The Institution of Railway Signal Engineers Inc

Australasian Section Incorporated

TIME BASED MOVEMENT AUTHORITIES

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SUMMARY

Modern communications based signalling places improved signalling functionality on board the train.

This can be used to enforce conventional temporary speed restrictions using location based authorities. With these the train ensures its speed is maintained below the temporary maximum between two defined points.

In a related class are time based authorities. A time based authority commences at a specified time and continue to a specified event (which is not necessarily time based). Two examples are presented.

The first relates to a requirement to restrict passing speeds within a long tunnel to below a specified maximum (as is the case for the Seikan tunnel in northern Japan).

In this case the signalling system is aware of the location and authorized speed of the two passing trains in advance. With this knowledge a passing point can be predicted in terms of location. However, a speed restriction based on this criterion can be shown to be unsound as a provider of safety. Thus a safety benefit is obtained by defining the passing point in terms of time; a time based authority emerges.

The second relates to level crossing protection.

It is conventional in a class of signalling to require a train to obtain an authority to cross a protected level crossing.

Communications base signalling allows a train to communicate its arrival time to the level crossing as part of the process for obtaining that authority. This is another class of time based authority – the train obtains authority to cross at a specified time.

Once communicated, the train is able to regulate its progress safely to ensure it does not arrive prior to the specified time. The crossing is able to ensure that the standard warning is provided prior to the authorised arrival time.

The paper explores the characteristics of, and requirements for time based authorities.

1 INTRODUCTION

Modern communications based signalling places improved signalling functionality on board the train. It was indeed ETCS's ability to manage train overspeeds through curves and temporary speed restrictions which made the case for its adoption in NSW as a response to the Waterfall incident.

In the traditional railway train speeds are managed through a combination of published line speeds (in the Appendix to the Working Timetable in Victoria), published Curve speeds (in the gradients and curves book supported by instructions and lineside curve speed boards) and published Temporary Speed Restrictions (in the Weekly Notices in Victoria). It is of course up to the driver to ensure that these authorised maximum train speeds are complied with.

The thing that all these systems of speed authorities have in common is that they are associated with locations within the infrastructure.

Communications based signalling in the modern world enables these systems of authorised speeds to be incorporated into movement authorities issued to the train and managed by train-borne systems. Depending on the circumstances and the system, authorised speed may be built into the infrastructure model in the on-board system (the approach utilised in Japan), or it may be incorporated into the actual movement authority issued to the train as it enters the section.

By enabling existing infrastructure based authorities to be translated into cab based systems, great benefit can be achieved. But, as with any shift in technology, capabilities are not limited to mere translation of existing facilities. Infrastructure based speed authorities are necessarily tied to location. There is another class of authorities not generally found in infrastructure based systems which are tied to time. These time based authorities can be managed by train based systems and are the topic of this paper.

This paper will first consider a Communications Based Signalling approach to providing a simple location based authority, then show the extension of this system to time based authority types.

2 NOTATION & ABBREVIATIONS

Abbreviations are as follows:

ATP: "Automatic Train Protection" in its most general sense. Used here to represent any vital function included in the ATC (refer IEEE 1474.1 for discussion of ATC);

CBTC: Communications Based Train Control;

ERTMS: European Rail Traffic Management System;

ETCS: European Train Control System – a component of ERTMS;

TSR: Temporary Speed Restriction;

3 PROTECTION OF A WORKSITE USING LOCATION BASED AUTHORITIES

Location based authorities in their most simple form are found applied in temporary speed restrictions associated with worksite protection.

Conventionally, a worksite can be protected by setting up a temporary authority area with signage, flag-persons and possibly audible track warners. This temporary area will be located within an existing permanent authority area and will generally have a temporary speed restriction associated with it. Communications Based Signalling allows the temporary speed restriction to be managed by the train borne systems.

If we consider the process for setting up of worksite protection using movement authorities, we see that, from the poin of view of the worksite, the need is to request a temporary speed restriction to be applied between two geographic points in a section of track.

The request (which formally is an “offer”) is made in the first instance to the infrastructure based signalling system. Before the infrastructure system can communicate an acceptance, it must offer the Temporary Speed Restriction to all trains currently in or approaching the authority section and approaching the worksite being set up, and receive acceptance from them.

We will explore this process is some detail as an example of the currently conventional.

3.1 Process for the trackforce to establish the worksite

Figure 1a provides a typical layout showing the area where the TSR is required and Figure 1b illustrates the process steps needed to establish it.

Formally, the trackforce is offering a negative authority (since it involves establishing a restriction not otherwise present rather than releasing one) to all trains in the section using the infrastructure as an agent.

Like an offer of cancellation of a conventional movement authority, this offer involves the imposition of a restriction. This restriction cannot be put in place and the worksite cannot be set up until all relevant trains have accepted. As with approach locking, there is the chance of a train being too close to the worksite to slow to speed as required. Such a train will not accept and must be allowed to pass.

The restriction required for the reduced line speed will commence when the head of the train passes the geographic point at the entry to the worksite (it must have slowed to speed prior) and enters the worksite area. It will continue till when the tail of the train has passed the geographic point at the exit to the worksite, which marks the point at which the train has left the worksite area. The worksite cannot be established until all relevant trains have communicated acceptance of this offer to the trackforce.

In principle, the trackforce want to communicate with all relevant trains.

In practice the tackforce does not know of all the trains which are relevant and needing to respond to its offer, or their locations and other details. This information is held by the infrastructure system. So rather than have the trackforce deal with trains directly the trackforce request process is broken up into two halves (two authority loops).

In the first authority loop the worksite makes an offer (or makes an application – the same thing in this case) to the infrastructure and waits for acceptance.

In the second authority loop the infrastructure (as agent) makes the offer separately to each relevant train.

This second authority loop is resolved either by acceptance being communicated by all trains (based on the train knowing that it is able to comply with the requested speed restriction), or by any non-accepting train being seen to pass clear of the exit to the worksite (thus becoming no longer relevant to the request).

Once the infrastructure has received acceptance from all relevant trains, acceptance is communicated with the worksite and the worksite can then be safely established.

3.2 Why use an agent?

Looking at the above communications exchange, it can be seen that the worksite could have made its offer directly to all relevant trains without the need for the infrastructure in the middle. The problem with this approach is that the trackforce has trouble obtaining and managing the information needed to deal with “all relevant trains”. Likewise, for each train to know of the existence of trackforce to be able to accept is offer adds complexity. Putting the infrastructure system in the middle simplifies the communications for all concerned.

Even for the infrastructure, the concept of “all relevant trains” can be onerous. Taken generally, it could include all trains capable of passing the worksite including some trains not currently in operation (eg in maintenance) or currently running on other lines.

One benefit the infrastructure system brings to the process is the ability to define a practical boundary for the initial offer and then apply border protection once the worksite has been established.

The infrastructure’s involvement then becomes important in maintaining the worksite

3.3 Maintaining the worksite

With the trackforce authority in place between the trackforce system and the infrastructure system, there is no need for ongoing communication between the trackforce and the infrastructure system. The responsibility for maintaining this authority falls to the infrastructure system in its dealing when issuing movement authorities to trains wishing to enter the zone or the authority section containing the worksite.

The infrastructure controls the section containing the worksite by issuing authorities to trains to enter that section. Once the worksite has been established, no train can be provided with authority to enter the section unless it has accepted the TSR associated with the worksite.

There are two ways that this can be done. In today's systems, we see both in use in the various situations.

In method 1 the temporary speed restriction is included as a special condition attached to the authority issued. This is seen in ATP systems where train authorities issued always contain the speed restrictions for each section (no geographic information stored on board). But it can also be used in systems where the permanent speed restrictions are normally managed by the train separately from the movement authorities (as in many Japanese systems).

In method 2 the temporary speed restriction authority is agreed separately and prior to the main authority being offered. At its most basic, this occurs when the Temporary Speed Restrictions are published in the Weekly Notices (or equivalent) or when the geographic model held by the train is updated to include the temporary speed restriction. Safety is assured since the train cannot be given authority to enter the network (or relevant section of the network) without having the speed restriction included in its geographic model (ie having the current version of the infrastructure model on board). This is border protection.

Method 1 will be better at managing short duration and ad hoc situations. Method 2 will be better at managing pseudo-permanent arrangements where a TSR is likely to persist for months or years

3.4 Vacating the worksite

When all work is finished and the TSR no longer required (worksite fully vacated), the Trackforce provides a release to the Infrastructure System.

The infrastructure system will then pass this release to "all relevant trains" and no longer require the TSR to be applied to new movement authorities entering the section.

This step does not require the "Offer and Accept" cycle involved in establishing the TSR initially, since it is a contract completion process rather than the establishment of a new contract. The topic of the releasing process is beyond the scope of this paper.

4 MANAGING TRAIN PASSING SPEEDS INSIDE LONG TUNNELS

A problem in some ways similar to that of Trackforce protection is the one posed by the need to enforce maximum passing speeds inside long tunnels. Like the Trackforce protection case, a TSR is called for. Unlike the Trackforce protection case, the location of application for the TSR will vary depending on each individual train pair.

The situation considered here is that faced in Japan currently in the newly operational tunnel between Honshu and Hokkaido. This tunnel, which is more than 82km in length including approaches to portals, is capable of operating individual trains safely at 260km/hr line speed. However, trains passing each other inside the tunnel must be travelling at no more than 140km/hr each while they are actually passing each other.

Currently this constraint causes a blanket speed restriction of 140km/hr for all trains within the tunnel. However, significant transit time benefit is available by introducing a control whereby the trains slow only as they are actually passing.

Figure 2a shows the general layout and issue of TSR zones for passing trains.

Knowing the line speed and location for each train, the passing zone can be predicted with some accuracy. Establishment of a location based authority for a TSR would seem appropriate at first glance.

4.1 Location based approach explored

Utilising the worksite protection approach, the location for each train passing movement can be calculated (knowing the line speed and the location of each train) and a negative movement authority (with speed restriction between calculated locations) provided to each train.

Diagram 2b illustrates this process required to put in place this authority.

The general process steps which occur are as follows:

At step 0 the first train (train 1) enters the tunnel. It requests locations for TSRs but, since it is the first train in section, it is able to enter the tunnel without speed restriction. There are no "relevant" passing trains visible at this stage.

At step 1, the second train enters the approach section at the other end of the tunnel and requests authority for entry to the tunnel ("offer to treat" step). The infrastructure is aware of the location and line speed of each train. In some architectures, the infrastructure informs the second train of the location of the first train, in others it does not. Both cases may be considered.

At step 2, either the infrastructure or the second train calculates the applicable passing location (based on line speed of trains 1 and 2) and offers to train 1 (infrastructure as agent) a negative authority with the 140km/hr temporary speed restriction for the zone applicable to this location.

Under this arrangement, the speed restriction commences at the calculated location and generally remains in force till the trains have actually passed (train location functionality utilised – a topic outside the scope of this presentation. This detection may be based on data from the trains, or from the infrastructure). There is also an option to use calculated locations prior for this purpose.

At step 3, train 1 accepts this negative authority (applying the TSR) and communicates this to the infrastructure.

At step 4, the infrastructure offers a movement authority to train 2 (for entry to the tunnel) and including the negative authority (TSR) needed for safe train passing speeds.

This completes the provision authorities for safe passage of both trains. If communication of any step fails, the second train does not obtain authority to enter the tunnel and must wait for the first train to clear. This is safe for both trains.

The authority for the trains to return to line speed can be based on actual detection of the rear of the trains having passed each other, or by calculation of the location where this will have occurred.

4.2 The problem of trains travelling slowly

The problem with using calculated location for enforcing the speed restriction for passing occurs when one train travels at less than authorised line speed for part of the way. When this occurs the trains pass at a different location from that calculated.

Figure 2c illustrates the problem.

When one train travels slower than line speed for some of the approach distance, the location of the train pass will be closer to the slower train than calculated. Since the actual pass occurs at a different location to that calculated, the speed restriction for the pass is not fully enforced and actual passing speed can be significantly higher than the maximum permitted.

Use of a location based authority as discussed is thus not safe for all cases.

To overcome this problem, calculated "time of passing" can be used in place of "location of passing" for establishing the required speed reduction for the crossing movement.

4.3 Time based authority solution explored

Systems of location based authorities fit in well with modern infrastructure based signalling where authority points and other items of equipment are all found at fixed locations within the infrastructure. Time based authorities have not proved a good fit with fixed infrastructure.

Whilst location based authorities ("fixed blocks", for example) are quite conventional in modern signalling systems, time based authorities ("time interval working", for example) is not. One reason for this is that for this once common application in railway signalling, the time based option for movement authorities can be shown to be less safe.

Consider, for instance, time interval working and the problem of giving authority to a following train to enter a station. Up to the 1850s there were some versions of safeworking which allowed the signaller to watch a train go past towards a station (not visible and no telegraph available), then proceed to count up an appropriate time (perhaps 3 or 4 minutes to allow the first train to complete all tasks in the station). Based on time expired, the signaller could give a movement authority for a following train to enter the station. This approach, though cheap, suffered from the problem that if the first train was delayed for any reason, an accident could occur. Time based authorities in this case produced less than ideal outcomes.

Location based authorities, such as fixed block where the first train must be beyond a specified location before authority could be given to a following train, did not suffer from this deficiency and subsequently became the standard approach mandated for use in conventional signalling.

This success in for location based authorities for this one particularly important application has obscured the fact that the two approaches have always been complementary. There are some cases where safety will be provided utilising the location based approach; there are other cases where safety will be provided utilising the time based approach instead.

Our tunnel problem is a good example of just such a case.

If, instead of initially calculating the location where the train pass would occur, the calculation and subsequent TSR authority was based on the time when the pass would occur, the safety of the pass would be assured.

The process for establishing the authority is as shown in figure 2b, as for the location based authority case. The Figure 2d shows the general layout and issue of TSR zones for passing trains utilising the time based authority.

In this case, although the pass is calculated to happen at the same location, the actual authority is based on the calculated time of that passing. If one train slows as discussed above, the result will be that the pass will occur later than the calculated time, never before. Thus, slowing by the target time will always be safe.

Authority to return to line speed is favoured to be based on actual detection that the rears of the trains have passed (based on each train knowing its current location with accuracy, or on location data held by the infrastructure system), which is conceptually simple and safe though may not be convenient.

Is there an alternative? We could propose to use the calculated time for this, but either of these will allow one of the trains to accelerate too early in some cases. Thus, completion of the authority should be based on actual relative location of trains at the time of release, rather than on any predicted value. Neither initially predicted time or location gives a safe outcome in all cases and actual location should be readily available.

4.4 Continued adjustments to TSR authority on approach

The predicted values improve as they are continually re-estimated as the trains approach each other. Once the initial authorities are in place, the possibility exists to thus adjust the estimates on which the authorities are based. The actual authorities can then also be updated by the process shown in figure 2e.

Note that in this case the option for the TSR authority to be train to train (omitting the need for the infrastructure system as agent) is shown. The alternative with the infrastructure included (as common train location resource and agent) is also possible. For this section though, the advantages of the trains themselves requesting the authorities are explored.

In such a case, if one train slows or expects to slow, that train can offer the other train a revised authority based on a reduced speed and an amended passing time. This calculated time can assume its own planned speed and journey profile, but should assume that the other train continues at line speed unless the other train also undertakes to travel at a different speed (as a self-enforceable expectation).

Where both trains expect to run slow, there will be competing offers of authority out there. These should match provided the expected speed profile for each train is included in the agreement. The planned passing point may be amended and should improve as the time for the actual cross approaches. Safety and accuracy thus result for the final cross even if failure of communications occurs.

Predictions of train performance by the trains themselves, which control and enforce their own performance outcomes, will be better than predictions produced by infrastructure systems on their behalf.

This is an example of a “train to train” authority (whether or not the infrastructure system is used as agent). It is fundamentally different from the train protection functionality associated with following trains in that the amendment requires agreement between trains (since a “permission to speed up” may be involved for some cases). Since agreement is required between trains, the authority cannot be offered by the infrastructure (except as agent) to the trains either. The offer to amend may start with either train, but must always be accepted by the other train before being effective.

In case of communication anomaly, the “train to train” authority is always safe, whilst the “infrastructure to train” authority is not. Where the infrastructure acts as agent, the authority is of the form “train to infrastructure” (train as initial offerer) which reverses the more usual role. Another case where this occurs will be seen for the level crossing case discussed next section. The principle applied is that the offerer should be the party best able to control the outcome.

4.5 Multiple trains

One aspect of train movements in the tunnel is the possibility of multiple trains in each direction. This possibility does not change the principles to be used to determine the outcome. However, it becomes necessary to calculate passing times separately for each passing train pair involved.

In such context, true “train to train” methods for updating authorities are likely to be more complex and more prone to “colliding offers” than the options involving infrastructure system as agent.

The other thing to note is that as the complexity increases with more trains, the benefit reduces as the opportunity to run at higher speed is limited due to the number of conflicts to be negotiated. Rules concerning which train initiates which revised offer are also needed.

5 TIME BASED AUTHORITIES FOR LEVEL CROSSING PROTECTION

Another potential application for time based authorities is level crossings.

In the level crossing application, the fundamental signalling requirement can be expressed in the need to initiate the level crossing warning sequence a fixed time (typically 25 seconds) prior to the arrival of the train. To do this, a negative time element is what should ideally be slotted into the signalling.

Up till now, reliable negative time elements have been hard to come by. Various forms of prediction coupled with infrastructure based train detection systems have been used instead.

With the use of time based authorities, together with train-based train location systems, the means to provide a better and fail safe alternative to other constant warning technologies can be found.

5.1 Application of time based authorities

Diagram 3a shows a sample level crossing with train on approach.

In the level crossing application, the time based authority provides an authority for a train to enter a level crossing at a specified time. This time is enforced by the train on-board systems. In the absence of this authority, the train does not have authority to enter the level crossing at all. This absence of authority is represented in figure 3a by the virtual signal (not actually provided in the field) at the level crossing. If no authority is obtained the train must stop at the level crossing and apply alternate safeworking methods to cross.

The train applies to the level crossing for authority to cross at a specified time. This is the offer for the time based authority. The level crossing accepts, the general process being as shown in figure 3b.

On the level crossing side, the level crossing warning commences 25 seconds (or other warning time) prior to the authorised arrival time of the train and continues until confirmation by the train that it has cleared the level crossing.

Looking in more detail, the step by step method of operation (from the start) is as follows:

At step 0, the train obtains authority to enter the line section containing the level crossing(s) by the signalling. This authority includes the location of each level crossing (if not included in the static geography model held by the train-borne systems), but no authority to cross any of them. The train can enter the section, but authorities to cross level crossings must be obtained from the crossings themselves.

At step 1, the train enters the authority approach zone for a level crossing. This zone is defined in general terms to be comfortably beyond where the train would need to commence braking to stop at the level plus the time needed for the transactions to occur to obtain the required authority to cross. The train applies for authority to cross from the crossing. This takes the form of an offer which includes an authorised arrival time at the crossing. This authorised arrival time will include salient features of the trains operating plan including its plans for stopping at stations and estimated stopping times. These plans are not required to be enforced in detail. The only part of the plan which is enforced is the authorised arrival time at the crossing. The train is not permitted to cross early.

Note that, as for many things to do with level crossing signalling, the offerer and acceptor roles here are reversed compared with many other conventional signalling authorities (normally the infrastructure makes an offer to the train). This is similar to the case for the tunnel authorities discussed in the last section. The estimate of arrival time must originate from the train. There is no benefit in the additional process step which would provide this information to the infrastructure so that it could make the formal offer.

At step 2, the level crossing (infrastructure in isolation) communicates acceptance of the offer and prepares to activate the level crossing protection at the specified warning time before the train is authorised to arrive.

At step 3, the train prepares to enforce that it will not arrive at the crossing before the authorised arrival time. This is the situation as shown in figure 3a. The authority is place applies to a specified future time in the same way that in the tunnel case the TSR authority applied to a future specified time. In the current time the virtual signal is still red. To paraphrase a popular railway magazine, we now see “approach operation on steroids”.

As the train approaches, the train may make amended offers based on updated expected arrival times at the crossing. This exercise may appear trivial for a simple crossing, but for a crossing involving station stops and shunting possibilities within its control and holding sections, these updates to authority can be quite important. In some regional railways station stopping times can be variable and scheduled to exceed the level crossing warning time by a considerable margin, for instance. As the time for the train to actually cross the level crossing approaches, the estimate of time of crossing will improve so that the final warning given will closely match that required by relevant standards.

At step 4, the level crossing actually activates its warning devices at the specified interval (25 seconds typically) before the train arrives. This is illustrated in figure 3c.

At step 5, the train arrives at the crossing at the authorised time and the virtual signal clears to allow it to pass unimpeded. This is shown in figure 3d. Unlike conventional approach operation, the train knows with certainty that the virtual signal will clear at the specified time since this fact is included in its authority. No speed or stopping point needs to be enforced, only arrival time. The train crosses the level crossing at speed.

At step 6, the train crosses the level crossing and detects that it is clear (based on its location compared to that of the crossing). It then releases the authority (as complete) and advises the crossing that the move is complete.

At step 7, the crossing runs the completion cycle for the level crossing (booms up with no bells or flashing lights) or prepares for the arrival of a second train.

The above steps describe the case for a single train approaching a crossing. The process for multiple trains with multiple approaches is the same for each. Based on authorised arrival times, the level crossing infrastructure systems can itself determine the need to apply required holding sections, enforce minimum boom up times (by not accepting offers which would contravene such requirement, or delaying acceptance till a time when no contravention occurs) and other functions, and apply those requirements unilaterally. This is the further functionality beyond the actual time based authority.

5.2 What can go wrong?

Clearly this way of working pushes responsibility for enforcement of many functions squarely onto the train.

Train location detection is a topic beyond the scope of this paper. Passive tag technology combined with odometry can provide the basis for train-board location detection systems with accuracy sufficient for level crossing operation utilising the methods described. Train speed is known by the train due to its on-board systems.

CBTC and ETCS level 3 both require this level of on-board functionality and support enforcement.

Tolerances in these systems need to be taken into account when ensuring that arrival time is not prior to authorised arrival time.

There is no requirement for continuous communications in this system of level crossing operation. One successful exchange is sufficient to establish the authority to cross. Whilst successive cycles can improve the prediction of arrival time, these are not essential for safety. The maximum costs of poor communications are:

- Long warning times at crossings (situation normal); or
- Train does not obtain authority until braking has commenced (with complete loss of communications, the train is brought to a stand at the crossing).

Train enforcement is another topic beyond the scope of this paper. Clearly the ability of trains to enforce the time based authorities that have been agreed to (another train borne system requirement) is key to the functionalities described. ETCS standard functionality (enforcement of speed restrictions) has already taken these systems beyond the realm of providing "simple smart trainstops". The technology for time based authorities as described should not be insurmountable.

"Protection Systems" is also a topic beyond the scope of this paper. In the area of level crossings, the following features become possible:

- Level crossing "commencement of warning" can be communicated to the train together with other "state of health" information. This provides the possibility for the train to provide supplementary warning (eg blow horn) if minimum level crossing warning is not confirmed.
- Level crossing approach time (actual) can be measured by the train and logged. This information then becomes available for maintenance purposes.

One can always construct a scenario where a semi-trailer takes out the level crossing control cabinet after the train has obtained its authority to cross but before the crossing has commenced its warning. With no control cabinet the level crossing flashing lights will not operate, though the boom barriers (those not taken out by the semi-trailer) may lower to position. The outcome from such an event is similar for all automatic level crossing protection technologies. The difference with time based authority systems compared to earlier technologies is that if the semi-trailer arrives collides with the location case prior to the authority to cross being given, the train will stop at the crossing and not cross at speed if the crossing equipment is not functional.

The benefit of this improvement in safety should not be under-estimated.

Level crossing monitoring requirements with current technologies can be quite onerous on infrastructure providers. Leaving aside the scenario with the semi-trailer, there are numerous faults which can occur at level crossings which can cause level crossing protection equipment not to operate correctly. The possibility of mains power failure followed by batteries draining over the next day drives a regime of level crossing monitoring supported by maintenance response capability which can be significant in remote areas.

With time based authorities, the level crossing is made fail-safe against the failure modes which drive today's remote monitoring regimes. With the safety case link between remote monitoring and maintenance response time removed, the way can be opened to alternate cost-effective methods of monitoring driven by conventional reliability and availability goals.

Stopping a train at a defective level crossing may provide a safety benefit, but it is also an operational cost which should drive a need for level crossing warning equipment to stay reliable.

6 CONCLUSION

It is common for new technologies, when first introduced, to simply replicate the functions step by step of the technologies they replace. The first locomotives were iron horses, the first cars were horseless carriages. In both cases it took time to look beyond the capabilities of the horse and apply the new technology to its full potential, taking transport in the new directions which underpin the modern world.

Today's new technologies are no different in that respect.

In today's signalling can be found countless examples of modern communication based technologies and smart trains being applied to replicate what are recognisably the components of a fixed signalling system. Even in the naming of things we refer to "moving block" and "virtual block" in situations where probably there is no "block" involved at all.

The time based movement authority is an example of a facility not found in traditional fixed signalling systems, but can be provided by systems employing modern technologies. Two simple examples have been selected to illustrate the benefits available to those who look beyond.

Time based authorities can be used to solve a problem in the new tunnel between Honshu and Hokkaido and also to provide fail safe automatic level crossings (something very rare in today's technology) without a need for infrastructure based train detection (ie no track circuits or axle counters). But this is the tip of an iceberg.

As we celebrate the centenary of WW1 events, we can recognise where the new technologies were deployed using the old tactics. That was the battle at Somme. It took a couple of years beyond that for people such as Sir John Monash to put the new technologies together in new ways to produce the foundations of modern combined arms tactics. That was the battle at Hamel. From this distance we can recognise the difference.

7 REFERENCES

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AUTHOR

Peter Burns

Peter Graduated in Applied Science (Electronics) from Melbourne University in 1981.

He commenced as Professional Engineer with Victorian Railways that year in Signal Design., then progressed through various roles in Signal Design, Test and Development, Maintenance Management. He completed his MBA at Monash University in 1991.

Peter left PTC in 1994 to work for companies such as Alstom and Bombardier in places such as Sydney, Melbourne and Copenhagen.

In 2003, he joined with 2 colleagues to form *Rail Networks*, providing assistance over a number of years to Government as well as to Connex, the then franchisee for the Melbourne rail network.

Peter is currently director of the small consultancy firm "*PYB Consulting*" and as Chartered Engineer fills wide and various roles in rail organisations when they seek assistance. Recent projects have included RRLCMR and Signal Advisor to teams bidding and delivery of various Melbourne Grade Separation projects including the Burke/North/McKinnon/Centre Rd project.

Figures section 1: Trackforce protection

Figure 1a: Trackforce protection layout

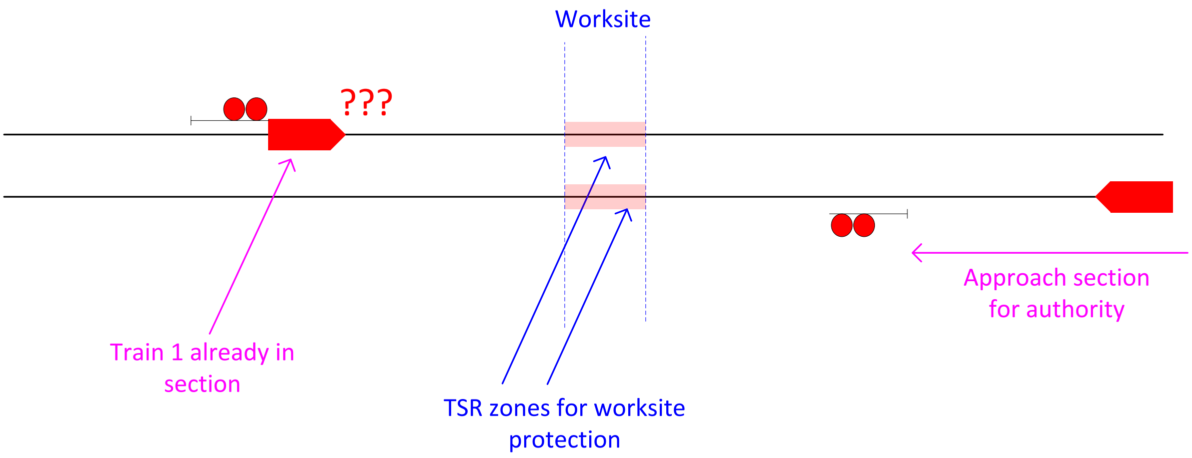
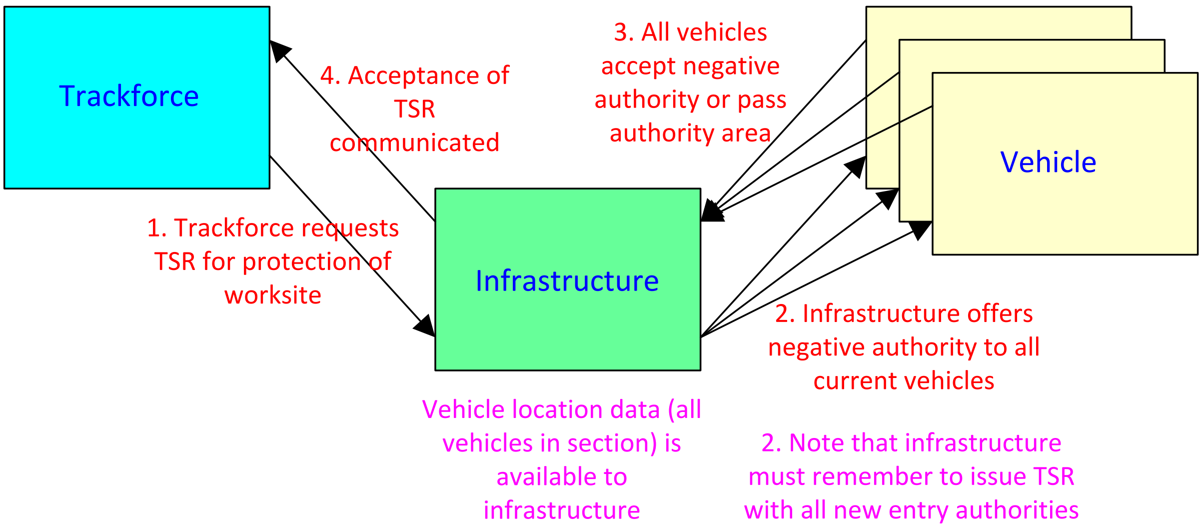


Figure 1b Trackforce protection process



Figures section 2: Tunnel Train Passing Temporary Speed Restriction

Figure 2a: Tunnel TSR layout (concept)

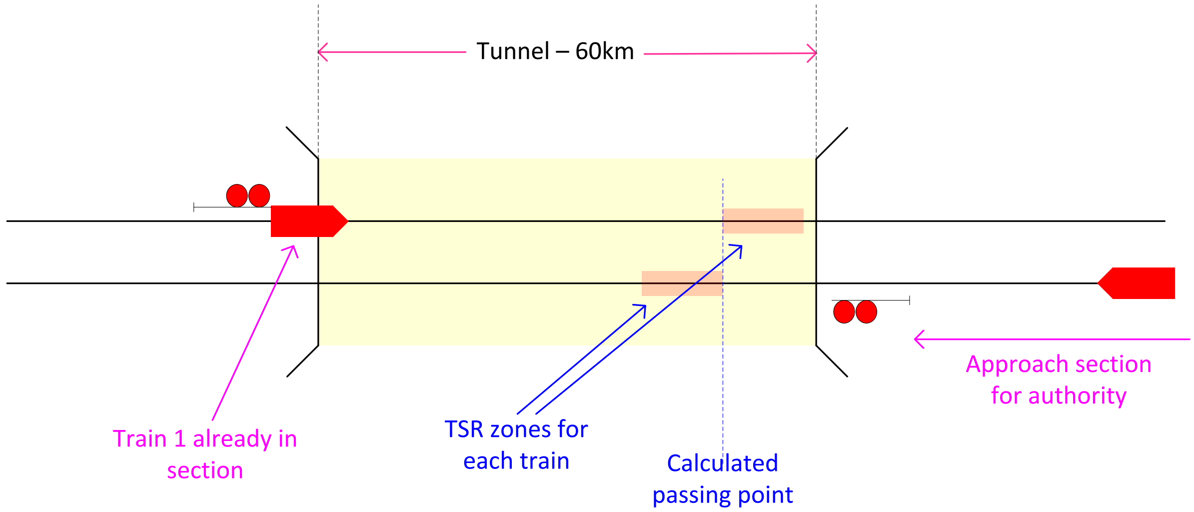


Figure 2b: Tunnel TSR authority process

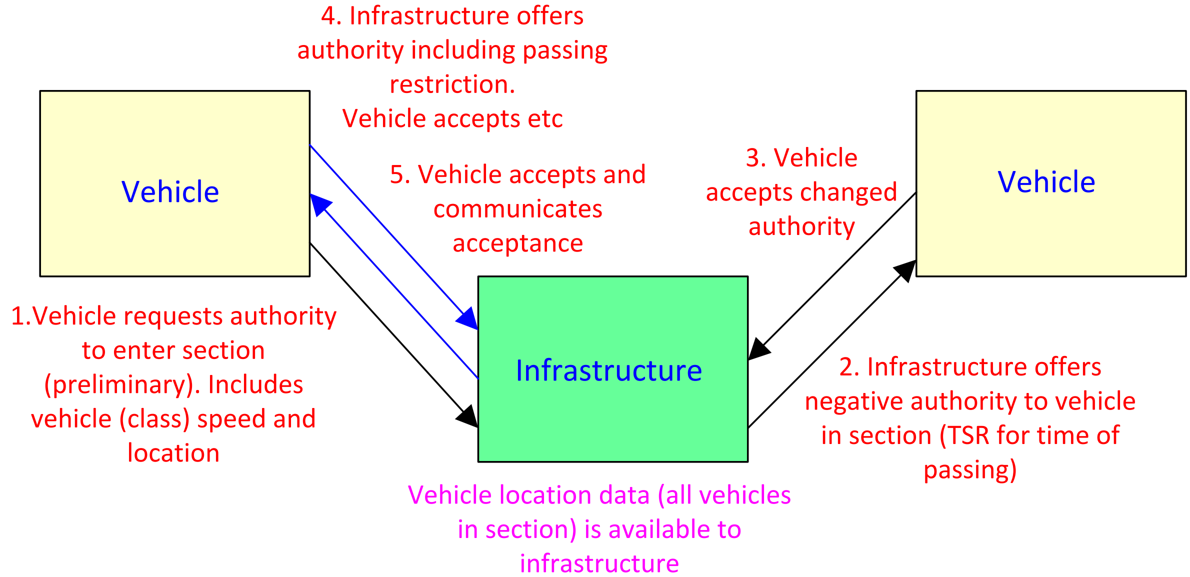


Figure 2c: Tunnel with location based authority (one train slow)

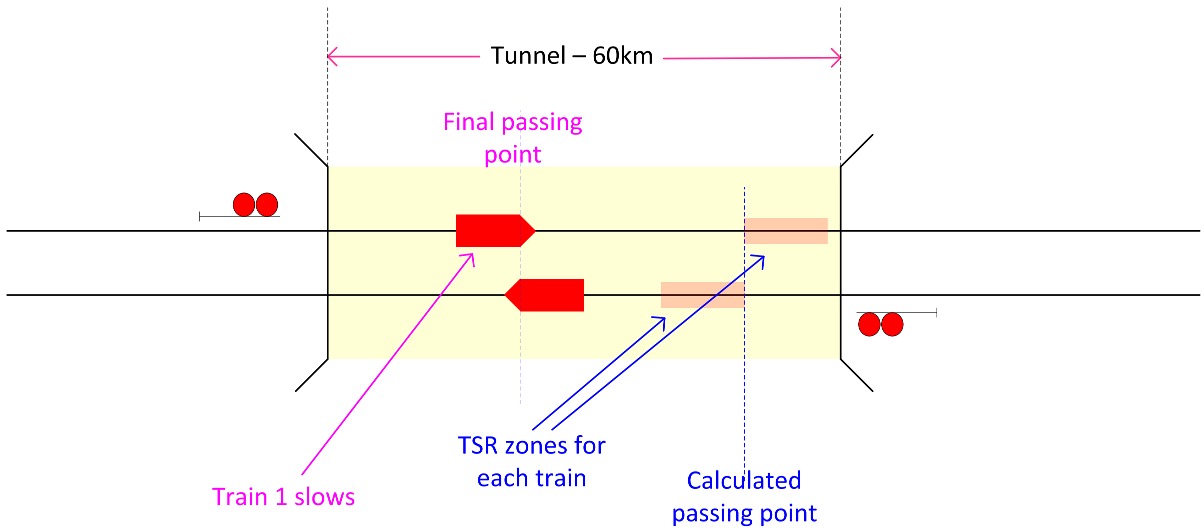


Figure 2d: Tunnel with time based authority (one train slow)

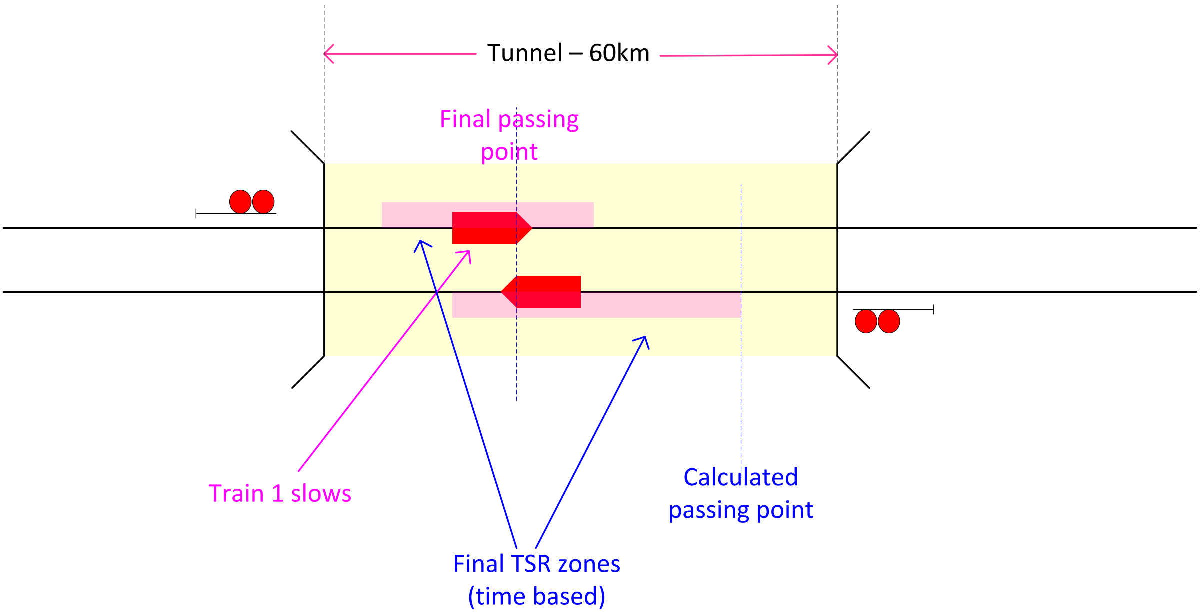
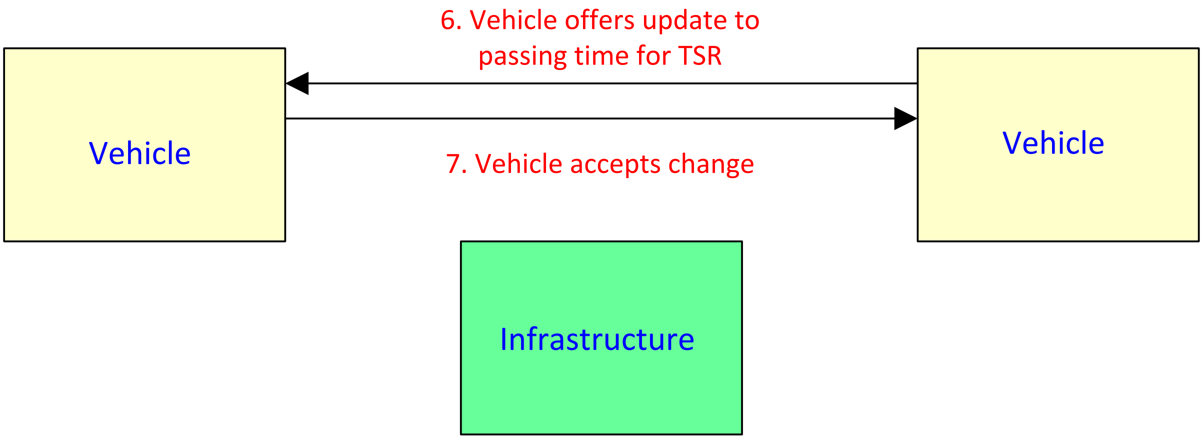


Figure 2e: Tunnel authority updates



Figures section 3: Level Crossing time based authority

Figure 3a: Level Crossing with time based authority (start)

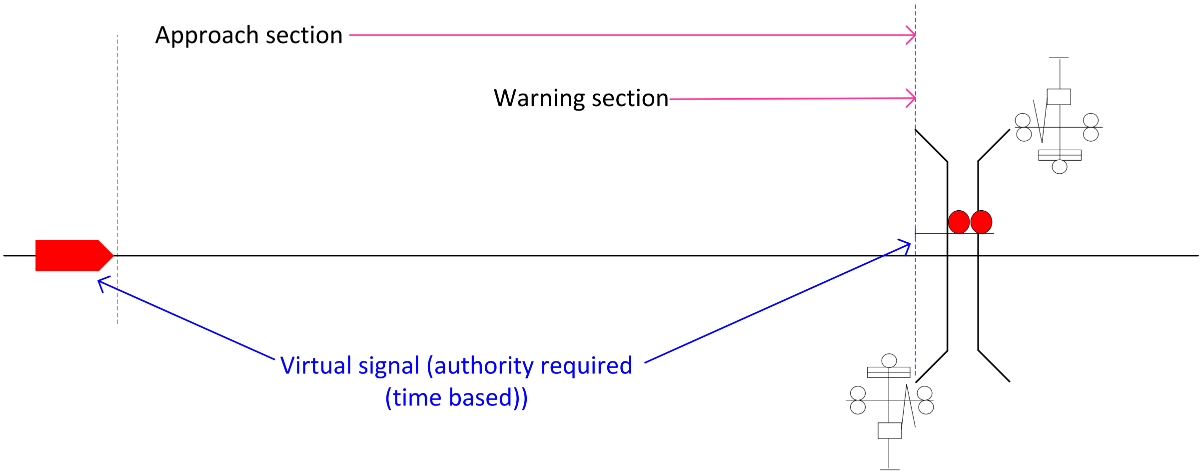


Figure 3b: Level crossing authorities

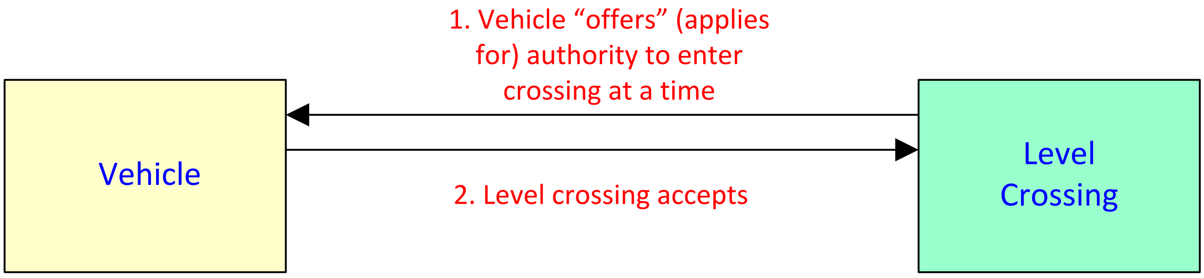


Figure 3c: Level Crossing with time based authority (warning commence)

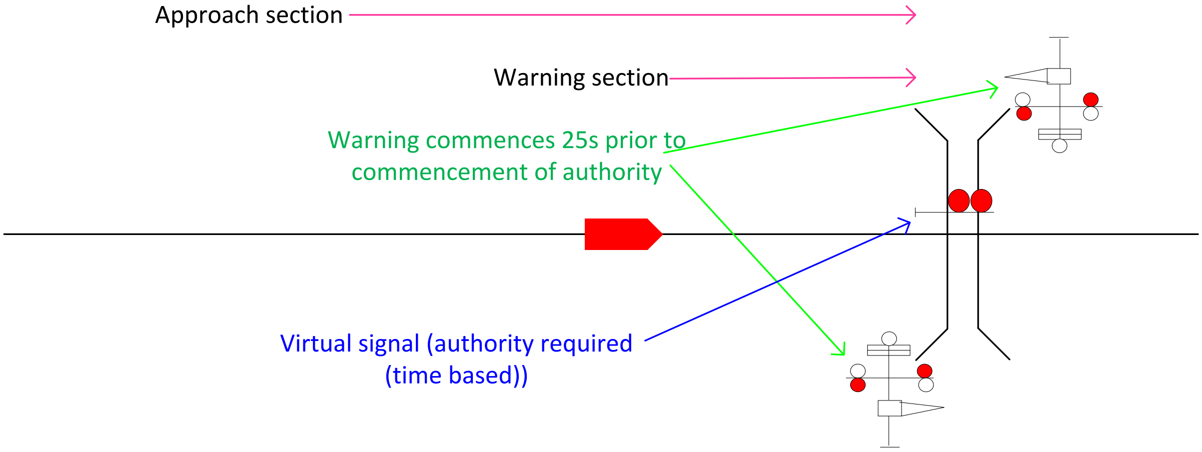
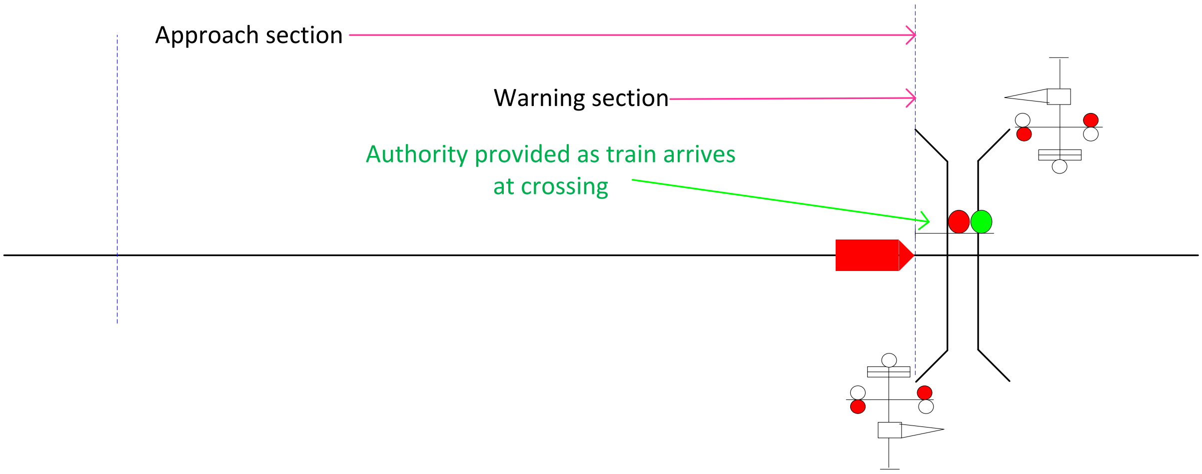


Figure 3d: Level Crossing with time based authority (train accepts authority)



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