ETCS Level 1 Limited Supervision for a Fast and Cost Effective Migration of Legacy Train Control Systems to ETCS

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What ETCS is

- The “European Train Control System” ETCS supervises train movement in regards to speed and distance travelled, based on information provided by an underlying signalling system.

- ETCS consists of onboard and trackside subsystems performing standardised functions and are communicating via Eurobalise, Euroloop and GSM-R using standardised protocols.

- ETCS provides full cab signalling and can be used either as an overlay onto classical signalling systems with lineside signals or without them.

- The term ERTMS is used when referring to ETCS and GSM-R as one system.

- ETCS has been developed to replace all existing mainline train control systems in Europe.
What ETCS is

- ETCS is fairly complex, as it has to deliver at least the functionality and performance of all systems it shall replace.

- Some requirements have been pushed even higher, e.g. the operating speed to 500 km/h.

- ETCS has to comply with the newest safety standards, and has been designed to achieve SIL 4 (Safety Integrity Level), the highest safety level.

- As a result of all these requirements ETCS is significantly more expensive than most existing legacy systems that only provide basic functionality (e.g. TPWS, Crocodile, TBL).
What ETCS is not

ETCS does not cover the aspects of

- interlocking and
- traffic management

ETCS is also lacking some function found in more advanced systems, especially CBTC systems, such as automatic train operation or remote diagnostics. ETCS will however evolve over the years, and some of these functions are already planned to be included in future baselines.
Goals of ETCS

Goals of users

- Reduction of the number of required systems for cross border traffic
- Simplification of cross border operation (e.g. no change of locomotive at border, operating rules)
- Increase of line capacity
- Increase of safety

Political goals of European Union

- Improving competitiveness of rail transport
- Opening of national networks to outside operators (free access)
- Competition between suppliers
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Introducing ETCS

- Today each country in Europe has between one and three train control systems in use.
- With the introduction of ETCS these systems shall be eliminated to allow seamless operation of trains across Europe.
- A solution has therefore to be found how to introduce ETCS across Europe and how to eliminate existing national systems.
Introducing ERTMS

Today there are at least 18 different train control systems in use in Europe:

- Ebicab 700
- Ebicab 900
- AWS, TPWS, TBL
- ZUB 123
- ATB-EG, ATB-NG, TBL
- Indusi (IATC), LZB, GNT
- TBL, Crocodile
- Indusi, also in RO, HR, YU, SI
- TVM, KVB, Crocodile
- SHP
- ASFA, LZB, Ebicab 900
- EVM
- Ebicab 700
- Indusi, LZB
- Signum, ZUB 121 / 262
- LVZ, LSD
- BACC, RSDD, SCMT
- Ebicab 700

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Introducing ETCS

Goal of ERTMS/ETCS: Only one train control system all over Europe
Introducing ETCS

Example of antenna arrangement on a vehicle for cross border traffic Switzerland – France – Germany prior to introducing ETCS
Introducing ETCS

Typical antenna arrangement on a vehicle for cross border traffic (what it should look like):
Introducing ETCS

ERTMS/ETCS

Key question is: how to get there in a reasonable time and at affordable cost
Introducing ETCS

- To simplify migration to ETCS a concept has been developed as part of the ETCS standard to allow ETCS equipped trains to run on lines equipped with legacy systems, using “Specific Transmission Modules” (STMs)

- The STM concept is an onboard concept, as trains are made to be compatible with tracks where either national systems or ETCS is used
Introducing ETCS with STM’s (Note: 3 countries have full ETCS rollout strategies):
Introducing ETCS with STMs

Example of antenna arrangement on a vehicle for cross border traffic
Switzerland – France – Germany with STM’s
Introducing ETCS with STMs

Issues with STMs
- Cost
- Complexity
- Installation space
- Energy consumption
- Availability
- Maintenance
- Operating rules

Note: cost figures from SBB study
Introducing ETCS with STMs

Goals of users

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Political goals of European Union

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- Competition between suppliers
Introducing ETCS with STMs, Conclusion

- The “STM” concept does not seem to solve most issues of the ETCS migration.
- It rather leads to a life extension of existing systems due to the significant investment necessary onboard.
- Better transition strategies are therefore needed to eliminate national system within a reasonable time after introducing ETCS.
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Introducing ETCS

- As shown the installation of multiple onboard system according to the STM concept can be costly

- Better transition strategies than the STM concept are therefore required for the introduction of ETCS in many cases

- Parallel installation of ETCS and national systems trackside to allow both ETCS and national system equipped trains to run is costly too, in addition the potential of ETCS can not be fully utilised if another system is used in parallel (capacity / safety)

- The aim should therefore be to eliminate national system when introducing ETCS
Introducing ETCS

- Important cost savings can only be achieved if existing infrastructure can be retained/reused both trackside and onboard during the introduction of ETCS, protecting existing investments.

- A lower cost variant of ETCS compared to full SIL 4 Cab Signalling should also be available, as the additional benefits of full ETCS (e.g. safety, capacity, high speed, cab signalling) are not required on many lines.

- The **Limited Supervision Mode** has therefore been defined to achieve these goals.
Limited Supervision Mode

The Limited Supervision Mode can be described as follows:

- The Limited Supervision Mode provides a scalable version of ETCS in regards to safety and functionality
- The Limited Supervision Mode is a fully standardised ETCS mode, like any other of the modes (e.g. Full Supervision, Shunting, On Sight Mode)
- The Limited Supervision Mode is not a national solution

SRS = system requirements specifications
Limited Supervision Mode

The Limited Supervision Mode can be described as follows:

- Cab signalling has been eliminated in a first step
- This makes it possible to use existing trackside information that is not sufficient for cab signalling from either a safety or functional point of view (data not SIL 4 or incomplete)
- Supervision is then performed in the background, and the driver is operating the train according to the lineside signals
- The level of supervision is scalable, from full braking curve supervision to simple stop / warning / proceed functionality

SRS = system requirements specifications
Limited Supervision Mode

Dual channel supervision

- Driver is following lineside signals
- Background supervision through ETCS on-board equipment Standard
- ETCS on-board equipment according to baseline 3 / 2.3.0d w/ CR 637

LEU = lineside electronic unit
# Full Supervision vs. Limited Supervision Mode

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<th>ETCS L1 LS</th>
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<td><strong>Data engineering</strong></td>
<td>Detailed engineering:</td>
<td>Simplified engineering:</td>
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<td></td>
<td>- Completeness of data</td>
<td>- Data as far as required / available</td>
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<td>- Individual / specific telegrams</td>
<td>- Use of a standard set of telegrams</td>
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<td>- Considerable effort for verification, validation, testing</td>
<td>- Minimum effort for verification, validation, testing</td>
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<td><strong>Movement authority</strong></td>
<td>Exactly measured</td>
<td>Simplified, e.g. supervision of speed reduction</td>
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<td><strong>Speed profile</strong></td>
<td>Detailed</td>
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<td><strong>Linking Information</strong></td>
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<td>LEU with Eurobalise</td>
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LS allows flexible and scalable ETCS implementation

LS allows fast ETCS rollout by using standardized / pre-defined ETCS telegrams
Full Supervision vs. Limited Supervision Mode

Comparison of DMI indications

DMI for Full supervision

Permitted speed  Planning area

Actual speed

Target speed  Mode information

Target distance

DMI for Limited supervision

Actual speed

Target speed  Mode information

Train Length: 100 m
Scalability of supervision functions and trackside equipment:

- Degree of supervision can be adapted according to the demands of the national signaling system (safety, performance)
- Range from simple “train stop” or “warning” functions up to “FS” functionality
- Not mandatory to equip all signals of a line to allow LS operation

Examples for scalability:

- Line section with high potential risk: continuous speed monitoring + automatic brake application
- Line section with lower potential risk: warning information + speed supervision after a defined distance
- Line section with low potential risk: warning information and triggering of emergency brake when passing red signal

FS = full supervision
Limited Supervision Mode

DP = Danger Point
Introducing ETCS with STMs

Goals of users

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Political goals of European Union

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- Competition between suppliers
The following basic requirements have been defined for the ETCS rollout in Switzerland:

- Enable trains equipped with only ETCS onboard system to operate on the entire Swiss network, eliminating the need STM’s or national systems onboard, by 2017
- Elimination of the existing national systems ZUB an Signum trackside by 2017
- Allow existing trains with national systems ZUB an Signum onboard to continue to operate on all lines except ETCS Level 2 lines beyond 2017
- Significant cost savings compared to a full ETCS Level 1 or 2 rollout
ETCS Rollout in Switzerland
Steps of the L1 LS rollout

Phase 1
Standardisation / Increase of safety
Replacement of ZUB / SIGNUM with ETCS-Components

- All mainline rolling stock equipped with Eurobalise-/Euroloop reader (ETM)
- Shunting and maintenance equipment still to be equipped
- 550 vehicles equipped with ETCS Level 2 by end 2006

Phase 2
Interoperability
ETCS Upgrade L1LS 2017

- ZUB and SIGNUM onboard antennas not required anymore
- Multiple onboard systems still required for unlimited network access (ZUB, SIGNUM, ETM, ETCS)
- Only ETCS required onboard for unlimited network access
- Existing rolling stock still able to run with national systems (including Eurobalise-/Euroloop readers)
Today’s SBB-Standard gauge network consists of approx. 10,500 Signals equipped with:

- ca. 7,500 with SIGNUM
- ca. 3,000 with ZUB & SIGNUM

Trackside installations of ZUB and SIGNUM will be replaced with ETCS components, but programmed with ZUB and SIGNUM data. Such installations are called:

- EuroZUB
- EuroSIGNUM

The ETCS-Components will be reprogrammed with additional ETCS information. This will be based on:

- Level 1 Limited Supervision

Priority will be on the North – South Corridor until 2012.
Level 1 LS Implementation in Switzerland
Long term development

Onboard
ETCS Level 2
ETCS only N/S-Korridore
ETCS only Korridor
ETCS only TILO (2014!)
Schattenfahrten

Conventional lines
ETCS Level 2
ETCS Tessin
ETCS N/S-Korridore
ETCS only Netz

Trackside
ETCS Level 2
GBT
Rhonetar
Zuläufe GBT
Rückbau RFE

Increase of capacity

Interoperability

2005  2010  2013  2015  2025  2030
2018  2020
Level 1 LS Implementation in Switzerland
Challenges of the L1 LS rollout
Level 1 LS Implementation in Switzerland
General concept is quite straightforward

- Eurobalises installed
- ZUB-Signal Adapter replaced by LEU
- SIGNUM / ZUB removed
- Eurobalises installed
Level 1 LS Implementation in Switzerland

The reality is quite complex

In reality the complexity is quite significant due to historically grown variety of interlocking types and of technical implementations.
Level 1 LS Implementation in Switzerland
The reality is quite complex
Level 1 LS Implementation in Switzerland
Small number of variants to interface to signals

ETCS L1 LS Network Wide Rollout

- Relay-interlockings and electronic interlockings without MSTT type element controllers
  - MiniLEU S11
    - approx. 5000 signals
  - LEU S21MS
    - approx. 2000 signals

- Electronic interlockings with MSTT type element controllers
  - ULK
    - approx. 1500 signals

- Eurobalise S11
- Eurobalise S21
- Euroloop S21
Level 1 LS Implementation in Switzerland
This result in two basic signal installations

LEU S21

- Signal circuit
- Power supply

miniLEU

- Signal circuit

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page 42 Wildenrath, 17 February 2012 Infrastructure & Cities Sector, Mobility and Logistics
Level 1 LS Implementation in Switzerland
Optimized solution for stop / warning / proceed

A special LEU has been developed for the large number of signals where only a stop / warning / proceed supervision is required (MiniLEU S11) with the following advantages:

- No external power supply required, zero power consumption
- Connects to existing relay contacts that control the SIGNUM, nor requiring any changes to the signal interface
- As a consequence very fast installation and commissioning, minimizing impact on operation
- Significantly higher safety level compared to existing SIGNUM through failure detection and self testing
Level 1 LS Implementation in Switzerland
Optimized solution for braking curve supervision

An improved version of the already proven LEU, the S21 MS has been developed to cope with some of the issues of the L1 LS rollout:

- Engineered data stored in external cartridge
- Reduced time for programming
- Extended diagnostics supports paperless commissioning
Level 1 LS Implementation in Switzerland
Optimized engineering processes and tools

SBB and Siemens have jointly optimized the whole engineering process, redefining the work split to minimize the number of both engineering and verification steps. Based on that Siemens optimized the whole tool chain used for engineering, installation, commissioning and verification.
Level 1 LS Implementation in Switzerland
Optimized engineering tools

The whole tool chain used by both SBB and Siemens has also been optimized and based on a common database.

This allows to at least partially automate the engineering steps.

Also many verification and validation steps can be automated.

As a result the amount of work required for engineering can be minimized and the number of errors reduced.
Standardized variants have been defined to replace the existing train control systems with LEU‘s where braking curve is required.

Where only stop/warning/proceed is required no changes to the existing infrastructure are required as the MiniLEU interfaces directly to the existing SIGNUM relay contacts.

Obsolete components are being removed during installation.

These measures help reducing installation cost, but also life cycle cost as maintenance is simplified.
Installation of L1 LS MiniLEU

30.05.2011

Installation of one of the L1 LS MiniLEU prototypes used for extended field trials

Key element of the Swiss ETCS rollout is the very fast conversion of all existing installations of ZUB and Signum to ETCS L1 LS
Installation of L1 LS MiniLEU

Start of installation of VORTOK Balise Mounting System, mounting of MiniLEU to signal mast
Installation of VORTOK balise mounting system, Eurobalises and MiniLEU finished
Installation of L1 LS MiniLEU

Cabling of MiniLEU in progress
The new cable between the MiniLEU and the junction box at the signal mast is prepared for a fast switchover during commissioning.
Installation and cabling of all components finished, signal ready for commissioning after **1 hour and 7 minutes**
Switchover from the existing Signum magnets to the MiniLEU including test and commissioning takes between 5 and 8 minutes. This can be done in regular traffic between train passages.
Installation of L1 LS MiniLEU

- The short installation and commissioning times are only possible due to the engineering and logistics concept applied.
- All components are prepared per signal in the factory, including
  - programming of the MiniLEU,
  - programming of the Eurobalises
  - labelling of all components.
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Only by using the Limited Supervision mode can the entire Swiss rail network be converted to ETCS within a few years.

The cost compared to ETCS L1 Full Supervision is significantly lower, as existing signal interfaces can be reused, minimizing the impact on the existing infrastructure.

The safety level will be significantly higher than with the existing legacy systems due to higher availability and improved functionality.

Full interoperability is achieved with Limited Supervision with any ERTMS equipped train.
Limited Supervision is an integrated feature of the ETCS baseline 3 (or baseline 2 with SRS 2.3.0d and CR 637)

It has been defined to provide a possibility of introducing ETCS at lower cost, mostly by reducing the engineering effort and by allowing reusing of existing interfaces and data that might not be sufficient for full cab signalling

The effort required for verification, validation, testing and acceptance is also significantly reduced, and existing operational principles and rules can be kept

The Swiss case proves that these goals can be met

Limited Supervision can be the ideal first step when introducing ETCS on a network
Thank you for your attention!