Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Rail Occurrence Investigation 2006/015
Final

Level crossing collision between

The Ghan Passenger Train (1AD8)

and a

Road-Train Truck

Ban Ban Springs, NT

12 December 2006

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Abstract

At approximately 1356 on 12 December 2006, a double trailer road-train truck drove into the path of *The Ghan* passenger train (1AD8) at the Fountain Head Road level crossing, Ban Ban Springs, Northern Territory. As a consequence, two locomotives, a wagon used for carrying passengers' private vehicles and nine passenger carriages derailed. There were no fatalities, however, the road-train driver and a female passenger were hospitalised and several other passengers and crew sustained minor injuries.

The investigation concluded that the truck was driven through the 'Stop' sign at the level crossing at a speed of about 50 km/h. The driver of the truck traversed the level crossing many times during the course of his 'working day' and had been in the habit of slowing rather than stopping at the level crossing 'Stop' sign. Factors influencing this act were the manner in which the task was normally performed, the expectation that a train would not be present and the operational constraints of road-train vehicles. It was also found that the ability of the road-train truck driver to hear the first two soundings of the train horn may have been compromised by his severe bilateral hearing loss.

The report identifies a number of safety issues and issues recommendations and safety advisory notices with the aim of preventing similar events.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

TERMINOLOGY USED IN ATSB INVESTIGATION REPORTS

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, risk controls and organisational influences.

Contributing safety factor: a safety factor that, if it had not occurred or existed at the relevant time, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Safety issues can broadly be classified in terms of their level of risk as follows:

- **Critical safety issue:** associated with an intolerable level of risk.
- **Significant safety issue:** associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable.
- **Minor safety issue:** associated with a broadly acceptable level of risk.

EXECUTIVE SUMMARY

At 1356:33[1] on Tuesday 12 December 2006, an empty double trailer road-train[2] truck drove into the path of *The Ghan* passenger train on the Fountain Head Road level crossing at Ban Ban Springs, about 170 kilometres south of Darwin in the Northern Territory (NT). At the time of the collision, *The Ghan* was travelling at a speed of 101 km/h and the road-train at an estimated speed of 50 km/h.

The Ghan consisted of two locomotives hauling a motorail wagon[3], a power van, 13 passenger carriages and a luggage van. The total weight of *The Ghan* was 1022 tonnes and the length, 425 m. The length of the road-train was about 36 m. On board *The Ghan* at the time of the accident were 64 passengers, 13 on-train staff and four train drivers. The driver was the sole occupant of the double road-train truck.

The first point of impact on the road-train was immediately behind the prime-mover cab with force sufficient to separate the prime-mover from the trailers. The prime-mover then spun away from the train and came to rest 18 m from the crossing on the northern side of the track. Simultaneously, the two trailers moved in a 'whipping motion' towards the left-hand side of the train, striking the two locomotives in the process. The trailers then rebounded and came to rest on top of each other about 16 m from the rail line on the southern side of the track.

Both locomotives, the motorail wagon and nine passenger carriages were subsequently derailed. The two locomotives broke away from the rest of the train and then each other. The lead locomotive stopped 440 m from the level crossing with five of the six wheel-sets derailed. The passenger carriages derailed and jack-knifed to the right but remained upright. With the exception of the vestibules/walkways between the carriages that concertinaed, no areas of occupation were breached or compromised during the derailment sequence.

The road-train driver suffered cuts, abrasions and general bruising. The two train drivers who were in the lead locomotive incurred superficial injuries only. Injuries to passengers and on-train staff were confined mainly to cuts and bruising. About 15 minutes after the collision, a female passenger still on board the train lapsed into unconsciousness. The passenger required medical attention and was later airlifted by medivac helicopter to the Royal Darwin Hospital, arriving at 1908. The road-train driver was taken to the Royal Darwin Hospital by road ambulance, arriving at 1858.

First response following the collision was provided by the on-train staff and personnel from the nearby GBS Gold Brocks Creek mine site. GBS Gold personnel arrived on site about 20 minutes after the accident; resources dispatched included medically qualified personnel, a company ambulance and a fire truck. Between about 1515 and 1610 all of the passengers and some of the on-train staff were transferred to the GBS Gold employee/contractor residential quarters (Cosmo Camp) about 17 kilometres from the accident site.

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1 The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred. The time of 1356:33 is calculated from the locomotive data event loggers.

2 Road-train – A combination road vehicle consisting of a prime-mover towing two or more trailers.

3 The motorail wagon is used to convey passenger's private vehicles.

Due to the distance from their respective stations, the first of the emergency services personnel were not in attendance until about 1620. At about 2000 the passengers were transferred from the Cosmo Camp to Darwin; arrival time in Darwin was between 2230 and 2300. Much of the NT rail corridor is characterised by its remoteness. The investigation found that this and the local climatic conditions could make a timely and effective response to a rail accident very challenging in some circumstances.

The Ghan had a valid authority to be on the section of track where the Fountain Head Road level crossing is located. Locomotive data logger analysis confirmed that the train was travelling within its maximum speed limit of 110 km/h and that the locomotive horn had been sounded three times immediately before the collision. Other sources of evidence confirmed that the lead locomotive's headlight was illuminated.

The Fountain Head Road level crossing is a passive level crossing controlled by 'Stop' signs that direct the drivers of road vehicles to stop and give way to on-coming trains before traversing the level crossing. The evidence is that the road-train truck driver who was approaching the crossing from the south, did not detect the presence of *The Ghan* approaching from the east (until the last seconds before the collision) and drove into the path of the train without stopping at the 'Stop' sign. Notwithstanding this, the investigation considered a number of factors that may have influenced the truck driver's actions. These factors included the nature of the road-train driver's task, the state of his health, the operational constraints of road-trains, control of road traffic at the level crossing and the compliance with and/or adequacy of the applicable level crossing standards.

The road-train truck driver worked for a company that was contracted to build a new access road for GBS Gold. In this role, the road-train truck driver had been conveying loads of road base material across the Fountain Head Road level crossing about 30 times each day for a period of about a month before the accident. During this time he had only seen about four trains, for none of which did he had to alter his normal driving pattern.

The investigation found that the road-train truck driver, his colleagues and other road vehicle drivers were in the habit of slowing rather than stopping at the Fountain Head Road level crossing. This was an unsafe practice as dense vegetation and the topography of the area adjacent to the road made it very difficult for a motorist approaching the crossing from the south to see a train approaching the crossing from the east until they had almost reached the 'Stop' sign at the crossing.

Evidence from the road-train truck driver indicated that he had significant hearing loss. The investigation found that his hearing loss could have compromised his ability to hear the train and its horn in the time before the collision. The results of a hearing test undertaken by the truck driver two months prior to the collision indicated that the extent of his bilateral hearing loss was severe and that he would not have met the requirements for an unconditional multi-combination (MC) heavy commercial vehicle license. The investigation also found that the road-train truck driver, despite about 40 years of truck driving, had never been medically examined in conjunction with obtaining or renewing his MC class license. This contrasts markedly with the regular medical examinations undertaken by safety critical rail workers including train drivers.

Although the length of the road-train involved in the accident was 36 m, road-train combinations of up to 53.5 m operate regularly to and from mines in the vicinity of the Fountain Head Road level crossing. Privately conducted time trials of road-trains by local mining interests had indicated that level crossing clearance times for 53.5 m B+2A road-train combinations may give cause for concern. Given that road-train combinations of 53.5 m operate throughout much of rural Western Australia, South Australia, Queensland, the NT and, to a small extent, New South Wales[4], the investigation sought to validate the clearance times for these vehicles and the adequacy of existing level crossing standards in order to determine if a broader safety issue existed.

In August 2007, the ATSB conducted clearance time tests on 53.5 m long B+2A road-trains at the Fountain Head Road level crossing, Ban Ban Springs. These tests found that, based on these clearance times, the theoretical models used to calculate sighting distances at level crossings are likely to be inadequate for the truck configuration tested.

On 5 October 2007, the ATSB released a supplementary report numbered 2006/015 titled '*Results of Trials for Heavy Vehicle Clearance Times at Level Crossings*'. This report details the methods used and the results of the clearance tests and found:

> Tests conducted on 53.5 m long B+2A road-trains at the Fountain Head Road level crossing, Ban Ban Springs, found that the procedure/standard used to calculate and/or assess the level crossing sighting distance was probably inadequate for the truck configuration tested. It is likely that sighting distances at other level crossings controlled by 'Stop' signs, used by high combination gross mass road vehicles, may be similarly deficient and more research is needed to accurately assess this risk.

The report recommended that the State and Territory road transport authorities and rail regulators consider the implications of this safety issue and take action where it is considered appropriate.

As a result of its investigation into the collision between *The Ghan* and a road-train truck at the Fountain Head Road level crossing on 12 December 2006, the ATSB has recommended a range of safety actions that relate to the safety issues identified.

4 In New South Wales the only route approved for triple road-train combinations (53.5 m) is the Mitchell Highway from North Bourke to the Queensland border at Barringun. There are no railway level crossings on this route.

1 FACTUAL INFORMATION

1.1 Overview

At 1356:33[5] on 12 December 2006, a double trailer road-train truck[6] drove into the path of *The Ghan* passenger train (1AD8) on the Fountain Head Road level crossing at Ban Ban Springs (referred to in this report as the Fountain Head Road level crossing) approximately 170 kilometres south-east of Darwin, Northern Territory (NT) by road (130 kilometres directly).

As a consequence of the collision, two locomotives, a wagon used for carrying passengers private vehicles and nine passenger carriages derailed. There were no fatalities, however, the road-train driver and a female passenger were hospitalised and several other passengers and train crew sustained minor injuries.

1.1.1 Location

Fountain Head Road intersects the Stuart Highway approximately 45 kilometres south-east of Adelaide River and extends north-east for about 11 kilometres where it crosses the Alice Springs to Darwin rail line at a passive[7] public level crossing at Ban Ban Springs. The road is a two lane sealed carriageway that provides access to the Ban Ban Springs pastoral station and Fountain Head Mine. There is an access gate about 100 m beyond the level crossing which denotes the entry into private property and the change in status from a public to a private road.

At the level crossing, the roadway intersects the rail line at 90°; the orientation of Fountain Head Road is north-south and the orientation of the rail line is east-west. Road traffic from the Stuart Highway approaches the level crossing from the south; Darwin bound trains approach the level crossing from the east. The level crossing is controlled by signage that directs road users to stop at the 'Stop' sign and give way to trains that may be either on, or approaching, the level crossing.

There is a slightly falling gradient on the southern approach to the level crossing for road traffic travelling towards Fountain Head Mine/Ban Ban Springs pastoral station. The road grade is level for about 10 m either side of the crossing. The rail line is straight on a slightly rising, undulating grade for trains travelling towards Darwin. At the time of the accident the speed limit for road traffic approaching the level crossing was unlimited[8] and the line speed for rail traffic was 115 km/h.

The Alice Springs to Darwin rail line was constructed between early 2002 and late 2003 by a consortium that was known as ADrail[9]. ADrail performed this work

5 The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred. The time of 1356:33 is calculated from the locomotive data event loggers.

6 Road-train – A combination road vehicle consisting of a prime-mover towing two or more trailers.

7 Passive – road traffic is controlled by signs/devices that are not activated during the approach or passage of a train.

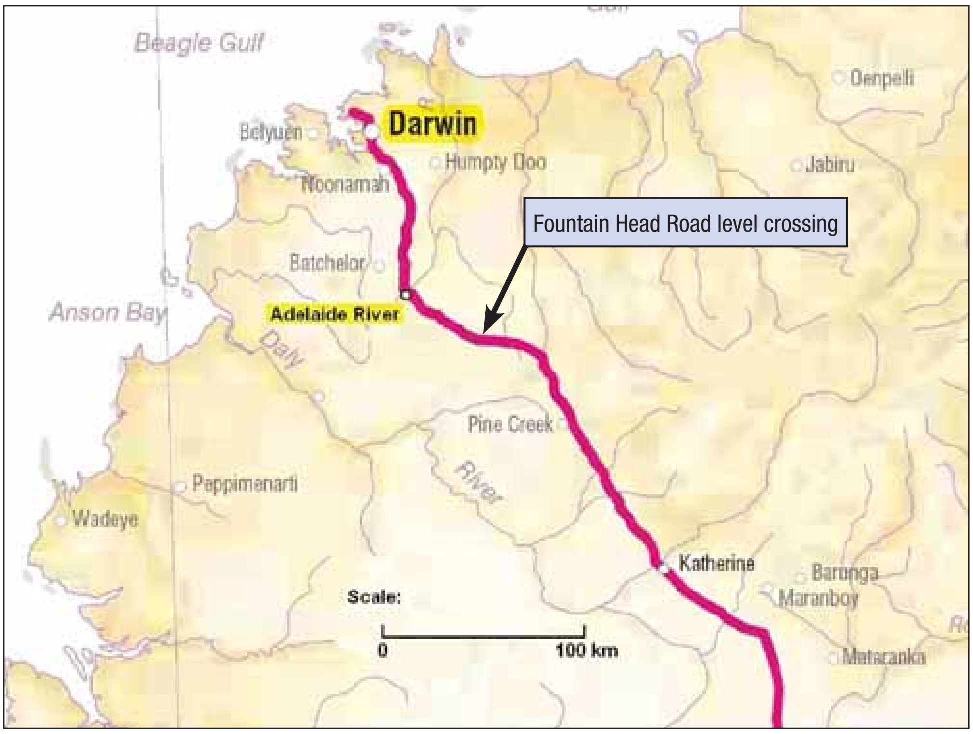
8 With the exception of buses with a gross vehicle mass of more than five tonnes and heavy vehicles with a gross vehicle mass of more than 12 tonnes the speed limit for road vehicles in the Northern Territory on some roads was unlimited before 1 January 2007.

9 ADrail comprised several major engineering companies and was accredited as an 'owner and operator' by the NT Department of Planning and Infrastructure for construction purposes. When the line was commissioned in late 2003 ADrail ceased operations.

under a 'design and construct' contract for Asia Pacific Transport. The Alice Springs to Darwin rail line was opened for commercial traffic in January 2004 and forms part of the Defined Interstate Rail Network (DIRN). This rail line and corridor is now managed and maintained by Freight Link Pty Ltd (FreightLink)[10].

The responsibility for the upkeep and maintenance of the Fountain Head Road level crossing, within the rail corridor, lies with FreightLink. Responsibility for the installation and maintenance of road markings and approach warning signage for the level crossing lies with the NT Department of Planning and Infrastructure (DPI).

Figure 1: Location of Fountain Head Road level crossing, Ban Ban Springs



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1.1.2 Train and crew information

The Ghan Passenger Train (1AD8)

The Ghan passenger train is operated by Great Southern Railway[11] (GSR) and travels the 2754 kilometres between Adelaide and Darwin in each direction twice a week. International tourists are a significant portion of the patronage for *The Ghan* service which, in the peak season, can consist of up to 24 carriages and upwards of 200 passengers. At the time of the accident though, *The Ghan* consisted of two locomotives hauling a motorail wagon[12], a power van, 13 passenger carriages and a luggage van. There were 64 passengers, 13 on-train (hospitality) staff and four train

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10 FreightLink is the operating company of Asia Pacific Transport.

11 Great Southern Railway is an accredited rail organisation providing interstate passenger rail transport linking Sydney, Melbourne, Adelaide, Perth and Darwin. GSR contracts the responsibility for train operations to Pacific National, who provide the locomotives and drivers under a 'hook and pull' arrangement.

12 The motorail wagon is used to transport the passenger's private vehicles.

drivers on board. Including the locomotives, the train weight was 1022 tonnes and the length, 425 m.

Passengers on *The Ghan* are accommodated in two classes of travel; Gold Kangaroo and Red Kangaroo. Each have separate accommodation, dining and lounge facilities, although there is no 'physical' barrier that prevents passengers moving between the two classes of travel.

The maximum permitted speed for *The Ghan* is 115 km/h. However, when hauled by an NR class locomotive (as in this case), the maximum speed is restricted to 110 km/h between Tarcoola[13] and Darwin because of axle load considerations[14].

Table 1: *The Ghan* consist 12 December 2006

No.	Vehicle Type	Number		Description
1	Locomotive	AN 5		
2	Locomotive	NR 109		
3	Motorail	AMPZ-249		Passengers' motor vehicles
4	Power van	HGEM-297		Supplies electricity for the train
5	Crew van	ER-207D		Accommodation for the locomotive & train crew
6	Passenger carriage	ARL-308F	I	Twin berths, 18 passengers
7	Passenger carriage	ARL-992T	J	Twin berths, 18 passengers
8	Passenger carriage	ARL-920Y	K	Twin berths, 18 passengers
9	Passenger carriage	AFC-305T		Gold Kangaroo lounge
10	Passenger carriage	DF-304R		Gold Kangaroo diner
11	Passenger carriage	ARM-947E	L	Train manager's office, deluxe cabin and twin berths, 16 passengers
12	Passenger carriage	ARJ-941K	M	Roomettes, 18 single berths
BOUNDARY BETWEEN GOLD AND RED KANGAROO				
13	Passenger carriage	BRJ-918E	N	Twin berths, 32 passengers
14	Passenger carriage	CDF-966K		Red Kangaroo diner
15	Passenger carriage	AFC-936C		Red Kangaroo lounge
16	Passenger carriage	BG-371K	R	Sitter 62 passengers
17	Passenger carriage	BG-370B	S	Sitter 62 passengers
18	Luggage van	HM-957Q		Passenger luggage

Pre-trip inspections

In accordance with the usual procedures, *The Ghan* was inspected twice prior to its departure from the Keswick passenger terminal in Adelaide on 10 December 2006 for the journey north to Darwin. One inspection was a full mechanical examination carried out by the contractors that maintain the train carriages, United Goninan[15]. This examination included the bogies, wheels, couplers, draft gear, the carriage bodies and auxiliary equipment. The other inspection was a test of the braking system with the locomotives coupled to the train. This inspection was conducted by a Pacific National (PN) train examiner.

13 Tarcoola is the junction station for the Darwin rail line on the western line between Adelaide and Perth. Tarcoola is located in SA. The Tarcoola to Alice Springs rail line was opened in 1980.

14 115 km/h is permitted if the axle load is 19 tonnes. 110 km/h is permitted if the axle load is 21 tonnes. An NR class locomotive has an axle load of 21 tonnes.

15 Now United Group Limited.

During the journey north, *The Ghan* was also inspected twice, once at Alice Springs (11 December 2006) and again at Tennant Creek (12 December 2006). These inspections were conducted by the train drivers and included the operation of the train brakes and a check for any obvious mechanical problems.

No faults were found in any of these inspections that would have placed *The Ghan* outside of required mechanical or operational parameters.

Train drivers

North of Alice Springs *The Ghan* train driving crew comprises two sets of two drivers. The two crews rotate periodically so that one crew is driving and the other crew is resting. The resting drivers are accommodated in a fully equipped crew van marshalled at the lead of the passenger carriage consist.

The driver operating *The Ghan* at the time of the accident was a 60 year old male who had in excess of 30 years experience in the rail industry, including over 20 years driving trains. He was based in Alice Springs and had worked on the Alice Springs to Darwin rail corridor for almost two years. The co-driver was a driver trainer[16] from Adelaide who was in the process of learning the route between Alice Springs and Darwin. This was his third trip on the line. He had in excess of 28 years experience driving trains.

All four drivers on *The Ghan* at the time of the accident were fit for duty in terms of certification/competency and the national medical standard[17].

GSR on-train staff

The GSR on-train staff numbered 13 and consisted of a train manager, a night manager, a Gold Kangaroo manager, two chefs, seven hospitality attendants and a train technician. The GSR train crew are based in Adelaide and share the crew van with the resting train drivers when not required for duty. General duties include attending to passenger requirements, train maintenance, train security and emergency response.

The GSR train crew emergency response training encompasses advanced resuscitation (including defibrillation and administering oxygen), fire safety/fighting, evacuation and assisting with train protection. In addition to this 'class-room' training, there is also scenario based practical emergency response training that is held on a periodic basis. Emergency response/first aid equipment such as fire extinguishers, axes, crowbars, sledgehammers, ladders, resuscitation kits (2), first aid kits, medical oxygen equipment and defibrillator are carried on board the train. In addition, there are two first response emergency medical kits, one containing medications that can be administered by the GSR train manager and one containing medications that can only be administered under the direction of a doctor.

All of the GSR on-train staff at the time of the accident held the appropriate and current certification for all aspects of their duties.

16 Driver trainer – Is a higher classification than that of a driver. Conducts en route and classroom assessments of drivers, various training courses and projects as required.

17 *National Transport Commission* (NTC) *National Standard for Health Assessment of Rail Safety Workers.*

Communication

At the time of the accident, *The Ghan* had a number of systems to meet external and internal communication requirements.

For external communications the AN class locomotive had a permanently mounted satellite telephone and a portable Iridium satellite telephone. The permanently mounted telephone used power from the locomotive electrical system and the Iridium telephone had a battery and charger. Within the passenger carriages of the train, a satellite telephone was permanently mounted in the train manager's office (in this instance in carriage ARM-947E) that used power from the train's electrical system. This telephone also had a back-up battery and was connected to an external aerial that was mounted on the roof of the carriage.

For internal communications between the train drivers and the GSR train staff[18] there was a VHF radio in the locomotive cab. In addition, all conversations between the GSR train staff could be monitored by the train drivers. If matters were being discussed that were of no relevance to the train drivers, such as passenger issues etc, the on-train staff could switch to a discrete radio frequency. In practice though, the common VHF channel was used nearly all the time.

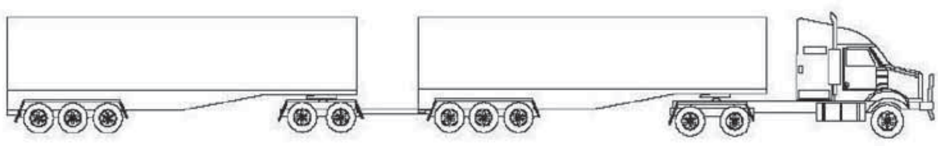
Communication between the working and resting train driving crews was also via the portable VHF radios.

1.1.3 Truck, company and driver information

Road-train truck

The road-train involved in the collision at Fountain Head Road level crossing consisted of a 1994 Mack prime-mover towing two empty side tip trailers. This combination was approximately 36 m long from the 'bull-bar' to the rear of the second trailer and had a combined weight of approximately 26 tonnes.

Figure 2: Double road-train



After the collision two roadworthiness examinations were conducted by the NT DPI Motor Vehicle Registry inspectors; a preliminary inspection at the accident site on the day of the collision and a detailed inspection at Katherine on 21 December 2006. Excluding accident damage, the following deficiencies were found:

- The prime-mover was in an un-roadworthy condition due to the driver's seatbelt being covered by the seat cover and a faulty seatbelt anchor.
- The first trailer was in an un-roadworthy condition due to wear on two tyres. In addition, this trailer was unregistered.

18 The train manager, night manager, Gold Kangaroo and Red Kangaroo managers and the on-train technician each had a portable VHF radio.

- The converter dolly between the first and second trailers was in an un-roadworthy condition due to wear on one tyre and the left front brake actuator hose having been disconnected and kinked over with a cable tie.

The exhaust system, suspension, and electrical systems of the road-train combination were in good condition and were as manufactured. With the exception of the disconnected actuator hose on the converter dolly, the brakes appeared in good condition.

Company overview

Downes Graderways Pty Ltd was the owner and operator of the road-train. The company was located at Katherine (NT) and had been involved in road construction and maintenance for many years.

Since October 2002, the NT DPI had issued infringement notices for non-compliance to Downes Graderways on nine occasions for a total of 24 offences. The notices were in relation to vehicles being operated overweight or in exceedence of vehicle height/width limitations and, one occasion, an unregistered and uninsured heavy vehicle and trailers on a public road.

Road-train driver

The driver of the road-train was a 57 year old male from Tennant Creek (NT). He had been employed by Downes Graderways on a casual basis of varying tenure for about five years. He was paid an hourly rate (in lieu of distance scales). The driver held a current NT MC class licence[19] and had extensive experience on various road maintenance, construction machinery and road-train combination trucks over a period of about 40 years. The road-train driver had one prior conviction in relation to an unregistered motor vehicle over 20 years previously.

The road-train driver had never been medically examined when applying for or renewing[20] his MC class licence. A medical examination is not required when applying for or renewing an MC class licence.

1.1.4 Environmental conditions

Evidence obtained from a number of people at the accident site indicated, at about 1400 on 12 December 2006, the weather was fine with a little cumulous cloud and very hot with little or no breeze. The closest Bureau of Meteorology weather station is at Pine Creek, about 50 kilometres from the accident site. At 1500 the Pine Creek station recorded a temperature of 32.2°C, a relative humidity of 53 per cent and an hourly average wind speed of 4 km/h.

19 MC class licence – A Multi-Combination licence. The holder may drive any motor vehicle or combination of vehicles other than a motor bike or a motor trike.

20 The road-train driver undertook a vision test when he renewed his MC class license in 2005.

1.2 The occurrence

1.2.1 Train journey

The Ghan arrived at Alice Springs from Adelaide on time at 1155 on 11 December 2006 with locomotive NR 70 leading AN 5. A fresh crew of four train drivers then boarded for the remainder of the journey to Darwin[21]. As the departure time of 1610 neared, the air conditioning unit for the driver's cab on NR 70 failed. As a consequence, it was decided to reverse the locomotives so that AN 5 was leading NR70. The time taken for the locomotive shunting meant that the train departed from Alice Springs 65 minutes late at 1715.

At 2200 *The Ghan* arrived at Tennant Creek. At this time the two 'working out' drivers were relieved by the drivers from the crew van and the southbound Ghan was crossed. While at Tennant Creek, NR 70 was exchanged for NR 109 from the southbound Ghan. This was so that NR 70 could be worked back to Adelaide for repairs to the air conditioning unit and the northbound Ghan, when the train arrived at Darwin, would have a locomotive with a serviceable air conditioning unit available for its return journey south. Departure of the northbound Ghan from Tennant Creek with AN 5 leading NR 109 was 50 minutes late at 0155 on Thursday 12 December 2006.

At 0645 that morning the driving crews again rotated so that the original 'working out' crew from Alice Springs were again driving. The Adelaide based driver trainer drove to Katherine where the train arrived 65 minutes late at 0905. The driver that was operating *The Ghan* at the time of the collision then took over the driving duties. Departure from Katherine was on time at 1209.

At 1252 train order number N205 was issued by train control in Adelaide[22]. This authorised the passage of *The Ghan* from block point 2553.000 km to block point 2606.000 km. The Fountain Head Road level crossing is located in this section of track at 2599.552 km. *The Ghan* passed block point 2553.000 km at 1325.

1.2.2 The truck task

Downes Graderways had been employed by GBS Gold Pty Ltd[23] on a short term basis to build a private 'loop road' in order to provide improved access from the Stuart Highway to the GBS Gold Brocks Creek Mine.[24]

On 12 December 2006 the owner of Downes Graderways and four of his employees were working on the road. All were domiciled in a company camp that was located 12 kilometres north of Pine Creek, about 60 kilometres from the work site. They had risen at about 0600 that morning and after breakfast, had driven to the work site in two vehicles. Arrival at the work site was between 0700 and 0730.

The road building task involved three trucks each with two tipper trailers conveying loads of road base (quarry rubble) from the Fountain Head Mine to various points

21 *The Ghan* is worked by a two driver crew from Tarcoola to Alice Springs.

22 Train control is provided from the Genesee and Wyoming Australia (GWA) facilities at Dry Creek South Australia.

23 GBS Gold Pty Ltd is a Canadian based mining company with gold mining interests in Canada, Western Australia and the Australian Northern Territory.

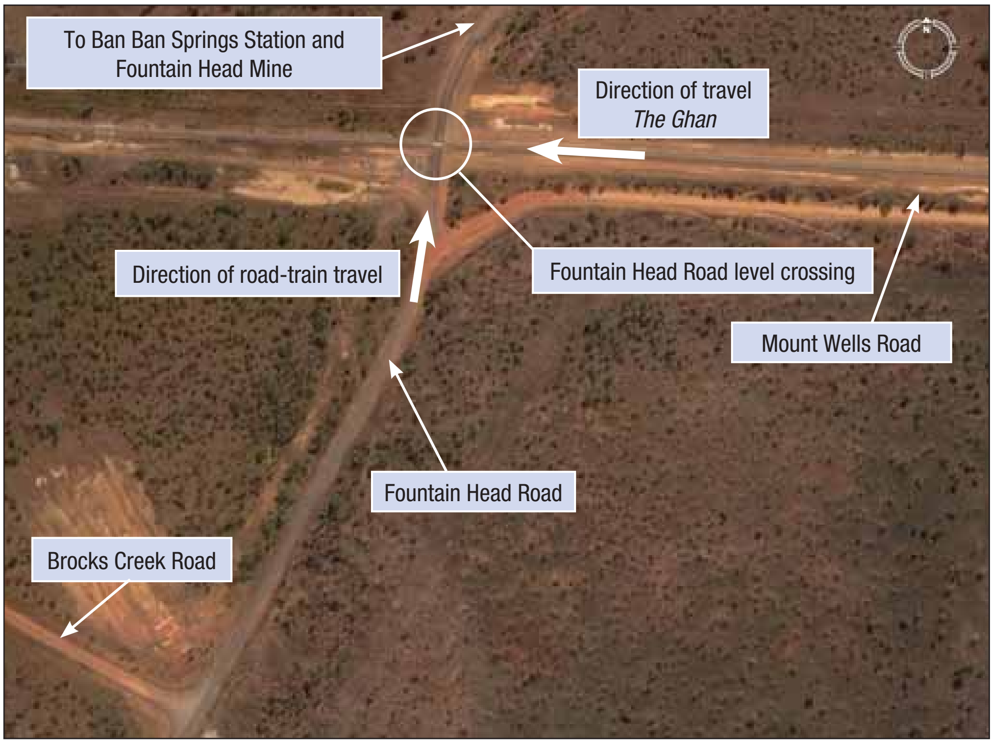
24 GBS Gold Brocks Creek Mine is presently an underground operation from which ore is extracted and transported a distance of about 65 kilometres to the Union Reefs Processing Plant. The mine had reopened in 2006 after closure period of about six years.

on the new 'loop road'. The distance between the Fountain Head Mine and the unloading point on 12 December was about 12 kilometres and, with the exception of about 250 m of Fountain Head Road in the vicinity of the level crossing at Ban Ban Springs, was private road. The company owner drove a grader at the unloading point and generally supervised the road construction operation. In addition, a loader driver was stationed at the Fountain Head Mine to load the trucks with the road base.

The trucks ran at 15 to 20 minute headways with loading and unloading at each end taking about ten minutes. Each truck made about 15 return trips per shift and each trip traversed the Fountain Head Road level crossing. This equated to about 30 movements over the level crossing per day per driver/truck and 90 movements over the level crossing per day for all three trucks. This traffic pattern had been fairly consistent, seven days a week, for about a month before 12 December 2006.

On the day of the collision the company owner and four employees had a lunch break from about noon to 1300 at the Fountain Head Mine loading point.

Figure 3: Satellite image, truck route



Google Earth – 2007 MapData Sciences Pty Ltd Copyright ©

1.2.3 Witness accounts

Train drivers

Just before 1400, *The Ghan* was approaching the Fountain Head Road level crossing. The driver was seated in the driver's seat on the left-hand side of the locomotive and the Adelaide based driver trainer was seated in the co-driver's seat on the other side of the locomotive.

The driver said he sounded the horn at the whistle board which is about 500 m from the Fountain Head Road level crossing and called 'Ban Ban crossing' to the co-driver. This call was acknowledged by the co-driver. The driver said that his normal practice is to then sound the horn again as he gets closer to a level crossing and, although he could not recall with absolute certainty, he believed that he had done so on this occasion.

The driver said that when they were about 100 to 150 m from the level crossing he saw a truck approaching from his left. He estimated that at first sighting the truck was about 100 m from the crossing and was travelling at about 50 km/h. Although he could not see all of the truck because it was behind a mound of dirt and foliage, he could see about halfway down the cab of the prime-mover, the top of the first trailer and part of the second trailer. Therefore, he knew it was a road-train rather than a semi-trailer.

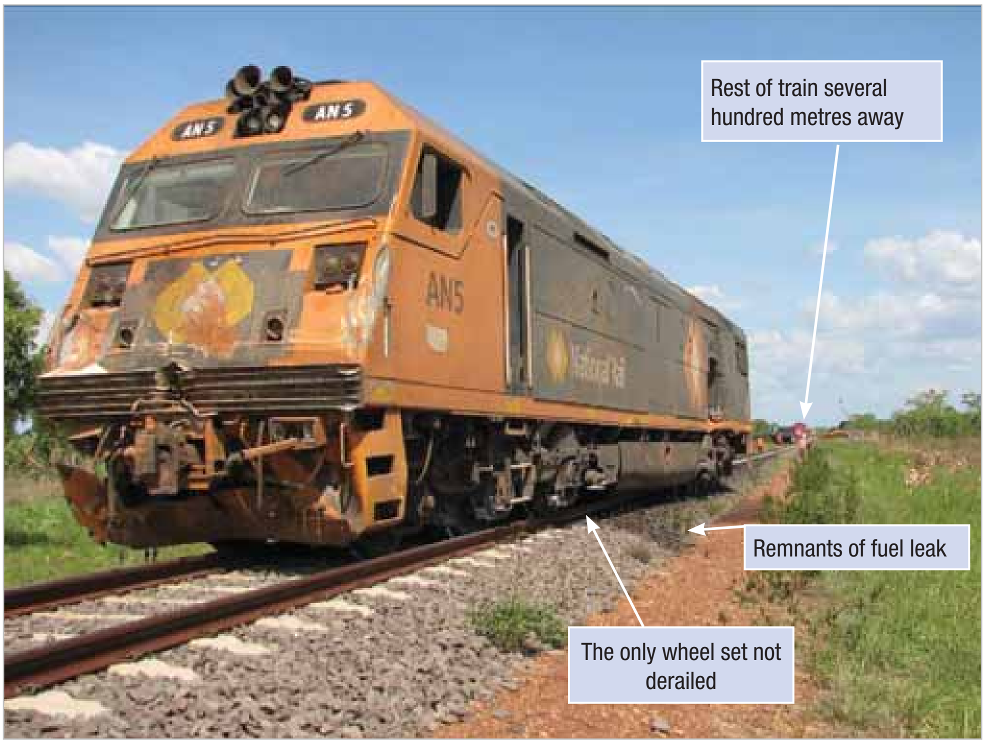
He immediately realised that a collision was imminent and made an emergency application of the train brake with his left hand and blew the horn again with his right hand. He yelled to the co-driver to 'hit the floor…hit the floor' as he was in the process of leaving the driver's seat. He did not think he had made it to the cab floor when the train collided with the truck.

Figure 4: Driver controls, AN 5

Just before the collision, the co-driver was using a pocket calculator to calculate the location (kilometre mark), based on average speed, where the two driving crews would rotate for the final time before the train arrived at the Berrimah terminal at Darwin. As such, he was observing the road ahead intermittently during this time[25]. The co-driver said that when the driver yelled the warning to him, he immediately stood up and saw a 'white/orange blur' go across in front of the locomotive windscreen. The collision occurred almost simultaneously. The co-driver then also threw himself to the cab floor. Both drivers then described the noise and lurching of the locomotive as 'frightening' as it continued on in a derailed state.

25 This is a routine function. It is necessary for train control to be aware of where and when the resting and working train crews rotate.

Figure 5: Lead locomotive separated from rest of train



The drivers said that immediately after coming to a stop they called the Pacific National Divisional Control Centre (PN DCC)[26] and the GWA train controller. They said these calls were made almost simultaneously; the driver calling the DCC on the locomotive satellite telephone and the co-driver the GWA train controller on the Iridium mobile satellite telephone. Both centres were told that *The Ghan* had hit a truck and that it was an emergency situation. They were told that, apart from superficial injuries, the train drivers were alright but the extent of any damage to the train and any injuries to the people on board was unknown.

During this time, a helicopter landed not far from the second locomotive, an occupant of which spoke to one of the resting drivers from the crew van. After a short while it took off again, which the drivers presumed was to seek assistance. A short while later a driver from the crew van yelled a warning, from outside the cab to the driver, that AN5 was leaking fuel and that the locomotive would have to be shut down and the electrical power isolated immediately. A few seconds after this the driver terminated the call to the DCC and shut the locomotive down. This action rendered the locomotive satellite telephone inoperable; the call between the co-driver and the GWA train controller had been terminated before this action was taken.

Road-train driver

Just before 1400, the road-train truck involved in the collision was returning (empty) to the Fountain Head Mine to collect another load of road base. The driver said that as the weather was hot he had the truck cab windows fully wound up and the air conditioner on. He said the only radio on inside the cab was the UHF radio that is used for operational communications.

26 The DCC monitors and co-ordinates the passage of Pacific National trains with the various train control centres. The DCC is in essence a coordination centre, not a train control centre.

The road-train driver said that the front gate (door) on the first trailer had come loose after the previous unloading so he stopped the vehicle about 200 to 300 m from the level crossing, got out, and with the assistance of a shovel to take the weight off the hinge, closed the gate. He then got back into the cab and continued towards the level crossing.

He said that he had just changed up to the 'high box' (on the truck's gearbox) as he came to the level crossing. He estimated the truck's speed to be about 20 to 30 km/h. When the cab of the truck was almost on the rail line, he heard the sound of a train horn. He looked around to his right and, out of the side window, saw a train coming at him. He immediately applied power in order to try to move the prime-mover's cab over the rail lines and clear of the approaching train.

The next thing he remembered was that the prime-mover was being thrown about and, shortly after, came to a rest on a lean not far from the road. He immediately got out and waved to a helicopter that was in the vicinity. The helicopter came straight down and landed on the road a short distance away from the prime-mover. An occupant alighted, walked to where he was standing and asked how he was.

Figure 6: Prime-mover of road-train

The road-train driver said that he normally did not stop at the 'Stop' sign at the level crossing. Rather, he said his practice in the past had been to slow the truck, look for a train and then drive over the level crossing at about 15 to 20 km/h. He had also applied this routine at other level crossings that he used in the vicinity. He said other road-train/truck drivers he knew used the same practice at level crossings.

Train staff and passengers

One of the relief drivers (who had just been called for duty) was in the crew van seated, facing in the direction of travel, near a window. He felt a jolt and looked out the window and then felt another bigger jolt. He then caught a glimpse of a truck either at impact or moments after impact. He did not see the truck approaching the level crossing.

No other crew member or passenger said they saw or heard anything before impact. However, the majority spoke of several jolts that were generally of an increasing magnitude. They also spoke of being thrown about and unsecured items coming loose as the carriages either derailed or came to a stop.

Ban Ban Springs station manager

At the time of the collision the station manager from the nearby Ban Ban Springs cattle station and his son (the pilot) were mustering cattle in a paddock adjacent to the rail line in a Robinson R22 helicopter. This task involved low flying with frequent turning manoeuvres. The station manager, who was in the left-hand seat of the helicopter, recalled seeing an empty truck coming down the Brocks Creek road about 1.5 kilometres from the level crossing. Shortly after, a big cloud of dust was seen rising from the vicinity of the Fountain Head Road level crossing. He then realised that there had been a collision and communicated this to his son, who then landed the helicopter on the road at the entrance gate of the Ban Ban Springs station, about 100 m from the level crossing.

The pilot stayed with the helicopter while the station manager went to speak with the road-train driver. A short time later they took off again and landed close to the second locomotive. During this time they noticed people with fire extinguishers jump out of the train to put out a fire which had started beside the track. Other people were coming to the carriage doors but nobody seemed to be panicking. After quickly assessing the situation and what response they thought would be needed, they flew to the GBS Gold Brocks Creek mine site several kilometres away.

While the helicopter was at the accident scene the pilot called his mother at the Ban Ban Springs station using a satellite telephone to alert her to the accident. She then called the Adelaide River NT Police at about 1400.

Neither the station manager nor the pilot saw the train approaching the level crossing.

Figure 7: Image taken by the helicopter pilot moments after landing the second time

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1.2.4 The collision

The impact of the collision caused the prime-mover and two trailers of the road-train to separate and come to rest either side of the rail line immediately to the west of the Fountain Head Road level crossing.

Figure 8: Separation of prime-mover and trailers

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After the initial impacts, *The Ghan* continued past the collision point, progressively derailing as the train decelerated. During this time, the lead locomotive broke away from the second locomotive and the motorail wagon (that was coupled to the second locomotive) broke away from the passenger carriages. By the time *The Ghan* had stopped, both locomotives, the motorail wagon and nine passenger carriages had derailed and the lead locomotive was several hundred metres ahead of the second locomotive, motorail wagon and the rest of the train.

Figure 9: Aerial photograph, lead locomotive out of sight

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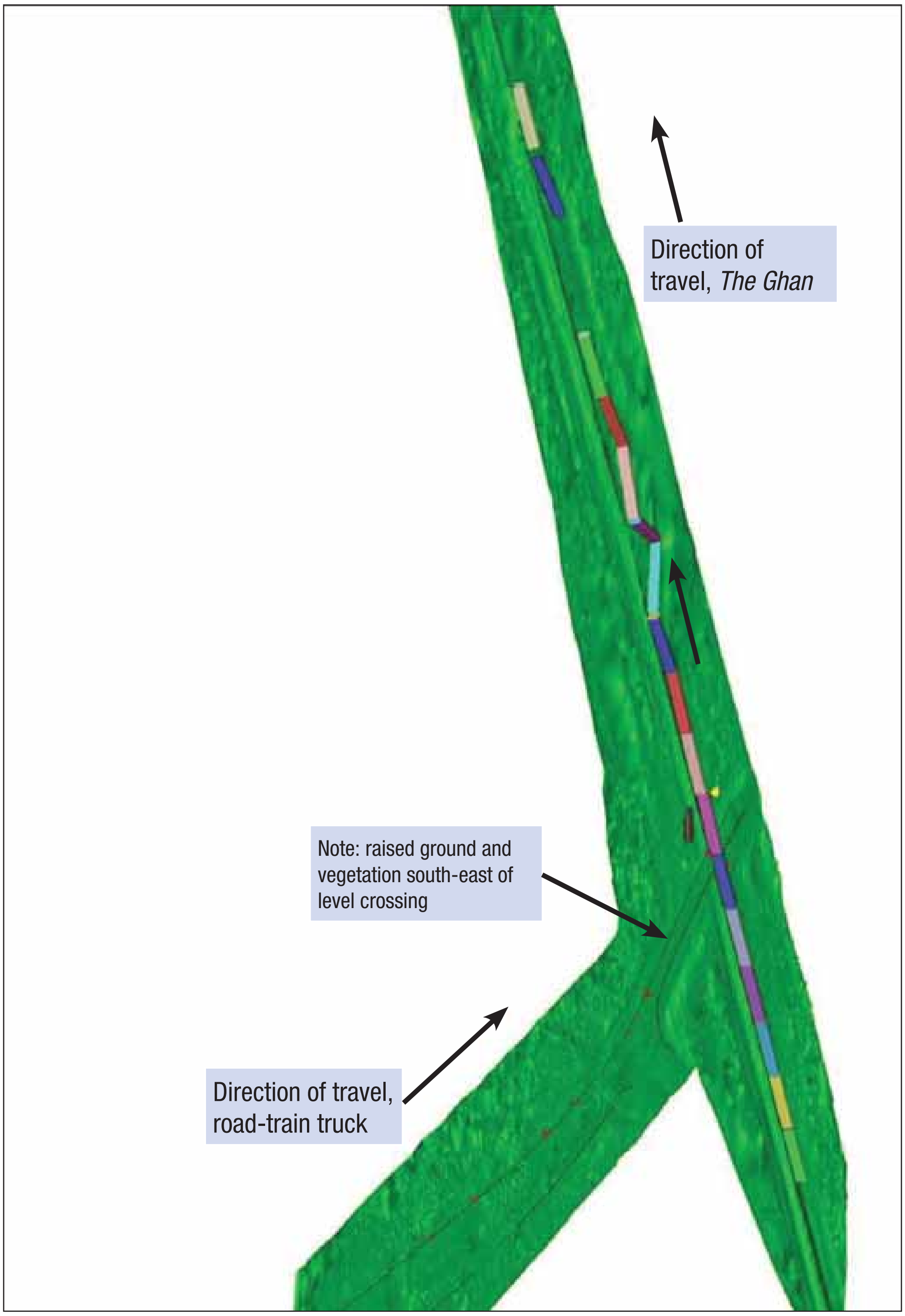
Figure 10: ‘3D’ reproduction of accident site



1.3 Post occurrence

1.3.1 Emergency response

GSR on-train staff

The accident occurred near the end of the single Gold Kangaroo[27] 1300 lunch sitting. There were 40 passengers in the Gold Kangaroo dining carriage and 22 passengers in the vicinity of the Red Kangaroo dining and sitting/bar areas. Two passengers, who had just finished their lunch, were in the carriage in front of the Gold Kangaroo dining carriage (ARL 920Y) returning to their accommodation. The bulk of the GSR staff were also in the vicinity of the Red and Gold Kangaroo dining/lounge carriages. The Gold Kangaroo dining carriage was the eighth carriage from the two locomotives and the Red Kangaroo café and Red Kangaroo lounge carriages were the 12th and 13th carriages from the locomotives.

The Gold Kangaroo dining and lounge carriages came to a stop with all wheels derailed at a slight angle (horizontally) to the track bed and a slight lean (vertically) to the right. The Red Kangaroo café and lounge carriages did not derail and came to a stop about 2.5 carriage lengths before the level crossing.

Within the first minutes after the train had stopped, some of the GSR on-train staff were conducting a preliminary check on the passengers and other GSR crew members. Others were checking the condition of the road-train driver and extinguishing the fire that had started beside the train. The train technician, who had been in the power car rectifying a fault, shut the diesel generators down due to the angle of the power van and leaking fuel. Whether this action or the forces of the collision/derailment had cut the power supply (including air conditioning) to the train consist was not able to be established.

Once initial details were known, the train manager contacted GSR management in Adelaide with advice of the accident.

External agencies

Shortly after 1400 the Adelaide River NT Police were advised of the accident by the wife of the Ban Ban Springs station manager. Minimal details were available at this time. This information was then passed on to NT Police headquarters in Darwin.

At about 1414[28] the Ban Ban Springs station manager and his son landed at the GBS Gold Brocks Creek mine site car park and notified the people at the office of the accident. It was quickly agreed to dispatch appropriate personnel and resources to the site. Also, the NT Police at Adelaide River were (again) advised of the accident by the GBS staff.

Within minutes of being told of the accident, GBS Gold management staff at the mine had despatched three medically qualified employees to the accident site. Upon their arrival, the magnitude of the situation was radioed back to management at the Brocks Creek mine and further assistance and supplies requested.

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27 If there are over 48 Gold Kangaroo passengers two meal sittings are required.

28 1414 – The time recorded by GBS Gold.

Regional[29] police, health clinic, fire and emergency services (FERG) personnel as well as resources from Darwin and Katherine (St John's ambulance, additional police etc) were all progressively deployed to the accident site. In addition, the Darwin Emergency Command Centre was activated and Katherine and Darwin hospitals were placed on standby. All attending emergency services were recorded as being at the accident site by 1623.

1.3.2 Injuries

The road-train driver sustained some cuts, abrasions and general bruising. The locomotive co-driver sustained superficial injuries to his knee and head and one relief driver in the crew van had a foot injury. In the passenger carriages, the injuries were initially confined to cuts, bumps and bruising.

However, about 15 minutes after the collision a female passenger, who was said to have struck her head on a dividing partition in the Gold Kangaroo dining car during the collision/derailment sequence, collapsed and lapsed into unconsciousness. Initially, she showed no response to stimuli, even pain. Breathing difficulties also became apparent. She was attended to by two doctors (both passengers) and GBS staff until she was airlifted by medivac helicopter to Royal Darwin Hospital. By the time the helicopter was ready to depart for Darwin her condition had improved to the extent that she would respond to stimuli by opening her eyes.

1.3.3 Evacuation of passengers

With the exception of the injured female passenger and a relative accompanying her, passengers were initially confined to the Gold Kangaroo dining or the Red Kangaroo lounge/dining carriages while emergency response activities took place. During this time discussions took place between all of the parties involved in the emergency response (including authorities off site) with regard to when and where to evacuate the passengers.

Because the temperature inside the carriages was rising, some thought was given to de-training the passengers but keeping them on-site until the arrival of buses from Darwin. With this in mind, plans were made to provide facilities (portable toilets, shade etc) at the accident site. However, GBS Gold made an offer to transport the passengers to their employee/contractor accommodation base (Cosmo Camp), about 17 kilometres from the accident site. This camp was air conditioned and fully stocked with food and water.

The evacuation of *The Ghan* was then carried out by the GSR on-train staff with assistance from GBS Gold personnel. All passengers, except for the injured female, a relative and those rendering assistance, were then evacuated to the southern side of the train via a single door of the carriage immediately behind the Gold Kangaroo dining carriage (ARM-947E). This carriage, although all wheels were derailed, was still reasonably level and the steps were in close proximity to the ground[30].

Between 1515 and 1610, the passengers and ten of the 13 GSR on-train staff were transferred to the Cosmo Camp in GBS Gold vehicles. Here they were given food and water and checked for injuries by ambulance paramedics. At about 2000 the passengers departed from the Cosmo Camp in buses for Darwin. Arrival in Darwin was between 2230 and 2300.

29 Daly River, Batchelor Adelaide River and Pine Creek. These distances range from 60 to 110 kilometres

30 There were no mobility impaired passengers on *The Ghan.*

The road-train driver left the accident site in an ambulance at 1702 and arrived at the Royal Darwin Hospital at 1858. The injured female passenger was lifted out of the train on a stretcher through a window in the Gold Kangaroo lounge carriage (removed earlier for ventilation purposes) and carried to the medivac helicopter. The medivac helicopter departed from the accident site at 1825 and arrived at the Darwin hospital at 1908. One of the passengers assessed at the Cosmo Camp was found to have a suspected broken wrist and another suspected spinal injuries. Both were transported to the Royal Darwin Hospital for further checks in an ambulance which followed the bus from the Cosmo Camp.

1.3.4 Damage

The Ghan

The damage to the lead locomotive (AN 5) as a result of the initial impact was relatively minor and confined to the width of the locomotive front from the bottom edge of skirt and cowcatcher to the bottom edge of the windscreen. The damage resulting from a secondary impact of the road-train trailers, about two-thirds along the left-hand side of the locomotive, was more severe (see 2.1.1). The force was such that the diesel engine was torn from its mounts and, for a moment, became airborne (within the body of the locomotive), thereby causing further damage to surrounding locomotive components. The fuel tank was also damaged. Locomotive AN 5 was assessed as being repairable but extensive work was necessary, including the removal and replacement of the damaged midsection of the locomotive. The cost of the repair was anticipated to be in the order of $1.5 million. The locomotive was returned to service in December 2007.

Locomotive NR 109 sustained damage to the underframe (including air reservoirs and sludge tank), deformation of the side sill, walkway, engine and radiator cab frames and bogie components such as wheels and traction motors. The cost of the repair was approximately $227,000. The locomotive was returned to service in mid March 2007.

The motorail wagon, the power van and eight passenger carriages sustained considerable damage during the derailment sequence. The extent of damage varied but, in general terms, mainly involved the diaphragm and headstocks, underframe and associated piping and auxiliary equipment, bogies, sheeting and, on some carriages, longitudinal side wall members. The motorail wagon and passenger carriage ARL 920Y were assessed as uneconomical to repair. The trailing six carriages that did not derail were not damaged.

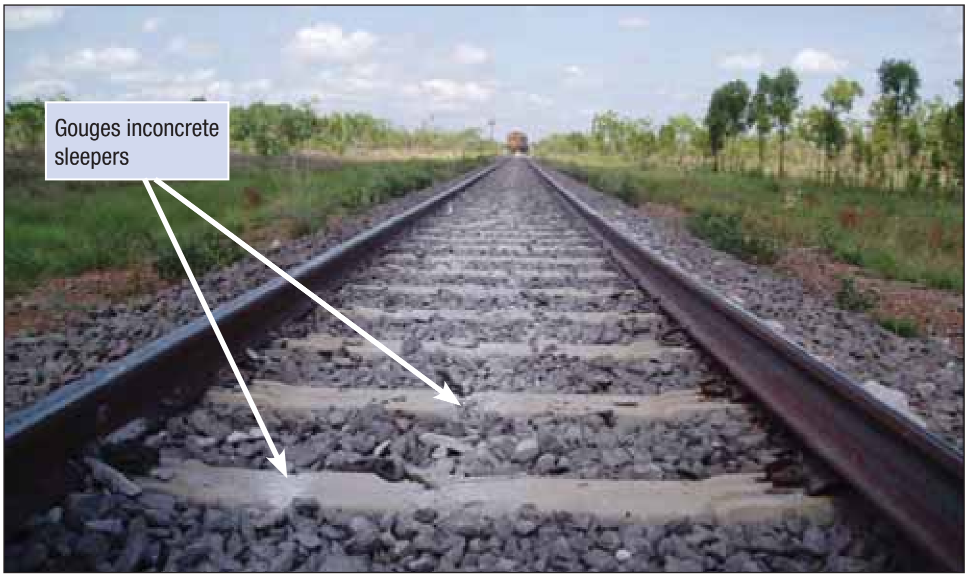
Rail infrastructure

The rail infrastructure from the level crossing to where the second locomotive (NR 109) had stopped, a distance of about 280 m, was extensively damaged. Of note is that there was a twist of almost 90° in the right-hand rail between the level crossing (which is supported by the road structure) and a fracture at a weld a short distance past the level crossing. It is likely that the forces exerted by the 'whipping motion' of the road-train's trailers and their impact with the side of the locomotives in combination with the derailed bogies resulted in the rail twist and subsequent fracture of the weld (see 2.1.1).

Figure 11: Damage to rail infrastructure in the vicinity of derailed carriages

Damage to the rail infrastructure between the second locomotive and the lead locomotive, a distance of 160 m, was mainly confined to gouges on the cement sleepers, rail damage and some ballast displacement.

Figure 12: Damage between second and lead locomotives, taken from immediately in front of NR 109



In all, 392 concrete sleepers and 300 m of rail between the level crossing and the vicinity of the second locomotive required replacement before the track could be re-opened. A further 317 concrete sleepers and 165 m of rail beyond this point were replaced in due course. The estimated cost of the repairs to the rail infrastructure was $536,000.

The road-train

The prime-mover, converter dolly and two trailers suffered substantial structural damage, including significant distortion of the truck and trailer chassis. The prime-mover and the body of the second trailer had become detached from their respective chassis. The road-train combination was damaged beyond repair.

Figure 13: Damaged prime-mover (right) and trailers (left)

1.3.5 Site recovery

Undamaged rollingstock was hauled from the site by rail while heavy lift cranes relocated the remaining rollingstock clear of the track. The track was reopened for rail traffic (under a speed restriction) by about 0400 on Saturday 16 December 2006.

2 ANALYSIS

ATSB investigators were mobilised from Canberra, Brisbane and Adelaide and arrived on site at approximately 0125 on Wednesday 13 December 2006. By 1640 on Wednesday 13 December 2006, examination of the accident site was largely completed, allowing rail organisations to begin recovery works.

Investigators examined and photographed the accident site, the road approach to the accident site and the train and road-train truck in situ. Also, a site survey was compiled with all wreckage in situ.

Evidence was sourced from various witnesses, rail companies accredited in the NT, local mining interests, the owner of the road-train truck, the Royal Darwin Hospital and NT Governmental agencies, including emergency response personnel. Evidence included train control voice logs, locomotive data logs, train driver and road driver employment histories and relevant standards and sight distance models pertaining to level crossings.

2.1 Sequence of events analysis

2.1.1 The collision analysis

The Ghan's data logger examination

Both locomotives (AN 5 and NR 109) were fitted with data event loggers. The data from these locomotives was downloaded in the presence of the ATSB in Adelaide on 18 December 2006. It was found that the data logger on AN 5 had not recorded all parameters correctly since 2207:32 on 11 December 2006. This was about seven minutes after the arrival of *The Ghan* at Tennant Creek where the train waited for about two hours before NR 70 was exchanged for NR 109 from the southbound Ghan.

The parameters not recorded correctly on AN 5 were:

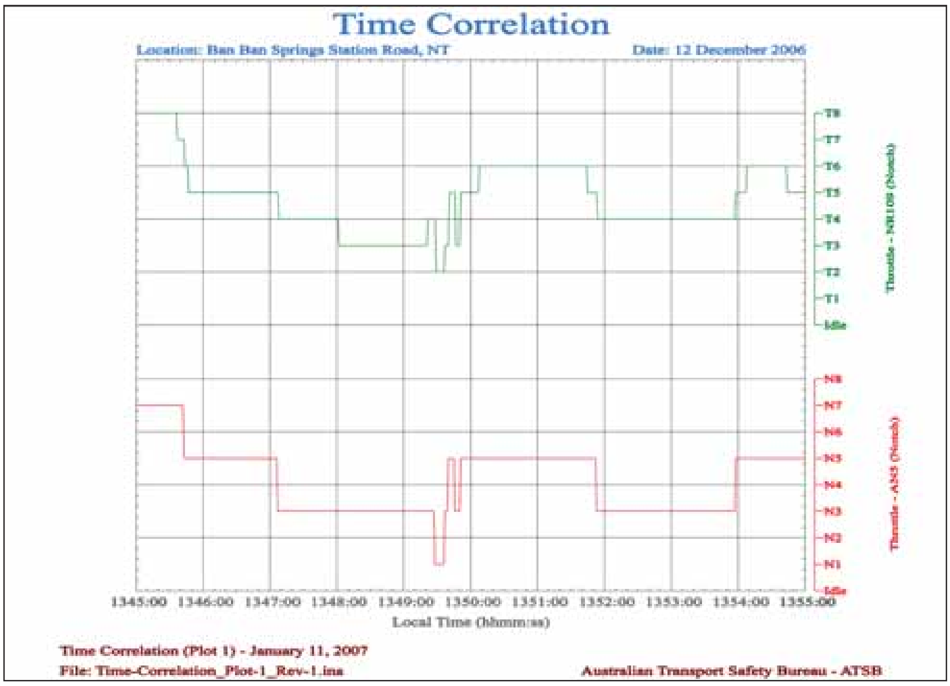
- Throttle – notch two, four, six and eight (full power) were not recorded.
- Brake-pipe pressure – The brake-pipe, when fully charged is normally about 490 kPa. At this pressure the train brakes should be released and only apply as this pressure reduces. However, a pressure of between 273 kPa and 172 kPa was recorded even when the train was moving. This indicates (erroneously) that the train brakes were hard on at all times.
- Brake-cylinder pressure – When the locomotive brakes are released, 0 kPa should be in the brake cylinders. When fully applied about 350 kPa should be in the brake cylinders. A pressure of 13 kPa was recorded in the brake cylinders when no brake applications had been made.
- The headlight was recorded as being off at all times, even when moving at track speed during hours of darkness. This is highly unlikely and was therefore considered to be inaccurate.

All parameters on NR 109 were correctly recorded. However, the data logger on the second locomotive does not record whether the headlight on the lead locomotive is on or off.

The time recorded by the two locomotives was not synchronised. The throttle settings on the two data loggers, which are recorded at a maximum rate of once per second, were used to synchronise the time. Due to time differences (propagation delays, sampling time etc) the same parameter change may be recorded slightly before or after a given time when compared with the recorder in the other locomotive. Thus the time correction for each data logger was set to best match several changes in this recorded data.

The time recorded by NR 109 was used as the standard time. This meant that 54 minutes and 32 seconds had to be subtracted from the time recorded by AN 5. Figure 14 shows the throttle settings from the two locomotives after the time had been correlated.

Figure 14: Time correlation immediately before collision



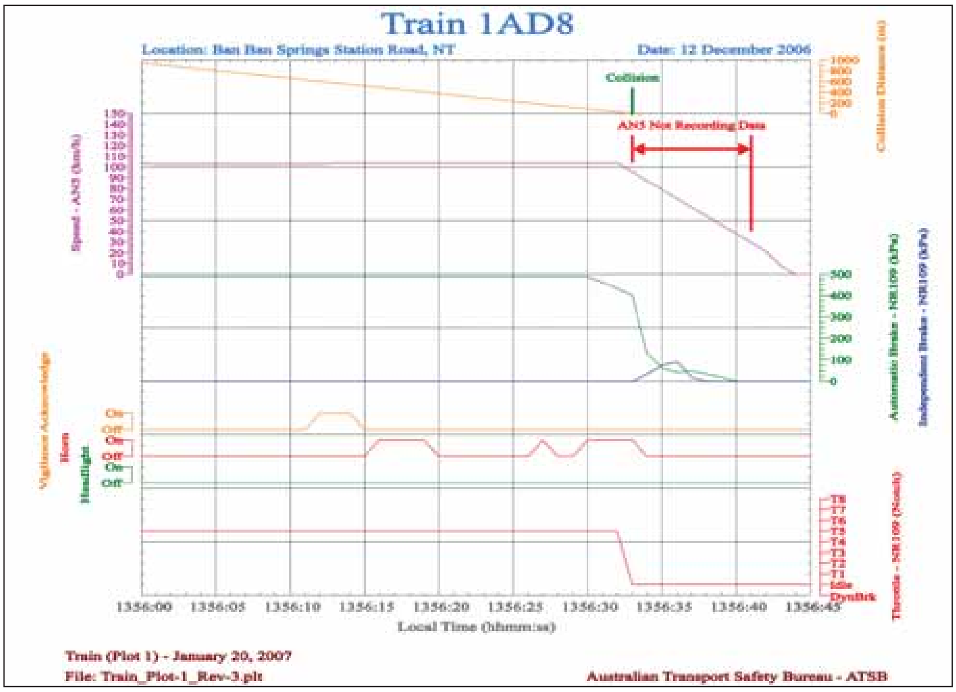
The speed recorded by the two data loggers between 1345:00 and 1356:00 differed by +3.3 to -1.9 km/h. The speed recorded by the data logger on AN 5 was used for the analysis.

Key events recorded were:

- At 1356:00 the leading end of AN 5 was 946 m from the collision point, the speed was 104 km/h, the throttle was in notch five and the brakes were released.
- At 1356:16 the leading end of AN 5 was 488 m from the collision point, the speed was 104 km/h, the throttle was in notch five, the brakes were released and the horn was sounded for four seconds (488 m to 373 m from the collision point).
- At 1356:27 the leading end of AN 5 was 172 m from the collision point, the speed was 104 km/h, the throttle was in notch five, the brakes were released and the horn was sounded for one second.

- At 1356:30 the leading end of AN 5 was 85 m from the collision point, the speed was 104 km/h, the throttle was in notch five, the brakes were released and the horn was sounded[31].
- At 1356:32 the leading end of AN 5 was 28 m from the collision point, the speed was 104 km/h, the throttle was in notch five, the brake-pipe pressure was 434 kPa and decreasing, and the horn was still sounding.
- At 1356:33 the collision occurred. The speed was 101 km/h (recorded from NR 109), the throttle was in idle, the brake pressure was 399 kPa and decreasing and the horn was off.
- At 1356:38 AN5 separated from NR 109.
- At 1356:44 AN5 was recorded as being stationary[32].

Figure 15: Data download AN 5 and NR 109



It appears from the data log that the train driver's first reaction to sighting the truck was to sound the horn at 1356:30 when the front of the train was 85 m from the collision point. Allowing for a nominal reaction time of 2.5 seconds, the truck was probably seen when the lead locomotive was about 158 m (or 5.5 seconds) from the collision point. Between 1356:30 and 1356:33, the brake-pipe pressure had fallen by 90 kPa, a rate consistent with an emergency application of the train brake. With the exception of the headlight (recorded as being off), this closely corroborates the accounts given by the train drivers.

The pilot of the helicopter that landed twice at the accident site in the period immediately following the collision took several photographs of the accident site using his mobile telephone. One of these photographs was taken as he took off for

31 The horn was recorded as sounding continuously between 1356:30 and 1356:32.

32 The data logger on AN 5 did not record continuously after the collision. AN 5 would have actually stopped sometime after 1356:44.

the Brocks Creek GBS Gold mine site (Figure 16). The leading locomotive (AN 5) headlight appears to be illuminated. The helicopter can be heard overhead (in the background) of the recordings of the conversations between the train drivers and the train control and coordination centres (see section 2.1.2). These conversations occurred before the drivers were told to shut down the locomotives and isolate the electrical power which would have extinguished the headlight. It is thought that the person seen approaching AN 5 in figure 16 is the off-duty driver from the crew van who told the drivers in the cab of the locomotive to shut it down.

Figure 16: Locomotive AN 5 shortly after the accident, headlight appears to be illuminated

Reproduced by permission of Mr D. Clarris.

Calculated truck speed

The train driver estimated the speed of the truck to be no less than 50 km/h. He also estimated that, at first sighting, it was about 100 m from the level crossing. This distance would have placed the truck behind the mound of dirt and foliage that is on the south-eastern side of the level crossing (see 2.3). However, the eye level of a seated train driver is such that he can see over the mound of dirt and through the foliage, albeit intermittently.

The road-train driver's evidence is that as he approached the level crossing, he had stopped on Fountain Head road approximately 200 to 300 m before the crossing to close an open door on the leading trailer. After a short while, the truck was underway again, with the driver progressing through the low range gears and, by the time the truck was at the level crossing, the driver stated that he had reached the 'high box' gear range. The road-train driver estimated his speed to be about 20 to 30 km/h at the level crossing. When almost on the rail line he heard the train horn, turned his head to the right about 90 degrees, and sighted *The Ghan* at a distance he estimated to be 40 to 50 m from the level crossing.

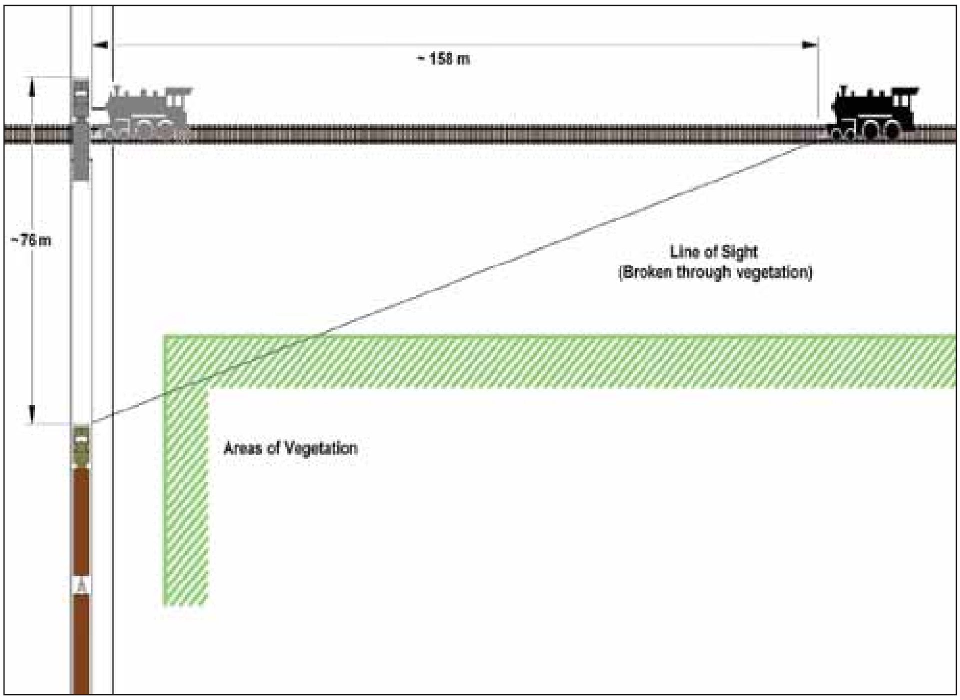
If the truck was 100 m from the level crossing at first sighting as estimated by the train driver, it would have to be travelling at an average speed of about 65 km/h to reach the level crossing in the calculated 5.5 seconds from first sighting by the train driver. This speed is unlikely. Conversely, if the truck was travelling at 20 km/h, the lowest speed estimated by the road-train driver, then the truck would have only been about 25 m from the level crossing when first sighted by the train driver. This too is unlikely, given that this would place the front of the prime-mover, as seen by the train driver, in front of the dirt mound. The train driver recalled, quite distinctly, that he first saw the top portion of the truck over the top of the dirt mound. Therefore, it is likely that the actual speed of the truck was somewhere between the train driver's estimate of (no less than) 50 km/h and the road-train driver's estimate of 20 to 30 km/h.

The truck speedometer was found stuck and indicating about 50 km/h after the collision. While it is possible that the force of the collision could have caused the speedometer to jam at any speed, it is also possible, perhaps probable, that the speed indicated on the speedometer was the truck's speed at impact.

Figure 17: Truck speedometer jammed at about 50 km/h

If the truck was travelling at an average speed of 50 km/h on the approach to the level crossing then, 5.5 seconds before the collision, it would have been about 76 m from the level crossing when the train driver first sighted it. This scenario seems to be the most likely.

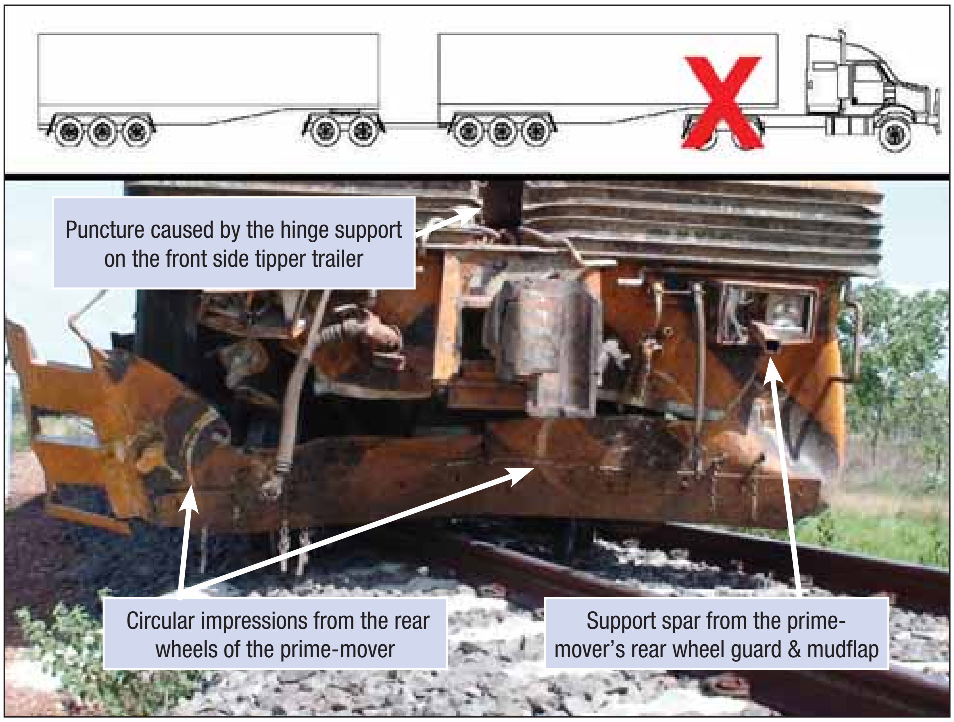
Figure 18: Distances travelled, for both train and truck, between train driver sighting the truck and the collision



Collision sequence

The initial impact was distributed across the front lower half of the lead locomotive (AN 5) and appeared to have been primarily absorbed by the bottom edge of the skirt and/or cowcatcher up to the bottom edge of the windscreens. Markings on the cowcatcher indicated that the point of impact was between the two axles of the prime-mover (the pivot point between the prime-mover and first trailer). In addition, a hole had been punched in the front of the locomotive immediately above the cowcatcher; this was consistent with an impact with the truck's first side-tip trailer hinge support that was located immediately above the pivot point of the trailer. Also, a steel bar was found imbedded in the locomotive's left-hand ditch light. This steel bar was the wheel guard and mudflap support spar that was later found to be missing from the rear of the road-train's prime-mover.

Figure 19: Point of impact



At impact, the prime-mover and trailers began to bend in an angular 'V' shape above the prime-mover's rear axles. The force caused the prime-mover and trailers to separate in a violent manner. The prime-mover then spun away from the train and came to a rest 18 m from the crossing on its northern side. Simultaneously, the two trailers moved in a 'whipping motion' towards the left-hand side of the train, striking the two locomotives in the process. They then rebounded and came to a rest on top of each other about 16 m from the crossing on the southern side of the track.

The first trailer struck the side of the lead locomotive (AN 5) while the second trailer struck the side of the second locomotive (NR 109). The impact was sufficient to punch large holes in the sides of both locomotives.

The force of the initial impact (both longitudinal and lateral) was sufficient to cause the two leading wheel-sets of the lead bogie on the lead locomotive (AN5) to derail to the right-hand side of the track. The third wheel-set of the lead bogie did not derail. The second (trailing) bogie then derailed all wheels to the left-hand side of the track. The derailment of the trailing bogie may have occurred as a result of the initial impact (that rotated the locomotive sufficiently) or due to forces resulting from the lead trailer striking the side of the locomotive, or a combination of both.

Figure 20: Left-hand side of locomotives AN 5 (left) and NR 109 (right)

The lead locomotive then continued in a derailed state for 440 m with the leading two wheels of the front bogie derailed to the right-hand side of the rails and the second bogie derailed all wheels to the left-hand side of the rails. Importantly, the third (trailing) wheel-set on the lead bogie that did not derail was instrumental in keeping the locomotive on a relatively straight trajectory.

During the collision sequence it appears that the lead bogie of the second locomotive (NR 109) fell between the rails with its right-hand wheels running along the web of the rolled right-hand rail. The second locomotive then continued travelling in this state with the second bogie acting like a zipper that spread and unclipped the rail from its fastenings as it went. The wheels on the rear bogie of NR 109 and bogies of the following wagons fell completely between the two rails and travelled along the four-foot making hard contact with the concrete sleepers.

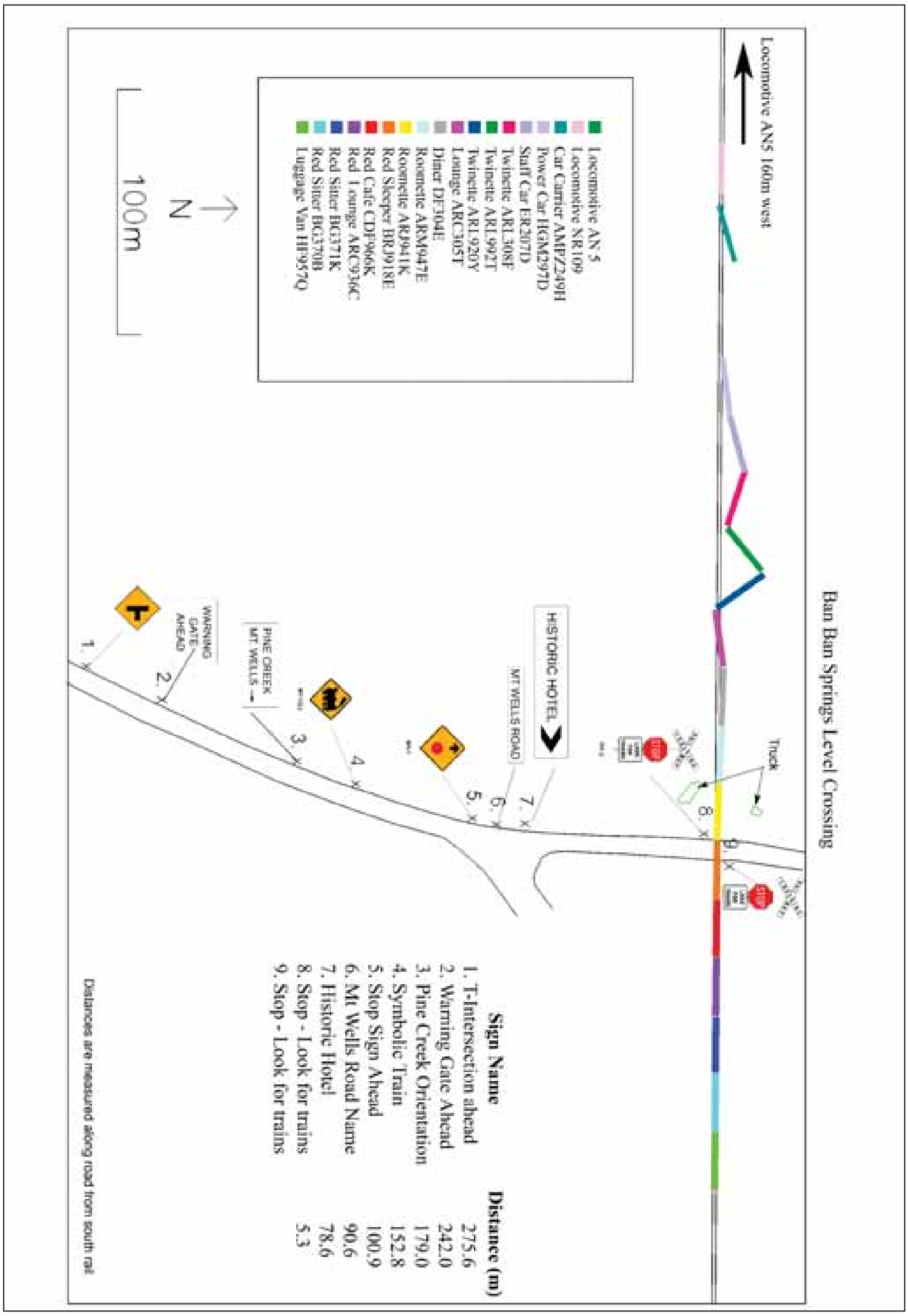
Figure 21: Leading end of locomotive NR 109

The repeated impact of the wheels resulted in the failure of the majority of the concrete sleepers. This meant that the rail gauge could not be maintained and so the controlled passage of the following rail vehicles was lost. The second locomotive broke away from the lead locomotive and, in a derailed state, slowed dramatically. Momentum and the lack of lateral constraint caused the following wagons to bunch and jack-knife (predominantly) to the northern (right-hand) side of the track.

Figure 22: *The Ghan* carriages jack-knifed, northern side of the track

By the time the train had stopped, the two locomotives, the motorail wagon and nine passenger carriages had derailed, the fuel tanks on both locomotives had been ruptured and a minor grass fire had ignited adjacent to the track. The lead locomotive was 160 m from the second locomotive and 440 m from the level crossing.

Figure 23: Site plan



Summary

The determination of the sequence of events before and during the accident was hampered by the failure of the data logger on the lead locomotive to record a number of parameters correctly. A correlation with the data logger on the second locomotive enabled the timing for a number of key events to be established. However, the operation of the locomotive headlight, one of the most important elements of a level crossing accident, was not recorded. It was extremely fortunate that photographic evidence, taken from the air within minutes of the accident, was obtained which corroborated the train driver's recollection that the headlight was on.

The analysis of the locomotive data loggers and the photographic evidence that the headlight was illuminated indicates that the driver of *The Ghan* was operating the train in accordance with the applicable rules and procedures and that he did all that could be done when the road-train was driven into the path of his train.

The evidence from the road-train driver and the estimation of its speed clearly indicate that the road-train truck was driven in front of *The Ghan* without stopping. The speed of the road-train immediately before the collision was likely to have been in the vicinity of 50 km/h.

The analysis of the sequence of events also highlights how fortunate it was that, despite a collision speed of 101 km/h and the derailment of five of the six wheel sets, the lead locomotive remained upright and on a straight trajectory while travelling 440 m before coming to a stop. In terms of the safety of the locomotive crew, this good fortune cannot be overstated.

2.1.2 Emergency response analysis

Train drivers

Voice logs of the conversations between the driver/co-driver of *The Ghan* and the PN DCC coordinator and the GWA train controller were examined to determine key events in the first response sequence. The transmission times recorded at the GWA train control and PN DCC centres were not accurate by a significant margin. Therefore, it was necessary to correlate the times in the communication sequence by using the 'time stamps' on the Iridium portable satellite telephone records[33].

It was apparent, within the first few minutes of locomotive AN 5 stopping at 1356:44[34], that the driver had established contact with the PN DCC on the locomotive satellite telephone. This time is calculated as 1358:38[35]. The driver then relayed all details of the collision that were known at the time. Simultaneously, a conversation between the GSR 'on board' train staff and the co-driver can be heard in the background on the 'local' VHF radio. Of note is that two minutes and 20 seconds into the transmission, at 1400:58, the driver advises the PN DCC that the helicopter was hovering and seemed about to land.

33 The Iridium telephone network uses an orbiting satellite network. The location of the satellite telephone on the earth's surface is calculated and the difference between Co-ordinated Universal Time and the local time is then made. The times recorded are accurate to within seconds.

34 It is not possible to correlate the times between the locomotive data log and the Iridium satellite telephone time stamps.

35 When both drivers are speaking to the GWA train controller and PN DCC at the same time, they can be heard simultaneously on the voice logs. The length of the conversation on the locomotive satellite telephone was subtracted from the point where the co-driver is heard to speak to the GWA train controller on the portable Iridium satellite telephone at 1404:25.

After one unsuccessful attempt, the co-driver established contact with the GWA train controller on the Iridium satellite telephone at 1404:25[36]. The driver and co-driver conversations can both be heard from this time. The co-driver also relayed all known details to the GWA train controller and requested attendance of the emergency services. At 1407:30 the co-driver terminated this call.

During these conversations a helicopter can be heard departing overhead at 1406:20. At about 1407:55, while the driver was still speaking with the PN DCC coordinator on the locomotive satellite telephone, one of the drivers from the crew van is heard yelling that there is a fuel spill and that the locomotive will have to be shut down and the electrical power isolated[37]. The driver advised the PN DCC of this and terminated the call at 1408:11.

At 1411:05 the driver again made contact with the PN DCC on the Iridium satellite telephone and confirmed that the electrical system on AN5 had been isolated and that there were at least three passenger carriages derailed. The extent of injuries was still unknown.

After some more information regarding the overall situation was obtained, the driver contacted GWA train control on the Iridium satellite telephone. After several unsuccessful attempts, he was connected at 1455:41. The driver then advised that there appeared to be no serious injuries and that a couple of doctors (who were travelling on the train) were examining passengers and crew. The GWA train controller was then given information regarding the manner in which the train and locomotives were derailed and a brief description of the damage incurred. This call then dropped out. At 1503:53 a connection was re-established on the same telephone. During this subsequent conversation the driver and the GWA train controller dealt with safeworking issues such as cancellation of the current train order and the protection of the train.

While the working drivers were communicating with the GWA train controller and the DCC, the drivers from the crew van had spoken to an occupant of a helicopter that landed in their vicinity, extinguished a number of grass fires and shut down the second locomotive. This locomotive had also been leaking fuel/sump oil. They then checked on the condition of GSR on-train staff and rendered general assistance as required.

The drivers said that the portable Iridium satellite telephone was very unreliable. The satellite telephone in the train manager's office and (later) police telephones were used a number of times to speak to rail authorities and to relay messages to family.

Train control

The GWA train controller notified the NT Police assistance line of the collision at 1409:20[38]. The police assistance line operator said that they had just received advice from another source but the details were scant. The GWA train controller told the NT Police that the train drivers were alright and that they were going back to see how the passengers and GSR on-train staff were.

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36 1404:25 is the time-stamp recorded by the Iridium satellite telephone network.

37 The locomotive satellite telephone is inoperable with the electrical power isolated.

38 Time recorded by the times stamps on the Northern Territory Police assistance line.

At about 1428 the GWA train controller received a call from a PN DCC coordinator who asked where the emergency services were coming from. The train controller said they were responding from Darwin. The PN DCC coordinator then told the train controller that there was a fuel leak and both locomotives had been shut down.

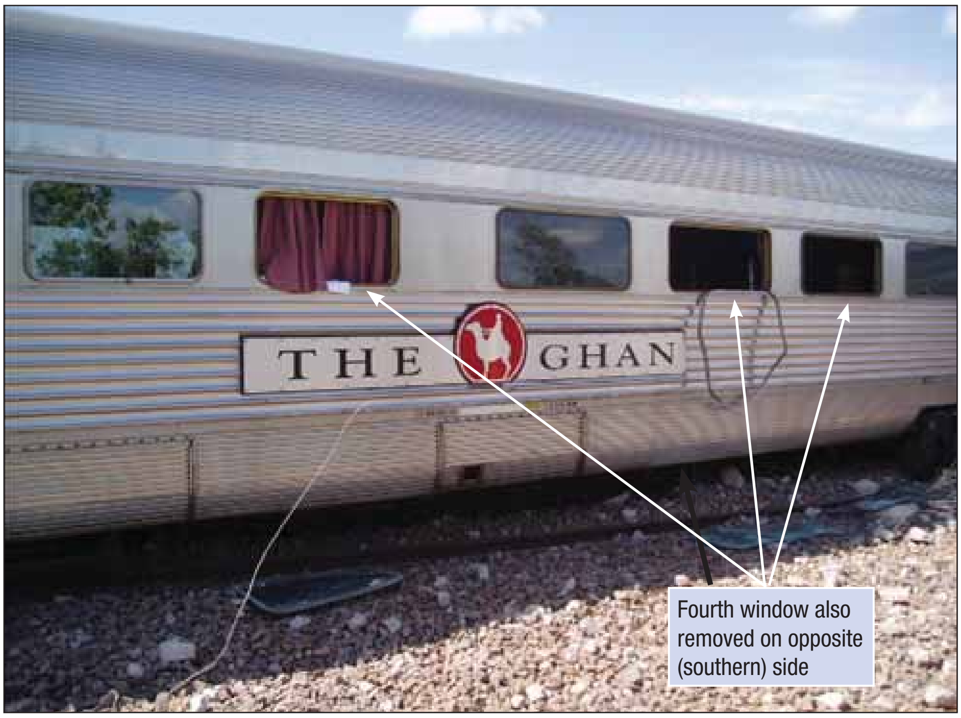
GSR on-train staff

After an initial assessment of the overall situation the train manager and Gold Kangaroo manager took charge and coordinated all operational and passenger needs between them. All passengers were then accounted for and their condition assessed.

One of the first decisions taken was to confine all passengers to their current location; the Gold Kangaroo dining and Red Kangaroo lounge cars. This decision was made after ensuring that there was no risk of fire in this proximity and was due in part to external and internal hazards such as extreme heat, uneven ground and the angle at which some of the derailed carriages were lying. Also, there was a desire to keep all passengers together for overall incident management purposes. This confinement was in accordance with GSR's incident management policy in such circumstances.

Because the air conditioning was not functioning, passengers were monitored for signs of heat stress, given fluids and, where necessary, wet towels. In order to improve ventilation in the Gold Kangaroo lounge car four windows were removed with a sledgehammer a short time after the transfer of the unconscious female passenger to this carriage. GSR staff had limited involvement in caring for the unconscious passenger because of the availability of medically qualified persons from GBS Gold and the two doctors travelling as passengers who had made themselves known to the GSR staff.

Figure 24: Gold Kangaroo Lounge Car (AFC 305T)



At around 1450 GSR on-train staff and GSR's Adelaide-based management agreed to an offer by GBS Gold for passengers to transfer to the company's Cosmo employee/contractor camp. It was decided to leave all passenger luggage on site for later transfer to Darwin because of the safety issues associated with accessing some of the derailed carriages and a desire to evacuate the train as quickly as possible. A name tag with a note of any injuries was then attached to all passengers and medical requirements ascertained. After arrival at the Cosmo Camp GSR staff assisted in the completion of individual incident forms and obtained the nominated emergency contact details of all passengers.

Satellite telephone communications, individual portable radios, advance knowledge of the passengers' pre-existing medical conditions, (including medications), and an emergency response checklist were issues where GSR on-train staff cited the potential for improvements.

GBS Gold mine staff

The GBS Gold Brocks Creek mine is about five kilometres from the Fountain Head Road level crossing. The mining operation has personnel trained in medical and emergency response on site. In addition, a mine ambulance, mine fire truck and a range of heavy equipment and medical supplies are available. The GBS Gold Brocks Creek mine is by far the closest facility to the Fountain Head Road level crossing able to provide any measure of structured emergency response in the event of an accident or incident.

The notification of the collision, received at 1414 from the Ban Ban Springs station manager, resulted in a number of appropriate emergency response actions which were quickly initiated by the mine staff. For example, it was decided to appoint an 'incident coordinator' and a 'site coordinator' at the Brocks Creek mine site and accident site respectively. In order to ensure the line of communication remained open, both were instructed to remain by their radio at all times. At about the same time it was decided to despatch medically qualified employees (a Remote Area Nurse-level 4, a paramedic and a senior first aid attendant) to the accident site in the company ambulance. Other personnel and equipment, including the Brocks Creek mine fire truck, were also quickly despatched.

Meanwhile, at 1419, the incident coordinator contacted the NT Police at Adelaide River with a request for an emergency response. The police advised that the Adelaide River and Pine Creek Fire and Emergency Response Groups (FERG) had just been notified and would be on their way as soon as possible.

Shortly after arrival at the accident site the GBS Gold employees in the mine ambulance checked on the condition of the train drivers. They appeared to be alright. They then liaised with GSR on-train staff regarding the condition of passengers, other crew and the road-train driver. The road-train driver was said to be injured, but not badly. At 1425 they advised the incident coordinator that there were no known serious injuries.

They then went to the northern (opposite) side of the level crossing to attend to the road-train driver who was sitting propped up against one of *The Ghan* carriages. He was checked over in situ and (as reported), appeared to have no major injuries. However, he was suffering from shock, had deep lacerations on his back, a sore neck and some bruising. While attending to the road-train driver they were told that a female passenger was unconscious in the Gold Kangaroo lounge carriage. They then delegated care of the road-train driver to the Pine Creek medical clinic staff (who had just arrived) and proceeded to the Gold Kangaroo lounge carriage to attend to the female passenger.

At 1453 the earlier advice regarding injured persons (at 1425) was updated with the advice that a female passenger was unconscious and would need to be airlifted from the site. The incident coordinator immediately relayed this request to the NT Police at Adelaide River.

At about this time it was also decided to arrange to have the uninjured passengers and some of the on-train staff transferred to the GBS Gold Cosmo Camp, about 17 kilometres from the accident site. Additional GBS Gold staff and vehicles were then readied and by about 1515 the transfer of these passengers had begun.

Between 1515 and 1600 the GBS incident coordinator, in response to requests from the site coordinator, requested several updates of the estimated arrival time of the medivac helicopter. At 1623 the Adelaide River NT Police advised that the estimated time of arrival was 1700. The incident coordinator recorded the arrival of the medivac helicopter as 1648.

By about 1700 the active involvement of GBS personal at the accident site was almost complete as all attending emergency service personnel had arrived. The GBS mine manager and health and safety manager remained on site until about 1830 to finalise the handover to the emergency services. Involvement of GBS personnel at the Cosmo Camp, who attended to the needs of passengers and on-train staff, continued until the departure of the buses for Darwin at about 2000.

Figure 25: Passengers at the GBS Gold Cosmo Camp

Emergency services

The various emergency service centres are located some distance from the Fountain Head Road level crossing. Specifically, NT Police have stations in Darwin, Daly River, Batchelor, Adelaide River, Pine Creek and Katherine. St John Ambulance has bases in Darwin and Katherine. Medical centres are located at Batchelor, Adelaide River and Pine Creek and FERG volunteer organisations are based in Pine Creek and Adelaide River[39].

Shortly after the notification had been received from the NT Police at Adelaide River senior Darwin NT Police decided to set up an emergency operations centre at the NT emergency call centre at Berrimah. Calls to NT emergency services requesting assistance are received and managed at this centre.

The first emergency services to arrive on site were the Adelaide River and Pine Creek medical clinic staff in troop carriers[40] at about 1450 and 1455 respectively. St John Ambulance supervisors from Darwin and Katherine arrived in St John sedans[41] at about 1600, ambulances from Darwin and Katherine arrived at 1620 and 1626 respectively. The first NT Police on site were from the Pine Creek station[42] and arrived at about 1605. Additional resources from other regional police stations and Darwin began to arrive shortly after. The Adelaide River and Pine Creek FERGs arrived at about 1610 and 1615 respectively.

Meanwhile, at 1453, the GBS incident coordinator had told the police at Adelaide River that a medivac helicopter would be required. The medivac helicopter is based at RAAF Base Tindal[43] on contract to the RAAF to provide support to No. 75 Squadron. It is available for civilian search and rescue work as authorised by the Commanding Officer of No. 75 Squadron. The helicopter is owned and operated by CHC Helicopters (Australia).

A request for a possible tasking had been lodged at RAAF Base Tindal at 1445 and authorisation was given at 1450. At this time the flight crew had been stood down for the day and the helicopter de-fuelled in preparation for scheduled maintenance. The flight crew were recalled and a tanker load of fuel organised. Confirmation of the tasking was received at about 1500. Delays due to a mechanical failure of the fuel tanker, transfer of the helicopter to the Tindal civil terminal and time for a medical team to arrive from Katherine meant that departure was not until 1610.

On arrival at the accident, site St John Ambulance personnel were quickly able to ascertain that the two injured persons (the road-train driver and unconscious female passenger) were receiving appropriate medical treatment. When the medivac helicopter arrived at the accident site (at 1648) the GBS Gold Brocks Creek paramedic and medically qualified passengers handed over care of the injured passenger to the medivac team. The Katherine based ambulance and crew then went to the Cosmo Camp to check the condition of passengers and crew.

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39 Approximate distances by road from the Ban Ban Springs level crossing are Darwin 170 kilometres, Katherine 165, Daly River 120 kilometres, Adelaide River and Pine Creek 70 kilometres.

40 A 4WD medically equipped vehicle.

41 A medically equipped sedan. Can only convey patients in a seated position.

42 At the time of notification this Pine Creek unit was in the vicinity of Adelaide River and on the way to Darwin.

43 RAAF Base Tindal is located about 15 kilometres south of Katherine. The helicopter is a Sikorsky 76A+.

Figure 26: Emergency services and medivac helicopter

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Medical treatment rendered

The road-train driver was checked over and given general first aid on site. Because of a possibility of neck/spinal injuries he was placed in a neck brace before being transferred to the Royal Darwin Hospital in an ambulance. At the hospital further treatment to lacerations was administered and various x-rays conducted. No serious injuries were found. He remained in hospital for several days for observation and treatment.

The unconscious female passenger was placed on oxygen and cannulated[44] within a short period of her collapse. Vital signs were then checked and a secondary survey conducted to establish a baseline for vital sign observations. Apart from a bump on the head, no physical injuries were found. Initially she was assessed as having a Glasgow Coma Score of three[45]. Between this time and the handover to the medivac medical team she had several petit mal seizures[46] and reflux with occasional vomiting. However, her state of consciousness gradually improved until, at the time of handover to the medivac medical team, she was assessed as having a Glasgow Coma Score of 11. In view of her decreased state of consciousness she was sedated, immobilised and intubated for the helicopter transfer to the Royal Darwin Hospital.

At hospital she was admitted to intensive care and further checks, including scans and x-rays, were conducted. No physical injuries were identified. The next morning she was extubated and transferred to Darwin Private Hospital for a further 48 hours. No lasting physical injuries were apparent.

44 Cannulation is the insertion of a flexible tube into the body (normally a vein) which is used to insert medication and/or fluids.

45 Glasgow Coma Score is a neurological scale which aims to give a reliable objective way of recording the conscious state of a person for initial and continuing assessment. At 15 the person is fully conscious and coherent; at three the person is unconscious and shows no response to stimuli, even pain.

46 A petit mal seizure is a temporary disturbance of brain function caused by abnormal electrical activity in the brain and is characterised by abrupt, short-term lack of conscious activity (absence) or other abnormal change in behaviour.

At the GBS Cosmo Camp ambulance officers identified two passengers as having suspected injuries. One was found to have a suspected broken wrist and another suspected spinal injuries. The wrist was immobilised and a neck brace fitted before both were conveyed to the Darwin Royal Hospital in an ambulance. The ambulance followed the bus with the passengers from the Cosmo Camp.

Summary

The train drivers notified the PN DCC and the GWA train controller in a timely and accurate manner; they also isolated the train's locomotives and dealt with rail safeworking issues. The notification of the accident, although timely and accurate, was conveyed to the PN DCC as first priority rather than the GWA train controller. The GWA train controller performs the management function of this corridor and, as such, is tasked with notifying the emergency services in the event of an accident. The PN DCC does not perform this role. It is also noted that the times recorded on the voice logs at the GWA train control centre and PN DCC were inaccurate by a significant margin. The voice logs at these centres are a vital source of evidence in the event of an accident or incident. It is fortunate that, in this instance, a correlation of times using satellite telephone records was able to be made. This correlation allowed an accurate determination of a number of key events after the accident.

GSR on-train staff rendered assistance in accordance with the GSR emergency response procedures and good practice. The decision to confine passengers to the Gold and Red Kangaroo dining and lounge carriages could have been problematic, due to heat considerations, if the confinement had been extended. However, a decision to transfer passengers to the Cosmo Camp was, in the circumstances, made in a timely manner. Given the internal hazards in the derailed carriages and external hazards at the accident site, the decision to confine passengers to these two carriages was, in the first instance, sound.

Apart from the proximity to the GBS Gold Brocks Creek mine site, the accident happened at a remote locality. GBS Gold personnel responded very quickly and provided considerable resources in the form of personnel, emergency response equipment and facilities. The medical treatment given to the injured female passenger and road-train driver by the medically qualified GBS Gold employees (and medically qualified passengers from *The Ghan*) was timely and appropriately administered. The overwhelming opinion of all involved was that GBS Gold personnel responded to the accident in an exemplary manner.

By the time of arrival of the first NT Police (at about 1605) only the train drivers, four GSR on-train staff, the road-train driver, the injured female passenger and her son remained. All others had been evacuated to the Cosmo Camp. This was the cause of some consternation. When the first definitive details of the accident were relayed by the GWA train controller (at 1409:20), the extent of the derailment and injuries were unknown. The emergency service and volunteer organisations at the Darwin and regional centres then had to be notified and mobilised. This, in conjunction with the distances from the accident site, made a quicker response unlikely.

A concern expressed by the train drivers and on-train staff was the difficulty experienced when attempting to alert rail authorities to the accident. The operation of the satellite telephones provided on *The Ghan* proved to be at best, intermittent, and this led to the use of the police communications system which was on-site later in the afternoon.

In the broader context, the train crew and emergency services personnel expressed concern about the difficulties associated with appropriate emergency services response in remote areas. The Darwin rail corridor is, in places, a considerable distance from the nearest sealed road. A timely response, especially in wet season conditions, would be very challenging in such localities.

2.1.3 Passenger questionnaire

The ATSB sent a questionnaire to all passengers who were on *The Ghan* at the time of the accident. Of the 64 passengers 44 responded (68.8 per cent).

The passenger questionnaire was designed to canvas a number of matters relevant to the accident and emergency response and asked passengers a wide range of questions regarding events occurring before and after the accident, the accident itself and demographic information. Overall passengers were asked to respond to 49 items by ticking a box or circling the most appropriate answer.

The results presented in this report represent the responses and experiences of the passengers. Individual responses have been treated confidentially by the ATSB.

Some of the key results of the passenger questionnaire were:

- Over 57 per cent said that they either did not receive any safety information from the on-train staff or could not remember the information. Over 60 per cent said they did not know where the emergency exits were located, over 80 per cent said they did not know where the emergency exit door keys were located and only one passenger said they knew where the first aid kit was located[47]. Some passengers offered additional information that indicated safety information was provided but that it was 'lost' in the 'welcome aboard' announcement that was made shortly after leaving Adelaide.
- Over 80 per cent indicated that no fixed objects, including seating, moved during the accident sequence. Non-fixed items such as cutlery, plates, drinks etc did move during the accident sequence.
- Over 70 per cent indicated that post-accident instructions given by on-train staff were clear.
- Sixty-eight per cent said the first source of assistance rendered was from the on-train staff, nearly 16 per cent from fellow passengers and seven per cent from GBS Gold mine staff.
- Eighteen passengers said they had been injured as a result of the accident or after the accident. Twelve said they were injured during the collision/ derailment sequence, three while alighting from the train and three did not indicate when the injury occurred. One passenger said they were injured twice, during the accident sequence and again while alighting from the train.
- Sixteen of the 18 passengers said they obtained their injuries because of contact with fixed objects (12), contact with another person (4) and three from being pushed backwards and forwards (some nominated more than one category).

47 GSR does not encourage access to first aid kits by passengers unless accompanied by a GSR employee.

- The most frequent injury was said to be stiffness or soreness. This was followed by bruising, pain and head injury. Other injuries were delayed emotional response, headache and stiff neck. Nine passengers said they received first-aid treatment. (Note: over 30 per cent of passengers did not respond to this question.)
- Passengers were asked to rate the overall effectiveness of assistance by the ambulance, FERG, police, on-train staff and GBS mine site personnel as satisfactory, unsatisfactory or unsure. Over 93 per cent rated the assistance provided by GBS Gold employees as satisfactory and over 77 per cent rated the assistance provided by the on-train staff as satisfactory. These two categories were by far the highest rated.

2.2 Crashworthiness of the train

Given the forces that the locomotive and carriages were subjected to, both at impact and during the subsequent derailment sequence, the chance of major injury (or worse) was high. Therefore, the crashworthiness of *The Ghan* is a critical consideration.

2.2.1 Locomotives

A key facet of locomotive design is the protection afforded to the locomotive crew in the event of an accident. In this instance, the initial impact occurred between the cowcatcher/skirt of AN 5 and the pivot point between the prime-mover and the first trailer of the road-train. Although this point of contact allowed some of the collision force to be absorbed as the prime-mover and lead trailer moved in an angular direction, the longitudinal and lateral forces of the impact were nevertheless very high due to the speeds of the train and the road-train.

Despite this, damage in the vicinity of the locomotive crew cabin was basically confined to the front sloping panels below the windscreens and the skirt/cowcatcher, auto coupler area. There was no damage of any note from the windscreens to the top of the locomotive and, importantly, the crew cabin was not breached. The point of contact with the road-train and the fact that the locomotive remained upright during the derailment sequence, were probable factors in the retention of crew cabin integrity. Apart from loose items such as hand-held radios and personal belongings, cabin fixtures remained intact.

2.2.2 *The Ghan* carriages

Protection afforded to passengers, off duty drivers and on-train crew is a key consideration in the event of an accident. In this instance, ten carriages of *The Ghan* passenger train, including the motorail wagon, derailed.

Passenger carriages

Seven of the 10 vehicles that derailed were passenger carriages. An examination of these carriages revealed that no fixtures such as doors, tables/seating, television sets, fixed panels, windows etc had dislodged during the derailment. This was also evident in work areas such as the kitchen and bar areas. However, many unsecured items such as glassware, crockery, cutlery and personal belongings were thrown about. This was most evident in the kitchen/pantry and bar areas where some cupboard doors opened, thereby allowing contents to spill out.

Figure 27: Kitchen, Gold Kangaroo carriage

With the exception of one end-carriage door between the Gold Kangaroo lounge carriage and the adjacent sleeper carriage (ARL 920Y), no interconnecting end doors or side door exits jammed. However, during the derailment sequence, some of the carriages concertinaed, thereby causing flexing that opened up the walkway/ vestibule areas between these carriages. Had someone been in these areas when the accident occurred, their safety could have been jeopardised.

Figure 28: Vestibule area between concertinaed carriages

Apart from the walkway/vestibule areas as mentioned, occupant safety was not compromised by failed carriage structural components. Any danger to passengers or staff within the carriage saloons resulted from the unrestrained movement of persons and/or unsecured items.

Figure 29: Gold Kangaroo dining car. All fixtures in place

Crew van

The relief locomotive drivers were in the crew van 'kitchenette' area when the accident occurred. In this area, an upright two-door refrigerator which is bolted to the floor came loose during the derailment. No other fixtures were dislodged.

Damage was incurred to headstock, gangway, coupler stops, skirting, side door and end wall including roof edges. Auxiliary components such as air reservoirs and a compressor mounting and frame were also damaged.

Again, occupant safety was not compromised by failed carriage structural components. Any danger to the locomotive drivers (apart from the refrigerator that moved) resulted from their own unrestrained movement and unsecured items within the confines of the crew van.

Power van

The GSR train technician was in the power van at the time of the collision. The underframe, bogies, skirts, end walls and coupler stops etc, sustained structural damage. External (under car) fuel tanks, reservoirs and auxiliary equipment were also damaged.

No interior fixtures, including the diesel engines, generators and associated equipment were dislodged.

Motorail wagon

This wagon incurred significant structural damage. At the time of the accident four motor vehicles were being carried on the motorail wagon, three in the lower deck and one in the upper deck. These vehicles were secured by adjustable wheel 'clamps'. The vehicle on the top deck partially dislodged; the three on the lower deck remained substantially secured.

Figure 30: Motorail wagon

Summary

The collision and derailment sequence imparted severe forces on the derailed carriages and motorail wagon, particularly those that concertinaed sideways. With the exception of the vestibules/walkways between the carriages that concertinaed, no areas of occupation were compromised or breached as a result of the derailment.

2.3 Level crossing

Level crossings are the physical interface between the road and rail transport systems. Both modes of transport operate as separate entities, have different rules, procedures and characteristics in terms of operational constraints and neither generally has advance knowledge of when the other will be encountered at the interface. Even at actively[48] controlled level crossings, the warning that a train is approaching is mostly given at, and not in advance of, the level crossing to the road vehicle driver.

For trains, the most significant operational constraint with respect to level crossings is the limited ability of the driver to see and then avoid a collision with a road vehicle. Given their relative size and weight, trains cannot brake or accelerate at anywhere near the rate of even the largest road vehicles. In most instances, the only action a train driver can take to avoid or mitigate the effects of a potential collision is to sound the horn to hopefully alert the road vehicle driver and apply emergency braking to slow the train to lessen the impact.

The onus is almost always on the road vehicle driver to make informed, safe decisions and take the appropriate actions to avoid a collision with a train at a level crossing. Thus the road traffic control measures applied at level crossings, which are contained in the relevant standards, are the primary way in which the risk of a collision is mitigated (in combination with the applicable road and rail traffic rules and compliant driver behaviour). An examination of these standards, in terms of the compliance and adequacy of the Fountain Head Road level crossing, is therefore necessary.

2.3.1 Level crossing control warrants and standards

The requirements for road traffic control measures at level crossings in Australia when the commissioning of the Alice Springs to Darwin rail line was taking place in late 2003 were (in broad terms) as follows:

- The level of control (whether it should be passive or active or variants thereof) was based on site specific considerations such as sighting distances, traffic volumes, cost considerations, geometry etc.
- Sighting distance requirements for passive level crossings were contained in warrants that varied from State to State.
- Signs, devices and road markings used to control road traffic at level crossings accessible to the general public were to be in accordance with the provisions of the Australian Standard, AS 1742.7-1993 *Manual of uniform traffic control devices Part 7: Railway crossings.*

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48 Active control – Where devices such as flashing lights, gates or barriers etc are activated before and during the passage of a train through a level crossing.

2.3.2 Compliance with warrants and standards

Overview, Alice Springs to Darwin

Due to the low volumes of rail traffic and in many cases, road traffic, the majority of level crossings in the NT are passively controlled. This is illustrated by the fact that of the 171 level crossings between Alice Springs and Darwin, 145 are passively controlled. Of 145 passively controlled level crossings, 124 are occupation level crossings[49] and 21 are public level crossings. The majority of occupation level crossings are not named and are referred to by a kilometre location only.

Due to the costs associated with creating and maintaining sight distance triangles for 'Give-Way' level crossing control, 'Stop' sign control was adopted as the default control measure between Alice Springs and Darwin.

When the construction of the Alice Springs to Darwin rail line was nearing completion at the end of 2003, level crossing sighting distances at public level crossings was raised by the construction consortium (ADrail) as an issue that needed to be addressed.

Following discussions between the NT DPI, ADrail and FreightLink, it was agreed that all public level crossings would have a sighting distance of at least 1000 m. This distance was in excess of the various sighting warrants that existed in 2003 and, at a train speed of 115 km/h, gave a road vehicle just over 30 seconds to clear the level crossing. ADrail then improved sighting distances on all public level crossings where necessary to meet this agreed standard. This work was completed before the rail line was opened for commercial use.

To validate the arbitrarily agreed sighting distances adopted between Alice Springs and Darwin, individual public level crossings were then assessed by the NT DPI in accordance with a sighting distance assessment model used by the Queensland Department of Main Roads[50]. This model was one of the few available at the time that incorporated a road vehicle length of 53.5 m in the sighting distance formulas. This validation was also completed before the rail line was opened for commercial use.

When the Australian Level Crossing Assessment Model (ALCAM[51]) became available for use in the NT in 2004 and relevant personnel in the NT DPI were trained in its use, all public level crossings in the NT were audited against the model. These audits identified a small number of level crossings where deficiencies such as sighting distance or clearance distances existed. After consultation with stakeholders it was decided that at these level crossings road vehicle lengths would be restricted or train speeds reduced. The assessment of level crossings under the ALCAM was a large task and, as a consequence, continued for some time after the rail line was opened for commercial use.

49 An 'Occupation' level crossing is constructed for the use of the owner or occupier of private land.

50 Revision 7(a): 2003. The sighting distances in this model were derived from the formulas contained in chapter 21 of the *Road Planning and Design Manual*, Qld Department of Main Roads.

51 ALCAM – The Australian Level Crossing Assessment Model is a risk assessment tool which takes into account over 70 factors at each site. There is an industry transition to this assessment model. This model was not available in 2003.

AS 1742.7 (1993) is not applicable to occupation level crossings that are provided for the exclusive use of the occupier[52]. The Northern Territory's *AustralAsia Railway (Special Provisions) Act* (in essence) specifies that where an occupation level crossing exists that the rail owner and land owner are to manage the use of the level crossing. Nearly all occupation level crossings in the NT were part of the design brief of the rail corridor and the easement agreed between the NT DPI and the landowner. The risk assessment in these instances was coordinated and conducted by the rail operator and the landowner directly, and was primarily based on sighting distance and the type of road vehicle to be used[53]. Therefore, occupation level crossings were not assessed by the NT DPI in the manner that public level crossings were.

2.3.3 Fountain Head Road level crossing

Sighting distance

The Fountain Head Road level crossing affords limited visibility of approaching trains to the drivers of road vehicles when, as was the case in this accident, the road vehicle is travelling north and a train is approaching from the east (from Alice Springs). In this situation the road vehicle driver's view of the track to the east is totally obscured by a mound of dirt and trees until their vehicle is about 17 m from the nearest rail line. Although not as restricted, there is also a limited view of approaching trains when a road vehicle is travelling south and a train is approaching from the west (from Darwin). In this instance, a clear view is not obtained until the road vehicle is about 21 m from the nearest rail.

'Give-Way' level crossing control requires a sighting distance sufficient to enable a driver of a road vehicle to see an approaching train and decide whether to continue and clear the level crossing or whether to stop before the level crossing. Road vehicles approaching the Fountain Head Road level crossing in either direction do not have sufficient vision of approaching trains for 'Give-Way' control. Therefore, despite the fact that 'Stop' sign level crossing control was adopted as the default control measure between Alice Springs and Darwin, the Fountain Head Road level crossing would not have met the sighting distance requirements for 'Give-Way' control in any case.

The critical issue at a level crossing controlled by a 'Stop' sign is that the motor vehicle driver must stop the vehicle at the 'Stop' sign and have the ability to see an approaching train from this position. If a train is seen the driver must then remain stationary (give way) until the train has passed. If a train is not seen the sighting distance must be sufficient to allow the road vehicle to clear the level crossing before the arrival of a previously unseen train.

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52 However, AS 1742.7 (1993) is applicable if the occupation crossing is used by other members of the public such as visitors to the land site. In effect this 'caveat' means that nearly all occupation level crossings would have to conform to AS 1742.7 (1993). Of note is that the revised AS 1742.7 (2007) has been amended to exclude the application of this standard to occupation level crossings that are used by other members of the public with the knowledge and agreement of the land occupier. In effect, this means that nearly all occupation level crossings do not have to be compliant with the revised AS 1742.7 (2007). This is a marked difference in the application of the current standard to occupation level crossings.

53 A recent example of an assessment carried out in this manner is that between FreightLink and GBS Gold at the Brocks Creek mine access road level crossing. The risk of collision between high combination gross mass vehicles and trains travelling at the maximum permitted track speed has been mitigated by a reduction in train speed and enforcement/monitoring procedures aimed at ensuring road vehicles stop at the 'Stop' sign.

Using the Queensland Department of Main Roads model, the minimum sighting distance for a stationary vehicle to proceed and clear the level crossing before the arrival of the train at the Fountain Head Road level crossing was calculated by the NT DPI as 635 m. The values for the parameters used to calculate this sighting distance were; train speed of 115 km/h, triple road-train truck length of 53.5 m, a 90 degree angle between road and rail, a width of rail of 1.1 m and a level grade (within 10 m either side of the level crossing). However, the Queensland model allows for an AAB quad road-train of the same length to be used in the calculation and these trucks have a lower value of acceleration than the triple road-trains used by the NT DPI in their calculation. If the AAB quad road-train configuration and correct rail width of 1.435 mm is used, the calculated sighting distance using the Queensland Main Roads model is 727 m. This figure (727 m) will be quoted when referring to the Queensland model in the remainder of this report.

Figure 31: Left photo is the view towards the east 40 m from level crossing, right photo is the view along the track to the east from the stop sign

The actual sighting distances for road vehicles stopped at the stop sign at the Fountain Head Road level crossing are, in clear weather, about 1200 m to the east and about 1000 m to the west. This is well in excess of the 727 m that was calculated using the Queensland model. Therefore, the Fountain Head Road level crossing is in compliance with the sighting distance requirements for 'Stop' sign control as assessed using a model applicable at the time and the arbitrarily agreed distance of 1000 m.

The assessment of level crossings using the Queensland Main Roads model also involves an estimate of the grade on the approach to the level crossing (beyond 10 m either side) and an estimated 85th percentile speed of road traffic. Although these parameters are not factors in the sight distance calculations for 'Stop' sign control, the road grade and the traffic speed on the approach to the Fountain Head Road level crossing was estimated at 4 per cent and 60 km/h respectively[54].

54 Road grade (beyond 10 m from the level crossing) and traffic speed estimations are used for sight distance triangle calculations for 'Give-Way' sign level crossing road traffic control.

At the time of the assessment in late 2003, the estimated road and rail traffic numbers at the Fountain Head Road level crossing were only four trains and 20 road vehicles per day. Since early November 2006, however, road traffic traversing the Fountain Head Road level crossing had increased significantly. In November/ December 2006 road movements associated with the road construction work alone were in the order of 90 per day. However, the increased road traffic did not exceed the next incremental threshold of 1000 vehicles per day contained in the ALCAM used by NT DPI to audit the crossing in 2004. Therefore, even at the increased level of road vehicle traffic, the originally calculated risk score for the Fountain Head Road level crossing would have remained unaltered.

Signs, devices and road markings

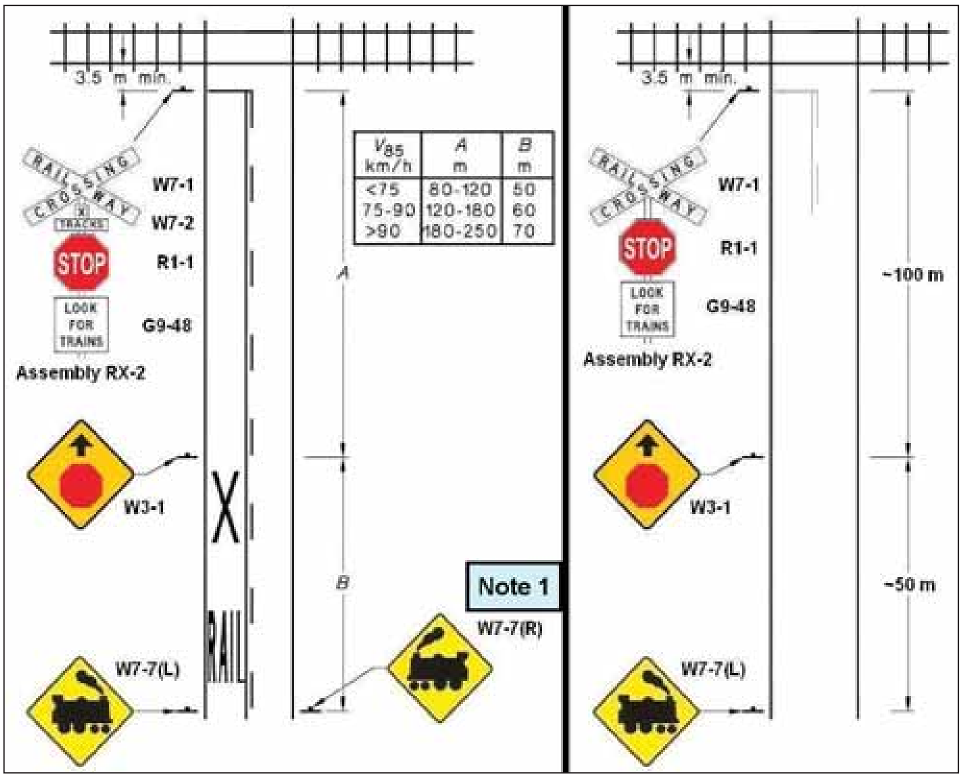
With the exception of a missing advance 'Railway Crossing Ahead' sign on the southbound (opposite) approach, all signs mandated by AS 1742.7-1993 *Manual of uniform traffic control devices Part 7: Railway crossings* for 'Stop' sign control of a level crossing were present on both sides of the Fountain Head Road level crossing.

Placement of the road signage at 100 m ('Stop Sign Ahead', W3-1) and 150 m ('Railway Crossing Ahead', W7-7(L)) and a sign size of 600 mm is consistent with a design based on 85 per cent of road vehicles travelling at less than 75 km/h as set out in AS 1742.7-1993. This would appear reasonable considering the slight curve leading up to the crossing (travelling north) and the station gate 100 m past the crossing would not permit road vehicles to travel at higher speeds.

Although very faded and, at times barely discernable, Fountain Head Road between the Stuart Highway and the level crossing had line markings installed. The following non conformances with AS 1742.7-1993 as intended for sealed roads that have line markings (barrier or lane markings) installed were identified:

- The 'Stop Line' was faded to a point where it could barely be seen.
- The 'RAIL X' marking, to be placed between the advance warning symbolic train and the 'Stop Sign Ahead' sign, was not installed.
- The road had been resurfaced (possibly at the time of level crossing construction) for 37.5 m on the southern side of the level crossing and 100 m to the gate to private property on the northern side of the level crossing. No barrier line/s had been reinstated.
- There was no barrier line extending from the stop line to the advance warning symbolic train sign on either side of the level crossing.

Figure 32: Left, signage and road markings as required by Australian Standard 1742.7-1993, right, signage and road markings as installed at Fountain Head Road level crossing on 12 Dec 2006



Note 1: AS 1742.7-1993 states that the right-hand 'Railway Crossing Ahead' sign, W7-7(R), is optional and only intended for use on busy roads. Consequently, this sign was not installed at the Fountain Head Road level crossing.

Figure 33: Left photo showing stop line barely discernable, right photo showing where road has been re-sealed with no barrier line

Also, the southern approach to the level crossing exhibited some 'sign clutter' in that multiple signs, unrelated to the warning signs for the level crossing, were in place. At times, these signs restrict the view of the advance level crossing warning sign. However, the 'Stop Sign Ahead' and the 'Stop' signs were both unobstructed and clearly visible.

Figure 34: Sign Clutter - Fountain Head Road level crossing, Ban Ban Springs (southern approach)

Given the experience of the road-train driver and the number of times that the level crossing had been traversed by him over the previous month, there is no doubt that he knew exactly where the level crossing was. Therefore, the deficiencies in the road markings and the 'sign clutter' are not considered to have contributed to the accident.

2.4 Locomotive horn audibility

The locomotive horn was sounded three times before the collision but failed to alert the truck driver to the approach of the train until the last few seconds. The effectiveness of locomotive horns generally in warning motorists at level crossings, and the performance of *The Ghan*'s horn in this instance, thus warrants further analysis.

2.4.1 Horn effectiveness – background

The detectability of a train horn by a road user is determined by a number of factors. These include not only the acoustic properties of the horn itself and the environment in which it is used but also the auditory function of the road user and their level of attentiveness (Rapoza, Raslear & Rickley, 1999; Raslear, 1996; cited in Dolan and Rainey 2005). The factors influencing an individual's attentiveness at level crossings include demands of the driving task, driver motivation, the perceived likelihood of a train being present and the influence of other potentially competing visual and auditory stimuli (Dolan & Rainey, 2005).

The acoustical properties of train horns depend on the number of 'chimes' and their individual 'size and shape'. Each chime is designed to produce a different fundamental frequency[55] below 700Hz with the chimes having the potential for several differing harmonics. The fundamental frequencies of a horn are selected on the basis that the low frequency is sufficient to penetrate the vehicle's shell (Keller & Rickley, 1993, cited in Dolan and Rainey, 2005). Furthermore the horns are designed to produce large amounts of harmonic energy that coincides with the most sensitive range of the human ear (cited in Dolan & Rainey, 2005).

As a general rule for each doubling of distance there is a decrease of 6 dB in sound pressure. Therefore a horn measuring 96 dB at 100 m would measure 90 dB at 200 m, and 84 dB at 400 m. Note however, there are many factors influencing the propagation of sound such as the medium, presence of reflective and absorbing surfaces, obstructions, whether the sound source is moving, etc.

2.4.2 Research supporting effectiveness of train horns

From the late 1970s numerous communities across the United States were imposing bans on the sounding of train horns at actively protected level crossings. By 2005, roughly 2000 bans were in place in 260 localities[56].

In 1984 the State of Florida authorised local communities to ban the sounding of the train horns and, by 1989, 511 of 600 eligible level crossings had night-time train horn bans in place. In 1990 a USA Federal Railroad Administration (FRA) study found that the number of night-time accidents at the ban locations had increased at a rate three times that of non-ban locations while the day-time accident rate remained almost unchanged. At the remaining 89 level crossings where no bans (either day or night-time) were in place night-time accidents increased by only 23 per cent. The FRA identified the bans as a safety risk and issued a directive in 1991 ending the train horn bans in Florida. In the two years following the issue of that order, night-time collision occurrences reduced by 68.6 per cent, which was almost a return to pre horn ban levels.

The Florida study led the FRA to conduct a similar study in 27 other States. This follow-up study, published in 1995, considered 2,122 level crossings used by 17 railroads where train horn bans had been in place between 1988 and 1994. Ninety-four per cent of these level crossings had train horn in place 24 hours a day and six per cent (118 level crossings) had night-time bans. This follow-up study concluded that level crossings with train horn bans averaged 84 per cent more collisions than similar level crossings with no bans.

On 24 June 2005 the FRA's 'Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings' (level crossings) took effect. This rule requires that locomotive horns be sounded at all public highway-rail grade crossings, except where there is no significant risk to persons, where supplementary safety measures fully compensate for the absence of the warning provided by the horn, or where the sounding of the horn as a warning is not practicable.[57]

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55 The lowest tone of a harmonic series.

56 There are about 153000 public level crossings (referred to as 'grade crossings') in the USA. The level crossings where the sounding of train horns had been banned was about 1.3 per cent of the total number of public level crossings.

57 'The Federal Railroad Administrator's Train Horn Rule', Congressional Research Service, 20 April 2007.

2.4.3 Research suggesting trains horns may be ineffective

The US National Transportation Safety Board (NTSB, 1998) investigated 60 accidents that occurred at passive level crossings over a nine month period[58]. One of the warning systems they looked at was the train horn.

The NTSB found that in 55 of the 60 accidents the train horn was sounded prior to impact. In 14 of the 18 cases they were able to interview the road user, the train horn was sounded. Overall 10 of the 14 cases did not hear the train horn. Three of these indicated however that they were still aware of the train's presence prior to impact. Eight of the 10 road users who did not hear the train stated either internal and/or external sounds distracted them from the horn's audibility. The types of distractions included passengers, stereo, and traffic. In seven cases drivers reported having their windows down, however four of these drivers still did not hear the train horn. However two of these four drivers reported other distractions.

In 1996 the NTSB, in cooperation with several Oklahoma-based companies[59], conducted train horn audibility tests within 13 different passenger and emergency vehicles. A three-chime Leslie horn was used with a sound level of 96 dB(A) at 100 feet (30.48 m), as required by FRA regulations. This project measured firstly, the insertion loss of each road vehicle[60], secondly, the audibility of the train horn when the vehicle's engine was at idle and thirdly, the audibility of the train horn when the vehicle's engine was at idle and the air conditioning set on high.

The tests revealed a maximum insertion loss of 33 dB in a 1986 Chevrolet Corvette, compared with a minimum insertion loss of 17 dB in a 1986 Freightliner cab-over tractor[61] (for full details see NTSB, 1998 report number PB98-917004). Under the condition of engine at idle (air conditioning fan off) the sound level of the train horn in a 1997 Thomas/Ford school bus was not audible (a dB level of -2 was obtained). In seven of the 13 vehicles, the train horn was not audible above the idling engine and fan noise. Furthermore, when the engine was at idle and the fan on high, the train horn did not meet the 10 dB difference needed above ambient noise levels necessary to alert the motorist in any of the vehicles. For example, the sound level in the 1986 Freightliner cab-over tractor reached 8 dB, whereas the 1997 Thomas/Ford school bus sound level was -11 dB.

The NTSB also concluded that the tests underestimated the level of interior noise that would occur in normal driving conditions as they didn't account for additional sources of ambient noise such as road surface texture, radio/music players and conversations.

Nevertheless, the NTSB noted, sounding train horns is an important element of grade crossing safety, and should be done unless effective substitutes are in place[62].

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58 This study was not designed to be statistically representative of the entire passive level crossing accident population.

59 Oklahoma Operation Lifesaver, Oklahoma Department of Transportation, and Burlington Northern Santa Fe Railroad.

60 Insertion loss refers to the difference between the measured sound values from an exterior sound source taken outside the highway vehicle and inside the vehicle (NTSB, 1998).

61 Similar to a B-double truck.

62 Mark V. Rosenker, Acting Chairman, National Transportation Safety Board, Testimony before the Subcommittee on Railroads, Committee on Transport and Infrastructure, United States House of Representatives, July 21, 2005, p. 2-3.

2.4.4 Test of horn, AN5 (*The Ghan*)

The horn mounted on AN 5 was a 5-chime Nathan Airchime[63]. This horn was tested after the accident to determine whether it met the required decibel level[64]. To meet the requirement the horn must achieve a minimum noise level of 88 dB(A), for a steady tone, at 200 m from the front of the vehicle when it is in the 'country' setting. Under this assessment the horn is operated four times for 15 seconds each, followed by a 30 second operation and is compared to the minimum requirements.

The results of the AN5 horn test indicated that it met the minimum requirements. The sound measurements were taken at the centre line and 7.5 m from the centre of the track as required (see Table 2).

Table 2: Results of AN5 horn tests

Test	Distance	Loudness				Pressure	Wind speed	Observations		
		dB(A)								
No	Metres	Required	Act RH	Act Centre	Act LH	(kpa)	m/s	Temp C°	Humidity	Background noise dB(A)
One	@200m	88dB(A) min	-	-	84 Peak 82 Ave	772	2	33	16%	54
Two	@200m	88dB(A) min	92 Peak 88 Ave	89 Peak 88 Ave	92 Peak 88 Ave	772	2	33	16%	51

2.4.5 Summary

The Ghan's horn complied with the relevant standard with respect to its decibel level. It was sounded three times before the collision, at 488 m to 373 m (four seconds), 172 m (one second), and 85 m from the level crossing. However the horn only alerted the road-train driver on the last activation despite the fact that it functioned correctly and met the relevant standard in terms of its loudness. It is of note that research into the effectiveness of train horns in alerting road users to the presence of trains at level crossings is not conclusive.

At passive level crossings the primary sense for detecting a train, whether it be at a crossing controlled by 'Give-way' or 'Stop' sign, is sight. In order to determine whether there is a train present, and its location, the road user must visually search the tracks in both directions. The secondary sense available to (most) road users is hearing. In the accident at the Fountain Head Road level crossing, the primary sense of vision was obviated because the truck driver did not stop at the 'Stop' sign and look. Therefore, it fell to his secondary sense, that of hearing, to detect the train's presence.

63 Manufacturing specifications indicated that the fundamental frequencies were 'C' sharp-277 Hz, 'E' natural-330 Hz, 'G' natural-392 Hz, 'A' natural-440 Hz and 'C' sharp-554 Hz.

64 DRAFT Code of Practice (CoP) for the Defined Interstate Rail Network – Volume 5: Rolling stock. Part 5 – Specific requirements for locomotives (Section 10.3.2).

2.5 The road-train driver

2.5.1 Did not stop

The road building task was repetitious, with the truck drivers each completing an estimated 15 return trips a day between the road base loading and unloading points and traversing the same route each time. The only break of any significance from this routine was for lunch, normally from about noon until 1300. The same road-train truck drivers had been performing the same task for about one month, seven days a week.

The road-train driver involved in the accident was very experienced. He had over 40 years experience operating road-trains and other heavy road maintenance equipment. His task on the day of the accident had varied very little, if any, from that he had been performing over the course of the previous month. To a driver of his experience the behaviour required to perform the task was primarily 'skills based'. That is, the task was essentially routine, one requiring limited cognitive processing and being performed almost automatically. Routine tasks involving 'automatic' responses can lead to a 'neutral' state of mind where past experience influences a person's actions or inactions.

There is no doubt that failing to stop at a level crossing 'Stop' sign is an unsafe act and a violation of the road rules. The road-train driver said that it was his usual practice to slow to 15 to 20 km/h, look, and proceed across the Fountain Head Road level crossing rather than stop. He also said that this was usual practice for the other drivers performing the same task and there is evidence to this effect from other sources. This practice was unlawful, and particularly risky at the Fountain Head Road level crossing given the limited opportunity for road vehicle drivers to sight trains in some circumstances.

On the day of the accident the truck driver stated that he did not stop the road-train at the level crossing before proceeding across. He also stated that he did not look in either direction along the track on his approach. He said that he had stopped 200–300 m from the crossing when he closed a trailer door. This was his explanation for why he failed to stop and look for a train at the crossing. He then accelerated from a standing start all the way to the crossing with analysis suggesting that by the time he reached the crossing the truck's speed was in order of 50 km/h. The reasons why the driver of the road-train failed, not only to stop at the crossing, or at least slow his vehicle and look for a train (his usual practice), actions which resulted in the collision, need to be analysed in order to understand what underlying factors may have been present.

2.5.2 Slip or lapse?

Slips and lapses occur at skills-based behavioural level and are sometimes referred to as 'automatic' or 'absent-minded' errors. Influences that often lend themselves to such errors are generally those that have the potential to cause attention or memory problems. In this instance these influences could be related to:

- environmental conditions
- fatigue
- distraction

- toxicology issues
- medical issues.

Environmental conditions

At 1405, when the accident occurred, the sun was approximately 30 degrees south of west and at an altitude of approximately 67 degrees. The elevation and angle are unlikely to have contributed to any significant level of glare for a driver approaching from the south. Also, the cabin of the truck was air conditioned; the road-train driver said the temperature in the cabin was at a comfortable level. In addition, the driver had been working in similar conditions for the previous month and so it is unlikely that the conditions in the time immediately before the collision contributed significantly to his actions.

Fatigue

The road-train driver said he had been sleeping well in the preceding weeks, normally from about 2000 until 0500 each night. Including travel time to and from the work site, he had been on duty from 0600 until about 1700 each day with a one hour break for lunch. This roster had been worked continuously (seven days a week) for about one month prior to the accident. He said that he had eaten lunch (a sandwich and a can of soft drink) at about noon on the day of the accident. Work resumed at around 1300, about one hour before the accident.

These hours of duty were assessed using the Fatigue Audit InterDyne (FAID) fatigue modelling program. The FAID program was developed in partnership with the Centre for Sleep Research at the University of South Australia. The algorithms within the FAID program allow for time of day effects (or circadian rhythm), the fatigue effect of the current shift's hours of work and the cumulative effect of the work hours over the previous seven days.

The FAID program does not make allowance for individual differences in the need for sleep, nor for differences in morningness-eveningness. In addition, the program does not make allowance for the effect of environmental/task factors such as noise, light and vibration on fatigue. However, the program is useful as a guide and is used by sectors of the aviation, rail and marine industry for roster compilation and fatigue management.

The FAID score for the road-train driver at the time of the accident was calculated at 66. Research by the Centre for Sleep Research suggests that a fatigue score of between 40 and 80 is moderate.

At interview, the road-train driver said that he felt alert during the time leading to the accident. Research indicates that individuals who are fatigued are not necessarily able to accurately assess how fatigued they are and/or the potential effects on their performance. However, in combination with the moderate FAID score, it appears unlikely that fatigue contributed significantly to the truck driver's actions in the time immediately before the collision.

Distraction

The requirement to close the gate on the front trailer in the minutes just before the accident could, in some instances, constitute a distraction to the truck driver. However, at interview there was no indication that, once back in the truck cabin, this task had distracted him in any way.

At the time of the accident the Ban Ban Springs station manager was mustering cattle in the helicopter on the opposite side of the rail line to the west of the Fountain Head Road level crossing. This operation was to the left of the road-train driver's line of vision as he approached the level crossing. Once again at interview, the truck driver gave no indication that the helicopter distracted him in any way, although he did say that the noise from the helicopter could have hindered his ability to hear the train's approach.

Toxicology issues

The NT Police did not conduct a breath test on the road-train driver at the accident site. However, the evidence from a number of sources is that the road-train driver did not drink alcohol. Blood samples were taken from the road-train driver at 2045 at the Royal Darwin Hospital on the day of the accident. The subsequent toxicological examination returned negative results for amphetamines, benzodiazepines, opiates, cannabinoids and other common drugs.

Medical issues

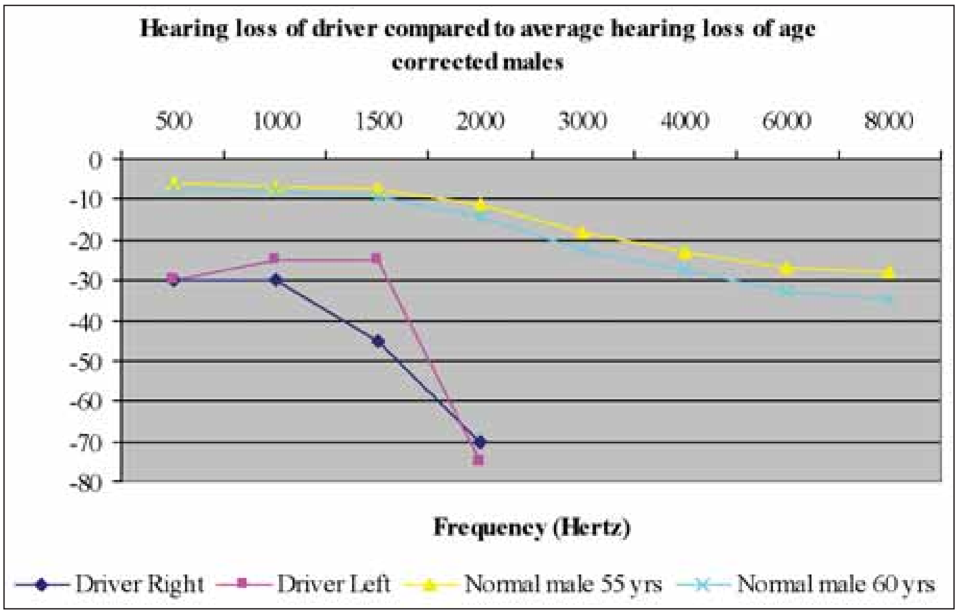
At interview the road-train driver indicated that health wise he was 'pretty well' but had industrial deafness. He also used glasses for reading only. When the ATSB contacted the last doctor he had seen, who indicated he was not the truck driver's regular GP, it was discovered that in October 2006 the road-train truck driver underwent a pre-placement medical examination for employment as a truck driver with a mining company in north-east NT. This examination indicated several health issues and potential lines of enquiry. A medical practitioner was consulted by the ATSB to interpret these medical results and draw what conclusions could be made. The medical issues that were considered to be of interest included his eyesight, severe hearing loss, glycosuria (sugar in the urine), and proteinuria (protein in the urine).

In 2005 the truck driver's eyesight was assessed during renewal of his licence by the motor vehicle registry and found to be within the limits for holding a commercial driver's licence. The mine medical results indicated degradation in his distance vision which did not exceed the requirements for his unconditional commercial drivers licence. However, the mine medical did not assess his peripheral vision. The licensing body also was not required to do so.

Peripheral vision is particularly important in detecting objects and movement outside the direct line of sight. In addition, the truck driver appears to have untreated kidney and metabolic disorders. The most likely explanation for this is untreated diabetes mellitus, however other medical disorders could explain the results. If this were the case however, this could have further degraded his vision, including peripheral vision. Degraded distance vision would have reduced his ability to see a train had he been looking in that direction. Degraded peripheral vision would have reduced his ability to detect the movement of the train approaching the crossing had he been looking directly ahead or just left or right of centre as he was approaching the crossing. However no firm conclusions can be drawn from this information as specialised assessments would be necessary to investigate the proteinuria and glycosuria results.

The results of the audiogram conducted as part of the mine medical indicated that in the better ear hearing threshold levels were: 30dB at 500Hz, 25dB at 1000Hz, 75db at 2000Hz, and no hearing threshold level registered at 3000Hz or above. To provide a relative comparison of the truck drivers hearing capability, age corrected curves developed by Spoor (1967) were used to compare with male individuals of a similar age (cited in Ward, Royster and Royster, 2000). Figure 35 provides a graphical representation of the road-train driver's hearing profile in both ears with these curves. Hearing threshold levels did not register at 4000Hz, 6000Hz, or 8000Hz.

Figure 35: Comparison graph



This comparison indicates that he had severe bilateral hearing loss, with the greater loss being in his right ear.

The road-train driver's severe hearing loss is a potentially significant factor in the collision. Had he either heard the train approaching at the time he said he was stopped and closing the gate on the trailer (which is unlikely given the train's distance from the crossing at that time), or either of the first two blasts of the train horn when he was approaching the crossing (a four second blast at 488 m and a one second blast at 172 m from the crossing), it is possible that he could have avoided the collision, or at worst, its consequences may have been less severe. While the helicopter mustering cattle may have made it more difficult to hear the train and/or its horn, it is probable that that road-train driver's hearing loss, particularly in his right ear (the direction from which the train approached), also affected his ability to hear *The Ghan* approaching the crossing compared with a male with 'normal' hearing of the same age.

2.5.3 Routine violation?

Downes Graderways were performing the road construction work under contract to GBS Gold. All of the Downes Graderways employees were inducted and assessed in accordance with GBS Gold procedures. The topic of level crossings was included as part of the road-train driver's initial induction training. All truck drivers were informed to ascribe to the signs controlling the crossings. The driver involved in the collision undertook the induction on 16 November and signed an induction document, in effect agreeing to abide by the GBS Gold company policy and procedures.

Although the initial induction training specified what was expected at level crossings and to abide by the sign/signal controlling the level crossing it is unclear as to whether spot checks were done either by the mining company or the trucking company. In addition, it is not clear whether the trucking company supervised drivers during routine operations (e.g., as part of standard operating procedures) or conducted routine checks on driver performance.

Level crossings were also discussed at toolbox meetings where topics of concern were raised. One issue that was raised was the lack of visibility on the southern approach to the Fountain Head Road crossing (the same direction that the road-train approached the site before the collision) due to the dirt mound and trees. The company owner indicated to drivers that when the truck is at a complete stop at the crossing itself the view in both directions of the track is not obstructed and had informed drivers to stop at the level crossing.

The road-rain driver's decision not to stop at the Fountain Head Road level crossing was an intentional behaviour referred to as a violation (Reason, 1990). There are two primary factors that foster the development of routine violations (Reason, 1990). Firstly, it makes the task easier. For example, it takes less time, and less time and effort to get the truck back up to speed if it is travelling slowly rather than when it has come to a complete stop. Secondly, if the behaviour occurs in a relatively indifferent environment, which was the case in this instance, where there was little likelihood that the road-train would be caught and/or sanctioned for failing to stop.

Routine violations are intended deviations from set rules or procedures that normally occur at skills-based behavioural level. Influences that often lend themselves to routine violations are the actions of peers, the rigour applied to workplace rules/procedures and the perceived amount of risk involved in the task at hand. Routine violations are characterised by the unsafe act being the normal way of performing the operation and are commonly associated with a lack of enforcement of procedures and a very low perception of risk.

In this instance, influences that could have affected the road-train driver's actions in the time leading up to the accident are:

- expectation and familiarity
- constraints associated with equipment
- the manner in which the task was usually performed.

Expectation

The road-train driver had crossed the level crossing about 30 times a day, seven days a week for the previous month. During this time he had only seen about four trains, all of which were freight trains and none of which he had to alter his driving pattern for. At the Fountain Head Road level crossing, freight/ore trains have a maximum speed of 80 km/h and *The Ghan*, depending on the axle load of the locomotive, has a maximum speed of 110 km/h or 115 km/h. At interview the road-train driver said he had no idea that *The Ghan* travelled so fast.

During the week preceding the accident the train timetable indicated that 22 trains, or an average of 3.14 per day, traversed the Fountain Head Road level crossing. Of these 18 were freight (or ore) trains and four were passenger trains (*The Ghan*).

However, when the working hours of the road-train driver and his colleagues are considered, this figure reduces to 14 trains per week or, an average of two trains per day. Also, at the worksite it was usual practice to broadcast a warning to other road-train/truck drivers on the UHF radio whenever a train was seen.

The perception of a road user that a train is unlikely to be encountered is further reinforced every time they use the level crossing when there is no train present. Research at level crossings (Caird, et al., 2002) has maintained that familiarity with a level crossing combined with the expectation that a train will not be present has the potential to lull road users into becoming complacent or developing poor looking habits. Further research indicates that an individual's response to a possible hazard is influenced by both the perceived probability of the adverse event occurring and of that individual's understanding of the severity of the consequences of the event (Schoppert and Hoyt, 1968 cited in NTSB, 1998). A person's perception of the probability of a given event is strongly influenced by past experience (Schoppert and Hoyt, 1968 cited in NTSB, 1998), and the frequency with which they encounter a train at a level crossing will influence the likelihood of the motorist stopping (NTSB, 1998).

The low volume of rail traffic seen during the road-train driver's working day, the slower speed of those trains that were actually seen and the practice of the road-train drivers to broadcast train sightings over the UHF radio (thereby reducing the expectation of seeing a train 'unannounced') may have contributed to, and reinforced, the road-train driver's routine practice of slowing down at the Fountain Head Road level crossing rather than coming to a complete stop.

Equipment constraints

A number of persons interviewed during the investigation said that, whenever possible, road-trains are not brought to a complete stop and that it is 'normal' to conduct a 'rolling stop'. This is where the driver will slow to walking pace but will not depress and release the clutch to start the truck from standstill. This is said to be desirable as there is less stress on the truck's drive line components. In fact, in situations where a stop is not mandated and it is safe to do so, a 'rolling stop' is seen as good driving practice.

The principle of not allowing a heavy vehicle to come to a complete stop unless necessary is taught at the Driver Education Centre Australia and the training manual of at least one major freight forwarding company makes reference to not stopping the vehicle unnecessarily as it 'saves on fuel, places less strain on the gear box and reduces the risk of breaking the drive shaft'.

Usual Practice

The fact that the road-train driver did not stop at the 'Stop' sign at the Fountain Head Road level crossing immediately before the collision with *The Ghan* is not in question. He stated freely that it was his usual practice to slow, look, and proceed across the crossing rather than stop.

The road-train driver had performed the same task, seven days a week, for about one month prior to the accident. Therefore, the total number of times he would have traversed the Fountain Head Road level crossing in either direction would have been in excess of 800. If the drivers of the other two road-trains were also traversing the Fountain Head Road level crossing without stopping, the total number of times the level crossing was traversed in this manner over the previous month is in the order of 2400.

Visibility along the rail line to the east at the Fountain Head level crossing is not possible until a northbound motorist is 17 m from the rail line. Similarly, visibility along the rail line to the west at the Fountain Head Road level crossing is not possible until a southbound motorist is 21 m from the rail line. Although it is dangerous (and unlawful) for a road vehicle to not stop at a level crossing that is controlled by a 'Stop' sign, the risk is exacerbated even more when visibility is as restricted as it was at the Fountain Head Road level crossing.

2.5.4 Conclusion

It is unlikely that the environmental conditions, fatigue or distraction contributed to an error by the road-train driver. This contention is further reinforced by his interview where he indicated that the road-train cab was comfortable, that he felt alert at the time of the accident and gave no indication of being distracted in any way. Likewise, the toxicological examination returned negative results for substances commonly known to affect concentration and cognitive judgement. The NT Police did not conduct a breath test within the required time-frame after the accident. However, evidence from a number of sources is that the road-train driver did not drink alcohol.

The road-train driver had severe bilateral hearing loss, with the greater loss being in his right ear. It is possible that his hearing loss contributed to the road-train driver's failure to detect the presence of the train until the final sounding of the horn. It is difficult to quantify the adverse impact on the train's audibility because of factors such as the insertion loss in the prime-mover truck cabin, engine noise, the topography in the area and the helicopter that was mustering cattle nearby.

The truck driver's hearing loss may have contributed to his failure to detect the train and thus be characterised as a 'slip or lapse' which contributed to his actions in the time before the collision in accelerating the road-train from a standing start 200–300 m from the crossing. However the evidence is that his usual practice was to slow the road-train, look for a train, and then drive through the crossing without stopping.

Factors that, in this instance, could lead to deviations from normal and accepted procedures or rules (violations) have also been examined. Specifically, 'expectation', equipment constraints and usual work practice. The evidence is that the road-train truck driver's expectation of seeing a train at the Fountain Head Road level crossing was low. This is evident when it is considered that the road-train truck driver had crossed this level crossing in the order of 800 times in the previous month and yet only saw four freight trains. Research indicates a propensity to become complacent or to develop poor looking habits in situations such as this due to an expectation that a train will not be present.

2.6 Medical standards

2.6.1 Heavy vehicle drivers, Northern Territory

Overview

Regulatory requirements in the Northern Territory for commercial drivers in the road-train driver's age group[65] dictate that every five years MC class licence holders are required to undergo a vision test. More extensive medical assessments become required only when a condition is reported by a health professional or self reported by the license holder.

The Northern Territory's *Motor Vehicles Act* (Section 11) requires a driver to advise the Registrar if they 'suffer from a physical or mental incapacity that may affect his or her ability to drive a motor vehicle with safety to the public'. Similarly, medical practitioners are also required to report instances where they believe a patient does not meet the fitness to drive criteria[66]. Examples of such illnesses or disabilities are given in an Austroads publication titled *Driving and Your Health* and include:

- blackouts or fainting
- vision problems
- epilepsy
- heart disease
- sleep disorders
- diabetes
- psychiatric disorders
- age related decline.

Physical and mental incapacity is assessed using the Austroads publication *Assessing Fitness to Drive for Commercial and Private Vehicle Drivers*[67] guidelines which provide criteria for determining whether a road user is fit to safely operate a vehicle under either a unconditional or conditional licence, or not at all. The guidelines are applied once it is either known or suspected that a medical issue exists. This publication is approved by the Australian Transport Council (ATC)[68] and is endorsed by all Australian driver licensing authorities and has a goal of reducing the risk of illness related accidents to a minimum.

The NT licensing authority also requires that a medical declaration is made when a driver initially applies for a licence or when an existing licence is renewed. The licence application form asks the broad question, 'Do you have any medical, physical or psychiatric condition that may affect your ability to drive/ride or control

65 For MC class license holders over 50 years of age.

66 In the first instance the patient should be encouraged to report the condition to the driver licensing authority themselves. Failing this, the medical practitioner's or health professional's duty to maintain the patient's confidentiality is qualified in certain circumstances in order to protect public safety.

67 The medical fitness criteria for commercial vehicles are more stringent than those pertaining to a private vehicle. This is due to the increased risk associated with greater time on the road and the risk of greater consequences in the event of an accident due to size and weight of the vehicle etc.

68 Australian Transport Council comprises Commonwealth, State, Territory and New Zealand Ministers responsible for transport portfolios. Its key role is to advise governments on the coordination and integration of all transport and road policy issues.

any motor vehicle for which you are licensed?' It does not ask any questions about specific medical issues.

A person may not indicate that they have a medical condition for several reasons including concern for losing or failing to obtain a licence, but also because they may not realise the significance of some medical conditions to the driving task particularly if they have been successfully functioning in the community for many years, or are unaware that they have a medical condition.

Other ways that the licensing authority may become aware of a medical issue is via physical presentation when obtaining/renewing a licence, reports made by the public, doctors and health professionals reporting the matter directly, and the police as a result of a motor vehicle accident.

The road-train driver

The driver of the road-train involved in the collision with *The Ghan* had never been medically examined in conjunction with the issue or periodic renewal of his MC class driver's licence. The evidence is that he had severe bilateral hearing loss which probably contributed to his inability to detect the presence of the train approaching the level crossing.

The commercial standards contained in Assessing Fitness to *Drive for Commercial and Private Vehicle Drivers* at section 10.1.2 states:

> While driving ability per se might not be affected by a hearing deficiency, responsiveness to critical events is an important safety consideration for drivers of commercial vehicles. These drivers therefore require a reasonable level of hearing in order to ensure their awareness of changes in engine or road noises which may signal developing problems, and their awareness of horns, rail crossings, emergency signals and sirens.

According to this standard the criteria for an unconditional licence (i.e., no restrictions) is **not** met:

> If the person has an unaided average hearing threshold level of equal to or greater than 40dB in the better ear. (Average hearing threshold is the simple average of pure tone air conduction thresholds at 500, 1000, 2000 and 3000 Hz).

If the standard can be met with the use of a hearing aid, a conditional licence may be granted by the licensing authority taking into account the opinion of an ear, nose and throat specialist and the nature of the driving task. Periodic review would be necessary in this instance. Advice regarding vehicle modifications that provide visual display of safety critical operations may also have to be sought.

When Austroads was contacted to determine how the audiogram results obtained at the road-train driver's employment medical examination results could be correlated with their medical standards, it was determined that the level of the truck driver's hearing loss was 43.33dB (based on (30+25+75)/3).

This level is below the 40dB hearing threshold level and indicates that the truck driver did not meet the requirements for an unconditional commercial heavy vehicle licence.

2.6.2 Train drivers

Train drivers have been medically examined periodically on State by State basis since the 1970s. In 2004 the *National Standard for Health Assessment of Rail Safety Workers* was approved by the Australian Transport Council. Under this standard, train drivers are classified as 'high level safety critical workers (category one)'. The principal determinant for a safety critical rail worker is:

> For any aspect of the task identified, could sudden incapacity lead to a serious incident affecting the public or the rail network?

The requirements of this category are no risk of sudden incapacity and good physical and psychological health. The aim of the category one health assessment is to identify any risk of sudden incapacity, assess overall physical and psychological health in conjunction with the occupational health and safety requirements of the rail safety work. For a train driver this health assessment is conducted as a minimum:

- before employment
- every five years until age 50
- every two years until age 60
- yearly thereafter.

The health assessment consists of:

- safety critical worker questionnaire and history
- comprehensive physical and psychological assessment
- vision and hearing
- screen based equipment examination if required
- drug screen if required
- cardiac risk score - fasting cholesterol (total and HDL), fasting plasma glucose and resting ECG.

A train driver so examined is classified as:

- fit for duty
- fit for duty subject to review
- fit for duty subject to job modification
- temporarily unfit for duty subject to review or
- permanently unfit for duty.

All four drivers on *The Ghan* had been assessed as fit for duty in accordance with the national standard for health assessment of rail safety workers.

2.6.3 Summary

A detailed comparison of the medical requirements of the *National Standard for Health Assessment of Rail Safety Workers* and the publication *Assessing Fitness to Drive for Commercial and Private Vehicle Drivers* has not been conducted as a part of this investigation. What is readily apparent though, is that there is a significant disparity between the two health assessment criteria in terms of the requirements for medical examinations. In short, health assessments for rail safety workers are conducted at mandated intervals; health assessments for commercial and private road vehicle drivers are conducted only when 'triggered' by a declaration from a license applicant/holder or a third party.

In this instance, this has resulted in some notable issues of comparison. *The Ghan* drivers had been examined since 2004 under the *National Standard for Health Assessment of Rail Safety Workers* and, before this, periodically under the State rail systems medical examination criteria since the 1970s.

Despite about 40 years of truck driving, the road-train truck driver had never been medically examined in conjunction with holding his commercial road vehicle driver's licence. His undeclared, undetected (by the licensing authority) and uncorrected bilateral hearing loss was severe enough that he did not meet the criteria to hold his unconditional MC class licence.

2.7 Road-train clearance times

Background

During the investigation of *The Ghan* collision and derailment, ATSB investigators noted that road-train B+2A side tipper combination vehicles of up to 53.5 m regularly used the Fountain Head Road level crossing and other roads and level crossings in the vicinity. These road-train combinations are over 17 m longer than the road-train involved in the accident at the Fountain Head Road level crossing and are the largest in terms of weight and length allowed on public roads in the world. It was also noted that some privately conducted clearance time trials had been recently undertaken, the results of which led to a potential concern regarding the adequacy of sighting distances as calculated by AS 1742.7 2007.

In order to 'validate' the times of the privately conducted trials, further testing was undertaken by the ATSB with the cooperation of the NT DPI, GBS Gold and BJB Joint Venture (rail track maintenance) at the Fountain Head Road level crossing on Wednesday 29 August 2007. Five different road-train combinations and drivers were used in the testing, although the road-train combinations were similar in most aspects. The distance measured was a combination of the requirements of AS 1742.7-2007 and the length of the road-train, a total of 66.9 m. Twelve tests were conducted.

Figure 36: B+2A Road-Train Combination

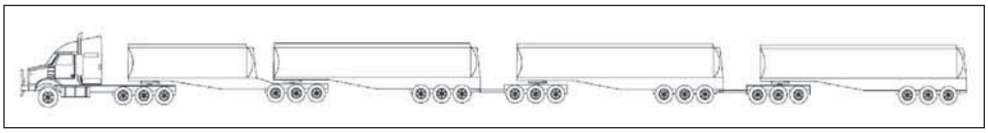


Figure 37: Northbound B+2A road-train during test

Times detailed in table 3 are inclusive of 3.25 seconds driver reaction/mechanical delay estimation.

Table 3: Level crossing clearance time test results

TIME OF DAY/TEST NO.	PRIME-MOVER MODEL	GEARS USED	DIRECTION	RESULTS	LOADED/ EMPTY
0930 (1)	T904	5	Northerly	33.25 seconds	Empty
0940 (2)	T904	5	Southerly	46.25 seconds	Empty
1005 (3)	T904	5	Northerly	45.25 seconds	Loaded
1040 (4)	T904	5	Southerly	46.25 seconds	Loaded
1045 (5)	C500	6	Northerly	31.25 seconds	Loaded
1058 (6)	C500	1	Southerly	68.25 seconds	Loaded
1100 (7)	T904	2	Northerly	40.25 seconds	Loaded
1110 (8)	T904	6	Southerly	40.75 seconds	Loaded
1135 (9)	C500	5	Northerly	33.25 seconds	Empty
1145 (10)	C500	1	Northerly	50.25 seconds	Empty
1247 (11)	C500	1	Southerly	54.25 seconds	Loaded
1310 (12)	C500	1	Southerly	71.25 seconds	Loaded

Conclusions

As detailed at 2.3.3 of this report, the required sighting distance at the Fountain Head Road level crossing for a stationary road vehicle to proceed and clear the level crossing before the arrival of a previously unseen train was calculated by the Queensland Main Roads model (revision 7(a) 2003) as 727 m. Using the same values for the parameters as those used in the Queensland Main Roads model for road-train length, train speed, angle of road-rail interface and a level grade, the amended AS 1742.7-2007 calculates the required sighting distance at 766.2 m. However, if a four per cent grade is factored into an assessment conducted under AS 1742.7 the sighting distance is calculated at 937.8 m[69].

A train travelling at 115 km/h (31.94 m/s) will take 22.8 seconds to travel 727 m and 29.4 seconds to travel 937.8 m. A road-train of the type tested at the Fountain Head Road level crossing, loaded or empty, will not clear the level crossing within these times from a standing start at the level crossing stop line.

The maximum clearance time recorded when gears were changed was 46.25 seconds (on two occasions). An approaching train travelling at 115 km/h will travel just over 1477 m in this time. The maximum time recorded when low gear was held was 71.25 seconds. An approaching train travelling at 115 km/h will travel just over 2275 m in this time. Actual sighting distances would have to be in excess of these figures for a driver of this truck configuration to make an informed decision whether it is safe to proceed across the level crossing. Notwithstanding the obvious constraints in terms of topography and varying environmental conditions, there would be significant difficulty for a person to see and/or judge the speed of an oncoming train at such distances. Further research is needed in this regard.

On 5 October 2007, the ATSB released a supplementary report numbered 2006/015 titled *'Results of Trials for Heavy Vehicle Clearance Times at Level Crossings'*. This report fully details the methods used and results of the clearance tests and found:

> Tests conducted on 53.5 m long B+2A road-trains at the Fountain Head Road level crossing, Ban Ban Springs, found that the procedure/standard used to calculate and/or assess the level crossing sighting distance was probably inadequate for the truck configuration tested. It is likely that sighting distances at other level crossings controlled by 'Stop' signs, used by high combination gross mass road vehicles, may be similarly deficient and more research is needed to accurately assess this risk.

The ATSB advised the State and Territory road transport authorities and rail regulators to consider the implications of this safety issue and take action where it is considered appropriate.

This supplementary report may be viewed at the ATSB <website www.atsb.gov.au>

69 The grade beyond 10 m either side of the level crossing was assessed at four per cent during the assessment by the NT DPI under the Queensland Main Roads sighting distance model (see 2.3.3). If followed absolutely, this model will not factor in a grade for 'Stop' sign control if that grade is further than 10 m from the level crossing. In this instance, the grade within 10 m of the level crossing was assessed as level. Therefore, no allowance for the four per cent grade beyond 10 m either side of the level crossing was made using the Queensland Main Roads model. AS 1742.7 (2007) is not prescriptive in this regard and simply refers to a grade correction factor. However, if some 'licence' is taken and the four per cent grade is factored in, the calculated sight distance of the Queensland Main Roads model is 928 m. Given the lengths of the road-trains that use this level crossing, this assumption would not seem unreasonable.

2.8 53.5 m road-train combination routes

The Australian Vehicle Standards Rules (AVSR) is based on the Australian Design Rules and provides the framework for in-service standards. The model legislation was developed by the National Transport Commission in consultation with States and Territories, all of whom have implemented the regulations. The operation of road-train combinations of up to a length of 53.5 m is allowed in Australia under the AVSR.

Given the vast distances and relatively sparse population of much of rural Australia, efficient land transport (be it road or rail) is of vital importance on a number of counts. Because of the large amounts of freight that road-train combinations can carry, the road transport freight task can be performed with fewer road vehicles. Prima facie, this has favourable implications for road safety and efficiency.

The declaration of routes where high combined gross mass vehicles are allowed to operate is done on a State by State basis. Road-trains of up to 53.5 m are authorised in Western Australia, South Australia, Queensland, the Northern Territory and, to a small extent, New South Wales[70].

The NT, in terms of routes kilometres approved for 53.5 m road-trains in proportion to the total road network, has the highest percentage of road-train approved routes in Australia. In the NT, road-train combinations of up to 53.5 m operate on an 'open access' basis which, in effect, allows their operation on all non-urban roads. By default, they are allowed to traverse any public or occupation level crossing in the NT. The size of the NT and population demographics, has made the extensive use of road-trains a commercial necessity.

The salient point, in the context of road-train clearance times, is that there are many level crossings across much of rural Australia where the road/rail interface involves the use of freight and passenger trains and road-train combinations of up to 53.5 m.

2.9 Road/rail interface, organisational context

In 1998, the NT Government became a signatory to the Intergovernmental Agreement on Rail Safety. This was followed by the proclamation of the *Northern Territory Rail Safety Act 1998*. This Act is the cornerstone of the NT rail safety regulatory system.

To assist with strategic co-ordination and oversight of rail safety, the NT Government, through the NT Regulator, established the NT Rail Safety Committee in 2001. This committee comprises representatives from all major stakeholders in the NT including the NT DPI, the NT Department of Planning and Environment, the NT Police, Fire and Rescue Services, WorkSafe and rail organisations that are accredited in the NT. This committee acts as a forum for discussion of all issues related to rail safety in the NT.

To focus specifically on level crossing safety, the NT Level Crossing Safety Committee was also established. This committee comprises representatives from the NT DPI rail safety unit, the NT DPI road safety/road network unit, the Local Government Association of the NT, the NT Department of Justice, NT Police,

70 In New South Wales the only route approved for triple road-train combinations (53.5 m) is the Mitchell Highway from North Bourke to the Queensland border at Barringun. There are no railway level crossings on this route.

rail organisations that are accredited in the NT and the Australian Trucking Association. This committee is chaired by the NT DPI Executive Director Transport.

The NT Level Crossing Safety Committee reports to the NT Minister for Infrastructure and Transport who, in turn, is a member of the Australian Transport Council (ATC). The ATC is, in essence, a forum for Commonwealth, State, Territory and New Zealand Ministers to consult and provide advice to governments on the co-ordination and integration of transport and road policy issues. The efficiency, safety and environmental performance of all modes of transport are key objectives of the ATC.

In August 2003 the ATC tabled a report titled *National Railway Level Crossing Safety Strategy*. The objective of this strategy is to reduce the number, cost and trauma of crashes between trains and any road users by the most cost-effective means. A series of 'strategic actions' was identified in this report (Appendix A) aimed at a cost-effective improvement of level crossings.

The Australasian Railway Association (ARA) has developed a National Railway Level Crossing Behavioural Strategy that is aimed at modifying road user behaviour at railway level crossings. In June 2006 the ATC endorsed the implementation of the strategy. The behavioural strategy forms part of the ATC's National Railway Level Crossing Safety Strategy and builds on the work of the National Road Safety Strategy. The behavioural strategy will work towards the national development and delivery of programs through each jurisdiction.

The National Transport Commission (NTC) was established as an independent body to assist the ATC in achieving its objectives. As a component of this task, the NTC is required to prepare a three year strategic plan and work program for approval by the ATC. A recent initiative of the NTC is a discussion paper on 'Strategic Directions and Reform Initiatives'. A component of this paper is a section on 'Enforcement Guidelines to Support Improved Safety at Level Crossings'. In this section the NTC acknowledges, inter alia:

> Aggregate statistics indicate that level crossings are the priority for rail safety reform. It is considered to be the most significant form of latent risk both from a public safety perspective (e.g. potential for a collision between a train and a truck) and a commercial perspective (e.g. recent example of truck collision with freight train).

The discussion paper continues to say that the NTC is working with the National Rail Level Crossing Behavioural Coordination Group (BCG) to implement the National Rail Level Crossing Behavioural Strategy and that this will be guided by the outcomes of a national behavioural survey that is being conducted in 2007. Envisaged is:

> Promulgation of enforcement guidelines developed through a national pilot by the BCG to enable enforcement agencies to better identify and target effective interventions. Furthermore, the NTC proposes to consider the potential for technology to provide warnings about on-coming trains at passive level crossings (e.g. using short wave radio communications between trains and trucks).

The NTC, being a multi-modal national body reporting directly to the ATC, is well placed to research and advise on these matters.

The NT DPI has a clear mandate to review issues arising from accidents such as the occurrence at the Fountain Head Road level crossing and to consider strategies proposed by the ATC. Some of the ATC strategies contained in the National Railway Level Crossing Safety Strategy that are relevant to the occurrence at the Fountain Head Road, Ban Ban Springs on 12 December 2006 involve stakeholder education and enforcement.

Stakeholder education and information

The strategic action to address the issue of stakeholder information is:

> Develop awareness and understanding through participation amongst the public, engineers, the police and other to improve responses, engineering and enforcement (may be similar to U.S.A. 'Operation Lifesaver').

There have been a number of initiatives overseen by the NT DPI aimed at developing awareness and understanding of rail safety issues during construction and since the opening of the rail line between Alice Springs and Darwin. For example, the NT Rail Safety Committee liaised regularly with ADrail (the construction consortium) with regard to an education program before the Alice Springs to Darwin rail line was opened in 2004. Since the line was opened, education campaigns have been undertaken by the Road Safety Branch of the NT DPI and FreightLink. These campaigns are aimed at promoting public awareness of risk of rail operations and safe motorist behaviour at level crossings and are conveyed through television, radio and newspaper advertising and posters. This is valuable work that should continue.

Examples of operations that involve participation by other agencies such as the police and public (through the FERG organisations) are the desktop emergency exercise conducted in August 2006 and an emergency field exercise that was held in Alice Springs in early 2007. Given the remoteness of much of the rail corridor in the NT, a properly planned and coordinated emergency response is absolutely vital in the event of a rail accident, particularly if a passenger train is involved. Emergency exercise training such as this is invaluable and should continue.

Legislation, regulation and enforcement

The strategic action to address the issue of legislation, regulation and enforcement is:

> Ensure that laws and penalties are clear, understood, appropriate and enforced.

In 2007 the NT Government introduced a demerit points system and increased fines for infringements of the Australian Road Rules. Failure to obey traffic control measures at level crossings will incur three demerit points. In addition, penalties for such offences have been increased from $80 to $500. The increased penalty recognises the often serious consequences of level crossing crashes to both the users of road and rail systems. The decision to increase the penalties followed two major level crossing accidents in the NT in 2006. One of these accidents is the subject of this investigation report. This initiative was accompanied by a multi-media advertising campaign.

3 FINDINGS

3.1 Context

At approximately 1356 on 12 December 2006, a double trailer road-train truck drove into the path of the Adelaide to Darwin Ghan passenger train at the Fountain Head Road level crossing, Ban Ban Springs, about 170 km south of Darwin.

From the evidence available, the following findings are made with respect to the collision and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

1. The road-train truck driver did not stop the road-train at the stop sign at the Fountain Head Road level crossing when *The Ghan* was approaching this level crossing. Therefore, he was unable to give-way to *The Ghan* as is required.
2. The evidence is that the road traffic control measure of 'stop and give-way to trains' at the Fountain Head Road level crossing, Ban Ban Springs, was not being complied with by a number of road vehicle drivers before the accident on 12 December 2006. [*Safety Issue*]

3.3 Other safety factors

1. Due to the lack of visibility at the Fountain Head Road level crossing it is very difficult to see a train approaching unless a stop is made at the 'Stop' sign and the track then visually 'searched' by the road vehicle driver in both directions.
2. Road markings on the southern approach to the Fountain Head Road level crossing were either faded to a point where they could not be seen or were missing altogether. 'Sign clutter' on the northbound approach to the level crossing reduced the visibility of the advance level crossing warning sign. [*Safety Issue*]
3. The road-train truck driver had severe bilateral hearing loss which compromised his ability to hear *The Ghan* and/or its horn in the time leading up to the collision.
4. The extent of the road-train truck driver's hearing loss would have made him ineligible to hold his unrestricted Multi-Combination commercial vehicle driver's license.
5. Regulatory requirements for commercial drivers in the road-train truck driver's age group dictate that every five years MC class licence holders are required to undergo a vision test. More extensive medical assessments are required only when a condition is reported by a health professional or self reported by the licence holder. [*Safety Issue*]
6. The distances required to be travelled by the emergency services personnel made a quicker response unlikely.

7. Due to re-fuelling, re-engaging the air crew and obtaining a medical team from Katherine, there was some delay in the departure of the medivac helicopter from Royal Australian Air Force Base Tindal.
8. The remoteness of much of the Northern Territory rail corridor and the local climatic conditions could make a timely response to an accident challenging in some circumstances, particularly in the wet season. [*Safety Issue*]
9. The portable satellite telephone carried in the lead locomotive of *The Ghan* was the only means of communication (in close proximity) that the train drivers had once the locomotives were shut down. This satellite telephone worked intermittently at best. [*Safety Issue*]
10. Notwithstanding the communication difficulties, notification of the accident to the Pacific National Divisional Control Centre was expeditious and subsequent updates were regular. However, notification to the Genesee Wyoming Australia Adelaide Train Control Centre was not as timely and updates not as regular. [*Safety Issue*]
11. The data logger on the lead locomotive of *The Ghan* was not recording several key parameters correctly (or at all). [*Safety Issue*]
12. The time stamps on the voice transcripts at the Pacific National Divisional Control Centre were inaccurate by a wide margin. [*Safety Issue*]
13. The time stamps on the voice transcripts at the Genesee and Wyoming Adelaide Train Control Centre were inaccurate by a wide margin. [*Safety Issue*]
14. The passenger survey indicated that the majority of *The Ghan*'s passengers (who responded to the survey) did not know where the train's emergency exits or door keys were located. A slight majority of the respondents (57 per cent) did not remember receiving (or could not remember the contents of) the safety information that was given by the train staff at the start of the journey. [*Safety Issue*]
15. The road-train truck involved in the collision was in an un-roadworthy condition.
16. Tests conducted by the ATSB on 53.5 m long B+2A road-trains at the Fountain Head Road level crossing in August 2007 found that the procedure/standard used to calculate and/or assess the level crossing sighting distances was probably inadequate for the road-train configuration tested. It is likely that sighting distances at other passive level crossings controlled by 'Stop' signs, used by high combined gross mass vehicles, may be similarly deficient and more research is needed to accurately assess this risk. [*Safety Issue*]

3.4 Other key findings

1. *The Ghan* had a valid authority to be on the section of track where the Fountain Head Road level crossing is located and was being operated in accordance with the relevant rules and procedures. Before the driver sighted the road-train the locomotive horn had been operated twice. This is in excess of the requirements of the relevant rules and procedures.
2. Despite bearing the initial force of the collision at 101 km/h, the drivers' cabin was not breached or compromised. That the locomotive remained upright,

despite travelling 440 m after the collision with five of six wheel-sets derailed, was a key factor in this favourable outcome.

3. With the exception of the vestibules between some of the concertinaed carriages, no area of the passenger or crew carriages of *The Ghan* was breached or compromised as a result of the collision or derailment. That the carriages remained upright was a key factor in this favourable outcome.
4. The first response measures taken by GBS Gold staff were of a very high standard, both in terms of timeliness and the level of assistance provided
5. The decision by Great Southern Railway on-train staff to confine passengers to designated carriages before transfer to the GBS Cosmo Camp was sound in terms of minimising exposure to external hazards and for incident management purposes.
6. The distance between Darwin and the GBS Gold Pty Ltd Cosmo Camp and the time taken to procure buses in Darwin meant that the decision to transfer passengers and some staff from the accident site to the GBS Gold Cosmo Camp as a first step in the evacuation process was sound.
7. All road-train drivers of Downes Graderways had been appropriately inducted by GBS Gold in the GBS Gold Brocks Creek mine site safety procedures before starting work on road construction as contracted by GBS Gold.
8. The agreed level crossing sighting distances for 'Stop' sign control (about 1000 m) between the Northern Territory Department of Planning and Infrastructure, ADrail and Freight Link Pty Ltd were in excess of the requirements contained in the relevant standards.

4 SAFETY ACTIONS

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the rail industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

4.1 The National Transport Commission

Safety issue

Regulatory requirements for commercial drivers in the road-train truck driver's age group dictate that every five years MC class licence holders are required to undergo a vision test. More extensive medical assessments are required only when a condition is reported by a health professional or self reported by the licence holder.

ATSB safety recommendation RR20080003

The Australian Transport Safety Bureau recommends that the National Transport Commission and jurisdictions note the wider implications of this safety issue and consider measures to address them.

4.2 Australian Transport Council/Australasian Railway Association

Safety issue

The evidence is that the road traffic control measure of 'stop and give-way to trains' at the Fountain Head Road level crossing, Ban Ban Springs, was not being complied with by a number of road vehicle drivers before the accident on 12 December 2006.

Action taken

The National Railway Level Crossing Behavioural Strategy was endorsed by the Australian Transport Council of Ministers in June 2006. In order to support this behavioural strategy the Australasian Railway Association initiated the inaugural National Rail Safety Awareness Week (Rail Safety Week) in July 2006. This was followed by Rail Safety Week 2007, held in July 2007. Rail Safety Week is a collaborative event that includes input from Government agencies from all States and Territories and major rail operators. The 2007 event also included New Zealand participants. Activities were undertaken in all States, Territories and New Zealand.

In the Northern Territory, activities encompassed press releases from the Chief Minister, Minister, FreightLink and Great Southern Railways, multi-media coverage and a high school level crossing safety poster competition. In addition, police enforcement was heightened.

Also in July 2007, the National Rail Level Crossing Behavioural Coordination Group commenced work on examining existing data, conducting statistical analysis and company-based enforcement in the Northern Territory. It is intended that this work will serve as a 'case study' which demonstrates how companies might change the behaviour of their own employees/contractors where level crossings are involved. The project is scheduled for completion in early 2008.

Overall, the Australasian Railway Association has identified level crossing safety as one of their seven safety initiatives and has released a Level Crossing Policy Statement in support of level crossing safety. This policy statement conveys a heightened concern regarding level crossing safety and calls for a focus on education, enforcement and engineering by all concerned.

4.3 State and Territory road transport authorities and rail regulators

Safety issue

Tests conducted on 53.5 m long B+2A road-trains at the Fountain Head Road level crossing, Ban Ban Springs, found that the procedure/standard used to calculate and/or assess the level crossing sighting distance was probably inadequate for the road-train configuration tested. It is likely that sighting distances at other passive level crossings controlled by 'Stop' signs, used by high combined gross mass road vehicles, may be similarly deficient and more research is needed to accurately assess this risk.

Action taken

This issue was placed on the agenda of the meeting of the Rail Safety Regulators Panel (RSRP) that was held in November 2007 at the request of the Northern Territory Regulator who presented specific safety concerns to the committee members. A decision was reached that the secretariat of the RSRP would check with AusRoads in relation to what initiatives/research they were taking in that respect.

The ATSB supplementary report numbered 2006/015 was placed on the agenda of the January 2008 meeting of the NSW Level Crossing Strategy Council (LCSC) at the request of the Chief Executive of the NSW Independent Transport Safety and Reliability Regulator. The LCSC is the interagency forum for agencies involved in level crossing safety management and regulation in NSW.

The Queensland Main Roads Department has advised that it considers safety at level crossings, particularly in relation to heavy vehicles, to be of the utmost importance. They intend to participate actively and abide by the recommendations of an Austroads project that is intended to review the performance characteristics and nominate best practice in relation to heavy vehicle access at rail level crossings.

Standards Australia advised that its committee noted that the preliminary investigations have indicated that the acceleration characteristics of a vehicle similar to that involved in the crash were poorer than those specified for sight distance calculation purposes in the Australian Standard AS 1742.7: Manual of uniform traffic control devices, Part 7: Railway crossings. Communication is taking place with the ATSB, through Committee members to determine what adjustments need to be made to the acceleration characteristics of a long vehicle for sight distance calculations, as a result of these findings. The Standards Committee will make the necessary amendment to the standard as a result of these adjustments.

ATSB safety advisory notice RS20070001

On 5 October 2007, the ATSB released a supplementary report numbered 2006/015 titled 'Results of Trials for Heavy Vehicle Clearance Times at Level Crossings'. This report contained safety advisory notice RS20070001 to State and Territory road transport authorities and rail regulators.

4.4 Northern Territory Department of Planning and Infrastructure

Safety issue

The evidence is that the road traffic control measure of 'stop and give-way to trains' at the Fountain Head Road level crossing, Ban Ban Springs, was not being complied with by a number of road vehicle drivers before the accident on 12 December 2006.

Action taken

The Northern Territory Department of Planning and Infrastructure have overseen rail safety campaigns undertaken by the Northern Territory Rail Safety Committee before and after the Alice Springs to Darwin rail line was opened in 2004. These campaigns were aimed at promoting public awareness of the risk of rail operations and safe motorist behaviour at level crossings and took the form of television, radio and newspaper advertising and posters.

Since the accident at the Fountain Head Road level crossing:

- A level crossing assessment group has been formed and is further examining all level crossings in the Northern Territory, including occupation level crossings, under the Australian Level Crossing Assessment Model. A number of additional assessment criteria have been established and all level crossings are to be properly mapped and named.
- The NT Government introduced a demerit points system and increased fines for infringements of the Australian Road Rules. Failure to obey traffic control measures at level crossings will incur three demerit points. In addition, penalties for such offences have been increased from $80 to $500.

ATSB safety recommendation RR20080004

The Australian Transport Safety Bureau recommends that the Northern Territory Department of Planning and Infrastructure takes action to address this safety issue.

Safety issue

The remoteness of much of the Northern Territory rail corridor and the local climatic conditions could make a timely response to an accident challenging in some circumstances, particularly in the wet season.

Action taken

The Northern Territory Rail Safety Committee coordinated a desktop emergency exercise in 2006 and an emergency field exercise of a simulated level crossing accident at Alice Springs in early 2007.

ATSB safety recommendation RR20080005

The Australian Transport Safety Bureau recommends that the Northern Territory Department of Planning and Infrastructure takes action to address this safety issue.

Safety issue

Road markings on the southern approach to the Fountain Head Road level crossing were either faded to a point where they could not be seen or were missing altogether. 'Sign clutter' on the northbound approach to the level crossing lessened the visibility of the advance level crossing warning sign.

ATSB safety recommendation RR20080006

The Australian Transport Safety Bureau recommends that the Northern Territory Department of Planning and Infrastructure takes action to address this safety issue.

4.5 Pacific National

Safety issue

The portable satellite telephone carried in the lead locomotive of *The Ghan* was the only means of communication (in close proximity) that the train drivers had once the locomotives were shut down. This satellite telephone worked intermittently at best.

ATSB safety recommendation RR20080007

The Australian Transport Safety Bureau recommends that Pacific National takes action to address this safety issue.

Safety issue

Notwithstanding the communication difficulties and the trauma being experienced by the train drivers, notification of the accident to the Pacific National Divisional Control Centre was practically immediate and subsequent updates regular. However, notification to the Genesee Wyoming Australia Train Control Centre was not as timely and updates not as regular.

ATSB safety recommendation RR20080008

The Australian Transport Safety Bureau recommends that Pacific National takes action to address this safety issue.

Safety issue

The data logger on the lead locomotive of *The Ghan* was not recording several key parameters correctly (or at all).

ATSB safety recommendation RR20080009

The Australian Transport Safety Bureau recommends that Pacific National takes action to address this safety issue.

Safety issue

The time stamps on the voice transcripts at the Pacific National Divisional Control Centre were inaccurate by a wide margin.

ATSB safety recommendation RR20080010

The Australian Transport Safety Bureau recommends that Pacific National takes action to address this safety issue.

4.6 Genesee and Wyoming Australia

Safety issue

The time stamps on the voice transcripts at the Genesee and Wyoming Adelaide Train Control Centre were inaccurate by a wide margin.

ATSB safety recommendation RR20080011

The Australian Transport Safety Bureau recommends that Genesee and Wyoming Australia takes action to address this safety issue.

4.7 Great Southern Railway

Safety issue

The passenger survey indicated that the majority of passengers (who responded to the survey) did not know where the emergency exits or door keys were located. A slight majority of these respondents (57 per cent) did not remember receiving (or could not remember the contents of) the safety information that was given at the start of the journey.

ATSB safety recommendation RR20080012

The Australian Transport Safety Bureau recommends that Great Southern Railway takes action to address this safety issue.

APPENDIX A : NATIONAL RAILWAY LEVEL CROSSING STRATEGY

Strategic Response

Issue	***Strategy***
Train Conspicuity	Ensure that road users can see either an approaching train (locomotive or carriages), or a train that is already on the railway level crossing.
Car and Truck Driver Responses	Ensure that drivers identify railway level crossing sites, and respond appropriately.
Pedestrian Responses	Ensure that pedestrians identify railway level crossing sites, and respond appropriately. Ensure that people with disabilities are provided with appropriate information by way of site design and other initiatives.
Site Assessment, Prioritisation and Treatment	Ensure that railway level crossing sites, including pedestrian crossings separate to road crossings, are designed and constructed to an appropriate standard. Develop appropriate Australian design standards for railway level crossing protection equipment including the operation and timing of flashing lights, boom barriers, pedestrian signals and gates, and active advance warning signs. Develop uniform criteria for the establishment of the level of protection for road vehicle and pedestrian crossings. Ensure that designs are appropriate for people with disabilities and other vulnerable road users.
Close level crossings where appropriate.	Investigate low cost treatments including active warning signs, beacons, strobe lights and other alerting devices at railway level crossings.
Stakeholder Education and Information	Develop awareness and understanding through participation amongst the public, engineers, the police and others to improve responses, engineering and enforcement (may be similar to U.S. 'Operation Lifesaver').
Data Collection	Enable effective national data comparisons.
Funding	Seek additional funds for railway level crossing safety. Allocate funds for railway level crossing treatments within the context of broader transport infrastructure priorities.
Rail Industry Involvement	Industry involvement in engineering, education and enforcement programs. Ensure appropriate train standards and operation.
Legislation, Regulation and Enforcement	Ensure that laws and penalties are clear, understood, appropriate and enforced.
Coordination	Develop consistency in information, assessments, standards and practices between States. Implementation of the Strategy should be well managed, co-ordinated, monitored and reviewed.

APPENDIX B : SOURCES AND SUBMISSIONS

Sources of information

GBS Gold Pty Ltd

Downes Graderways Pty Ltd

Great Southern Railway Ltd

Genesee and Wyoming Australia Pty Ltd

Pacific National Pty Ltd

Freight Link Pty Ltd

The Association of American Railroads

The Australasian Railway Association

The Ban Ban Springs Station Manager

The double road-train truck driver

The Bureau of Meteorology

The Ghan Train drivers

The Ghan On-train staff

The Ghan Passengers

The National Transport Council

The National Transportation Safety Board (USA)

The Northern Territory Police and emergency services personnel

The Officers of the Northern Territory Department of Planning and Infrastructure

The Royal Darwin Hospital

USA Federal Railroad Administration

United States National Library of Medicine

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

A draft of this report was provided to:

- The National Transport Commission
- The Northern Territory Department of Planning & Infrastructure
- The Northern Territory Emergency Service
- Great Southern Railway
- Pacific National
- Freight Link Pty Ltd
- Genesee & Wyoming Aust Pty Ltd
- GBS Gold Pty Ltd
- *The Ghan* train drivers
- *The Ghan* Train Manager
- *The Ghan* Gold Kangaroo Manager
- *The Ghan* Night Manager
- The double road-train driver
- Downes Graderways Pty Ltd
- The Ban Ban Springs Station Manager
- The Commanding Officer No. 75 Squadron.

The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

APPENDIX C : MEDIA RELEASE

***The Ghan* level crossing collision: final ATSB report**

The ATSB investigation of a collision between *The Ghan* passenger train and a double road-train has found that the accident occurred because the road-train was driven through a 'Stop' sign at a level crossing at an estimated speed of 50 km/h, linked to local truck driver practice and medical issues.

The final report by the Australian Transport Safety Bureau also found that *The Ghan* hit the road-train just behind its prime mover at a speed of 101 km/h on the afternoon of 12 December 2006 at the Fountain Head Road level crossing at Ban Ban Springs, about 170 kilometres south-east of Darwin.

Both of the train's locomotives, a wagon and nine passenger carriages subsequently derailed. Many of the 64 passengers and 17 staff on board sustained minor injuries with the driver of the road-train and one passenger hospitalised for several days following the collision.

The road-train driver had been carrying road-base material across the Fountain Head Road level crossing about thirty times each day for the previous month and had apparently only seen about four trains in that time. It was the driver's practice, and that of other drivers engaged in the same work, to slow rather than stop at the level crossing.

The train driver had appropriately sounded the locomotive horn three times before the collision and the headlight was illuminated and on high beam.

The investigation found that road-train driver had severe bilateral hearing loss, to the extent that he would not have been eligible to hold his unrestricted heavy vehicle licence, and that this hearing loss would have compromised his ability to hear the locomotive horn in the time leading to the collision.

The ATSB also noted concerns regarding the adequacy of sighting distances at level crossings for vehicles up to 53.5 metres long using such crossings.

The ATSB investigation report acknowledges the initial emergency response measures taken by GBS Gold Pty Ltd and the work being undertaken by the Australian Transport Council, the Northern Territory Government and the Australasian Railway Association in regard to initiatives intended to raise public awareness of the safety risks associated with level crossings.

The ATSB report recommends that relevant authorities consider the issues identified by the investigation in relation to the medical examination of heavy vehicle drivers, sighting distance requirements at level crossings used by high combined gross mass vehicles, driver compliance at railway level crossings, and accident response in light of the remoteness of much of the Northern Territory rail corridor.

Level crossing collision between *The Ghan* Passenger Train (1AD8)
and a Road-Train Truck Ban Ban Springs, NT, 12 December 2006