# 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



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#### 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)



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#### 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.



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#### **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



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#### Introducing ETCS



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#### Introducing ETCS

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



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#### Introducing ETCS

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



#### Introducing ETCS



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#### 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 STMs

Introducing ETCS with STM's (Note: 3 countries have full ETCS rollout strategies):



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#### Introducing ETCS with STMs

Example of antenna arrangement on a vehicle for cross border traffic Switzerland – France – Germany with STM's



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#### 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



- 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 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 achieve 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



#### **Full Supervision vs. Limited Supervision Mode**

	ETCS L1 FS	ETCS L1 LS
	Detailed engineering:	Simplified engineering:
Data engineering	<ul> <li>Completeness of data</li> <li>Individual / specific telegrams</li> <li>Considerable effort for verification, validation, testing</li> </ul>	<ul> <li>Data as far as required / available</li> <li>Use of a standard set of telegrams</li> <li>Minimum effort for verification, validation, testing</li> </ul>
Movement authority	Exactly measured	Simplified, e.g. supervision of speed reduction
Speed profile	Detailed	Simplified SSP / permitted braking dist.
Linking Information	Exact distance between balises	Not required (optional)
Gradients	Detailed gradient profile	Simplified gradient
Safety level	SIL4	SIL1 to SIL4 (depends on trackside data)
Indications	Full cab signaling	Limited indications, use of lineside signals
On-board	Standard ETCS EVC	Standard ETCS EVC
Trackside	LEU with Eurobalise	LEU with Eurobalise

LS allows flexible and scalable ETCS implementation

LS allows fast ETCS rollout by using standardized / pre-defined ETCS telegrams

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Full Supervision vs. Limited Supervision Mode

#### Comparison of DMI indications

#### DMI for Full supervision



#### DMI for Limited supervision



#### **Full Supervision vs. Limited Supervision Mode**

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

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#### **Limited Supervision Mode**



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#### Introducing ETCS with STMs

#### 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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#### ETCS Rollout in Switzerland Level 1 Limited Supervision



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



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#### ETCS Rollout in Switzerland Steps of the L1 LS rollout

#### **National Systems** National & ETCS Systems National Systems with **ETCS-Components** Phase 2 Phase 1 Interoperability Standardisation / Increase of safety ETCS Upgrade L1LS Replacement of ZUB / SIGNUM with ETCS-Components 2017 ⇒ ZUB and SIGNUM onboard ⇒All mainline rolling stock ⇒ Only ETCS required onboard equipped with Eurobaliseantennas not required anymore for unlimited network access /Euroloop reader (ETM) ⇒ Multiple onboard systems still $\Rightarrow$ Existing rolling stock still able ⇒Shunting and maintenance required for unlimited network to run with national systems equipment still to be equipped access (ZUB, SIGNUM, ETM, (including Eurobalise-/Euroloop ETCS) readers) $\Rightarrow$ 550 vehicles equipped with ETCS Level 2 by end 2006

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#### ETCS Rollout in Switzerland Steps of the L1 LS rollout





#### Level 1 LS Implementation in Switzerland Long term development



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### **SIEMENS**

#### Level 1 LS Implementation in Switzerland Challenges of the L1 LS rollout



**SIEMENS** 

#### Level 1 LS Implementation in Switzerland General concept is quite straight forward





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#### Level 1 LS Implementation in Switzerland The reality is quite complex



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#### Level 1 LS Implementation in Switzerland The reality is quite complex

### **SIEMENS**



#### Level 1 LS Implementation in Switzerland Small number of variants to interface to signals



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#### Level 1 LS Implementation in Switzerland This result in two basic signal installations

### **SIEMENS**



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

### SIEMENS

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

### **SIEMENS**

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.



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Level 1 LS Implementation in Switzerland Standardized installation variants

### SIEMENS

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



30.05.2011 13:15

Start of installation of VORTOK Balise Mounting System, mounting of MiniLEU to signal mast

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#### Installation of L1 LS MiniLEU



30.05.2011 13:29

Installation of VORTOK balise mounting system, Eurobalises and MiniLEU finished

#### Installation of L1 LS MiniLEU



30.05.2011 13:49

#### Cabling of MiniLEU in progress

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#### Installation of L1 LS MiniLEU



30.05.2011 14:01

The new cable between the MiniLEU and the junction box at the signal mast is prepared for a fast switchover during commissioning.

#### Installation of L1 LS MiniLEU



30.05.2011 14:22

Installation and cabling of all components finished, signal ready for commissioning after **1 hour and 7 minutes** 

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#### Installation of L1 LS MiniLEU



31.05.2011

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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#### Level 1 LS Implementation in Switzerland Summary / Conclusions

- 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



#### ETCS Level 1 Limited supervision Summary / Conclusions



- 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!

