they were defined as parked. In such case the parking brakes were to be engaged as an additional technical barrier.

In the AIBN's view, the four-hour rule is not an adequate barrier since it depends on the active intervention of operating personnel and because it does not apply to rolling stock that is parked for less than four hours. However, in the AIBN's opinion, the four-hour rule cannot be removed until other independent barriers have been established to prevent rolling stock from breaking loose and rolling uncontrolledly. The AIBN considers that the provision reflects that somebody has identified a danger associated with the parking of rolling stock in an A track for a lengthy period, and this cannot be disregarded until a complete barrier analysis has been carried out of the Alnabru shunting yard.

Based on the analysis in section 0, the AIBN has doubts about whether the local rules for Alnabru meet the parking requirements of the Train Operation Regulations.

3.5.7.2 *Procedure for releasing the mechanical brake*

This is a procedure that is not part of the NNRA's governing documents, but that is described in the instructions/special rules for the brakes at Alnabru. The procedure is not signed or dated, and it has never been audited. The interviews with the local traffic controllers showed that some knew of the procedure while others did not. However, it was unusual to follow the procedure step by step:

> *'When I started at Alnabru, I was told time and time again that I should set the shunting route and then release the mechanical brake. (...) But obviously, you could say that once you had released the brake, you just tore out the 'dwarf' signal and parked on the side.*
>
> *And I didn't absorb it. And so I had a big realisation when this happened – that, of course – you see what I mean? But one learns from bad habits.*

> *How can they build a system that you can do this with if it is prohibited? ...And we were never told that to do this was prohibited. I have never read it before (...). The way that* [the traffic controller involved] *does it is the way we do it – there is nothing more to be said about that. I do it and everybody else does it.'*

In the AIBN's view, there is such lack of clarity about how to achieve the procedural requirement of ensuring that the locomotive is in control that different local traffic controllers are bound to do it in different ways. The AIBN feels that the local traffic controller may find it difficult to meet the procedural requirement for checking that the locomotive is connected to the freight car set in a stressed/hectic work situation combined with an operator station that is not suitable for that kind of monitoring function. The AIBN finds it strange that the requirement for making sure that the shunting engine is connected comes last in the description. This should definitely be the first step in such a procedure. It is the clear opinion of the AIBN that a procedure for releasing the mechanical brake must require that it is the operators/shunting personnel in the field who are responsible for requesting that the mechanical brake be released and for ensuring that the shunting engine is connected when a shunting route that bypasses the access brake is set. Readback and hearback must then be used to ensure that the request is correctly understood.

Several NNRA staff have also mentioned that the procedure is unclear and of poor quality since it is a mixture of a technical system description and operating instructions. The AIBN has been informed that the procedure is being revised by the NNRA and that it will be changed so that it becomes an operating procedure only. In the AIBN's view the procedure must describe a practice whereby the mechanical brake is not opened unless this is explicitly requested by the shunting personnel.

3.5.8 Summary

Based on the information that the AIBN obtained from the informants during the investigation, the AIBN believes that the operating personnel involved in the accident acted in accordance with a joint work practice that was established at Alnabru at the time of the accident. The AIBN therefore believes that there is a need to further analyse the safety management and safety culture of the organisations involved.

3.6 Safety management

3.6.1 Introduction

According to Reason (1998), an essential characteristic of a good safety culture is that it is an 'informed culture'. In the absence of accidents, the best way to maintain people's awareness of risk is to collect the right types of data. An efficient safety management system therefore constitutes the principal basis for an informed culture. In an informed culture, those who manage and operate the system have up-to-date knowledge of the human, technical, organisational and environmental factors that affect the overall safety situation (Reason, 1998, pp. 194-195).

Hence, it was essential for the AIBN to determine whether the organisation was aware of the problems relating to runaway rolling stock, inadequate operational and technical safety barriers, and the risks relating to the changed form of operation and the use of the A tracks at Alnabru. The AIBN has checked whether the problems are dealt with in various types of safety documentation, including: risk assessments, nonconformity and incident reporting, governing documents and follow-up/inspection of operations and work performance. These are elements of a systematic and informed safety management system. The AIBN has therefore reviewed how these elements of safety management were addressed by CargoNet AS and the NNRA in relation to the accident and the safety situation at Alnabru.

3.6.2 Were the organisations aware of the risk?

One of the first questions that the AIBN posed in its investigation concerned the extent to which the organisations involved were aware of the risk of runaway rolling stock and the lack of barriers in that respect. The AIBN therefore focused on this aspect in its interviews with the NNRA and CargoNet AS, and in its review of the documentation.

Training for the purpose of providing factual knowledge is deemed to be well addressed by both organisations. Nevertheless, a fact like the inadequacy of barriers against runaway rolling stock was not presented in the theoretical part of the training, but has become a part of the practical training in the form of experience transfer.

3.6.2.1 *The Norwegian National Rail Administration (NNRA)*

All the nine local traffic controllers who were interviewed by the AIBN said they knew there were problems in tracks G4 and G5 with respect to barriers:

> *'We were completely aware of the fact that there are actually no barriers there.'*

Several people described that the requirement for parking a freight car set on a G track was that it was supervised, and that local traffic controllers who were new to the job were told that locomotives must not be uncoupled in a G track except where shifting personnel were present and in control of the freight car set.

Some local traffic controllers also describe cases in which freight cars have rolled towards the main track at Alnabru South when heavy freight car sets have been slipped from an A track to an R track, and bumped into freight cars parked in the R track. However, none of the local traffic controllers with whom the AIBN has spoken had thought of the possibility that freight cars would break loose and roll uncontrolledly from an A track towards the G tracks:

> *'No, people have not had sufficient imagination to conceive of anything going wrong on this scale… but then we have sort of relied on the brake systems and the procedures we have as being satisfactory.'*

This means that the local traffic controllers knew that there was no automatic 'emergency exit' from the G tracks. However, only a few of the operating personnel with whom the AIBN has spoken have stated that this matter has been discussed or raised with management.

The AIBN is under the impression that the operating personnel had adapted their work practice to the lack of barriers in the G tracks, but that no explicit concern about safety was raised with anybody at a higher level:

> *'Well, we have sort of learnt to live with the fact that this is what it is like. No, in no way have we made any demands in this area before the accident.'*

This is confirmed by the other organisations (the team leader, area manager, traffic manager, district permanent way superintendent and safety advisors) who say that they had not been notified of any concerns relating to problems with runaway freight car sets or lack of barriers. Nor has the AIBN been able to find any documented 'traces of concern' relating to this area in Synergi or other forms of reporting (the working environment committee, safety meetings) in the NNRA.

3.6.2.2 *CargoNet AS*

In the AIBN's opinion, the possibility of freight cars breaking loose and rolling uncontrolledly from an A track towards the G tracks had not been perceived by operating personnel in CargoNet AS either. However, all 12 shunters and all four team managers with whom the AIBN spoke in CargoNet AS confirmed that they knew that tracks G4 and G5 lacked barriers. This was a matter that the shunters had discussed amongst themselves and of which new recruits were informed. This means that interviews with other shunting personnel confirmed what was described as follows by the shunter who was involved in the accident:

> *'The first thing we tell them when they are new to the job is that they must avoid G4 and G5 unless they have air brakes. Then they cannot use the tracks. We explain it to them by saying that the run goes straight to the city.'*

Through the AIBN's interviews it became clear that the safety representatives in CargoNet AS at Alnabru believed they had tried to raise the problems at a higher level in CargoNet AS's system through the safety meetings. However, they were unable to confirm (though they hoped) that CargoNet AS's management had followed up the problem in relation to the NNRA:

> *'Yes it has been raised – I know this since we have discussed it a lot, but they have put forward a good explanation of why it [barriers] does not exist. But I do not understand why it has not been put into place - that is strange.'*

Some of the more senior shunters described that management had lacked stability and knowledge of the work processes at Alnabru, so it was not reported as a problem since people did not believe anything would be done.

The AIBN has been unable to find any documentation of the problem having been raised at a higher level in CargoNet AS's organisation. The terminal manager at the time of the accident was unaware of this possibility until the accident actually took place. The person in question was also of the opinion that the shunters had adapted to the situation through their work practice and that they had not reported the matter since *'they knew that they were banging their head against the NNRA'*.

3.6.3 Reporting and the nonconformity system

The reporting and nonconformity system is an important safety management tool that can be used to get an overview of undesirable incidents and dangerous circumstances, and hence an overview of where the problems lie. Based on the AIBN's interviews with both the NNRA and CargoNet AS, and on documentation from Synergi, the AIBN is under the impression that under-reporting took place in both organisations at Alnabru. Both organisations therefore lacked an important element of a systematic and informed safety management system. The operating personnel's concerns relating to the problem of runaway rolling stock and inadequate operational and technical barriers may have been lost as a consequence of the above. In the interviews, the AIBN asked why undesirable incidents or dangers might not be reported by operating personnel.

3.6.3.1 *The Norwegian National Rail Administration (NNRA)*

The NNRA's list of reported incidents at Alnabru does not suggest that the circumstances surrounding the accident (runaway freight car sets, inadequate operational and technical barriers or communication failure between local traffic controllers and shunters) had been reported as problems in Synergi prior to the accident.

There was no practice of reporting HSE matters through the Synergi system. Any HSE matters were handled outside Synergi, through performance evaluation and planning discussions, staff meetings and corresponding channels for issuing orders.

The NNRA's statistics show that, from 2000 and up until the accident took place, there was a slight upward trend in the reporting. After the accident there has been a steep rise in the number of reports that concern conditions, including working environment conditions. The AIBN believes that the increase in reporting has to do with the increased focus on safety and the local traffic controllers' work situation following the incident, and that it does not necessarily reflect any deterioration in the working conditions.

If we look more closely at the relationship between reported cases of damage/loss/injury and reported near-misses/conditions, it seems that the number of reported near-misses/conditions is much too low. This can be explained by the logic of Heinrich's so-called iceberg theory from1931 to the effect that the number of undesirable incidents increases almost exponentially with the decrease in the degree of severity (300 near-incidents: 29 minor incidents: 1 case of serious loss) (Hovden et al, 2004). The AIBN recognises that the iceberg theory cannot contribute to explaining major accidents and that the absence of minor incidents and near-incidents is no guarantee that there is a low risk of a major accident. Nevertheless, the AIBN regards the theory as relevant to an evaluation of the figures from the Synergi statistics and the relationship between incidents, near-incidents and conditions.

The AIBN believes that this indicates that until the time of the accident there was under-reporting of the condition category and potentially dangerous condition category in Synergi. It was also confirmed through the AIBN's interviews with operating personnel, managers and support functions that they were not good enough at reporting. On the basis of the AIBN's interviews, there are two primary reasons for inadequate reporting on the part of the local traffic controllers:

1. Several of them had experienced a lack of response and it did not always seem as if the reported matter was taken seriously:

   'There is probably under-reporting. There is tacit agreement that not everything should be reported. Nothing is done with the reported matters anyway.'

2. Reporting is to some extent considered to be informing on one's colleagues, and hence there is a strong reluctance to report anything that a colleague has done:

'I feel that it is a bit disloyal to colleagues to write a report on something that did not necessarily involve any danger at all (...) one can simply speak with the person (...) instead of making it into such a formal thing.'

The AIBN has formed the clear opinion that, as a consequence of the lack of response and that *'nothing is done'*, not all local traffic controllers see the utility value of the reporting system. Another factor is that operating personnel are not quite clear about what they should report (including the definition of an undesirable incident), and hence, it may be up to each of them as to what they perceive as dangerous.

Our informants among safety staff and line managers are clear that there has not been enough reporting at Alnabru. At the same time, they also say that the problem of under-reporting applies to the NNRA in general. It is also evident from DNV's survey of the safety culture, that the NNRA has room for improvement regarding reporting and organisational learning.

3.6.3.2 *CargoNet AS*

CargoNet AS's overview of reports relating to Alnabru show a steep downward trend since 2003, but, according to CargoNet AS, this is because conditions/near-misses that are detected during inspections and rectified before departure are no longer registered. However, as in the case of the NNRA, there seems to be a disproportionate relationship between the reported number of accidents and the reported number of near-misses/conditions.

It is clear from the interviews that the shunting personnel have primarily reported via the Synergi nonconformity system when unfortunate incidents have occurred in the field, particularly where these have impeded or delayed their work and in the case of specific physical and technical conditions. The personnel have not used Synergi to raise safety concerns of any other kind, for example the absence of barriers in the G tracks or HSE conditions.

At the same time, the AIBN is under the impression that the operating personnel at Alnabru have been relatively good at using their safety representatives to notify of physical/technical conditions. Moreover, annual safety inspections are carried out with the focus on physical aspects, and the documentation from these inspections show that simple technical matters that are registered are corrected on a continuous basis.

Our interviews with operating personnel, support functions and line managers in CargoNet AS also suggest inadequate reporting. The following are highlighted as reasons why people do not always report:

1. Lack of response to what is reported has led to resignation and that people have gradually given up reporting:

   'But when we get no reply to what we write, time after time, we end up not writing. We don't know what happens to it, perhaps it ends up in a corner where nobody sees it.'

2. Shunting is generally dangerous. The threshold for reporting is therefore high and it is up to the individual to assess what he/she feels to be dangerous:

'But shunting is generally a very dangerous operation, so I think it varies a lot from one person to the next as to what is perceived as dangerous, what is understood to be a risk and what a situation could potentially escalate to .'

If you are writing [a report], you wait until you are back at your desk, which may be after a certain period and then it doesn't feel so dangerous anymore.'

3. Reporting can be experienced as informing on one's colleagues:

   'And that concerns what we have always found hard and still do, namely getting one colleague to more or less inform on another, for example, if I see that he has made a mistake, many people will be reluctant to report it'

Several people mention specifically that they do not know what happens to cases that are raised with the NNRA either by notification to the local traffic controllers or via the rail terminal's management.

3.6.4 Governing documentation and management follow-up

It is food for thought that the operating personnel did not use or were not familiar with two procedures/provisions that could potentially have stopped the chain of events in question. One concerns the danger associated with parking rolling stock in an A track for an extended period of time, while the other concerns the danger associated with rolling stock that is not coupled to a locomotive. The AIBN's inquiries show quite clearly that both procedures/provisions were partially 'dormant' and not very well known to operating personnel.

In the AIBN's opinion, the fact that there are two examples of 'dormant' provisions suggests both that there are weaknesses relating to how governing documents are prepared, maintained and distributed, and that non-compliance with the provisions cannot be regarded as isolated mistakes. The AIBN has therefore looked more closely at how management ensures that governing documents are valid and complied with. The Safety Regulations require that established barriers be made known along with the functions they are intended to serve. If the procedures in question were not intended as barriers, then that would suggest that the governing documents were in need of revision and simplification.

3.6.4.1 *The Norwegian National Rail Administration (NNRA)*

The investigation has shown that Alnabru has not been subject to any audits, spot checks or inspection of operations by the NNRA. Hence the AIBN feels that an element that should have been part of the safety management for Alnabru was missing. Through interviews with the line management and safety support functions in the Traffic Division, it became clear that there were several reasons why Alnabru has not been subjected to audits or inspections. They stress that it is a combination of the line management not demanding it, a lot of pressure, many ongoing projects and few safety advisors in the Traffic Management Division.

The entire set of instructions for the slip control centre at Alnabru, which included the procedure for releasing the mechanical brake, had neither been audited nor signed and dated, and it could not be found in the NNRA's governing system. The AIBN believes that if an audit of the instructions that apply to the local traffic controllers at Alnabru had been carried out before the accident, it could potentially have revealed that the procedure for releasing the mechanical brake had not been revised, signed or dated. It is somewhat more doubtful that an audit would have shown that the procedure was inadequate and that, in practice, the local traffic controllers did not comply with it.

The investigation showed that the 'four-hour' rule described in the section description (*Strekningsbeskrivelsen*) had never been revised or evaluated. Hence the rule had not been adapted to the change that had taken place in how the A tracks were used or to the parking provisions of the Train Operation Regulations. The rule had not been incorporated in the NNRA's (owner of the provision) training schedules. The AIBN is concerned that such a provision exists, the origin and intention of which cannot be documented, and the AIBN regards this as a further failure of the safety management.

The NNRA has informed us that they had not received any input from the railway undertakings to the effect that the 'four-hour rule' could not be complied with or was insufficient. Hence there was nothing to trigger a revision or an evaluation of the rule.

The informants in the NNRA believe that they do not have permission or are not authorised to check up on or audit the railway undertakings' compliance with the provisions that apply to the NNRA's network. The NNRA regulates access to its tracks through a track access agreement. Hence the NNRA should be able to decide how to check whether the requirements of the agreement are being complied with. The NNRA should request information and actively promote compliance with rules and regulations by the railway undertakings that operate on the NNRA's infrastructure. The AIBN understands that such a 'supervisory' function may be demanding for the NNRA, but nevertheless believes it to be an important part of safety management.

It is also worth noting that elements of the total management system for the NNRA are spread between a number of channels and come from various sources. The various documents (circulars, section handbook etc.) also have varying status. For example, some of the informants are in doubt as to whether the information in the section handbook should be regarded as governing, or whether it has the status of more general guidelines for use of the infrastructure:

> *'I believe that there is less (...) respect for the operating manual or section handbook than for the traffic rules on the NNRA's network or an S circular (...) I don't consider it to be rules or instructions.'*

Some informants express frustration with respect to training and quality assurance on the part of management to ensure that procedures are correctly understood and used by operating personnel. The railway sector is known for the vast number of procedures people are expected to comply with– a *'dictatorship of procedures'*. Some also describe the governing system as being too extensive and difficult to find one's way around – *'shelf safety'*. The AIBN believes that inadequate follow-up by management can mean that an excessive part of the responsibility is pushed down to the operational level.

In general, the NNRA should have more focus on making sure people understand why the various rules and provisions exist, and on distinguishing between provisions that require absolute compliance as operational barriers and information of a more general nature. It is obviously easier for operating personnel not to comply with rules when they don't understand the purpose and background of the rules.

3.6.4.2 *CargoNet AS*

The AIBN has been informed by the director for freight terminals in Norway that, on being appointed, he presented all employees at the terminals with a zero tolerance policy relating to breach of the safety provisions. Both the freight terminal director and the safety manager are in favour of consequence management and clearly state that CargoNet AS must abide by the principle that all rules must be complied with, regardless of whether or not the point of the rule is understood. Any disagreements, unclear points or wishes to change the rules must be raised through other channels.

The AIBN has been informed by CargoNet AS that no systematic review had been carried out of the section description that applied to Alnabru. System audits and inspections look at the overall picture and any amendments to the governing documents. Hence such audits are not able to detect latent faults and deficiencies in each individual provision/procedure.

The AIBN would like to point out that it is important for any organisation to focus on the reasons for any breach of the safety provisions. If the focus is on punishment in the event of a breach of the safety rules, this may have a bearing on people's willingness to report nonconformities that they themselves or other people are responsible for (See Reason, 1997). As described in section 0, employees of both the NNRA and CargoNet AS feel that reporting can be perceived as informing on one's colleagues. In the AIBN's view, operating personnel wish to work safely and comply with the safety provisions, and there are very few cases in which the rules are breached intentionally.

3.6.5 Risk assessment

Risk analyses are used to obtain a basis for decisions relating to safety, and are an element in risk-based safety management. The AIBN has reviewed all risk analyses that were available for Alnabru, whether from the NNRA or CargoNet AS, at the time of the accident.

3.6.5.1 *Available risk analyses from CargoNet AS and the NNRA*

The AIBN found that the NNRA has not recently carried out any risk analyses that address potential risks relating to the Alnabru area as a whole.

The risk analysis carried out by the NNRA in 2001 identified the risk associated with unbraked rolling stock that can therefore end up on the main track at Alnabru South. However, the analysis team was divided in its view of whether this was a realistic incident and, hence, identifying measures was not a priority. The AIBN has interviewed one person from CargoNet AS who participated in the risk analysis. That person believes that this constituted an attempt on the part of CargoNet AS to notify of the lack of barriers. The person also claims that, when this was put to the vote, CargoNet AS was outnumbered by the NNRA which claimed that there were sufficient safeguards on this point and that the participants from CargoNetAS were not competent to overrule the NNRA. At the same time, they were not left with the feeling that this was a scenario that could actually occur or that the NNRA was mistaken, so they left it at that when the matter was mentioned in the report. This was confirmed by another informant in CargoNet AS, who said that the problem of runaway freight cars had not been discussed with the NNRA since 2001. However, the AIBN would like to point out that the risk analysis mentions freight cars that slide from the R tracks and not the danger of freight cars rolling uncontrolledly from an A track and onwards from a G track.

The section analysis by DNV in 2001 contained no further details relating to Alnabru. The AIBN is also sceptical when the analysis prescribes a procedure whereby any runaway rolling stock approaching Oslo S shall be directed into the tunnel, where it will come to a stop at the lowest point. This does not seem to have been properly thought through.

The risk analysis for Alnabru which was carried out in 2004 was never completed. Based on a review of the document that was circulated for comment, the AIBN has formed the opinion that this analysis identified several conditions that had a bearing on the accident, including the lack of barriers in the G tracks and communication failure between the local traffic controller and the shunter. It was unfortunate that the risk analysis was never completed and that the proposed measures were never implemented. On the basis of the AIBN's interview with employees of the NNRA, it seems that the organisation may be vulnerable in the absence of certain key persons.

The most recent analysis carried out by the NNRA was a change analysis of the local traffic controllers' work situation in 2006 in connection with the restructuring of the terminal. However, that analysis was very limited, while at the same time documenting several of the problems involved in the local traffic controllers work situation. This analysis was the basis for the decision that the Central Control Tower would always be manned by two traffic controllers.

The AIBN has received CargoNet AS's most recent update of the risk situation at Alnabru, from September 2008. It is very interesting that the updated risk picture described for Alnabru in 2008 also mentions the possibility that rolling stock could end up on the main track, even though it is quite clear that, in this case too, what was considered was the possibility of rolling stock slipping from an A track to an R track. The lack of barriers in the G tracks is not mentioned in the analysis.

Both the risk analysis initiated by the NNRA in 2004 and CargoNet AS's update of the risk picture for Alnabru in 2008 pointed out that there had been a change in the form of operation in that the number of slipping operations had been reduced while the number of shunting operations had increased. The NNRA's analysis pointed out that this had an impact on the workloads of both local traffic controllers and shunters, and that it could have consequences for communication between the driver of the shunting locomotive, the shunter and the local traffic controller. However, none of the proposed measures were implemented since the analysis was never completed. CargoNet AS's risk analysis was limited to registering the changes that had taken place and did not stress that the structural changes could have an impact on workload or communication. None of the analyses comment on the parking of freight car sets in the A tracks as a change from what the situation used to be.

3.6.5.2 *Methodical considerations*

The people that the AIBN have interviewed in the NNRA's management and safety support organisation have clearly expressed that they have not done enough to identify and take into account the changes that have taken place over time at Alnabru. The person in charge of safety documentation in the NNRA's Infrastructure Management Division also said that he/she was *'surprised when, following the accident, they only found old risk analyses'*. It is the AIBN's impression that the NNRA systematically conduct risk analyses in connection with major changes, in addition to risk identification for entire sections (section analyses). However, Alnabru was not covered by the NNRA's system for identification of risk because minor changes had taken places over time and had not been significant enough for the need for an analysis to be apparent, and because the large section analyses did not encompass the activities at Alnabru.

Furthermore, one informant in the NNRA's safety support staff described that there was an 'imprinted attitude' among operating personnel that it was inconceivable that anything could go wrong. When operating personnel participate in risk analyses, this attitude may have an impact on how risk is assessed in those cases where there is no statistical basis and no established technical barriers.

Based on the NNRA risk analysis method as described in the Safety Manual, existing risk analyses for Alnabru and information obtained through interviews with people from the NNRA, the AIBN believes that the NNRA should focus more on clarifying and describing barriers in its risk analyses, including describing how and why barriers can fail. Among other things, the purpose of this must be to ensure that the 'no single point of failure principle' is complied with through the establishment of independent/functional operational and technical barriers. In the AIBN's view, the NNRA's Safety Manual and methods of risk assessment methods should be updated in this respect.

All the people that the AIBN interviewed in CargoNet AS felt that it was the NNRA that is responsible for carrying out risk assessments to identify the type of problems that that the accident was a manifestation of. CargoNet AS conducts regular risk analyses limited to its own areas and activities, but the AIBN believes that CargoNet AS's risk analyses have corresponding methodological limitations and weaknesses [to those of the NNRA].

The AIBN thinks that it is only natural that CargoNet AS should concentrate its efforts on its own activities. In a complex system such as Alnabru, it is particularly important that all organisations involved contribute to the establishment of barriers against single errors. CargoNet AS and CargoNet AS's personnel are closer to the source of danger and better able to identify various safety problems that are less apparent to the NNRA.

The AIBN believes that risk assessments for such areas should have more focus on conducting thorough barrier analyses of work processes. As long as the main focus of the risk assessments is establishing risk figures for top events (top-to-bottom approach) by assessing probabilities and consequences, these assessments are unable to encompass the complex risk picture at Alnabru. In this type of activity, in which there are few accidents, it is also expedient to look at the barriers that are in place to prevent errors and at the consequences of errors for the various types of work processes that are going on (bottom-to-top approach).

3.6.5.3 *Oslo Havn KF*

The AIBN finds it difficult to see any way in which Oslo Havn KF could or should have detected the risk associated with the possibility of runaway rolling stock from Alnabru, a risk that not even the NNRA or CargoNet AS had detected in their safety management.

3.7 Culture

3.7.1 Introduction

There are some obvious similarities in the way the informants from CargoNet AS and the NNRA describe their work and the challenges associated with their work. It is thus meaningful to speak of an underlying safety culture across the organisations that are involved in the activities at Alnabru. In the following, we shall look at some of the most prominent of these general common features. They are not necessarily directly linked to safety, but they are nevertheless important components in a description of the cultural features that contributed to making the accident possible.

In this context, ‘safety culture’ is defined as having to do with 1) the socially constructed reference framework that influences the way in which members of a group interpret information, symbols and behaviour, and 2) the social conventions that regulate behaviour, interaction and communication within the group (Antonsen, 2009).

The first part of the definition is largely concerned with the way an organisation is able to process information about risk. Here, the main focus is on understanding why some weak danger signals are identified and addressed, while others end up in the blind zone with respect to risk. The second part of the definition has to do with the norms that regulate what is regarded as socially acceptable and desirable behaviour by members of a group.

3.7.2 Storytelling

The first thing that becomes apparent when reviewing the interviews is that storytelling has an important place in the interaction between railway employees. Many of the informants have worked on the railways for a long time, and virtually all the interviews contain a story of one kind or another about how things used to be on the railways, situations in which the work was particularly challenging due to heavy snowfall, or other stories that say something about what it is like to work on the railways.

3.7.3 Nonconformity and incident reporting

Another common feature worth mentioning is the attitude to formal nonconformity and incident reporting, which we looked at in section 0. All the informants are aware of the existence of Synergi and some say they have written reports. Nevertheless, formal reporting does not seem to be an integrated part of the operational activities.

The review suggests firstly that reporting is not entirely socially acceptable among colleagues – to some extent it is something that ‘one does not do’. The use of words like *‘informing on one’s colleagues’* in connection with reporting, suggests that reporting is seen in the context of allocating blame in connection with incidents that have taken place. It is otherwise worth noting that it is not necessarily the fact that one is told that one has made a mistake that poses the biggest problem. It has more to do with the formalisation of the handling of the case. This is different from receiving verbal feedback from a colleague. Secondly, several people have described that, in their experience, very little has happened as a result of what they have reported and that this reduces their motivation for reporting.

Some informants have also described Alnabru as a yard which *’lives with nonconformities’* on a daily basis, and that there has been a self-monitoring system under which people have tried, as far as possible, to solve any problems informally on site. Some are also of the opinion that Alnabru is a tough workplace and that the threshold for reporting is therefore higher.

3.7.4 Information processing and informal communication

In the definition of safety culture as mentioned above, the ability of organisations to process information about risk was stressed. This has to do with how risk assessments are carried out, which scenarios are defined as the most relevant and how weak danger signals can be identified.

In the years preceding the accident, there were several information sources that touched on the problem of the absence of barriers against runaway rolling stock from Alnabru. As described in section 0, risk analyses have mentioned the problem in various ways and it is clearly demonstrated by the description in 0 that operating personnel knew of the lack of run-off points in tracks G4 and G5, but that nobody had envisaged the possibility of freight cars rolling uncontrolledly from an A track to a G track.

In one of the interviews we were told that, in 2006, one of the local traffic controllers had written an email to management expressing concern about what were described as ‘problematic conditions at the southern end’. The email mentioned the scenario of runaway rolling stock ending up on a main line, but did not specifically mention the problem of freight cars parked on the A tracks.

In interviews with personnel from both CargoNet AS and the NNRA, several people described that, in their experience, safety matters had been raised but that the information tended to disappear somewhere in the organisation. This phenomenon is also described in DNV’s report on the safety culture in the NNRA.

This can be seen in the context of how the informants describe the forms of communication within the NNRA and CargoNet AS. Some describe how they have raised operational problems, but that this is generally done through the more informal channels like e-mail or telephone. All in all, verbal communication seems to be the most important form of communication. This has its benefits, in that it is a channel that enables the transfer of ample information about safety. However, there is a considerable drawback to informal communication in that it cannot be documented or traced to the same extent as formal communication. This means that it becomes difficult to keep track of developments over time in relation to safety problems that cannot be resolved by simple measures. Too much emphasis on informal communication will also make it difficult to combine information from various parties, which, when seen together, can provide important information about safety conditions relating to the activities. When there are gradual changes of the type that have taken place at Alnabru, involving several separate organisations, the ability to process information systematically is very important.

3.7.5 Regulatory management and top-to-bottom communication

A culture characterised by informal communication is in many ways a paradox in a business that is regulated to such an extent as the railway business is. However, regulatory management of the organisation primarily involves top-to-bottom communication. However, this is only one half of the management loop in safety management. The AIBN believes that the main problem concerns bottom-to-top communication in the organisation. Weaknesses relating to two-way communication between management/staff and operating personnel indicate that the NNRA and CargoNet AS rely on the regulations themselves to provide adequate safety management.

The AIBN found that a strong belief in procedures was also expressed in the interviews with personnel from both the NNRA and CargoNet AS. This attitude comes across very strongly in the following quote:

> *'I had not considered that Alnabru was not without holes. I had thought there were so many rules on the railways and that they were being observed. I felt it was safe because all the procedures were being complied with. It turned out afterwards that there was a hole.*

It therefore appears to be a paradox that neither the procedure for releasing the mechanical brake nor the four-hour rule were in use, both of which could potentially have stopped the chain of events. There is nothing to suggest that there was any intentional breach of rules or regulations. The description in section 0 showed that both provisions were 'dormant' and not very well known to operating personnel. The lack of familiarity with the rules among the shunters and local traffic controllers is all the more reason to question what sort of tradition there has been in communicating governing documents.

Communication of governing documents seems to be based on a simplified view of communication, whereby it is assumed that there are relatively few problems involved in conveying a message from a sender to a recipient. Communication is largely seen as informing – the focus is on sending a message, not knowing much about how the message is understood by the recipient (see Figure 23 Linear communication model).

We also recognise this simplified view of communication in the communication between the local traffic controllers and shunters, where there has been little attention to the possibility of misunderstandings or the use of readback-hearback and fixed phrases as barriers in that connection.

Both in the NNRA and in CargoNet AS, operational procedures are largely communicated through experience-based learning. Using the knowledge of experienced employees is clearly favourable to the training of new personnel, but it also involves a danger of 'preserving' established practice and it may have an adverse effect on the operational part of the organisation's ability to respond to new management signals and procedures.

3.7.6 Local adaptation

The use of A tracks for parking freight cars is a result of more traffic and a shortage of space, and it also simplifies shunting operations. This usage does not seem to be a result of any formal decision-making process on the part of CargoNet AS or the NNRA. It is rather an informally based practice that has developed over time to adapt to local needs at Alnabru. Such local adaptation takes place in most enterprises, and as long as none of the managers in the NNRA or CargoNet AS react to such use of the A tracks, it is only natural that this becomes an established part of the way in which shunting operations are handled at Alnabru.

Gradual changes in usage and practice of this type have proved difficult to detect through risk assessments. This has to do with what some people call 'practical operation' (Snook, 2000): Small, local adjustments will always be made when performing a task, in order to carry out the task as smoothly as possible. Seen separately, these changes may not represent a safety problem of any magnitude, but seen together they may involve a change of practice whereby the safety margins are being systematically reduced without it being immediately apparent or measurable.

Both the increased traffic load and the change in the usage pattern have taken place over a long period of time. It is evident from the interviews conducted by the AIBN, as well as from the minutes of meetings and the risk analysis documents, that the lack of parking space was a persistent and explicitly mentioned problem for both the NNRA and CargoNet AS for several years prior to the accident. However, few sources mention that the consequences for safety of the changes in the form of operations and the use of the A tracks for parking had been discussed or analysed internally or between the organisations.

The AIBN sees this as a breach of the principle that all changes shall be subject to risk assessment. Both the NNRA and CargoNet AS explain this by the changes having been so small from one year to the next that the need for a change analysis was not apparent. It was also a recurring feature of the interviews that neither the employees nor managers of CargoNet AS had recognised that the use of the A tracks had any material impact on safety. For CargoNet AS, use of the A tracks appeared to be a necessity in order to maintain production and efficiency. The AIBN is under the impression that, after the accident, employees and managers in the NNRA are now tending to notice that use of the A tracks for parking and adjusting freight car sets may constitute a safety problem.

3.8 Internal and inter-organisational collaboration

3.8.1 Introduction

Activities at Alnabru, as in the railway business in general, are carried out in collaboration between several independent organisations. This means that an analysis of the safety culture cannot be limited to what characterises the culture of each individual organisation. It is perhaps even more important to study the culture that has developed in the interfaces between the various groups.

The AIBN has focused on studying both the NNRA's and CargoNet AS's organisational structure relating to Alnabru, as well as the meeting structure and the forums for employee participation internally and in collaboration between the two organisations. The purpose has been to find out whether organisational structure and collaboration have had any bearing on the extent to which the organisations were adequately informed about the risk conditions. It is a known fact that collaboration in the interface between two different organisations can involve particular safety problems.

3.8.2 Organisational structure and internal communication

3.8.2.1 *The Norwegian National Rail Administration (NNRA)*

It was a surprising discovery in the investigation that the area manager with personnel responsibility for the local traffic controllers at Alnabru did not have his workplace in the Central Control Tower at Alnabru. Moreover, the person in question had line manager responsibility for all the local traffic controllers at manned stations in the Oslo area, which made him responsible for 62 people all together. Considering the special position of Alnabru as a shunting yard and freight terminal, and the large volume of traffic and the many shunting operations at the terminal, which in turn meant that the local traffic controllers at Alnabru were exposed to relatively high pressure at work, the AIBN finds that this way of structuring responsibility was unfortunate.

A team leader, without personnel responsibility, had been appointed for the local traffic controllers at Alnabru, whose position can be compared with the position of a foreman in the industrial sector. The AIBN is under the impression that the team leader was concerned about the work situation of the local traffic controllers and that he knew a lot about Alnabru shunting yard, but that he/she did not have sufficient organisational authority to follow up this aspect. In addition, the team leader had important duties regarding operations, the market and dialogue with the railway undertakings, which meant that he/she had limited time to follow up the local traffic controllers.

As a consequence of the survey of the local traffic controllers' work situation that was carried out after the accident, the NNRA has now appointed a separate line manager at Alnabru, who has personnel responsibility for the local traffic controllers.

Before the accident, the local traffic controllers tended to work a lot of overtime, and after the accident things came to a head as a result of psychological factors which resulted in an extensive sickness absence as well. The AIBN is under the impression that there was a strong feeling of frustration among some of the local traffic controllers on this point. The interviews conducted by the AIBN were obviously coloured by negative thoughts following the accident, and it is difficult to assess the extent to which this frustration was present prior to the accident. At the same time, there is no doubt that the manpower situation was difficult. The AIBN has been informed that the area manager for the local traffic controllers had raised this with the line management but without getting any response. When interviewed by the AIBN, the team leader for the local traffic controllers at Alnabru said that there was not enough recognition of Alnabru as you moved upward in the system and that the NNRA's official channels were felt to be very long.

Alnabru has been represented on the joint working environment committee for the eastern geographical area (*Bane øst*) and the eastern traffic area (*Trafikk øst*), and there has not been any separate consultative body for Alnabru. Nor did Alnabru have its own local safety delegate. This may have meant that the problems that were particular to Alnabru were not sufficiently noticed by the organisation. One of the changes introduced by the NNRA after the accident was to appoint a local safety delegate for Alnabru. The investigation has confirmed AIBN's impression that this has been something that the local traffic controllers have missed and that they subsequently have faith in a monitoring role thus appointed from among the employees.

The AIBN believes that the NNRA's structure did not take account of the complex operational and ownership conditions at Alnabru, and that this may have had a bearing on safety.

3.8.2.2 *CargoNet AS*

Interviews with CargoNet AS's managers and employees at Alnabru have left the AIBN with the impression that the organisation already has forums in place for employee participation. However, it also appears that the safety management system did not manage to identify the fact that operating personnel knew that there were insufficient technical barriers to prevent freight cars getting out onto the main line.

The former terminal manager told the AIBN that he/she felt that CargoNet AS had not been paying enough attention at Alnabru. He/she therefore spent some time on marketing

Alnabru within the CargoNet AS system. Some of CargoNet AS's informants mention that they feel that decisions are being made by people with insufficient experience of the operational processes, who don't take enough notice of the operators' input.

> *'But I think it's a bit arrogant, they don't listen to the people who do the practical work. It's better to make decisions a bit higher up, then you don't get to hear the complaints. Instead of listening to people who actually work out there and do things the way they say… I know they can't listen to everybody, but they could at least use a bit of our input.'*

3.8.2.3 *Summary*

One last point to note regarding relations and communication between the various groups within the NNRA and CargoNet AS concerns the relationship between the various levels of the railway activities. After the railway activities were deregulated, there was a growth in management and staff functions whose background or skills tended not to be from the traditional railway sector. Even though this subject was not brought up in many of the interviews, it's worth mentioning, since it relates to the ability to identify, understand and deal with information regarding safety conditions in those activities. The following quotation illustrates this:

> *'In CargoNet AS and the NNRA (...) there are loads of managers who've come in with no background or knowledge of the railway system as such, and who have a long way to go before they understand how our systems work. (...) And that has its pros and may have its cons. But at the same time we have to be aware of what skills they bring to an enterprise – or lack of skills – so that we can compensate a bit here.'*

There is also a language side to this situation. The railway culture is known for having many distinctive expressions and descriptions for things like equipment, infrastructure and rules, which it takes a long time to get used to.

> *'Railway language is a special kind of language. You have to learn it to understand what's going on, what people are saying and doing.'*

Although this cannot be directly linked to the events that caused the accident, it indicates an important area for risk communication in railway operations. It indicates that information about risk is not independent of the language through which it is communicated, and that different levels of the organisations involved in railway operations have different qualifications for understanding this language.

The AIBN feels that this may have had an effect on the extent to which the management of the organisations involved were informed about the risk conditions and danger factors at Alnabru. In this context, it is significant that the local traffic controllers' team leaders and the then CargoNet AS terminal manager say that there was not enough recognition of Alnabru from the higher levels of their respective organisations.

3.8.3 <u>Collaboration between CargoNet AS and the NNRA at Alnabru</u>

CargoNet AS expressed strong concern for the consequences of allowing several transport companies to operate concurrently in the terminal and shunting area. The AIBN has seen that the safety assessment carried out by DNV for the NNRA in 2010 regarding opening the terminal to multiple operators had a limited methodology and that not enough people were allowed to participate in the assessment.

However, the AIBN feels that allowing other railway undertakings to operate at Alnabru was not a significant factor in the accident. Based on this, the AIBN will essentially restrict itself to analysing the collaboration between CargoNet AS and the NNRA at Alnabru, and their respective responsibilities. The AIBN has concentrated on Alnabru in particular, but would also like to discuss some general features of the collaboration between these two enterprises.

Employees and managers in both organisations describe that the ongoing operational collaboration mainly runs smoothly. The AIBN feels that this partly goes back to the days when they were all colleagues together, many of CargoNet AS's and the NNRA's experienced freight personnel having worked together in the same organisation for many years. The employees of both organisations describe this as one of the reasons why they work together so well. However, it comes across more strongly in CargoNet AS's organisation that the employees are marked by being part of a commercial organisation.

One example of a good relationship that helps to prevent accidents and has a positive effect on working conditions is the relationship between two very experienced people in each organisation, namely CargoNet AS's operations coordinator and the Alnabru local traffic controllers' team leader. However, their work together involves dealing with short-term, difficult, specific challenges that can arise very suddenly. The subject of missing safety barriers was therefore not one that they discussed while working together on matters relating to the operations at Alnabru.

At a more overall level, the parties describe the relationship between the NNRA and CargoNet AS as being generally good. A few disagreements are mentioned, including disagreements on the quality of the infrastructure. One of CargoNet AS's informants puts it like this:

> *'On a purely operational level things have worked really well. But we've really struggled with very many other things. Things like infrastructure, I mean when there are faults and defects – poor infrastructure.'*

Frustration because of inadequate maintenance and repair of infrastructure is also seen in light of the lack of funds in the NNRA and the fact that the tracks used for shunting are felt to be low priority for the NNRA, at the same time as it is difficult to communicate this information to a high enough level in the NNRA.

The AIBN has reviewed minutes of meetings and feels that arenas like the coordinated safety rounds and safety coordination and quality (SCQ) meetings work well for those matters on which the representatives in the meetings are authorised to make decisions. What seems to be more difficult, however, is when a system of line responsibility requires decisions at a higher level, i.e. when the matter must be brought up in another forum. For example, the minutes show that SCQ matters can be recurring items on the agenda, without there being any proposals for solution or follow-up.

The regular, coordinated safety rounds have focused on the physical conditions outside in the yard. The safety rounds have been very appropriate for that particular purpose, particularly since they are carried out by CargoNet AS and the NNRA jointly, so that they are able to do something about the problems they discover.

The NNRA is the infrastructure manager, and in accordance with section 4-3 final paragraph of the Safety Regulations, must take into account the effects that the various railway companies' activities have on the network. The NNRA is also the principal enterprise under the terms of the Working Environment Act. The AIBN therefore assumes that the NNRA is responsible for coordinating the safety work of the individual companies at Alnabru. In the AIBN's opinion, the NNRA has not sufficiently followed this up, for example through conducting thorough risk assessments.

The accident shows a technology that is tightly coupled (ref. Perrow, 1998), while the organisations that are operating it are fragmented and loosely coupled. The AIBN feels that this has created an imbalance which has allowed safety to slip below the acceptable level. Alnabru has lacked an overall safety function able to address and deal with safety-related information from both the NNRA and the railway undertakings. Safety work is currently divided between many different support functions and forums, internally and between the various organisations.

3.9 History and development

3.9.1 Introduction

This section deals with what in the AIBN's view is the basic premise that allowed the accident to happen. Alnabru was being used in a manner for which it was not originally intended, as a result of structural changes and a growth in railway freight traffic, and the fact that the work of redeveloping it did not keep pace with those other changes.

3.9.2 Development

Interviews with NNRA and CargoNet AS employees have given the AIBN the impression that Alnabru shunting yard is worn out and outdated. This can be partly put down to political prioritisations, but the CargoNet AS and NNRA employees at Alnabru also feel that the relative priority given to passenger and freight traffic by NNRA had also had an impact on the condition of Alnabru on the day of the accident.

The AIBN refers to the NNRA's own studies of the technical condition of the infrastructure, and would particularly like to emphasise that Alnabru has been promised improvements and new infrastructure for some time. Factors described as critical by employees of the NNRA and CargoNet AS include insufficient space for parking, worn-out rolling stock and the design of the Central Control Tower.

Many people are of the opinion that Alnabru, with its special position within the Norwegian rail freight sector, has had to put up with and deal with conditions that wouldn't be allowed in most other places. This can be best illustrated by the phrase *'Alnabru is the hub of freight traffic,'* but also that *'Alnabru lives with nonconformities',* as one of the managers put it. The AIBN feels that focusing on efficiency and productivity in a worn-out yard and terminal has had an impact on the workloads of the operating personnel. The AIBN asks the question as to whether this has also reduced the safety margins.

In interviews with the AIBN, CargoNet AS has expressed that part of the reason why Alnabru has not been developed or remodelled in line with the structural changes and growth in freight traffic, is that the NNRA has not had enough competence in freight traffic. The informants say that they are convinced that many of the old NSB's freight resources went to NSB Gods and subsequently the private company CargoNet AS after they separated from the NNRA in 1996, and that rail freight transport in general – and Alnabru in particular – has suffered under the effects of this.

One factor that CargoNet AS points out in this context is that they have not been able to get as involved as they would like in planning processes and important decisions that specifically concern freight traffic and Alnabru. Not only that, but the NNRA has allowed more railway undertakings to start operating at Alnabru, and this has certainly not relieved CargoNet AS's frustrations.

3.9.3 Remodelling and development plans

The earlier remodelling plans and the 2008 remodelling process mainly covered the freight handling section of Alnabru and did not look at traffic management as a whole or whether any of the railway technical systems needed to be upgraded. The focus may therefore seem to have been on increasing the flow of goods through the terminal without sufficiently evaluating whether the facility's systems could satisfactorily maintain a 'good enough' level of safety.

The AIBN has not evaluated whether 'more freight trains' will constitute a real increase in traffic through Alnabru, in relation to how much there was before 12 December 2010. As section 2.12.2 shows, the budgets and 2010-2019 National Transport Plan clearly aim to increase the amount of freight that is carried by rail. The AIBN understands that Alnabru's current capacity is still below what it was before the accident of 24 March 2010.

In 2010, the NNRA drew up plans, accompanied by risk analyses, for a total remodelling of Alnabru, which also included safe train and shunting operations. In a memo from the NNRA to the Ministry of Transport and Communications, it says that the completion time for this kind of reconstruction project is long and extremely complicated. Provisional plans say that the remodelling should be finished by 2021, but the AIBN understands that some studies and further planning still have to be completed before final approval can be granted so that construction work can start. We do not know how much any of this will hold back progress on the project.

The normal budgetary processes annually allocate funds to the NNRA for investment, operations and maintenance. The AIBN has not assessed whether the funds allocated for operations and maintenance are sufficient to uphold an acceptable level of maintenance and ensure that the technical systems are of an adequate standard, although these are to some extent described as being extremely poor.

It is difficult to predict whether the new run-off points (see section 5.1.1) together with existing barriers on other tracks will be sufficient for an increase in the number of freight trains passing through Alnabru. It is also difficult to form a clear opinion as to whether these barriers will be good enough during the remodelling phase of Alnabru, since the project has been described as extremely complicated. The AIBN would like to point out that since some major elements of the current technical system are extremely poor and since, according to the renewal plan, the completion date for the first phase of construction is a long way off, there must a particularly high focus on safety in the years ahead. If necessary, a number of measures should be introduced, including temporary technical solutions, operating procedures and a levelling out or reduction in the number of freight trains, in order to achieve the aim of maintaining and further improving the high safety standards in the rail transport sector. A total risk picture must be established for Alnabru, which must be kept updated in step with developments.

3.10 Supervisory authority

3.10.1 Introduction

A risk-based management principle is based on thorough risk analyses which quantify the probabilities and consequences of accidents. This kind of strategy depends on a thorough understanding of risk. For supervisory bodies, a risk-based principle means allocating resources where they are most needed, and where measures can be expected to have the greatest effect. Naturally, this reduces supervisory activities elsewhere (Skjæveland, 2003).

After the accident, the NLIA carried out an inspection of the NNRA which focused on Alnabru's Central Control Tower, found several breaches of the provisions of the Working Environment Act and issued orders on this basis. Supervisory bodies in Norway are generally run on a risk-based basis, and the railway undertakings will be the subject of NLIA inspections in connection with work accident, but also if anyone has reported concerns about the working environment or personal safety. In addition, campaigns and projects aimed at more general working environment problems may also have consequences for parts of the railway industry. The AIBN doubts whether any individual NLIA inspections before the accident could have identified the complex railway technical problems that the accident can be related to.

The NRA is expected to follow up issues of railway technical safety pursuant to railway legislation. The AIBN believes that the NRA must contribute more to ensuring that a complex area such as Alnabru has a functioning overall safety management system, even though responsibility for safety lies with the railway enterprises.

3.10.2 The role of the Norwegian Railway Authority (NRA)

The NRA advises that their assessment of the railway's risk picture is ongoing and is based on reported incidents. The AIBN has seen that the NRA handles large numbers of reported incidents, and that before the accident, there was nothing in this material which could have identified any particular risk at Alnabru. The NNRA states that, of a total of 1900 incidents reported at Alnabru, only two are of relevance to the accident.

As a consequence of the under-reporting that was described in section 3.6.3, the AIBN believes that the figures on which the NRA bases its risk-based inspections provide an incomplete risk picture. In addition, it is worth noting that fewer incidents do not guarantee a low risk of accidents. Bearing all this in mind, the AIBN believes that the NRA should make more use of other supervisory methods in order to uncover conditions with the potential to cause major accidents, and in order to establish better risk scenarios so as to be able to prioritise their supervisory activities. The AIBN sees from the NRA's 2009 annual report that the authority had to limit its supervisory activities, particularly the number of inspections, as a result of the staffing situation.

The NRA points out that it checks every application that it receives against the regulatory requirements. This enables the NRA to document whether the applicant is 'compliant', i.e. that the application meets all the formal requirements. In the AIBN’s view this does not necessarily guarantee an acceptable level of safety in every case. The concept can be summarised as 'safety versus compliance' and has been discussed in several contexts, including aviation. The AIBN refers to sections 2.8.2 and 2.8.3 in SL report 2009/02/eng on a serious aviation incident above the Folgefonna glacier on 14 September 2005.

Documentation examined by the AIBN has shown that the NNRA could not produce a comprehensive risk picture that reflected the situation at Alnabru before it notified of the changes to the terminal. Nor had the NNRA analysed how the notified changes might impact the total risk level. The AIBN feels that the fact that the NRA did not request a comprehensive risk picture reflecting the situation at Alnabru before the notified changes is not in line with a risk-based supervisory principle. The Alnabru terminal has been described as the 'hub' of rail freight traffic, and therefore constitutes critical infrastructure for the Norwegian economy. Bearing in mind the changes in rail freight traffic via Alnabru, the need to adapt the facilities to the structural changes, and the fact that planning and remodelling will take several years, the AIBN feels that the NRA should have requested a comprehensive risk picture for the current situation.

The AIBN has not intended to carry out a comprehensive assessment of the function of supervising the railways, but through this investigation has discovered that Alnabru does not seem to have been sufficiently 'seen' by the NRA. The AIBN finds that the safety management systems of the railway enterprises did not manage to uncover the potential for a major accident at Alnabru. There were fundamental faults and defects in the operational and technical safety barriers that were in breach of railway legislation. The NRA's supervisory activities were not able to uncover these breaches at Alnabru. There is a gap between what can be expected of a risk-based supervision based on supervisory principles, and the supervisory activities that the NRA has actually carried out in practice.

Although the responsibility for safety lies with the railway enterprises, the AIBN would nevertheless like to see the NRA taking a more proactive role in how these enterprises live up to this responsibility. This is particularly important in the task of controlling the risk of major accidents in complex areas. The AIBN is not sure whether the NRA's supervisory activities and priorities are sufficient to satisfy the principles of risk-based supervision. Based on this, the AIBN feels that the NRA would benefit from assessing how its supervisory methods might move in a more risk-based direction.

4. CONCLUSIONS

In the AIBN’s view the immediate causes of the accident were a combination of active and latent failures (Reason, 1997). The active failure consisted of a misunderstanding between the local traffic controller and the shunter concerning which shunting route to set, which caused the freight car set to start rolling from the A track at Alnabru. The latent failures relate in particular to the absence of physical barriers in the form of run-off points, which could have helped to reduce the consequences of the misunderstanding. In this respect the accident is a breach of the principle according to which railway operations shall be planned, organised and performed in a manner that ensures that a single point of failure does not lead to loss of life or serious injury.

4.1 Investigation results

4.1.1 Operational and technical factors

Operational and technical factors consist of safety problems relating to technology, infrastructure, rolling stock, uncertain events, work practices and barriers, which had a direct bearing on the chain of events and which in combination contributed to the accident and the scope of the damage and injuries.

a) A practice had developed at Alnabru shunting yard whereby the A tracks were extensively used for temporary storage between loading operations. The freight car set in question was parked in an A track every night.

b) The provision that an additional brake shall be used when parking in an A track for more than four hours was 'dormant' and unknown to CargoNet AS's shunting personnel. The freight car set had therefore been secured using the A track's mechanical brake only.

c) When the shunter added an additional car to the freight car set, the local traffic controller was sure that the freight car set was to be shunted for loading. The shunter did not intend to move the freight car set and had disconnected the shunting engine.

d) A misunderstanding arose between the local traffic controller and the shunter concerning which shunting route to set, which resulted in release of the mechanical brake.

e) The local traffic controller did not make sure that the shunting engine had control of the freight car set before releasing the mechanical brake.

f) The procedure for releasing the mechanical brake was 'dormant' and unknown to the local traffic controllers. The local traffic controller may have been affected by the ergonomic conditions in the Central Control Tower, responsibility for training a trainee and the absence of the assistant local traffic controller.

g) The rolling freight car set was not observed in time to stop it by means of the lowering brake or to divert it to buffer track T1/T2 through tracks G2/G3.

h) There were no run-off points for tracks G4/G5. Hence, the freight car set was able to leave Alnabru via the freight track towards Loenga.

i) No arrangements were in place to divert, derail or stop the freight cars in a controlled manner once the freight car set had left Alnabru.

j) The empty freight cars had a very low centre of gravity and hence particularly good running properties. They passed through track 10 and the derailer at Loenga without derailing.

k) On leaving Loenga the freight car set continued though a heavily trafficked area. The time of the accident was favourable in this case, with the jet fuel train parked at Gardermoen and moderate traffic in the port area.

4.1.2 Safety management and organisational factors

Safety management and organisational factors are factors relating to the organisations involved (structure, culture, coordination) that can help to explain why the operational and technical factors were present or arose in the chain of events.

a) No procedures had been established for the use of standard phrases or readback-hearback in communications between local traffic controllers and shunting personnel at Alnabru with a view to preventing or detecting any misunderstandings.

b) Neither the NNRA nor CargoNet AS had defined what constituted safety-critical information, and they had not emphasised the establishment of a common reference framework to ensure unambiguous and efficient communication between shunting personnel and local traffic controllers.

c) The use of A tracks for parking freight car sets was a result of an increase in traffic / shortage of space, and the fact that it simplified shunting operations.

d) The practice of using A tracks for parking freight car sets had not been the subject of a formal decision-making process, including safety analyses, in the NNRA and CargoNet AS.

e) The operating personnel knew that there was a situation without run-off points on tracks G4 and G5, and they had adapted their work practice accordingly. The matter had not been formally considered as a safety problem by the NNRA and CargoNet AS.

f) Nobody in CargoNet AS or the NNRA had identified the risk of freight cars starting to roll uncontrolledly from an A track towards the G tracks leaving Alnabru.

g) The investigation has disclosed a lack of trust in and social acceptance of the reporting and nonconformity systems of both the NNRA and CargoNet AS.

h) Verbal communication had been a central form of communication in both the NNRA and CargoNet AS. As far as possible, problems have been resolved informally on the spot, at the expense of documentation and traceability.

i) Two examples of 'dormant' provisions show that there were weaknesses in how governing documents were prepared, and in the way in which they are currently maintained and distributed in the NNRA's own organisation and in CargoNet AS.

j) Governing documents do not adequately distinguish between barriers and information of a more general nature.

k) Alnabru was not covered by the NNRA's system for risk identification because minor changes had taken place over time and not been significant enough for the need for an analysis to be apparent, and because the section analyses did not encompass the activities at Alnabru.

l) The available risk analyses for Alnabru from both the NNRA and CargoNet AS are inadequate with respect to work processes and barriers, and they rely excessively on previous events (incident statistics).

m) Structurally, the NNRA had not taken into account the complexity of the operations and ownership structure in the Alnabru area.

n) The communication of risk in both CargoNet AS and the NNRA may have been influenced by differences between the skills and technical terminology of operating personnel and management and support functions.

o) The NNRA had not adequately followed up its responsibility as infrastructure manager and Principal Enterprise pursuant to the Working Environment Act. Alnabru lacked an overall safety function and no overall risk assessment had been carried out since 2001.

4.1.3 Framework conditions relating to safety

Framework conditions relating to safety have to do with keeping abreast of technological developments, prioritisation and supervision/inspections with a bearing on the organisations involved and safety at Alnabru.

a) As a consequence of structural changes and the growth in freight traffic by rail, combined with inadequate remodelling/development of the facilities to accommodate these developments, Alnabru was being used in a way that had not originally been intended.

b) A focus on efficiency and productivity in a worn-out, outdated yard and terminal, and an insufficient focus on updating safe work practices had reduced safety margins.

c) Remodelling/developing Alnabru had not happened as a result of both political prioritisations and the NNRA's own prioritisation of freight traffic.

d) As a consequence of under-reporting and the fact that few minor incidents are no guarantee that there is little risk of a major accident, the figures on which the NRA based its supervision do not provide a complete risk picture.

e) The NRA had not requested any overall risk picture for Alnabru, as it was before the notified changes, from the NNRA.

4.1.4 Other investigation results

Other investigation results are important safety information or findings, but which are not deemed to have contributed to the accident.

a) No technical faults were found in the infrastructure or rolling stock.

b) The route chosen for the freight car set – towards Loenga and onwards to track 10 with the derailer –was a reasonable choice in the given situation.

c) Under certain circumstances, the freight car set could have ended up on Hovedbanen or Østfoldbanen. These lines are also without barriers for stopping runaway rolling stock.

d) The way the rescue work was organised and the resources that it provided were adequate and good.

e) The notification and evacuation process in the event of runaway rolling stock is an uncertain one. It is difficult to predict which route the rolling stock will take and where and when it may derail.

f) Oslo Havn KF could not and should not have been expected to identify the risk associated with the possibility of runaway rolling stock from Alnabru.

4.2 Main conclusion

The AIBN has carried out a causal analysis in order to understand why the accident could slip though the safety philosophy on which the 'no single point of failure' principle is based. The AIBN believes that each of the following specific conditions was necessary for the accident to occur:

- A gradual change in the use of the railway facilities at Alnabru and a lack of remodelling/development to accommodate this.

- Lack of systematic processing of safety-critical information on the part of both the NNRA and CargoNet AS.

- Communication across interfaces (between the NNRA and CargoNet AS) contributed to allowing the possibility of the misunderstanding that was the immediate cause of the accident.

- In their own way, local practices ('dormant' provisions) at the shunting yard were a contributory (though not sufficient alone) cause of the accident.

Each of these four conditions were necessary preconditions for the accident. A combination of two-way communication regarding safety-related factors is required to detect this type of problem and take action to prevent it, and central control is necessary to define effective measures. The AIBN feels that this has been lacking at Alnabru.

Despite the fact that all four conditions were necessary for the accident to happen, the investigation found that the lack of systematic processing of safety-critical information was a characteristic feature of both the NNRA and CargoNet AS. There was as lack of tradition of reporting incidents and nonconformities, inadequate communication and implementation of governing documents, inadequate and fragmented risk assessments, and not enough systematic work to register and process safety-critical information from the operational parts of the organisation. This has to do with the ability to convey information between the various levels involved in order to identify, assess and reduce risk. It meant that, until the accident occurred, neither the NNRA nor CargoNet AS were aware that Alnabru had fundamental faults and defects with respect to operational and technical safety barriers.

The NNRA had not adequately followed up its responsibility as infrastructure manager and Principal Enterprise, for example through carrying out overall risk assessments. In a complex system such as Alnabru, it is particularly important that all the organisations involved contribute to establishing barriers against single points of failure. This does not seem to have been properly addressed. Alnabru lacked an overall safety management whereby the risk that followed from the many changes that had taken place over time could be identified.

Through its investigation, the AIBN found that Alnabru appears not have been adequately 'seen' by the NRA. Even though it is the railway undertakings that are responsible for safety, the AIBN would like to see a more proactive supervision of how they fulfil this responsibility. This is particularly important with a view to controlling the risk of major accidents in complex areas.

5. MEASURES TAKEN AFTER THE ACCIDENT

5.1 Measures taken by the NNRA after the accident

The NNRA has implemented a great number of technical, operational and organisational measures after the accident (see the list of measures in Annex D).

5.1.1 <u>New run-off points at Alnabru</u>

In S circular 121-2010 dated 27 October 2010, the NNRA announced that the new run-off points at Alnabru South would be put into use at 13:00 on 7 November. The normal position of these points (towards the buffer stops) shall prevent rolling stock from rolling towards Bryn when no train route has been set across the points. These run-off points prevent freight cars from rolling onwards from the G tracks. An alarm is triggered if the points are set to the train route for more than five minutes.

The NNRA has informed the AIBN that the sliding buffer stops mounted behind the run-off points are designed to brake rolling stock of 1,000 tonnes by approximately 10 km/h and of 750 tonnes by approximately 15 km/t. The rolling stock is then expected to slide down the gradient behind the buffer stops where it will be slowed down further. The rolling stock will end up in a sand drag that, together with bank of earth, will be sufficient to dissipate the remaining kinetic energy in a more or less controlled manner. The Norwegian Rail Authority has granted the NNRA permission to use the measure.

Figure 25: New run-off points at Alnabru South. (Photo: the NNRA)

Figure 26: Sand drag after sliding buffer stops. (Photo: the NNRA)

The new points at Alnabru South are normally set to the sliding buffer stops. The points are set to the freight train track when a train route is set. An alarm is triggered if the interlocked train route has been set to the freight train track for more than five minutes.

In an emergency, the local traffic controller can override the interlocked train route by simultaneously pressing two push buttons on the main control system's panel. The points will then be set towards the sliding buffer stop.

The emergency release push buttons (encircled in red) are secured with plastic covers to prevent pushing them accidentally.

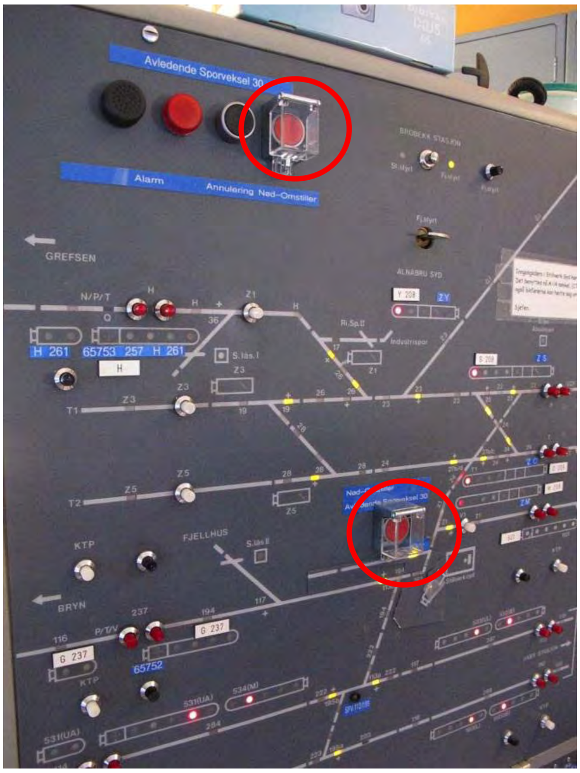


Figure 27: Push buttons on the main control panel tha must be operated in order to switch the points at Alnabru South.

The AIBN points out that the freight car set in question had a speed of approximately 25 km/h and a mass of 436 tonnes at this particular point. In addition, in a given situation, the function of the run-off points will depend on the local traffic controller becoming aware of the situation in time.

5.2 Measures taken by CargoNet AS after the accident

CargoNet has informed the AIBN that they have observed the stricter rules that were introduced by the NNRA following the accident. In other words, no shunting operations have taken place without the freight cars being connected to a locomotive and having the air brakes engaged.

CargoNet AS issued three C circulars in which these provisions were made clear, though two of them were not limited to Alnabru:

- C circular 4-2010 concerning *Bruk av sikkerhetsbremseapparat under skifting* ('Use of safety brakes during shunting' – in Norwegian only)

- C circular 8-2010 concerning *Muntlig kommunikasjon under skifting* ('Verbal communication during shunting' – in Norwegian only)

- C circular 11-2010 concerning *Skifting inn/ut av vognverksted Alnabru* ('Shunting in and out of the freight car repair shop at Alnabru' – in Norwegian only)

Apart from this, CargoNet AS has not implemented any specific measures relating to Alnabru as a consequence of the accident.

5.3 Measures taken by Oslo Havn KF after the accident

Some written communications from HAV to the NNRA following the accident are cited below:

Letter dated 7 May 2010 from HAV to the NNRA

Oslo Havn KF wrote to the NNRA and asked for a *'statement of which measures the NNRA will implement in order to prevent the possible recurrence of this type of accident.'* The Port Director also stressed:

> *'That it is an absolute requirement that the port authority shall not carry the risk of failure of the national railway network or the operations thereon. Oslo Havn HF must have a guarantee on this point. The port finds the possibility of the occurrence of similar accidents to be unacceptable, given the dramatic consequences in terms of both material damage and for everyone who works there or uses the port.'*

On 12 May 2010, the NNRA replied, providing a description of those measures that had been implemented against runaway rolling stock. The NNRA also stated that it would like to review the emergency plans and notification lists together with Oslo Havn KF. Such a meeting has been held, and the notification procedures have been changed.

As a consequence of the accident, Oslo Havn KF shall carry out a revised risk and vulnerability analysis relating to the railway system in Sydhavna in order to consider whether any planned solutions should be changed. In that connection, Oslo Havn KF asked for a meeting with the NNRA, since they need to work together in order to get a complete overview of the risks in the port area. It is also pointed out that the NNRA may need input from Oslo Havn KF in its own risk assessments.

6. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway proposes a total of seven safety recommendations.[6] The immediate safety recommendation from the preliminary report of 3 May 2010 is maintained as Safety Recommendation RW No 2011/02 on the basis of the AIBN's comments on the new run-off points in section 5.1.1.

Safety recommendation RW No 2011/02T

The barriers established to prevent rail cars without brakes from breaking loose and rolling away from Alnabru have been inadequate. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration to analyse the operational situation at Alnabru and to establish necessary barriers so that runaway rail cars cannot roll out of the station.

Safety recommendation RW No 2011/03T

Alnabru was not covered by the NNRA's system for risk identification because minor changes had taken place over time and not been significant enough for the need for an analysis to be apparent, and because the section analyses did not encompass the activities at Alnabru. The risk analyses available for Alnabru from both the NNRA and CargoNet AS are also inadequate with respect to work processes and barriers. They are excessively based on establishing risk figures for top events (top-to-bottom approach) and previous incidents. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration and CargoNet AS to review and improve their systems for risk assessments and analyses.

Safety recommendation RW No 2011/04T

Alnabru lacked an overall safety management that could identify the risk that followed from the many changes that had taken place over time. There was no safety function that could address and deal with safety-related information from both the NNRA and the railway undertakings at the overall level. The safety work was divided between many different line and support functions, and forums, internally and between the various organisations. The Accident Investigation Board Norway recommends that the Norwegian Railway Inspectorate order the Norwegian National Rail Administration and CargoNet AS to review and improve the way safety work is organised, in order to ensure the overall safety of freight terminals and shunting yards.

Safety recommendation RW No 2011/05T

The investigation has uncovered a lack of trust in and social acceptance of the reporting and nonconformity system in the NNRA and CargoNet AS. In the case of both the NNRA and CargoNet AS, the main problem concerns the ability to communicate information between the various levels that are involved in identifying, assessing and reducing risk. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration and CargoNet AS to improve their safety management, with a particular emphasis on collecting and processing information in order to improve the safety culture.

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[6] [3] The investigation report is submitted to the Ministry of Transport and Communications, which takes necessary action to ensure that due consideration is given to the safety recommendations, cf. Regulations of 31 March 2006 No 378 relating to official investigations into railway accidents and serious railway incidents etc. (the Railway Investigation Regulations) Section 16..

Safety recommendation RW No 2011/06T

The immediate cause of the accident was a misunderstanding between the local traffic controller and the shunter. Neither the NNRA nor CargoNet AS had defined what should constitute safety-critical information, and they had not emphasised the establishment of a common reference framework to ensure unambiguous and efficient communication. No procedures had been established for the use of standard phrases and readback-hearback. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration and the railway undertakings to review communication in connection with shunting operations, define safety-critical information, and establish barriers to prevent/detect misunderstandings.

Safety recommendation RW No 2011/07T

Two provisions that could potentially have prevented loss of control of the freight car set were not in use or known to the operating personnel at Alnabru. This shows that there were weaknesses in how governing documents were prepared, and in the way in which they are currently maintained and distributed in the NNRA's own organisation and in CargoNet AS. Governing documents do not adequately distinguish between barriers and information of a more general nature. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration and CargoNet AS to update and distribute governing documents and ensure that they are understood.

Safety recommendation RW No 2011/08T

There are no barriers in the tracks towards Loenga or Oslo S that can divert, derail or stop runaway rolling stock in a controlled manner so as to prevent loss of human life and serious personal injuries. It is not possible for the traffic controller to release any main train routes instantly. The Accident Investigation Board Norway recommends that the Norwegian Railway Authority order the Norwegian National Rail Administration to consider whether it is necessary to establish barriers in order to protect the freight train track from Alnabru to Loenga, Hovedbanen and Oslo S station.

Accident Investigation Board Norway

Lillestrøm, 23 March 2011

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LIST OF DEFINITIONS

Acceptance criteria	*Acceptable risk level. The results of risk analyses shall be compared with the criteria for acceptable risk.*
ALARP principle	*As Low As Reasonably Practicable. The principle of reducing risk to a level that is 'as low as reasonably practicable.'*
WEC	*Working environment committee. In enterprises that regularly employ 50 persons or more, it is mandatory to have a working environment committee on which the employer, employees and company health service are represented.*
ATC	*Automatic Train Control. A collective term for the systems known in Norway as DATC (partial ATC – trains stop automatically on passing a red light) and FATC (full ATC – trains do not exceed the maximum permitted speed).*
Run-off points	*Points that prevent rolling stock from entering a specific track.*
Barriers	*Technical, operational or organisational measures that separately or together could have prevented or stopped the chain of events in question, or limited the consequences of the accident.*
Buffer stop	*A device that prevents trains from going past the end of a rail section (other than points or a junction).*
CTC	*Centralised Traffic Control. A system that enables railway signalling systems to be remote controlled. Controlled by the traffic controller from a CTC centre.*
DATC	*Partial ATC. A system that stops trains automatically if they pass a red light.*
Dwarf signal	*Signal regulating local train movements at a station.*
Ebilock 850	*Ebilock 850 was the first generation electronic signalling works produced by the former EB Signal (now Bombardier).*
Mechanical brake	*Beam brakes in the arrival tracks that pinch against the rail car wheels. Spring-loaded brakes that are released by means of compressed air and that engage when the compressed air is released. Designed to hold freight car sets of up to 1000 tonnes.*
GSM-R	*GSM-R (R for railway) is based on the GSM communications standard and is the European wireless communications standard for railways. GSM-R has several priority levels for point-to-point calls, quick connection time, emergency calls and group calls.*
Main approach signal	*A signal giving the all clear for approaching a station area.*
Railway undertaking	*Any public or private undertaking whose main business is to convey goods and/or passengers by rail, for which the undertaking is obliged to provide traction power, including an undertaking that supplies traction power only.*

Railway enterprise	*An enterprise whose business is goods or passenger transport, infrastructure and/or traffic management.*
Lowering brake	*Allows for controlled lowering of train sets from the braked position on the arrival track. Braking power is achieved by means of compressed air and can be regulated in steps.*
PLC system	*Programmable logic controller system*
Readback	*The recipient's repetition of a message or appropriate parts of a message back to the sender of the message in order to receive confirmation that it was correctly received.*
RPD	*Recognition-Primed Decision model*
Timetable	*Schedule of traffic operations, valid for a timetable period.*
Central signalling system	*'Control tower' in railway stations of a certain size, containing a collection of safety systems and workstations for monitoring and ensuring safe train operation.*
Safety management	*Systematic activities designed to ensure safety in an organisation.*
Shunting stock	*Rolling stock that is moved during shunting.*
Shunter	*Person in charge of shunting who is responsible for ensuring that it is carried out safely.*
Shunting engine/ shunting locomotive	*Traction vehicle used during shunting.*
Shunting order	*The railway undertaking's specification of planned shunting movements to be carried out on any particular day.*
Shunting route	*One or more tracks or part(s) of tracks designated for use during a shunting operation.*
Shunting	*Shunting is carried out to make or break a train, to move rolling stock along a track, to move rolling stock from one track to another or to park rolling stock. Shunting can be carried out a) by pulling or pushing freight cars that are coupled to a traction vehicle, or b) by letting freight cars run down an incline without being coupled to a traction vehicle (pulled by their own weight).*
Slip control system	*Safety system that controls the shunting station's track braking systems and shunting systems.*
Track usage schedule	*The railway undertaking's schedule for use of the container terminal's shunting, loading and parking tracks.*
Derailer	*A device that prevents rolling stock from entering a specific track.*
Switch-point	*Mechanical device that makes it possible to run rolling stock from one track to another.*
S circular	*A circular that announces temporary and permanent changes to the traffic rules.*

STEP	*Sequential Timed Events Plotting.*
Train	*A traction vehicle with or without cars, which has been assigned a train number in a schedule, and which is to be run from a specific place of departure to a specific place of arrival.*
Local traffic controller	*A station operator who is in charge of monitoring and securing train operations and other activities at his/her local station and adjacent block sections that are not remotely controlled.*
Rail Traffic controller	*An operator who monitors and controls train operations and other activities that impact the safety of traffic from a control room.*
Train route	*A designated track for an individual train's operation at a station and/or along a railway line.*
Traffic management	*Traffic control and other coordinating functions that contribute to ensuring the safety of train operations and shunting.*
Main departure signal	*A signal giving the all clear for departure from the station area.*
Safety representative	*A person elected by the employees of an enterprise to safeguard the interests of employees in matters relating to the working environment.*
Car set	*A series of coupled railcars that are not connected to a traction vehicle.*

ANNEXES

Annex A: Alternative train routes

Annex B: Schematic map - track usage schedule

Annex C: Investigative process and investigation methodology

Annex D: List of measures from the Norwegian National Rail Administration

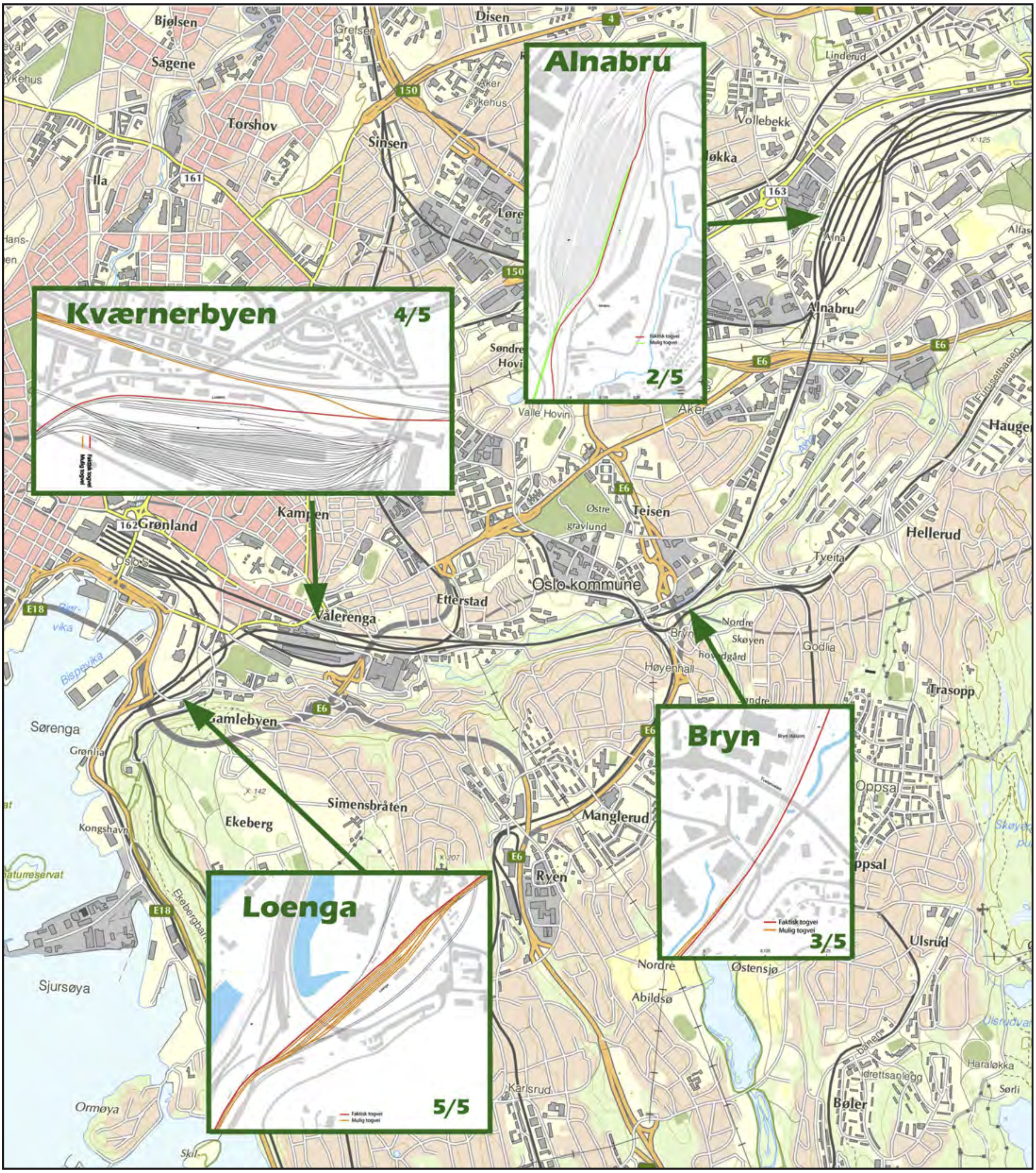
Annex E: List of documents from the Norwegian Railway Inspectorate

Annex F: Alnabru – history and time line for development

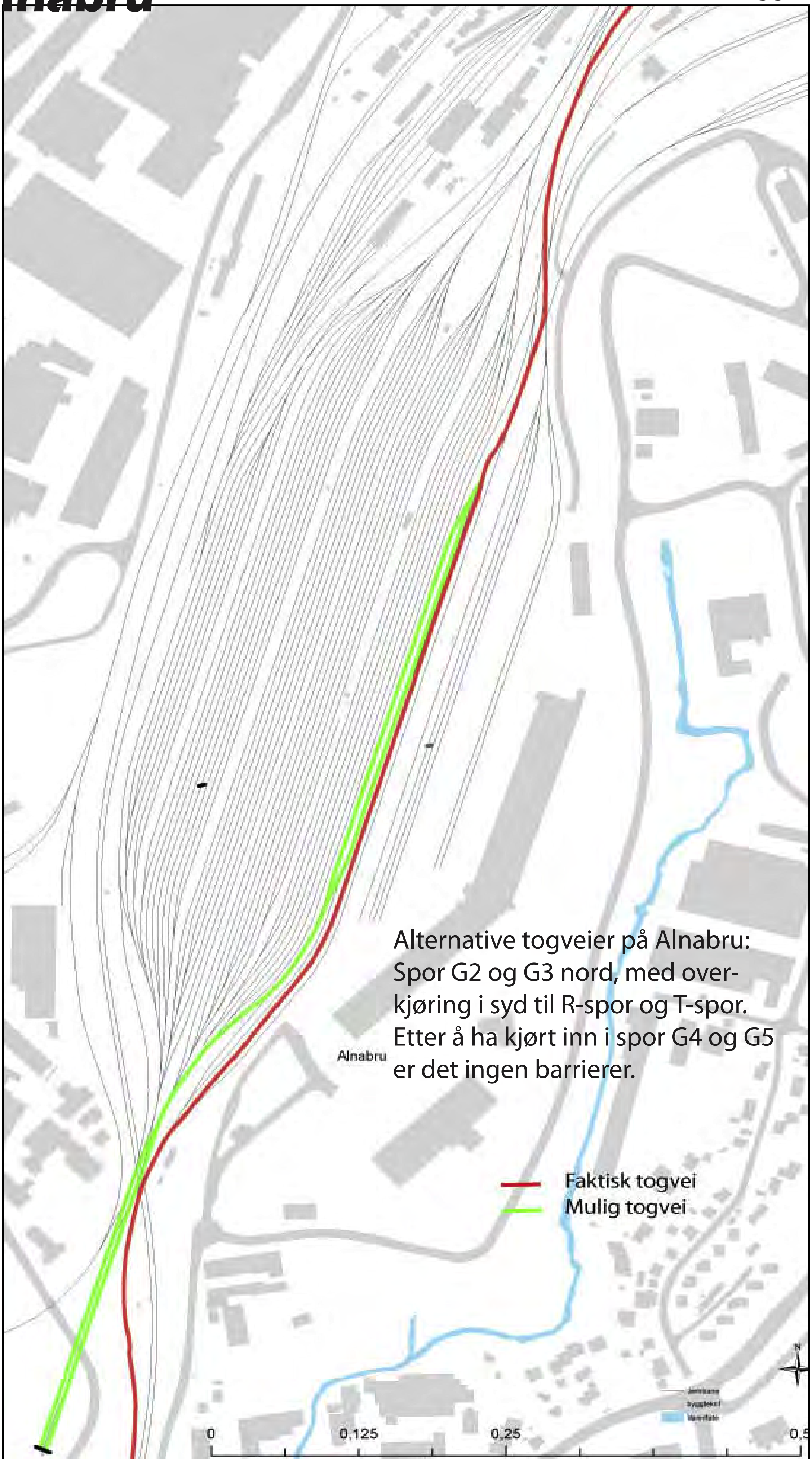
Annex G: Event-cause-barrier analysis

The annexes are in Norwegian only.

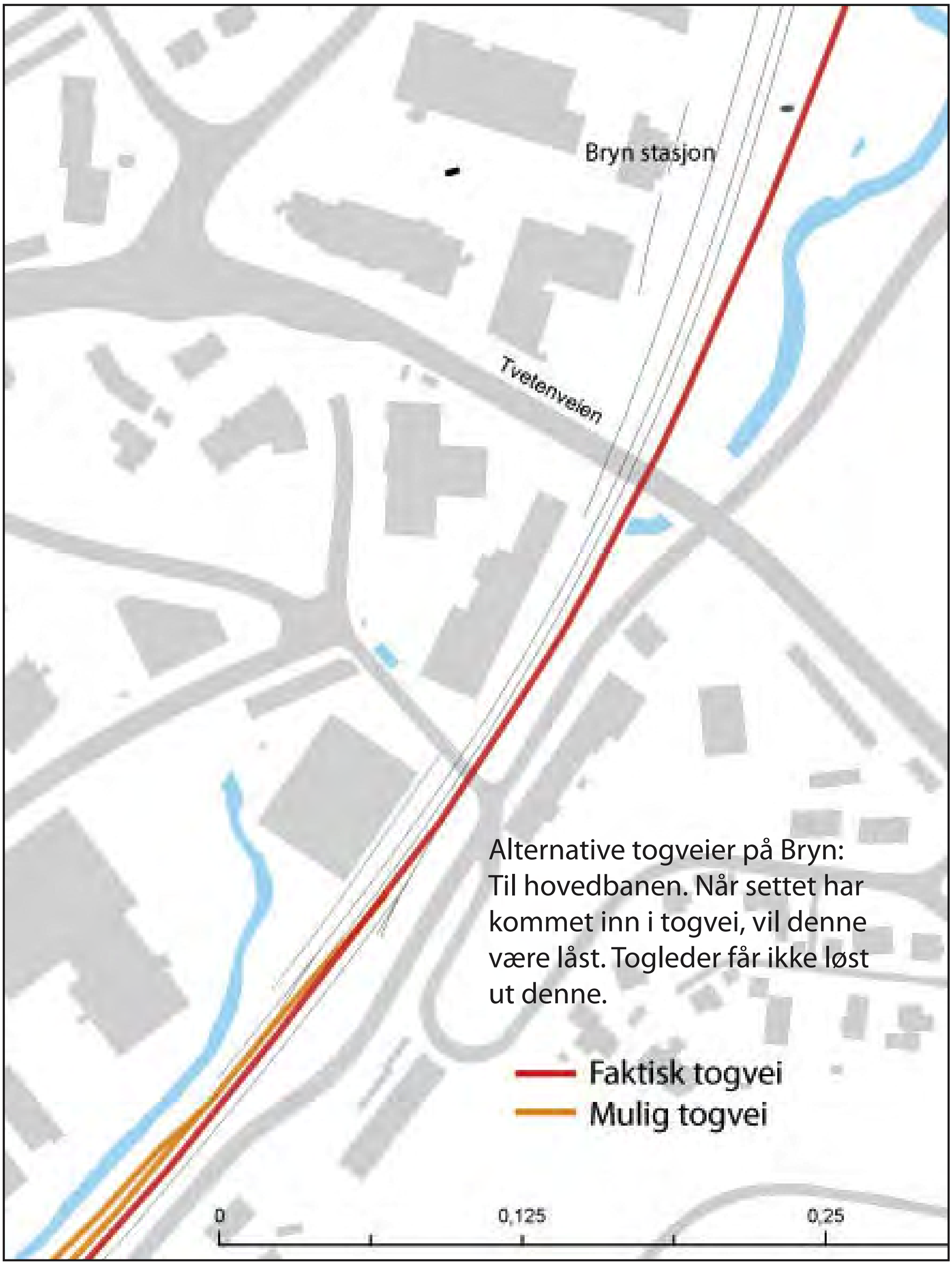
Alternative togveier mellom Alnabru og Sjursjøya 24. mars 2010



Alnabru

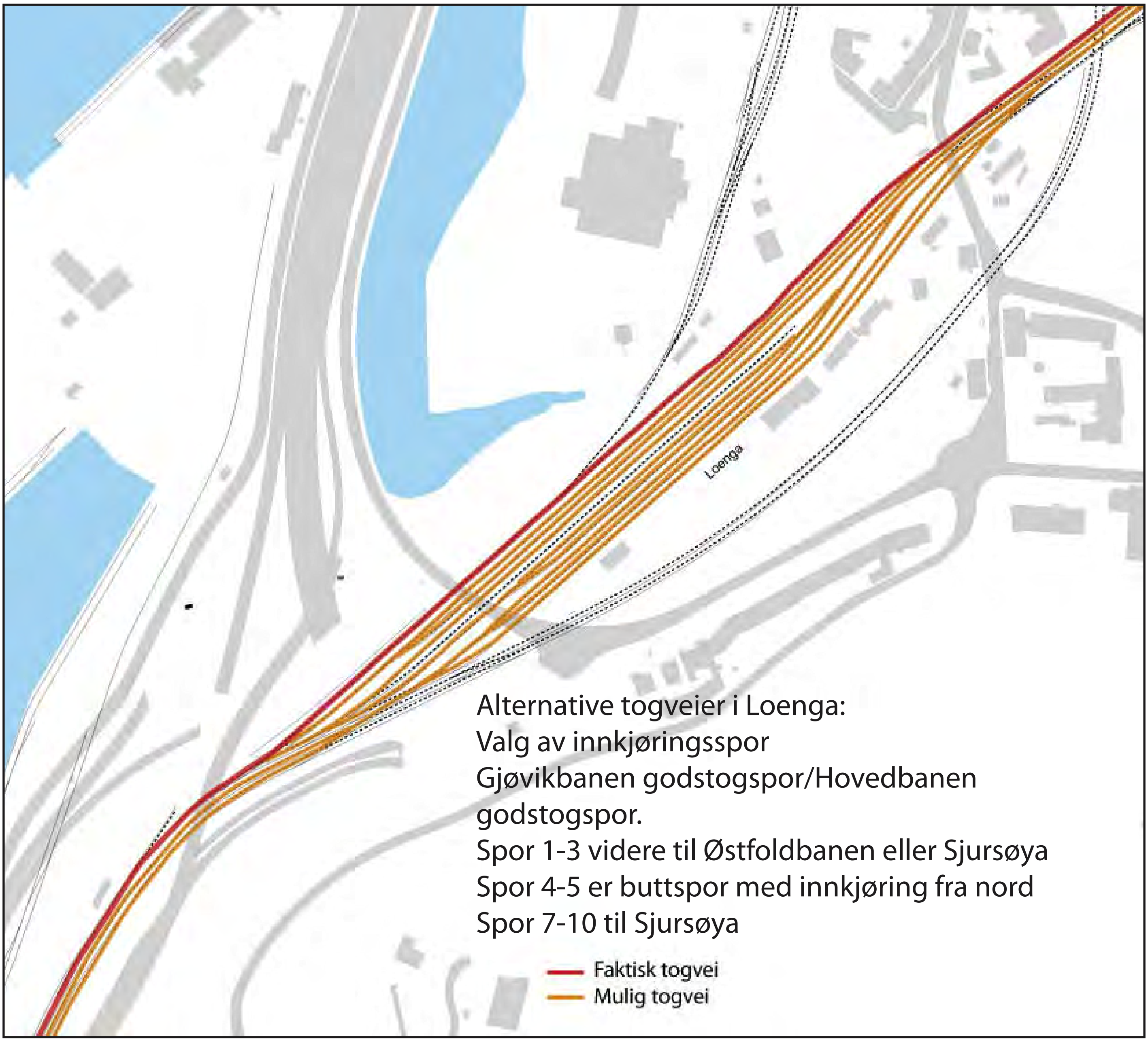

Alternative togveier på Alnabru:
Spor G2 og G3 nord, med over-
kjøring i syd til R-spor og T-spor.
Etter å ha kjørt inn i spor G4 og G5
er det ingen barrierer.
Alnabru
Faktisk togvei
Mulig togvei
N
0
0,125
0,25
0,5

Bryn

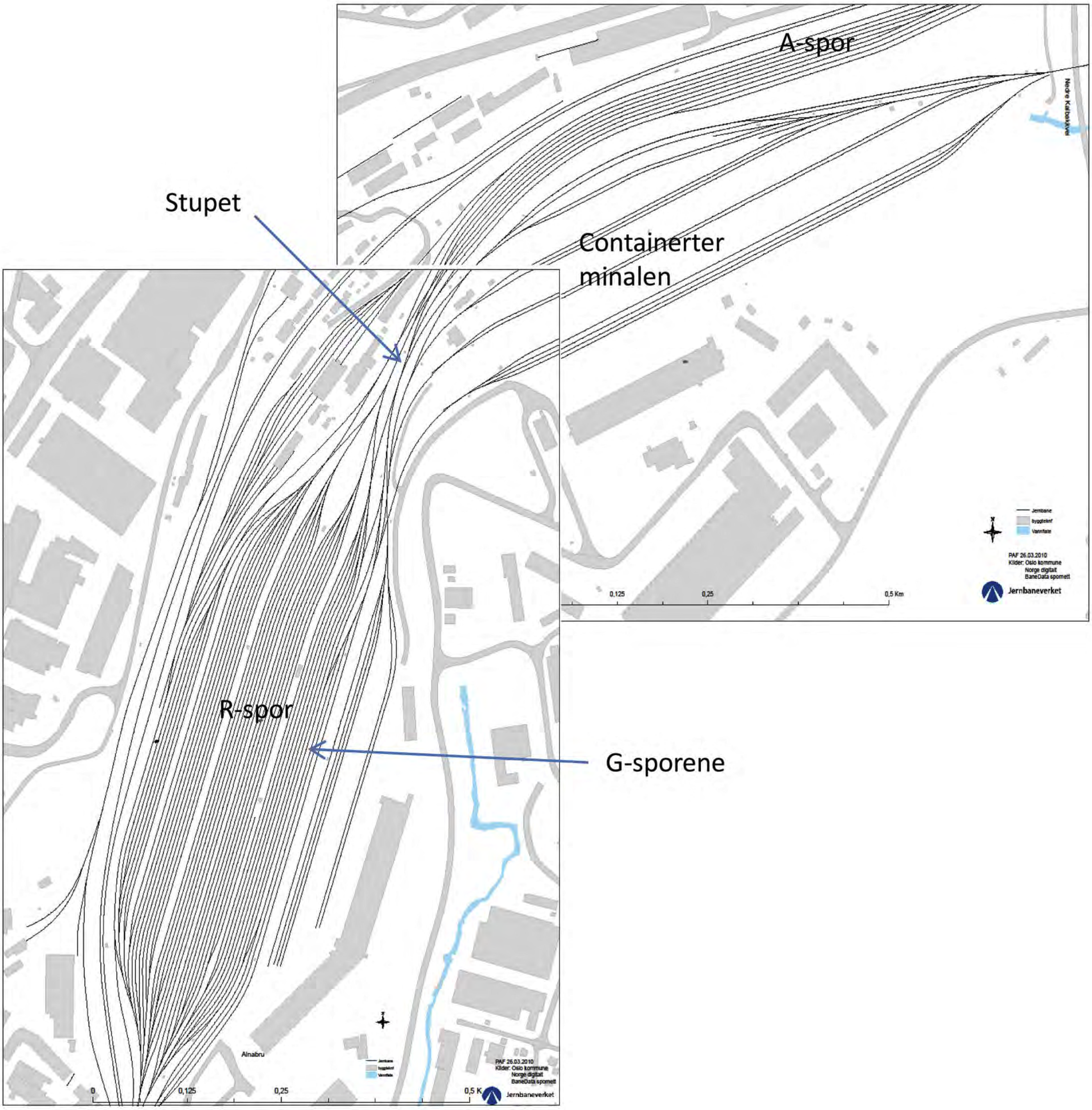

Bryn stasjon
Tvetenveien
Alternative togveier på Bryn: Til hovedbanen. Når settet har kommet inn i togvei, vil denne være låst. Togleder får ikke løst ut denne.
Faktisk togvei
Mulig togvei
0
0,125
0,25

Kværnerbyen/Lodalen

Loenga


Loenga
Alternative togveier i Loenga:
Valg av innkjøringsspor
Gjøvikbanen godstogspor/Hovedbanen
godstogspor.
Spor 1-3 videre til Østfoldbanen eller Sjursøya
Spor 4-5 er buttspor med innkjøring fra nord
Spor 7-10 til Sjursøya
Faktisk togvei
Mulig togvei

Oversiktskart Alnabru



VEDLEGG C

UNDERSØKELSESPROSESS OG METODIKK

Dette vedlegget beskriver SHTs undersøkelsesprosess og sikkerhetsperspektiv i undersøkelsen av ulykken.

1.1 Forundersøkelse

Hensikten med SHTs forundersøkelser er å samle informasjon og data for derigjennom å danne et bilde av hendelsesforløpet i ulykken. Forundersøkelsene utgjør også det videre grunnlaget for å undersøke hvilke operative, tekniske og organisatoriske forhold som hadde betydning for at ulykken skjedde.

SHTs forundersøkelser i forbindelse med denne ulykken har involvert tekniske undersøkelser av infrastruktur, signalanlegg og vognmateriell både på Alnabru og Sjursøya, testkjøring i godstogsporet, gjennomgang av logger og bildemateriell, samt samtaler med involvert jernbanepersonell og vitner. I tillegg startet SHT innsamling av diverse dokumentasjon relevant for ulykken (styrende dokumentasjon, prosedyrer/instrukser, tekniske beskrivelser av signalanlegg og sporsystemer, samt risikobeskrivelser relatert til arbeidsprosesser og infrastruktur).

1.2 Kartlegge hendelsesforløp: etablere STEP-diagram

Hensikten med kartlegging av hendelsesforløpet er å beskrive i tidsmessig detalj hva som skjedde, hvordan ulykken utviklet seg, samt hvem/hva som var involvert på en slik måte at de påvirket hendelsene da vognstammen trillet fra Alnabru til Sjursøya.

I denne undersøkelsen har SHT benyttet STEP-metoden (Sequential Timed Events Plotting) for å kartlegge hendelsesforløpet. Et STEP-diagram er et tids- og aktørdiagram som illustrerer hendelsesforløpet i ulykken gjennom en multilineær kjede av hendelser (handlingene til hver aktør som var involvert i ulykken beskrives på en egen linje i diagrammet). På denne måten får man et oversiktelig bilde av forholdet mellom de ulike aktørenes handlinger og den tidsmessige sammenhengen mellom disse. Basert på en systematisk vurdering kan diagrammet avdekke tilleggsmomenter og mangel på informasjon om hendelsesforløpet, dvs. hva som bør undersøkes nærmere.

1.3 Identifisere sikkerhetsproblemer

STEP-diagrammet er videre et utgangspunkt for å identifisere mulige sikkerhetsproblemer som påvirket forløpet av ulykken. Sikkerhetsproblemer identifiseres i STEP-diagrammet der hendelsesforløpet kunne vært avbrutt, avvik fra tiltenkt sikker drift, eller steder hvor man kunne endret på utstyr/rutiner/systemer for å forhindre ulykken.

Forundersøkelsen, kartlegging av hendelsesforløp og identifikasjon av sikkerhetsproblemer dannet grunnlaget for SHTs foreløpige rapport om ulykken (publisert 3. mai 2010), samt SHTs umiddelbare sikkerhetstilråding til Jernbanetilsynet i denne forbindelse.

1.4 Barriereanalyse

Følgende definisjon av barriere er benyttet i barriereanalysen: *tekniske, operasjonelle eller organisatoriske tiltak som hver for seg eller i samspill, kunne forhindret eller stoppet det aktuelle hendelsesforløpet, eller begrenset konsekvensen av ulykken*.

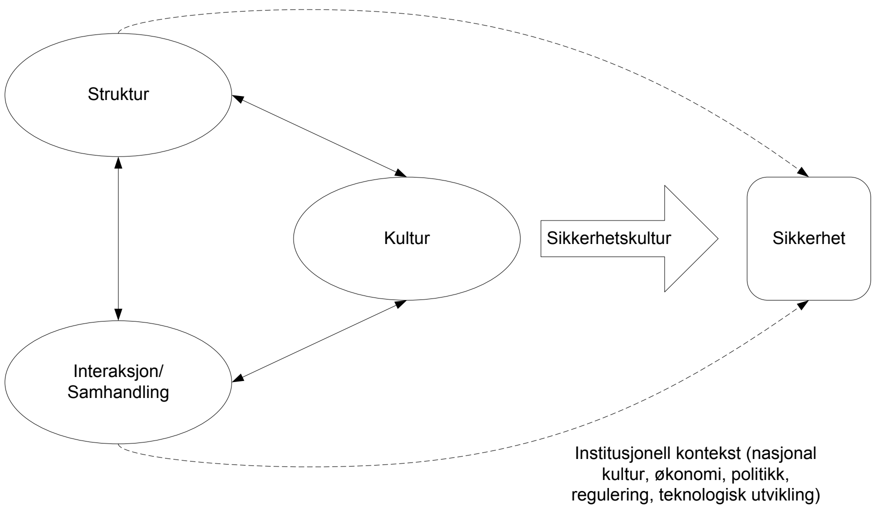
Basert på STEP-diagrammet ble hendelsesforløpet sammenstilt på en tidslinje (handlingene til de ulike aktørene settes sammen) for deretter å identifisere steder hvor barrierer kunne stoppet den videre utviklingen. Barriereanalysen settes inn i et diagram hvor identifiserte barrierer struktureres i tidsmessig rekkefølge i forhold til hendelsesforløpet. Barriereanalysen viser barrierer som var etablert og som fungerte, svakheter og svikt i eksisterende barrierer, samt manglende barrierer som ikke var etablert på ulykkestidspunktet.

1.5 Årsaksanalyse

Hensikten med årsaksanalysen er å kartlegge og forstå hvordan og hvorfor sikkerhetsmessige systemer og barrierer som skulle forhindret ulykken i å oppstå ikke fungerte eller var tilstede. For hvert sikkerhetsproblem formulerte SHT flere spørsmål som det var vesentlig å søke å besvare gjennom årsaksanalysen. Årsaksanalysen baserte seg på en omfattende kartlegging av tekniske løsninger, operasjonell arbeidspraksis, samarbeid og kommunikasjon, sikkerhetsstyring, kultur, organisasjon og ledelsesforhold i de involverte organisasjonene.

1.5.1 <u>SHTs sikkerhetsperspektiv og tilnærming til årsaksanalysen</u>

Kartleggingen har hatt som teoretisk utgangspunkt at organisasjoner består av tre ulike hovedelementer (struktur, interaksjon/samhandling og kultur) som igjen kan påvirke sikkerheten og medvirke til ulykker. Figur 1 viser sammenhengen mellom de tre aspektene ved organisasjoner og forholdet til sikkerhet:



Figur 1: Oversikt over aspekter ved organisasjoner og forhold til sikkerhet (Kilde: Antonsen, 2009).

Struktur spesifiserer den vertikale og horisontale fordelingen av oppgaver (organisasjonskart), roller, ansvar og autoritet i organisasjoner, styringssystemer og prosedyrer, samt fysiske strukturer som teknologi, infrastruktur og driftsprosesser.

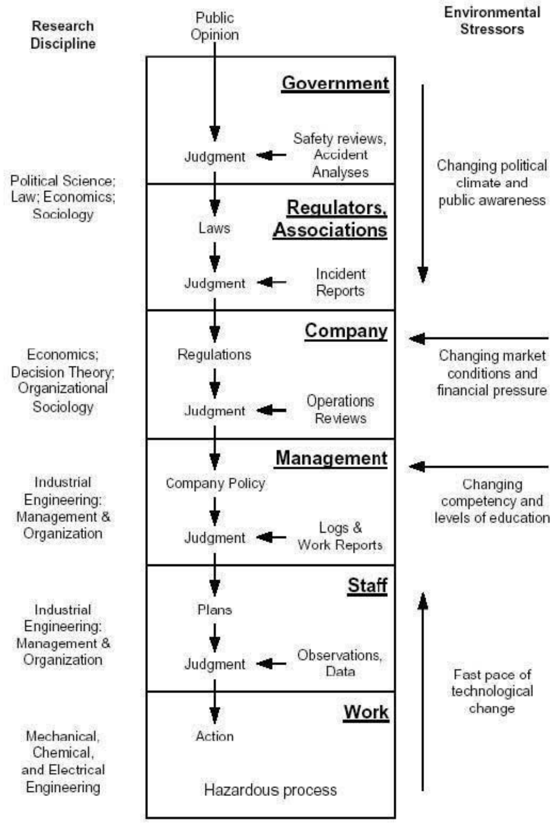
Interaksjon/samhandling er prosessen der sosiale relasjoner og roller dannes og virker, og hvor sosialisering foregår. Dette er prosesser innen en enkelt organisasjon og mellom organisasjoner, herunder samarbeid mot felles mål, informasjonsflyt og kommunikasjon.

Organisasjonskultur utgjør de uformelle aspektene ved organisasjoner, dvs. de delte verdier (hva som er betydningsfullt), normer (akseptert atferd – "slik vi gjør det her hos oss"), holdninger, symboler og kunnskap. Sosial interaksjon er en av hovedprosessene i konstruksjon av kultur. Organisasjonskultur kan derfor ikke studeres i isolasjon fra struktur- og samhandlingsaspekter ved organisasjoner.

Sikkerhetskultur er her brukt som en begrepsmessig merkelapp for å betegne forholdet mellom organisasjonskultur og sikkerhet. Sikkerhetskultur defineres her til å handle om 1) de sosialt konstruerte referanserammene som påvirker måten medlemmene av en gruppe fortolker informasjon symboler og atferd, og 2) de sosiale konvensjonene for atferd, interaksjon og kommunikasjon som gjelder innenfor gruppen (Antonsen, 2009).

Den første delen av definisjonen handler mye om hvordan en organisasjon er i stand til å bearbeide informasjon om risiko. Hovedfokus ligger her på å forstå hvorfor noen svake faresignaler fanges opp og adresseres, mens andre havner i en risikomessig blindsone. Den andre delen av definisjonen omhandler de normene som regulerer hva som anses som sosialt akseptabel og ønskelig atferd blant medlemmene av en gruppe.

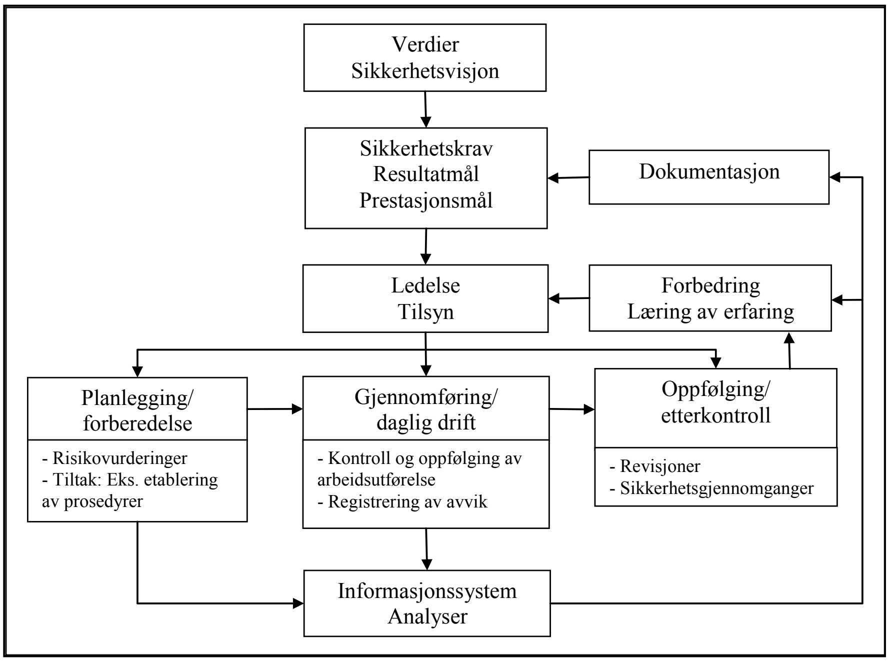
Videre tar SHT utgangspunkt i Rasmussens beskrivelse av det sosiotekniske system involvert i risikostyring som et rammeverk for årsaksanalysen (se figur 2). SHT ser det som viktig å kartlegge hvordan alle nivåer og forhold relatert til det sosiotekniske systemet på Alnabru kan ha påvirket og medvirket til ulykken. I årsaksanalysen har SHT arbeidet seg oppover i Rasmussens sosiotekniske system fra den spisse enden (operativt personell) i arbeidsprosessene på Alnabru til den butte enden (ledelsen) i de involverte organisasjonene. Analysen har også søkt å kartlegge rammebetingelsene i form av regelverk, kontroll og tilsyn (herunder både Jernbanetilsynet og Arbeidstilsynet) som skal tilrettelegge for sikkerhet på Alnabruområdet. SHT har også vurdert andre ytre forhold og rammebetingelser som kan ha hatt betydning for sikkerheten.



Figur 2: Det sosiotekniske systemet involvert i risikostyring (Kilde: Rasmussen, 1997).

I følge Reason (1997) er et vesentlig kjennetegn ved en god sikkerhetskultur at det er en ”informed culture”, dvs. velinformert. I fravær av ulykker er innsamling av riktig type data den beste måten å opprettholde årvåkenhet for risiko. Et effektivt sikkerhetsstyringssystem utgjør derfor det prinsipielle grunnlaget for en informert kultur. I en informert kultur har de som leder og drifter systemet løpende kunnskap om de menneskelige, tekniske, organisatoriske og miljømessige faktorer som påvirker sikkerheten som helhet (Reason, 1997, s. 194-195).

Som et ledd i forståelsen av hvordan strukturelle forhold kan ha påvirket den operasjonelle arbeidspraksisen på Alnabru og den faktiske sikkerheten på ulykkestidspunktet, har SHT hatt fokus på å kartlegge de systematiske aktivitetene, rutinene og ledelsesprosessene som var etablert i de involverte organisasjonene for å ivareta sikkerheten. Dette vil i praksis si sikkerhetsstyringssystemet til de involverte organisasjonene. Sten (2003) har etablert en ”generisk” modell som omfatter nødvendige elementer i et sikkerhetsstyringssystem.



Figur 3: Elementer i sikkerhetsstyring (Kilde: Sten, 2003).

1.5.1.1 *Gjennomføring av årsaksanalysen og informasjonskilder*

Med utgangspunkt i Rasmussens beskrivelse av det sosiotekniske system og sammenhengen mellom struktur, kultur og samhandling i organisasjoner ble spørsmålene i årsaksanalysen rettet mot flere nivåer.

SHT benyttet samtaler og dokumentgjennomgang som primære informasjonskilder til årsaksanalysen. Det ble utarbeidet semi-strukturerte samtaleguider til bruk i samtalene. Totalt gjennomførte SHT samtaler med omkring 40 personer.

Årsaksanalysen startet med samtaler med operativt personell (skiftepersonell og togekspeditører) med formål å kartlegge den operasjonelle arbeidspraksisen på Alnabru. For det operative personellet ble det utført gruppesamtaler hvor to togekspeditører/skiftere/teamledere deltok. Totalt har SHT hatt samtaler med ni togekspeditører (i tillegg til involvert togekspeditør). I CargoNet AS hadde SHT samtaler med 10 skiftere (i tillegg til involvert skifter og fører av skiftemaskin) og 5 teamledere.

Med utgangspunkt i funnene fra samtalene med operativt personell, ble det gjennomført samtaler med ledelses- og støttefunksjoner i CargoNet AS og Jernbaneverket. I CargoNet AS gjennomførte SHT samtaler med driftskontrollør for Alnabru, terminalsjef på ulykkestidspunktet, terminaldirektør, HMS-leder og sikkerhetssjef. I Jernbaneverket gjennomførte SHT samtaler med togekspeditørenes gruppeleder, oppsynsmann for infrastruktur på Alnabru, områdesjef togekspedisjon Oslo, trafikksjef øst, sikkerhetsrådgiver trafikk, kvalitets- og sikkerhetssjef trafikk, banesjef, sikkerhetsrådgiver bane og sikkerhetssjef bane øst.

Tabell 1: Samtaleoversikt.

Samtaler Jernbaneverket		Samtaler CargoNet
Trafikk:	***Bane:***	
Involvert togekspeditør		Involvert skifter og fører av skiftemaskin
9 togekspeditører		10 skiftere
1 togleder		5 teamledere
Gruppeleder togekspeditører Alnabru	Oppsynsmann Alnabru	Driftskontrollør
Områdesjef togekspedisjon Oslo	Banesjef Østfold Kongsvingerbanen og Alnabru	HMS-leder
Trafikksjef trafikk øst		Terminalsjef
Sikkerhetsrådgiver trafikk	Sikkerhetsrådgiver Østfold Kongsvingerbanen og Alnabru	Terminaldirektør
Sikkerhets- og kvalitetssjef trafikk	Sikkerhetssjef bane øst	Sikkerhetssjef

I forbindelse med årsaksanalysen gjennomførte SHT også befaringer på Alnabru skiftestasjon og sentralstillverk, trafikkstyringssentralen på Oslo S og Loenga stasjon. I forbindelse med befaringene ble det også mulighet for samtaler med tilstedeværende personell.

Videre har SHT gjennomgått en rekke dokumentasjon fra Jernbaneverket og CargoNet AS vedrørende Alnabru herunder sikkerhetsstyringssystem, prosedyrer/instrukser, møtereferater, risikokartlegginer og Synergiregistreringer.

SHT har også gjennomgått en kartlegging av sikkerhetskultur i Jernbaneverket som Det Norske Veritas (DNV) har gjennomført på oppdrag for Jernbaneverket våren 2010. DNV har benyttet et lignende perspektiv på sikkerhetskultur som SHT har hatt som teoretisk utgangspunkt i årsaksanalysen.

SHT har gjennomført møte med Oslo Havnevesen og mottatt diverse dokumentasjon vedrørende risikovurderinger i forhold til jernbanesporene på Sydhavna.

Når det gjelder eksterne rammebetingelser har SHT gjennomgått relevant regelverk, samt dokumentasjon fra Jernbanetilsynet og Arbeidstilsynet vedrørende Alnabru, tilsynsvirksomhet, søknader/meldinger og tillatelser. SHT har også gjennomgått utbyggingshistorikk og foreliggende planer for utbygging/ombygging av Alnabru.

1.5.1.2 *Ekstern bistand*

Ved gjennomføring av årsaksanalysen har SHT hatt bistand fra konsulent først fra SINTEF Teknologi og samfunn og deretter fra Safetec. Bistanden har bestått av kvalitetssikring av SHTs undersøkelses- og analysearbeid i forhold til nyere teori og forskning relatert til organisasjoner og sikkerhetskultur spesielt.

Bistanden inkluderte også en analyse av utvalgt samtalemateriale som SHT innhentet i forbindelse med undersøkelsen, og utarbeidelse av et internt notat med hovedvekt på sikkerhetskultur basert på dette. I samråd med SHT ble 9 transkriberte samtaler med totalt 17 informanter valgt ut for nærmere gjennomgang. Dette utgjorde det primære datamaterialet for denne analysen. I tillegg ble det gjort en gjennomgang av havarikommisjonens sammendrag av samtaler med ledelse og støttefunksjoner i Jernbaneverket og CargoNet AS.

Analysen har vært inspirert av en kvalitativ forskningsmetodikk kalt ”grounded theory” (Glaser og Strauss, 1967). Datamaterialet kodes ut fra hva som fremstår som viktige tema i hvert intervju. Eksempler på slike koder er ”etterlevelse av 4-timersregel” og ”kommunikasjon om risikoforhold”. Kodene forsøkes deretter sett i sammenheng for å formulere eventuelle underliggende tema. I presentasjonen av resultatene fra analysen er det valgt ut sitater for å illustrere slike underliggende tema. Sitatene må med andre ord ikke ses primært som løsrevne synspunkt fra enkeltindivider, men som eksempler på gjennomgående trekk i datamaterialet.

Referanser

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Rasmussen, J. (1997): *Risk management in a dynamic society: a modeling problem*. Safety Science Vol. 27, No 2/3, pp. 183-213.

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Tiltaksliste Alnabru pr 20.12.10

Saknr	Tiltak	Tidsplan	Referanser
1	Ny sporveksel 30	Er utført	S-sirk 121-2010
2	Ny sporveksel 21 (har sammenheng med sporveksle 30 og sporgeometri.)	Er utført	
3	Jordvoll og gryte	Er utført	
4	Forsterket endebutter med ny skinnegang T1 og T2	Er utført	
5	Nødutløsning av togvei til/fra godssporet. Dette medfører at dekningsveksel 30 legger seg over til avvik umiddelbart.	Er utført	S-sirk 121-2010 Beskrivelse tatt inn i rev. utgave av stillverksinstruks for hovedstillverket (Stillverk midt og syd)
6	Innlagt lydvarsling etter 5 min når vekselen ligger for kjøring til/fra Godstogsp/Brobekk og som kan kvitteres ut av Txp. Ny varsling igjen etter 5 min. Verneombud har satt krav om analyse vedrørende støynivå/intervaller.	Er utført Vil bli utført snarest	
7	Anordne slik at signal kan settes opp i forkant når klart for tog i retning Godstogsporet og Brobekk, men at signal ikke aktiviseres før et nærmere definert sporfelt blir belagt. Det samme for motsatt retning. Dette p.g.a at omlegging av dekningsveksel ikke skjer unødvendig tidlig.	Tiltak kan ikke gjennomføring på kort sikt	

Saknr	Tiltak	Tidsplan	Referanser
8	Sporveksel 501/514 Verksted Syd. Hindring av materiell i bevegelse fra Vst. Syd mot G1 Tiltak: Pulsing av veksel 501/514 slik at materiell som ukontrollert kommer i bevegelse fra vst syd vil bli ført mot endebutt oppsatt i nærhet av veksel 514.	Risikoanalyse under utarbeidelse/sluttføring. Plan for gjennomføring ikke satt men beregnet ferdig før 01.01 Ligger til godkjenning hos SJT	
9	Sperring i slippstillverk I det tekniske anlegget er det ingen teknisk sperre som hindrer at dvergtogvei legges direkte ut fra A-spor mot G-spor når fastholderbremsen og nedfiringsbremsen åpnes.	Tiltak kan ikke gjennomføring på kort sikt	*Ref.stillverksinstruksen for sporbestemmer delanlegg 7 Alnabru punkt 1.1.2. punkt b3:* Betingelser for at tog med tilkoblet lok. i nord kan bakkes fra et ankomstspor utenom tilløpsbremsen er at dvergtogvei legges fra A-spor mot vedkommende tilløpsbrems.
10	Ved kjøring fra G- spor mot besatt spor i A -spor må dvergsignalene R1 og R3 kunne vise "varsom kjøring tillatt (mot A-Spor med besatt spor og aktivisert sporbremser, dersom det er lys i stopp for lok før gjeldende A- spor) I dag må dette forgå forbi disse signalene i stopp. Dette kjelder ikke for kjøring fra kulbremsen forbi dvergsignal R29 mot besatt spor i A-spor	Tiltak kan ikke gjennomføring på kort sikt	
11	Strømtilførsel Alnabru Syd vil bli forbedret. Flere nye sporveksler vil få sporvekselvarme. Dette utføres fortløpende.	Gjenstår kun veksel 19 øvrig er utført	

Saknr	Tiltak	Tidsplan	Referanser
12	Sporvekselvarme A-spor Det vil fortløpende bli montert varme i bremsene i A-spor	Ferdig montert januar 2011 (forsinket pga kulde)	
13	Sporsperre ved dvergsignal R52 ved verksted Nyland Syd. Pulsing av sporsperre slik at den automatisk går i pålagt stilling. (Dette er samtidig et innspill fra lok.personalet Cargo Net) Trafikk har også spilt inn ønske om varme i sporsperren. .	Risikoanalyse gjennomført Plan for gjennomføring ikke kjent.	
14	Kjøring til og fra Verksted Nyland Syd. Tydeligere signalisering for lok personalet for kjøring fra Alnabru mot Verksted Nyland. (Pr i dag tilkjennegitt med dvergsignal på hovedsignalets mast)	Risikoanalyse gjennomført Her må signalmiljøet si noe om en løsning. Plan for gjennomføring ikke kjent.	
15	Sikring av planovergang mellom tilløpsbrems og dalebrems.(Rett nedfor stillverk) Trafikk ønsker denne planovergang sikret opp mot sikringsanlegget.	Trafikk og Marked har i overensstemmelse med Verneombud stengt planovergangen. Bare helt nødvendig kjøring tillatt. Bane har ikke foreløpig kommet med plan for når planovergangen vil bli sikret opp mot sikringsanlegget.	Notat/instruks til Txp er utsendt. Seksjon sikkerhet i TM ser på om ny brukerveiledning for planovergangen skal inn i revidert instruks for stillverket eller som en egen prosedyre.

Saknr	Tiltak	Tidsplan	Referanser
16	Flere pulsinger av sporveksler. Gjelder i vesentlig grad G-spor.	Innsendt til SJT for godkjenning	
17	Utarbeidelse av teknisk bakgrunnsdokumentasjon av sporbremser/slippstillverk ved hjelp av beregninger og/eller fysiske tester. Godkjenning/aksept for bruk av sporbremser hos SJT	Bane utarbeider plan for utarbeidelse av dokumentasjon samt søknad om godkjennelse til bruk av sporbremser og slippstillverk	
18	Helhetlig vurdering av bruksmønstrene på Alnabru basert på gjennomgangen av tekniske barrierer og oppdateringen av analysen Denne analysen er en overordnet analyse vedrørende helhetlig vurdering av bruksmønstrene på Alnabru. Så snart arbeidet med de prioriterte øvrige analyser (div. analyser omhandlende tiltak for å tette igjen åpenbare "sikkerhetshull" (jfr. f.eks dekningsveksel)) er ferdige, starter fullføringen av arbeidet på den overordnede analysen.	Beregnes å være grovt på plass før nyttår men nødvendig å finpusse, presisere og (delvis) kvantifisere den etter nyttår (fra mail C.Busch 2.12) Analysen utføres i regi Bane Sikkerhet.	
19	Analyse for å ta i bruk normalt driftsmønster R-spor. R-sporene anbefales åpnet for skifting uten bruk av trykkluftbremser.	S-sirk til godkjenning hos TTG/TS	Sporveksel 30 er lagt inn som en ny barriere for å forhindre at vogner skal kunne trille ned mot Bryn, Oslo S eller Loenga, hvis vogner skulle komme ukontrollert ut av lokalområde I. Se S-sirkulære 121-2010

Saknr	Tiltak	Tidsplan	Referanser
20	Gjennomgang av beredskapsplanverk og varslingslister sammen med Oslo Havn OH uttrykte at de har behov for varsling hvis materiell kommer i ukontrollert bevegelse fra Loenga retning OH, men de må først internt enes om hvordan de ønsker denne varslingen utført for at den skal få fullgod effekt i påkommende tilfelle.	Avholdt møte mellom TØ og Oslo Havnevesen (OH) pr. 15.9. TØ foretok en gjennomgang av TJN vedr. bestemmelser knyttet opp mot skifting. Rutiner for hvordan forholdes ifm. skifting på OH sine spor (dvs. skifting fra Loenga mot OH) ble presisert. Likeens rutiner for hvordan samhandling/kommunikasjon foregår mellom OH og JBV ved sporarbeider på OH. Eget notat sendt Txp Loenga angående oppstart skifting OH. JBV meddelte også at man vil etablere en grensestolpe for å tydelig markere grensen mellom OH og det nasjonale jernbanenettet (mellom Loenga/Sjursøya).	

Saknr	Tiltak	Tidsplan	Referanser
21	Presisere krav om gjentakelse av muntlige ordrer, tillatelser og underretninger for skifting "Readback"	S-sirk. 73/2010 sendt ut 1.7.2010.	S-sirk. 73/2010
22	Logging av kommunikasjon i forbindelse med trafikkstyring av skifting.	Påbegynt planlegging for å kunne logge kommunikasjon i forbindelse med trafikkstyring av skifting.	
23	Togradio Frequentis Eksisterende LCT terminal har ikke stor nok kapasitet. Krav fra Trafikk vedr Frequentis: Tognummerliste på displayet, 1200 går til togleder og 1800 går til txp	Frequentis er installert for opplæring og alle er pr dato opplært. Begrenset versjon iverksettes 20.12.10 (Ikke tognummerliste og varierende indikeringer på display hos fører)	Analyse avholdt 17.11. Rev analyse 30.11 S-Sirk 145-2010
24	Signalgiver Alnabru Syd Primæroppgave blir å legge togveier ved togs inn og utkjøring etter retningslinjer fra Txp. Sekundæroppgaver blir etter behov å assistere ved skifting, avbremsing av vogner jmf skifteinstruks og snørydding.	TM har innleid godkjent personale fra Baneservice som var operative fra 11.10.10 Signalgiver har fast tilhold i Alnabru Syd sine lokaler som er oppgradert.	Egen prosedyre/instruks er utformet.

Saknr	Tiltak	Tidsplan	Referanser
25	Arbeidsmiljøanalyse (Pålegg i Arbeidstilsynets rapport.) Undersøkelsen skal kartlegge: Jobbkrav, Rolleforventninger, Kontroll i arbeidet, Positive utfordringer, Sosialt samspill, Områdesjef, Mestring av arbeidet, Utmattelse i arbeidet, Engasjement i organisasjonen Arbeidsglede og engasjement i jobben.	Er gjennomført. BHT har gjennomgått resultatene med leder, tillitsvalgte, verneombud og personalseksjonen i Trafikk. Leder, eventuelt sammen med BHT vil deretter gjennomgå resultater med personalet. Handlingsplan for jobbing med arbeidsmiljø lages i fellesskap.	

Saknr	Tiltak	Tidsplan	Referanser
26	Arbeidspådragsanalyse (Pålegg i Arbeidstilsynets rapport.) Kartlegging av arbeidsoppgaver, arbeidsbelastning, arbeidstidsordninger, arbeidsmiljø, utforming av arbeidsplassen, teknisk utstyr/hjelpemidler, opplæring, rutiner og styrende dokumenter. Gjennomgang av relevante stillingsbeskrivelser, lokale prosedyrer og retningslinjer, tidligere utførte risikoanalyser og kartlegginger på Alnabru, opplæringsplaner, ruteplan, innrapporterte UH på Alnabru, resultat fra utførte vernerunder. Befaring og samtaler m/personell på vakt Ivaretakelsen av grensesnittet mot trafikkutøver Intervju Vurdering av sikkerhetskulturen lokalt på Alnabru opp mot JBVs generelle sikkerhetskulturkartlegging. Sette seg inn i DNV rapport Vurdering av de faktorene som enkeltvis eller samlet kan ha helse- og sikkerhetsmessig konsekvenser for togekspeditørene på sentralstillverket Fareidentifikasjon og RA Sammenstille resultatene og skrive rapport Vurdering av konkrete tiltak og anbefalte aksjoner ved redusert bemanning på sentralstillverket. Analyse og dokumentasjon	Er under forberedning	

Saknr	Tiltak	Tidsplan	Referanser
28	Gjennomføre grovanalyser for løpsk materiell for alle relevante steder på jernbaneverkets nett.		

ARKIVSAKER 12 av 12 funn.

ArkivSakID	Klassering	Sakstittel	Saksansv	Saksdato	Ant
'10/436	1-SF2-521	Jernbaneverket - Tekniske barrierer Alnabru Syd		24.06.2010	4
'10/246	1-SF2-669	Togulykke - Alnabru - Sjursøya		09.04.2010	55
'10/223	1-SF2-669	Jernbaneulykke Alnabru - Sjursøya		25.03.2010	2
'10/66	1-SF2-008	Høring - Alnabru Containerterminal		29.01.2010	2
'09/690	1-SF2-008	Høring - Planforslag til offentlig ettersyn - planprogram for Alnabru - Breivollområdet		30.11.2009	1
'09/629	1-SF2-551	JBV - Kjøring av lokomotiver fra verksted Grorud nord til Alnabru - Unntak fra togframføringsforskriften		05.11.2009	4
'08/468	1-SF2-551	Jernbaneverket - Kjøring av lokomotiver fra verksted Grorud nord til Alnabru - Unntak fra togframføringsforskriften		18.09.2008	2
'06/579	1-SF2-511	Green Cargo - Tillatelse til å transportere nye T-banevogner på strekningen Charlottenberg - Alnabru		15.08.2006	2
'06/553	1-SF2-511	CargoNet AS - Søknad om tillatelse til å transportere nye T-banevogner for AS Oslo Sporveier på strekningen Alnabru-Grefsen		26.07.2006	2
'06/516	1-SF2-661	SHT - Rapport om alvorlig jernbanehendelse		04.07.2006	12
'06/262	1-SF2-521	Jernbaneverket - Nye Alnabru containerterminal - Melding om prosjekt		20.03.2006	36
'00/397	1-SF-74	Framføringstillatelse og transporttillatelse for arbeidsmakiner tilhørende Fa GBM Hermann Wiebe Achim Tyskland på strekningen Kornsjø - Alnabru		07.09.2000	2

Dokumenter i arkivsak : 2006000262

Ant.poster: 35

Nr	Type	Adm.enh	Saksbeh	Avs/mottaker	Journalposttittel	Journalposttittel2	Brevdato	AvskrDato
35	U	STE		Jernbaneverket	Vedrørende høring av tilleggsutredning - Alnabru containerterminal - Nye godsspor og mulige stasjonsløsninger på Grorud		16.07.2010	
34	I	STE		Jernbaneverket	Alnabru containerterminal - Høring av tilleggsutredning - Nye godsspor og mulige stasjonsløsninger på Grorud		07.07.2010	16.07.2010
33	U	STE		Jernbaneverket	Alnabru Containerterminal Nord - Planlagte planoverganger		04.02.2010	
32	I	STE		Jernbaneverket	Alnabru Containerterminal Nord - Planlagte planoverganger		22.01.2010	25.03.2010
31	I	STE		Jernbaneverket	Referat fra ststusmøte 16.03.2009		26.03.2009	17.09.2009
30	U	STE		Jernbaneverket	Vedrørende melding for Alnabru Containerterminal Adkomstområde ACA etappe 0 og Depotområder ACD		22.09.2009	08.03.2010
29	I	STE		Jernbaneverket	Melding for Alnabru Containerterminal Adkomstområde ACA etappe 0 og Depotområder ACD		01.09.2009	22.09.2009
28	I	STE		Jernbaneverket	Oversender organisasjonskart		16.02.2009	18.02.2009
27	I	STE		Jernbaneverket	Referat fra statusmøte mellom SJT og JBV om Alnabru Containerterminal		16.02.2009	18.02.2009
26	U	STE		Jernbaneverket	Høring hovedplan - Alnabru containerterminal depotområde		06.02.2009	
25	I	STE		Jernbaneverket	Alnabru containerterminal depotområder - Høring av hovedplan		15.01.2009	06.02.2009
24	U	STE		Jernbaneverket	Vedrørende hovedplan del 1 for Alnabru containerterminal adkomstområde (ACA)		12.09.2008	
23	I	STE		Jernbaneverket	ACA Alnabru Containerterminal Adkomstområde - Hovedplan del 1 - Høring		03.09.2008	17.09.2008
22	I	STE		Jernbaneverket	Oversendelse av sikkerhetsbevis		25.08.2008	28.08.2008
21	U	STE		Jernbaneverket	Tillatelse til å ta i bruk infrastruktur - endret infrastruktur på Alnabru Containerterminal Nord		27.08.2008	
20	X	STE		Saken	Telefonnotat - samtale med Anne-Marie Braaten fredag 22 august 2008		22.08.2008	
19	X	STE		Saken	Telefonnotat - samtale med Anne-Marie Braaten		21.08.2008	
18	I	STE		Jernbaneverket	Søknad om å ta i bruk endret infrastruktur på Alnabru Containerterminal Nord - Nye og reviderte vedlegg	To vedlegg ikke skannet	19.08.2008	28.08.2008
17	I	STE		Jernbaneverket	Søknad om å ta i bruk endret infrastruktur på Alnabru Containerterminal Nord		30.06.2008	28.08.2008
16	I	STE		Jernbaneverket	Prosjekt Stor-Oslo - Alnabru containerterminal		06.03.2008	13.03.2008
15	X	STE		Saken	Gjennomgang av risikoanalyse Alnabru terminal Nord - sikkerhet endelig anlegg		17.03.2008	
14	U	STE		Jernbaneverket	Vedrørende melding om midlertidig endring i infrastruktur Alnabru sentralstillverk - stillverk Midt ute av bruk		13.03.2008	
13	U	STE		Jernbaneverket	Alnabru containerterminal - midlertidige endringer		27.02.2008	
12	I	STE		Jernbaneverket	Alnabru Containerterminal - Godkjenning av kjørevei - Endret infrastruktur - Søknad om unntak fra sikkerhetsforskriften		18.01.2008	17.03.2008
11	I	STE		Jernbaneverket	Alnabru Containerterminal - Ettersender risikoanalyse		21.01.2008	17.03.2008
10	U	STE		Jernbaneverket	Vedrørende melding om endring i infrastruktur Alnabru Containerterminal		11.12.2007	
9	X	STE		Mona Stryken	Sjekkliste melding om Alnabru Containerterminal		21.11.2007	
8	I	STE		Jernbaneverket	Alnabru Containerterminal - Godkjenning av kjørevei ved SJT - Melding om endret infrastruktur		09.11.2007	11.12.2007
7	U	STE		Jernbaneverket	Vedrørende grensesnitt mellom ulike typer signalanlegg		04.07.2006	
6	I	STE		Jernbaneverket	Alnabru Ny containerterminal - Svar til SJT vedr. melding om utbyggingsprosjekt		23.06.2006	27.06.2006
5	I	STE		Jernbaneverket	Alnabru containerterminal - befaring - fremdriftsplan 18.05.2006		23.05.2006	06.06.2006
4	U	STE		Jernbaneverket	Vedrørende melding om utbyggingsprosjekt - Nye Alnabru containerterminal		02.06.2006	
3	I	STE		Jernbaneverket	Alnabru Ny containerterminal - Referat fra informasjonsmøte mellom JBV IU og SJT		16.05.2006	23.05.2006
2	X	STE		Saken	Vurdering av melding Alnabru Containerterminal		07.04.2006	
1	I	STE		Jernbaneverket	Utbyggingsprosjekt 960127 - Nye Alnabru containerterminal - Melding om prosjekt - Overs. dokumentasjon		15.03.2006	06.06.2006

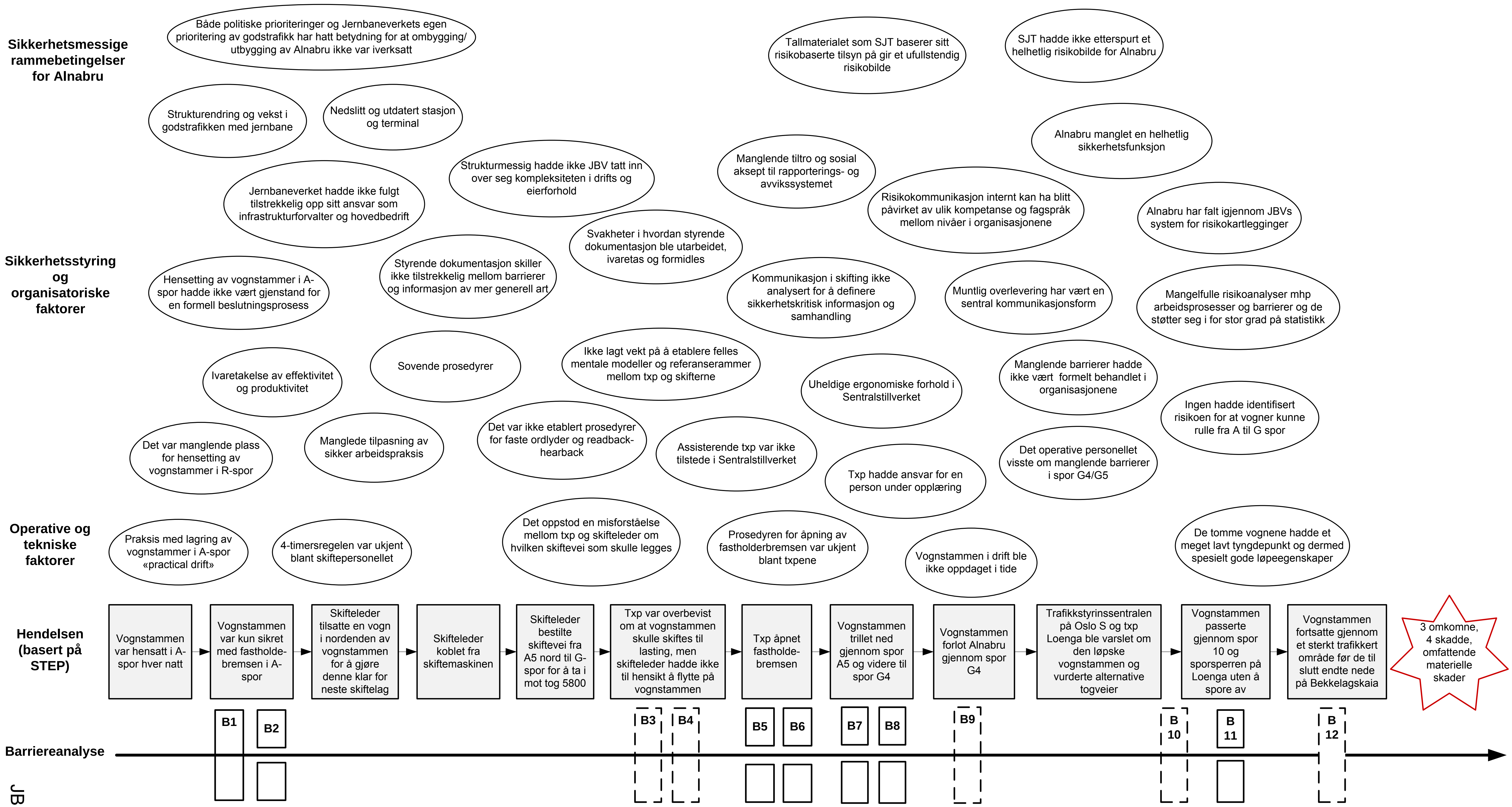
Alnabru historikk

Periode	Hendelse	Tidspunkt
Før 1970	Godsanleggene på Alnabru planlegges og bygges ut gjennom "Anlegget Oslo sentralstasjon", en dedikert prosjektorganisasjon organisert under NSB Hovedadministrasjonen	
1970-1979	Alnabru sentralskiftestasjon (Alnabru S) ble fullført og overlevert til "driften". Alnabru godsterminal (Alnabru G) ble ferdigstilt på Alnajordet, det som i dag kalles "gamla". Trafikken bestod i hovedsak av vognlast som ble sortert til og fra tog via Alnabru S. Alnabru (S og G) var en stasjon i Oslo distrikt ledet av en stasjonsmester.	1971
	Plan for ny godsterminal på Alfaset designet for å handtere containertrafikk ble lagt frem	1979
1980-1984	Alna-elven ble lukket med en 1,2 km lang kulvert fra Nedre Kalbakkvei og nedover, og elvedalen ble fylt opp med masse (trinn 1). Det ble arbeidet med strategier for rasjonalisering og omlegging av godstrafikken på jernbanen bl.a. gjennom et sentralt styrt prosjekt (Gods 84).	1981
1985-1989	Planen for Alfaset-terminalen ble justert bl.a. for å gi plass for samlastvirksomheter i tilknytning til containerterminalen. Bygging av de første deler av Alfaset-terminalen ble igangsatt (trinn 2) i regi av Anlegget Oslo sentralstasjon.	
	NSB ble divisjonalisert, distriktene lagt ned og erstattet av divisjoner, bla. Godstrafikkdivisjonen, Togdriftsdivisjonen, Banedivisjonen etc.	1987?
	Divisjonene ble internt omstrukturert og fikk ny ledelse og nye navn, bl.a. NSB Gods. Alnabru ble inkludert i NSB Gods, men delt i to ansvarsområder: Alnabru S ble ansett å ha en riksdekkende funksjon og ble lagt til NSB Gods Drift, mens terminaldelen (Alnabru G) ble en del av terminalområde Oslo Akershus.	1989?
1990-1995	Utbyggingen av Alfaset-terminalen fortsatte i regi av anlegget Oslo sentralstasjon med ferdigstillelse av forbindelsessporet til Grorud og terminalsporene benevnt fra C10 og til og med C41 (trinn 3). Forbindelse mellom Alfaset-terminalen og Alnabru S ble anlagt via sporene G2 og spor 200 (senere omdannet til G3).	1992
	De første rene containertogene kjører ut fra Alfaset-terminalen. Trafikken over Alnabru (S og G) er fortsatt en blanding av containertrafikk og vognlast, størstedelen er fortsatt vognlast.	1992
	Utbyggingen av EBILOCK sikringsanlegg for terminalen ble startet	
	Anlegget Oslo sentralstasjon ble nedlagt, restarbeidene ved byggetrinn 3 ble overført til baneregion Øst	
	Utbyggingen av terminalsporene C42-C44 samt etablering av kranbane og containerkraner på Alfaset ble gjennomført som et nytt investeringsprosjekt i NSB Gods (trinn 4)	1993/94
1996-1999	Sporforbindelsen mellom Alfaset-terminalen og Alnabru S ble endret, spor G4 og G5 ble bygget, først som buttspor, senere som gjennomgående spor.	
	Utbyggingen av EBILOCK fullføres	1999?
	Containertrafikken over Alnabru øker og det foretas tilpassinger i terminalene andre steder i landet.	

Alnabru historikk

Periode	Hendelse	Tidspunkt
	NSB Gods omorganiseres og deles etter produktene Containerekspress, Vognlast, Systemtog og Ekspressgods. Alnabru G blir hovedsetet for Containerekspress.	1997
	Alnabru S og Alnabru G får på nytt felles ledelse en periode før Alnabru S overføres til Jernbaneverket	1997-1999
2000-2005	Enheten Vognlast slås sammen med Containerekspress. Produktet vognlast avvikles. Det arbeides med å etablere et eget godsselskap med egen lisens.	2000-2002
	NSB Gods blir erstattet CargoNet AS med NSB og Green Cargo som eiere.	2002
	Kombitrafikken øker sterkt mens vognlast forvinner i regi av CargoNet AS.	
	Green Cargo AS oppretter eget vognlasttilbud på enkelte destinasjoner	
2006-2010	Flere nye jernbaneselskaper som driver godstrafikk opprettes og ønsker å trafikkere over Alnabru.	
	Det foretas enkelte mindre justeringer i terminalsporene på Alfaset for å øke kapasitet og å tilrettelegge for andre trafikkutøvere.	

Vedlegg G: Hendelse- barriere- årsaksdiagram
Jernbaneulykke med vognstamme i utilsiktet drift fra Alnabru til Sydhavna 24. mars 2010



B1. Barriere fungerte: Fastholderbrems fungerte som forutsatt

B2. Barrierebrudd – barriere fungerte ikke: Parkeringsbrems ikke benyttet

B3. Barriere ikke etablert: Ikke etablert rutiner for faste ordlyder i kommunikasjon mellom skifteleder og txp

B4. Barriere ikke etablert: Ikke etablert rutiner for readback-hearback av kommunikasjon mellom skifteleder og txp

B5. Barrierebrudd – barriere fungerte ikke: Togvei utenom tilløpsbrems lagt og fastholderbrems løst ut uten at txp i tilstrekkelig grad hadde forsikret at skiftemaskinen hadde kontroll over vognstammen

B6. Barrierebrudd: Manglende redundans i stillverket da assisterende txp ikke var tilstede

B7. Barrierebrudd – barriere fungerte ikke: Nedfiringsbrems stoppet ikke vognstammen da vognene i drift ikke ble oppdaget i tide

B8. Barrierebrudd – barriere fungerte ikke: Vognene ble ikke avledet til R47 gjennom G2/G3 da vognene i drift ikke ble oppdaget i tide

B9. Barriere ikke etablert: Sporene G4/G5 hadde ikke noen avledende sporveksler eller andre former for barrierer

B10. Barriere ikke etablert: Det var ikke lagt til rette for å kunne avlede, avspore eller stoppe løpske vogner på en kontrollert måte etter Alnabru

B11. Barrierebrudd – barriere fungerte ikke: Kurve og sporsperre i spor 10 stoppet ikke vognene – sporsperre tåler maks 50 km/t

B12. Barriere ikke etablert: Det var ikke etablert barrierer på Sydhavna for å stoppe løpske vogner i høy hastighet

Diagrammet er ikke uttømmende for SHTs analyse av ulykken, men det illustrerer SHTs undersøkelsesprosess og sikkerhetsperspektiv.