# IRSE INTERNATIONAL TECHNICAL COMMITTEE

## Level 3 : From High Speed Vision To Rural Implementation

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# Introduction

This article is part of a series of articles by the IRSE-ITC on the subject of „what is preventing ERTMS level 3 from entering into service".

ERTMS/ETCS (hereafter called "ETCS") is a train control system designed to replace all existing national systems on the Trans European Rail Network. It enables trains equipped with on-board units from different suppliers to operate freely over track equipped by the same/different suppliers. It consists of both on-board and trackside subsystems. ERTMS is specified to allow implementation in three functional and performance levels. The levels range from a "conventional" but interoperable ATP system using spot transmission (Level 1), a level adding continuous communication via radio, allowing to increase line performance and the elimination of wayside signals (Level 2) and a level replacing wayside train detection with on-board localisation, allowing to eliminate much of the trackside train detection equipment (Level 3).

Whilst levels 1 and 2 have been developed and are in operation, for main line railways, level 3 exists only on the drawing board. For main line railways, level 3 promises significant benefits for the Infrastructure owners, but adds extra systems and complexity to the train-borne equipment. On top of that some difficult technical issues remain unsolved, limiting the potential field of application.

A trial of ERTMS Regional is being implemented on the Västerdalsbanan (Repbäcken – Malung) in Sweden and is about to enter into service, extending ERTMS applications to Regional Lines.

### Short description of level 3

ERTMS Level 3 is characterised by the fact that a train in level 3 determines its own location, using position references transmitted by fixed Eurobalises and its on-board odometry. It transmits this location data to the radio Block Centre, which issues movement authorities to the trains under its control.

# Strengths and Weaknesses

### Railway Undertakings

For a railway undertaking or infrastructure operator, level 3 is attractive because it dispenses with the requirement for trackside train detection equipment. This not only saves investment and Maintenance costs, but also reduced the exposure of staff to working in or near the tracks, which reduces Health and Safety risks.
Of course this can only be accomplished if the robustness of the systems and the maturity of the ERTMS implementations allows deployment of Level 3 without the use of fallback systems.

Train Operators

Train operators are unlikely to see direct benefits of investing in Level 3 train-borne equipment rather than L2. In fact a solution to the issue of train integrity proving (refer to other article in this series) is likely to require additional equipment to be installed on some, mostly locomotive hauled, trains.

An indirect benefit of Level 3 might be the availability of additional train paths and/ or reduced cost of such paths, if Infrastructure access charges were to become subject to the laws of supply and demand.

On the other hand operators are likely to have further requirements for functions to be delivered by future train-control systems that are not within the scope of the present ERTMS product set. Such requirements might include train service regulation (conflict and delay detection and resolution), energy optimisation driving support, automatic train operation (ATO).

Security issues

Recently, virtually every railway around the world has been confronted a dramatic rise in the occurrence of copper and cable theft. In some cases this has led to a wrong-side failure and where return conductors are removed, electrocution is a possible hazard as well. It might be argued that ETCS level 3 mitigates these risks, to an extent (on an electrified railway obviously return conductors will still be required). On the other hand, as a centralised, communications base IT system, ETCS level 3 will inherently require more protection against cyber attacks, jamming etc. These IT related hazards have traditionally not been taken into account in the design of railway signalling systems and it remains to be seen whether or not the level of protection offered by the Euroradio links over GSM-R and the networked RBCs will prove to be adequate.

Does Level 3 deliver more capacity than L2?

Most protagonists of Level 3 claim capacity benefits over and above those delivered by level 2 of up to 10%-20%. However, some doubt this, as level 2 when implemented as a high performance block system, possibly using virtual intermediate block signals to improve train spacing, seems to be able to deliver the same performance levels, although at much higher equipment cost. In addition these studies usually compare theoretical headway calculations in isolation, where in reality net work capacity is determined by many other factors such as station layout, and platform capacity, timetabling constraints dictated by fleet and commercial constraints etc. It might be significant that CBTC systems delivering traffic densities of around 24 trains/hour on a given track are usually found only in rapid transit applications. They benefit from uniform train performance characteristics and uniform timetables/diagramming in those types of railways.

Cost

Some studies estimate the capital savings on infrastructure equipment for ETCS level 3 to be in the order of 25% as compared to level 2 and even up to 50%or 60% when compared with a multi aspect signal block system (TRL report chapter 4.3, based on Network rail's SEU cost model)). This of course would be offset by an cost increase in the required communication systems on board, train integrity proving systems etc.

Other benefits

Once the closed loop control system that is inherent to level 3 is in place, other options emerge, such as tighter network control, conflict detection and resolution, energy optimised driving leading to "even greener" mobility. However none of these functionalities are part of the ERTMS/ETCS specifications (in fact the "M" in ERTMS

seems to have been “lost in space” during the development), increasing the risk of non-interoperable bespoke implementations emerging.

Engineering Flexibility
The design and engineering for pure ETCS Level 3 line does not need to take into consideration all aspects of signal sighting, block length based on train / train category braking characteristics etc. And should therefore be more cost effective and flexible, e.g with regard to changes in timetabling, train fleets etc. On the other hand the pre-requisite of course is that all trains are equipped and/or special provision be made for the movement of non-equipped trains, maintenance vehicles.

Vehicle admission
Whilst on the one hand and at present, the requirement to fit all vehicles with an EVC capable of ETCS L3 functionality seems to be an obstacle and cost disbenefit. On the other hand, vehicle route acceptance will no longer be complicated by complex EMC and shunting compatibility issues, or other detection system induced restrictions, shunt assistors and / or complex traction current filters would be needed. Of course in practical terms, such benefits can be reaped much earlier and realistically in „closed environments” such as mass transit railways and may never be obtainable on a larger network where the network wide roll out may not likely to be achievable.

Possession management
In ETCS level 3 trains become virtual self locating and reporting objects and this property can be used to extend the same level of protection from „conflicting movements” to entities such as track gangs, maintenance plant etc. This makes possession management simpler and inherently safer, examples of this have been implemented on the Betuweline using Hand Held Terminals. In fact this feature is applicable to level 2 as well, because the only requirement is to have a centralised Movement Authority (MA) issuing system, I.e. The Radio Block Centre (RBC) and can in fact be overlaid on all signalling systems that employ an „interlocking machine” capable of communicating with an RBC.

Resilience
An inherent benefit of a Level 3 system would be enhanced resilience and faster recovery from disturbed situations. As trains can move closer together as they approach a pinch point in the network, or a location where e.g. a points failure exists. Likewise resuming speed and recovering normal operating conditions could benefit from this “harmonica effect”. Of course the absence of many track-circuits at least in non-point areas will itself lead to fewer equipment failures and delay minutes. This may o the other hand be offset by a higher dependence on communication systems and the potential for very dramatic and disruptive failures if the communications were lost entirely. Providing redundancy and fallback systems to address these issues will of course detract from the predicted cost savings.

# Unsolved Issues

Train Integrity Proving
The issue of train Integrity proving does not have a generic solution yet, making Level 3 an option available only in such cases where a solution exists and or the risk would be deemed acceptable (trainsets, fixed formation fakes, rural lines). For trainsets, loco-hauled passenger trains and fixed formation trains a practicable solution seems feasible,

but for freight trains made up of individual cars, a solution that is affordable, practical and logistically manageable does not exist.

### Radio Bearer Service

The near total dependence on radio if Level 3 is ever to become a reality must raise questions re the capacity of radio networks to cope with the volume of data to be exchanged on a typical busy main line or suburban area. It is doubtful whether GSM-R would be able to handle the traffic and therefore L3 may be dependent on having a new radio standard in place. The so called LTE (Long Term Evolution) system as advocated at the Indian Convention thus missing out the 3G standard, may become a pre-requisite for L3.

### ERTMS Regional

ERTMS Regional is a development of Trafficverket, the Swedish infrastructure operator, Bombardier and the UIC. It is aimed at providing a signalling and control system for (very)lightly used regional lines, which account for 21% (2116 km) of the Swedish network and builds on the principles employed in an earlier version of the Swedish Radio block system, based on Sweden's ATC2 technology, in operation since 1995. Its aim is to reduce the cost of equipping the line with a signalling system by 50%, which we were told is achieved, albeit on the assumption that the cost of providing GSM-R coverage had already been absorbed by the national requirement to provide full GSM-R coverage on the network. Interestingly, the system is based on an open architecture with the interface specifications owned by Traffickverket.
In short, ERTMS regional is based on a combined interlocking and RBC processor which set routes and issues command to local trackside elements which are connected to object controllers. These object controllers communicate with the IXL/RBC computer either over GSM-R (using GPRS), cable of in the trial even an ADSL internet connection. Interestingly the ERTMS part of the specification is unchanged ERTMS level 3 with fixed blocks, based on Class 1 specification (baseline 2.3.0d), so trains equipped for running on ERTMS regional lines have no problem continuing onto the main line, or into main stations equipped to „standard" ERTMS level 1 or level 2.
Since the lines are so lightly used (typically in the pilot line 8 passenger trains and 8 freight trains per day) and the passenger trains are single car DMUs anyway, the risk of train separation is accepted, so the unsolved problem of train integrity proving is left for another day.
Level crossings on stations are controlled trough the object controllers, on the open line there autonomous level crossing installations can be left as is, but there is an option to control them using the functions to be integrated in ERTMS baseline 3. In short a brake curve is established to any level crossing controlled by ERTMS, the strike in point is marked by a balise, the train reports being in the strike in zone and waits for confirmation of the level crossing's closure before extending the movement authority beyond it.
The ITC was pleased to be taken on a demonstration run of the system between Repbäcken and Mosbjäck and observe its functioning first hand. In fact this turned out to be the final night of formal testing in shadow mode, before a commissioning decision was to be taken.

## Conclusion

Whether or not Level 3 really delivers benefits other than savings on train detection and OH&S hazard reduction remains to be seen. The proof of the pudding is in the eating, but

for main line railways, the chef is still hiding in the kitchen. Early implementations such as ERTMS regional certainly provide an interesting appetiser!