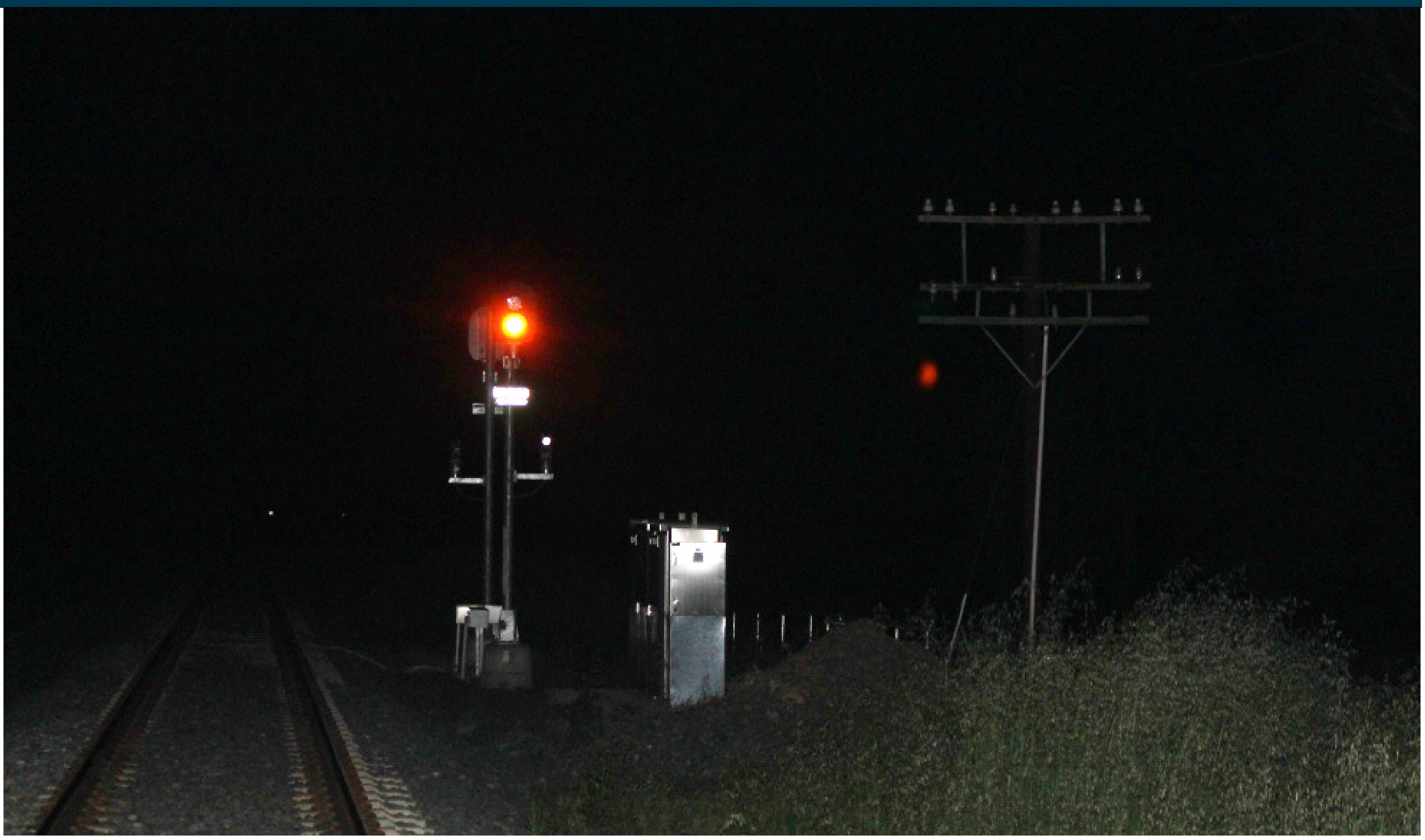
Australian Government

Australian Transport Safety Bureau

Signal irregularity reported by crew of train 5BM7

Culcairn North, NSW | 7 April 2013



Investigation

ATSB Transport Safety Report

Rail Occurrence Investigation

RO-2013-013

Final – 5 March 2014

Source: Cover photo supplied by Australian Rail Track Corporation (ARTC).

Released in accordance with section 26 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

© Commonwealth of Australia 2014

Ownership of intellectual property rights in this publication
Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Commonwealth of Australia.

Creative Commons licence
With the exception of the Coat of Arms, ATSB logo, and photos and graphics in which a third party holds copyright, this publication is licensed under a Creative Commons Attribution 3.0 Australia licence.

Creative Commons Attribution 3.0 Australia Licence is a standard form license agreement that allows you to copy, distribute, transmit and adapt this publication provided that you attribute the work.

The ATSB's preference is that you attribute this publication (and any material sourced from it) using the following wording: *Source:* Australian Transport Safety Bureau

Copyright in material obtained from other agencies, private individuals or organisations, belongs to those agencies, individuals or organisations. Where you want to use their material you will need to contact them directly.

Addendum

Page	Change	Date

Safety summary

Signal DIS-CN03 (right) and DIS-CN07 (left) from about 350 m

Source: ARTC

What happened

On 7 April 2013 southbound freight train 5BM7 was travelling at near track speed (115 km/h) on the main line of the Culcairn North passing loop in New South Wales. On rounding a sweeping right-hand curve the driver saw the headlight of an opposing train and also saw that the signal (CN03) ahead was at stop. He immediately made an emergency brake application to stop the train just before signal CN03 thereby averting a collision with the opposing train which was entering the southern end of the passing loop.

There were no injuries or damage as a result of this occurrence.

What the ATSB found

The ATSB investigation of available technical evidence, showed that the signalling system was operating correctly at the time of the incident and therefore the signal (DIS-CN03) preceding the signal at stop (CN03) should have been displaying a caution aspect (yellow). However, the crew of train 5BM7 had perceived signal DIS-CN03 at clear (green) and were therefore not expecting signal CN03 to be at stop (red).

As the train was not fitted with forward facing video equipment the ATSB was unable to substantiate the observations of the train crew with respect to the aspect of signal DIS-CN03.

What's been done as a result

The train operator, Aurizon, has advised that it has forward facing cameras on about 8.5 per cent of its locomotive fleet and that it is likely that this type of technology will be fitted to all locomotives purchased in the future.

The Rail Industry Safety and Standards Board (RISSB) has advised that it will encourage its membership and the wider rail industry to adopt the use of independent data validation systems, such as forward facing video on trains, to assist with coming to a better understanding of rail occurrence events, such as signal irregularities.

Safety message

The Australian Transport Safety Bureau encourages rail operators to consider the use of independent data validation systems, such as forward facing video on trains, to provide a source of information to assist in coming to an understanding of rail occurrence events, such as signal irregularities.

Contents

The occurrence

Train 5BM7 was a regular Aurizon intermodal freight service scheduled to operate from the Acacia Ridge Terminal, Brisbane (Queensland) through to North Dynon, Melbourne (Victoria). The train departed Acacia Ridge on 4 April 2013. The journey through to Junee in New South Wales was generally uneventful but the service incurred considerable delays en route, about 24 hours in total.

Train 5BM7 arrived in Junee (485.670 km)[1] at about 2312[2] on 6 April. A crew changeover was planned at Junee, with the Junee to Melbourne sector to be operated by a qualified driver and a second person/observer who was not qualified to drive. The driver and second person signed on for duty at Junee, at 2315. The crew that had worked the earlier sector advised the Junee to Melbourne sector crew that although the train functioned satisfactorily the braking performance did not feel as good as normal.

On joining the train, the Junee to Melbourne sector driver completed the prescribed safety checks before departing Junee at midnight. On departing Junee, the driver observed the distant signal ahead, at caution; he made a brake application and decided that the train's braking performance was acceptable. Shortly thereafter, a Junee network control officer (NCO) contacted the driver and advised him of signalling problems through Harefield (497.612 km). The driver was subsequently authorised by the NCO to proceed through the area under a Special Proceed Authority.

Train 5BM7 arrived at Bomen (513.691 km) at 0028 on 7 April. It was delayed about 14 minutes waiting to cross with an XPT passenger train before departing at 0044. At about this time, an opposing freight movement (7MC2) was departing Albury. Both trains were converging on Culcairn (Figure 1). Train 5BM7 passed through Wagga Wagga at 0052 and then crossed with train 7MB4 at Uranquinty. Train 5BM7 continued towards Culcairn passing through Henty (580.286 km) at 0137. By this time, train 7MC2 was at Gerogery (619.900 km) crossing with another Melbourne bound train.

Figure 1: Location of Culcairn, New South Wales

Source: Geoscience Australia

The two trains, 5BM7 and 7MC2, were now about 40 km apart. The NCO had pre-planned for the two converging trains to cross at the Culcairn North passing loop. In preparation for the cross the NCO had pre-cleared a route for train 7MC2 into the loop with train 5BM7 continuing along the main line up to signal CN03, which was at stop.

1 All track distances in this report are referenced from the Sydney Central passenger train terminal.

2 Local time was Australian Eastern Daylight Time. (Coordinated Universal Time (UTC) +11 hours).

Figure 2: Location of signals approaching Culcairn North passing loop

Source: Geoscience Australia

About 3 minutes after passing through Henty, the driver of 5BM7 saw a series of signals displaying green (Figure 2).

He and the second person cross called[3] the signals, DIS-CN01, CN01 and DIS-CN03 as displaying a clear (green) indication when they approached and passed them.

After passing signal DIS-CN03 (about 0144) train 5BM7 rounded a sweeping right hand curve. Shortly thereafter, the driver saw what he believed was the headlight of an opposing train. He then noticed that signal CN03 was at stop. He made an emergency brake application then used the local train radio to challenge the approaching train (7MC2).

Train 5BM7 was about 1,600 m from signal CN03. The train started to slow, decelerating at a progressively faster rate as the train's speed reduced. The train eventually came to a stand about 50 m before signal CN03. The driver had averted the train's passing signal CN03 at stop and a potential of a collision with train 7MC2.

Post Occurrence

After coming to a stand, the driver of 5BM7 initially spoke with the driver of the opposing train (7MC2) regarding the events that had transpired.

During that conversation, the driver of 7MC2 spoke of an almost identical occurrence that took place on 28 May 2011.

3 The process of a driver and second person confirming and verbally calling the meaning displayed by a signal to the other crew member, and that its meaning is being obeyed.

Shortly after that discussion, the driver of 5BM7 communicated with the NCO. The NCO told the driver of 5BM7 that signal CN03 had been at stop for quite some time before his train had arrived at the North Culcairn passing loop and that signal DIS-CN03 should have been at caution (yellow). The NCO further stated that if signal DIS-CN03 was displaying a clear (green) indication something was wrong.

The NCO collected available information from the driver before dispatching train 5BM7 at 0152.

At 0153, the NCO spoke with the rostered signal technician about the occurrence. The signal technician requested that the NCO not signal train movements through Culcairn North until the signalling system had been checked for correct operation. He also asked the NCO to speak to the driver of an approaching train (ST21) and request that the driver observe the aspect displayed by signal DIS-CN03. The driver of ST21 reported that signal DIS-CN03 was displaying caution (yellow) as his train passed it. During this period, the signal technician reviewed the Phoenix replay file and contacted his manager, a signal engineer, with respect to the reported incident. The signal engineer made arrangements for the testing of the signalling system before allowing train services to operate normally, that is, using the signalling system.

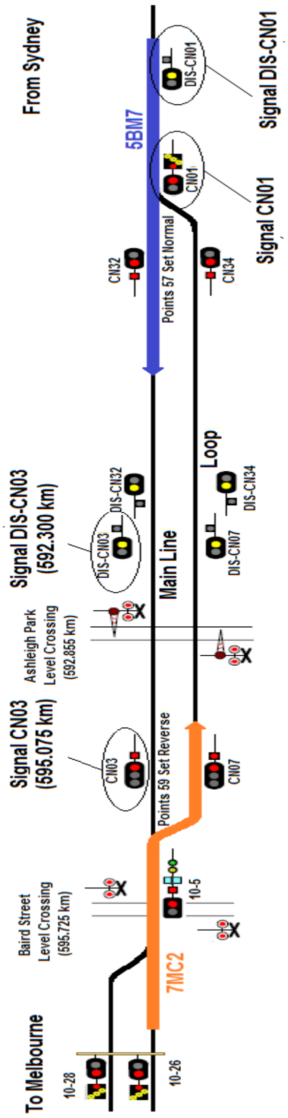
Context

Location

Culcairn is a small New South Wales regional town (Figure 1) located 597.8 km by rail southwest of Sydney and about 50 km north of Albury. The Culcairn North passing loop is 4.52 km north of Culcairn on the Melbourne to Sydney rail line.

Train control and signalling

Figure 3: Signal arrangement - Culcairn North, passing loop



Source: ATSB

The Culcairn North passing loop (Figure 3) is controlled by fixed colour light signals that use Rail Vehicle Detection (RVD)[4] and are remotely controlled from a network control centre located in Junee.

For train 5BM7 travelling towards Melbourne, entrance onto the main line was over 57 points set normal and controlled by signal CN01. The train then proceeded onto the main line past distant signal[5] DIS-CN03 before reaching home signal[6] CN03.

For train 7MC2, travelling towards Sydney through Culcairn on the main line, entrance into the Culcairn North loop was over 59 points set reverse and controlled by signal 10.26 at Culcairn.

The braking distance for freight trains can be significant and therefore train drivers are required to commence braking well in advance of a projected stopping point. As a consequence, it is necessary to provide train drivers with advance information regarding the status of indications displayed by fixed signals[7] ahead of the train movement.

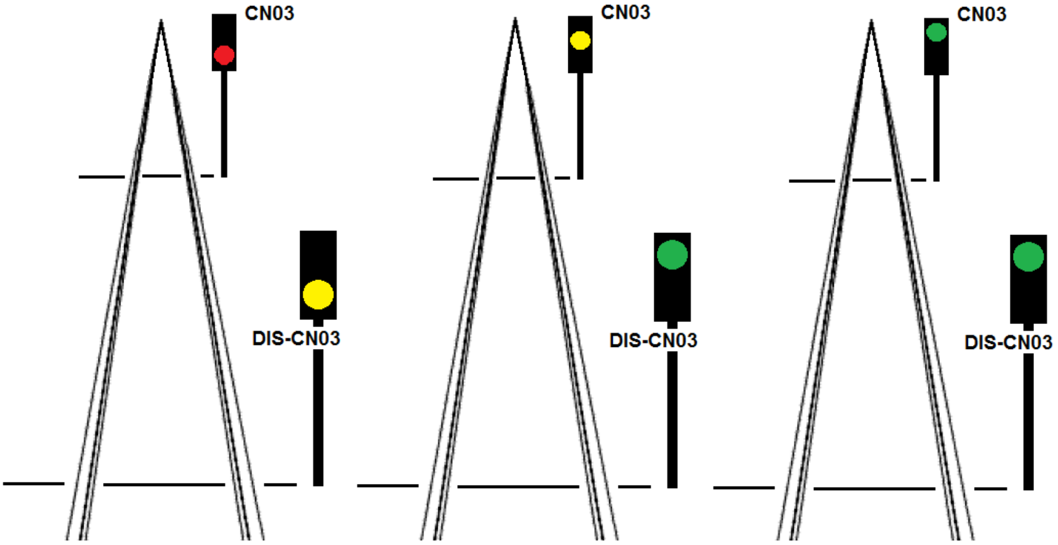
The signalling system through Culcairn North provided advance information regarding the status of signal CN03 (Figure 3 and Figure 4) by way of signal DIS-CN03 located 2.775 km before it. Signal DIS-CN03 displays a clear (green) when CN03 displays a caution (yellow) or clear (green) and a caution (yellow) if signal CN03 is at stop (red). The correct display/interpretation of signal DIS-CN03 therefore allows a driver to safely slow their train and bring it to a stand before passing signal CN03, if displaying a stop (red) indication. This becomes critical especially in conditions of restricted visibility (for example fog, rain, etc.).

On the morning of 7 April 2013, visibility was excellent and the driver of train 5BM7 could see signal CN03 displaying a stop indication well in advance. On this occasion he was able to stop train 5BM7 before passing signal CN03 by making an emergency brake application, consequently avoiding the risk of collision with train 7MC2.

---

4 RVD: The portions of line where the system of safeworking relies on track circuiting or axle counters.
5 Distant signal: Usually shows only CLEAR or CAUTION and cannot be used to protect the portion of line to the next signal.
6 Home signal: Used to protect points and other identified risks.
7 Fixed signal: A manually or power operated signal which is permanently located near the line.

Figure 4: Aspect displayed by DIS-CN03 with CN03 at stop, caution and clear



Source: ARTC NSW Rules and Procedures, drawing ATSB

Signalling hardware – Culcairn North

The signalling hardware through the area comprises:

- Field equipment: Signals, points, track circuits, etc. These items of equipment feed information from the field into the interlocking plant (Microlok). Signals communicate to train drivers the status of the line and signals ahead.
- Interlocking Plant (Microlok): Microlok is a proprietary microprocessor-based logic controller specifically designed for railway fail-safe[8] applications. The system provides all the necessary interlocking functions between points, signals and conflicting train routes. The system processes all the various field inputs and drives the outputs interfacing with designated field equipment while simultaneously maintaining a log of the various commands and the state of the input/output field equipment using an event logger.
- The Phoenix control system: Is a non-vital[9] CTC[10] system that provides real time monitoring and control of field hardware including signals, points, track circuits and the associated management of train movements. Signal, points, track and train movement data is captured by the Phoenix event logger.

Both the Microlok and Phoenix data files can be used to reconstruct events for the examination of signalling-related occurrences.

Train and train crew information

At the time of the occurrence, the train comprised four locomotives, (LDP 003 leading, LDP 009, LDP 008 and LDP 004 trailing) hauling 37 wagons having a total length of 1,489 m and a trailing mass of 2,561 t.

---

8 Fail-safe: The capability of an item or a system to ensure that any failure in a predictable or specified mode will result only in that item or system reaching and remaining in a safe condition.

9 Non-vital: Signalling equipment and circuits are considered non vital where failure to function correctly would not cause an unsafe outcome of the signalling system. Non-vital equipment and circuits do not affect the safe operation of the signalling system.

10 Centralised Traffic Control (CTC): A system of remotely controlling the points and signals at a number of interlocked stations, junctions and crossing loops in automatic signalling areas, from a centralised control room or signal box.

The driver of train 5BM7 had over 35 years of experience, was familiar with and had been certified for the route including the line through Culcairn North to Culcairn. The second person was not a qualified train driver but was familiar with the route from Junee to Melbourne, including the section between Culcairn and Culcairn North having travelled over the route about 12 times before the occurrence. He was aware of, and trained in, the signal cross calling process and stated that he knew the indications displayed by signals through this area. The driver and second person held the appropriate competencies for the tasks being performed.

Both had been assessed as fit for duty in accordance with the requirements of the *National Standard for Health Assessment of Rail Safety Workers* which includes testing for colour recognition.

Environmental conditions

Weather observations for the night of the occurrence were obtained from the Bureau of Meteorology (BoM). The BoM has a weather station at the Albury airport approximately 50 km south of Culcairn. At 0130 (15 minutes before the occurrence), the Albury airport weather station recorded a temperature of 12.2° C with no discernible rain having been recorded in the 24 hour period preceding the occurrence. Wind speed was 0 km/h. The subsequent weather recording at 0200 (15 minutes after the occurrence) was almost identical to that recorded at 0130.

At the time of the occurrence, about 0145, there was limited background lighting, the moon was well below the horizon and there was no source of external illumination, other than the train's headlight. The driver and second person described the conditions as being dark and a clear night with good visibility.

Safety analysis

The driver and second person of train 5BM7 recounted seeing distant signal DIS-CN03, on the main line through Culcairn North, as displaying a clear (green) indication as they approached it. As a result they expected that home signal CN03 was at proceed and the track ahead was clear of any opposing trains. After passing signal DIS-CN03 and rounding a sweeping right hand curve, the driver saw the headlight of a train and that home signal CN03 was at stop (red).

The train driver's actions after passing signal DIS-CN03 were influenced by the perception it was showing a clear (green) indication.

Consequently, the following safety analysis focuses on:

- examination and testing of the signalling system
- factors that may have influenced the train crew's perception of the indication displayed by distant signal DIS-CN03.

Examination and testing of the signalling system

Following the occurrence, the Australian Rail Track Corporation (ARTC) investigated the integrity of the signalling system through the:

- Review of Phoenix replay files.
- Analysis of the Microlok data files, in particular commands sent to and input/output events recorded at signal DIS-CN03.
- Examination of and testing of field equipment, in particular signal DIS-CN03 for correct operation.
- Conspicuity of signal DIS-CN03
- Review of any previous reported occurrences and/or wrong side failure[11] events.

This data was also supplied to the ATSB for review and analysis.

Analysis of test results

The Phoenix system, by design, does not show the indication displayed by distant signal DIS-CN03. Nonetheless, the Phoenix replay did show that home signal CN03 was at stop (Figure 5) well before train 5BM7 passed the preceding signals DIS-CN01, CN01 and DIS-CN03. The driver of 5BM7 confirmed that home signal CN03 was at stop (red) when he first saw it, just after he observed the headlight of the opposing train 7MC2.

It was established that the opposing route for train 7MC2 was set into the Culcairn North loop with 59 points set reverse well before train 5BM7 approached Culcairn North. Microlok checks that 59 points are set reverse before allowing signal 10.26 to clear for the loop. The interlocking is such that signal CN03 is prevented from clearing unless 59 points are set normal. These two logic conditions, that is, 59 points reverse and 59 points normal, are mutually exclusive and support the observation by the train crew that signal CN03 was at stop (red).

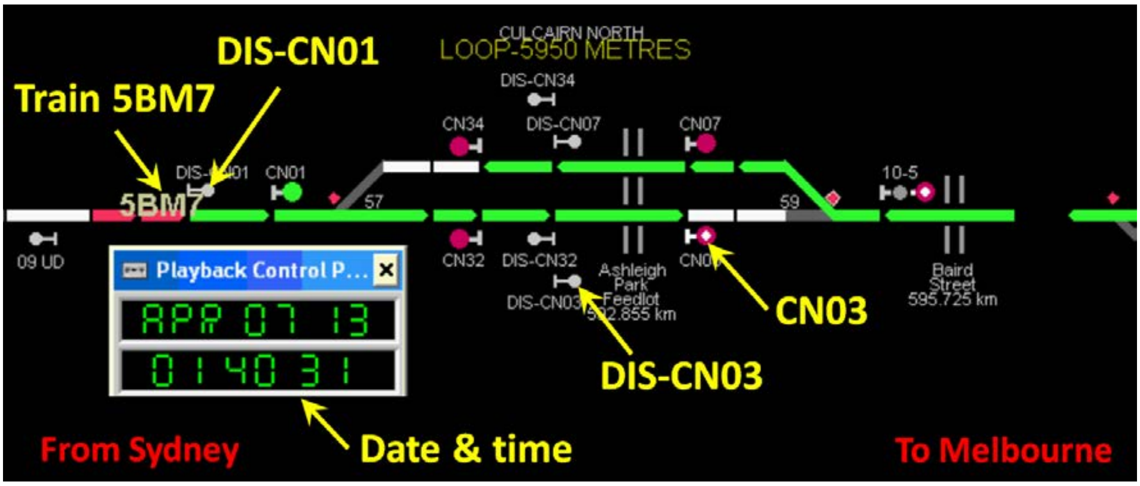
Examination of the Phoenix replay file showed that for the entire time that train 5BM7 approached signal CN03, the signal was at stop (red). At no stage did signal CN03 display anything other than a stop (red) indication.

While the Phoenix system does not show whether signal DIS-CN03 displayed a caution (yellow) or clear (green) the Microlok system records all input/output commands to field equipment. A review of the Microlok data showed that signal DIS-CN03 was set to green at 1441 on 6 April and

[11] A failure in a system which causes a potentially dangerous situation to exist.

returned to a caution (yellow) shortly thereafter due to the passage of a train. The next instance of the Microlok data showing signal DIS-CN03 being set to green was at 0532 on 7 April, about 4 hours after the occurrence. There was no Microlok activity to indicate that DIS-CN03 had been set to green at any stage between these two events. That is, Microlok data showed that DIS-CN03 remained/was at caution (yellow) for the passage of train 5BM7.

Figure 5: Phoenix display (replay) showing train 5BM7 about to pass signal DIS-CN01. At this time signal CN03 is at stop (red) and the opposing route set into the loop



Source: ARTC

Further tests

The Microlok system date and time was checked on 7 April and found to be correct. The Microlok system error log was also downloaded and examined. No errors were recorded on 6 and 7 April. It was therefore considered highly unlikely that there were any abnormal events associated with the Microlok system that may have contributed to the incorrect display/operation of signal DIS-CN03 for the passage of train 5BM7.

The cables that feed DIS-CN03 were examined and found to be in good condition. The earth leakage detectors were correctly set with no evidence of any earth leakage having occurred. This indicates that cable integrity was sound and that there was no false electrical feed that may have contributed to the incorrect operation of DIS-CN03.

A physical inspection of the site established that there were no signs of vandalism or graffiti that may have rendered any part of the signalling system ineffective. While the driver/second person of train 5BM7 reported rocks being thrown at the train as it passed through Culcairn, this was about 4 km south of signal DIS-CN03.

Maintenance had been performed in accordance with the prescribed ARTC requirements and standards.

Other signalling irregularities

A review of signal faults and incidents for the Culcairn North area was undertaken, with a particular focus on any wrong side signal failure events involving Microlok.

- No instances of wrong side signal failures were identified as having occurred in the Culcairn North area.
- It was noted that an almost identical event where signal DIS-CN03 was reported as displaying a ‘green’ indication with CN03 displaying stop (red) had occurred on 28 May 2011. An examination by the ATSB of all available signalling data including the Phoenix replay and Microlok data for this occurrence did not identify any wrong side signal failure or signalling system irregularity.

- An investigation by the ATSB into a signalling irregularity at Cootamundra, New South Wales (RO-2009-009) found a design error in the signalling system as the cause of a wrong side failure. On that occasion photographic evidence was available to assisted investigators in identifying the cause.
- The ATSB has noted that for occurrences where the potential for a wrong side failure exists, the ARTC has historically been proactive in the examination, identification and rectification of problems to mitigate the risk of similar/future occurrences.

Summary of signalling system performance

- There were no electrical defects identified with the signalling system and/or associated hardware that would have resulted in signal DIS-CN03 displaying an incorrect (green) indication.
- No maintenance anomalies were identified. Maintenance was performed in accordance with the ARTC requirements.
- An inspection of signal DIS-CN03 and the adjacent area established that there were no signs of vandalism or graffiti that may have rendered the signalling system ineffective.
- There was no evidence of wrong side signal failures at Culcairn North.

In conclusion, there was no technical evidence to suggest that the signalling system at Culcairn North, in particular signal DIS-CN03, was faulty or displayed a clear (green) indication as train 5BM7 approached/passed it on 7 April 2013.

Factors influencing the train crew's perception

The primary task for the driver of 5BM7 was to control the train movement and safely negotiate the track ahead, which included the correct observation and interpretation of signal DIS-CN03. Although the second person was not a qualified driver, he was required to cross check the observation and interpretation of signal indications with the driver, which included signal DIS-CN03.

In the context of the driver and second person correctly responding to a signal indication, their performance may be influenced by factors such as:

- the extent to which the signal was conspicuous and easy to observe
- the extent to which a signal indication was expected
- the train crew's workload at that point in time and the existence of any distractions
- task competency, including training, experience and route knowledge
- the influence of factors associated with the dynamics of crew interaction
- the influence of factors such as fatigue, drugs, alcohol or a medical condition

Conspicuity

Conspicuity refers to an object's ability to capture attention. With respect to signals, this can include factors such as brightness, focus, direction, surrounding environment and physical location.

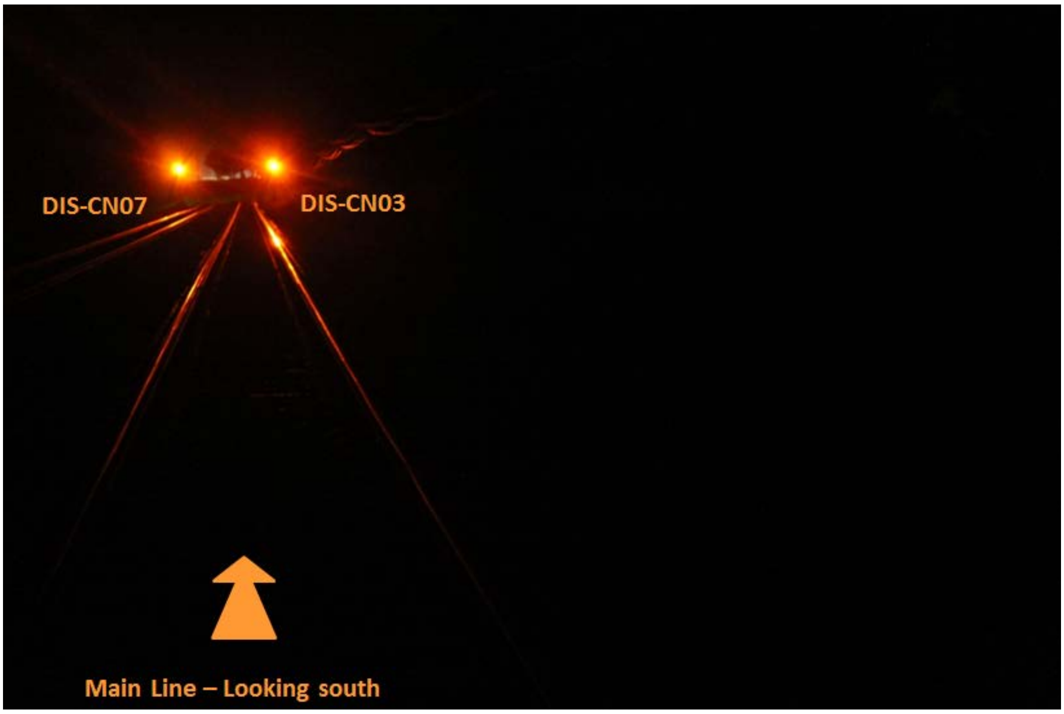
DIS-CN03 was a light emitting diode (LED) type signal that provided a strong/distinct light both up close and at a distance. During interview, both the driver and second person indicated that signal DIS-CN03 was clearly visible, on this occasion 'green', at a considerable distance and close up. Both the driver and second person recalled cross calling the signal indication as green.

A subsequent night inspection of signal DIS-CN03, at distances ranging from 2.5 km through to 50 m, established that each of the two aspects (yellow and green) that could be displayed by the signal were distinct and clearly visible (Figure 6). The surrounding area approaching signal

DIS-CN03 was examined for evidence of extraneous lighting or reflections off surfaces that may have been a source of green illumination. None was identified. There was no evidence of trees or other physical obstructions along the track that may have compromised the driver's or second person's view of the signal.

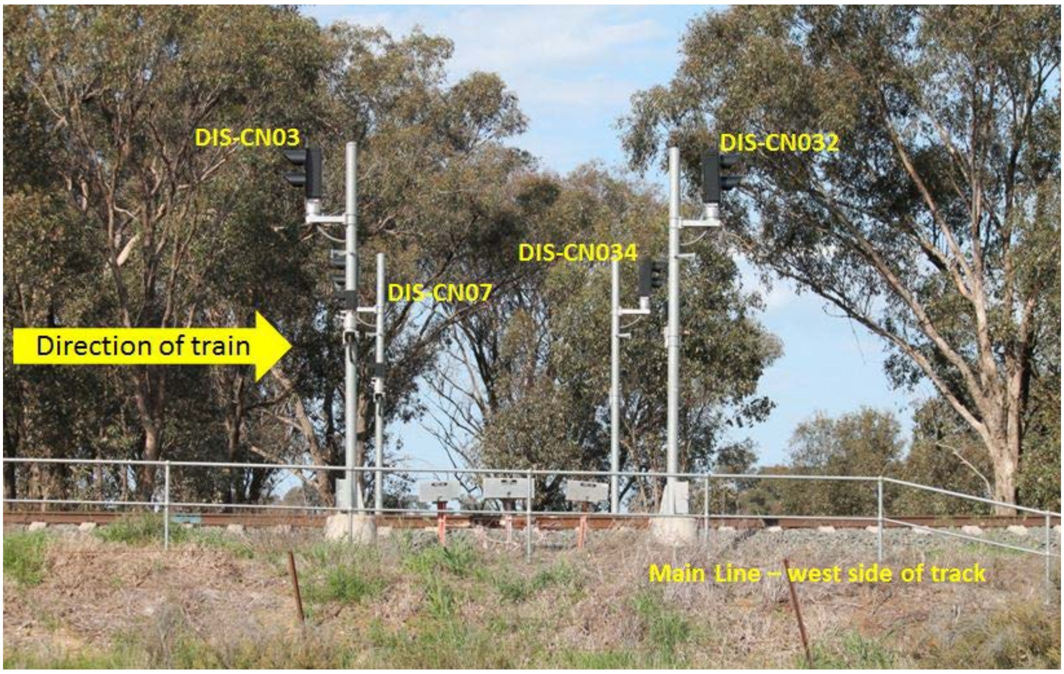
Signal DIS-CN03 was located on the right side of the main line. Signal DIS-CN07 was located on the left side of the loop. Both signals face north and are directly adjacent to one another (Figure 6 and Figure 7).

Figure 6: Photo of DIS-CN03 'yellow' aspect about 350 m before signal



Source: ARTC

Figure 7: Photo showing signals DIS-CN03, DIS-CN07, DIS-CN32 and DIS-CN34



Source: ARTC

Although signals are generally located on the left side of the track in the direction of travel, the driver of 5BM7 had regularly travelled the route and during interview confirmed that he recalled seeing signal DIS-CN07 displaying a caution (yellow). Examination of the signalling data established that it was in fact displaying a caution (yellow). Had the driver confused the indication displayed by signal DIS-CN07 for that of signal DIS-CN03, his response would probably have been to slow the train in anticipation of finding the next signal at stop.

Based on the available evidence, it is considered that signal conspicuity, including location of the signal, was unlikely to have been a factor that influenced the driver and second person's perception of the aspect displayed by signal DIS-CN03.

Attention: distraction, workload, inattentional blindness

Distraction can be understood as a type of inattention, where a person's attention is diverted by a particular event or object. Driver distraction has been more specifically defined as 'the diversion of attention away from activities critical for safe driving toward a competing activity (occurring) voluntarily or involuntarily.'[12]

Driver distraction can include a range of factors either inside or outside a vehicle that draws on limited human physical, visual and cognitive resources, and can result in a degradation of the driver's performance. For example, eating, drinking, operating devices integral or brought into the vehicle (mobile telephone), smoking and conversing with another occupant are all factors that may distract from the driving task. While this research was conducted in the context of the driver of a road vehicle,[13] the findings would, in all probability, be pertinent to the operators of other machinery, including trains.

As train 5BM7 approached signal DIS-CN03, the driver and second person recounted that they were not busy and did not consider themselves distracted by externalities, or otherwise inattentive due to workload issues. It was calculated that with signal DIS-CN03 visible at a distance of at least 2.5 km, and the train travelling at or near the allowable track speed of 115 km/h, as was the case on this occasion, the driver had in excess of 78 seconds of uninterrupted sighting to correctly recognise and respond to the signal. It is unlikely, given the workload at the time, that the driver and second person would have been inattentive to the driving task for this extended period of time.

Looked but did not see

Research has shown that in road accidents, critical or important information may have been detectible but the motorist did not attend to or notice that information.[14] These are often termed 'looked but did not see' events and include a phenomenon known as inattentional blindness.

Inattentional blindness occurs where 'people devote their attention to a particular area or aspect of their visual world, (and) tend not to notice unexpected objects, even when those objects are salient, potentially important, and appear right where they are looking.' This does not necessarily mean an individual was 'not paying attention', but rather that their limited attentional resources were occupied elsewhere. Research suggests that inattentional blindness can occur when attention is mistakenly filtered away from important information and can be affected by mental workload, expectation, conspicuity and capacity. In short, a person may fail to detect an object even though they were looking directly at it.

The driver and second person advised that as train 5BM7 approached signal DIS-CN03 they were not particularly busy and considered that their attention was fully focussed on the task at hand; driving the train, including the observation of signals.

---

[12] Regan, M.A., Hallett, C. & Gordon, C.P. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accident Analysis and Prevention, 43,* 1771-1781.

[13] It has been estimated that driver inattention contributes to 25% of road accidents, and that distraction is a contributing factor in over half of these inattention accidents (Young et al. (2003)

[14] Green, M., Senders, J. (2004). Human error in road accidents. *Visual Expert*

Considering the available evidence, it was concluded that it was unlikely that distraction or inattention due to workload or attentional focus elsewhere were factors that influenced the driver/second person's perception of the aspect displayed by signal DIS-CN03.

Expectancy

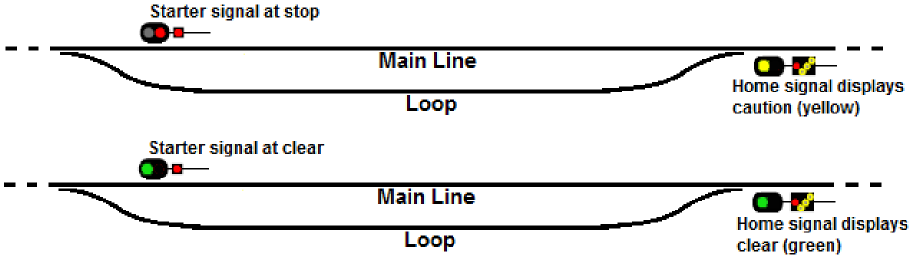
Another factor closely related to attention, and which can influence performance, is expectancy. An individual's expectations of future events can significantly influence their interpretation of information in the environment. Research has established that individuals often fail to notice unexpected events, even ones that are important. Even when objects are designed for visual distinctiveness, they will be missed if they do not fit within an individual's expectations.

Overcoming the powerfulness of expectancy is challenging, particularly because people will generally assume that, by looking in the right direction, unexpected objects and events will grab their attention.[15] Similarly, research has shown that a person's perception of the probability of a given event is strongly influenced by past experience and the frequency with which they encounter the event.[16] A person's perception that an event is likely to occur in the future is reinforced every time the person encounters that event.

During interview, both the driver and second person indicated that after having crossed with train 7MB4 at Uranquinty, they were unaware they would cross with another train (7MC2) at Culcairn North. The NCO was not procedurally obliged to inform the crew of 5BM7 about the presence of train 7MC2 approaching from the opposite direction and in this instance did not do so. As train 5BM7 approached Culcairn North, both the driver and second person recalled that, they saw a series of signals displaying green. It was therefore possible that the driver and second person developed an expectation that they had a clear run, which reinforced their perception of an uninterrupted sequence of signals, all displaying clear (green).

Additionally, the signalling arrangement at longer passing loops like Culcairn North differs from many of the shorter crossing loops on the Melbourne to Sydney (New South Wales) corridor. At the shorter crossing loops (Figure 8) the home signal at the entrance to a crossing loop also serves as the distant signal for the starter signal located at the exit of the crossing loop. For this configuration a driver entering the main line of a crossing loop with the starter signal at stop (red), would encounter the home signal at caution (yellow). When the starter signal is at caution (yellow) or clear (green), the driver would encounter the home signal at clear (green). Thus the indication at the home signal provides key information about the starter signal.

Figure 8: Simplified signal sequence through main line - short passing loop



Source: ATSB

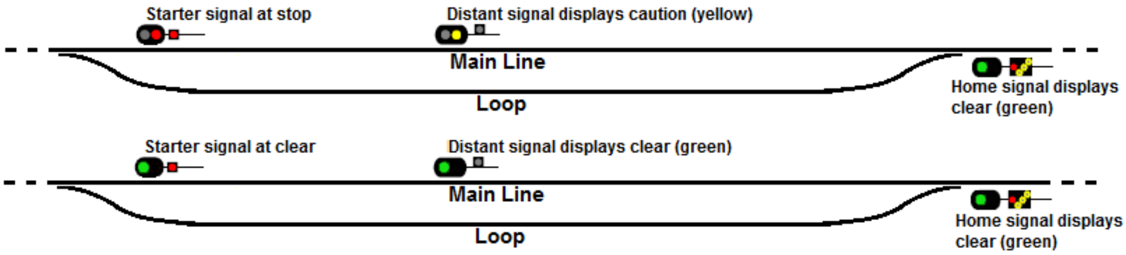
By contrast, the arrangement at the longer passing loops incorporates additional signals located about halfway along the loop (Figure 9). These intermediate signals, like DIS-CN03, only ever display caution (yellow) or clear (green) depending on the status of the starter signal (CN03) located at the exit of the crossing loop. As a result, home signals, like CN01, at the longer passing

15 Chabris, C. & Simons, D. (2010). *The Invisible Gorilla and other ways our intuition deceives us.* Harper Collins: Hammersmith.

16 Schoppert and Hoyt, 1968 cited in National Transportation Safety Board (1998a). *Safety at passive grade crossing.* Volume 1: Analysis. Safety study NTSB/SS-98/02. Washington DC.

loops will always display a clear (green) indication, unless the main line ahead is occupied in which case they will be at stop (red).

Figure 9: Simplified signal sequence through main line - long passing loop



Source: ATSB

It could be argued that based on many years of experience with the signalling arrangement in use at shorter crossing loops, that a driver observing signal CN01 at clear (green) may erroneously, and perhaps with limited conscious attention, have interpreted this to mean that starter signal CN03 at the loop exit would be clear (green). This may have led to a misperception of the intermediate signal, DIS-CN03 as being clear.

Interview evidence indicated that the driver was familiar with the signal configuration for the crossing loop at Culcairn North. He recounted having crossed opposing trains at Culcairn North on numerous occasions and also reported many experiences when an NCO had not provided information about opposing train movements. The driver's accumulated experience of negotiating the crossing loop at Culcairn North was characterised by variability and was therefore unlikely to result in an expectation bias for this area. While it cannot be ruled out, it is considered unlikely that the driver had developed an expectation of a clear run through Culcairn North based on his previous experiences, or that he made assumptions about CN03 based on observations of CN01.

The second person had not yet developed sufficient knowledge of the area to support a compelling argument that his perception of the indication displayed by signal DIS-CN03 was adversely affected by expectancy.

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.[17] 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

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

in work performance, and increased errors of omission.[18] Fatigue impairment has been identified as causal in many accidents and incidents such as Signal Passed at Danger (SPAD) events.

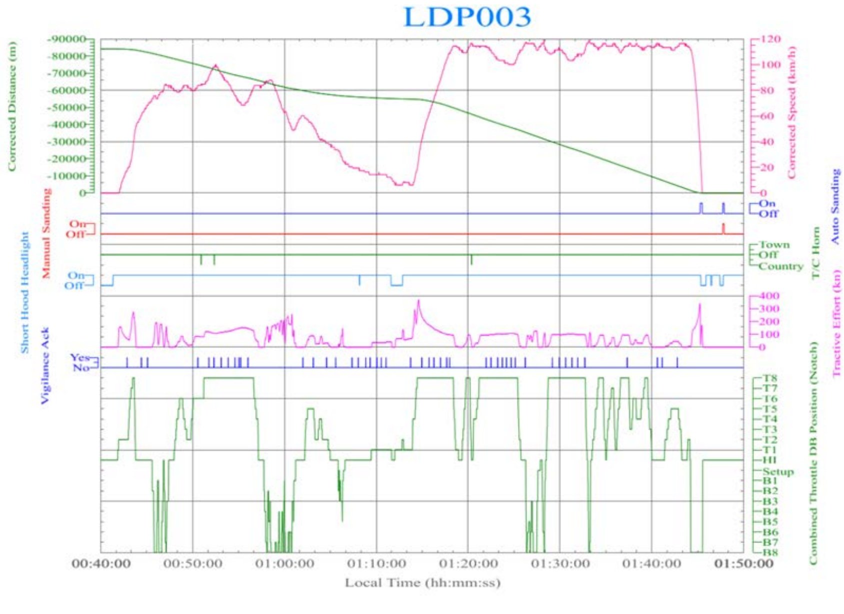
In this case, the driver was based in Junee, New South Wales. His roster shows that he had not worked the previous 8 days before commencing work on 6 April. He indicated that he was well rested during the period before commencing work. There was no evidence to suggest that the driver's performance was impaired by insufficient sleep prior to commencing shift.

The second person had worked several day shifts (0500 to 1300) prior to commencing work on 6 April. He had driven by car from Melbourne that morning, departing at 0800, and arrived in Junee at about 1330. He went to the hotel and rested before waking at about 1500 to have a meal. He then went back to bed and slept until about 2200, before waking and booking on for duty at 2315. At the time of the event, it is estimated that the second person had obtained around 10 to 11 hours of sleep in the past 24 hours, albeit broken into three phases. It was therefore unlikely that his performance was fatigue impaired due to insufficient sleep.

However, it must be noted that the time of the event (0145) was within a period of reduced human performance based on normal circadian rhythms. The possibility of a time of day effect on fatigue was therefore investigated via the examination of vigilance controls.

The lead locomotive LDP003 was fitted with an event logger. It records data such as date/time train speed, distance travelled, traction effort, throttle position and operation of the vigilance system.[19] An examination of available evidence and data extracted from the event logger in the minutes before the occurrence (Figure 10) established the following:

Figure 10: Extract of data down loaded from locomotive event logger



Source: Data source Aurizon, graph ATSB

- The driver was actively responding to the vigilance system. The data shows that the last vigilance response was at 0142:59, 87 seconds before the driver made an emergency brake application. The data also established that the driver was actively controlling/maintaining the train's speed close to 115 km/h, with a range of throttle commands. There were eight throttle adjustments made between the vigilance response at 0142:59 and the emergency brake application.

---

18 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.

19 Vigilance system - A system that will react by directly initiating an emergency brake application if an acknowledgment input is not received within a specified time increment.

- The driver rapidly responded to the headlights of the opposing train (7MC2) and signal CN03 when observed at stop (red). He immediately challenged the approaching train and made the emergency brake application.

On balance, it is unlikely that either the driver or second person were experiencing significant fatigue impairment at the time of the occurrence.

Crew dynamics

Considering the significant difference in experience between the two crew members, the effects of crew dynamics, and particularly authority gradient and conformity issues were investigated.

Authority gradient is a term used to describe the influence on crew communications where there is a significant difference in experience, expertise or authority. Research with flight crews has established that in crews with a steep authority gradient, the second person is often less likely to openly disagree with the senior crew member, and that this conformity effect can occur even when the junior crew member is aware of significant safety issues.[20] [21] There are a range of personality as well as cultural factors which can also influence the effect of an authority gradient.

The effects of crew dynamics can be subtle and are not necessarily easily observable by the crew members themselves. While this was the first time that the driver and second person had worked together, interview evidence indicated that the pair had talked easily during the trip and that the second person was sufficiently confident to assert his opinion. There was no compelling evidence to indicate that the second person's actions and observations had been adversely affected by crew dynamics.

Medical and toxicology

An examination of the driver's and second person'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. Neither the driver nor second person was known to have any sight impairment issues that should have affected their ability to correctly read signal DIS-CN03.

The driver and second person were not tested for the presence of alcohol or drugs post incident as there had been no specific breach of any rules or regulations.

Independent data validation

The ATSB was able to verify the operation of technical systems through examination of data and event recorders. For example, what the NCO could see on the Phoenix display and what actions the NCO takes are recorded and can be replayed for investigation analysis. In addition, the signal interlocking system includes event recording for verification of electronic inputs and outputs.

While driver actions are recorded by the locomotive data loggers, there is no independent method for verifying what the driver can actually see. In this case, without having an independent source of data, the ATSB was unable to clearly determine and verify what colour was being displayed by signal DIS-CN03 at Culcairn on 7 April 2013.

An independent data validation system, such as forward facing video on trains, would provide an invaluable mechanism/source of information in coming to an understanding of rail occurrence events, such as level crossing near misses and collisions, safeworking irregularities and signal irregularities including the trapping of an intermittent wrong side failure event.

---

20 Ginnett, R. (1993). Crews as Groups: their formation and their leadership. In Wiener, E.L., Kanki, B.G. & Helmreich, R.L. (eds.). *Cockpit Resource Management.* Academic Press: San Diego. pp71-98.

21 Skybrary (2013). *Authority Gradients*. http://www.skybrary.aero/index.php/Authority_Gradients

Findings

From the evidence available, the following findings are made with respect to the reported signal irregularity involving distant signal DIS-CN03 at Culcairn North on 7 April 2013. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (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 operating environment at a specific point in time.

Contributing factors

- As train 5BM7 approached Culcairn North, the driver and second person recalled seeing a series of signals displaying green.
- As the train approached and passed distant signal DIS-CN03, the driver and second person perceived it to be at clear (green). However, home signal CN03 was at stop (red), so distant signal DIS-CN03 should have been at caution (yellow).

Other factors that increase risk

- **There was insufficient verifiable data to clearly determine and substantiate any potential safety issues associated with the signalling system at Culcairn North. [Safety issue]**

Other findings

- There were no defects identified with the signalling system or signs of vandalism or graffiti that would have resulted in signal DIS-CN03 displaying a false ‘green’ indication. There was also no evidence of extraneous lighting and/or reflections off surfaces that may have resulted in the display of a false ‘green’ indication.
- The driver was suitably qualified, had sound route knowledge and had been assessed as medically fit. The second person had developed an understanding of the route and signalling system, had been deemed competent for the task he performed and assessed as medically fit.
- It is possible that the driver and second person’s perception of distant signal DIS-CN03 was influenced by cognitive, social or environmental factors. However, the investigation could not identify strong evidence to support such an explanation.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and 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 directly involved parties were provided with 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.

Independent data, an aid for understanding signalling occurrences

Number:	RO-2013-013-SI-01
Issue owner:	Aurizon
Operation affected:	Rail Operators – All rail operators.
Who it affects:	All rail operators throughout Australia.

Safety issue description:

The ATSB investigation was unable to substantiate the reported observations of the train crew without having an independent source of data, such as forward facing video on train 5BM7.

Proactive safety action advised by: Aurizon

Aurizon advised that:

> Aurizon currently has forward facing cameras on approx 8.5% of its locomotive fleet. These are located on numerous 5020, 6020, 6006, 4400 and 4300 Class Locos. Aurizon, with all new purchases, takes into consideration all available technology that may suit the application of the equipment. It is likely Aurizon will continue to add this type of technology to all new locomotive fleet purchases.

ATSB comment:

The ATSB is satisfied that the action proposed by Aurizon will adequately address this safety issue.

ATSB safety advisory notice RO-2013-013-SAN-031 to: All rail operators

The Australian Transport Safety Bureau encourages rail operators to consider the use of independent data validation systems, such as forward facing video on trains, to provide a source of information to assist with coming to an understanding of rail occurrence events, such as signal irregularities.

Action advised by: Rail Industry Safety and Standards Board

The Rail Industry Safety and Standards Board (RISSB) have advised that:

> The RISSB will encourage its membership and the wider rail industry to adopt the use of independent data validation systems, such as forward facing video on trains, to assist with coming to a better understanding of rail occurrence events, such as signal irregularities. Further, RISSB will actively communicate this intent through its regular Safety Management Group meetings, in conjunction with the ATSB.

ATSB comment:

The ATSB is satisfied that the actions proposed by the Rail Industry Safety and Standards Board (RISSB) will assist in adequately addressing this safety issue across the rail industry.

Current status of the safety issue:

Issue status: Adequately addressed

Justification: The actions proposed by Aurizon and the Rail Industry Safety and Standards Board (RISSB) should adequately address this safety issue.

General details

Occurrence details

Date and time:	7 April 2013 – 0142 ESuT	
Occurrence category:	Incident	
Primary occurrence type:	Reported Signal Irregularity	
Location:	4.52 km north of Culcairn, New South Wales	
	Latitude: 35° 37.552' S	Longitude: 147° 02.642' E

Train details

Train operator:	Aurizon	
Registration:	5BM7	
Type of operation:	Intermodal Freight Service	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Damage:	None	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Aurizon
- Bureau of Meteorology
- The Australian Rail Track Corporation (ARTC)

References

- ARTC Engineering (Signalling) Standards NSW.
- 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.
- Chabris, C. & Simons, D. (2010). *The Invisible Gorilla and other ways our intuition deceives us.* Harper Collins: Hammersmith.
- Ginnett, R. (1993). Crews as Groups: their formation and their leadership. In Wiener, E.L., Kanki, B.G. & Helmreich, R.L. (eds.). *Cockpit Resource Management.* Academic Press: San Diego. pp 71-98.
- Green, M., Senders, J. (2004). Human error in road accidents. Visual Expert
- National Transport Commission (2008). *National Rail Safety Guideline. Management of Fatigue in Rail Safety Workers*.
- National Transport Commission (2013). *National Standard for Health Assessment of Rail Safety Workers*.
- Regan, M.A., Hallett, C. & Gordon, C.P. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accident Analysis and Prevention, 43,* 1771-1781.
- Schoppert and Hoyt, 1968 cited in National Transportation Safety Board (1998a). *Safety at passive grade crossing.* Volume 1: Analysis. Safety study NTSB/SS-98/02. Washington DC.
- Skybrary (2013). *Authority Gradients*. http://www.skybrary.aero/index.php/Authority_Gradients
- RISSB National Guideline - Glossary of Railway Terminology

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 Aurizon, the Office of the National Rail Safety Regulator, the Office of Transport Safety Investigations, the Australian Rail Track Corporation and train crew.

Submissions were received from Aurizon, the Office of the National Rail Safety Regulator, the Office of Transport Safety Investigations, the Australian Rail Track Corporation and train crew. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB 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 factors related to the transport safety matter being investigated.

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 it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

24 Hours 1800 020 616
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au

Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation

Signal irregularity reported by crew of train 5BM7
Culcairn North, NSW, 7 April 2013

RO-2013-013
Final – 5 March 2014