European Train Control System

What ETCS is and how does it actually function

Driver Cabin equipped with ETCS Level 2 Instruments

By Dr. Frank Wingler, December 2012

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WHY ERMS/ETCS?:

In Europe there are 20 different national Signalling and Automatic Train Protection Systems in use, hampering the cross border traffic. In the coming decades the train traffic on the most important magisterial lines should be controlled by the **European Rail Traffic Management System**, **ERMS**. It's most important tool is called "***EUROPEAN TRAIN CONTROL SYSTEM, ETCS"*****,** with the component **GLOBAL SYSTEM FOR MOBILE COMMUNICATION-RAILWAY, GSM-R. ETCS is a CONTROL – DEMAND.**

The European Union is promoting since 1990 actively the development, prototyping and industrialisation of the standardised **ETCS** for achieving interoperability on cross border corridors and opening the procurement markets. **ETCS** should replace the national train protection systems, minimise conflicting situations and increase the safety and the route-capacity. ETCS should help to overcome the incompatibility of the different national train control systems by a uniform **NORM.** A universal concept with 3 so-called application **LEVELS** allows by a stepwise migration process to link the new systems optimally on trackside with the existing broad range of signalling installations. **ETCS** can be deployed in addition to existing national train protection systems.

Under the leadership of the European Commission the European Signalling Industries ***ALCATEL, ALSTOM, ANASALDO, BOMBARDIER, INVENSYS, SIEMENS and THALES*** developed the appropriated technical standards, hard and soft-wares. Leading in GSM-R – the data radio communication technology on basis of common Mobile GSM Network Systems - is ***KAPSCH Carrier Com.***

The European Union made ERMS compulsory for new to build railway lines in Europe. The language of the new European Technology is English.

The main obstacle for the introduction by European Railway Undertakings is the high investments costs and the complexity. The invest costs to retrofit a single locomotive with ERTMS onboard equipment is in the range of 200. to 250.000 Euro. Private train operators are reluctant to invest such huge amount of money, since the old train protection system (LZB, Linienzugebeinflussung) in Germany provides nearly most aspects of ETCS Level 2. Further obstacles are national constraints and concerns of national safety authorities, who see a lot of bugs in the complex software. The economical case for ERTMS is not always given. The deployment in Europe does not run in the expected coordinated and accelerated way with a stable version. Another problem is that things become very fast obsolete.

By the time of the ERTMS World Conference Stockholm April 2012 only 4000 km of the European Network had been managed by ERMS and only 11000 km had been under ETCS installation or in progress. Pioneers are the Spanish ***RENFE*** with 2000 km under ERTMS management and the Italian ***TRENITALIA*** with its new High Speed Network. The small country Luxemburg has already installed ETCS on all of its lines. Austrian ÖBB and Swiss SBB have lines under tests. ERTMS application is tested in Norway. Switzerland and Denmark will become the second European countries with ETCS installed on all of its

main lines. Denmark has already signed an agreement with ***ALSTOM*** and ***THALES,*** latter specified on the track and line equipments.

The Signalling Supply Industries, the Union of Signalling Industries, UNISIG, are canvassing worldwide to make ERTMS a global train control and protection concept and to sell their equipments on the world market hoping a return of investment. China is using modifications of ETCS. The emerging rail networks in Saudi Arabia, which can afford high capital investment, will be managed by ERMS applications. ETRC is interesting for Railways, who build new lines and for Railways, who do not have any **AUTOMATIC TRAIN PROTECTIVE SYSTEM like India and SriLanka.**.

To implement ERMS applications is a costly and thorny exercise. The challenge of the implementation of the new system and the advanced technology is, to recruit and retain enough skilled engineers. The lack of enough skilled and trained engineers is exacerbating the implementation problems.

Mr. David Waboso, the engineering director of London Underground pointed out recently:

"***With the new generation of communication-based-train control a huge amount of equipment is being placed on trains. The more we put on trains, the more there is to go wrong***"

On a Signalling conference in Bad Nauheim, Germany, which I attended last year, it was emphasised, that **COMPLEXITY OF SIGNAL SYSTEMS** make train operation vulnerable to technical failures and human errors. The July 23rd 2011 rear-end-collision at Wenzhou, China, (see **Picture Gallery**) is a shining sample, what might happen as a result of mixed technical and operational shortcomings (human malfunction) in conjunction with the complexity of the CTCS-2, comparable to ETCS Level 1.**The contribution of Human Factor with its Human Error plays mostly an important role,** when it comes to a hazard.

HOW DOES ETCS WORK!:

The line equipment is defined by application levels. The onboard computer, the so-called ***EUROPEAN VITAL COMPUTER, EVC,*** is able to master and command all ETCS application versions. EVC is downwards compatible.

LEVEL 0:

Level 0 is no automatic train protection system in addition to the national Automatic Train Protection System, if there is any.

The locomotive driver commands the train in the conventional way according the Signalling set by the **Movement Authority, MA,** and the Timetable. The train is protected by the given conventional train protection system, as far there is any. So-called yellow colour **EURO-BALISES** (see **Picture Gallery**) are spot transmitters and are installed in regular distance on the track sleepers transmitting into the cap the position and the permissible speed. Balises can distinguish the train direction either by numbering of the specific balise in a balise group or by two adjacent laid balises. **BALISES** are **TRANSPONDERS**, as you find on chips of warehouses to secure wares against thefts. The locomotive or power-car when passing over a Balise provides with its antenna underneath the Balise with energy by a high frequent field; and a small data package of 210 to 830 bits is exchanged with the onboard computer. The Balises transmit local

information and route-parameters as well the track condition-profiles to inform the train driver. The Balises are not connected by any cable directly to the Movement Authority. They are individually programmed either by the manufacturer or direct on way side. Track occupancy for interlocking is monitored in the conventional way by track-circuits or axle-counters.

In Germany, Austria and Spain a **CABLE LOOP** (see **Picture Gallery**) on express lines transmits continuously in addition to the permissible speed the location into the drivers cab, so that the driver can control on a computer display the actual with the given time-tabling, knowing always his exact position. The Cable Loop carries out linear data transmission according to the principle of a track conductor. The Driver stays in contact by GMS-R voice radio with the central control room or so-called **MOVEMENT AUTHORITY, MA**, latter providing the interlocking and the controlling of the signals.

German and Austrian Railways have since 1926 an inductive working automatic Train Protection System commanding the emergency brake system of the locomotive in case the driver over-speeds, disregards a signal aspect or leaves a caution or danger aspect unanswered. German Federal Railways operates the densest GSM-R network in Europe for radio communication between the Loco Driver and the MA. Actually in Germany there is no need for costly ERMS/ETCS except to provide a train protection and control system for international cross border traffic. Systems have been developed to enable foreign railways with ETCS equipment to recognise the German Train Protection System.

LEVEL 1; Limited Control:

Prerequisite is, that the Locomotive, Power-Car or Rail-Car is equipped with an interface controlling speed and brake. The traction unites must have exact working speedometers and must have an automatic train stop device.

Level 1 (see **Pictogram 1**) functions in addition to an already given national Signalling, Track-Occupancy Monitoring, Interlock Systems, Train Control and Automatic Train Protection Systems, if there is any. Its perspective is to over-bridge the national systems for cross border operability. Level 1 replaces national automatic Train Protection Systems with the luxury of additional information's of the line situation ahead, transmitted into the cab. **Level 1 reminds the train driver of the signal aspect ahead.** It can serve also as an Automatic Train Protection System in addition to the local system or in case there is none previously installed, like in Sri Lanka. It functions as a full Automatic Train Protection System.

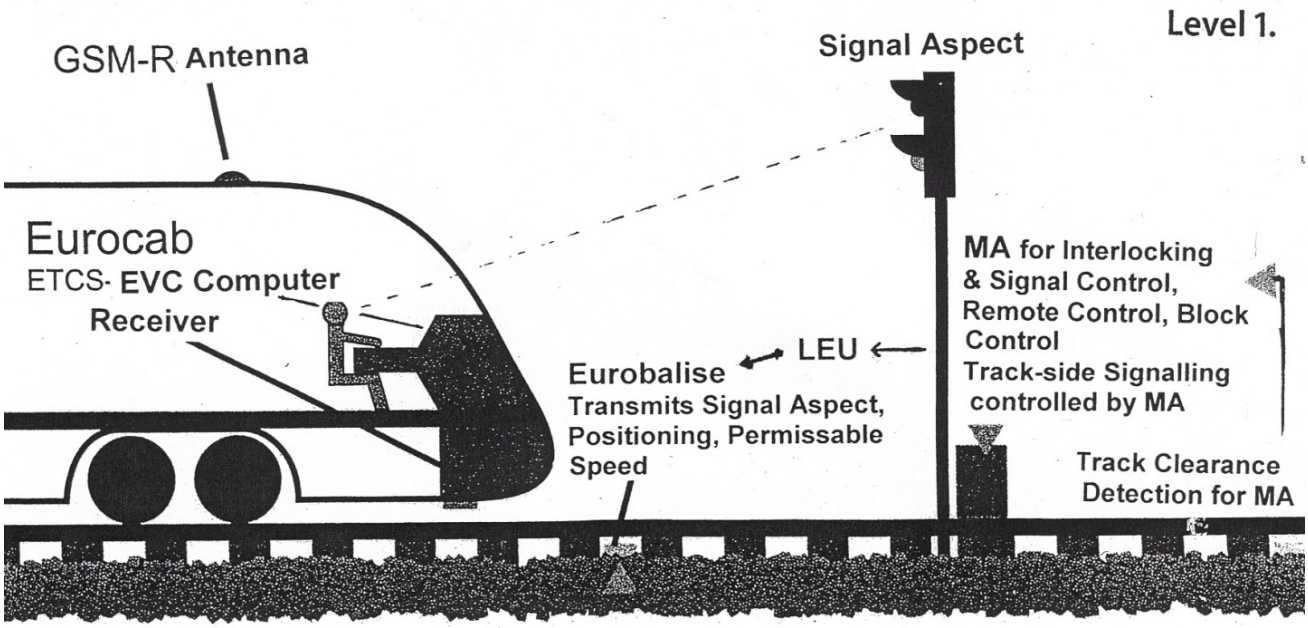
Level 1 secures the Signal Signalling Points by means of the **EUROBALISE (nonlinear)**. The Balises are switchable with data connection with other trackside devices e.g. with signals via a **LINE SIDE ELECTRONIC UNITE, LEU**. The balises transmit the next signal aspect, permissible speed (controlled by the movement authority) into the cab, the Gradient and the Permission/Track Clearance from the Movement Authority. They are connected via **LEU** with the **MOVEMENT AUTHORITY** or Central Control Room. Track-Clearance or Track-Occupancy is detected in conventional way by track-circuits or axle-counters.

At **Level 1** the onboard computer, the **EUROPEAN VITAL COMPUTER, EVC**, knows its position on the track. The MA sets the Signals in the conventional way according the route situation. The MA cares also for the interlocking. There is no direct communication between the Movement Authority (Control Room, Signal Cabin) and the Cab-Computer,

EVC. The Signal gives its information to the **LINE SIDE ELECTRONIC UNITE, LEU.** The LEU switches the Balise. The onboard ECV recognises the Signal Aspect via the **LEU** and the **BALISE**. The **CONTROL LOOP** at **Level 1** is not closed. But the Loco Driver can communicate with the MA by Voice Radio Communication.

Level 1 is a system to upgrade existing railway lines.

The safe rear-end position and safe front-end positions are calculated according speed and train direction in intervals. According German Safety Regulations **Level 1** with nonlinear Eurobalises is only allowed up to 160 kmph, nevertheless in Spain trains run 300 kmph with **Level 1.**



Pictogram 1: ETCS Level 1

LEVEL 2; Unlimited Control:

Trains running on **Level 2** (see **Pictogram 2**) are guided as on **Level 1** by the Movement Authority, responsible for track permission, signalling, interlocking, switch control, block control ect..

Level 2 transmits the Signal Information of the MA direct into the driver`s cab. Wayside Signal Posts are not needed, unless they are needed for redundancy and for trains without ETCS **Level 2**. The cab signal system enables shorter block sections and therefore higher route or line capacity than trackside signalling. The Train Movements are controlled by the MA or Control Room. The link is the **RADIO BLOCK CENTRE, RBC,** connected with the train by Mobile Data Communication GSM-R. RBC is a line-side Electronic Unite. The RBC is connected by cable with the Movement Authority. The Balise transmit the positioning parameters to the cab installed with the **EUROPEAN VITAL COMPUTER, EVC,** which commands the traction/speed and brake control. EVC is an onboard computer system. Via GSM-R and RBC the EVC transmits the train position to the MA.

Level 2 provides a **CLOSED CONTROL LOOP**.

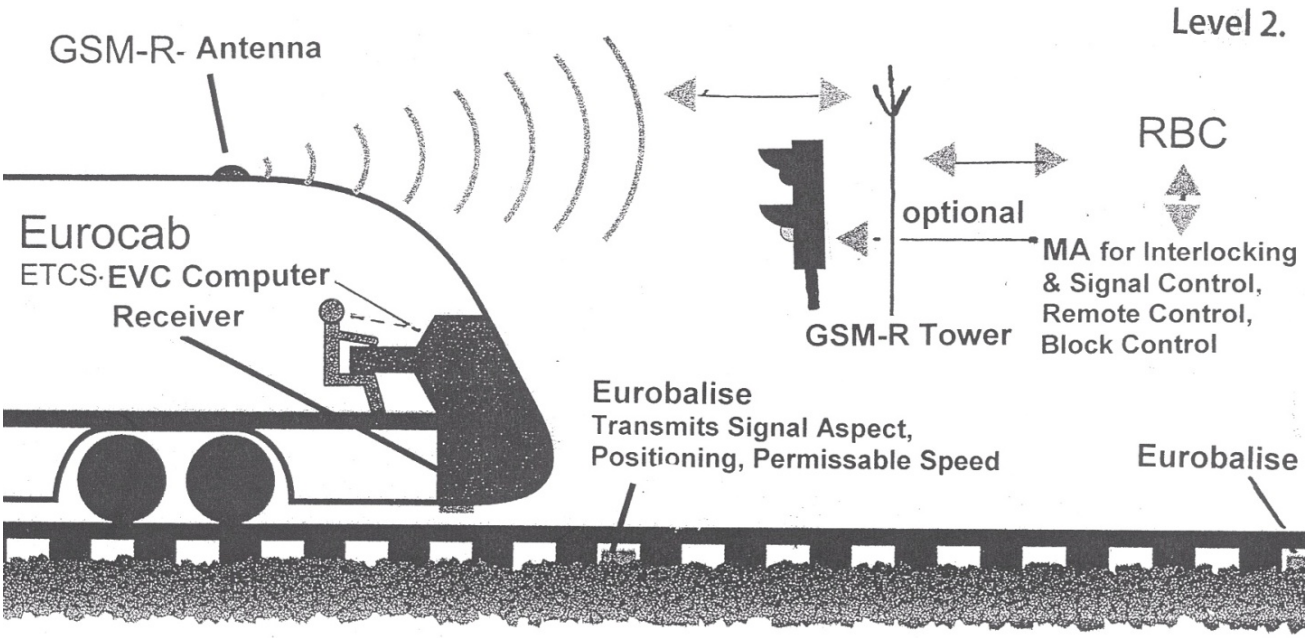
The screen of the EVC displays all vital information to the Train Driver. The EVC interprets and combines all data and information and manage the communication with the RBC and transmits the train position to the MA via the RBC by GMR-S in form of a mobile short message, sms. The EVC can also command the traction and brake system. The EVC is

downwards compatible to **Level 1**. If a train reaches from a non Level 2 track a Level 2 track the system will be automatically activated. On route the moving train enrols itself automatically to the next RBC from one network to the next receiver like a mobile.

The onboard computer master differentiates operational modes as ***LIMITED SUPERVISION, FULL SUPERVISION, 16 SHUNTING MODES, SLEEPING MODE*** (latter for multiple traction) amongst other specific operational modes.

Level 2 demands a dense coverage of GMR-Receivers (Towers) and installed RBS unites, like one expects from a mobile provider. In hilly terrain and mountainous ranges this might become problematic

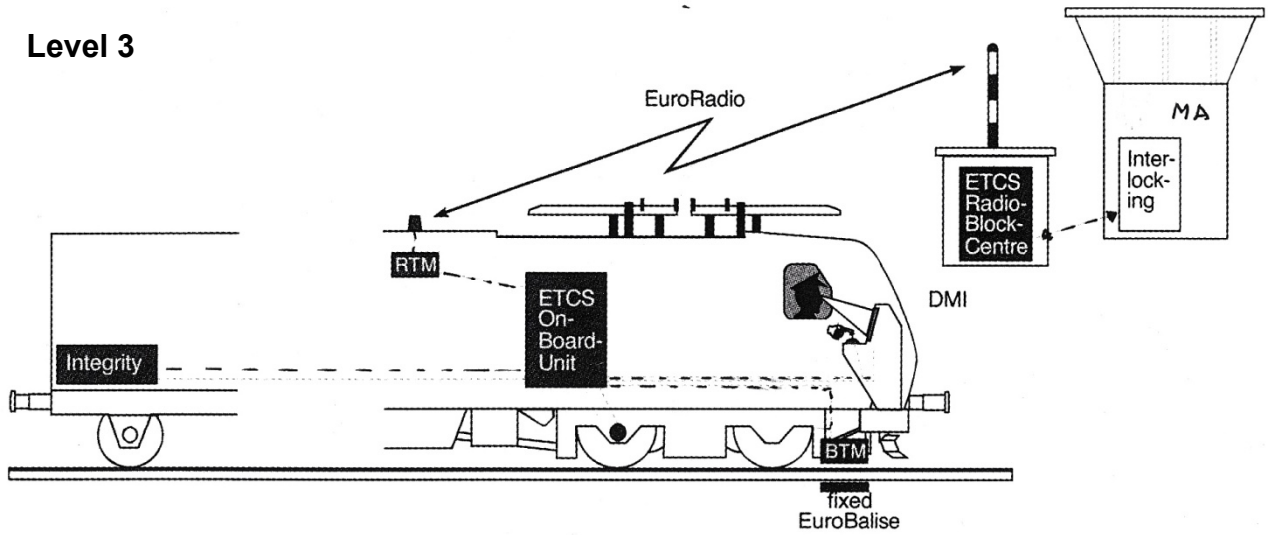
Level 2 is of interest for new to build Railway Systems like in Saudi Arabia, Africa, Australia or Iran.



Pictogram 2: ETCS Level 2

LEVEL 3:

Level 3 is an upgrade of **Level 2**; see **Pictogram 3**. It operates without any line-side Signal Post. On **Level 3** installed tracks only trains ready for this level can run. All trains report continuously via GSM-R/RBC their position and receive by GSM-R their command how to run in correct speed and space to the next train. Trains run in braking distances. Each train defines the clear route behind by his length, speed, and brake power. The solutions for reliable train integrity supervision are highly complex and are hardly suitable for transfer to older models of freight rolling stocks and movement authorities. Therefore **Level 3** is not in focus of the European Railways and Railway Industries.



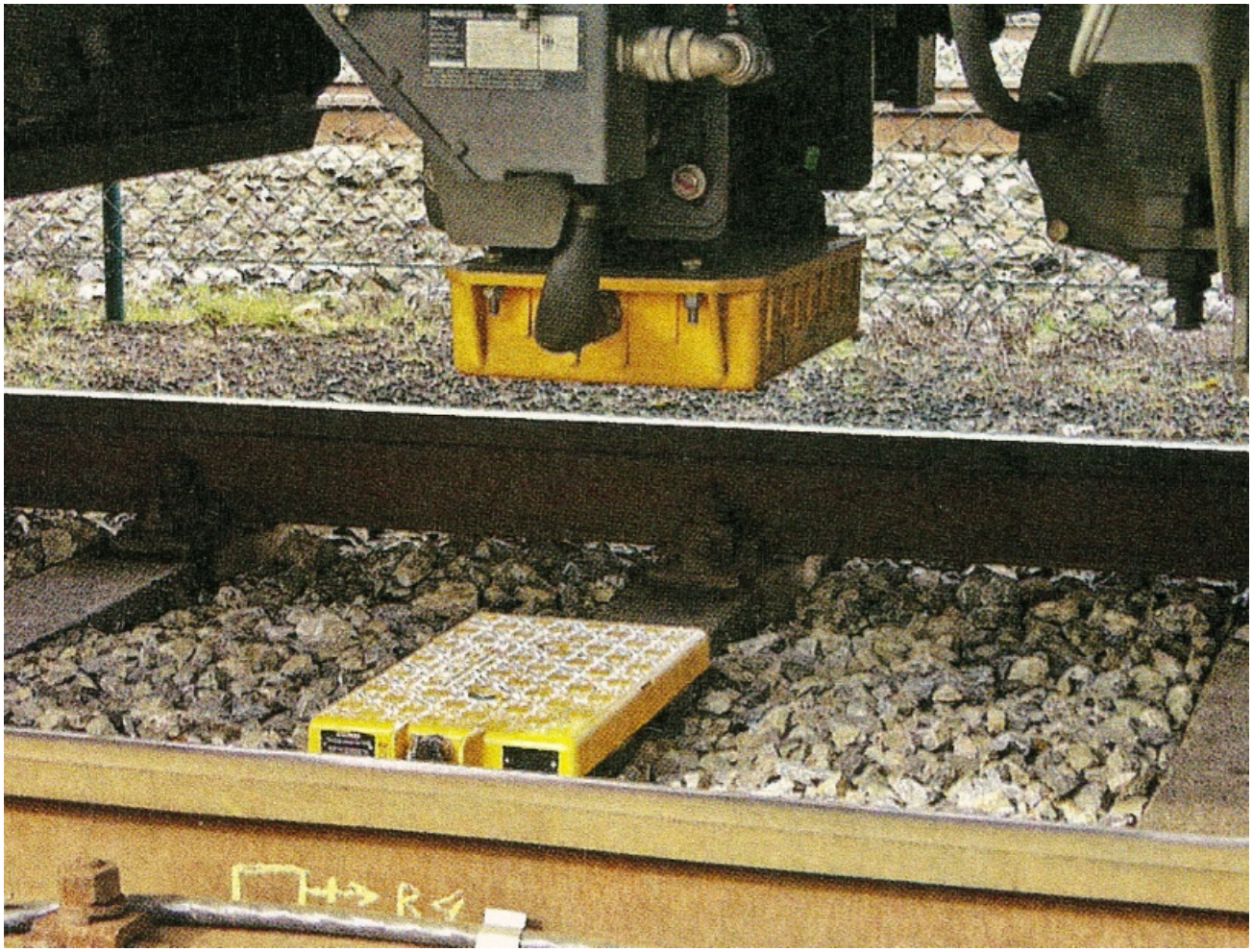
Pictogram 3: ETCS Level 3

Conclusion:

The new technology allows cab-based equipments to replace line-side signals. This gives improved operational performance and better system capacity by redefining the concept of track section. Using continuous position reporting by the train, the section becomes a safe “envelope”, in which each train operates. The “envelope” increases or contracts according to the speed of the train, its braking distance and other characteristics. This provides much more operational flexibility and a closer spacing of trains for higher route-capacity, without compromising safety principles.

The deployment of ERTMS/ ETCS with its high need for capital investment becomes a business case. The question is, if it also cuts costs while improving safety and increasing route capacity. The bottleneck is not only the Investment Costs but also the Engineering Capacity and the Deployment of enough skilled and trained personnel.

PICTURE GALLERY

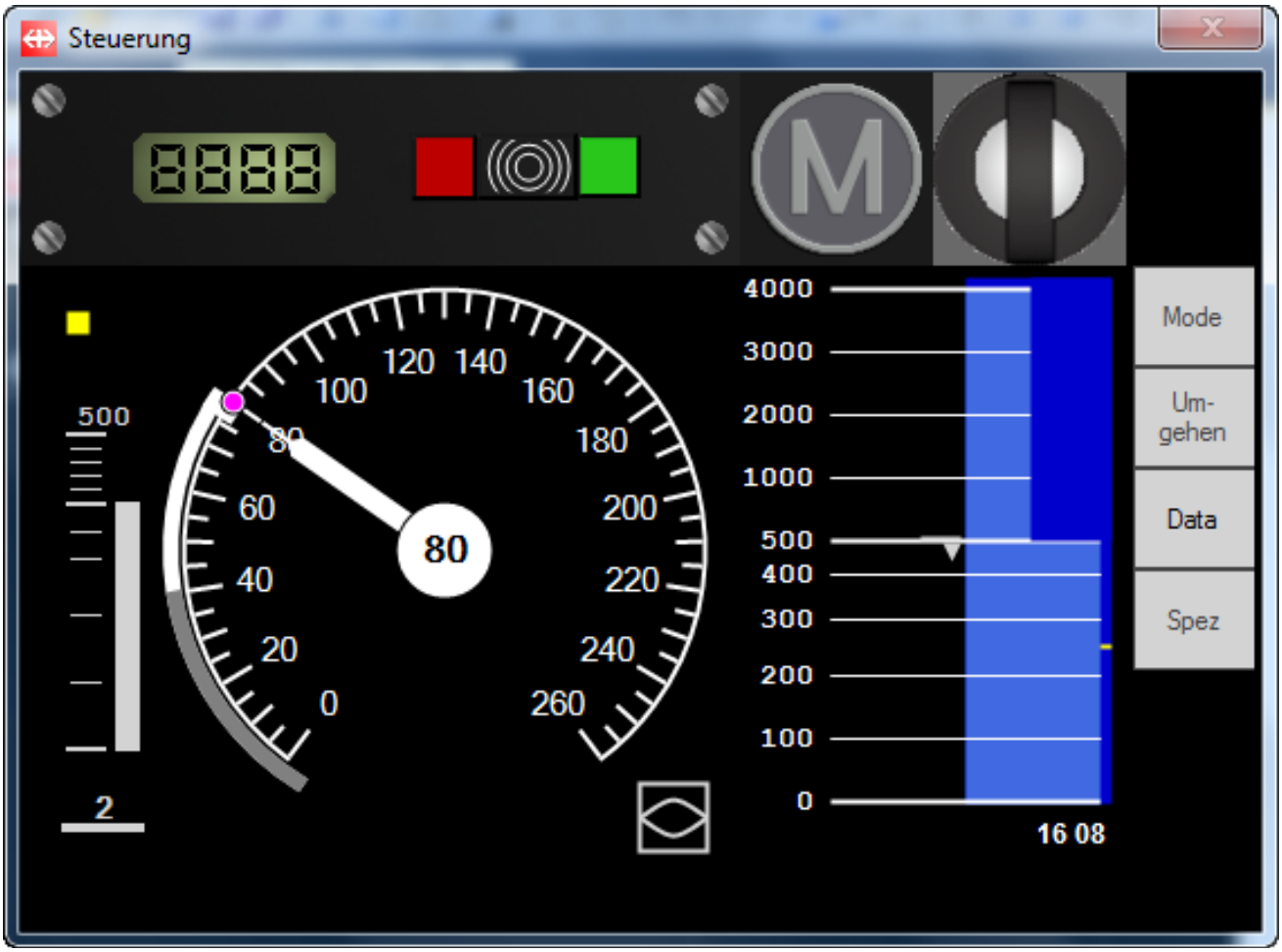


Nonlinear Eurobalise & Receiver

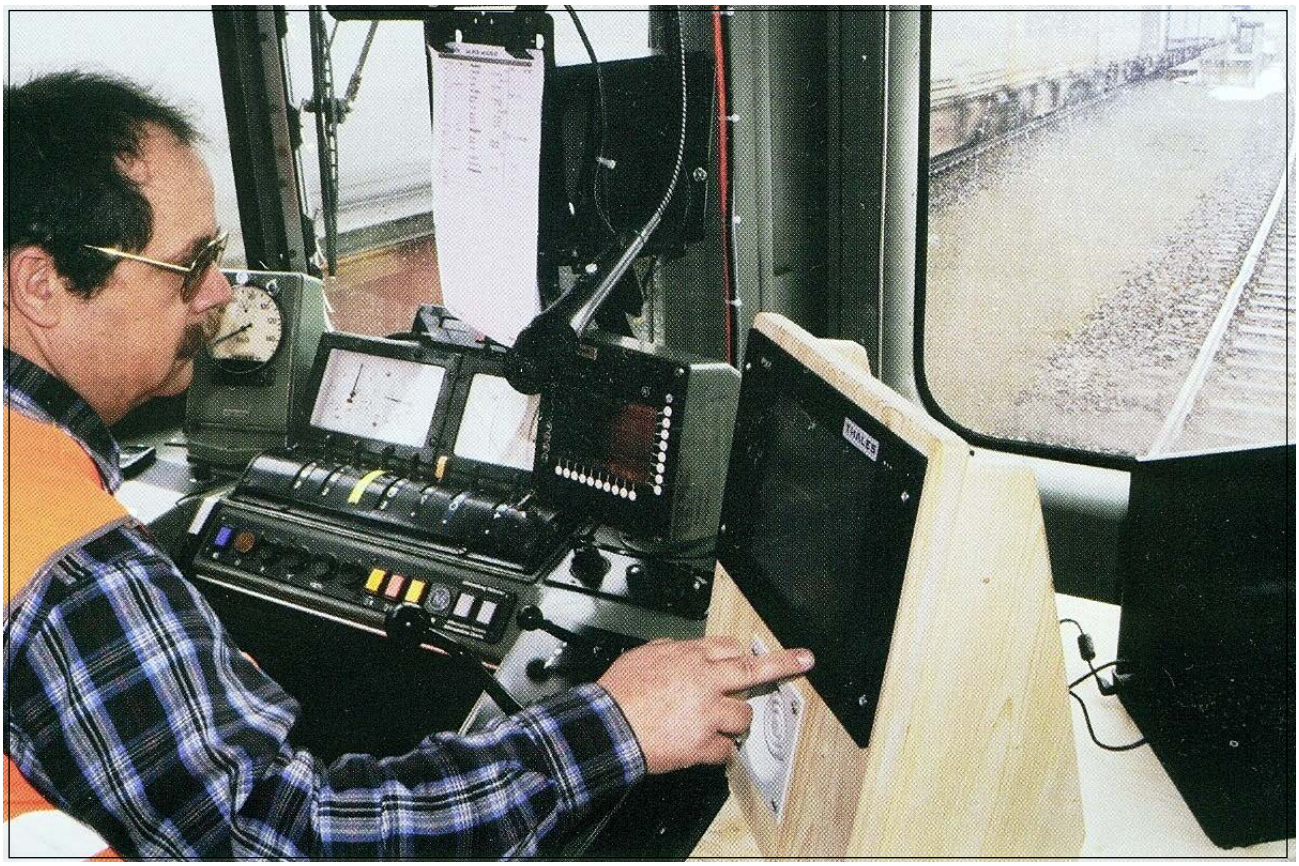
Nonlinear Eurobalise

Linear Cable Loop

GSM-R Tower

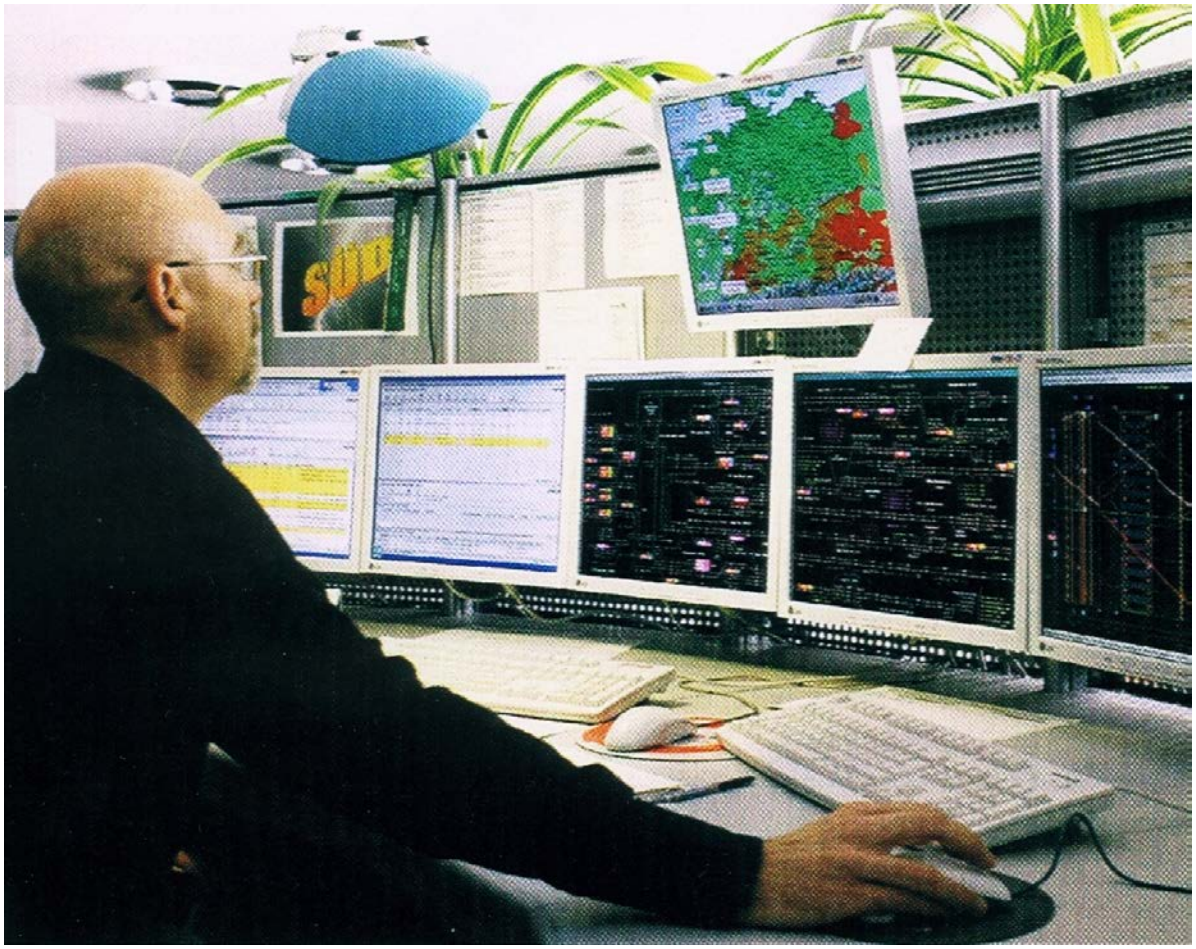


Display of Onboard ETCS- EVC Computer, Level 2



ETCS Level 2 Test in Cabin of a Swiss EMU

Display of ETCS, MA, Control Room



Operator in MA, Control Room

Nothing is "***FAIL SAFE***" in this technical World: The Result of technical Vulnerability with organisational Shortcomings and Human Malfunction; Wenzhou Train Crash, July 23rd**,** 2011, China

Bibliography

Peter Stanly, ***ETCS FOR ENGINEERS***, Eurailpress, DVV Media Group, Hamburg, Germany, published 2011, ISBN: 978-3-7771-0416-4;

Peter Winter, ***EUROPEAN TRAIN CONTROL SYSTEM, ETCS***, 2012 CAETS/ SATW Symposium, August 30th, Zurich, Switzerland.;

Jochen Trinkauf, ***PLANUNG, PROJECTIERUNG und PRÜFUNG von ETCS-STRECKENAUSRÜSTUNG*** in EI, Eisenbahningenieur – International Trade Journal for Rail Transport & Technology, No. 04, April 2012, p.8; Eurailpress, DVV Media, Hamburg, Germany;

David Bringshaw, ***NOW OR NEVER FOR ERTMS IN EUROPE***, in International Railway Journal, Vol. 522, issue 6 June 2012, p.2, ISSN 2161-7376;

Friedhelm Weidelich, ***EUROPEAN TRAIN CONTROL SYSTEM, HOW DOES ETCS ACTUALLY FUNCTION?*** In Eisenbahnkurier, Nr. 484, Januar 2013, p.40, EK-Verlag, Freiburg, Germany, ISSN 0170-5288.