IRSE INTERNATIONAL TECHNICAL COMMITTEE

Train Integrity, making ETCS L3 happen

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While ETCS L1 and L2 projects are actually being realized all over Europe and the world, many infrastructure managers stick to the vision of ETCS L3 as the ultimate solution of an interoperable train control system.

With ETCS L3 the trackside signaling infrastructure can further be reduced. With trains determining and forwarding their position and integrity by themselves, conventional train detection systems like track circuits and axle counters would become obsolete. Infrastructure managers could get rid of the trackside train detection systems which today are causing a significant maintenance effort and account for up to 50% of the disturbances and failures of the signaling system.

In such a railway system infrastructure managers who are today relying on track circuits for broken rail detection would need to introduce alternative procedures and equipment to monitor the condition of the rails.

The absence of trackside train detection systems shifts more responsibility for the safe operation of the railway from the infrastructure managers to the railway undertakings. The latter have to make sure by means of vital technical onboard equipment and safe operational procedures that their trains remain complete throughout the whole journey. Any left alone or lost vehicle would result in a non detectable obstacle on the track endangering the safe journey of other trains. Like the trackside train detection systems, onboard train integrity monitoring systems need to comply with the highest safety integrity levels. On high speed trains and lines operated with short headways these systems require high performance in terms of detection of any loss of train integrity or system failure which has to be notified to the trackside control center within seconds.

At present only few activities on the train integrity topic are visible in the profession of signal engineers. Industry is focusing on the finalization of the ETCS SRS 3.0.0 which shall close important open issues of the present deployed versions like harmonised braking curve calculation, handling of level crossings and others. These functionalities are needed on the corridors of the Trans European Network (TEN) which are actually being equipped with ETCS L1 and L2 systems all over Europe.

The vision of ETCS L3 is actually pursued within the UIC ERTMS Regional project and a pilot application on a Swedish regional line. ERTMS Regional is however not addressing the aspect of onboard train integrity monitoring systems. The pilot project relies on established trackside train detection equipment and operational procedures i.e. staff checking the train integrity which is considered to be sufficient for regional lines with low traffic only.

In October 2000 the Train Integrity Monitoring System Working Group (TIMS WG) of the former EEIG ERTMS Users Group finalized their work on the TIMS Functional Requirement Specification (FRS).

A look at the patent applications in this field shows a peak in the years 1999 to 2001 but only few applications in recent years.

The technical solutions for train integrity heavily depend on whether the trains have an overall electrical infrastructure or whether the air brake pipe is the only link between the vehicles besides the mechanical couplings.

Modern passenger trains are equipped with bus systems used for traction and vehicle control functions, traditional mainline trains are using the UIC cable which has cores that can be used to implement a train bus system. On these trains a TIMS system can be implemented with reasonable engineering effort, the main challenge is the high safety requirements of this function compared to the non vital train control functions. In some countries passenger and freight trains are equipped with automatic couplings or EP brake systems. The electrical infrastructure of these systems could also be used as the backbone of a TIMS system.

The ultimate challenge for monitoring train integrity is with freight trains that have no electrical infrastructure along the train. This is the field which most of the patent applications on the matter are focusing on. An analysis of these patents shows different solutions which can be classified into three classes.

1) Systems relying on an end of train device

- Detection of the train head and tail position by means of satellite positioning systems. The position of the train end device is transmitted by radio to the evaluation unit installed on the leading vehicle. Due to the non continuous coverage by satellite signals through shading caused by buildings, topography and tunnels a satellite based system needs to be complemented by a second, diverse system.
- Radio devices at head and tail of the train, evaluation of the signal transmission time on the leading car.
- Detection of brake air pipe pressure reduction on the last vehicle and radio transmission of the status to the evaluation unit on the leading vehicle.
- Train end device feeding acoustic waves into the brake air pipe which are evaluated on the leading vehicle.

2) Systems needing no train end device

- Ultrasonic signals fed into the rail across the wheels of the leading vehicle, detection of spacing and number of wheels by evaluation of the reflections provided by the wheels of the subsequent cars.
- Monitoring of several parameters of the air brake pipe on the leading vehicle like pressure or volumetric air flow.
- System injecting acoustic signals into the brake air pipe on the leading car and evaluation of the reflections.

3) Systems relying on both trainborne and trackside infrastructure

- Transmitting start and end of train signals to trackside device and back to train
- Comparison of known number of axles on board with number of counted axles trackside

Products relying on end of train devices and GPS are commercially available today and are used as part of an onboard signaling system on freight railways running mostly in dark territory i.e. areas without trackside signaling infrastructure.

Due to the latency of the pressure reduction in the air brake pipe when a train is separated, systems monitoring the pneumatic brake system may not offer the performance which would be needed on European main lines operated with comparably short headways.

Besides the technical limitations of such systems caused by physical constraints of both satellite coverage and air brake pipe behavior, the need to mount an end of train device is an operational headache. Procedures would have to be established and staff to be provided to ensure that a suitable end of train device is available and mounted on the last car whenever a train is composed. Such operational constraints are incompatible with the logistical requirements of high performance railways.

From an operational perspective systems not relying on an end of train device are far more interesting. But these systems have to face even more difficult physical constraints. It is almost impossible to reliably detect brake pipe leakage somewhere along the train with low latency times on the leading vehicle. Tests performed by Deutsche Bahn AG have shown that acoustic waves fed into the air brake pipe are heavily reflected and attenuated the higher the frequency. Practical frequencies would be in the range between 10 and 20 Hz. In this area there are however considerable disturbances caused by the noise of the train movement especially when the brakes are applied.

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Solutions needing trackside infrastructure are economically less interesting since they require similar investments and maintenance efforts as the currently used tracks circuits and axle counters.

The railway undertakings' responsibility for train integrity also has a political and economical dimension. The life cycle cost of a part of the signaling system is shifted from the infrastructure manager to the railway undertaking. While the trackside infrastructure of most railways is subsidized by the public authorities, more and more private railway undertakings appear in the area of passenger and freight transport. The latter have to compete without being subsidized with road and air transportation. Any additional cost is further reducing their competitiveness. In the context of the free access regulations of the TEN, the introduction of an ETCS L3 system in one location could have a considerable economical impact on many railway undertakings operating their fleet on the corridors of the TEN. They would have to upgrade their rolling stock to ETCS L3.

Making ETCS L3 happen is not only dependent on the availability of suitable solutions to the task of onboard train integrity monitoring. Economical and political aspects have to be considered as well. The provision of practical, reliable and vital train integrity monitoring systems seems to be very difficult on trains that have no electrical infrastructure. As a consequence, for the time being, the introduction of ETCS L3 might be limited to dedicated passenger lines or corridors operated with state of the art freight trains that are equipped with a train bus system allowing for train integrity monitoring.