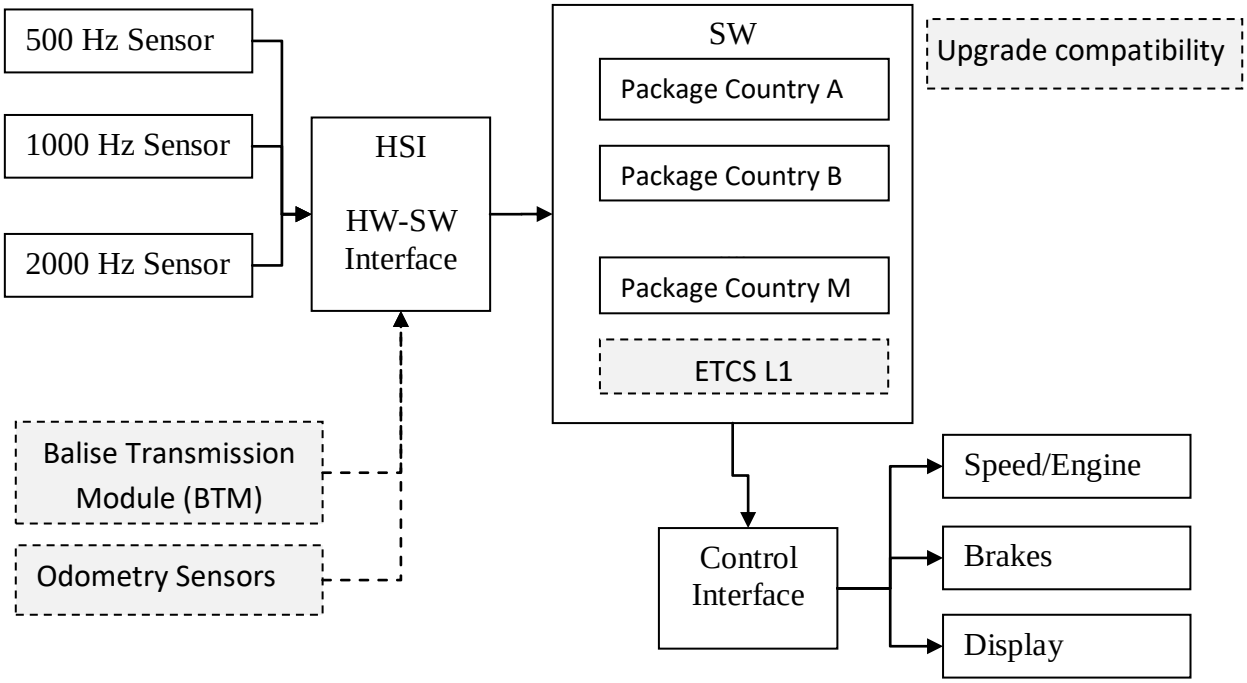
Indusi XC – ETCS Ready

Cross Country Indusi Locomotive Safety System

1. Concept

Most Balkan + Central European countries have an Indusi based rail safety system.

Indusi system uses 3 frequencies to inform the passing train about active restrictions.



Different countries have different policies and signaling conventions, but the signaling is done via 3 common frequencies (500 Hz, 1000Hz and 2000Hz). A common set of sensors receives these signals. A HW-SW interface processes and provides those inputs to a uC. A modular SW running on the uC supports installation of country specific packages for the implementation of the safety regulations. Speed/Engine and Brake commands are generated accordingly. Information is sent to Driver's Digital Display.

The system is ETCS ready (upgrade to ETCS possible without uC replacement). The RH850/U2C provides 8MB Flash, 1.5MB RAM, and 320MHz single-core lockstep capability – sufficient to host ETCS Baseline 1 software without hardware modification.

2. Why Indusi?

Comparing Indusi with other national safety systems from Europe, it is the most relevant and cost effective for CEE operations.

Rank	Safety System	Countries Covered Effectively	Extra Cost vs. Pure Indusi	Operational Flexibility	Overall Benefit for Romania	Comment
1	Universal Indusi (500/1000/2000 Hz)	Romania, Bulgaria, Serbia, Croatia, Slovenia, Eastern Turkey, parts of Hungary/Austria	Lowest	High	Highest	Best value-for-money. Covers your core profitable corridor (Constanta → Central Europe) with minimal extra hardware.
2	Indusi + EBICAB	Above + Greece, Sweden, Norway, Portugal	Medium-High	Very High	Medium-High	Adds Greece but significantly more complex and expensive.
3	Full ETCS Level 2	Almost all Europe	Very High	Highest	High (long-term)	Future-proof but extremely expensive now.
4	Indusi + ETCS	Maximum coverage	Highest	Highest	Medium	Overkill for the next 8–10 years.

This is a mid-term solution that is ETCS ready but it also offers **cross-border** compatibility before full ETCS adoption.

3. uC Architectures

Architecture	Caches?	Pipelines?	Multicore?	ETCS capable?	Certification ease
x86 (modern)	Deep	Complex	Often	Yes	Hard
ARM Cortex-A	Yes	Complex	Often	Yes	Hard
ARM Cortex-R	Small or none	Simple	Rarely	Yes	Moderate
ARM Cortex-M7	Optional (can disable)	Simple	No	Limited	Easy
RISC-V (simple core)	None	Very simple	No	Limited	Very easy
Renesas RH850	Optional (can disable/deterministic)	Simple	No	Yes (used in ETCS)	Easy

Renesas RH850 is selected for ease of certification

Indusi XC uses a single-core, cache-free, deterministic µC architecture — powerful enough for ETCS, simple enough for SIL4 certification without cache/pipeline/multicore complexity.

4. uC Selection

RH850 series:

Series	Target Application	Speed	Flash	RAM	Lockstep Cores	Best for Indusi XC?
RH850/U2A	Cross-domain / Zone	400MHz	16MB	3.6MB	Up to 4+4	**Excellent** — Future-proof, high headroom
RH850/U2C	Body/Safety/Security	320MHz	8MB	1.5MB	Up to 2+2	**Great** — Lower cost, still ETCS-capable
RH850/E2x	Powertrain	400MHz	Large	Large	Multiple	**Good** — Real-time optimized
RH850/F1x	Body control	Lower	2MB	Lower	Optional	**Limited** — Possibly underpowered for ETCS

RH850/U2C (single core or 2+2 lockstep mode) is selected because it offers:

- **Enough headroom** for Indusi today + ETCS tomorrow
- **Lower cost** than U2A
- **Latest connectivity** (CAN-XL, Ethernet TSN, I3C) — future-proof
- **Proven 28nm process** with low power consumption
- **ASIL-D certified** — certification path is clear

5. From Indusi XC to ETCS L1

ETCS L1 is conceptually a direct evolution from a system like Indusi. This means the transition is simpler.

What ETCS L1 Changes for Indusi XC:

Works Alongside, Not Instead Of: ETCS L1 is designed as an overlay system on existing national signaling like Indusi. This means Indusi logic can remain as a fallback, simplifying the transition. ETCS L1 layer is added to the Indusi software;

Eliminates the Need for Radio: Unlike Levels 2 or 3, ETCS L1 does not require continuous radio communication via GSM-R. This is a significant cost and complexity reduction. It removes the need for a GSM-R modem and complex Radio Block Center (RBC) integration.

Simpler Trackside Interface: Trackside communication for L1 is purely spot-based via Eurobalises. The data telegrams are relatively small (1023 bits each), which is very easy for the U2C to process.

Compatibility with the CEE Corridor: ETCS L1 is already deployed on core routes in the target CEE region (e.g., Budapest–Hegyeshalom line in Hungary), making it a practical choice.

What Needs to be Added to Indusi XC for ETCS L1

ETCS L1 upgrade requires two main components:

- Balise Transmission Module (BTM): An antenna and reader to receive data from Eurobalises on the tracks. Many commercial BTM units are SIL4 certified and available as off-the-shelf modules, saving significant development and certification costs.
- Odometry Sensors: ETCS needs a more precise position and speed than Indusi. This can be achieved with redundant wheel speed sensors and inertial measurement units (IMU).