Reference material

Quick Release of Approach Locking

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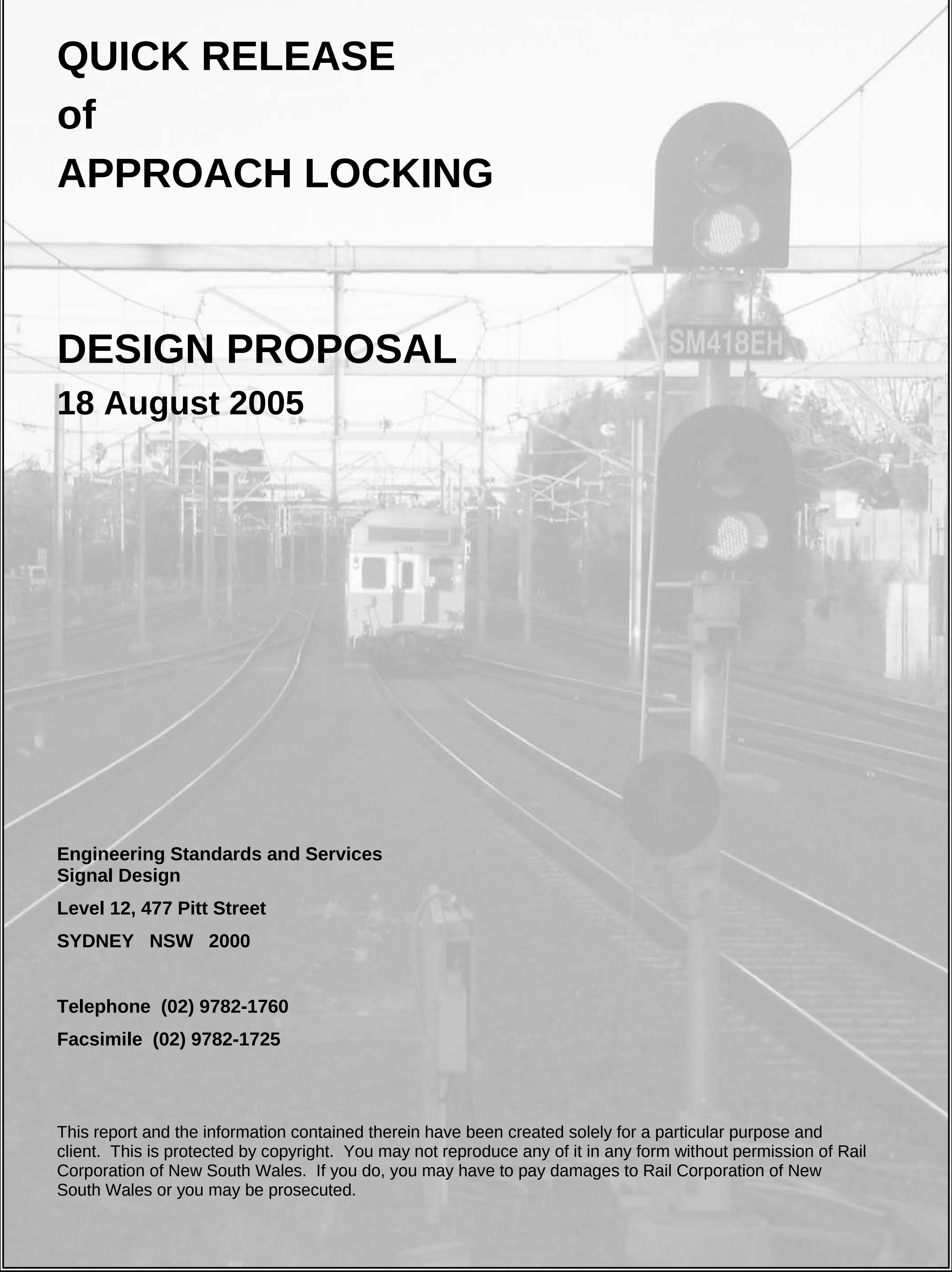
Authorised by: Chief Engineer Rail, Asset Standards Authority
Published: September 2013

CountryLink CityRail RailCorp

QUICK RELEASE
of
APPROACH LOCKING



DESIGN PROPOSAL

18 August 2005

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QUICK RELEASE
of
APPROACH LOCKING

DESIGN PROPOSAL

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1 BACKGROUND

Approach locking of signals is an important safety feature of modern railway signalling. Its purpose is to ensure that if a train is approaching a signal showing a proceed indication which is subsequently changed to stop, any hazards protected by the signal (points, crossings, etc) cannot be immediately changed. The train must either be allowed sufficient time to stop, or be proved to no longer be approaching the signal. One method for proving that the train is not approaching the signal is to detect that it has in fact occupied the track circuits past the signal.

This paper reviews options to provide system functionality in a manner compatible with the new interlocking methodology, to better meet the operational needs of a high-capacity metropolitan passenger service.

2 EXISTING ARRANGEMENTS

Entrance – exit style interlockings in NSW have been the usual style of interlocking in the metropolitan area. The logic has been developed over the years, and there are a number of features and constraints in the design.

With regard to approach locking, the following features are typical:

- Track down releasing of Approach Locking.
- TZR/NR functions for automatic normalising that protect against a common mode failure releasing locking in the face of a train.
- Shunting requires the signaller to manually cancel the route as the auto normalising does not operate when the berth track is occupied.

With the rise of Microlok interlockings in the metropolitan area, it was decided that the NX style of route calls would be largely replaced with the OCS style to standardise and simplify control system interfaces.

The following changes to route normalising were implemented:

- No drop track releasing is provided on main aspects (may be provided on shunts, except where a shunt is provided only to move trains over track failures.)
- An RSR is provided for route setting and normalisation. Route normalisation is initiated by the ‘A’ track dropping the RSR.

The changes achieved the following desired outcomes:

- Considerably simplified route normalising data without loss of safety integrity, which reduces data design time and simplifies the checking process.
- Consistent route normalisation when the signal is passed irrespective of whether the approach tracks remain occupied, without signaller intervention required by cancelling the route.

Generally, it was considered that operational impacts would either be minimal, or at least more positive than negative. However, in high traffic areas the requirement to wait for time release of approach locking can have significant impacts on operations. This can occur during shunting moves, when part of a train may remain on the approach side of the signal, or where signals are closely spaced, a second train may keep a signal approach locked after the first train has passed the signal. This second effect has a major impact at junctions.

3 DESIGN GOALS OF THE NEW ARRANGEMENTS

The following situations, where release of approach locking can be problematic, have been identified.

Situation	Existing NX	Existing OCS	Criticality in new scheme
Shunt locomotive off train onto B track.	No auto normalising while berth track occupied	Normalises after ALSR timed out	Desirable
Route release at home signal (trailing junction), train shorter than signal section.	OK	OK	Desirable
Route release at home signal (trailing junction), train longer than signal section.	No auto normalising while berth track of outer signal occupied	Normalises after ALSR timed out	Desirable
Normalising of outer signal at junction - second train approaching in auto section.	OK	Normalises after ALSR timed out	Essential

As Microlok is being deployed into areas of higher traffic density, the use of time releasing, or having the comprehensive approach path clear will not be satisfactory in all situations. It is now desired to again provide a quick release of the approach locking. This re-introduces an element of risk, in that an interlocking cannot readily distinguish between a track circuit dropped by a train or by a fault, and so track circuit faults could release the approach locking.

The NX interlocking used three tracks to normalise the route: berth track down then up, and AT and BT down. By this method, and with the use of a timer to protect against power supply interruption, it was practically impossible for a single fault to normalise the route.

In order to maintain consistent normalising of routes, it is intended that the new quick release will not require the berth track up. With this constraint, it is then undesirable to use the berth track down in the normalising. It provides little extra protection against unsafe normalising, and may in fact ensure that other failures can release the approach locking when, and only when, the train is occupying the berth track - that is, when the danger would be greatest.

The goal then is to provide a quick release of approach locking that uses only two tracks, while keeping the risk of improper release of locking as low as reasonably practicable.

4 DESCRIPTION OF THE NEW ARRANGEMENTS

4.1 Options

Three options have been developed for consideration. These options all rely on only two track circuits. For the purpose of discussion, they are designated AT and BT, but respectively represent the first and second tracks past a signal in any given route.

The two tracks, each having two states (up or down) can be combined to produce four states:

i. AT up, BT up;

ii. AT down, BT up;

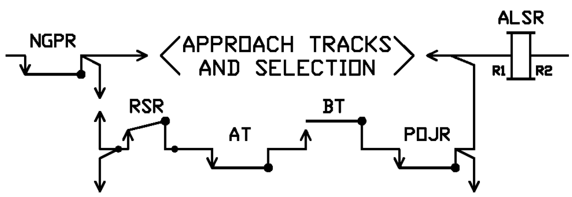
iii. AT down, BT down;

iv. AT up, BT down.

These are listed in the order that would be observed during the normal passage of a train.

The following options each test for a sequence of two or more of these states. State (i) is required for the signal to initially clear (with the exception of shunt routes, which may be protected in other ways).

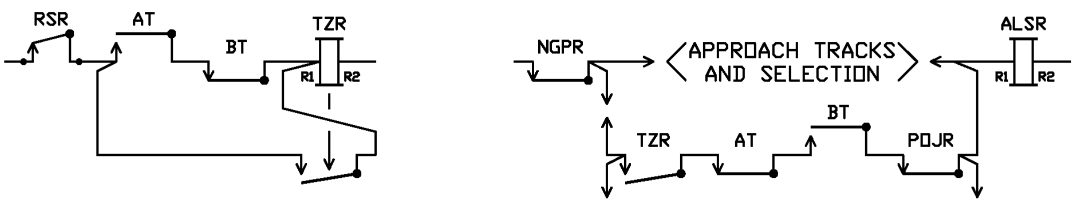
4.1.1 RSR down, AT up, BT down to release ALSR



Required state sequence: (i), ANY, (ii) or (iii), ANY, (iv)

This is based on an arrangement used on other railways. However, the track circuit sequence is not rigorously enforced. RSR can be dropped with BT already down. If AT then picks again, ALSR will pick immediately and the route will normalise. Also, if AT momentarily drops then picks, and BT drops later, the route will normalise. Simple single-fault failures could release the locking while a train is approaching. Another shortcoming of this method is that RSR does not drop during auto reclearing, so route could remain approach locked if auto reclearing is cancelled after the B track picks.

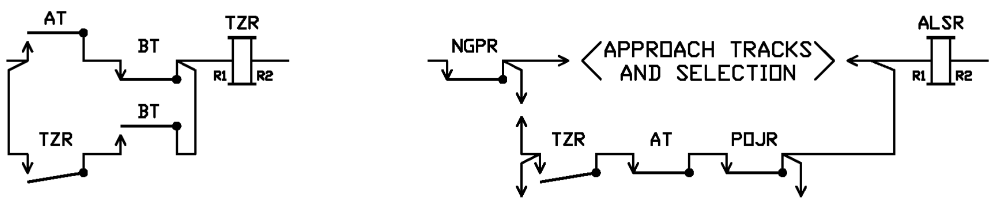
4.1.2 AT down, BT up in TZR. TZR up, AT up, BT down to release ALSR



Required state sequence: (i), ANY, (ii), ANY, (iv)

While RSR can still be dropped with BT already down, the use of the TZR function as shown ensures that at some stage in the sequence, BT is up with AT down. However, the stick path used means that once the TZR is picked, there is no continuous enforcement of correct track sequence. As with option 1, this allows for apparently simple failure scenarios to effect the release. For example, a block joint failure could leave both track circuits susceptible to traction current fluctuations, which can result from trains braking and/or accelerating several hundred metres away, even on different running lines. By using the RSR to reset the TZR, this arrangement, like Option 1, will not cycle ALSR during auto-reclearing and may remain approach locked after auto-reclearing is cancelled.

4.1.3 AT down, BT up in a self-releasing TZR. TZR up, AT up to release ALSR.



Required state sequence: (i), ANY, (ii), (iii), (iv)

(Note that the arrangement shown is optimised for use in Microlok data. Relay installations will require a different circuit to achieve the same function.)

This version of the TZR includes BT down in the stick path, so that if BT picks before AT, the TZR drops out when AT picks, and the ALSR cannot be released. At either state (ii) or (iii), a bobbing track can reverse the sequence to a previous state, but the correct progression must be repeated from that previous state. It is still possible for single failures to occur which would unsafely release the locking, but the failure scenarios are more complicated.

4.2 Preliminary Assessment

4.2.1 Functionality

In section 3, functional requirements were identified.

Under normal operating conditions, all three options will normalise the route by the same sequence of track circuit occupancy, and the route will be normalised when the A track picks up behind the train. The different options are distinguished by their ability to discriminate between expected and unexpected track sequences.

By not requiring the berth track clear, all three options allow quick release of the approach locking when any part of a train passes the signal and continues off the A track. This will allow the route to normalise after a locomotive shunts off a train, or when a second train is already in the approach, either through an automatic section or if the previous signal has not normalised for some reason.

On the other hand, by requiring the A track up, all three new options have a shared deficiency. If the approach path is not clear and the train remains on the A track for some reason, the approach locking must time out before the route can normalise. This could occur where the train is longer than the signal section, or just long enough to occupy the A track while stopped at the next signal with a second train approaching. As this is not going to be a problem at every signal, it is not included in the general arrangements, but a possible solution is addressed in section 7.

Situation	Criticality	Option 1	Option 2	Option 3
Shunt locomotive off train onto B track.	Desirable	OK	OK	OK
Route release at home signal (trailing junction), train clears A track.	Desirable	OK	OK	OK
Route release at home signal (trailing junction), train remains on A track, second train approaching	Desirable	Times out after 120". Section 7 examines possible enhancement.		
Route release at home signal (trailing junction), train longer than signal section.	Desirable	Times out after 120". Section 7 examines possible enhancement.		
Normalising of outer signal at facing junction - second train approaching in auto section.	Essential	OK	OK	OK
Cycling of ALSR during auto-reclearing	Desirable	No	No	OK

All three options meet all the functional requirements originally identified. The inability of the logic in Options 1 and 2 to cycle the ALSR during auto-reclearing could have operational impacts if auto-reclearing has to be cancelled between close-following trains.

4.2.2 Safety

Obviously, the less rigorous the sequence checking is, the more likely it is that faults could provide an unsafe release of the approach locking. On the other hand, the more complex a protective arrangement is, the greater the chance that the protective system can itself fail, leaving other hazards exposed or creating new hazards. As there is no such thing as "perfect safety" in any field of human endeavour, judgement must be made to achieve a balance of conflicting requirements.

In this case, Option 1 provides only basic sequence checking, and does not prove the sequence continuous. Option 2 introduces an extra function, the TZR, to provide a more restrictive test at one stage of the sequence, but again does not require a continuous sequence. Option 3 requires the sequence to be a continuous match for the normal passage of the train, but achieves this without significantly increasing complexity.

On the basis of these observations, further assessment will focus on Option 3. If Option 3 is not fit for purpose, neither would Options 1 or 2 be. If Option 3 is found fit, there is little to be saved by using Option 1, and even less for Option 2, instead of Option 3, but risks may be increased.

5 IMPROPER RELEASE BY FAILURE

The primary concern when incorporating a quick release in the approach locking is to minimise the possibility of failures releasing the locking when it could be unsafe to do so. For the purposes of this discussion, failures will be classified as either complete failures or partial failures. The resultant effect on track circuits will be classified as either stable or unstable.

5.1 Definitions

5.1.1 Failure Modes

In this context, a complete failure is considered to be a situation where a device is in a stable condition which produces continuous failed inputs to the interlocking, and which is not overcome without deliberate intervention by staff. An example would be a blown fuse or broken wire. Under this definition a short circuit block joint, although it may be a permanent condition, may be classified as a partial failure if the affected track circuits are not held continuously down by the block joint failure.

A partial failure may include:

- Power supply "brown-out" (low volts) - some devices may drop out, some may hold up as long as usual criteria are met but will fail to pick up once dropped, and some devices, especially non-vital relays, may not be impaired.
- Self-restoring faults - a unit may shut down for a period, most commonly related to aging components and/or temperature factors, and then start operating again. This may occur once or repeatedly.
- The actions of persons unaware of possible consequences, causing and/or overcoming a failure. For example, failures have been recorded where a signal electrician working in a location bumps other equipment, or removes an incorrect fuse or pin.

5.1.2 Track Circuit Status

For the purposes of this analysis, track circuits will be regarded as either stable or unstable. Stable operation will include correct operation to detect train presence or absence, and also failure involving only a single change of state. Unstable operation is where, in the absence of a train, the track circuit changes state twice or more within the approach locking timer duration.

5.2 Equipment Failures

No scenario involving only complete and / or stable failures has been identified in which approach locking can be released unsafely. Any partial, unstable, failure affecting both the A and B tracks could provide the release depending on timing issues.

However, it can be reasonably argued that if an object can be proved to be working correctly, it is unlikely to fail in the short term without the influence of external factors. This means that if a route can be set and the signal cleared, the track circuits have been proved to be working, and are unlikely to fail within the next few minutes.

5.2.1 120v Power supply

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	No - Protected by POJR
Comments		
Additional Controls	Not required	

5.2.2 Relay Room 50V Power Supplies

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Low - See comments
Comments	Dual channel or N+1 rectifier units are used to prevent failure of a single unit affecting the operation of the interlocking. Failure of a single channel will cause an alarm in the controlling signal box, but is unlikely to result in an unstable output.	
Additional Controls	Not required	

5.2.3 Location 50V Power Supply:

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Low - See comments
Comments	Dual channel or N+1 rectifier units are used to prevent failure of a single unit affecting the operation of the interlocking. Failure of a single channel will cause an alarm in the controlling signal box, but is unlikely to result in an unstable output.	
Additional Controls	Not required	

5.2.4 24V Power Supply

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Low - see comments
Comments	If the A and B tracks are both jointless, a partial fault on a common 24V supply could cause both to drop and re-pick. Due to inherent component differences, one could pick slightly slower than the other, potentially releasing the approach lock, but sequence must be correct. More likely that in early stages of power supply failure, only one track will fail, and fault will be identified before progressing. In the event of intermittent shutdown of power supply, the off time is likely to be tens of seconds.	
Additional Controls	Preferable that critical tracks are not fed from a common power supply, except in the case of a large supply powering many tracks and/or having redundancy.	

5.2.5 Track feed / relay

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	No - subject to current restrictions on configuration and use of audio tracks.
Comments	Includes power supply fuse, track fuse, transformer or transmitter, receiver(s) and/or relay(s), matching transformer, and wiring from location to the tuning unit or trackside connection box. Generally failure of any of these items can only affect a single track circuit. The exceptions are centre-fed AF tracks and AF tracks with DPU.	
Additional Controls	Design principles to govern how AF centre-fed or DPU tracks may or may not be used for releasing approach locking.	

5.2.6 Traction currents

Failure Mode	Will behave as a partial failure.	Partial
Track Circuit Status		Unstable
Poses Release Risk		Yes
Comments	Traction imbalances in impedance bonds or AF tuning units can reduce impedance across the track. As traction currents vary, track circuits can drop then pick again. Tracks over pointwork are particularly vulnerable. Traction current variations could be caused by trains on parallel tracks, and possibly kilometres away.	
Additional Controls		

5.2.7 Track Cables and Connections

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Only with AF tracks
Comments	At block joints, a bad track cable or connection can only affect one track circuit. A single bad track connection at a tuned loop will affect both tracks. Environmental factors such as moisture or heat could cause intermittent electrical interruption, and again, one track could pick before the other.	
Additional Controls		

5.2.8 Block joints

Failure Mode	Complete	Partial
Track Circuit Status	May be unstable	Unstable
Poses Release Risk	Yes	Yes
Comments	Depending on configuration (single rail or double rail track circuits, track circuit technology), may fail none, one, or both tracks either directly or by traction current effects. Where due to traction current, the tracks may be unstable.	
Additional Controls		

5.2.9 Points rodding, steel structures, spark gaps

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	No
Comments	Defective insulation in point rods can short-circuit a track. The track circuit could also be shorted at block joints within the turnout where polarity of the one track circuit is swapped, or by rail fastenings touching a steel structure such as a bridge, or by short-circuit spark gaps. As only one track circuit is affected, the approach locking cannot be released.	
Additional Controls		

5.2.10 Sagging tracks

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Under adverse environmental conditions, the track circuits may become unstable, dropping and picking repeatedly.	
Additional Controls		

5.2.11 Human Action - Vandalism

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Faults caused by vandalism may in some cases clear themselves, or may be removed by the vandals or other people.	
Additional Controls		

5.2.12 Human Action - Engineering works

Failure Mode	Complete	Partial
Track Circuit Status	Stable	Unstable
Poses Release Risk	No	Yes
Comments	Infrastructure teams have caused track circuit failures by a variety of means. However, most affect only one track at a time, or are sustained for extended periods. Signaller(s) should be consulted before engineering works are undertaken in an interlocked area.	
Additional Controls		

6 SAFETY ANALYSIS

For a single failure to permit unsafe normalisation of a route, several factors must coincide:

- The situation must occur in an interlocked area;
- The two track circuits used to release the locking must both be affected;
- The signaller must not be aware that the tracks are unstable;
- Due to the delays applied to track circuit functions, the track circuits must simultaneously be up for several seconds to permit the signal to clear;
- The signal must remain clear for several seconds in order that the driver of an approaching train will see a higher indication and begin to adjust the speed of the train accordingly;
- The track circuits must then drop and pick in correct sequence; and
- The train must be approaching with speed and distance such that it cannot be stopped safely.

The existing failure reporting system is not geared toward identifying faults of a nature that could cause unsafe release of the approach locking with the proposed arrangement. A simple analysis of a limited set of records is included in Appendix B.

Anecdotal evidence from technical specialists supports the risk analysis assertion that a proved item is unlikely to fail. Track circuits will either be stable and reliable, completely failed, or so unstable that the signals affected will not remain clear for more than a few seconds, and the signallers will be aware that there is a problem.

The following table shows an assessment of the safety of all three options during the failures previously identified as posing a risk. The safety ranking is a comparative value only, as the lack of comprehensive track circuit failure data precludes calculation of probabilities. The safety rank is given a value on a scale of 1 to 5, 5 being the most safe. In this situation, 5 is applied to occurrences in which unsafe release should not be possible. Other values are based on a relative assessment of the rigour of the sequence testing in each option.

Assuming that for any failure that can affect both tracks, the probability of each track dropping is equal, the probability of producing each of the states identified in section 4.1 is 1/4. If a single failure should affect both tracks, the relative probability of a providing an unsafe release is:

Option 1: 1/4 x 1 x (1/4 + 1/4) x 1 x 1/4 = 1/32

Option 2: 1/4 x 1 x 1/4 x 1 x 1/4 = 1/64

Option 3: 1/4 x 1 x 1/4 x 1/4 x 1/4 = 1/256

6.1 Safety Ranking

Element	Failure Mode	Effect on Track Circuit Status	Additional Control	Safety Rank		
				Option		
				1	2	3
Track Circuit 24V supply	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.	Design to ensure critical tracks do not share common small power supply.	5	5	5
Track circuit TX - AF centre fed or DPU	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.	Design to ensure these configurations not used where risk exists.	5	5	5
Traction Current Imbalance - AF Tuned Loop	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Block joint short circuit - any configuration	Complete or Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Track Cable - AF tuned loop equipment	Partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Sagging tracks	Complete or partial	Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4
Human Activity - Vandalism, Infrastructure (civil) work		Unstable. If both critical tracks affected, could pick ALSR depending on timing issues.		1	2	4

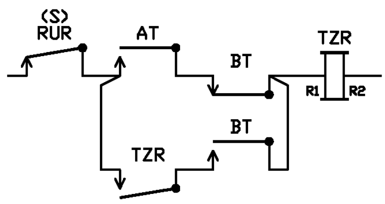
Recognising the other factors involved, such as signaller awareness of faults, and the timing of a train approaching, it is reasonable to conclude that Option 3 presents minimal risk to safety. Option 2 may also provide a sufficient level of safety, but Option 2 offers no technical or economic advantage over Option 3.

7 ENHANCEMENTS

The following is an assessment of enhancements that may be desirable or required in particular situations. They will not be considered part of the basic logic for release of approach locking, but would only be used where required and according to restrictions as noted.

7.1 Shunting Onto Occupied B Track

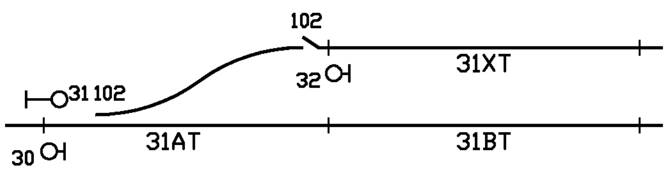
If a train has been signalled into a route, and remains on the B track, the TZR will remain up. If a shunt route is then cleared onto that occupied B track, the approach locking would not be effective because the A track and TZR are both up - if the signal were returned to stop, the route would normalise immediately. To avoid this, shunt RURs down are added in series in the front of the TZR logic.



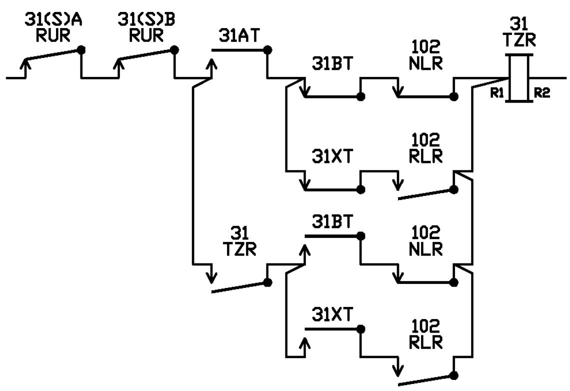
When the shunt route is set, the RUR picks and the TZR drops out. While the B track remains occupied, the TZR will not pick again, and in this case the ALSR must either time out or the approach path must be clear for the route to normalise.

This arrangement is only required for Option 3.

7.2 Selecting Alternate "B" Track Through Points

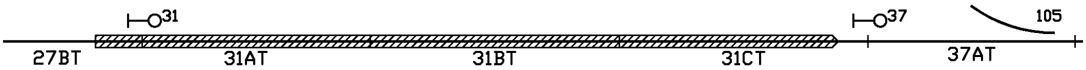


Where the A track has facing points, the B track will be different depending on the lie of the points. The correct B track must be selected to ensure that approach locking cannot be compromised by a train on the "wrong" B track, but can still be released by the passage of the train. Similar selection is required in Options 1 and 2.



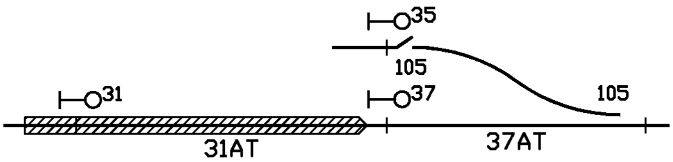
7.3 Use of Route Release Track Timers

When the train is longer than the distance between signals, the signal(s) in the rear will not normalise until the approach timer expires. The approach locking would affect trailing points in the overlap.

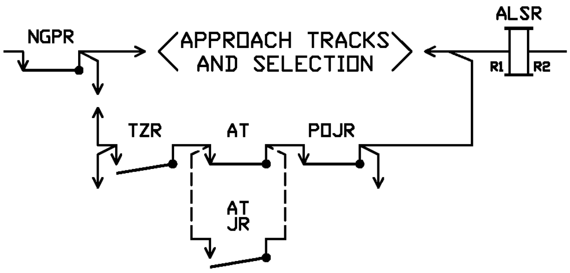


If a train stopped at a signal is still partly on the A track of the first controlled signal, a train approaching in the automatic section would keep the outer signal approach locked.

In some parts of the Sydney and Strathfield areas, signal spacing can be less than 160m, even as little as 50m in the City Railway and ESR. The issue is even more critical in these situations, as close signalling is obviously associated with high traffic density, and waiting for a 120 second timer can have a large impact on the timetable.



In limited circumstances, where required for operating purposes, an existing route release timer can be used to qualify the A track in the approach lock release.



7.3.1 Risks with the Route Release Timer

The use of the route release timer introduces a new risk, in that a failure of the timing track could allow premature normalising of the route.

The signal will be returned to stop by the track circuit failure, possibly leading to a technical SPAD. However, as long as the timing track remains failed, there is no danger in the immediately affected route.

1. If there is one track circuit between the signals, the failed track will pick the TZR, and the timer will provide the approach lock release, but the track down prevents points within the route being moved;
2. If there are two track circuits between signals, the timing track would be the B track, and when it fails it will prevent the TZR from picking, so the route cannot normalise until the approach timer expires or the approach tracks are clear;
3. If there are three or more track circuits, the timing track does not appear in the TZR. The TZR will pick if an approaching train, unable to stop at the affected signal, enters the route, and the approach lock will be released as soon as

both the route timer and the TZR are up. Points in the route will be locked by route holding. The timer can only qualify route holding in the overlap.

The risk is in the overlap, past the next signal, where a trailing junction or opposing route could be released by the release timer.

1. If the next signal is clear, the early release of the approach locking poses no danger.
2. If the next signal is clear, and subsequently returned to stop, it is safely approach locked while the first affected signal is approach locked or the failed track circuit remains down, until its own approach lock timer expires.
3. If the next signal is already normal, the early release of the approach locking and route holding could pose a risk.

In the situation where the next signal is already normal, the driver of an approaching train should be preparing to stop at that signal. The danger is that for some reason, the driver does not stop the train before the signal. Route holding is provided specifically to protect against this.

	Position of train when timing track fails		
Number of tracks between signals	**Approaching warning signal - Existing NX or new arrangement**	**Approaching legitimate Stop signal - Existing NX**	**Approaching legitimate Stop signal - New arrangement**
One	Final warning signal fails, returns to Stop. Preceding signal aspects drop back. Driver should attempt to stop at failed signal, may SPAD failed signal but should stop before legitimate stop signal.	N/A - train is already on timing track.	
Two		With A track down, B failed, approach locking released. NX style TZR picks when train off berth track, route normalises. Route released when timer expires.	TZR picks with train on A track. Timing track fails and starts timer with train on A track. Route release timer may not be long enough to prove train has stopped or is capable of stopping.
Three (or more)		Approach locking released when train reaches B track. NX style TZR picks when train off berth track, route normalises. Route released when timer expires.	

Generally it must be assumed that the driver will be attempting to stop the train at the signal correctly displaying Stop. As shown in the table, there is practically no danger unless the train has already passed the last warning signal when the timing track fails.

For most situations involving suburban or interurban trains and two tracks between signals, the proposed arrangement is no less safe than current NX logic with auto-normalising, which has been in use since 1980. With a route release timer of at least 30 seconds, a train travelling at only 20 - 25km/h will be off the berth track before the timer expires, and so both NX and the new logic would normalise at about the same time.

As long as the A track is no more than three times longer than the B track, if the train has already occupied the A track when the B track fails, the train will either be able to stop before, or only a few metres past the intended stop signal, or if it overruns excessively it will have been travelling fast enough to do so before the release timer expires.

Where there are three or more tracks between signals, the risk is increased, and the potential benefits decreased. Normally a CityRail train will be clear of the A track, as the total length of the B and C tracks is unlikely to be less than 200m. If the train is longer than the B and C tracks, it is unlikely to brake as well as a suburban train, and so the longer braking time and the greater distance between signals (inferred by the several tracks) means the train will take most of the 120 -second approach lock timer to stop.

7.3.2 Conditions for use of Route Release Timer

The use of the route release timer to qualify the A track in the approach locking release is not to be applied unless an operational requirement is identified, and then only according to the following rules.

As this scheme is intended for use with computer-based interlockings, the signal controls and the track timer use the same track bit. This ensures that the signal will display stop when the track circuit fails. If used in relay-based systems, care must be taken to ensure that the timer could not be started without the signal being returned immediately to stop, for example if the timer is on the track 2PR which may fail independent of the 1PR.

It is only to be used where a route release timer is provided for a legitimate route release; a timer is not to be provided for the sole purpose of quick release of approach locking.

If not required for the passenger services, the route release timer will not be provided for the benefit of freight operations.

This quick timer release may be used where there is one track of less than 200m between signals. As identified in 7.3.1, due to the close spacing of signals an approaching train will already be braking for the functioning stop signal, and the failure of the timing track as the train approaches will return the approach signal(s) to stop and the train will come to a stand within a safe distance.

The timer may be used where there are two tracks between between the first and second controlled signals after an automatic section, if the second track is less than 200m, and the first track is no more than three times the length of the second. In this situation a train standing at a stop signal could remain on the A track of the first controlled signal, which could otherwise be approach locked by a train in the automatic section.

There is no advantage gained by using the route release timer to release the approach locking of the second or subsequent controlled signal where there are two tracks between signals. The train will have released the approach locking on at least one previous signal by the TZR. The approach locking should not be released by a short timer in this situation.

The route release timer is not to be used in the approach lock release where there are three or more tracks between signals.

8 VALIDATION

To validate the function of the proposed new arrangement, the Microlok testing simulation for Sefton Park resignalling was modified to include the Option 3 arrangement on Leightonfield 61 signal. 61 was chosen as it provided realistic opportunity to test the releasing with the enhancements outlined above - 61 has two main and two shunt routes over facing points, with a route release timer on 61ZT. The test results are attached in Appendix A.

9 CONCLUSION

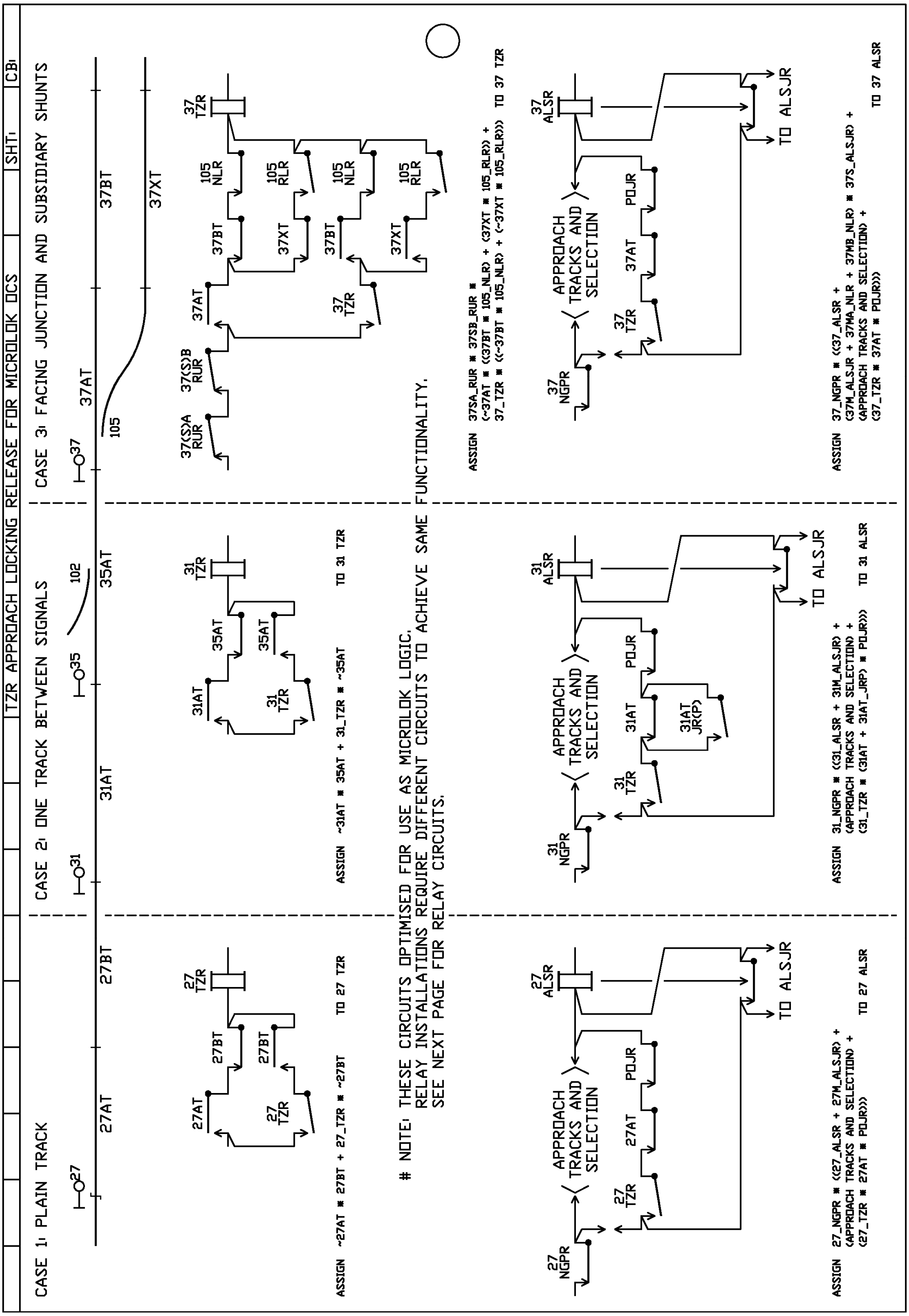
All analysis to date indicates that the logic identified as Option 3 is suitable for use in providing a quick release of approach locking. It meets the operational requirements to improve flexibility in high-traffic areas, and with a minimum of complexity provides a very high degree of safety. It is recommended that this quick release arrangement be adopted as a new standard for RailCorp signalling.

Route release timers to release approach locking will only be required in special circumstances as identified in section 7.3 and is subject to conditions listed there.

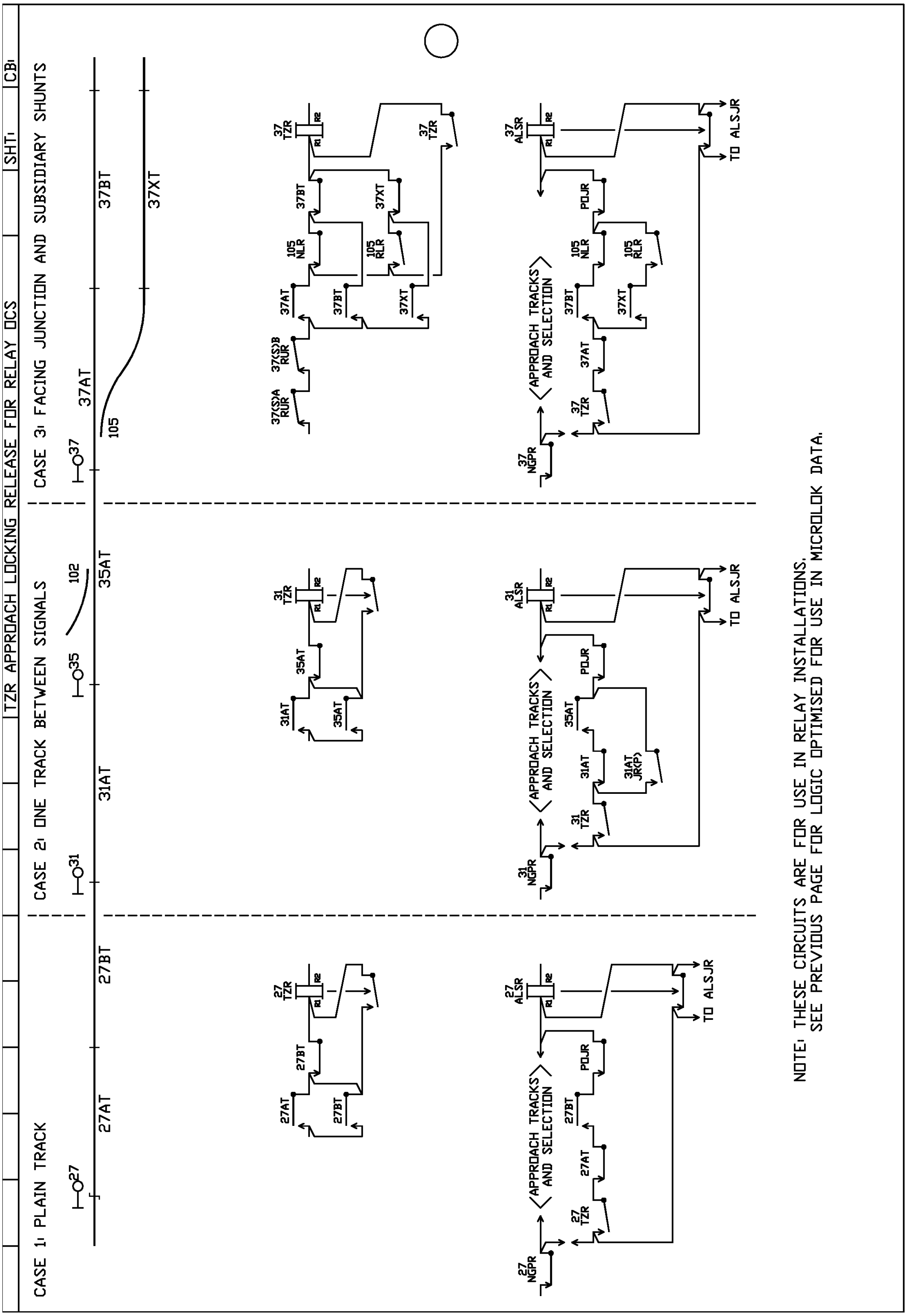
Situation	Existing NX	Existing OCS	Option 1	Option 2	Option 3
Shunt locomotive off train onto B track.	Signaller action required	120" timer	OK	OK	OK
Route release at home signal (trailing junction), train clears A track	OK	OK	OK	OK	OK
Route release at home signal (trailing junction), train remains on A track, second train approaching.	OK	120" timer	OK using short timer	OK using short timer	OK using short timer
Route release at home signal (trailing junction), one or two tracks between signals, train longer than signal section.	Signaller action required	120" timer	OK using short timer	OK using short timer	OK using short timer
Route release at home signal (trailing junction), three or more tracks between signals, train longer than signal section.	Signaller action required	120" timer	120" timer	120" timer	120" timer
Facing junction, second train approaching in auto section - outer signal does not normalise.	OK	120" timer	OK	OK	OK
ALSR cycled during auto-reclearing with close following moves	Yes	No	No	No	Yes
Safety	High	High	Lower	Lower	High

APPENDIX A: SAMPLE CIRCUITS AND DATA

Logic Optimised for Micolok Use



Circuits for Relay Use



In the Microlok processor, a "front" bit "opens" in the same processing cycle as the "back" closes, and vice versa. As there is a finite delay in relay contacts changing over, the circuits for relay use differ from the Microlok logic but provide the same functionality.

APPENDIX B: TESTING OF LOGIC, LD61 SIGNAL, SEFTON PARK SIMULATION

Normal Operating Scenarios	Routes (M)A	(M)B	(S)A	(S)B	Comments
Single through train. Set route. Operate track circuits as for normal passage of train approaching and passing signal. ALSR should pick when all approach tracks clear, with A track still occupied.	✓	✓	✓	✓	
Single train, detach locomotive and draw forward. Set route. Operate track circuits as for normal passage of train approaching signal. With berth track occupied, drop A track then B (or X) track. ALSR should pick with A track, with berth still occupied. TZR will remain up while B (or X) track occupied. With B (or X) track still occupied, proceed to next test.	✓	✓	✓	✓	
Cancelled shunt route onto occupied second track. With the second track still down and TZR up, set shunt route. Ensure TZR is dropped. Cancel route, ensure approach locking is effective. With B (or X) track still occupied, proceed to next test.	N/A	N/A	✓ ✓	✓ ✓	
Use shunt route onto occupied second track. With the second track still down, set shunt route. With approach occupied, drop A track, pick A track. Ensure approach locking still effective.	N/A	N/A	✓	✓	
Pick B track, ensure approach locking still effective.	N/A	N/A	✓	✓	
Second track occupied, set route to call points to opposite position. Manipulate tracks to pick TZR, pick A track, leave B or X track down. Set route over points in opposite position, ensure TZR drops.	✓	✓	✓	✓	
With approach occupied, cancel route, ensure approach locking effective.	✓	✓	✓	✓	
Route set over points, shunting moves on adjacent track. Set route. With approach occupied, drop A track, then track which would be second with points in opposite position (ie points normal, drop X track). Pick A track, ensure approach locking remains effective.	✓	✓	✓	✓	
Tracks bobbing, normal passage of long train Set route. With approach occupied, drop A track, pick A track, drop A track.	✓	✓	✓	✓	
Drop B track, pick B track, drop B track. Ensure route still approach locked.	✓	✓	✓	✓	
Long train and Route Release timer Set route. With approach occupied, drop all tracks to next signal. Ensure route remains approach locked until expiry of route release timer.	✓	N/A	N/A	N/A	SP61 does not meet criteria for use of route release timer, but proves concept.
Set route. Drop route release timer track on adjacent track (ie Y track with points normal). Drop A track, ensure that at expiry of route release timer approach locking is not released.	N/A	N/A	N/A	N/A	

Note that in the context of this testing, X track (first track after A with points reverse) refers to 61WT.

Failure Scenarios	**Routes**				**Comments**
	(M)A	**(M)B**	**(S)A**	**(S)B**	
Second track drops before A track Set route. With approach occupied, ensure approach locking remains effective at each step: Drop B (or X) track.	*	*	*	*	B (or X) Does not cancel route
Drop A track.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Drop A track, pick B (or X) track.	✓	✓	✓	✓	
Pick A track	✓	✓	✓	✓	
A track picks before second track drops Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Drop B track.	✓	✓	✓	✓	
Pick B track.	✓	✓	✓	✓	
A track drops, then wrong second track for points position drops. Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track.	✓	✓	✓	✓	
If points normal, drop X track (drop B track if points reverse).	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Tracks drop simultaneously Set route. With approach occupied, ensure approach locking remains effective at each step: Drop AT, BT or AT, XT simultaneously. Ensure TZR does not pick up.	✓	✓	✓	✓	
Pick A track.	✓	✓	✓	✓	
Pick second track.	✓	✓	✓	✓	
Tracks pick simultaneously Set route. With approach occupied, ensure approach locking remains effective at each step: Drop A track, then second track (TZR should pick).	✓	✓	✓	✓	
Pick AT and second track simultaneously.	✓	✓	✓	✓	

Note that in the context of this testing, X track (first track after A with points reverse) refers to 61WT.

APPENDIX C: PRELIMINARY ANALYSIS OF ACTUAL TRACK CIRCUIT FAILURES

A report covering the year Jul 22 2004 - Jul 22 2005 was extracted from IFMS, and reviewed for track circuit failure data.

At the time of preparing this document the review is incomplete, but the following details have been observed from the IFMS report:

Period Reviewed:	22 Jul 04 - 21 Oct 04	92 days
Total track circuit failures	249	~ 2.7/day
Unstable track failures [1]	58	~ 23.3%
Failure affects two tracks [2]	36	~ 14.5%
Failure affects controlled signal [3]	145	~ 58%
SPAD of affected signal [4]	2	~ 0.8%

This is obviously a limited sampling, but it yields the following:

For Option 3, the probability of unsafe normalisation based simply on the product of the identified occurrence rates and the assumed relative probability of the sequenced failures shown in section 6 is:

$0.233 \times 0.145 \times 0.58 \times 0.008 \times 0.004 = 6.3\times10^{-7}$

or 1 unsafe normalisation in 1.6 million track circuit failures. At 2.7 failures per day, this translates to a roughly 1-in-1600 year event.

It is important to understand that this calculation is based on a statistically small sample, and the method of calculation has not been validated. Also, IFMS reports may not record all relevant details. Specifically:

1. Failures identified as "Unstable" include those reported as momentary, intermittent, came good after first train, or OK on arrival of staff. They have not been divided up to exclude those which are continuously down for longer than the normal 120" approach timer, unless the record states that a data logger revealed a long failure time.
2. Failures identified as affecting two tracks include those which have identified potential, on the basis of the equipment affected, to affect two tracks, even if only one track is listed on the report. This primarily relates to trackside components of jointless tracks, and short circuit block joints. In most cases only one track has been recorded failed in the report. The number of incidents where two tracks are actually affected is thus lower than shown in the table. Also, failures affecting two tracks may not have affected the two critical tracks for releasing the approach locking - the failure could affect the berth track and A track, or B and C tracks, etc. The number shown in the table does exclude those incidents where the failure is originally reported as affecting multiple tracks, but this is due to grouped indications to the signal box.
3. The records do not always record which signal is affected, so an attempt has been made to determine this based on track circuit names, local knowledge, and other information (such as track failed due to defective points rod insulation). Except where otherwise known tracks with distance-based

numbers are assumed to affect automatic signals, and tracks with lever-based numbers are assumed to affect controlled signals. This is not universal practice, as some controlled signals work over distance-numbered tracks, and some automatic signals between controlled signals in larger interlockings have been given lever-number identifications.

4. 1 of the 2 SPADs identified was not reported as a SPAD, but "signal returned to stop in face of train". There is no mention of whether the train actually passed the signal, if it pulled up short of the signal, or if it was even moving - it may have been waiting to depart a platform. The second SPAD occurred when a track in the overlap, not in the signal route, failed. There is also no reference to the severity of the SPADs - whether the overrun was only a few metres or hundreds of metres. For all other track circuit events, there is no reference to trains approaching affected signals.

It is also worth noting that there have been no recorded instances of unsafe release of approach locking, even in older interlockings where approach locking did not extend back to the first warning signal, and single drop track release was provided.