Australian Government

Australian Transport Safety Bureau

Collision between freight trains 1901S and 5132S

Dry Creek, South Australia | 11 October 2011

Investigation

ATSB Transport Safety Report

Rail Occurrence Investigation

RO-2011-016

Final - 3 April 2013

Australian Government

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SAFETY SUMMARY

What happened

At approximately 0105 on 11 October 2011, empty ore train 1901S, operated by Specialised Bulk Rail Pty Ltd, passed signal 13 displaying a stop indication at Dry Creek Junction in South Australia.

Train 1901S subsequently collided with loaded grain train 5132S, operated by Genesee and Wyoming Australia Pty Ltd, that was travelling in the opposite direction and traversing the turnout at Dry Creek Junction to enter the Dry Creek North Yard.

The collision was at low speed and there was no injury to the train crew of either train. There was significant damage to the crew cab of the lead locomotive of train 1901S and to the grain wagons of train 5132S that were struck during the collision.

What the ATSB found

The ATSB determined that the collision between train 1901S and 5132S was a result of train 1901S passing signal 13 at stop (SPAD). The SPAD of signal 13 was a result of the driver-in-training and co-driver (supervising driver) of train 1901S becoming distracted during the approach to the preceding signal, 135, which was displaying a caution aspect indicating that signal 13 ahead was at stop.

The investigation revealed that a combination of individual actions and systemic issues contributed to the collision. The driver's lack of route knowledge, combined with an expectation of a clear run through the area probably influenced his failure to observe signal 135 at caution. The supervising driver was completing an administrative task that diverted his attention away from the primary task of supervising the actions of the driver-in-training.

The absence of adequate procedures to provide supervising drivers with sufficient direction as to the nature of their supervisory role and to inform of the level of competency attained by a driver-in-training resulted in the breakdown of operational risk controls.

The ATSB investigation explored fatigue impairment as a causal factor related to the SPAD of signal 13. While fatigue impairment was not considered a contributing safety factor in this occurrence, the importance of a rigorous fatigue risk management program subject to continual improvement is highlighted.

What has been done as a result

Following the collision at Dry Creek Junction, Specialised Bulk Rail Pty Ltd amended procedures that clarify the role and responsibilities of a driver supervising a trainee, and introduced arrangements to inform the supervising driver of the trainee's level of competency.

Safety message

Rail operators must implement robust procedures that systematically manage the supervision, training, and assessment of drivers' route knowledge to ensure competency and address any risks inherent in the operational task.

CONTENTS

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

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, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, 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 in the interests of improved transport safety.

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.

Risk level: the ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

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

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

1 FACTUAL INFORMATION

1.1 Overview

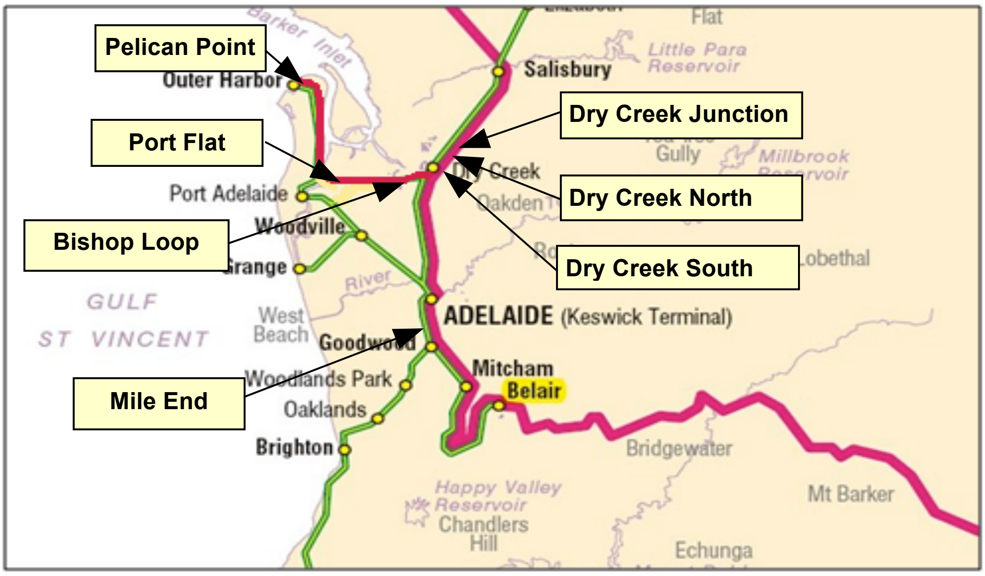
At about 0105[1] on 11 October 2011, empty northbound ore train 1901S travelling on the interstate main line from Pelican Point (Outer Harbor) to Rankin Dam (near Coober Pedy) in South Australia passed signal 13 at Dry Creek Junction displaying a stop (red) indication, an event commonly referred to as a 'Signal Passed at Danger' (SPAD)[2]. Train 1901S subsequently collided at low speed, approximately mid-consist, with loaded southbound grain train 5132S which was travelling in the opposite direction and traversing a turnout at Dry Creek Junction to enter the Dry Creek North Yard.

The collision caused no injuries to the crew of either train. The collision caused significant damage to the crew cab of the lead locomotive of train 1901S and to several grain wagons of train 5132S.

1.1.1 Location

Dry Creek Junction is located approximately 16.8 track kilometres (Figure 1) from Adelaide. It is located on the Defined Interstate Rail Network (DIRN) between Adelaide and Crystal Brook, managed by the Australian Rail Track Corporation (ARTC). Dry Creek Junction enables southbound train movements from the DIRN to access the adjoining Dry Creek North Yard.

Figure 1: Location of Dry Creek Junction



Geoscience Australia. Crown Copyright ©.

[1] The 24-hour clock is used in this report and is referenced from Central Daylight-saving Time (CDT), UTC +10.5 hours.

[2] Signal Passed at Danger – Unauthorised passing of a signal displaying a stop indication. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

The ARTC provides network control, for the portion of the DIRN incorporating Dry Creek Junction, from the network control centre located at Mile End near Adelaide.

Genesee and Wyoming Australia Pty Ltd. (GWA) manage the Dry Creek North Yard from the GWA train control centre located at Dry Creek South; it is not part of the DIRN.

1.1.2 Train information

Train 1901S

Train 1901S was operated by Specialised Bulk Rail Pty Ltd (SBR) and provided a scheduled bulk freight service to the mining industry. It consisted of two locomotives (SCT 014 leading and SCT 015 trailing) hauling a crew van, fuel wagon and 88 PQGY wagons conveying containerised ore and had a total length of 1276 m. At the time of the collision train 1901S was empty travelling on a return trip from Pelican Point to Rankin Dam with a gross mass of about 2398 t. The train was operating with the lead locomotive off-line and the trailing locomotive (SCT 015) providing motive power.

Crew of train 1901S

Train 1901S was crewed by a team of four drivers. The drivers were rostered to operate the train in rotating eight-hour shifts throughout the trip. Two of the crewmembers, a driver (in training) and co-driver (supervising), were operating the train at the time of the collision. The remaining two drivers were in the attached crew van.

The driver had approximately 37 years driving experience in the rail industry interstate, before commencing employment with SBR in April 2011. At the time of the collision, the driver was undergoing route competency training under the instruction and supervision of the co-driver.

The co-driver had approximately 40 years driving experience in the rail industry in South Australia predominantly driving between Adelaide, Cook and Alice Springs, before commencing employment with SBR in August 2011. The co-driver was qualified in route knowledge for the section of track between Pelican Point and Rankin Dam, including the section of track where the collision occurred.

Train 5132S

Train 5132S was operated by GWA. It consisted of three locomotives (705 leading, GM40 and GM47 trailing) hauling 55 wagons containing grain and was travelling from Gladstone (about 225 km north of Adelaide) to Port Flat, South Australia.

Train 5132S was 901 m in total length with a gross mass of 5210 t. Two crewmembers, a driver and co-driver, operated the train. The crew were fully qualified for the sections of track between Gladstone and Port Flat.

1.1.3 Signalling and communications systems

Signalling

A Centralised Traffic Control (CTC) safeworking system[3] governs train movements on the DIRN within the Adelaide metropolitan area, including Dry Creek and Dry Creek Junction. The CTC uses a dedicated telemetry system (Phoenix) to transmit control commands and receive indications between the ARTC network control centre (located at Mile End) and the trackside interlocking equipment, which interfaces with the signals and other equipment.

The Phoenix system segregates the network control commands and indications into functional areas. A number of visual display units indicate the status of controlled signals and other trackside equipment within each functional area. Functional areas are configurable, enabling a Network Control Officer (NCO) to work a single area or combine areas of control as required. At the time of the collision between trains 1901S and 5132S, the NCO was controlling the Adelaide metropolitan and the Western functional area.

The NCO, via remote operation of colour light signals, controls authority for the passage of trains through an area. The colour light signals display both a 'proceed authority' and 'speed information'[4] to the train driver.

At the time of the collision, Dry Creek Junction (Figure 2) comprised two co-acting turnouts (9/9A points) to enable southbound train movements on the DIRN access into the Dry Creek North Yard. The clearance of signal 14 provided the authority to access the Dry Creek North Yard. The clearance of signal 13 provided the authority to proceed through Dry Creek Junction from the southern approach on the DIRN, with the preceding signal 135 providing the train driver with advance warning of the status of the line ahead and whether signal 13 was at stop (red), caution (yellow) or clear (green).

The indications available to signal 135 were:

- Green, indicating that the block ahead is clear and signal 13 is at CAUTION or CLEAR for normal speed
- Yellow, indicating that the block ahead is clear and signal 13 is at STOP
- Red, indicating STOP.

The proper sighting and interpretation of indications displayed by signal 135 was essential for a train driver to manage a train correctly when advancing toward signal 13.

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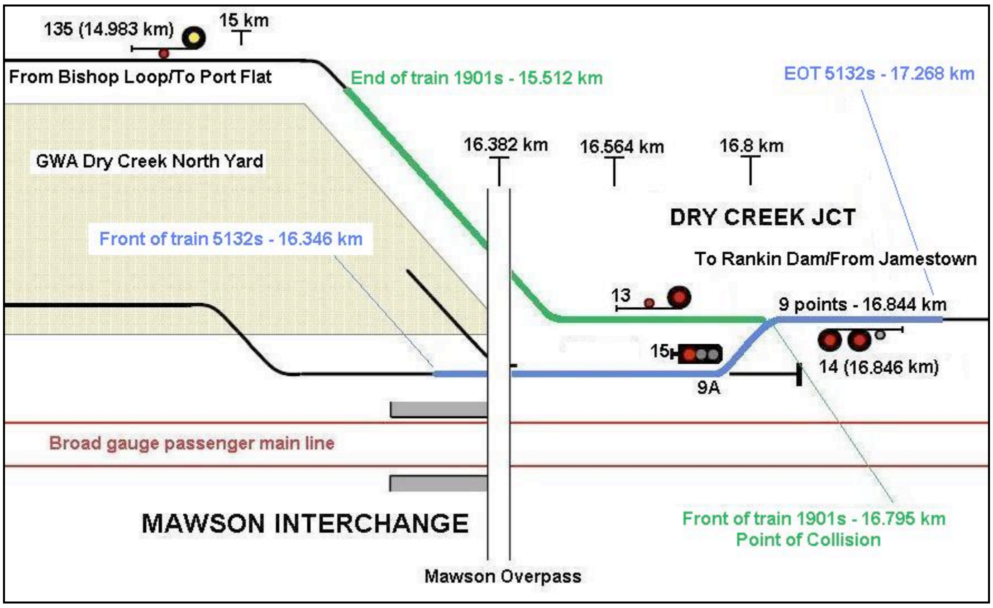
3 Centralised Traffic Control (CTC): A safe working system of remotely controlling points and signals at a number of locations from a centralised control room. (Source: Glossary for the National Codes of Practice and Dictionary of Railway Terminology)

4 Speed signalling – Indicates to a driver maximum permissible speed and that the block ahead is occupied or clear.

Figure 2: Incident site Dry Creek Junction



Communications

The NCO and train crews communicated using a dedicated ultra-high frequency (UHF) radio system. The voice communication system segregated functionality into various areas that coincided with the signalling system. Each functional area operated on a discrete UHF channel, with the Adelaide metropolitan and western control areas operating on UHF channels four and two respectively. At the time of the collision between trains 1901S and 5132S, the NCO was monitoring both UHF channels.

1.1.4 Environmental conditions

Weather observations on the night of the collision were obtained from the Bureau of Meteorology (BoM). The BoM weather station is located at Parafield Airport, approximately two kilometres north of Dry Creek Junction.

At 0100 on 11 October 2011, the Parafield Airport weather station recorded a temperature of 11.6 °C with a relative humidity of 89 per cent and wind speed of 20 km/h, gusting to 28 km/h from the west. The weather station also recorded a light rainfall gauging of 0.2 mm between 0100 and 0118.

The moon phase was waxing gibbous[5], approaching full moon on 12 October 2011.

1.2 The occurrence

On Monday 10 October 2011, train 1901S was assembled at Pelican Point in preparation for the scheduled return mineral service to Rankin Dam. Following the

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[5] Waxing gibbous - after the 'first quarter' (moon showing half) the sunlit portion of the moon continues to increase through to 'full moon'. Source: Geoscience Australia

completion of a holding test[6], train 1901S departed Pelican Point at approximately 2300 and arrived at Bishop Loop near Wingfield about 30 minutes later.

Train 1901S remained at Bishop Loop until the arrival of the rostered working-out train crew, the crew operating train 1901S at the time of the collision. The crew signed on for duty at the SBR Regency Park depot at 0001 on 11 October 2011, and had travelled by road to Bishop Loop. The crew consisted of the incident driver who was under instruction learning the route as a driver-in-training, and a co-driver who was qualified for the route and was supervising the incident driver.

Following their arrival, a handover briefing was undertaken and the working-out crew then took control of the train. The driver of 1901S, the incident driver, contacted the NCO and notified the train's readiness for departure. The NCO advised that clearance would only be given up to signal 1 at Dry Creek South, due to the movement of a train (7DA2) into the Adelaide Freight Terminal and light engines[7] through the Dry Creek crossing loop.

At about the time that train 1901S was preparing to leave Bishop Loop and travel northwards through Dry Creek, train 5132S was at Two Wells (about 29 track kilometres to the north of Dry Creek Junction) where it had crossed an opposing train and was beginning to travel south towards Dry Creek.

Train 1901S departed Bishop loop at about 0030 and proceeded to signal 1 at Dry Creek South where it remained for approximately 20 minutes, waiting for train 7DA2 to clear the main line. During this time, the light engines also cleared through the Dry Creek crossing loop. Shortly after train 7DA2 cleared the main line, signal 1 displayed a proceed[8] aspect. Train 1901S then entered the main line and accelerated towards Dry Creek North. Meanwhile, train 5132S had departed Two Wells and was travelling towards Dry Creek. In preparation for receiving 5132S into the Dry Creek North Yard, the NCO pre-set points 9/9A and signal 14 at the northern end of Dry Creek Junction to direct the train into the yard. Signal 13 was at stop.

Train 1901S continued towards Dry Creek North passing three signals at proceed before approaching signal 135 (Figure 2). At about this time the driver of train 1901S observed the bright headlights of what he believed to be a locomotive undertaking shunting operations at the northern end of the Dry Creek North Yard which was ahead and slightly to the right of his direction of travel. Train 1901S continued past signal 135, towards signal 13 at Dry Creek Junction, maintaining a speed of about 60 km/h.

The headlights were from train 5132S, which was traversing the turnout (9/9A points) at Dry Creek Junction at a speed of approximately 15 km/h, entering the shunt main track that runs parallel to the ARTC main line. Approximately 22

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6 Air brake examination to check that the brakes on the last three vehicles of a train will remain applied for a predetermined time in the event of a breakaway. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

7 A locomotive or locomotives coupled without vehicles. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

8 When applied to the aspect of a fixed signal means the caution or clear indication. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

wagons of train 5132S had cleared the fouling point[9] and the remainder of the train (33 wagons) still occupied the main line.

The lead locomotive of 5132S was within the shunt main as train 1901S approached along the main line. The driver of 1901S flashed the headlight and operated the locomotive warning device to alert the crew of 5132S to dim the headlights of their locomotive. As the front of train 1901S passed the lead locomotive of 5132S the crew of train 1901S observed signal 13 at stop and saw that the remaining wagons of train 5132S occupied the line ahead.

The driver of train 1901S made an emergency application of the train brake approximately 100 m prior to signal 13, however train 1901S passed the signal at stop and travelled a further 218 m before colliding approximately mid consist with train 5132S.

As train 1901S passed signal 13, the Phoenix screen at the Mile End network control centre showed an alarm display, alerting the NCO that 1901S had passed signal 13 at stop. The NCO in response attempted to contact the crew of train 1901S by radio but received no reply.

1.2.1 Post occurrence

Immediately following the collision, the driver of the train 5132S contacted the ARTC network control officer at Mile End declaring an emergency and a suspected collision. The ARTC network control officer attempted again to call train 1901S but was unable to contact the crew by radio.

At this time, the crew of the train 1901S had detrained from the lead locomotive (SCT 014). The driver had proceeded back along the train to check the welfare of the resting crew in the crew van, while the co-driver contacted the SBR Train Co-ordinator by mobile telephone to notify of the collision. The co-driver then made a series of other telephone calls to notify various parties, including ARTC Network Control. There were no reported injuries to the crew of train 1901S or 5132S.

The collision caused train 1901S to uncouple at several locations along its length. There was significant damage to the lead locomotive, so the crew of 1901S shut down and isolated this locomotive from the remainder of the train. In the process of isolating the lead locomotive and transferring the brake control to the trailing locomotive (SCT 015), the brakes released along the train.

GWA staff responding to the incident from the GWA Dry Creek South depot noted the train brakes on 1901S releasing and observed that an uncoupled portion of the train had begun to roll away. When the brake hoses separated, air exhausted from the airline and the brakes automatically re-applied. As a safety precaution, GWA staff then secured the uncoupled portion of train 1901S by the application of a number of wagon handbrakes.

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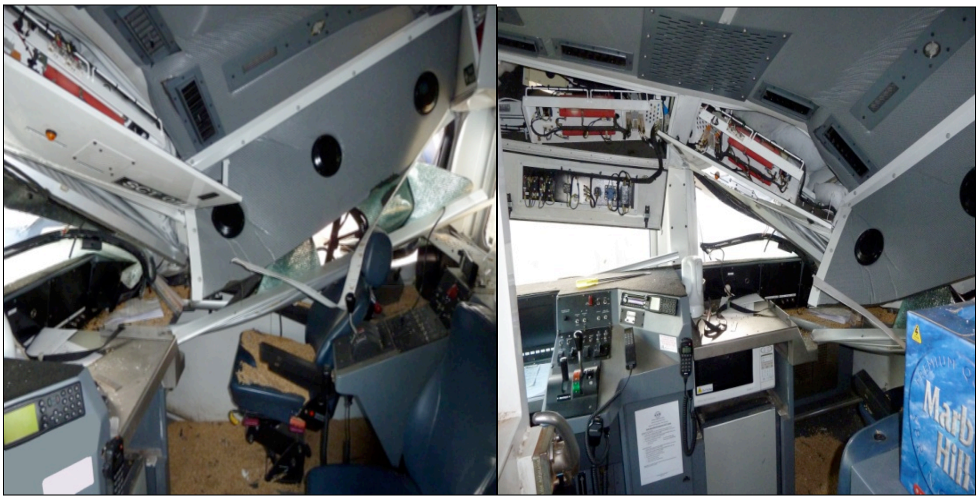
9 The position on a siding or secondary track beyond which a vehicle will foul the structure gauge of the main track. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

Damage to rolling stock and track

The collision resulted in significant damage to the right-hand side of the driver compartment (Figure 3) and lead bogie of the lead locomotive, SCT 014, of train 1901S. The extent of damage meant that the locomotive was not movable until the completion of an inspection and temporary repairs on site.

Figure 3: Internal collision damage to locomotive SCT 014 driver compartment



The impact with train 5132S was approximately mid consist, resulting in significant damage to three wagons (CGAY 899H, CGAY 896D, CGAY 903D), splitting the side of each and causing grain to spill onto the track (Figure 4). The impact force from the collision also caused wagons CGAY 896D and CGAY 903D to derail.

Following the removal of grain and re-railing, GWA removed the damaged CGAY wagons for stabling.

Figure 4: Collision damage to the side of CGAY 896D

An inspection of the track revealed that there had been minimal damage to the infrastructure, requiring only minor repairs to the alignment and turnout rails. The ARTC reopened the track to rail traffic at 2310 on the day of the incident following the replacement of a short length of rail and associated fastenings in the turnout.

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2 ANALYSIS

At 0204 on 11 October 2011, the Australian Transport Safety Bureau (ATSB) received notification from ARTC of a main line collision involving two freight trains at Dry Creek North.

The ATSB dispatched two investigators, who arrived on site at about 0300 on 11 October 2011. The ATSB investigators photographed evidence and plotted the position of rolling-stock, signals and track at the accident site and interviewed the crew of train 1901S. This information was later supplemented with the information provided by the crew of train 5132S, Phoenix images, voice logs, train data logs and various safety management procedures from each operator.

Based on the initial examination of the evidence it was determined that:

- There were no deficiencies in the track condition that contributed to the collision
- There was no indication of any mechanical deficiencies with train 5132S that contributed to the collision
- Train 5132S was managed and driven in an appropriate manner. The actions of the train driver in the handling of 5132S did not contribute to the collision. At the time of the collision, the crew of train 5132S was appropriately qualified and route certified. Both drivers were assessed medically fit in accordance with the *National Standard for Health Assessment of Rail Safety Workers* and had signed on fit for duty.

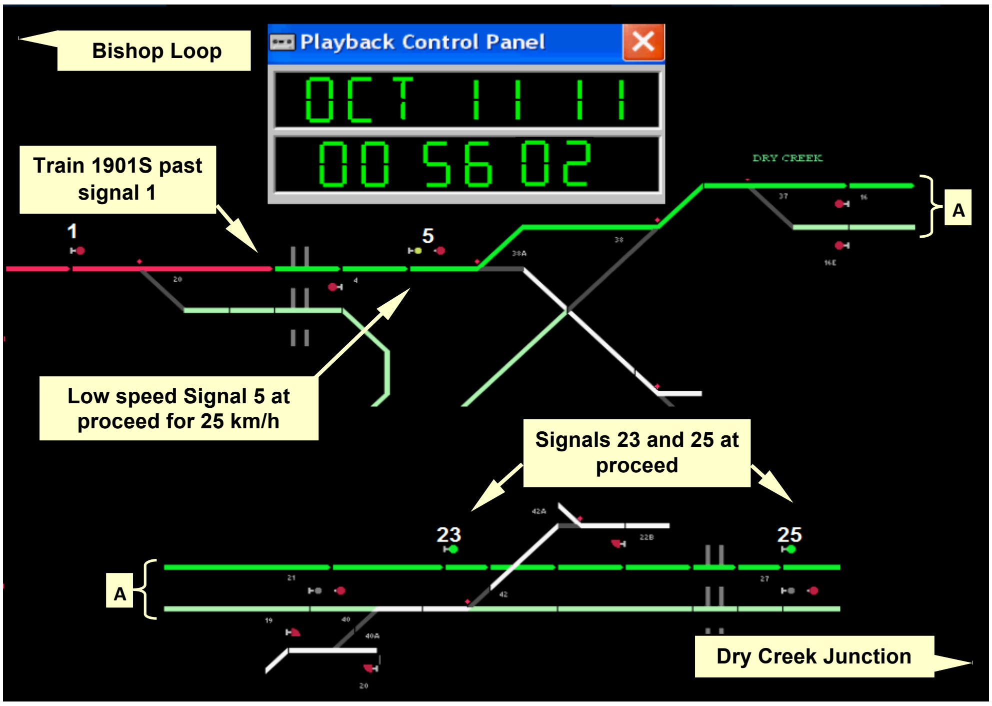
2.1 Sequence of events analysis

The following reconstruction of the events is based on information obtained from statements given by the train crews involved in the collision, data obtained from the locomotive data loggers, the replay of network control centre voice logs and Phoenix display files.

Following the handover briefing with the previous train crew the working-out train crew went to the cab of locomotive SCT 014. The incident driver (hereafter referred to as the driver) communicated with the ARTC Network Control Officer (NCO) indicating readiness for train 1901S to depart Bishop Loop. Extracts from the ARTC network control voice logs established that, prior to clearing the Bishop Loop departure signal, at about 0027, the NCO advised the driver that there were two other train movements at Dry Creek and that train 1901S would be held at signal 1, Dry Creek South, until these trains had cleared the area. There was no mention at that time or subsequently of other opposing train movements in the Dry Creek area.

Train 1901S departed Bishop Loop arriving at signal 1, Dry Creek South at about 0033. When train 7DA2 and the light engines had vacated Dry Creek South, signal 1 cleared to proceed. Train 1901S entered the triangle connecting the railway from Pelican Point to the main line (Figure 5) passing signal 1 at 0056:02. The driver then proceeded to advance train 1901S through Dry Creek in accordance with the signal indications.

Figure 5: Reconstruction of Phoenix playback showing signal indications as train 1901S passed signal 1 and entered triangle



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As train 1901S progressed through Dry Creek, the driver and co-driver cross checked the signal indications and discussed an appropriate driving strategy for the track ahead. They determined that there was a slight rising grade[10] and decided to accelerate the train to a target speed of 60 km/h due to a Temporary Speed Restriction (TSR) of 60 km/h just prior to the Mawson Overpass at Dry Creek North. To achieve the target speed, the driver began to apply power increasing the train speed as they approached signal 25 at Dry Creek. An examination of the locomotive data log confirms the application of power to throttle notch T8 (full power position). The data log also shows the throttle remained in notch T8, increasing the train speed towards 60 km/h (Figure 6) as the train passed signal 135.

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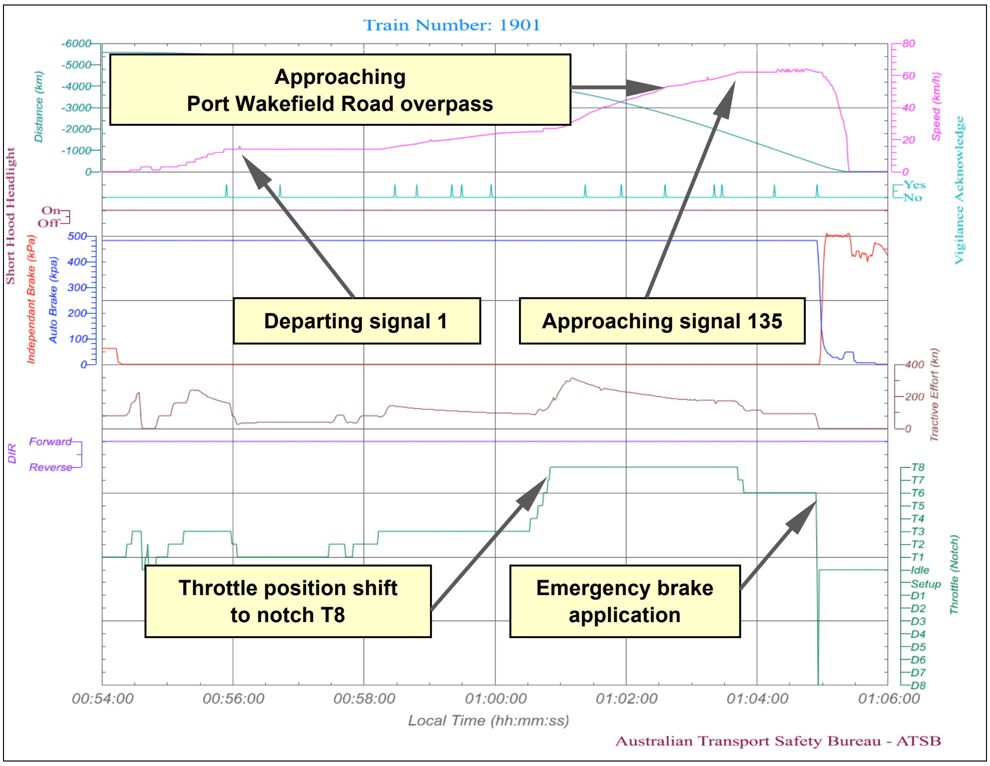
10 The rate of slope of the surface of the track in the direction of travel. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

Figure 6: Data log extract from train 1901S showing speed and throttle settings as it approached signal 135

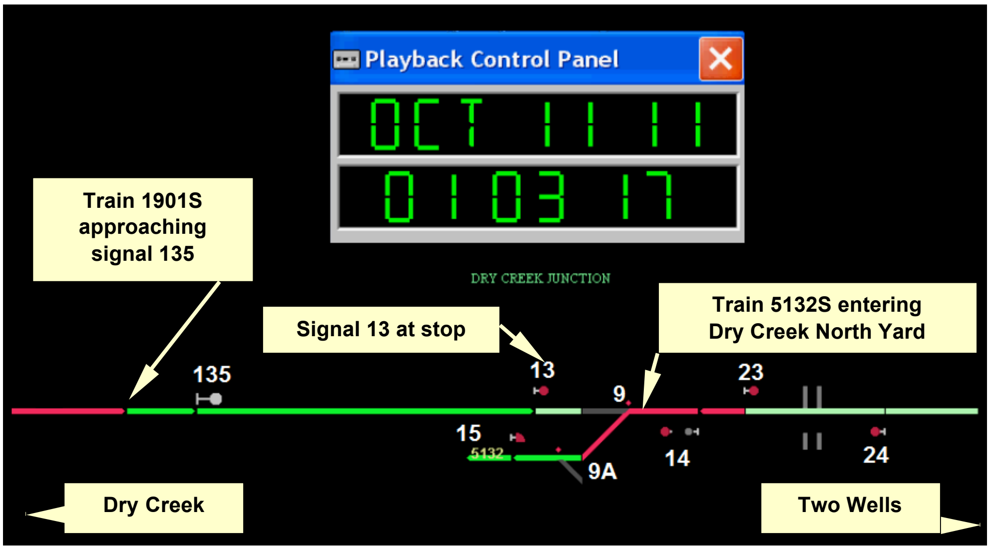


At about 0102, as train 1901S approached the Port Wakefield Road overpass, with signal 135 beyond, the co-driver contacted the SBR Train Co-ordinator in Melbourne by mobile telephone and reported the train's departure from Bishop Loop. During this period, the co-driver was fully engaged in the task of reporting the train running information to the NCO, so had diverted his attention from the primary tasks of observing the track ahead and monitoring the actions of the driver.

Shortly after, train 1901S had progressed under the Port Wakefield Road overpass and approached signal 135, the driver diverted his attention to the bright headlights of a locomotive at the opposite end of the Dry Creek North Yard, which was slightly to the right in the direction of travel. The driver and co-driver later stated that they had assumed the lights were from a locomotive shunting within the Dry Creek North Yard, and had begun a discussion about the practice of having headlights on high beam in a yard.

There was, however, no locomotive shunting within the Dry Creek North Yard at that time. An examination of the Phoenix playback later established that the headlight was that of the lead locomotive (705) on train 5132S, which was moving southwards and entering the Dry Creek North Yard (Figure 7).

Figure 7: Extract from Phoenix playback, Train 1901S as it approached signal 135 and Train 5132S entered Dry Creek North Yard



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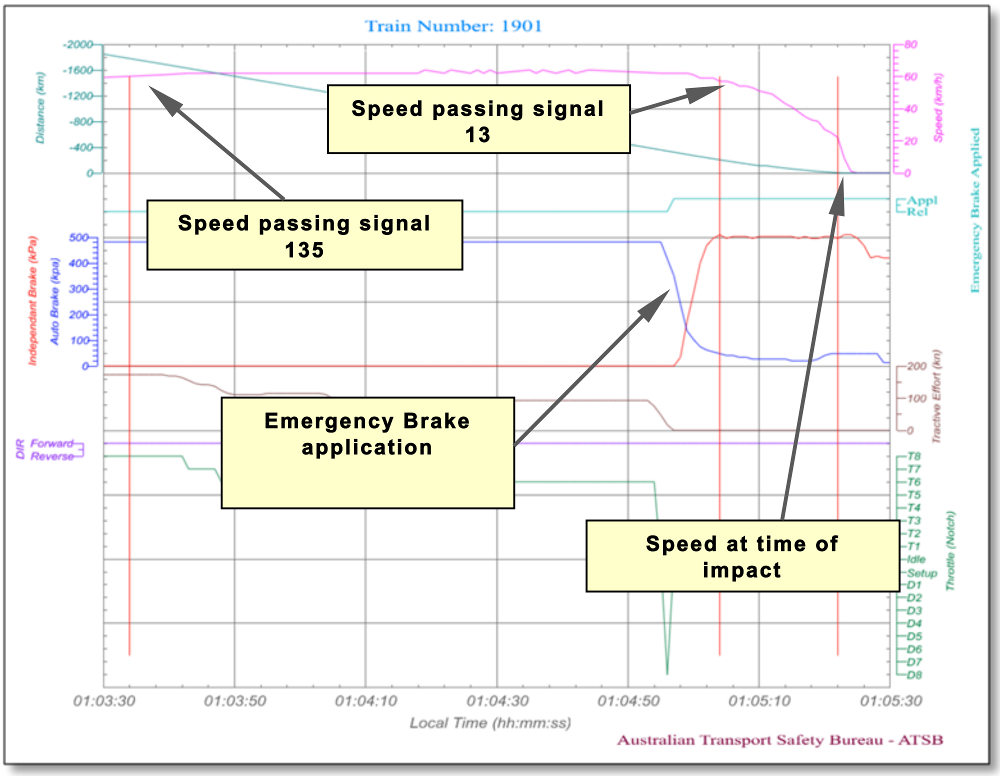
Train 5132S had passed signal 14 at Dry Creek Junction at about 0102 and traversed turnout (9/9A points) that connects into the main line at Dry Creek North Yard. The driver of 5132S stated he was proceeding through Dry Creek Junction cautiously and had the headlight (on locomotive 705) on low beam with the ditch lights on so he could check the position of the points ahead. The crew of 5132S stated that as they passed under the Mawson Overpass they saw the headlight of 1901S ahead.

An examination of the data log of locomotive 705 confirmed that train 5132S was travelling at low speed (15 km/h) as it passed through Dry Creek Junction. The driver further reduced speed to 8 km/h as the train passed under the Mawson Overpass.

Shortly after 0103, train 1901S passed signal 135 (Figure 8). The driver and co-driver both stated that they did not recall observing signal 135 (yellow-Caution), which would have provided advance warning about the status of signal 13 ahead (at stop).

As 1901S progressed towards Dry Creek Junction, the driver continued to maintain a relatively constant speed of about 60 km/h. The driver remained distracted by the bright headlights ahead and, believing that the opposing train was engaged in shunting operations in the yard, he flashed his headlight to prompt the driver of the locomotive ahead to dip his lights.

Figure 8: Data log extract from train 1901S showing the relative position of signals 135 and 13, and the speed at time of impact with train 5132S

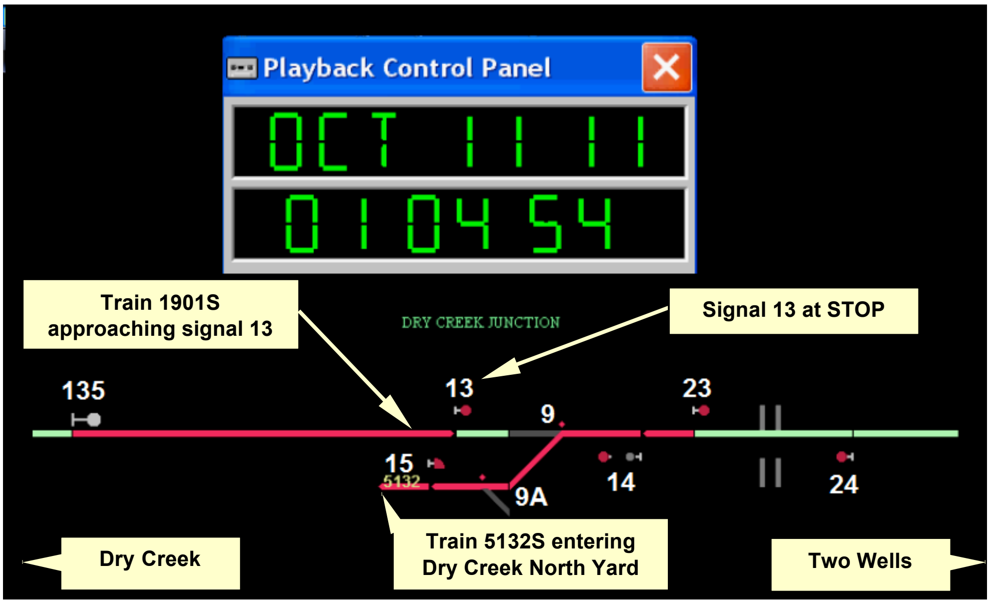


The driver and co-driver continued to focus their attention on the locomotive ahead, and continued their discussion on the practice of having bright lights on in a yard, remarking that it made it hard for the drivers of an approaching train to see ahead.

It was established that when train 1901S had passed the lead locomotive of 5132S, the driver and co-driver (1901S) sighted signal 13 at stop (Figure 9) and saw the back end of train 5132S occupying the main line ahead.

The data log of locomotive SCT 014 recorded that at 0104:57 (approximately 100 m from signal 13) the driver made an emergency brake application. Train 1901S passed signal 13 displaying a stop aspect at 0105:03, and travelled a further 218 m before colliding at a speed of approximately 22 km/h with the wagons mid consist of train 5132S.

Figure 9: Extract from Phoenix playback, train 1901S approaching signal 13



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As part of the preliminary analysis it was determined that the correct observation of signal 135 and appropriate response to the signal aspect was essential for train 1901S to be brought to stand at signal 13 Dry Creek Junction. In addition, train handling and train braking performance may have been factors that contributed to the collision.

The balance of the report therefore focuses on examining the most probable factors that contributed to the collision including:

- The correct operation of the signalling arrangements at Dry Creek Junction
- Identification of any mechanical deficiencies with train 1901S that may have contributed to the collision
- The actions of the train crew of 1901S, including train handling and the factors that may have influenced those actions
- Rail resource management and organisational procedures for the management of crew training, supervision and pairing.

2.2 Signalling

The design of the signalling system through this area requires that signal 135 should display a caution normal speed (yellow) if signal 13 is at stop. An examination of the Phoenix playback file confirmed that signal 13 was at stop from around 0056, when train 1901S departed signal 1 at Dry Creek South through to the SPAD event at around 0105.

The Phoenix playback file, by design, does not show whether signal 135 is displaying a stop, clear normal speed aspect (green) or caution normal speed aspect (yellow) as it was an automatic signal.[11] Although the driver and co-driver do not recall sighting the indication displayed by signal 135, ARTC conducted a test of signal 135 shortly after the collision. It was determined that the signal aspects displayed were in accordance with design, that is when signal 13 was at stop, signal 135 displayed a yellow aspect. Observations by investigators shortly after the collision found that signals 135 and 13 were clearly visible (i.e. at full luminescence with sighting unobstructed) for approaching trains. Investigators observed that there was no obvious permanent background lighting that may have interfered with the sighting of the signals.

ARTC advised that there was no record within their SIMS[12] database of wrong-side-signal failures[13], signals passed at danger (SPAD) or signal sighting issues, associated with signals 135 or 13 for the period 1 July 2007 to 10 October 2011. There was no evidence to indicate that the signalling system was faulty and it was therefore concluded that signal 135 had correctly displayed a yellow aspect (caution) during the period that train 1901S had approached it.

2.3 Train braking performance

Specialised Bulk Rail operated train 1901S in accordance with the braking performance parameters outlined in the *Draft Code of Practice for the Defined Interstate Rail Network – Volume 5: Rolling-stock.*

Appendix A of the Draft Code lists the maximum stopping distances for freight trains categorised as either Long Express Freight or Medium Freight, depending on the train length and trailing mass. Braking performance detailed in the standard was for a full service brake application on level track.

Train 1901S with a trailing mass of 2130 t and a total length of 1276 m was categorised as a long express freight train. Based on a speed of 60 km/h, the specified stopping distance for a long express train is 776 m.[14]

An examination of the data log from SCT 014 found that 1901S was travelling at a speed of 62 km/h immediately prior to the emergency brake application, at a distance of 321 m from the point of collision. The application of emergency braking decelerated train 1901S to a speed of 22 km/h at the point of collision with train 5132S.

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11 A signal that is normally controlled exclusively by the operation of track circuits. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology

12 Safety Incident Management System is the ARTC database that stores Train Control Reports entered by Network Control Officers of events reported on the network. Records prior to 1 July 2007 were archived.

13 A failure in the signalling system which causes a potentially dangerous situation to exist. For example, if a train is not detected by the signalling system, or if a train is approaching a level crossing and the flashing lights and/or boom gates fail to operate, or where a proceed signal is displayed where a Stop signal should be displayed. (Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology)

14 Draft Code of Practice for the DIRN. Vol 5. Rolling Stock Standard.

An evaluation of the deceleration performance of train 1901S (undertaken by an independent consultancy on behalf of SBR) determined that, had a collision not occurred, the predicted additional distance to reach a complete stop was in the order of 32 m after the point of impact. The total braking distance between the emergency brake application and the predicted point where train 1901S would have come to rest was therefore in the order of 350 m.

The overall braking distance to stop train 1901S with the emergency brake application was around half that specified for a full service brake application and was therefore within the operational limits specified for train 1901S.

Both the driver and co-driver stated that following the application of the emergency brake, they believed that there was sufficient distance ahead and they expected the train to stop prior to colliding with 5132S. In this case, it is likely that the drivers' perception of the distance ahead and the train's braking performance was distorted due to the high stress situation being experienced by them at that time.

In situations of high stress, such as that experienced in the moments leading up to a collision, it is common for individuals' attention to be directed away from temporal cues, thus distorting their ability to accurately assess time passing.[15] In this situation, the drivers' attention was instead directed towards external spatial cues, such as the light of the other train, and the tasks required such as the application of the emergency brake. This is often experienced as "time slowing down" wherein individuals in emergency situations will commonly recall perceiving that they had more time to recover the situation than the real time actually permitted. Given the potentially life threatening cues presented to both drivers upon realisation of the imminent collision, it is likely that their misperception of the distance covered after application of the brake was due to time perception distortion.

2.4 Train crew

Both the driver and co-driver (supervising driver) of 1901S, while having had extensive driving experience, were relatively new employees of SBR with approximately 5 months and 2 months service respectively.

An examination of the SBR roster found that since commencing employment with SBR, the driver had undertaken 14 return trips as a member of the train relay crew on the ore train service between Pelican Point and Rankin Dam. Of those trips, he had been rostered on six occasions to work as a second person in the cab of the locomotive through Dry Creek to Port Augusta. Prior to the night of the collision, the last occasion that the driver was in the cab through Dry Creek travelling to Port Augusta was 1 September 2011, almost 6 weeks earlier.

A review of the SBR documentation found records of competency, for the driver, in various units of the Transport and Logistics (Rail Operations) qualification as well as the Code of Practice and addendums applicable to the DIRN. Further, he had been assessed as competent in route knowledge to operate, as a second person, for the sections between Islington and Dry Creek North, and as a qualified driver for

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15 Hancock, P.A. & Weaver, J.L. (2005). On time distortion under stress. *Theoretical Issues in Ergonomics Science. 6 (2)* 193–211.

the sections between Tarcoola and Manguri, which is located about 35 km to the north of Rankin Dam.

SBR accepted the co-driver’s route knowledge qualifications, obtained through his previous employer, as current, when he commenced employment. SBR did however recertify the co-driver in the theory component of the Code of Practice and addendums applicable for the DIRN. Based on his position as a qualified locomotive driver, SBR considered the co-driver to have the requisite skills to provide supervision and to allocate duties to a driver-in-training.

SBR had only recently paired the driver and co-driver in the crew roster. They had worked train1901S, as a pair on two previous occasions. On both of those occasions, they had been rostered to rest in the crew van as the train travelled through Dry Creek toward Port Augusta. The night of the collision was the first time that the driver and co-driver had been rostered to operate the locomotive together on this section of track since they had joined SBR. It was also the first time the driver had driven a train on the main line through Dry Creek Junction.

2.5 Factors affecting train crew actions

Given the significant distance required to stop a freight train travelling at main line speeds, the vigilance of the crew is essential to ensure that signal aspects and other cues are perceived and actioned appropriately to enable effective train handing. Having established that the train crew did not respond to the preceding signal (signal 135) displaying the correct aspect during the approach of train 1901S, the remaining analysis focuses on factors influencing the actions of the driver and co-driver, namely the non-observation of signal 135 and the subsequent late response to signal 13.

The primary task of the driver was to control the movement of train 1901S to safely negotiate the track section ahead. Similarly, the primary task of the supervising driver in this instance was the normal co-driver tasks plus providing supervision of the driver to ensure his actions in controlling the train were appropriate for the conditions ahead.

The tasks required by the driver and co-driver were to observe and crosscheck the correct interpretation of signal indications, and to respond to potential hazards. If the attention of the driver or co-driver was elsewhere, then this may have reduced their capacity to correctly perceive the indication displayed by a signal ahead or comprehend cues to the potential of a conflicting train movement.

Human information processing is limited in that each person has finite mental or attentional resources available to attend to information or perform tasks at any particular time. In general, if a person is focussing on one particular task, then their performance on other tasks will be degraded.[16]

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16 Kahneman, D. (2011). *Thinking Fast and Slow.* Farrar, Straus & Giroux: New York.

In the context of a train crew responding to a signal indication, the extent of performance degradation may depend on factors such as:

- the extent to which the signal is conspicuous or easy to observe
- the extent that a particular signal indication is expected
- the train crew workload at that point in time and the existence of any distractions
- task competence including factors such as driving experience, route knowledge and crew coordination
- the influence of other factors such as fatigue, drugs, alcohol or a medical condition.

2.6 Signal conspicuity

Signal 135 was located to the left of the track at the 14.983 track km point and is approximately 1571 m in advance of signal 13 (Figure 2). At 0103, as train 1901S approached signal 135, the moon was at an azimuth of 335 49', an altitude of 46 50' and approaching full moon, but the weather was overcast.

Investigators attending the site shortly after the incident observed that the indication displayed on signal 135 was clearly visible and it was unlikely that ambient light conditions or permanent background lighting impeded its conspicuity. An examination by ARTC of signal 135 on the following day, established that the signal lenses were in good condition, the signal mechanism was operating correctly and the aspect displayed would have been distinct and clearly visible for a distance of at least 600 m. There were no physical obstructions observed that may have compromised the drivers' view of the signal. As a result, the sighting of signal 135 was not a factor in the incident.

2.7 Expectancy

The ARTC voice recordings show that the NCO had advised the crew of 1901S, prior to their departure from Bishop Loop, that there would be a delay at signal 1 due to other train movements, including some light engines moving through the Dry Creek crossing loop. The driver of 1901S stated that whilst stopped at signal 1, he had observed only one train (7DA2) travelling towards the Adelaide Freight Terminal. At that time, it was likely that the driver formed an expectation of sighting one remaining movement on the track ahead, a light engine.

The driver reported that when the NCO cleared Signal 1 to proceed and as 1901S progressed towards Dry Creek, he and the co-driver developed a driving plan focussed on increasing the train's speed to 60 km/h. They based their plan on the assumption that they would now have a clear run on the main line, with a chance of sighting a light engine operating on an adjacent line. It appears that the driver of 1901S formulated a mental model, which assumed he had all available train movement information for the journey through the Dry Creek area. This was not the case.

The NCO did not provide any incorrect information. He was not procedurally obliged to inform the crew of 1901S of the presence of train 5132S approaching from the opposite direction and in this instance did not do so.

The crew's expectation of a clear run on the main line, reinforced by a sequence of three signals at proceed, probably also influenced their false perception that the headlight of the opposing train was a locomotive undertaking shunting operations in the Dry Creek North Yard. They did not perceive the headlight to be that of an opposing train (5132S) moving from the main line into the yard.

2.8 Workload and distraction

At the time of approach to signal 135, the co-driver was engaged in a phone conversation with the SBR Train Coordinator, and was completing paperwork required for the trip. This competing administrative task diverted the co-driver's attention from his primary task of supervising the actions of the driver during the period that the train was approaching signal 135. This had the effect of the co-driver not observing signal 135 displaying a caution aspect.

At about the same time the driver's attention was diverted from scanning for signals by the appearance of an opposing train headlight. With his attention focussed on the headlight ahead, he did not detect signal 135 displaying a caution indication. With both driver and co-driver distracted from the task of signal sighting, train 1901S then passed signal 135 with neither the driver nor co-driver observing it displaying a caution aspect.

2.9 Task Competence

2.9.1 Role of the supervisory driver

Tuition of route knowledge and two driver operations are safety measures employed within the rail industry to mitigate the risk of train driver error. Route knowledge provides drivers with situational awareness and the ability to plan operations by allowing them to think ahead and anticipate future requirements,[17] as well as enabling driver detection of abnormal track conditions. To that end, drivers are required to demonstrate sound route knowledge through an assessment of competency for each route they drive.

Similarly, the intent of two driver operations is to provide redundancy for the variability of normal human performance, in that a single driver may miss a critical signal, whereas two drivers are less likely to do so. A second driver also permits cross checking of signals and other cues. In a situation where one driver is undergoing training to develop route knowledge, these risk mitigations may be less effective. The vigilance of the supervising driver to the driving tasks and visual cues therefore becomes of particular importance in ensuring safe operations.

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[17] McLeod, R.W., Walker, G.H., Moray, N. & Mills, A. (2005). Analysing and Modelling Train Driver Performance. In J.R. Wilson, B. Norris, T. Clarke & A. Mills (Eds.), *Rail Human Factors. Supporting the Integrated Railway* (pp 70-80). Ashgate: Aldershot.

At the time of the incident, both the driver and co-driver had considerable train driving experience, but were also both new employees with SBR. The driver was new to the area of operations and considered by SBR to be a driver-in-training for this route. The co-driver was qualified and certified as competent to drive the route, and therefore assessed to be suitable as a supervising driver. Comparable driving experience and comparable company experience can make for a complex social dynamic between a pair of drivers, where the roles of leader and follower are not as clearly defined as might be the case with a combination of a senior driver and junior driver. In this situation, definition and acceptance of leader and follower roles and tasks becomes an important risk mitigator in managing the crew dynamic for effective performance.

The SBR Safety Management System (SMS) included a range of procedures to address the management of worker competency for a main line locomotive driver. An examination of the relevant SMS procedures provided by SBR found that they did not provide the co-driver with sufficient direction as to the nature of his supervisory role for a driver-in-training. The co-driver had not been provided with training or guidance on the nature or level of the supervisory tasks required of him. Nor did he have available to him relevant records detailing the driver's progress / stage of training on the route, which would have enabled him to assess any risks inherent in the task.

Additionally, it was not clear on the roster or in other documentation that the co-driver's role for this shift was a supervisory one. As a result, the co-driver was obliged to rely solely on his own knowledge and experience of the driver, to make a judgement about the nature and priority of his supervisory and other tasks.

After establishing a driving plan with the driver, the co-driver diverted his attention from supervising the actions of the driver to the conduct of secondary communication and administrative tasks. Had the co-driver been provided with sufficient guidance as to the priority of his supervisory role over these secondary tasks, and therefore been fully engaged in assuring the safe operation of the train by observing the track ahead, as well as the actions of the driver, it is more likely that he would have seen signal 135 and drawn the driver's attention to the signal displaying a caution indication.

2.10 Toxicology, medical and physiological factors

The driver and co-driver of train 1901S were each tested for the presence of alcohol post incident; the results indicated 0.00 per cent blood alcohol concentration. There was no evidence to suggest that either the driver or co-driver's actions were affected by alcohol.

An examination of the driver's and co-driver's health assessment records confirmed that health assessments were current and that the individuals had been assessed as meeting the required standard, prescribed by the *National Standard for Health Assessment of Rail Safety Workers*. There was no evidence to suggest that any medical or physiological factors affected their performance leading up to or during the incident.

2.11 Fatigue management

2.11.1 Fatigue

In the context of human performance, fatigue is a physical and psychological condition primarily caused by prolonged wakefulness and/or insufficient or disturbed sleep.[18] The National Transport Commission recognises five main factors contributing to fatigue impaired work performance, including:

- the duration of a duty period (time on task), and the rest breaks within and between shifts
- inadequate sleep (or sleep debt), which results from inadequate duration and quality of prior sleeps
- circadian effects, which involve working and sleeping against natural body rhythms that normally program people to sleep at night and be awake and work during the day
- the type or nature of the task being undertaken (workload)
- the work environment.

Fatigue can have a range of influences on performance, such as decreased short-term memory, slowed reaction time, decreased work efficiency, reduced motivational drive, increased variability in work performance, and increased errors of omission.[19] Fatigue impairment has been identified as causal factor in accidents and incidents such as SPADs.

Both the driver and co-driver were rostered off duty on 8 October 2011. The driver worked from 0200 to about 0700 on 9 October 2011, and the co-driver worked from 1400 to 2230 the same day. Both reported having a normal sleep on the night of 9 October, and neither was rostered on duty on 10 October. Both the driver and co-driver also reported obtaining some sleep in the evening of 10 October prior to signing on at 0001 on 11 October, and neither reported feeling fatigued at the start of the shift. As the collision occurred just over one hour into the shift, it is unlikely that the crew were experiencing a significant level of acute fatigue either leading up to or at the time of the collision.

Table 1 shows the drivers' roster for the planned trip. Although fatigue impairment was unlikely to have existed at the start of the trip, some aspects of the planned roster indicated the potential for fatigue to develop during the relay operation, unless sound fatigue risk management practices were in place.

The use of rostering patterns similar to that illustrated in Table 1 for train crew undertaking relay operation is becoming more prevalent in sectors of the rail industry. Drivers' ability to obtain sufficient restorative sleep during rest breaks between work periods is therefore critical in supporting safe relay operations. Accordingly, the ATSB examined aspects of the operator's fatigue risk

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18 National Transport Commission (2008). *National Rail Safety Guideline. Management of Fatigue in Rail Safety Workers.*

19 Battelle Memorial Institute (1998). *An Overview of the scientific literature concerning fatigue, sleep, and the circadian cycle*, Report prepared for the Office of the Chief Scientific and Technical Advisor for Human Factors, US Federal Aviation Administration.

management system with the objective of fostering the principle of continuous improvement in operators' fatigue risk management programs.

Table 1: Train 1901S Crew Roster

	Day 1	Day 2	Day 3
Driver 1	Prep Train 1901S 1630 - 2359	0001 – 0800 (Rest) 0800 – 1600 (Work) 1600 – 2359 (Rest)	0001 – 0800 (Work) 0800 – 1600 (Rest) 1600 – 2359 (Work)
Driver 2	Prep Train 1901S 1630 - 2359	0001 – 0800 (Rest) 0800 – 1600 (Work) 1600 – 2359 (Rest)	0001 – 0800 (Work) 0800 – 1600 (Rest) 1600 – 2359 (Work)
Driver 3	-off-	0001 – 0800 (Work) 0800 – 1600 (Rest) 1600 – 2359 (Work)	0001 – 0800 (Rest) 0800 – 1600 (Work) 1600 – 2359 (Rest)
Driver 4	-off-	0001 – 0800 (Work) 0800 – 1600 (Rest) 1600 – 2359 (Work)	0001 – 0800 (Rest) 0800 – 1600 (Work) 1600 – 2359 (Rest)

2.11.2 Sleep requirements

It is generally agreed that most people need at least seven to eight hours of sleep each day to achieve maximum levels of alertness and performance. A review of relevant research concluded:

> …we can make broad assumptions from existing literature that obtaining less than 5 h sleep in the prior 24 h, and 12 h sleep in the prior 48 h would be inconsistent with a safe system of work. Furthermore, wakefulness should not exceed the total amount of sleep obtained in the prior 48 h. [20]

Subsequent research has indicated support for these proposals, with notable increases in accident rates or task performance errors when sleep is reduced below five to six hours in a 24-hour period[21,22,23]. Therefore, when considering the rostering of rest breaks, it would be prudent to ensure that drivers are provided with rest periods that afford at least six hours of restful sleep in each 24-hour period.

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20 Dawson. D. & McCulloch, K. (2005). Managing fatigue: It's about sleep. *Sleep Medicine Reviews, 9,* 365-380.

21 Dorrian, J., Sweeney, M., & Dawson, D. (2011). Modelling fatigue-related truck accidents: Prior sleep duration, recency and continuity. *Sleep and Biological Rhythms, 9,* 3-11.

22 Thomas, M.J.W. & Ferguson, S. A. (2010). Prior sleep, prior wake, and crew performance during normal flight operations. *Aviation, Space, and Environmental Medicine, 81 (7),* 665-670.

23 Williamson, A., Lombardi, D.A., Folkard, S., Stutts, J., Courtney, T.K., & Connor, J.L. (2011). The link between fatigue and safety. *Accident Analysis and Prevention, 43,* 498-515.

2.11.3 Rest breaks between shifts

Like other operators in the Australian rail industry, SBR conducts relay operations with two crews of two drivers. Each crew alternates eight hours of operation with eight hours of rest throughout the trip. Rest breaks are taken in a relay van on the train, whilst under way.

SBR limited the relay operations shifts to eight hours duration, which is consistent with research findings of increasing error risk for shift lengths over eight hours.[24] However, the relay rostering system also restricts the rest breaks to eight hours. This is known as a fast rearwards rotating shift system, where each subsequent shift start time is earlier than the last shift start time (rearward direction of rotation) and the rest break between those shifts is restricted to eight hours (speed of rotation).

Fast rearwards rotating shifts have been shown to be problematic for train drivers' sleep patterns. In a simulator study comparing fast rearward rotation with an eight-hour rest period between work shifts and a slower rearward rotation with a 12-hour rest period between work shifts, Thomas and Rasleur (1997) found that all drivers on rearward rotation experienced increasing difficulty in achieving sufficient sleep over the duration of the study. This effect was exacerbated for the fast rotation group.[25]

2.11.4 Duration and quality of sleep afforded during relay operations

Although SBR and other rail operators provide modern relay vans with a range of facilities designed to enhance the resting drivers' comfort, the sleep quality and quantity obtained is necessarily compromised by the noisy, moving and shaking nature of the vans[26,27]. Further, each eight-hour rest break cannot be considered to be a full eight-hour sleep opportunity, as drivers also need to eat, attend to hygiene needs and generally wind down from their shift, and then also awaken with sufficient time to prepare for their oncoming shift during this eight-hour period.

To address concerns about the effect of relay operations on drivers' sleep and performance, researchers from the University of South Australia conducted a series of studies looking at different relay operations:

- A 40-hour relay operation with the train departing at 2000: drivers obtained an average of about four hours sleep in each eight-hour rest period. There was

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[24] Folkard, S., Lombardi, DA, & Tucker, P. (2005). Shiftwork: Safety, Sleepiness and Sleep. *Industrial Health, 43,* 20-23.

[25] Thomas, G.R., Rasleaur, T.G., & Kuehn, G.I. (1997). *The effects of work schedule on train handling performance and sleep of locomotive engineers: a simulator study.* Federal Railroad Administration.

[26] Jay, S. M., Dawson, D. & Lamond, N. (2006). Train drivers' sleep quality and quantity during extended relay operations. *Chronobiology International, 23* (6), 1241-1252.

[27] Darwent, D., Lamond, N. & Dawson, D. (2007). The sleep and performance of train drivers during an extended freight-haul operation. *Applied Ergonomics, 39,* 614-622.

sizeable variation amongst drivers, with some only getting 2.5 hours sleep during the rest breaks[28]

- A five-day relay operation with the train departing about 0330-0500 and incorporating one significant rest period away from the train in the middle of the relay operation: drivers averaged 3.3 hours sleep in each eight-hour rest period in the relay vans, with rest periods at night associated with more sleep than those during the day[29]
- A four-day relay operation with the train departing about 0800 and incorporating a significant rest period away from the train in the middle of the relay operation: drivers obtained an average of three hours sleep in each eight-hour rest period in the relay vans, with rest periods at night associated with more sleep than those during the day. Sleep quality was found to be poorer in the relay vans compared to at home or during the layover.[30]

There was insufficient detail to calculate how much sleep drivers obtained in each 24 or 48-hour period prior to commencing a shift. However, it would appear that at least some drivers obtained less than five hours sleep in the previous 24 hours or less than 12 hours sleep in the previous 48 hours prior to commencing a work period during these operations, representing an elevated fatigue risk.

2.11.5 SBR assessment of roster

SBR's assessment of the drivers' roster was primarily based on the use of a bio-mathematical fatigue modelling program known as the Fatigue Audit Interdyne (FAID). Bio-mathematical models attempt to predict the effects of different working patterns on subsequent job performance, with regard to the scientific relationships among work hours, sleep and performance.[31] FAID requires hours of work as a single input. 'It assigns a recovery value to time away from work based on the amount of sleep that is likely to be obtained in non-work periods, depending on their length and the time of day that they occur.'[32] That is to say, FAID does not predict fatigue *per se* but rather predicts a sleep opportunity, producing a work-related fatigue score.[33]

SBR had conducted a fatigue risk assessment for the relay driver role and had considered the fatigue risk to be moderate. Based on this assessment, SBR established a FAID target threshold score for relay drivers of 80. The maximum FAID scores of the driver and co-driver, of train 1901S, for the actual hours worked

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28 Lamond, N, Darwent, D. & Dawson, D. (2005). How well do train drivers sleep in relay vans? *Industrial Health,* 43, 98-104.

29 Jay et al (2006).

30 Darwent et al (2007).

31 Dawson, D., Noy, Y.I., Harma, M., Akerstedt, T. & Belenky, G. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis and Prevention, 43,* 549-564.

32 Roach, G.D., Fletcher, A. & Dawson, D. (2004). A model to predict work -related fatigue based on hours of work. *Aviation, Space, and Environmental Medicine, 75(3),* 61-69.

33 Dawson et al (2011).

in the preceding four-week period were assessed by SBR to be 66 and 77 respectively, which satisfied SBR's fatigue risk assessment requirement.

When evaluating rosters, there are however a number of documented limitations with over- reliance on bio-mathematical models such as FAID. Because the distribution of fatigue across a given population of employees working the same roster is significant, it is difficult to generalise from the average data generated by a bio-mathematical model.[34] As noted by the Independent Transport Safety Regulator (ITSR) of New South Wales, '…fatigue models are appropriate to use as one tool to help evaluate group rosters to help identify how aspects of fatigue exposure are distributed. Model outputs... should never be the sole basis for a safety risk management decision regarding work hours.'[35]

ITSR also stated that 'a FAID score of less than 80 does not mean that a work schedule is acceptable or that a person is not impaired at a level that could affect safety.' The United States Federal Railroad Administration (FRA) also cautioned against reliance on a FAID threshold score of 80, finding that scores lower than 80 can be associated with 'extreme fatigue.'[36]

In addition, use of the FAID score in isolation is problematic in assessing the recovery permitted by a rest break because the score focuses on the time of day that the work occurs, rather than time of day of the rest break. The FAID score assumes that all rest breaks are of equal recovery value; it will recover in a linear fashion regardless of the time of day that the rest break occurs.[37] Use of the FAID 'sleep estimate' function in addition to the FAID score can therefore strengthen the risk assessment of roster designs. The sleep estimate function does account for time of day, so used in combination with the FAID score as well as other considerations, it can be a useful tool to reveal fatigue risk, which may be apparent despite the score being less than 80.[38] In this regard, SBR's FAID-based analysis of the relay roster included information on estimated sleep, which noted that for some shifts, drivers would on average achieve just 4.1 hours sleep in the previous 24 hours and 10.6 hours sleep in the previous 48 hours.

FAID is a useful tool to account for hours of sleep opportunity provided, and, when the sleep estimate function is used, can estimate likely sleep obtained during a given rest break. However, it cannot account for the hours of sleep actually achieved by individuals, nor for the quality of that sleep. In addition, it was not based on data involving situations such as when the rest break is taken in an underway relay van. The presence of these additional factors in relay working necessitates additional fatigue risk controls.

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34 Dawson et al (2011).

35 Independent Transport Safety Regulator (2010). *Transport Safety Alert 34 - Use of bio-mathematical models in managing risks of human fatigue in the workplace.* www.transportregulator.nsw.gov.au

36 Federal Railroad Administration (2010). *Procedures for Validation and Calibration of Human Fatigue Models: The Fatigue Audit InterDyne Tool.* www.fra.dot.gov/rpd/downloads/TR_Procedures_or_Validation_and_Calibration_final.pdf

37 Independent Transport Safety Regulator (2010).

38 Independent Transport Safety Regulator (2010).

2.11.6 Monitoring of sleep obtained

Modern fatigue risk management requires a number of elements and levels of risk control. Dawson and McCulloch[39] as well as the National Transport Commission[40] have proposed the following levels of risk control:

- **Level 1: Sleep Opportunity** – Training, Scheduling Rules; Fatigue Modelling; Sleep / Medical Disorder Screening;
- **Level 2: Sleep Obtained** – Training; Prior Sleep Wake Data; Sleep / Medical Disorder Screening
- **Level 3: Behavioural Symptoms –** Training; Symptom Checklists; Physiological Monitoring; Self Report Behavioural Scales; Physiological Monitoring;
- **Level 4: Fatigue Related Errors –** Fatigue / Error Proofing Strategies; SMS Error Analysis System; and
- **Level 5: Fatigue Related Occurrences –** SMS Incident / Occurrence Analysis System.

SBR provided evidence of practices consistent with control mechanisms at Level 1 of the above model, including fatigue awareness training, fatigue modelling (using FAID), as well as sleep disorder screening. SBR also provided some evidence of practices for detecting fatigue impairment at the commencement of a shift when that shift originates at one of SBR's sidings, whereby shunters and train examiners have an opportunity to observe and converse with drivers prior to commencing a driving task. However, from the evidence provided, SBR had no specific process for ensuring that drivers obtained sufficient sleep in the period prior to starting a trip or prior to starting any shift within a trip. Nor was there a documented process for collecting information on average sleep obtained during relay operations to inform fatigue management practices.

2.11.7 Other fatigue management controls

SBR had a number of fatigue management controls in place, including as mentioned above, limiting relay operation shifts to eight hours duration, fatigue awareness training for drivers, fatigue modelling, and sleep disorder screening. Additionally SBR provides modern rest facilities within the relay vans, conducts two driver operations and makes use of vigilance controls within the locomotive cab to monitor driver alertness.

However, the use of a fast rearwards rotating roster, in combination with the known difficulties of at least some drivers in obtaining sufficient sleep while on relay operations, requires careful management of fatigue risk. Rail operators conducting relay operations should also consider incorporating clear practices for determining sleep obtained both prior to commencing relay operations and during relay rest breaks, as well as higher-level fatigue controls such as self-report behavioural

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39 Dawson & McCulloch (2005).

40 National Transport Commission. (2008).

scales, fatigue-induced error proofing strategies, and monitoring and analysis of self-reported sleep obtained whilst on relay operations.

2.12 Driver competency management

The organisational control and oversight of rail activities through the implementation of an effective Safety Management System (SMS) is fundamental to achieving safe operations on a railway. Essential elements of every SMS are the procedures to govern the supervision, structured delivery, assessment and monitoring of worker competency to ensure the timely attainment and maintenance of those competencies.

The SBR SMS contained various procedures, checklists and registers that identify the competency requirements for locomotive drivers and other rail workers. The units of competency specified for locomotive drivers generally referenced the certificate levels (I to IV) within the Transport and Logistics (Rail Operations) qualification.

A key unit of competency within this qualification was the operation of a train with due consideration to the route conditions, for which SBR had developed additional resources in the form of a number of specific 'Route Knowledge Packages' to identify the route conditions likely to be encountered on the track.

The SBR Route Knowledge Package – Dry Creek to Port Augusta stipulated the minimum requirement prior to assessing a driver for competency was "One return trip required for learning the route", "One return trip for pre evaluation" and 'One return trip for sign off as competent."

SBR advised that this requirement ensured a driver-in-training did not request a formal assessment before attainment of necessary route knowledge experience and the paired driver had undertaken a pre-evaluation of the driver-in training's route knowledge.

The Route Knowledge Package sets a 'minimum standard' for a driver-in-training learning a route. It allows the driver-in-training, subject to the availability of rostered duty times, to choose when and on which routes they operate a train and then self-appraise their performance before undertaking pre-evaluation and formal competency assessments. However, there was no formalised process for the driver-in-training to record route experience or for the paired driver (supervising driver) to document feedback related to the performance of the driver-in-training. The availability of such information to a supervising driver or assessor would likely aid in their understanding of the status of learning achieved by the driver-in-training and assist them in determining the level of mentoring required and the identification of risk to the operational task to be undertaken.

Training governance

The importance of providing a trainee with opportunity to practise new skills is well established. However, unstructured practice without objectives, appropriate stimulation, and useful feedback has been shown to be counterproductive.[41] Additionally, delays in the provision of opportunity for a trainee to develop their skills should be minimised to achieve optimal training outcomes and to avoid skill decay.[42] [43] [44]

While the SBR SMS allowed for the identification and recording of the required competencies when achieved, the procedures governing worker competency did not provide for structured programming to ensure effective practice, or for documentation of progress toward the timely development of route knowledge by the driver-in-training.

It was the practice of SBR to identify a driver-in-training within the crew roster as a “second person,” requiring that they be supervised by a route qualified locomotive driver when operating a train. However, the roster entry for the day of the collision did not identify the driver as a second person.

The reliance by SBR on the work roster to identify the second person and to record individual drivers’ operational exposure to various routes in developing their knowledge had the potential to either preclude a driver-in-training from operating over a route or create extended periods between operating over that route. The work roster is also a dynamic document likely to be subject to numerous operational changes.

The cyclic nature of the ore train roster and potential for change may create an operating environment that is not conducive to reinforcement of learning in a systematic and structured fashion. In this instance, the driver-in-training had experienced periods of 39 and 27 days between being rostered to work in the cab of the locomotive in the direction of travel on the sections of track between Dry Creek and Port Augusta.

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41 Cannon-Bowers, J. A., Rhodenizer, L., Salas, E., & Bowers, C. A. (1998). A framework for understanding pre-practice conditions and their impact on learning. *Personnel Psychology, 51*, 291–320.

42 Arthur, W. Jr., Bennett, W. Jr., Stanush, P. L., & McNelly, T. L.(1998). Factors that influence skill decay and retention: A quantitative review and analysis. *Human Performance, 11*, 57–101.

43 Grossman, R. & Salas, E. (2011). The transfer of training: what really matters. *International Journal of Training and Development, 15(2),* 103-120

44 Salas, E., Wilson, K., Priest, H. and Guthrie, J. (2006), ‘Design, Delivery, and Evaluation of Training Systems’, in G. Salvendy (ed.), *Handbook of Human Factors and Ergonomics*, *(3rd ed.)*. Hoboken, John Wiley & Sons. pp. 472–512

3 FINDINGS

3.1 Context

From the evidence available, the following findings are made with respect to the Signal Passed At Danger by Specialised Bulk Rail Pty Ltd ore train1901S and the subsequent collision with Genesee and Wyoming Australia Pty Ltd grain train 5132S at Dry Creek on 11 October 2011.

These findings identify the different factors that contributed to or were highlighted by the investigation of the accident. They should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

These findings identify the various events and conditions that increased the safety risk and contributed to the passing of signal 13 at red by train 1901S:

- The driver and co-driver did not observe signal 135 at caution, which resulted in them missing vital information as to the status of signal 13 ahead at stop.
- The attention of the driver was focussed on the headlight ahead and to the right, he did not detect signal 135 located to the left of the track displaying a caution aspect.
- The train crew's expectation of a clear run on the main line, reinforced by a sequence of signals at proceed is likely to have influenced their interpretation of the headlight of the opposing train (5132S) as being that of a locomotive undertaking shunting operations in Dry Creek Yard.
- The train driver's lack of route knowledge, combined with an expectation of a clear run through the area probably influenced his failure to observe signal 135 at caution.
- A competing administrative task diverted the co-driver's attention away from his primary task of supervising the actions of the train driver, who was a driver-in-training for the route, in the period that the train was approaching signal 135.
- Specialised Bulk Rail's Safety Management System procedures did not provide the supervising drivers with sufficient direction as to the nature of their supervisory role. *[Minor safety issue]*

3.3 Other safety factors

- There were no formalised processes for a driver-in-training to record their experience in learning a route, or to document feedback related to their performance, for use by supervising drivers or assessors to assist in mentoring them. *[Minor safety issue]*
- Worker competency procedures were deficient in providing a structured program for the development of route knowledge by the driver-in-training. *[Minor safety issue]*

- SBR's process for assessing its drivers' roster for relay operations relied excessively on a score produced by a bio-mathematical model, and it had limited mechanisms in place to ensure drivers received an adequate quantity and quality of sleep during relay operations. *[Minor safety issue]*

3.4 Other key findings

- Signal 135 had correctly displayed a yellow aspect (caution) during the period that train 1901S had approached it.
- The aspect displayed on signal 135 was clearly visible and was unlikely to have been impeded by ambient light conditions or permanent background lighting.
- The braking performance of 1901S was within the allowable maximum stopping distances specified in the *Draft Code of Practice for the Defined Interstate Rail Network – Volume 5: Rolling-stock*.

4 SAFETY ACTION

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.

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.

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.

Specialised Bulk Rail Pty. Ltd. (SBR)

Procedures for supervising drivers did not provide sufficient guidance of accountabilities and key result areas

Minor safety issue

Specialised Bulk Rail's Safety Management System procedures did not provide the supervising drivers with sufficient direction as to the nature of their supervisory role.

Response from Specialised Bulk Rail Pty. Ltd.

> SBR conducted an internal investigation on this incident and raised a formal OFI [Opportunity for improvement] to address this issue, which has since been closed.
>
> OFI-SBR-2011-005 – The Investigation of the SPAD at Dry Creek on 11th October 2011 which resulted in the collision between SBR 1901S and GWA 5132S recommended that SBR Main Line Drivers in charge of a trainee should be formally briefed by Train Crew Supervisor/Rail Operations Manager on the level of competency of the trainee, when commencing on roster with a trainee/driver under supervision.
>
> Drivers PD [position description] has been amended as follows The driver who's name is written on the topmost line of the roster out of the two drivers is considered to be the " driver-in-charge" of the train and will be responsible for all decisions made about the train. The Driver will be responsible to make themselves aware of the level of Competence of any Second person rostered on with them. The second person, must work under the instruction of the driver in charge, who will make the call on train running activities.

ATSB assessment of response

The Australian Transport Safety Bureau is satisfied that Specialised Bulk Rail Pty Ltd has initiated action to address the safety issue.

Procedures did not provide information of the status of learning

Minor safety issue

There were no formalised processes for a driver-in-training to record their experience in learning a route, or to document feedback related to their performance, for use by supervising drivers or assessors to assist in mentoring them.

Response from Specialised Bulk Rail Pty. Ltd.

> SBR encourages and supports drivers who diarise and make notes during the learning process. SBR also provides materials with which to do so. SBR has reviewed this position for forming a panel of training staff, including our RTO [registered training organisation] to consider this proposal. The panel consisted of the four staff with a combined experience in driver training of over 70 years. It included a senior driver trainer, our operations manager, a manager who was formally the CEO of a major rail industry training organisation and our current RTO CEO. The collective opinion of these training staff was; to mandate this would be counterproductive to safety and learning outcomes. Records that can be accessed by other than the trainee would most likely result in "sanitised" notes and diary entries that will not achieve the best learning outcomes. Trainees must feel free to record information as truthfully as possible and in a manner that assists in their learning. They should not be distracted from learning, by formalising notes for later record keeping purposes. Driving assessments and are formally recorded by instructors, when a trainee's assessment is completed.

ATSB assessment of response

The Australian Transport Safety Bureau notes the response provided by Specialised Bulk Rail Pty Ltd. The provision of a formal briefing to the driver in charge, at the commencement of a roster, adequately addresses the safety issue.

Procedures do not adequately program the attainment of route knowledge competency

Minor safety issue

Worker competency procedures were deficient in providing a structured program for the development of route knowledge by the driver-in-training.

Response from Specialised Bulk Rail Pty. Ltd.

> OFI-SBR-2011 -002 - The Investigation of the SPAD at Dry Creek on 11th October 2011 which resulted in the collision between SBR 1901S and GWA 5132S recommended that SBR set reasonable defined time limits/trips for driver route knowledge learning which are clearly communicated to all drivers.
>
> Route Knowledge documentation is amended to show: After 7 return trips the trainee may be assessed at the discretion of the trainer.

ATSB assessment of response

The Australian Transport Safety Bureau is satisfied that Specialised Bulk Rail Pty Ltd has initiated action to address the safety issue.

Fatigue management controls to assess and monitor train crew undertaking relay operations

Minor safety issue

SBR's process for assessing its drivers' roster for relay operations relied excessively on a score produced by a bio-mathematical model, and it had limited mechanisms in place to ensure drivers received an adequate quantity and quality of sleep during relay operations.

Response from Specialised Bulk Rail Pty. Ltd.

Specialised Bulk Rail provided inclusive details of its fatigue management program specifically highlighting that:

> The locomotives in use by SBR are designed to minimise driver task load. SBR's locomotives are some of the newest on the interstate network, and have incorporated many design features to mitigate fatigue risk...
>
> Sleep opportunity, with crew facilities are designed to maximise restorative sleep is crucial to reducing fatigue. SBR has dedicated crew rest facilities attached to each relay operating train. As with the locomotives, these rest facilities have been designed to maximise restorative sleep opportunities...
>
> In designing rosters, SBR assesses each roster with FAID software to design rosters that will minimise fatigue, if appropriate restorative sleep opportunities are taken by the drivers when given the opportunity...
>
> SBR believes that its rostering practices, in context, are conducive to reduced fatigue risk and adverse safety outcomes... SBR's specific risk context, without prolonged or persistent fatigue, we believe supports a view, supported by research that SBR's rostering practices are likely to reduce the risk of drivers experiencing fatigue associated with impaired performance.

ATSB assessment of response

The Australian Transport Safety Bureau notes the response provided by Specialised Bulk Rail Pty Ltd. The Australian Transport Safety Bureau encourages the continual improvement of fatigue risk management programs by rail transport operators to ensure that the risk from fatigue is managed so far as is reasonably practicable.

APPENDIX A : SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

Australian Rail Track Corporation Ltd

Genesee and Wyoming Australia Pty Ltd

Geoscience Australia

Specialised Bulk Rail Pty Ltd

The Bureau of Meteorology

The crew of train 1901S

The crew of train 5132S

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Submissions

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

A draft of this report was provided to:

- Australian Rail Track Corporation Ltd
- Genesee and Wyoming Australia Pty Ltd
- Specialised Bulk Rail Pty Ltd
- The crew of train 1901S
- The crew of train 5132S

Submissions were received from Specialised Bulk Rail Pty Ltd, the driver of train 1901S and the Australian Rail Track Corporation Ltd. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly

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Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
Collision between freight trains 1901S and 5132S
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