Independent Investigation Report

Collision Indian Pacific Passenger Train 3AP88 and Freight Train 3PW4N

Zanthus, WA

18 August 1999

TRANSPORT

14 September, 1999

Mr Mike Harris
A/Director General of Transport
441 Murray Street
PERTH WA 6000

Dear Mr Harris,

In accordance with Section 5 of the Rail Safety Act 1998, the draft Key Business Process 4 – Independent Investigations of the Office of Rail Safety and the Terms of Reference, I am pleased to present you with the results of an independent investigation into the railway accident at Zanthus on the Trans Australia Railway on August 18 1999.

The report includes a description of the accident, an analysis of factual information surrounding the event, findings, significant contributing factors, identification of immediate and planned safety actions and a number of recommendations. It was not the purpose of this investigation to attribute blame or apportion liability.

During the investigation, I was provided with invaluable cooperation by the Australian Transport Safety Bureau, Australian Rail Track Corporation Ltd, National Rail Corporation Ltd and Great Southern Railway.

Yours sincerely,

Arthur Ruvidini
Major Projects Manager

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Executive Summary

At 1706 hours on 18 August 1999 the Indian Pacific passenger train No. 3AP88, Adelaide to Perth, was inadvertently directed onto the loop line at Zanthus where a freight train, No. 3PW4N, Perth to Whyalla was standing and as a consequence a low speed collision occurred between the two trains. The collision resulted in seventeen passengers and four train crew members being conveyed to Kalgoorlie Hospital by the Royal Flying Doctor, luggage/smoking lounge car HM311, on the Indian Pacific passenger train derailing and sustaining extensive damage and significant damage sustained to locomotives NR51, NR15 and passenger coaches. The east west rail link at Zanthus was closed to train operations until 1305 hours on August 19, 1999.

At the time of the collision, there were one hundred and eighty one (181) passengers, sixteen (16) Great Southern Railway On Train staff and five (5) Train Crew (drivers) on the two (2) trains. Thirty one (31) passengers and fourteen (14) On Train staff have reported sustaining some injury or side effects. Of the twenty one (21) persons conveyed to Kalgoorlie Hospital by the Royal Flying Doctor, only two (2) were held in hospital overnight for observation. One remained in hospital subsequently for some weeks.

There was no damage incurred to track and infrastructure.

The Indian Pacific Passenger train 3AP88 is owned and operated by Great Southern Railway using locomotives and locomotive crews provided on a "Hook and Pull" contract with National Rail Corporation. Freight service 3PW4N is operated by National Rail Corporation.

Australian Rail Track Corporation owns the track section and provides Train Control management from the Adelaide Control Centre. The train management safeworking system in operation over the section of line is a Train Order System. Mainline to loop points are fitted with electric points motors, equipped with mechanical point indicators and coloured light indicators, which are activated locally by push button switches provided in a control box at the equipment room.

The investigation found that the collision resulted from a crew member of train 3PW4N operating a push button control, as 3AP88 approached the points, altering the setting of the main line points from normal to reverse diverting train 3AP88 on to the loop. There was no mechanical or electrical interlocking system to prevent the movement of the points in front of the approaching train.

Procedural measures have been instituted to prevent a similar occurrence in the short term pending completion of a system upgrade being undertaken by Australian Rail Track Corporation. The system upgrade will provide a time interlock designed to prevent the movement of the points for a precise period related to the stopping time for an approaching train. The upgrade programme has commenced and is expected to be completed by December 1999.

Introduction:

As a result of a collision between two trains at Zanthus on the Trans Australian Railway, Western Australia, on 18 August 1999, the Director General of the Western Australian Department of Transport appointed an independent investigator to conduct an investigation into the accident in accordance with the Rail Safety Act 1998.

The terms of reference for the Rail Safety investigation are as indicated below:

- *To establish the factual circumstances leading to, and immediately following the collision.*
- *To receive and consider relevant evidence and comment provided by involved parties.*
- *Identify the cause or causes of the accident and any other contributing factors, including any human factors or underlying matters contributing to the accident, focussing on rail safety issues.*
- *Examine the post-incident emergency recovery procedures.*
- *Make appropriate recommendations designed to prevent such occurrences.*

The investigation should be conducted in accordance with Section 5 of the Rail Safety Act 1998 and the draft Key Business Process 4 – Independent Investigations of the Office of Rail Safety.
The investigation is to be commenced immediately and the draft report provided to the Director-General within 3 weeks of the commencement date. Should any circumstance prevent completion of the investigation within the specified time frame, early notification is to be provided to the Director General.
The independent investigator is empowered to use the provisions, granted to independent investigators under Part 5 of the Rail Safety Act 1998 for the purposes of the investigation.
The Investigation Report is to address the Terms of Reference and other issues as determined by the investigator. The Investigation Report is to be delivered to the Minister and Director-General on completion of the investigation. All matters related to the investigation are to be treated as confidential and the Report is not to be released to any other person without approval from the Director-General.

The Independent Investigator was provided with general and technical assistance by the Australian Rail Track Corporation, National Rail Corporation, Great Southern Railway and Rail Services Australia. These organisations were able to provide records, logs of events leading up to the collision, operating procedures and analysis of data loggers. An investigator with experience specialising in human behaviour factors was provided by the Australian Transport Safety Bureau to assist the Independent Investigator Their open participation and co-operation in the investigation process is acknowledged.

It was not the purpose of this investigation to attribute blame or apportion liability to any person or organisation.

Investigation Methodology:

Experts, from each of the involved parties, were invited to assist the Independent Investigator with the gathering and reviewing of evidence.

All relevant materials, data (points and locomotives) and voice (control tapes) logs, and records of preliminary investigations conducted by the involved parties were collected from relevant parties.

All information was analysed and reviewed then the sequence of circumstances prior to, during and immediately following the collision were captured on an events and conditions flow chart.

Data logs, voice recordings and reports on the occurrence were cross verified.

Occurrence site was visited to witness a normal crossing being undertaken by the trains of the same type and at the same time of the day as the collision occurred. Visual inspection of sighting distance for safeworking equipment was also conducted.

Interviews with each of the five train crew members of 3AP88 and 3PW4N were conducted.

Operating procedures, safeworking equipment and environmental factors were analysed.

All evidence was extensively analysed to establish the cause and contributing factors through a process of eliminating systems and procedures that operated in accordance with normal safeworking parameters and identification of those that worked contrary to safeworking principles or failed to provide adequate safeguards against safeworking error.

The Reason model was utilised in analysing the factors surrounding this accident.

Footnote:

The Reason model of accident causation has become one of the most widely applied systemic approaches to accident analysis. Reason maintains that accidents generally arise from a combination of immediate active failures which trigger the accident, and pre-existing system failures which create the circumstances in which the accident occurs.

1.0 Factual Information

1.1 Sequence of Events

On Wednesday, August 18, 1999, an EM80 Track Recorder entered the loop at Zanthus from the west end at 1352 hours and departed from the loop at the east end at approximately 1405 hours. Data loggers at the points indicated that the operation of the main line points at each end was by hand and that each set of points was left correctly set for travel on the main line.

Later in the day, an east bound National Rail Corporation Freight Service train no. 3PW4N, crewed by three drivers, was admitted by a Rail Services Australia contract workman from the main line to the loop at the western points at Zanthus at 1620 hours, western standard time, to fulfil a Train Order crossing with the Indian Pacific Passenger Service train no. 3AP88 operated by Great Southern Railway and crewed by two drivers.

As previously agreed by the crew when booking on for duty at 1135 hours at Kalgoorlie, the crew of 3PW4N effected a crew rotation on arrival at Zanthus with the member joining the cab being briefed concerning the current Train Order and crossing details. At approximately 1652 hours, train no. 3PW4N received and confirmed a further Train Order from Train Control for travel east of Zanthus. Some four to five minutes later, train no. 3AP88 received and confirmed a further Train Order for travel west of Zanthus. Train 3AP88 requested admittance from train 3PW4N to the main line at Zanthus. This was given by Train 3PW4N confirming that the east end points were set for the main line and that train 3AP88 could proceed.

On observing the locomotive headlight of the approaching train 3AP88, a crew member alighted from locomotive NR51 of train 3PW4N and walked to the east end points, checked the setting, then moved to the equipment room and stood near the points push button control box. The driver on the stationary locomotive of train 3PW4N noticed this crew member open the push button control box.

The Australian Rail Track Corporation Code of Practice stipulates 50 kph as a maximum speed for the train taking the main line for a cross. Train 3AP88 made a controlled approach to the east end facing points with train speed dropping gradually from 111km/hr, at a distance of approximately 3.3km from the east end points, to 52km/hr at 58m before the facing points. It was at this point that an emergency brake application was made when the train crew noticed the east end facing points move from being set for the main line across to the crossing loop and the flashing green indicator light change to flashing red. Although under full braking, the train travelled a further 148 metres from the point of emergency brake application before colliding with NR51, the locomotive of the stationary train no. 3PW4N. The force of the impact pushed locomotive NR51 eight metres back along the loop towards the west end points.

The crew of 3AP88 protected themselves in different ways; one moved to the vestibule of the locomotive, the other braced himself against the dashboard of the locomotive. The crew member of 3PW4N sitting in the drivers position of Locomotive NR51 jumped from the locomotive towards the main line when he realised a collision was inevitable. One crew member was already on the ground, and the third, sitting at 90° to his longitudinally positioned bunk in the crew van, was thrown on to the bulkhead of the door and suffered bruising to his right arm. None of the other drivers was injured. Australian Rail Track Corporation Train Control was advised of the collision by Train 3AP88 at approximately 1709 hours (WST). Train Orders WP69 and WP68 were cancelled at 1828 hours and 1836 hours respectively.

Australian Rail Track Corporation, on notification at 1709 hours, immediately invoked their organisation's emergency incident plan advising emergency services and train operators of the accident. Emergency medical staff and the Royal Flying Doctor service were mobilised. Crew members from the trains together with Rail Services Australia workmen rendered First Aid and assistance to the injured at the scene of collision.

1.2 Injuries

Seventeen passengers and four train crew from the Indian Pacific were taken to Kalgoorlie Hospital by air. Two were admitted to hospital for an overnight stay. One was released the following day, however, the other remained as a patient for some weeks.

One crew member from 3PW4N suffered a bruised arm and was expected to be off work for up to two weeks.

Subsequent to the accident and up to September 4, thirty one (31) passengers and sixteen (16) Great Southern Railway On Train staff had reported sustaining some type of injury or side effects.

Great Southern Railway will continue to monitor this situation.

1.3 Damage to Equipment

Damage to Great Southern Railway passenger vehicles occurred in varying degrees of severity to all 19 coaches from minor internal damage to severe under carriage damage and write off of one luggage/smoking lounge car. Great Southern Railway have advised that estimated damage cost to coaches is $5.0 million, however, this is not expected to be finalised for about three months.

Locomotive damage initially reported by National Rail Corporation was estimated to be approximately $400,000, however, this is likely to be closer to $1 million and will not be identified for some months.

1.4 Other Damage

1.4.1 Track

Track infrastructure was not damaged and was not a contributory factor to the collision.

1.4.2 Environmental

There were no spillages of any kind to adversely impact on the environment.

1.5 Personnel Information

1.5.1 Train Crew Details – 3PW4N

	Driver 1	**Driver 2**	**Driver 3**
Sex	Male	Male	Male
Age	57	44	42
Classification	Driver	Driver	Driver
Medical Status Date	Good 05-03-1999	Good 09-08-98	Good 06-02-98
Limitations	Nil	Nil	Nil
Locomotive Qualification	10-05-98	15-09-96	23-10-96
NR Class Training: Last assessed as competent on the Parkeston to Cook corridor Completed ARTC Network Operating Procedures	 29-07-98 04-06-98	 Due to be assessed 17-09-97	 28-07-98 17-09-97
Checklists conducted	29-07-98, 11-03-99	23-06-98	11-01-98, 14-02-99, 28-07-99

Each driver recorded a negative result when breath tested on site at 2200hours following the accident and attended a group counselling session on arrival at Kalgoorlie.

1.5.1.1 Crew Activity

Each driver has worked for National Rail Corporation for a period of four years and had not worked together regularly as a crew. Two of the three had become permanent as a crew pair in recent times with the remaining driver being on the 'holiday' roster which involved relief of drivers taking annual leave.

On being admitted to the loop, at the western end, train 3PW4N proceeded to approximately an engine length clear from the fouling points at the east end. A crew rotation took place and the new crew member joined the driver in the cab and was briefed about the Train Order details.

Following a wait of some thirty minutes, the headlight of train 3AP88 was noticed approaching and one of the crew got off the locomotive to do the roll by inspection. The driver remaining on the locomotive admitted the approaching train to Zanthus by a radio message.

The driver on the ground was observed at the points and then making his way to the equipment room. As train 3AP88 approached the driver in the locomotive of train 3PW4N noticed the points were starting to turn. Realising what was about to occur, he jumped from the locomotive towards the main line and took himself clear of the locomotive.

Following the collision, he returned to the cab of the locomotive and rang National Rail Strategic Operation Control.

1.5.1.2 Crew Circumstances

The driver on the ground at the points indicated that on noticing train 3AP88 coming down the hill into Zanthus he checked the points, watched the train approach, opened the push button control box and without knowing why and not remembering, pressed the button to set the points for the loop. At this stage he reported he was not thinking about what he was doing but what he had to do when he got to Cook. When he heard the points motor going and saw the points starting to move, he immediately pushed the green button to alter the points travel, however, the points continued to travel to the reverse position. This is a normal feature of motor driven points.

The driver who activated the points claimed not to have had more than fifteen to twenty hours sleep from Friday, August 13 up to the time of coming on duty at 1135 hours on August 18. He had taken a nyal decongestion cough mixture on Sunday 16 August and took some cold and flu tablets on Tuesday 17 August.

The crew had experienced a 42 hour break from driving prior to this shift and indicated that at Cook a minimum of eight hours is available on this roster with breaks as long as 12 hours. The break at Cook on this occasion was rostered to be 19 hours, 20 minutes.

1.5.1.3 Neuropsychological Assessment

Following the accident, a standard assessment was carried out by a Clinical Neuropsychologist to evaluate whether the driver on the ground had been suffering from any pre-existing neurological conditions which may have impaired his job performance. No evidence was found to indicate that the driver was suffering any such condition.

1.5.2 Train Crew Details – 3 AP88

	Driver 1	**Driver 2**
Sex	Male	Male
Age	42	46
Classification	Driver	Driver
Medical Status Date	Good 28-10-97	Good 09-02-98
Limitations	Nil	Nil
Locomotive Qualification:	19-12-97	10-10-96
NR Class Training: Last Assessed as competent on the Parkeston to Cook corridor	18-05-99	09-08-99
Completed ARTC Network Operating Procedures	02-01-98	20-08-97
Checklists conducted	06-04-98, 15-05-99	21-05-98, 04-08-99

Both drivers recorded a negative result when breath tested on site at 2200 hours following the accident and attended a group counselling session on arrival at Kalgoorlie.

1.5.2.1 Crew Activity

The drivers had approximately two and four and a half years experience as Drivers with National Rail Corporation. At approximately 1700 hours and about 7 or 8 kilometres out from Zanthus, contact was made by radio with the crew of 3PW4N seeking permission to enter Zanthus. From about 2 kilometres the flashing light indicator could be seen flashing constant green indicating that the points at Zanthus had been set for the main line.

The train speed was being controlled to allow a roll by inspection of the train, at fifty (50) kilometres per hour, by the crew of 3PW4N. Both drivers noticed the flashing light indicator change from flashing green to flashing red at a distance of 50 to 150 metres from the points. The driver estimated that the speed of the train was close to 50 kmh when the emergency brake was applied and about 20 kmh at impact.

1.5.2.2 Crew Circumstances

The crew protected themselves in different ways when it was realised that a collision was inevitable; one braced himself against a wall of the vestibule of the locomotive and the other against the dash of the locomotive. Neither driver was injured although one suffered muscle ache as a result of bracing himself against the wall.

The drivers reported that they had no difficulty in sleeping and commented that the use of a fatigue index in rostering of crews had provided the best roster experienced with ample rest periods between shifts.

1.5.3 Competency

All drivers have been through a comprehensive checklist of activities relating to engineman skills and safeworking procedures applicable to the drivers assigned task on the day and are competent drivers.

1.6 Train Information

One hundred and eighty one (181) passengers, sixteen (16) Great Southern Railway On Train crew were on board the Indian Pacific passenger train 3AP88, which consisted of nineteen (19) coaches and locomotive NR15 and totalling 469 metres in length with a trailing gross load of 838 tonnes.

Train 3PW4N, the stationary freight service was only partly loaded and comprised of twenty seven (27) wagons, 542 metres long and with a gross weight of 713 tonnes.

1.7 Weather

The weather at the time of the accident was cloudy but clear with good visibility. The sun was to the right of the driver and did not obscure vision.

Bureau of Meteorology data at Kalgoorlie, the nearest weather recording location to Zanthus, on August 18 was as follows:

Time	Wind Direction	Wind Speed	Wind Gusting	Temperature	Humidity
1600	NW	13 Knots	18 Knots	15.6	61%
1630	NW	10 Knots	14 Knots	15.4	64%
1700	NW	11 Knots	13 Knots	14.5	66%
1730	WNW	11 Knots	13 Knots	14.5	66%

Rain

0800-0900 hours 2 points
0900-1400 hours 1.8 points

Cloud Cover

1500 hours 6/8th cover
1800 hours 5/8th cover

Sunset Kalgoorlie
(Bickley Observatory provided this information)

1729 Hours

1.8 Recorded Information

1.8.1 Train Data Logger Analysis

The following analysis was conducted by National Rail Corporation.

Locomotive NR51 Train 3PW4N

TIME	DISTANCE	SPEED KPH	BRAKE PIPE KPA	EVENT DESCRIPTION
1622.25	1808.002	15	503	Train 3PW4 approaching Zanthus loop (west end) facing points in dynamic brake producing 376 traction motor amps. The brake pipe was fully charged to 503 kpa with the automatic train brake released and the headlight switched on.
1622.51	1807.913	9	503	Train speed further reduced to 9kph with dynamic brake in use and producing 168 traction motor amps.
1623.20	1807.854	4	503	Train speed further reduced to 4 kph with dynamic brake in use and producing 56 traction motor amps.
1623.29	1807.841	4	503	Train 3PW4 arrives some metres in advance of the Zanthus (west end) loop facing points where track maintenance staff set the facing points for the loop. Locomotive NR51 records the throttle being placed from dynamic brake into the idle position.
1623.32	1807.838	3	503	At speed of 3 kph, throttle notch 1 selected. Due to delay between exiting dynamic brake and applying power, no traction motor amps are recorded.
1623.50	1807.821	3	503	At a speed of 3 kph, and still in throttle notch 1, 152 traction motor amps are recorded.

Locomotive NR51 Train 3PW4N

TIME	DISTANCE	SPEED KPH	BRAKE PIPE KPA	EVENT DESCRIPTION
1624.53	1807.764	3	503	Automatic brake application implemented as train 3PW4 approaches the east end of the Zanthus loop.
1625.03	1807.756	0	448	Train 3PW4 arrives into Zanthus loop and is recorded as being stationery from this time to the time of impact with train 3AP8 at 1706.02
1706.02	1807.754	0	468	Locomotive NR51 records an impact that commences an automatic brake application with the brake pipe having reduced from 496 kpa to 468 kpa in 1 second. The locomotive independent brake was applied with 434 kpa.
1706.03	1807.754	2	165	Train speed recorded as 2 kph in a reverse direction with the brake pipe reduced to 165 kpa, the locomotive independent brake recording 420 kpa and the throttle in the idle position.
1706.05	1807.753	0	13	Train speed recorded as zero with the brake pipe pressure at 13 kpa and the locomotive independent brake applied with 448 kpa. Throttle recorded in the idle position. The locomotive reverser selector handle was recorded in the forward position.

From the available information, train 3PW4 appears to have been operated in a manner consistent with National Rail's standard operating procedures and the track owner's safeworking requirements up to arrival into Zanthus.

Locomotive NR15 Train 3AP88

TIME	DISTANCE	SPEED KPH	BRAKE PIPE KPA	EVENT DESCRIPTION
1703.02	737.628	112	496	Normal train running with throttle in notch 2 position and headlight on.
1703.03	737.597	112	496	Automatic brake application initiated to reduce train speed on approach to Zanthus location board in preparation for 50 kph roll by inspection speed.
1703.04	737.566	112	468	Automatic brake application continued with brake pipe reduced to 468 kpa.
1703.15	737.223	111	461	Automatic brake application continued with brake pipe reduced to 461 kpa. Locomotive horn sounded to maximum intensity of 9 out of 9. Horn sounded at a distance of 4.365 km from the Zanthus (east end) loop facing points.
1703.16	737.192	110	461	Locomotive horn continued to be sounded to maximum intensity of 8 out of 9.
1703.32	736.722	98	441	Automatic brake application continued with brake pipe reduced to 441 kpa. Speed reduced to 98 kph and throttle in notch 2 position.
1703.51	736.244	83	441	Automatic brake application released and brake pipe commenced to recharge. Train speed 83 kph with the track grade on approach to Zanthus to further reduce the train speed to the required 50 kph without further brake application.

Locomotive NR15 Train 3AP88

TIME	DISTANCE	SPEED KPH	BRAKE PIPE KPA	EVENT DESCRIPTION
1703.54	736.177	78	496	Brake pipe fully recharged with automatic brakes released. Train speed 78 kph and throttle to notch 2 position.
1704.38	735.269	72	496	Train speed 72 kph and throttle moved from notch 2 position to notch 1 position.
1705.25	734.382	61	496	Train speed 61 kph and throttle moved from notch 1 position to idle position.
1705.53	733.947	52	496	Emergency brake application implemented at a distance of 58 metres prior to the Zanthus loop (east end) facing points, and a total of 148 metres from the point of impact. Train speed 52 kph and throttle in idle position.
1706.00	733.853	42	34	Emergency brake application fully applied with brake pipe depleted to 34 kpa and train speed reduced to 42 kph. Independent locomotive brake applied with 144 kpa.
1706.06	733.799	27	62	Impact point with locomotive NR51 on train 3PW4 in Zanthus loop. 13 seconds had elapsed from the time of the emergency brake application to impact.
1706.07	733.796	10	62	Following initial impact the speed of locomotive NR15 reduced to 10 kph from 27 kph in 1 second.
1706.12	733.791	0	48	Locomotive speed recorded as zero at a distance of 8 metres and 6 seconds following the initial impact. Locomotive NR15 headlight was switched on throughout the incident.

From the available information, train 3AP88 appears to have been operated in a manner consistent with National Rail's standard operating procedures and the track owner's safeworking requirements.

The reduction in speed from 52 to 27 kmh within 148 metres indicates that the braking effort was consistent with expected performance.

The data logger information from locomotive NR15 indicates that train 3AP88 (Indian Pacific) was managed in a manner consistent with passenger comfort and safety and in accordance with train driving rules and practice. The crew's immediate response minimised the risk to safety.

1.8.2 Self Restoring Switch Data Logger

Three print outs were obtained from:

- Zanthus East End at 0052 hours 19th August 1999.
- Zanthus West End at 0113 hours 19th August 1999.
- Zanthus East End at 1154 hours 19th August 1999.

A time difference of 13 minutes between real time and logger time has been noted on the print taken from the Eastern End of Zanthus. The times recorded by the data logger are 13 minutes behind local real time.

Functions recorded by the data logger are limited to the time and date of the following functions:

- The count recorded by each of the four proximity switches when trains are entering or departing the crossing loop, counts are not recorded for through moves on the main line.
- Any hand operation of the points.
- Any temporary or permanent non-performance of a proximity switch, i.e. a 'lock on' which occurs when the magnetic field is disrupted for a period of time which exceeds preset values.

Functions not recorded by the data logger include, the indication displayed by the flashing light indicator, the position of the points nor operation of the pushbuttons.

Analysis of SHEET 1.
Location: Zanthus East

1351 - 1352 hours +13 minutes = 1404 – 1405 hours 18th August, the EM80 track recording car departs the loop with the points in hand mode.
When the EM80 had cleared the facing mainline points, the machine was restored to motor function as indicated by the print out at 1352 + 13 = 1405 hours.

Analysis of SHEET 2

Location: Zanthus East

1351 – 1352 hours + 13 minutes = 1404 – 1405 hours 18th August, the EM80 track recording car departs the loop with the points in hand mode.

When the EM80 had cleared the facing mainline points, the machine was restored to motor function as indicated by the print out as 1352 + 13 = 1405 hours. This indicates the machine was restored to Normal.

At 1139 hours + 13 minutes = 1152 hours 19th August, at the completion of the sequence i.e. the wreckage was pulled clear and the points could complete the function.

The logger has timed and dated the end of the last sequence commenced, this is consistent with the points being set to reverse and then an attempt being made to reset the points to normal in the face of Train Number 3AP88.

The printout indicates that:

Proximity switch A1 counted 8 axles
Proximity switch B1 counted 7 axles
Proximity switch A2 counted 0 axles
Proximity switch B2 counted 0 axles

Reference to the document “Trans Australia Railway, Self Restoring Switches Functional Description of Control System” states under the heading Sequence of Operations sub heading loss of Count interrupted by reverse detection broken that wheels continue to be counted in 3 second interval between when Reverse Detection breaks and Reverse Slug picks.

This means that counts will be recorded for three seconds after the loss of reverse detection, in this incident reverse detection was lost approximately 1-1.5 seconds before the leading axle of 3AP88 passed over the first proximity switch A1.

With a train speed of approximately 50 KM/H which equals 13.88 metres/second it follows that the system would have counted the axles for the first 20.8 metres of rolling stock, then stopped the count.

This figure is consistent with the axle spacing of the rolling stock involved in the incident.

Further reference to the Functional Description, identifies the following will occur.

- The Isolating Relay will de energise
- The Isolating Relay will cut power to the point machine
- Movement of the point blades will cease

Details of the last train to use the Crossing loop are shown on the last line of the print out timed and dated at 1301 hours + 13 minutes = 1314 hours on 14th August 1999 (four days earlier), when an axle count of 282 was recorded on all four proximity switches.

Analysis of SHEET 3

Location: Zanthus West

1351 hours 18th August EM80 enters the Crossing loop by operating the point machine in hand mode.

1612 hours 18th August 1999, Train 3PW4 enters the Crossing loop, a count of 114 is recorded on all four proximity switches, this is the prime requirement for the points to restore to normal.

1.8.3 Train Control Voice Logger Tapes

Indicate correct application and issue of Train Orders applied to both trains, Train 3AP88 was to take the main line and Train 3PW4N to take the crossing loop. This was confirmed by a hard copy of the Train Order issued by Train Control.

1.9 Occupancy Control Systems

1.9.1 Train Order Working

Train Order working comprises the issue of a proceed authority in the form of a Train Order which authorises a train to move between specified locations, and is issued by the Train Controller to the train crew or qualified worker who arranges delivery to the train crew. The train crews are required to observe the instructions in the Train Order together with any signal indications. The route over which a train is authorised to move by Train Order is verified as clear through manual procedures. The setting and verification of points is undertaken by the train crew themselves at unattended locations or by qualified workers at attended locations and shall comply with the instructions contained within the Train Order or by rules and procedures which includes the requirement for crossing or passing of trains.

1.9.2 Track Side Signage

A Location Board is installed two kilometres in advance of the Yard Limit Board at Zanthus.

A Yard Limit Board is installed approximately 160 metres from the facing point.

A Mechanical Point Stand connected to the point blades displays indications as follows:

Green Arrow:	Indicates the main line points are set for the main line.
Yellow Dumb Bell:	Indicates the main line points are set for the crossing loop.

The point stand targets installed at the east end of Zanthus are in good condition.

Flashing Light Indicator at the east end of Zanthus is clearly visible at the Location Board. This was witnessed and agreed on 19th August by representatives of National Rail, Great Southern Railway and ARTC and Loss Adjusters acting for National Rail and Australian Rail Track Corporation, after the collision on the 18th August 1999.

1.10 Flashing Light Indicators

The flashing light indicators are provided as an enhancement to the mechanical point indicators, and display the following indications to approaching trains.

Indication	Condition
Flashing Green	Both the facing and trailing points are set and locked for the mainline.
Flashing Green followed by Flashing Red	The facing points are set and locked for the mainline, the trailing points have not set and/or locked for the mainline
Flashing Yellow	Facing points are set and locked for the Crossing loop; the trailing points are not detected in this condition.
Flashing Red	Facing points and possibly the trailing points are not set or locked, or the points are in transit.

The system is defined in the Australian Rail Track Corporation Code of Practice (TA 01 Page 5) under definitions as:

“Flashing Light Indicator: A flashing light indicator provides an enhancement to the indication displayed on the point stand indicator at the facing and trailing points at the location”.

By definition, the system is not considered a signal system. Flashing Light Indicators are not defined as absolute nor permissive indications, marker lights or marker disks are not fitted and the indicators are not numerically identified.

Track circuits are not used in the system; hence the indicators do not cancel, when passed by a train as is the case with conventional signal systems.

The system is not fitted with approach locking, a feature unique to formal signalling systems, but relies on adherence to procedures for correct operation.

A Programmable Logic Controller (PLC) is used to collect and process inputs from the four proximity switches, two push button functions and the point machine detection contacts, the output governs the aspect displayed to approaching trains.

The indications displayed by the flashing light indicators are unlike the indications displayed by conventional signal systems.

The flashing light indicators do not give a proceed indication, but indicate the setting of the facing and trailing points. The authority to proceed is provided by the Train Order and not by the Flashing Light Indicators.

1.11 Train Driving Rules And Procedures

1.11.1 Trains Crossing at Unattended Locations on Train Order Territory with Flashing Light Indicators and Self Restoring Points First Train is to take the Crossing loop.

(a) When the train crew have established that the train to take the crossing loop will enter the yard first, or when the train crews involved are not able to communicate, the train crew of the train to take the crossing loop must:

- Stop the train before the counters at the facing points
- Reverse the facing points and observe the correct flashing light indication is displayed
- Give an admittance signal and then rejoin the engine
- Enter the crossing loop and stop before the fouling point at the far end of the loop.
- Report train arrival to the Train Controller.
- Confirm that the points ahead are correctly set for the main line.
- Give an admittance signal to the train crew of the train to take the main line.

(b) The train crew of the train to enter the main line must:

- Not pass the yard limit board until admitted by the train crew of the opposing train.
- Enter the main line on receipt of an admittance signal observing that the correct flashing light indication is displayed.
- Confirm that the train on the crossing loop is complete.
- Fulfil any other instructions contained in their Train Order for that location.
- Obtain a Train Order.
- Proceed in accordance with their Train Order.

Note: The train crew may traverse the main line at a speed not exceeding 50km/h until such time as the train has passed beyond the standing train.

(c) The train crew of the train on the crossing loop must:

- Confirm that the train traversing the main line is complete.
- Fulfil any other instructions contained in their Train Order for that location.
- Obtain a Train Order
- Set the points for departure
- When the train crew has rejoined the engine, proceed in accordance with their Train Order.

1.12 ARTC Upgrade Project

On 27 April 1999, Australian Rail Track Corporation advised rail operators:

"Track Access commenced a review of the current self restoring points on the TAR prior to the take up of ARTC and since that time considerable research has been undertaken into the upgrading of the existing system to provide a viable system. Whilst the present system has proven the viability of operation of self restoring points with limited technology it has reached the end of its economical life. At no time has a wrong side failure with the system been proven, however the system has not been as reliable as it should have been due to a number of factors including train length and speed over the current counters.

Effective 19 May 1999 Tent Hill is to become a trial site for an upgraded system and the following details the changes which will occur both to the system and the Regulations governing the use and indications displayed by the system."

Following successful trial results, introduction of this system has commenced working eastwards from Parkeston and is expected to be completed in December 1999.

Workmen at both ends of Zanthus were involved with this project placing track bonding cables, changing batteries and location signs amongst other things. None of this work impacted on the operation of the points at Zanthus on 18 August and no alterations had been made to the existing points control system.

1.12.1 Description of the System

The points will be detected through track circuits in lieu of the present "axle counter" system and therefore whilst a movement is over the track circuited area the points will not be able to be operated accidentally. Movements through the main line will be able to operate up to 110km/h.

Location Boards will be placed 2500 metres from the Yard Limit Board and will be erected in accordance with the recommended standard viz. 2500 metres has been determined as a stopping distance for the maximum length trains now being operated over the corridor and hence this distance will become the new standard for advisory signs.

The Yard Limit Board will generally be placed 100 metres from the facing points except a greater distance is required for any regular shunting but then not more than 250 metres from the facing points.

The flashing light indications will be upgraded with a new lens intended to be visible for a distance of 2500 metres and become known as light indicators. Repeaters for the flashing light indications will be installed at 31 locations.

The indications will be changed from the present flashing system to that detailed below-:

1. Points set and locked for the main line throughout, train may proceed at normal speed – steady green.
2. Facing points set and locked for the main line, point at the far end of the yard not correctly set and locked for the main line – steady yellow.
3. Facing points not set and or locked for the main line – points at the far end of the yard may also not be set and or locked for the main line – steady red.
4. Facing points set for the crossing loop – flashing yellow.

Points stands will continue to display indications as per the Code of Practice section 11.4.

1.12.2 Enhancement to the System

As a result of the accident at Zanthus, ARTC have made a variation to the upgrading project to provide a suitable door switch in the push button control box at each main line set of points and crossovers. This door switch is to be protected from inadvertent operation and will provide a 2-3 minute time delay in the normal and reverse operation of the points. Work west of Cook will be retrofitted and work east of Cook will be done in conjunction with the major upgrade work.

The modification of the new system consists of an electrical switch which detects the opening of the door of the push button enclosure. When the door is open, the switch will result in the following two activities:

- A contact of the switch opens and places the enhancer to the red indication. This is achieved by the door switch contact being directly in the coil circuit of the searchlight relay. The red indication will be displayed at all times when the door is open.
- The point machine control push buttons will not accept a command until a timer circuit has counted down from a predetermined value (suggested to be 90-120 seconds, this has yet to be confirmed). At the expiry of the count down period, a Light Emitting Diode (LED) mounted on the panel on which the push buttons are mounted will show a steady white light indicating that the points will now accept a command. It will not be possible to lodge a command until the count down is complete; the system will ignore all activity on the push buttons until the time delay has elapsed.

At the end of the countdown, the points may be moved using the push button, but the enhancer will display a red indication until the push button box door is closed, at that time, the enhancer will display an indication consistent with the position of the points.

2.0 Analysis

2.1 Introduction

The investigation determined that no mechanical or technical failures in the points, track or rolling stock contributed to this accident. However, the railway safety system is more than a collection of mechanical or technical components. People are an important element of the total system, and it is clear that human error was the triggering event which immediately precipitated this accident.

It is clearly undesirable that a single error should be able to result in a major accident of this nature. While flawless human performance is a worthy aim, it is in reality rarely achievable. It is apparent that the system in operation at Zanthus relied on perfect human performance to ensure safety.

2.2 Active Failures

In common with most accidents, the collision at Zanthus involved an active failure committed by a person. This was the error of pushing the points reverse button as the Indian Pacific was approaching the main line facing points. Almost certainly, the driver intended to open the push button control box and then wait for the train to pass before pushing the points reverse button.

This action was almost certainly a 'skill based' error in the sense that the person who committed it had no intention of performing the action at that time, but pushed the button in an 'automatic' fashion, apparently out of habit. The fact that he immediately realised his error and attempted to restore the points to the normal position indicates that he had not intended to move the points at that time.

Skill-based errors occur in situations where a person performs a routine series of simple actions regularly, with the result that the actions can be performed with little conscious control. If the person intends to perform an action in a manner which is different to their habit, but is distracted and fails to consciously modify their behaviour, then the habitual but undesired action sequence may be performed inadvertently. Such actions have been shown to contribute to many industrial and transport accidents. It appears that the habit of the driver was to open the box and then push the reverse button immediately after. In this case, it seems that the act of opening the box led inadvertently to the act of pushing the reverse button.

The driver's error in moving the points at the wrong time was not an isolated event.

In April 1996, a freight train was derailed at Malbooma when the points were inadvertently changed as the train was passing over the points. In addition, information was obtained in the course of the Zanthus investigation indicating that several drivers have nearly pushed the reverse button at the wrong time, but had stopped themselves from doing so at the last moment.

Clearly the potential exists to commit a skill-based error and change the points at the incorrect time. Given the serious potential outcome of such an error, there is a need for stronger defences either to prevent such errors occurring, or to minimise their consequences should they occur.

The driver in question reported that over a period of five days prior to commencing duty he had experienced only 15 to 20 hours sleep and had taken decongestion cough mixture and cold and influenza tablets. Having experienced all of this lack of sleep he still presented himself for work. This could be considered a possible second failure in reporting to work because of an admirable sense of loyalty and commitment to the company. However, it could be argued that a person who has experienced this small amount of sleep over an extended period should not have been at work.

2.3 Local Factors

Opening the box and accessing buttons before a train had passed, clearly increases the potential for human error. Yet at the time of the accident, there was no detailed standard procedure to regulate how drivers should go about changing the points at crossing loops.

An operating procedure issued by the track owner clearly identifies what a driver must do to exit a crossing loop but does not specify any mandatory order of action.

It is quite clear that the practice of opening the push button control box prior to the arrival of a train to carry out a cross is normal practice.

2.4 Organisational Issues

2.4.1 Operating Procedures

Procedures for carrying out roll-by inspections and crossings are outlined by the train operator and the track owner. Respectively, while the track owner specified procedures to be observed by operators, these did not extend to a sufficient level of detail. The rail operator specified operating procedures for its drivers however, these also, did not specify in detail the procedures to be followed at crossing loops.

It was not clear during this investigation whether the responsibility for specifying such procedures lies with the track owner or the operator. Because there are a number of operators that have trains traversing the Trans Australia Railway, there is a need to resolve this ambiguity and ensure that safety-critical procedures are specified at an appropriate level of detail.

2.4.2 Risk Management

The Australian and New Zealand standard on Risk Management acknowledges that the management of risk is an integral part of the management process. Risks can derive from sources such as natural events, technological issues and human behaviour.

In October 1997 a risk analysis of safeworking systems was prepared for Track Access, South Australia. In considering the Train Order Working system in use on the South Australian portion of the Trans Australia Railway, the report concluded that; "The primary risk factor is the almost total reliance on the integrity of the staff using the same (ie) the human factor …… It is the professional opinion that Train Order Working as and where employed by Australian National has not been considered in terms of the human element and the potential for human error." That report recommended that the current system be replaced with a new system designed with human fallibility in mind.

In October 1998 a review of safeworking systems and safety management was prepared for ARTC. This report stated that previous comments contained in the 1997 report were still relevant. However, it also acknowledged that some significant amendments had been made following the recommendations contained in the October 1997 report, specifically in the procedures for Train Order Working. Conditional Train Orders had been prohibited and drivers must speak to Train Control at the loop immediately preceding a booked crossing. The report stated that; "This is a positive enhancement to the safety of what continues to be an exposed system of Train Control but has significantly reduced some of the risks inherent in the system."

While individual errors cannot be predicted, the overall risk of human error can be estimated. Published data is available from industry, in general, which identifies the probability of a human error on a routine activity such as activating a control button. Clearly, identifying the probability of human error associated with safety-critical activities in a railway operating environment is of high importance.

2.5 Rail Incident Databases

An important source of information to identify hazards in advance of accidents is an incident database, coupled with appropriate level of data analysis. Incident databases in most Australian industries have traditionally focused on technological or mechanical failures and generally contain little information on the human performance failures which present risks to the system. This is despite the fact that human behaviour is the largest contributor to accidents in complex technological systems such as rail transport.

All states in Australia maintain rail incident databases. The information is reported to a central agency which has the responsibility to identify potential safety hazards. However, the lack of human factor data in the database, and the lack of satisfactory data analysis has resulted in a failure to identify proactively system risks.

2.6 Failed or Absent Defences

There was no formal procedure specifying in detail how the crossing should be accomplished. A checklist or other formal procedure to guide the driver may have reduced the likelihood of an error occurring.

The system which existed on the day of the accident was not error-tolerant. In particular, there was no locking system or other method to prevent inadvertent activation of the points.

2.7 Emergency Response

Reaction of the three organisations to the accident was swift and efficient given time and location of the accident. Train Control Adelaide was a prime mover in co-ordinating activities and this role was pivotal in the successful operation of rendering assistance and evacuating some 200 people from the site.

The Royal Flying Doctor Service treated some 20 people on site, assisted by a nurse from Coonana, or at Kalgoorlie Hospital.

A doctor and his wife, travelling on the Indian Pacific, rendered immediate First Aid assistance together with crews from both trains. The on board doctor was able to identify emergency requirements and consequently ambulance and plane requirements.

The Royal Flying Doctor Service decided to take the injured people to Coonana air strip forty kilometres away. This was based on the pilot's knowledge that a safe landing could be made.

Passengers were taken off the Indian Pacific, which did not have power, as a safety measure and were provided with blankets and variously housed in the crew van of 3PW4N, the Zanthus barracks and around fires in the open.

Westrail provided two Prospector rail cars to transfer people back to Kalgoorlie. Perth passengers arrived in Perth in two groups at about 0845 hours and 1600 hours on August 19.

It is understood that the Kalgoorlie police will be conducting a review of the emergency operation with each rail organisation attending. These organisations are planning their own internal review over the next few weeks.

Currently Transfield, employed under contract by Australian Rail Track Corporation, and Loongana Lime maintain a number of airstrips adjacent to the Trans Australian Railway. This issue is being investigated by Australian Rail Track Corporation with the aim of ensuring that all airstrips are maintained to a satisfactory standard.

It is considered that the commitment from all staff on site was excellent under the conditions and circumstances of the location.

3.0 Conclusions

3.1 Findings

- The crew of 3PW4N had resumed work at 1135 hours after a break of 42 hours.
- Train 3PW4N successfully operated a cross at Blamey.
- All drivers were qualified for their assigned task.
- The collision occurred in daylight with good visibility.
- Both trains received after fulfilling “Train Orders” for travel beyond Zanthus
- The crew of train 3AP88 operated the train in a professional competent manner.
- The crew of train 3AP88 confirmed the mainline setting of the points.
- The flashing green light indicator was clearly visible to the crew of 3AP88.
- Setting of the eastern end points for the mainline confirmed by a workman at the western end after admitting 3PW4N to the loop.
- Crew of 3AP88 requested admittance for the mainline.
- Driver of 3PW4N admitted 3AP88 and confirmed points set for the mainline.
- Driver on 3PW4N saw the driver on the ground open the push button control box.
- Driver on 3PW4N saw points change from main to loop in front of 3AP88.
- Driver at the equipment room remembers opening the push button control box.
- The driver stated that he did not know why he pushed the points reversing button.
- The driver stated he could not remember pushing the button.
- The driver on hearing points move and seeing them start to turn pressed the normal button.
- Both drivers of 3AP88 saw the flashing light indicator change from green to red and the points move from the main line to the loop.
- Emergency brake application made by driver of 3AP88 at 58 metres from the points.
- Train speed at impact was established as 27 kilometres per hour.
- No mechanical or technical failures in the points, track or rolling stock contributed to the accident.

3.2 Significant Factors

- The system in place on the day of the accident was unable to cope with the human error.
- There were no mechanical or electrical defences in place to prevent the points button being pushed in front of the train.
- Procedures on the part of owner and operator governing driver behaviour were not sufficiently detailed to specifically prevent out of sequence operation of the points.

4.0 Safety Action

4.1 Actions Taken ARTC/NRC

Australian Rail Track Corporation and National Rail Corporation have instituted action during the investigation as outlined below:

Australian Rail Track Corporation have issued the following train notice:

Train Notice	No	4448	1999	Issued	03-09-1999	Type: S	Operator: GEN
SAFEWORKING EQUIPMENT			Effective From		03-09-1999	Effective to:	

TO ALL CONCERNED:

ALL SAFEWORKING EQUIPMENT AND ASSOCIATED ENCLOSURES MUST REMAIN LOCKED UNTIL REQUIRED FOR ACTUAL TRAIN WORKING.

OPERATION OF THE EQUIPMENT MUST AT ALL TIMES BE CONDUCTED WITH DUE CARE AND CONSIDERATION FOR ALL TRAINS IN THE VICINITY AND IN ACCORDANCE WITH THE REQUIREMENTS OF THE CODE OF PRACTICE.

APPROPRIATELY QUALIFIED MAINTENANCE CONTRACTORS MAY OPERATE SAFEWORKING EQUIPMENT FOR THE PURPOSE OF MAINTENANCE AND TESTING ONLY AFTER GAINING APPROVAL TO DO SO HAS BEEN OBTAINED FROM TRAIN CONTROL.

National Rail Corporation have issued the following System Operational Notice which identifies where train crew are to position themselves for a Roll By Inspection but does not offer advice as to when the train crew should activate the points control buttons.

SYSTEM OPERATIONAL NOTICE

SON No: OPS 7/97

Title	Roll by Inspections
Applicable Dates	2 September 1999
Approved By	John Fullerton, Chief Operating Officer
Issued By	Angelo Demertzis, National Operations Manager
Date of Issue	10 September 1999
Issue No.	3

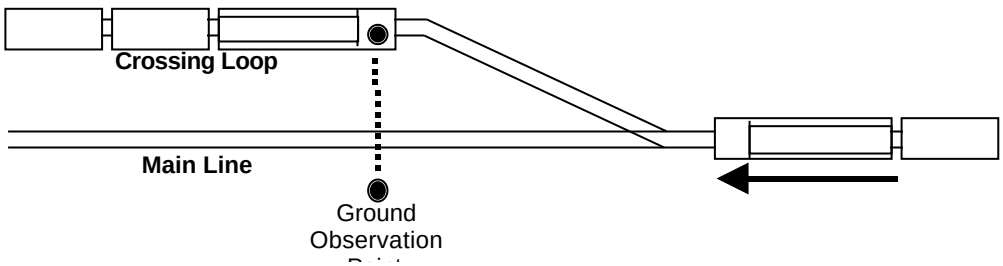
This replaces SON No. OPS 7/97 Issue No. 2 issued on 31 August 1999 and supersedes Operations Manual procedure OM B2-2 Issue 1, this procedure will be amended accordingly. The changes have been underlined.

When admitting trains to crossing locations, a roll by inspection of the train is to be performed by the Locomotive Drivers, where ever it is safe and practical to do so:

When crossing or passing trains

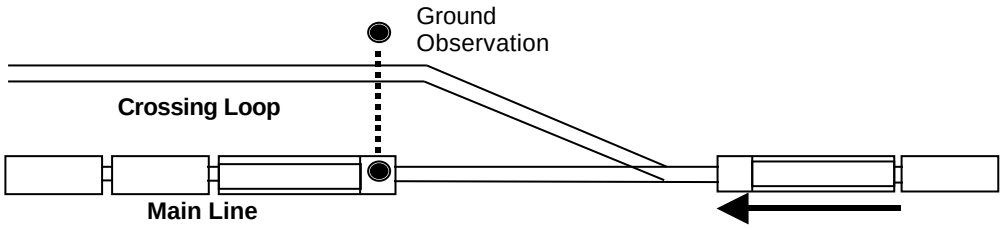
- After being relieved en route or in a yard
- At crew change and depot locations
- When arriving or departing trains into or from any yard where no qualified employees is present

At crossing loops and where infrastructure arrangements and/or ground conditions allow it to be done safely, one crew member is to be positioned in line with the locomotive on the opposite side of the main running line, ie:



Crossing or Passing Train through Main Line

At crossing locations where the stationary train is standing on the main line and the crossing train is to be admitted to the loop, where infrastructure arrangements and/or ground conditions allow it to be



Crossing or Passing Train to Take Crossing Loop

done safely, one crew member is to be positioned in line with the locomotive on the opposite side of the crossing loop, ie:
When crossing or passing trains at night, one driver should remain on the locomotive to operate the headlight on full beam when appropriate.

The state of the loading, bearing conditions (smoke, noise), dragging equipment, wheel flats and/or scale build-up should be particularly observed and reported, as well as anything else untoward.
Any defects or problems noted should be reported to the crew concerned via the local radio to Train Control, and to the National Operations Centre. When and where appropriate assistance is to be provided to the train crew to deal with the problem.

During times of inclement weather, drivers are required to make a judgement about the appropriateness of the roll by inspection. It is understood that it will not always be possible to carry out roll-by inspections.

4.2 Recommendations

It is not intended to specify any required major action which is clearly being addressed by the upgrade and enhancement of the system currently being installed by Australian Rail Track Corporation. This system will still simply be a self restoring switch system in a Manual Train Order Control System which relies on due care and diligence by those involved for safe operations to occur. The following recommendations are made:

1. Where there are vital safety-critical activities required to be executed, procedures should be provided with sufficient detail to ensure that what should occur does and in the correct sequence.

2. A risk analysis involving the human factor aspect of vital safety critical activities should be considered in framing procedures.

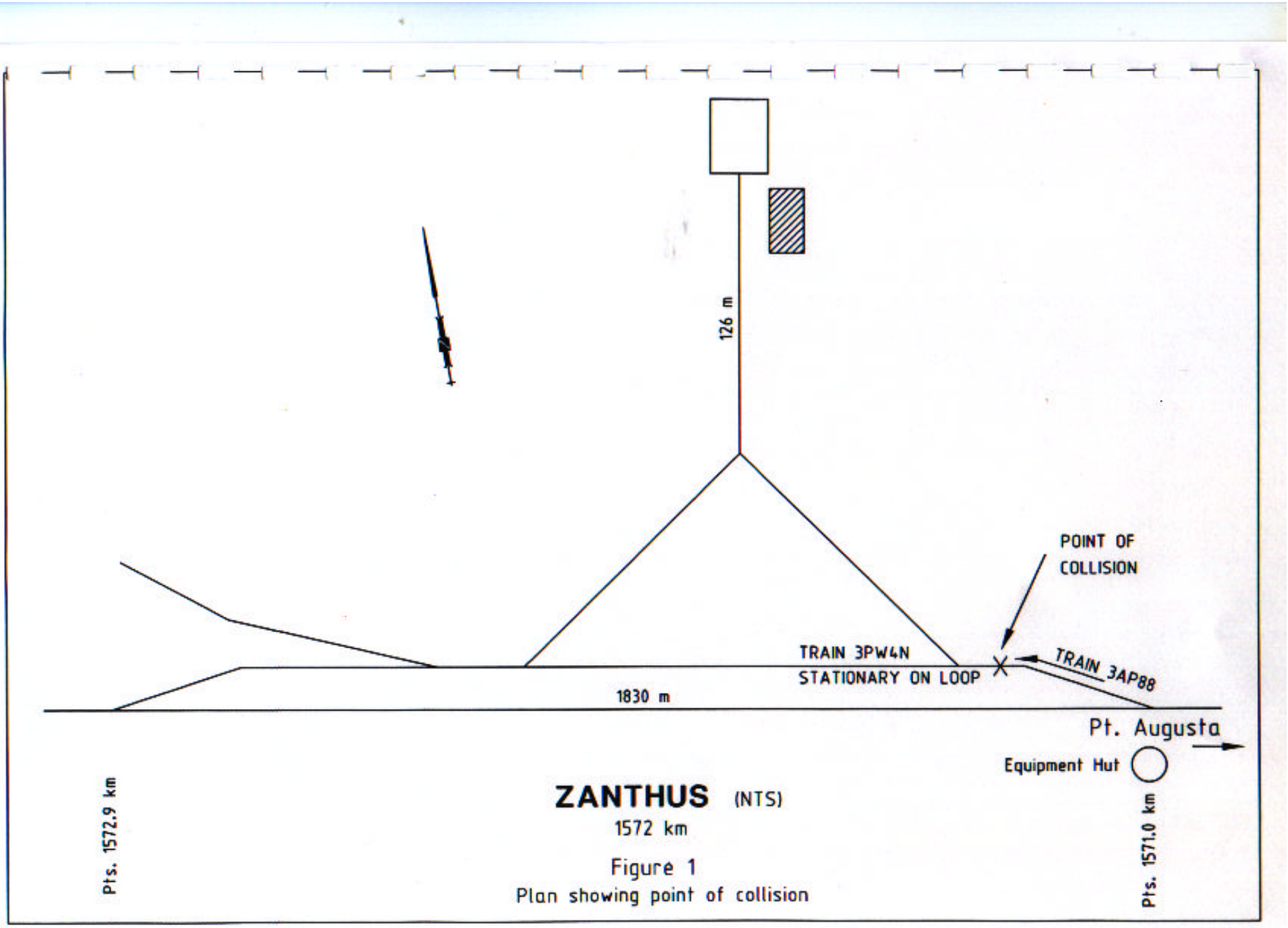
3. When trains are to effect a cross or a pass at a siding it is suggested that consideration be given to bestowing the person in the drivers seat at the time the responsibility to ensure safeworking procedures are effected correctly by the observer.

4. Provision of a checklist to be completed by the first train into either the loop or the main which will prompt a correct procedural process should be given consideration. Insertion of time of activation of points may be beneficial.

5. On going dialogue between the two trains to be involved in the cross concerning the checklist in 4 above may provide appropriate attention to safeworking procedures at the critical time.

6. During crew rotation the driver coming on duty on board the locomotive must read and counter sign the active Train Order under which the train is operating.

7. The enhancement of holding the points from operating and displaying a red indication for a prescribed time to protect any advancing trains should be carefully monitored and evaluated in the initial stage following installation.



ZANTHUS (NTS)

1572 km

Figure 1

Plan showing point of collision

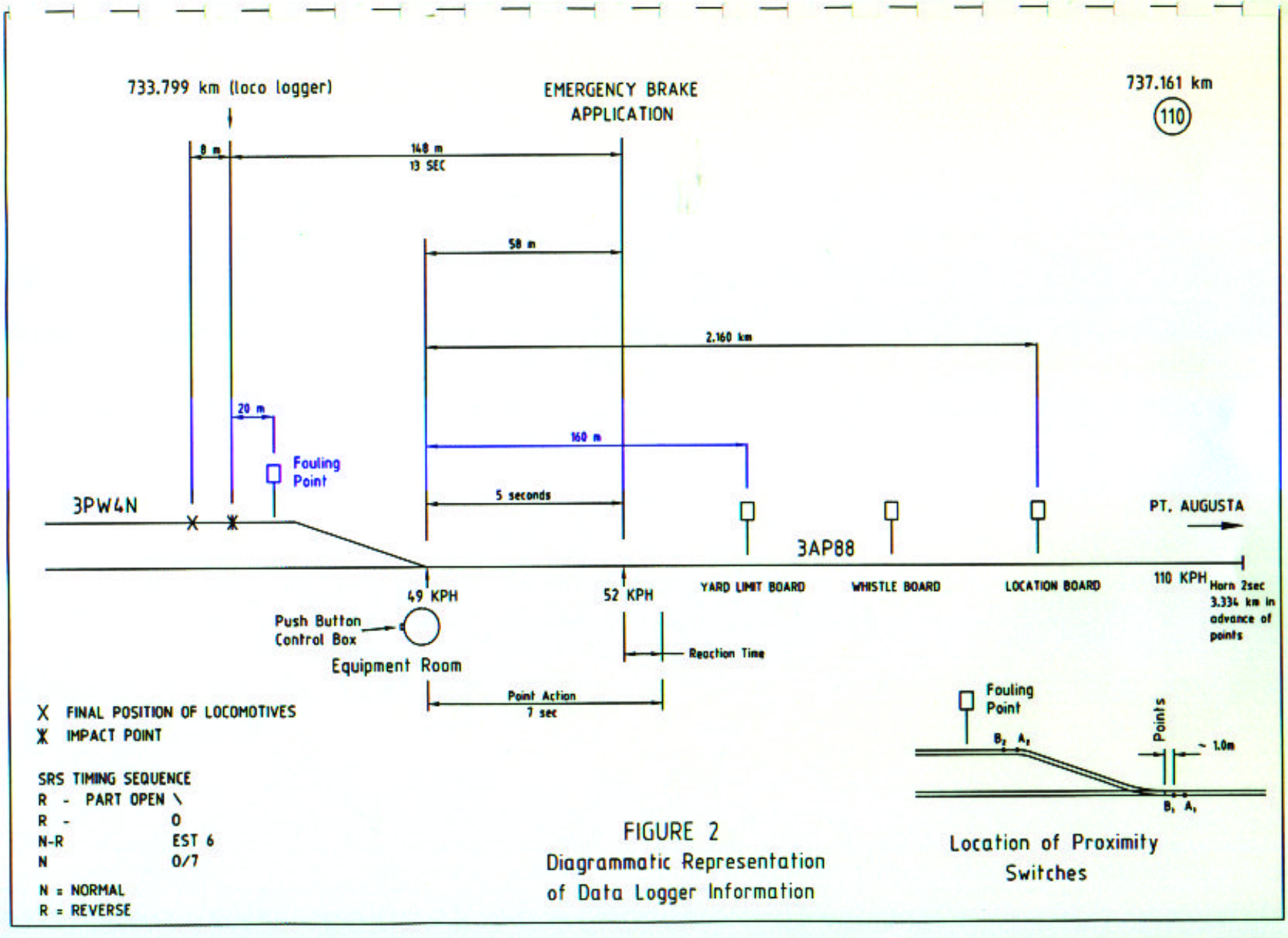


FIGURE 2
Diagrammatic Representation of Data Logger Information

Location of Proximity Switches

Figure 3: Locomotive NR51 and NR15 'nose to nose'.

Figure 4: Damage to IP Coach HM311

Figure 5: Damage to IP Coach HM311 positioned on turnout.

Figure 6: View of locked push button control box and yellow dumb bell indicating points set for loop

Figure 7:

Open push button control box on side of equipment room. As found on arrival of company representatives 19-08-1999

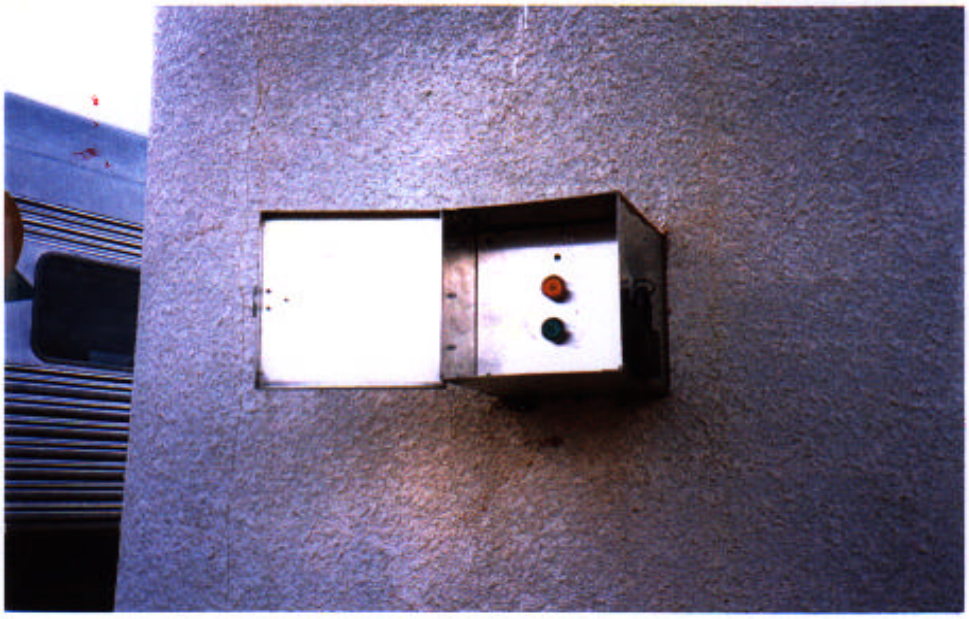


Figure 8: Push button controls for normal and reverse setting of points.

Figure 9: Flashing light indicator and yellow dumb bell showing points set for loop.

Figure 10:

Yellow dumb bell showing points set for the loop.

Figure 11: Carriage on points which are clearly set for loop.

Figure 12:

Point operation – after train removed but before operating points. Points commenced reversal to normal but not completed.

Figure 13:

Shows Fouling Point and new cable for upgraded control system.

Figure 14: Location of Fouling Point on loop and position of locomotive after collision.

Figure 15: Proximity switches on main.

Figure 16: Proximity switches on loop.

Events and Conditions Flow Chart

View Separate File

Zanthus Event Log (Excel Spreadsheet)

End of report