AXLE COUNTERS WITHIN SINGLE LINE SECTIONS – A SMART SOLUTION TO AN OLD PROBLEM?
SUMMARY

Axle counter technology is a proven, reliable method of track vacancy detection suited for a variety of installations. But despite the many advantages this technology can offer it has not rivalled conventional track circuits as a form of track vacancy detection within single line sections in Australia. This perhaps can be attributed to a number of inherent issues that impeded the effectiveness of axle counters system when configured to transmit data over long distances. However, in recent years there have been a number of advancements in both axle counter and telecommunications technology which have overcome some of these inherent issues. This paper investigates whether axle counter technology is now a smarter solution for single line sections, or if conventional track circuits still provide the best solution.

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1 INTRODUCTION
There are two key considerations with single line railways, first and foremost is safety. A form of safe working is required to prevent two opposing trains from being authorised into the section at the same time, which would obviously result in a head-on collision. This then requires some form of communication system between each crossing loop station, which leads onto the second issue, geographical location. Australian railways, like many others, are vast and the distance between crossing loops can be long. By nature single line railways are typically located outside metropolitan areas, often in remote rural areas. The geography can be challenging, ranging from desert, to coastal, to mountainous. The lines often see low volumes of rail traffic and typically don’t generate a significant amount of revenue, resulting in minimal capital investment. Given this, and the remoteness and rather limited maintainability of the lines, cost effective safe working solutions are typically implemented. There are a number of cost effective safe working systems suited to single line working, for example, Train Order Working, Staff & Ticket and Electric Token.

FIGURE 1 – SINGLE LINE RAILWAY SUNSET
Over the last decade there has been a significant increase in rail traffic volumes and this has stretched the capacity of some existing single line railways, leading to the construction of new crossing loops and improvements to the signalling system to increase capacity and revenue.

Furthermore, train operations have changed and rail operators are now running longer trains carrying higher tonnages. The procedure based safe working systems are no longer suited to today’s modern train operations. For instance it is not efficient to be unnecessarily stopping or slowing a 1550m long coal train with gross mass of over 9,000 tonnes. Given the growth in rail traffic and changes to operating practices, Centralised Train Control (CTC) has been implemented on single line railways to provide safe and efficient train operations. Conventional track circuit technology has widely been adopted within single line sections as a train vacancy detection system. However, axle counters offer some unique advantages over conventional track circuits, particularly over the coded track circuit. This paper will discuss the advantages and disadvantages, as compared to coded track circuits, to illustrate how axle counters can be implemented effectively within single line sections with CTC.

2 NOTATION
CBI – Computer Based Interlocking
CTC – Centralised Train Control
GIJ – Glued Insulated Rail Joint
MTBF – Mean Time Between Failures
TCP/IP – Transmission Control Protocol/Internet Protocol

3 THE ‘OLD’ PROBLEM
CTC typically requires continuous rail vehicle detection along the line, which in turn requires copper cabling or a suitable communications system for conveying the track circuit status. Previously this was achieved by one of the following methods:

• Line pole routes: Today is extremely expensive to deploy meaning it is not suitable for greenfield installations. There are still some line pole routes in service, but they are prone to open wire failures, lightning strikes and copper theft, are labour intensive and expensive to maintain.

• Line side cable routes: Initial deployment is less expensive; however the cables are still prone to theft and lightning strikes. Many operators choose to bury the cables in the ground, but this greatly increases deployment costs, which can exceed a $100/metre.

The methods discussed above are not economical for long sections, and have progressively been replaced by coded track circuit technology.

3.1 CODED TRACK CIRCUITS
Modern coded track circuits are a solid state, microprocessor-based track circuit which typically slot into a CBI card file. In addition to providing rail vehicle detection, they use the rails to transmit vital data (e.g. block controls) between interlocking stations. Inputs at the interlocking station are fed into system, encoded and transmitted through the rails. The signal is received at the other interlocking station, decoded and outputted via the appropriate interface circuitry.

Coded track circuits are typically used in remote, low traffic areas, where constructing kilometres of new cable route is not cost-effective and close signalling is not required. They have been implemented widely across various states in Australia. The technology has many advantages, in particular the elimination of
cable routes within the single section. However, the technology also has its limitations as outlined below:

- The communications link between the two interlocking stations is lost when a train enters the section.
- The transmission between two interlocking stations is asynchronous, only one code can be transmitted or received at anyone one time.
- There are a limited number of codes, this can limit functionality in more complex arrangements. In addition it may not be possible to monitor non-vital information (equipment alarms and warnings) in the section, unless another communications link (e.g. a 4G modem) is provided.
- Coded track circuits have an inherent delay both in terms of the communications and the track shunt / shunt clearing times. The reason for this delay is described in Section 3.1.1.

### 3.1.1 TIME DELAY ISSUES

Coded track systems generate between 20-30 individual codes. The transmission is half duplex in nature and each code is transmitted asynchronously, resulting in a communications cycle. Each code has a unique priority level, and when two or more codes are simultaneously activated by the application logic, only the highest-priority code will be transmitted.

To manage the communications, one end of the track circuit is assigned the “master”, and the other end assigned as the “slave”. The master initiates each communications cycle, and if possible, the slave will respond. Each message cycle (master send, slave respond) is approximately 6 seconds, but vital messages need to be initially received twice, then continuously two out of three, as part of the security of the protocol. The communications cycle and security protocol results in a 12-18 second delay per coded track within the section.

Diagram 1 shows a typical CTC single line section employing three coded tracks which pass the signal interlocking information from Interlocking A to Interlocking B and vice versa. Each track code originates from one interlocking and gets repeated within each coded track section before reaching the destination. In this scenario the delay in clearing Down Starter Signal 11M would be approximately 108 seconds for a crossing movement. [1]

A 108 second delay may not sound significant, but this delay accumulates every time a crossing movement occurs, increasing the transit times. When looking at a single line railway in its entirety, this delay starts to add up and it becomes an operational constraint. Table 1 demonstrates how this time delay is propagated over a 7 day period on a single line railway. The line in question is approximately 150km in length with 12 crossing loops.

<table>
<thead>
<tr>
<th>Period (24hrs)</th>
<th>No. of Trains</th>
<th>No. of Crossings</th>
<th>Averg. Delay (secs)</th>
<th>Total Delay 9mins/24hrs</th>
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</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>24</td>
<td>31</td>
<td>108</td>
<td>55.8</td>
</tr>
<tr>
<td>Day 2</td>
<td>24</td>
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<td>108</td>
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<td>302.4</td>
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<tr>
<td>Average Total:</td>
<td></td>
<td></td>
<td></td>
<td>43</td>
</tr>
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</table>

**TABLE 1 – SOURCED FROM TRAIN GRAPHS**

An average 43 minute delay over a 24hr period could equate to one extra train path. The figures above can be taken as a good indication. However, more sophisticated operational modelling would be desirable to verify these findings.
3.1.2 WRONG SIDE FAILURES

Track circuits have a long history of dependable operation in a variety of environments. Coded tracks add an additional level of complexity that has led to a number of reported wrong side failures. These are mainly associated with trains not being detected or ‘disappearing’ within the single line section.

Some of the reported wrong side failures can be attributed to the latency in data transmission. The track circuit shunt (the occupation of the track circuit) is actually determined by loss of communications, which requires two missed coded. However, because of the communications cycle this takes 12-18 seconds for the track to drop, and another 12-18 seconds to show clear after the shunt is removed. This essentially makes coded track circuits both slow-to-pick and slow-to-drop. As such there is a short window of time where a train enters the section and the first coded track doesn’t immediately drop.

There have been a number of reported wrong-side failures due to intermittent loss of shunt. This is mainly associated with small trains with less than eight axles and light rail vehicles that have a tendency to bounce, such as Diesel Multiple Units (DMUs). Like all conventional track circuits, coded track circuits rely on continuous contact with the rail to create a short circuit. When the rolling stock does not reliably shunt the coded track, this can result in a wrong side failure. Coded track circuits can be particularly sensitive to poor shunting characteristics as the codes (pulses) need to be transmitted over long distances (typically up to 15km). There are fixes to improve shunting characteristics of the rolling stock in the form of track circuit assistors. However, fitting an entire fleet can be very costly for rail operators.

The delayed track operation must be taken into account during design and testing. This complicates the interlocking controls to prevent potential wrong-side failures. The controls involve providing timers to hold the previous track down for a certain amount of time, depending on track length and maximum train speed. However this may introduce additional complications with split trains potentially appearing on the signaller’s panel, and additional controls may be required to prevent this.

Coded track circuits also complicate the principles / design integrity testing as there are a number of variables that need to be tested, including time delay, track length, train length and train speed. This adds an extra dimension to the testing as a number of different scenarios need to be tested to ensure these variables do not result in any wrong side failures.
3.2 SO WHY HAVEN’T AXLE COUNTERS BEEN CONSIDERED BEFORE?

It is widely documented that axle counter technology presents a number of advantages over conventional track circuits, and owing to their success axle counters have increasingly become a more popular form of track vacancy detection with rail operators in Australia. However, their application has generally been limited to standalone installations, e.g. as a single counting section over a turnout, and there has been very few installations within single line sections in Australia. The limited application of axle counters within single line sections can perhaps be attributed to the broken rail detection issues, which is discussed further on in this paper. It may also be down to some inherent issues with the older style generation of axle counter systems, in particular the way data is transmitted data between evaluators. With the older generation of axle counter systems, the data was typically synchronous. In such installations even a small latency in data transmission, such as 20ms, can result in a failed transmission, generating an error within the system. Very few existing ‘older generation’ axle counter systems allow for a configurable communications link timeout function. Because of the sensitivity to latency in data transmission, a very robust radio transmission system is required, this was typically provided through a microwave link. However, there is a significant deployment cost with this technology as it requires line of sight visibility.

Another issue with the older axle counter systems is standard serial transmission (with RS232 interfaces) is typically used to exchange data between two axle counter systems. Most systems use a point-to-point connection. This arrangement only allows one axle counter system to communicate with another at any given time. This resulted in limited diagnostics being available at the other end, which increased complexities in fault finding and maintenance activities, in particular where sections were connected over a data transmission system. This increased the MTTR as technicians had to drive between the evaluators, which took a significant amount of time. The requirement for a robust transmission system and the limited diagnostic information available at the evaluator suggested that axle counter where not suitable over long distances.
So why revisit axle counters? Well there is a new generation of axle counter systems available on the market and these systems have a number of improvements over the older style systems. Perhaps the biggest improvement is the ability to configure axle counters to transmit data over an Ethernet-based network using standard TCP/IP protocol, essentially allowing for a dedicated axle counter network (LAN / WAN), using a peer-to-peer architecture. This concept is relatively new for axle counter systems. However, for signalling interlocking applications, this configuration is well established and has been widely implemented for vital communication between CBIs. The use of standard TCP/IP protocol over an Ethernet network opens up the choices of suitable communications bearers as off-the-shelf, industry-standard communication systems and network devices such as Ethernet switches, servers and routers can be used. This significantly decreases the cost of implementing a network.

4.1 SUITABLE COMMUNICATION SYSTEMS
The communication system must ensure the integrity of all safety critical signalling data, however the degree of such ‘protection’ required from the communications bearer depends on the actual axle counter product and how much protection has already been built into the axle counter system. There are two options for the communication system; a closed network or an open network, both options are discussed below.

4.1.1 CLOSED NETWORK
The vital data links between CBI systems (distributed or centralised) are commonly implemented in accordance with EN 50159, which specifies a closed, dedicated network or communication links. Fibre optic based communication systems provide a secure, proven transmission system suitable for vital signalling communications. However, unless already installed for the signalling system, the cost of initial deployment is comparatively high, especially when buried in the
ground. For established (brownfield) installations, without an existing communications system, the use of radio bearer option presents a potential cost saving. These systems still require dedicated communication infrastructure to be installed, but they have relatively low capital expenditure requirements over long distances when compared to fibre optic installations. They can also be easily integrated with axle counter systems configured over an Ethernet network. Potential radio bearer options could include:

**Microwave Transmission Systems** – a well-established and proven technology that can be easily deployed. It is already used on a number of Railways for vital signalling communications and has been successfully integrated with axle counter systems within single line block sections. The major drawback is Line of Sight visibility requirement. The bulk of the cost associated with this option is not the equipment itself but the cost of access to the site and land acquisition at suitable RF locations. Rail corridor located sites typically do not provide the best RF locations.

**Near Line Of Sight Data Radio Systems** – similar to above, but do not require direct line of sight visibility between transmission sites, as they operate on lower frequency bands. Due to lower operating frequency and narrower channel bandwidth, these systems have lower transmission capacity than the microwave option. Other options could include UHF/VHF data radio modems that offer IP enabled connectivity and lower bit rate capacity.

**Trunked Digital Voice and Data Radio Networks**, such as TErrestrial Trunked RAdio (TETRA) – can provide both simultaneous voice and data radio coverage, and support TCP/IP protocol over a wireless Ethernet network. The technology is increasingly used for digital train radio systems, and has been successfully implemented for safety critical signalling applications.

**Ethernet Radios** - allow Ethernet networks to be extended wirelessly over increased distances, typically between 2km to 10km. Vital signalling and axle counter data can be transmitted over the wireless network. These systems require a small, pole mounted antenna and have a low DC operating voltage and power consumption, typically between 25W – 35W. There are a number of different frequency options for use in both licensed and license exempt bands (open spectrum). The advantage with these systems is they offer a cost effective alternative to conventional radio systems. The technology has been successfully trialled in NSW for vital signalling communication between CBIs, and have offered comparable reliability and performance to conventional vital data radio system.

### 4.1.2 OPEN NETWORKS

EN 50159 traditionally limited vital communication systems between CBIs and axle counter systems to closed, dedicated networks or links. However, most new CBI and communications based axle counter products have been engineered (and subsequently, type approved) to use open communications systems as per the requirements of EN 50159-2. Recently the requirements of EN 50159-2 have been consolidated into the amended EN 50159. This introduces opportunities, representing cost economies never seen before. Third party open transmission systems, such as Telstra’s IP WAN Network, provide a cost-effective alternative to private open transmission systems. IP WANs are extensively used for non-vital communication between the centralised control centre and the interlockings. If a more reliable and secure communications system is required, Broadband Digital Subscription Line (BDSL) may be a suitable option, albeit with a higher subscription fee.

Wireless Ethernet radio options and third party transmission systems are cost effective alternatives to conventional transmission systems as long as they meet the signalling product type approval requirements regarding EN 50159 standard compliance. They can also be easily integrated with Ethernet-based axle counter systems. Third party open transmission systems may not be suitable for all rail operators. Coverage, availability and security issues need to be assessed to determine their suitability for use in vital signalling applications, depending on the actual safety measures implemented in the signalling equipment itself against the typical telecommunications threats.
5 CODED TRACK CIRCUITS VS AXLE COUNTERS

Axle counters offer some unique advantages over traditional track circuits for train vacancy detection. This section discusses the advantages and disadvantages, as compared to coded track circuits, to illustrate how they can be used effectively where the maintenance or conditions affect the reliability of coded tracks.

5.1 ADVANTAGES

5.1.1 IMPROVED RELIABILITY

Operating conditions on single line railways can be challenging, and track and ballast conditions can be poor. Conventional and coded track circuits are both sensitive track conditions, in particular in wet conditions when the ballast resistance generally drops, track circuit reliability may be affected. Similarly track circuit operation is often unreliable on lines used less frequently where the rail surface can be badly oxidized (i.e. rusty rails) or covered with insulating films that impede the surface conduction properties. These conditions can lead to reduced track circuit reliability, affecting train operations. Axle counters operate independently of track and ballast conditions and have performed with better MTBF rates than conventional and coded track circuits. It has been documented many times that the reliability of axle counters is five times that of track circuits. Axle counters have also been used by rail operators to overcome particular problems with track circuits, such as in wet tunnel environments.

5.1.2 IMPROVED MAINTENANCE

Given the remoteness of some lines, faults within the single line block section can be very time consuming for a technician. Vehicle access can be extremely difficult, especially at night or in adverse weather conditions. The optimum solution therefore is to have
no signalling infrastructure within the block section, eliminating the requirement for periodic maintenance activities and any chance of a fault occurring. The length of an axle counter section is restricted only by the communications bearer, effectively allowing one axle counter section to be implemented for the entire block section. The maximum length of a coded track is 15km; therefore additional coded track circuits are required for longer block sections.

GIJs require corrective maintenance to tamp, grind and replace, all of which have to be undertaken during a possession. There can be limited windows to take possession for track maintenance activities. The elimination of GIJs within the block section removes the track maintenance requirements and associated failures caused by broken GIJs or short circuiting as a result rail head flow. Periodic maintenance of axle counter equipment mainly comprises of an annual check of counting head security and measurements of key system parameters.

5.1.3 REMOTE DIAGNOSTICS

The Ethernet network can be used to carry diagnostic information; this can support remote diagnostics via a network (e.g. Internet) from any location at any time. Remote diagnostic provides technicians with a powerful tool for remote fault finding and establishing the corrective action. Prior to attending a failure the technician can remotely access the system, diagnose the fault and determine the corrective maintenance required. The health status of the system can also be monitored remotely, allowing potential failures to be identified before they occur. Remote diagnostics is a major advantage for both isolated railways in rural areas, and on busy railways with limited on-track maintenance windows. It also facilitates real-time support with the manufacturer, who can have access to field diagnostic data.

5.1.4 REDUCED COMMISSIONING TIMES

As mentioned in Section 3.1.2, coded tracks can complicate the testing requirements which can increase the duration of the commissioning and the associated costs. This also poses a risk of a commission overrun, which again can be very costly. Axle counters have an advantage as they can be overlaid, set to work and certified before the commissioning. It can take as little as 35 minutes to install an axle counter head using a rail clamp. The calibration process is very straightforward, it involves holding a button down for a predetermined time and the calibration process is done automatically by the axle counter system. This means the set-to-work process can be undertaken during short windows between train movements. Conventional and coded track circuits require the rail to be cut and a GIJ to be welded in, the track circuits then need to be adjusted, set to work and certified.

5.1.5 INCREASED CAPACITY

There are no inherent time delays associated with axle counter technology that would impede the signalling system. Referring to Section 3.1.1 - Table 1, the use of axle counters could eliminate 43 minutes of delays within a 24hr period. This could potentially provide an additional train path per day, leading to an increase in Network capacity and operating revenue. An increase in Network capacity through the adoption of new technology may be more cost effective than constructing a new crossing loop, which can exceed $35million in cost. Axle counters can also improve the efficiency and reliability of the signalling system, so the potential for lost train paths as a result of infrastructure failures is reduced.

5.2 DISADVANTAGES

5.2.1 THE BROKEN RAIL DETECTION ISSUE

In simple terms coded track circuits, as a by-product only, offer some limited level of detection for broken rails. Most broken rail statistics in Australia suggest the success rate of broken rail detection through track circuits is approximately 50%. Axle counters will not detect any break whatsoever. So is this the end of the argument then? Well the argument lies with ownership, on one hand you can argue it is not a Signalling problem as the perway is not a signalling asset, and whilst the use of track circuits for broken rail detection is accepted, its efficiency is questionable. On the other the other hand you can argue it is a signalling problem as track circuits detect 50% of broken rails, and as a rail operator you may be reluctant to lose that level of broken rail detection. So if broken rail detection through track circuits is removed, alternative mitigation measures may be required to ensure that the overall risk of a derailment due to a broken rail is no higher on an axle counter fitted line than the risk that existed before the introduction of axle counters. The principal strategy for risk mitigation should be the detection of rail defects before breaks occur, and not the detection of rail breaks... There are several existing general track fault detection methods which may detect broken rails, these include foot patrols, high rail runs and rail inspection cars. These methods could be supplemented by new broken rail detection methods including:

- Ultra-sonic detection testing methods that pre-empt the occurrence of broken rails by identifying flaws developing within the body of the rail before a break develops.
- Compact train-borne systems that can be retro-fitted to rolling stock to monitor the track condition.
- Buried fibre optic filament and acoustic rail break detection systems.

Personally I believe the broken rail detection requirements should ultimately be determined by our civil colleagues, rather than hypothesised by Signalling Engineers. As each situation will be unique, it should be a risked-based approach based on statistics for that particular line or railway. This is not a new concept, axle counter systems are applied to railway networks in Europe where the investigations on broken rail detection by track circuits
has determined that the detection of these defects is limited and other methods of mitigating the issue outweigh the need for track circuit installation. I do acknowledge that the design, construction and maintenance requirements on European railways, in particular high speed railways, are superior to those applied to single line railways in Australia, and it wouldn’t be economical to apply those standards to most single line railways. However, many single line railways still rely on procedure based safe working methods that don’t necessitate track circuits, thus there is no broken rail detection. This risk is obviously acceptable to some rail operators, mainly depending on the type of traffic they are running.

5.2.2 ON-TRACK MAINTENANCE VEHICLES

Track maintenance vehicles (hi-rail vehicles) putting on or taking off axle counter sections can cause miscounts. It is therefore important that any disruption caused by hi-rail entering or leaving the long axle counter section within the block section is minimised. Depending on the operators’ requirements, the sensor heads for most systems can be configured to achieve reliable detection or reliable non-detection of hi-rail vehicles. If hi-rail detection is required, effective access could be managed through strategically positioned take-off points located close to reset panels, to allow a co-operative sweep release to be performed by a qualified worker. This method would require the development of new safe working procedures, which may also need to be extended to allow a suitably qualified worker to use the cooperative sweep release panel. Alternatively, if hi-rail vehicles are equipped with digital voice/data radio equipment, some radio platforms allow for in-built GPS positioning based location monitoring.

5.2.3 RESET PROCEDURES

In the event of a miscount, component failure or communications failure, a reset of the disturbed or occupied section is required. There are two types of axle counter reset procedures suited to single line sections:

Conditional Reset with low speed train sweep - Once the axle counter equipment has been reset, an aspect restriction is applied to protect against a train collision. The aspect restriction functionality is provided via the interlocking and is applied to all signalled routes over the affected section. A train must sweep through the section under a restricted aspect (normally red) and the driver must observe for any obstructions, meaning the train must travel at a reduced speed. After a train has cleared the section under an aspect restriction, and providing the count was successful, the interlocking will restore the section for normal train operations.

Co-operative Reset - In order to remove the need for a train sweep following a reset, a co-operative sweep release function is sometimes provided. This enables the aspect restriction to be lifted and the section to be returned to an unrestricted state. This procedure requires the co-operative action of the signaller at the control centre (signal box) and the signal technician on-site, who must confirm to the interlocking that the section in question is clear of obstructions before lifting the restriction. This is achieved by using a local panel.

5.2.4 ALTERNATIVE SOLITON

Performing a train sweep through the entire single line section would substantially increase the transit time, causing delays to the operator. However, the time taken for a technician to arrive on site, walk the section and confirm it is clear of obstructions would be far greater than the time taken to perform a train sweep. Therefore an alternative reset method is required for long block sections. One option could be to implement an un-conditional reset from the control centre. This solution could prove unpalatable to the risk adverse signal engineer, but such alternatives are available today in Australia. These procedures involve the driver of the last (that resulted in a miscount) confirming the integrity of their train. This is obviously prone to human error as the train controller (signaller) cannot physically verify the integrity of the previous train that travelled through the section train, or that the section is clear. However, this risk could be mitigated through the use of a GPS based End of Train (EOT) device. A lot of railway operators now use a bus based EOT device which also monitors brake pipe pressure. These systems could be used to prove the integrity of the train in the event of a miscount. But even going to this extent may be unnecessary today, due to all rolling stock being continuously braked.
5.2.5 CODED TRACK DATA TRANSMISSION

The benefit of coded track circuits is the ability to transmit movement authority data via the coded track circuit to the rolling stock. This application is mainly used for in-cab signalling and Automatic Train Protection (ATP) applications. It is acknowledged that an axle counter solution within the block section would not be suitable for railways with this arrangement.

6 AXLE COUNTER BLOCK SOLUTION

For the purpose of this paper, the requirements for an axle counter solution within a single line section has been developed. The following assumptions have been made:

• The signalling arrangements are based on NSW signalling standards for a CTC crossing loop.

• The signalling arrangements within the crossing loop (i.e. between the Up and Down Home signals) have been excluded.

• The block length is assumed to be 50km long.

6.1 REQUIRED INFRASTRUCTURE

The axle counter solution comprises of the following equipment:

• A 4G connection between the main evaluators at the relay room (home signal location)

• An Ethernet radio system between the distant signal location and relay room

• A CBI at the relay room for the interlocking controls

• An evaluator at the relay room to provide the I/O functionality for the block section controls

• An evaluator at the distant signal location to provide the I/O functionality for the distant signal controls

The coded track solution comprises of the following equipment:

• One coded track between the distant signal location and relay room (home signal location)

• Two 15km coded track circuit midsection with an intermediate track location

• A CBI at the relay room for the interlocking controls

• A CBI or object controller at the distant signal location to provide the I/O functionality for the distant signal controls
6.2 REQUIRED INFRASTRUCTURE

The signalling infrastructure requirements for a coded track solution vs. an axle counter solution are detailed in diagram 2. As can be seen, the main difference is axle counters have infinite length meaning no signalling infrastructure is required within the single line section, whereas the length of coded track circuit is limited to about 15km, meaning a mid-section track location is required. However, axle counters require an evaluator in addition to the CBI equipment and a communications bearer to transmit the block controls between the interlocking stations (crossing loops), whereas coded tracks do not.

6.3 BLOCK SECTION CONFIGURATION

The vital block section controls follow the same principles as the standard two-wire block circuit. However, the vital communication between the interlockings is over an Ethernet network with the axle counter system providing the interface. I/O boards and relays may still be required to provide the physical interface between the axle counter system and the local interlocking. Diagram 3 details an overview of how the axle counter system can be integrated between two distributed interlockings.
### A - Savings

<table>
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<td>Removal of Mid-section Location</td>
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<td>Detailed Design</td>
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<td><strong>Grand Total (A-B):</strong></td>
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Table 2 – Estimated Cost Savings for Axle Counters

### 6.4 COST SAVINGS

The actual cost difference between the two solutions is difficult to quantify as there are a number of variables that influence the overall cost. This includes the length of the block section, geographical location, interlocking equipment and the rail operator’s performance requirements. As a theoretical exercise a cost comparison between the two solutions in Diagram 2 have been estimated in Table 2. The cost comparison is limited to the additional signalling infrastructure within the section for the coded track solution and the cost of the communications system for the axle counter solution.

As can be seen in Table 2, there is a 15% cost saving per section, and this would be multiplied depending on the number of sections. However, it is important to note that some short single line sections do require a midsection location for the coded track solution. In addition rail operators may require a more reliable and secure communications system, such as BDSL which has much higher subscriptions fees.

### 7 CONCLUSION

So in summary we have old safe working methods no longer suited to today’s modern train operations, necessitating the requirement for CTC. This requires continuous track vacancy detection, which in turn requires a suitable communications system for the track circuit status. Cable trenching is expensive and not always practical. Coded track circuits solve the trenching problem but introduce an operational constraint and have the potential for wrong side failures.

Axle counter technology is an established alternative for train vacancy detection and provide some advantage over coded track circuits, including improved maintainability and reliability. The new generation of axle counter systems can communicate over an Ethernet-based network using standard TCP/IP protocol, allowing for more cost effective communication systems to be utilised. This has overcome many of the previous limitations that impeded axle counters when configured over long distances.

The broken rail detection issue will always be a topic of debate, in particular ownership. My personal belief is the integrity of the perway is not a signalling responsibility; however the integrity of the signalling system is. On that basis signalling are responsible for providing a reliable train vacancy detection system. If there are known issues with track conditions or rail-wheel interfaces, which have led to wrong side failures that cannot be readily resolved, then axle counters should be adopted.

Every axle counter installation will be unique and a risk assessment would need to be performed. Key to the decision is the consideration of forgoing partial broken rail detection through track circuits in favour of more reliable train vacancy detection system. As a signalling engineer, I would conclude the latter is more important. Finally, the cost for additional broken rail detection in place of track circuits may be offset by the economic benefits associated with axle counter technology.
Thomas is a Railway Signalling Engineer with 15 years industry experience in both the Australian and UK markets. He has a broad experience ranging from concept development to detailed design through to construction. The majority of his experience is in the consultancy industry, with a particular focus in project development; this includes feasibility studies, concept design, business case preparation and budgetary estimating. Recently Thomas has been involved in a number of axle counter projects on both heavy haul freight lines and suburban passenger railways.

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