UIC SAFETY UNIT

ETCS – HOF Return of Experience

Human and Organisational Factors Working Group

July 2025

INTERNATIONAL UNION
OF RAILWAYS

Contents

Introduction

This short report describes the first workshop of the ETCS-HOF network coordinated by UIC under the Human and Organisational Factors Working Group (HOFWG).

The network was created with the following objectives:

1.1. To create a community of practice for HOF aspects of design and implementation of ETCS
1.2. To share knowledge and understanding of HOF issues with ETCS
1.3. To identify common HOF issues with ETCS
1.4. To share best practices in resolving ETCS HOF issues
1.5. To identify proposals for improvements to the ETCS specification to be promoted to ERA

2. Workshop

The workshop was held in UIC, Paris on 11th and 12th June 2025. Attendees were specifically selected to hold both Human and Organisational Factors (HOF) knowledge or appreciation and ETCS knowledge so that the workshop did not have to spend time on building knowledge on either topic.

Attendees are listed in Appendix A.

Ahead of the workshop, a template was circulated to collect known issues from the invitees across five topic areas:

1. DMI issues
2. Onboard behaviour issues
3. Signalling and trackside issues
4. Training issues
5. Migration issues

The template was returned by seven organisations and the different issues raised were pooled as an input to the workshop. On the first morning, attendees spent one hour brainstorming issues across the five topics, including those submitted in advance, and one hour grouping and prioritising them. The full list of topics, groupings, and prioritisation are shown in Appendix B.

For the remainder of the workshop, the attendees worked in small groups on the highest priority items to discuss. Seven topic areas were discussed, each for approximately two hours. Workshop members self-selected the topics they wished to work on. Each group discussed and documented their thoughts on:

- The topic or issue area
- The source of the issue
- The human performance implications of the issue
- Possible solutions to propose

After the workshop, these notes were used to develop the 13 issues presented in this report.

3. Findings

This section presents the results of the workshop, covering 13 different Human and Organisational Factors issues that were discussed. Each issue is presented in a table, with a description of the issue, the human performance implications, and suggestions for possible mitigations.

The mitigations are proposed under four different headings:

- **Specification update** – it is suggested that an update to the ERA specifications would help to mitigate the issue.
- **Design/implementation** – the issue does not arise from a problem within the specifications, but from the interpretation or delivery of the specifications and can therefore be addressed during design, configuration, and implementation.
- **Training** – the issue can be appropriately addressed via training.
- **Further research** – the solutions to this issue are not yet fully understood and more investigation would be beneficial.

3.1. ISSUE 1: Disappearance of DMI text messages

Issue Description	Some railways describe an issue relating to text messages disappearing as soon as the driver acknowledges them, and before they can be communicated to the signaller.
Human performance implications	A flashing icon invites a quick response to acknowledge it, without necessarily understanding what information is being conveyed. Drivers may not read or absorb all information before acknowledging, and then the information is lost which means they cannot pass on accurate information on what was displayed. The need to remember information in a text message also places a memory burden on the driver which may reduce their attentional capacity while driving. This could contribute to safety of the line incidents.
Possible mitigations	**Design/Consultation:** This may be an issue with configuration/implementation. Mitigations could be related to guidance on configuration and implementation, particularly in terms of considering the salience of information as it flows through the system from trackside to onboard to the DMI and onward to operations and maintenance control centres. Specifically, in this case, sufficient numbers of messages should be capable of being stored in the message list so that drivers can scroll through them (when safe to do so) if they need to retrieve the information.

3.2. ISSUE 2: Older messages are inaccessible to the driver

Issue Description	Some railways describe that drivers cannot scroll through the text message list and find older messages. Only four lines of messages are available to view, and some messages take two lines. This may be related to the baseline being used.
Human performance implications	Multiple messages can be received in a short space of time, and drivers may not have read older messages before they are replaced by new ones. This could result in important information being missed and result in low situation awareness, ultimately leading to drivers making incorrect decisions which could contribute to a safety of the line incident.
Possible mitigations	**Design/implementation:** The recommended mitigation is to ensure that the message capacity on the DMI display is sufficient for the operation during design and implementation.

3.3. ISSUE 3: Lack of consistency in use of S_info

Issue Description	The sound S_info is used for various different meanings. While the S1_toofast and S2_warning have clear meanings with clear associated driver actions, S_info is not as clearly defined.
Human performance implications	Sounds should be used judiciously within alarm systems to draw attention to information that needs to be understood immediately. Overuse of sounds in alarm systems results in operators ignoring sounds as they become a nuisance. Excessive noise from alarms also impacts on attentional capacity, which could reduce driver performance and result in a safety of the line incident. The loose description of how S_Info should be used in ETCS (ERA_ERTMS_015560 v3, 14.3.1.1: “This is to draw the attention of the driver to some new visual information”) may result in creep and inconsistent usage of the sound. This could result in overuse of the sound, with the results described above.
Possible mitigations	**Specification update:** Suggested to update the specification with a stricter definition governing the usage of S_info by explicitly considering current research and good practice in this area. The definition should be clearly linked to the required driver response to hearing the sound, e.g. “This is to draw the attention of the driver to some new visual information presented on the DMI which the driver is required to be immediately aware of in order to control the train movement”. **Further research:** More widely, the issue around S_info stems from a lack of a clearly considered alarm philosophy and specification supporting ETCS. There is scope for more research which explicitly considers the information being conveyed, who it is directed to, what they need to do with it, and how quickly they need to act upon it.

3.4. ISSUE 4: Standardisation of translations on DMI

Issue Description	There is no standardisation of translation of DMI plain text messages between countries with similar languages (e.g. France, Belgium, Luxembourg, Austria, Switzerland, Germany). Different infrastructure managers may use different translations from the standardised English messages. This is in contrast to the fixed text messages which are defined in the specficiations along with standardised translations.
Human performance implications	During cross-border operations, drivers will convey the message that is displayed on their DMI to signallers when required, but this message may differ according to the translation used. This will add to signaller mental workload as they will need to match the conveyed message with the usual phrasing of that fault. It also introduces the potential for confusion and incorrect reporting of messages if the signaller makes an error in the interpretation. This creates a risk that the signaller does not apply the correct procedure based on the incorrect interpretation.
Possible mitigations	**Design/implementation:** The risk can be mitigated by the infrastructure manager including in their operational documentation a list of acceptable translations for each standardised English language message. **Specification update:** There is potential to produce a standardised translation in the form of a harmonised text messag guidance mandated to all manufacturers, infrastructure managers, and railway undertakings. This could cover both fixed and plain text messages and link to the TSI OPE.

3.5. ISSUE 5: Onboard language switch

Issue Description	Drivers must switch the DMI language during cross-border operations at the frontier point, often without stopping the train.
Human performance implications	The cognitive workload and visual distraction from operating the DMI reduces driver visual attention to the track and could lead to a missed trackside hazard.
Possible mitigations	**Specification update**: If standardized translations are provided in the specification, then there may no longer be a need to change the DMI language when crossing borders as the standard translation can be trained. **Specification update:** consider using a technical network balise to automatically change the onboard DMI language at frontier points.

3.6. ISSUE 6: Lack of warning for exceeding release speed

Issue Description	Release speeds are used in ETCS Level 1 to allow trains travelling towards a stop aspect to overpass the balise associated with the signal and receive a new movement authority, and in Level 2 where trains are required to stop very close to the End of Authority (EoA). In both cases, Release Speed Monitoring (RSM) imposes an emergency brake application and brakes the train to a stop if the release speed is exceeded. This is in contrast to other ETCS speed monitoring (CSM/TSM) which usually gives a 'too fast' tone allowing the driver to respond and reduce train speed before a penalty brake intervention. The penalty brake intervention in CSM/TSM also usually only reduces train speed to under the permitted speed rather than applying the emergency brake. There is no 'tolerance' for overspeed of the release speed. Release speeds may be set very low (e.g. 15km/h) which drivers may find difficult to comply with without heavy reliance on the DMI. Release speeds can also vary significantly, so drivers must frequently adjust to different release speeds. This is compounded by the use of S_info being too general to reliably inform drivers that RSM has been entered.
Human performance implications	The need for drivers to closely monitor the DMI in order to ensure the release speed is not exceeded means that their visual attention is allocated within the cab instead of externally. When the driver is approaching the stop point, they need to be 'heads up' to monitor the station platform, approach to buffers, signal aspect (in Level 1), etc. but RSM is prompting them to be 'heads down' to monitor the DMI, which leads to divided attention. Divided attention means that the driver is not able to fully attend to either stimulus (platform or DMI) and could miss important information in relation to either. In the case of the DMI, this can lead to unnecessary penalty brake interventions if the speed is not kept below RSM, resulting in unnecessary delays. In the case of the platform, dangerous behaviours or situations could be missed which would potentially contribute to a safety incident.
Possible mitigations	**Design/implementation:** The operational needs and constraints in the design should be carefully analysed, including HOF analysis, to ensure that the release speed is set at an appropriate level to meet drivability needs. • Higher release speeds should reduce the divided attention of drivers, but must be safe. • Release speeds can be varied trackside at each location, this could be confusing to drivers as the release speed varies by location. • Release speeds can also be calculated onboard, but this could be distracting as drivers have to monitor each one, and confusing to drivers as the release speed may 'step up' as the train approaches the EoA due to the correction of positional inaccuracy. **Design/implementation:** Whichever solution is chosen, the impact of release speeds should be tested and refined with drivers before entering operational service. **Design/implementation:** In order to help drivers maintain attention to both the DMI and the platform during RSM, where possible, platform information could be provided

	in-cab by means of CCTV displays This could help in situations where it is physically difficult to maintain sightlines to the platform while monitoring ETCS, but is still likely to result in divided attention.Future cab designs could consider head-up displays as a further mitigation. **Training:** Training should clearly explain release speeds and how to manage them, and give drivers the opportunity to practice managing release speeds as part of their training in a simulator. **Further research and guidance:** It would be useful to research example release speed applications. This could be achieved through analysis of emergency brake applications during RSM. The research output could be a guidance note/design principle covering the different options for release speed, including: • An advance warning, either speed or time based, to provide an opportunity for drivers to recover before an emergency brake intervention • Onboard vs trackside (fixed) calculation • Many trackside values vs few/one trackside valueSpecific test cases for setting release speeds • Specific training information and exercises for drivers

3.7. ISSUE 7: Training standardisation

Issue Description	There is little or no guidance on who should be trained on ETCS and to what level, with variation across Europe on the duration and content of training. Railways who are newly implementing ETCS also may not have the expertise to identify the training requirements and develop appropriate training materials. ETCS project implementation teams may focus on the technical aspects and leave training to existing operational departments who maynot have an in-depth understanding of the system. Existing training materials produced by ERA (e.g. generic ETCS Driver's Handbook) provide a valuable source of information, but they tend to focus on the 'how' and not the 'why'.
Human performance implications	ETCS is a complex system with multiple affected end user groups. A lack of understanding of the system among any of these groups can affect the efficiency of the implementation. Poor understanding of the system operation can lead to user frustration, and ultimately mistrust in the ETCS system. Understanding the principles of operation and why the system operates the way it does will promote a more resilient operation. Often there is a gap between the generic training material available and expectation of how ETCS will perform, and how it performs in practice. This means that drivers and signallers have to adapt and adjust to ETCS, creating additional cognitive workload as they find that the system does not perform as they expected it to. During the initial period of post ETCS implementation there tends to be a higher incidence of brake applications as operators 'learn' the functionality of the ETCS system in operation.
Possible mitigations	**Implementation:** Existing standardised generic materials, such as the generic ETCS driver's manual, can be used as a template to provide a minimum level of information.

	It is critical to supplement this generic material with specifics on how the railway organisations have chosen to deploy ETCS. **Specification update:** Further standardised training materials that explain the concepts and how ETCS works, rather than just how to interact with it. **Specification update:** Guidance on training could be produced to help railway organisations provide optimal training. Guidance could include: • Audience to be considered: e.g. drivers, signallers, trackside maintainers, rolling stock maintainers, project teams, operational management • Structure: a new System Requirements Specification (SRS) on training containingthe process of delivering the training, the minimum content, appropriate training media, responsible party (e.g. ERA, NSA, Railway Organisation) • Timing: frequency and duration of minimum training for each audience member, and maximum time between training and operational exposure. • Trainer minimum competence requirements. • Use of simulators, including the appropriate use of tablet-based (or part task) simulators and the types of scenarios that simulators are best used for.

3.8. ISSUE 8: ETCS Skill Fade

Issue Description	ETCS roll-out is a complex process over multiple years. As a result, operators may go considerable lengths of time between being trained on ETCS and actually using it in practice, and they may only drive or control ETCS equipped trains occasionally. Skill fade can occur in relation to: • System operation; • Decoding information on the DMI; • Accurately transmitting and receiving ETCS information.
Human performance implications	Train drivers rely on their skills to safely and efficiently operate their trains. Skills, in contrast to knowledge, are acquired through practice and repetition over time. If drivers do not have the opportunity to consolidate the knowledge provided through initial training, they may find it more difficult to develop and apply the skills of using ETCS. The same issues apply to signallers, controllers and maintainers as ETCS is rolled out. SNCF Voyageurs have experience that trains are more delayed and there are longer response times in the management of degraded situations involving ETCS as compared to TVM. On average, event processing takes half the time with TVM. Similarly, Infrastructure Managers have experience that processes and procedures for degraded operations and system recovery under ETCS can be less efficient than non-ETCS operations.
Possible mitigations	**Specification update:** Specify or provide guidance on: • Minimum training times • Maximum times between training and application • Criteria for a continuous training programme

	• Use of simulation to develop skills for degraded working, including low and high fidelity simulators. **Implementation:** Providing training on ETCS technical knowledge and ETCS systems to ETCS managers. **Implementation:** Job shadowing or "Live my life" (vis ma vie) can help different roles understand the changes under ETCS and how they affect different operational situations.

3.9. ISSUE 9: Signaller and driver communication

Issue Description	Differences in the terminology and symbology between driver and signaller interfaces can lead to confusion in communications.
Human performance implications	For effective communications, the two parties must have a shared mental model to provide a basis for shared understanding. Signallers and drivers have different perspectives on ETCS and developing a shared mental model relies on having a standardised understanding of the relevant icons, terms, and meanings. When the terms and symbols differ across driver and signaller systems, this shared mental model becomes more difficult to develop and apply. The DMI is highly specified, but the signaller HMIs are not, meaning that standardisation in the icons, terms, and meanings between the two roles is not guaranteed. The impact of this is potential confusion arising in communications and incorrect procedures applied.
Possible mitigations	**Specification update**: List of signaller information needs for HMIs providing a basis for IMs to specify what should be shown and how.

3.10. ISSUE 10: Fault management via driver-signaller reporting

Issue Description	Drivers and signallers are routinely used to detect and report trackside faults with ETCS. Faults appear on the DMI and drivers are mandated to report them to the signaller for resolution. This is inefficient, and places an additional workload and distraction burden on frontline operators. Even where IMs are trying to use remote detection and diagnostic technologies to manage trackside ETCS faults, they are reliant on RUs to share access to data in a timely manner to facilitate it and this is not always supported.

Human performance implications	Trackside faults may arise which have no immediate operational impact, but are disclosed via the DMI and required to be reported to the signaller for onward reporting. Neither the driver nor the signaller are directly impacted by the information, so this task is an additional unnecessary workload and distraction from their duties. For both parties, it can result in divided attention, which could contribute to other important information being missed. On the other hand, for maintainers this is critical information which is not always easy for them to access or align between different reporting systems (JRU, RBC logs, onboard systems and diagnostics, etc.). This makes the maintenance task more difficult, and reliant on potentially poor quality information relayed by operational staff.
Possible mitigations	**Further research**: System wide alarm management strategy • Describing information/data flows through the entire system • Describing human actions and decisions through the entire system, including operational and maintenance staff • Can drive contractual requirements between RUs and IMs to share information for fault detection and diagnosis **Specification update**: Develop a standardised protocol to send data to signal cabins • Bypass the need to access RU data and systems • Allow European Instruction forms to be (partially) auto-populated • Allows for fault detection and diagnosis to be partially automated and reduce the role of driver/signaller communications

3.11. ISSUE 11: Format of European Instructions

Issue Description	The format and requirements of the European Instructions does not support efficient and effective communications between signallers and drivers. The 'one size fits all' approach does not account for local specificities in the information that has to be managed, and the usability of the forms in the TSI OPE is low.
Human performance implications	Forms, if required, should match the procedure to provide a support to both parties on the process to be followed. This should be in terms of: • The information required to be passed • The tasks required to be performed • The sequencing of both information passing and tasks Having a form which does not support the process increases the risk of human error in correctly passing information or completing the correct tasks in the correct sequence. Furthermore, the need for a signaller to concentrate exclusively on the completion of a form (sometimes for 5-10 minutes) can have implications for overall service delivery, as a result of the signaller's attention being allocated to the paperwork.
Possible mitigations	**Further research:** Analysis of the extent to which the European Instructions increase safety and system resilience, in contrast to existing processes.

	Further research: Usability testing of European Instruction forms to identify the specific issues. **Specification update:** Review and update of European Instructions based on operational and HF best practice.

3.12. ISSUE 12: Diversity between System versions

Issue Description	There can exist multiple ETCS systems on a train or across a route, depending on the combination of level, baseline, and supplier. There is no clear identifier of the ETCS version in the current DMI presentation, and it is reliant on the driver to identify and recall the differences between these versions. For example, one organisation have different system versions installed on the same fleet, meaning a train can be driven in one direction under one system version and a different system version is in use in the return direction. Another organisation are in the process of updating their trains from ETCS 2.3.0d to ETCS 3.6.0, which means that as software upgrades are fitted drivers could be moving between trains with different versions. This is in addition to transitions over routes between ETCS and legacy national systems. Each system version can have variations in how it behaves, for example in the calculation of braking curves, differences in alarm presentation, etc.
Human performance implications	The subtle variation in system behaviours makes it difficult for a driver to develop an accurate and reliable mental model, and therefore more difficult for them to work safety and effectively with ETCS. How the ETCS system behaves may be subtly (or grossly) different depending on the system version, and drivers have to therefore maintain multiple mental models and choose the correct one for application in any given situation. This has impacts on: • The amount of training needed: more system versions means more training for drivers on the differences between them; • The driver's ability and confidence to correctly interpret situations and system behaviour: having to choose between mental models introduces the potential for drivers to select the incorrect one and be surprised by the eventual result; • Timeframes when dealing with faults: choosing the correct mental model may take longer and slow down responses to faults; • Volume and complexity of documentation: multiple system versions means more procedures and variations on procedures;
Possible mitigations	**Further research:** Proposed changes to system versions should be analysed before being released to understand how they may conflict with existing baselines and this information provided to IMs and RUs to inform their training and migration strategies. For some changes, it may be necessary to recommend that drivers are not permitted to drive some combinations of system versions.

	Specification update: The DMI should clearly show the system version at all times to help drivers select the correct mental model. Ideally, this would rely on more than alphanumeric indications (e.g. 2.3.0d vs 3.6.0) and use descriptors (e.g. similar to Android software names) or colour codes, for example. **Implementation:** The functionality chosen and represented in the operator's operational concept should be simplified to essential functionality from the operator perspective, to help manage complexity across system version. **Implementation**: If the DMI does not clearly display the system version, this can be added as a sticker to the hardware. **Implementation:** Provide clear training, using digital tools where possible, to help drivers and signallers recognise patterns and solutions between system versions. **Implementation:** Consideration of standardisation of ETCS during deployment.

3.13. ISSUE 13: "Bugs" in live software versions

Issue Description	Software manufacturers sometimes release upgrades with 'bugs' that they have identified and need to be addressed in the future software updates. The system is implemented with known bugs which are captured and rectified during a future update.
Human performance implications	While the software issues may not be safety critical, they hold the potential for a number of human factors concerns. First, they may introduce confusion and frustration for operators on how the system works, which can act as a distraction. Second, if the operator learns to live with a bug when it is first introduced, this way of working can become habitual and they may find it difficult to adapt when the software is updated. And lastly, bugs within the software can serve to reduce trust in the system; even if those bugs do not have direct safety implications, operators do not always make this distinction.
Possible mitigations	**Further research:** It would be beneficial to explore the types of bugs that have been experienced in live operations, and to analyse the potential human factors impact of these over time. **Specification update:** It could be useful to provide more information, based on the research, on how to analyse the human factors impact of bugs and provide guidance for railway organisations on the acceptability of different types of common bugs, as part of an overall user-centred design and testing process.

Next steps

The workshop was very successful and brought together a group of experts who demonstrated their ability to contribute to an improved ETCS system. The following activities are planned to progress this initial work:

1. Dissemination of this report by workshop attendees, including by ERA for consideration of proposed research and specification changes
2. Present results at the UIC HOFWG in September 2025
3. A UIC webinar to present the workshop outputs on 5 November 2025
4. Further analysis of the input templates provided by workshop attendees
5. Establish a UIC hosted Teams group to continue collaboration between workshop attendees
6. A further in-person workshop, possibly focused on ETCS change management, in 2026

Annexes

Appendix A: Attendees

Name	Organisation
Anna Windischer	SBB
Bernard Penners	Infrabel
Clarisse Lagaize Devoine	ERA
Elaine Thompson	Eurostar
Emmanuelle Bojkovic	SNCF Réseau
Eric Pebret	SNCF Voyageur
Florence Magnin-Lot	SNCF
Frédéric Barth	SNCF Voyageur
Frederik Calleeuw	Infrabel
Guillaume Foeillet	SNCF
Jean-Emmanuel Leroy	SNCF Voyageur
John Gunnell	Atkins Realis
Niels Brandenburger	DLR
Nora Balfe	Irish Rail
Richard Bye	Network Rail
Tom Godfrey	ARUP
Virginie Papillault	UIC

Appendix B: Full List of Topics

The topics below were identified during the brainstorming session and prioritised by participants voting for which they considered most important to work on together. The prioritisation exercise was only to determine which topics would be worked on during the remainder of the workshop and should not be interpreted as the relevant importance of the different issues. The topics in bold were selected for more detailed discussion which is presented in the next section. The number in brackets indicates the number of 'votes' received for that topic area.

Theme 1: DMI

- **Alerts and message presentation (6)**
- **Language used in messages (4)**
- Stopping location indications (2)
- Future specifications
- SoM/Data Entry

Theme 2: Onboard behaviour

- **Release speed (3)**
- Driving technique (1)
- Divided attention
- JRU
- Fault finding

Topic 3: Signalling/trackside

- **Communication/fault diagnosis (7)**
- **Communication between roles (4)**
- **Instructions/written orders (3)**
- Track maintenance
- Design/configuration

Topic 4: Training

- **Skill fade (6)**
- **Training standardisation (4)**
- Maintaining system SA (2)
- Simulation (2)

Topic 5: Migration

- Change management (6)
- **ETCS variation (4)**
- Scope of deployment (1)
- Lack of harmonisation (1)
- Migration from Class B to ETCS
- Interfaces
- Simulator testing
- Level transitions
- Level crossings

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