- 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.

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.

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

2 Physical and operational constraints

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.

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.

ZUSAMMENFASSUNG

Zugvollständigkeitskontrolle – eine Voraussetzung für ETCS L3

Die Einführung von ETCS L3 hängt nicht nur davon ab, ob eine passende technische Lösung für die Kontrolle und Anzeige der Zugvollständigkeit zur Verfügung steht. Wirtschaftliche und politische Gesichtspunkte müssen ebenfalls in Betracht gezogen werden. Die Bereitstellung eines praxisgerechten, zuverlässigen und sicheren Systems zur Kontrolle der Zugvollständigkeit scheint für Züge ohne eine elektrische Infrastruktur sehr schwierig zu sein. Dies hat zur Konsequenz, dass die Einführung von ETCS L3 derzeit beschränkt ist auf ausgewählte Personenverkehrsstrecken oder Korridore für Güterzüge, die nach dem Stand der Technik mit einem Bus-System mit der Möglichkeit zur Zugvollständigkeitskontrolle ausgerüstet sind.

The authors

The Institution of Railway Signal Engineers (IRSE), is the professional body for all those engaged in, or associated with, railway signalling, telecommunications and allied professions. Founded in 1912, the Institution aims to advance, for the public benefit, the science and practice of signalling and telecommunications engineering within the industry. It also works to maintain high standards of applicable knowledge and competence amongst the membership.

The IRSE International Technical Committee (ITC) is a forum for development of critical thinking on key technical issues and opportunities within the industry. ITC comprises around twenty senior participants drawn from very diverse national and industry backgrounds, and also benefits from the written input of several extra corresponding members.

ITC communicates with the industry and interested parties through the publication of reports and of technical articles available to the specialist press and published in several languages. While every care is taken to ensure the accuracy of the content of such publications, some topics are by their nature controversial, and the views expressed are necessarily those of the committee and not of the IRSE as an Institution with charitable status, and the user is responsible for any reliance that he may place on such information.