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Report

Simulation and validation of the CR1249 solution and related CRs

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2b	11/12/2015	Internal review	RT
3	16/12/2015	Distributed after discussion in EECT 16	RT

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1 Purpose of the document

The aim of this document is to report on the results of the validation campaign for CR 1249 bundle.

This version of the report represents the results after performing the complete validation campaign and additionally the outcomes of the EECT discussion on these results. In the conclusions the results of the validation process as well as the results of the EECT discussion are taken into account.

2 Background

The validation campaign for CR 1249 and some related CRs (e.g. 1084, 1187) was planned in order to get feedback from operational and ergonomics experts on the proposed technical solution and to report on the findings. To perform this ERA asked EUG to organise a simulation and validation campaign with the participation of relevant experts as well as drivers. The campaign consists of one session at the EUG offices in Brussels and one at the SNCF simulator in Lille. It is described in further detail in the action plan from 22/07/2015.

3 Description of the CR problem

SNCF/RFF discovered in simulations for the planned equipment of the Paris – Lyon line with ERTMS L2 that the driver would see and hear the pre-indication very often. Due to steep gradients the train speed is on uphill section considerably below the MRSP speed. This results in a long time between pre-indication and indication. The consequence is that in most cases the movement authority is updated in between and the train does not enter Target Speed Monitoring. Other railways (e.g. SBB) have also reported that due to the layout of some lines, drivers are annoyed by repeated pre-indication alerts which disappear immediately due to the extension of the MA.

This problem description was introduced to the CCM process as CR 1249. ERA developed a solution proposal which has been discussed and adapted several times in the EECT meetings. The validation is performed based on the solution proposals from 27/05/2015 and 07/09/2015.

4 Description of the solution to be validated

The solution to be validated consists of several elements:

4.1 Removal of Pre-Indication

As a result of CR 1107 the display of the planning area is now mandatory in Full Supervision. With this in mind the pre-indication is removed with the argument that all the information given by this functionality is now always visible in the planning area.

4.2 Display target speed of upcoming targets in planning area

To allow the driver to plan ahead, the speed of all upcoming targets is displayed numerically at the speed icons in the planning area. The target related to the indication marker is displayed in yellow (icon and speed number). This gives the driver a look ahead of the speed to which he will have to brake soon as done previously by pre-indication.

4.3 Configurable indication time

In order to adjust to different operational situations, the indication time is configurable on-board to a value set by the railway undertaking.

4.4 Indication marker calculation with current train speed (CR 1187)

Instead of calculating the position of the indication marker in the planning area with the MRSP speed the current train speed is used. The reason is to make sure that the indication marker reaches the bottom of the planning area exactly when Target Speed Monitoring is entered and the yellow indication is displayed in area B.

4.5 Masked targets (CR 1084)

A target is defined as masked when its indication location calculated at the speed of the first target is in rear of the location of that first target. If this is the case the driver would receive the pre-indication respectively indication too late. Therefore, the second target will be displayed at the location the first one would have been.

4.6 Falling hook effect

This effect occurs when the train speed is considerably below the MRSP speed. When going from Ceiling Speed Monitoring to Target Speed Monitoring the hook will immediately fall from the MRSP speed to the currently permitted speed. At that moment the permitted speed is always sufficiently above the train speed to allow enough time for the driver to start braking and follow the permitted speed.

5 Validation session at EUG

The meeting took place at the ERTMS Users Group in Brussels on 27/08/2015 from 10:00 to 14:00 and was attended by the following persons:

EEIG ERTMS Users Group	Mr Dijkman Ms Arenas Mr Treydel
Intergo	Ms Weeda
ATOC	Mr Le Vesconte Mr Bailes
VTEC	Mr Lartey
ATW	Mr Evans
RSSB	Mr Roberts
SBB	Mr Eckstein
DB Netz	Mr Eschlbeck
DB Fernverkehr	Mr Rieger
SNCF Mobility	Mr Samyn
SNCF Mobility	Mr Dussouchet
ÖBB	Mr Pisek
ÖBB Produktion	Mr Schuster
ERA (observer)	Mr Gemine

5.1 Description

In preparation of the meeting EUG created and distributed simulation videos illustrating different operational situations. The simulations have been done with tools from ERTMS Solutions and cover the following topics:

a) Configurable indication time (5s, 9s, 12s)
b) Operation with several targets and also masked targets
c) Driving at a low speed (to visualise the so called falling hook) and in RSM
d) Driving in OS

During the meeting the problem leading to the change request and the solution proposal have been explained. The main part was the discussion about all points to be validated, supported by the videos.

5.2 Results

This section lists the results of the validation meeting at EUG.

After watching the corresponding videos, it was agreed that the operational behaviour of the solution proposal is correct in general. In particular, there was agreement on displaying the target speeds in the planning area, the behaviour in situations with several targets and masked targets, the changed indication marker calculation and the falling hook effect.

Three issues of the solution proposal have been discussed during the meeting and are explained in the following sections.

5.2.1 New pre-indication with toggling proposed

In addition to the proposed solution especially the experts from UK see the need to give the driver a strong notification that braking might be required soon. This will give the driver some time to plan ahead and to decide when to start braking depending on the current conditions like low adhesion. They are of the opinion that the planning area is not sufficient since they consider that the indication marker in the planning area is not conspicuous enough to be relied upon. Not all participants shared these strong feelings of UK. For several of them the deletion of the pre-indication is acceptable. In order to reach consensus among the operational experts present, they came to the compromise to add a new pre-indication. This should look like the existing pre-indication and also include a sound. It should occur a fixed time before the indication and therefore be calculated with the current train speed. In order to meet different operational needs on different lines, it should be possible for the driver to toggle this functionality on and off. The operational experts still have to discuss this proposal within their organizations.

5.2.2 Speed values only at speed decreases in the planning area

The experts did not see any added value to show the values at speed increases. Therefore, they concluded to display the speed value only at all speed decrease icons in the planning area speed profile and not at speed increases in order to highlight the targets and avoid distraction.

5.2.3 Configurable indication time

Especially ÖBB is concerned that letting the railway undertakings configure the indication time represents a problem for drivers working on trains from different railway undertakings, or from different leasing companies, as they will have to adjust to a different behaviour each time. It would

undermine the current clear principle that the indication is the moment when the driver has to start braking to be able to follow the permitted speed. Some other railways, e.g. SBB, are also concerned about the configurable indication time. If the indication would be configured around 7s before the currently defined moment, the same problems, described in the introduction, with an annoying and unnecessary driver alert could occur on certain lines.

6 Meeting with CER Operational experts

On 12/10/2015 a special meeting was held in Brussels to discuss the operational aspects of the CR 1249 bundle between ERA, CER and EUG.

CER presented a joint DB/UK proposal to always show the Distance to Target (DTT) in area A2 and the Target Speed (TS) in a new area B9 above area B4 on the DMI. When approaching an indication location additionally the Time to Indication (TTI) shall be shown in area A1. The purpose is to give the drivers more time to react and to allow comfortable driving.

DB explained that removing the pre-indication leads to problems with the safety philosophy in Germany in reduced adhesion conditions. Today drivers are required in such a situation to lower the speed and start to brake at the pre-indication location. Since the pre-indication time increases when the speed is lower, this gives a sufficiently longer distance to brake the train to the required target speed. With the new solution this does not exist anymore. Only the planning area provides information of upcoming targets before reaching the indication point. To ensure a high availability the DMIs of new trains are fitted according to the redundancy concept of UIC 612. In case a display fails it becomes necessary to use the space of the planning area to accommodate other vital information. In this case the driver is not anymore able to anticipate an upcoming target with the planning area. With reduced adhesion braking at the indication location is too late to reach the target speed within the target distance.

7 Additional concerns from infrastructure managers

This section describes concerns raised by infrastructure managers not covered by the previous sections.

7.1 Configurable indication time

To let railway undertakings freely configure the indication time could be problematic for the reasons explained in the following two subsections.

7.1.1 Impacts on trackside design

The engineering of the trackside normally makes assumptions on the worst performing lambda train foreseen to run on the line. The calculated indication time (according to the current specifications) is used as the reference to determine the indication location for the worst braking trains and with that the moment to send an MA update to the train. The IM knows the maximum braking distance allowed on the line (which is equivalent to a specific EBD distance) and estimates other parameters in order to calculate the indication location for the worst braking train in a deterministic way, i.e. independent of the RU.

Allowing the RU to configure the indication time to any value he likes would undermine the deterministic behaviour of the worst braking trains. Since the IM has only one parameter in this context on which he can make requirements to the RU, i.e. the braking distance which is equivalent

to the EBD distance, and no way to require a specific indication time, inappropriate indication time values for the worst braking train would deteriorate the performance and the line capacity.

ERA answered this concern in the EECT meeting on 08/09/2015 (extract from the meeting minutes):

"… the indication time represents only a small contribution to the overall braking distance calculated by the on-board equipment, which depends on many other parameters (nominal emergency braking deceleration values, on-board correction factors, guidance curve , calculation of the lambda, etc...) relying upon the Railway Undertaking itself. For instance, how flat the braking curves are may strongly depend on the way a Railway Undertaking operate his train with regards its brakes maintenance policy. Above all ERA also recalls that the meaning of the indication (unlike the pre-indication whose any harmonised meaning could never be tabled by the Railways) remains the same as before (i.e. it is the trigger for the driver to act on the brakes), even though some flexibility is left to the RU to determine the indication parameter. Although the main driver is the brake build up time, the determination of this indication time can also for instance depend on how soft the GUI curve is and of the driving style that is expected from the drivers."

7.1.2 Missing relation to brake build-up time

In the SRS 3.4.0 the indication time is calculated as 0.8 x T_bs (brake build-up time), with a minimum of 5s in order to ensure there is enough time for the driver to apply the brakes.

With the solution for CR 1249 the T_Bs has disappeared from the calculation of the indication time and the RU can set the indication time to a specific value. If the train configuration is fixed it is no problem as the brake build-up time does not change. However, the situation is different for locos which can operate with quite varying train configurations for different journeys, reaching from short passenger trains to long freight trains. The brake build-up time for those configurations differs significantly. An indication time configured to a fixed value does not fit here. The indication would appear too early if the real brake build-up time is shorter than the one assumed when configuring the indication time. Even worse the indication would appear too late for staying within the permitted speed if the real brake build-up time is longer than the one assumed when configuring the indication time. Due to these effects the indication loses it's meaning to be the trigger to start braking.

7.2 More frequent interventions

During the discussion of CR 1249 Banedanmark expressed their concerns that the removal of the pre-indication could lead to more frequent interventions in their network.

Banedanmark decided to inhibit Service Brake Intervention in Target Speed Monitoring with the justification that with ETCS there would only be a very limited number of unintended brake interventions since the attention of the drivers is raised by the pre-indication when approaching a target. The removal of the pre-indication in combination with a relatively short configured indication time (defined by the RU) could increase the number of (emergency) brake interventions which leads to performance problems and higher wear on the rolling stock as well as on the tracks. It was questioned by BDK whether the change can be rated compatible when the operation is affected in this way.

8 Validation session at the SNCF simulator

8.1 Description

In order to acquire feedback from train drivers several sessions have been organised at the SNCF train simulator Simufer in Lille between 03/11/2015 and 10/11/2015. The simulator is used for research and consists of a projection of the virtual track and a cab allowing three-dimensional movements to give a realistic experience. The driver interface is similar to TGV trains. SNCF updated the simulator to incorporate the concerning Change Requests. The ergonomics expert and the EUG developed together a set of questionnaires to record the driver's feedback. A blank questionnaire and the answers of the drivers are provided as attachments to this report.

Seven drivers from six railways of five countries took part in the simulations. All the drivers had significant driving experience. This included running under ETCS L1 or L2 for freight, conventional passenger and high speed operations.

After an introduction to the background of the validation campaign and getting used to the simulator, the drivers were running several short scenarios covering the same topics as the videos created by EUG for the August meeting and additionally a longer scenario on the High Speed Line Paris – Lyon. The HSL scenario was executed one time with pre-indication and one time without it. After each run the drivers were asked to fill out one questionnaire.

Participants of the sessions:

Company	Name	Role	Attendance
SNCF	Mr Dussouchet	Session organisation	All days
SNCF	Mr Rousseau	Session organisation	All days
EUG	Mr Treydel	Session organisation	03/11, 04/11, 10/11
Intergo	Ms Weeda	Ergonomics expert	03/11
SBB	Mr Tonini	Driver	03/11
VTEC	Mr Lartey	Driver	04/11
ATW	Mr Evans	Driver	04/11
SNCF	Mr Dindin	Driver	05/11
NS	Mr Hodek	Driver	06/11
ÖBB	Mr Freiberger	Driver	10/11
ÖBB	Mr Sindelka	Driver	10/11

8.2 Results

This section summarises the driver's feedback mainly based on the questionnaires but also derived from discussions and explanations between the simulation runs.

8.2.1 Driving with the new solution

In general, it can be said that most of the drivers feel quite comfortable with the new solution. The preview for upcoming targets is much better. Almost all drivers were able to use the improved planning area information to anticipate the upcoming targets and to react in time on the speed changes without having the pre-indication. The general observation was that the driver got more comfortable with the new solution as they gained experience during the day.

A remark given by a number of drivers is that the pre-indication is very useful for raising the attention, especially in situations with distractions. However, if the pre-indication is shown too long as in the scenario on the HSL the attention decreases again. Then there is no added value and it unnecessarily draws the attention of the driver.

The drivers started braking with a normal braking force between the appearance of the indication and the moment the permitted speed starts decreasing. No one braked before the indication appeared, though sometimes the traction was cut before reaching the indication location.

The level of concentration needed is increased by the new solution. The drivers reported that they constantly monitor the planning area which conflicts with the obligation to observe the tracks on some lines (e.g. with user operated level crossings). Concerns were raised that in the simulations the driving is manageable whereas the experience could be different on conventional line with many stations, level crossings and speed changes.

Some drivers explained that they tend to drive more defensive and want to leave some margin for comfort. This could lead to a lower performance.

The new behaviour of the indication marker is accepted by all drivers.

8.2.2 Indication time

One scenario covered driving with three different indication times. The values were 5s, 9s and 12s. The drivers preferred the medium or long setting in order to have sufficient time to react. The shortest setting seems to be not comfortable enough.

One driver explained that the indication time does not matter for him as he normally reduces the speed before reaching the indication and then follows the permitted curve with some margin.

8.2.3 Preview of the speed changes ahead

In the simulator the values of speed changes are shown in the planning area for increases and decreases. The drivers mostly did not mention this as problematic. Some explicitly appreciated having all the information for coming speed changes, i.e. also for speed increases. In general, the drivers liked to be well informed about the situation ahead.

8.2.4 Falling hook

To investigate whether the effect of the falling hook could be problematic there was a scenario where the driver would be at a speed much slower than the Permitted and then enter Target Speed Monitoring respectively Release Speed Monitoring. The effect was seen by most but not all drivers. Only one driver saw it first as confusing but indicated that this is a matter of experience and training. Some other drivers also remarked that it looks strange, but in the end all drivers did not consider this effect problematic.

The ergonomics expert explained that it would in principle be better to have a smooth movement of the hook, but she shared the view of the drivers that the current solution is not problematic.

Implicitly the second part of the falling hook scenario (entering RSM directly from CSM) also addresses comment 23 of the UNISIG review sheet from 12/05/2015. Although the aim of the scenario was to investigate the falling hook effect it also showed that directly entering RSM without showing the release speed before was not reported by the drivers as being confusing.

8.2.5 Driving in OS without additional information

In comment 27 of the review sheet from 12/05/2015 UNISIG remarked that in OS, SR or UN without planning information the indication will be the first information for the driver of the moment to start braking. The driver's feedback confirmed that driving in On Sight without visual information is indeed very difficult.

Additionally, UNISIG highlighted that drivers could pay too much attention on the planning area if it is displayed in OS. In the simulator sessions the drivers however stressed that it would be helpful to display the planning area and the target distance in OS.

8.2.6 Sinfo at change of MRDT

With comment 26 of the review sheet from 12/05/2015 UNISIG raised the question why the sound Sinfo shall be played at every MRDT change. In 3.4.0 Sinfo is played when entering Pre-Indication Monitoring, which is considered to be the first part of Target Speed Monitoring. With the solution to be validated Sinfo is played when entering TSM or when the MRDT changes while in TSM. According to CR1084 the latter happens when an indication location of a new MRDT is passed. This situation is quite similar to entering TSM when the first indication location is passed. Therefore, playing Sinfo at MRDT changes seems to be appropriate.

It was not possible to test this behaviour during the validation campaign. In ERTMS Solutions tools playing sounds is currently not supported. In the SNCF simulator it was not possible to include a scenario with masked targets which would demonstrate the explained behaviour.

Despite not being tested the change appears to be reasonable and fully in line with the definition of Sinfo i.e. "draw the attention of the driver to some new visual information" (see DMI specification §14.3.1).

9 Discussion in EECT 16

In the EECT meeting 16 on 08/12/2015 EUG summarised the findings of the complete validation process as they are explained in the previous chapters of this document. ERA acknowledged specifically the problem described in section 7.1.2 as a technical shortcoming of the solution proposal which had to be corrected before including it in the mandatory specifications. In order to address this problem about the indication time a discussion took place on which formula to use for the calculation of the indication time. Since this would be a last minute change, leaving no room for a proper discussion with all relevant parties, it was agreed to minimise the impact on the existing formula in the SRS 340. The only change was to add the already existing driver reaction time T_driver (4s) to the original formula of the indication time, as a (partial) compensation of the deleted pre-indication.

$$T_{indication} = \max\{(0.8 * T_{bs}), 5\text{s}\} + T_{driver}$$

With this new formula the minimum indication time for good braking trains is 9s, which is in line with the results of the simulator sessions where the drivers generally preferred an indication time of at least 9s. The impact on trains with longer brake build up times may however be different. ERA (together with the sector) is currently preparing a long term perspective, including an ERTMS specifications roadmap, in which specific attention is given to the ERTMS braking curve model. Any possible further improvement of the newly defined indication time may be addressed in this long term context, but is outside the scope of this last minute change in the Baseline 3 Release 2 specifications.

10 Conclusions

This section draws conclusions on the most important topics of this validation campaign. It starts with the general feedback of the involved operational experts and the drivers and then summarises the detailed findings. Some of the findings continue to cause concerns in the railways.

10.1 General feedback

The operational experts in the August meeting and the drivers participating in the simulations gave in general quite positive feedback on the new solution. After getting used to it during the simulator session the drivers mostly concluded that the driving is comfortable or manageable. The additional information in the planning area is appreciated. In the simulator the drivers were mostly able to run without problems, but highlighted that the normal service is different from running in a simulator.

The ergonomics expert remarked that the number of drivers is too small to draw conclusions valid for all drivers in Europe. Furthermore, using a simulator and performing in an observed experiment the drivers will act, as some of them admitted, more concentrated than in normal driving situations. Despite these limitations the opinions and comments of the drivers give a valuable indication about the acceptability of the solution.

10.2 Configurable indication time

In the August meeting at EUG concerns were raised by ÖBB about letting the railway undertakings configure the indication time (see section 5.2.3). In the meantime also some IMs indicated to have concerns about this change as it could be incompatible to existing tracksides and makes engineering more complicated in the future (see section 7.1.1).

As explained in section 7.1.2 a fixed configured indication time without T_bs in the equation would be problematic for locos operating with different train configurations.

To address the missing relation between brake build-up time and indication time it has been decided in the EECT meeting 16 to use the indication time formula of SRS 3.4.0 and add an additional reaction time of the driver (see section 9). With this the issue of section 7.1.2 is solved. Additionally, as a consequence of this modification, the concern raised in section 7.1.1 is not relevant anymore.

10.3 Reduced adhesion

The safety problem under reduced adhesion conditions described by DB (see section 6) was not testable in the simulations and videos. It is not resolved with the current solution.

10.4 Values for speed increases in planning area

The operational experts concluded in the August meeting not to show the speed values at speed increase icons in the planning area in order to make a clear distinction between speed increases and decreases (see section 5.2.2). In the simulator session the values were shown for all speed changes in accordance with the solution to be validated. The drivers did not indicate to be confused by showing the speed value always. In general they appreciate to have as much information for planning ahead as reasonably possible (see section 8.2.3).

10.5 Additional information/notification before indication

Some railways see a need to give the driver additional information and/or notifications in advance of reaching the indication (see sections 5.2.1 and 6). It was explained by drivers during the simulator

sessions that the pre-indication is very useful to raise the attention of a driver when approaching a target, especially when there are distractions. The drivers feel they have to pay more attention with the new solution.

10.6 More frequent interventions

As detailed in section 7.2 there was a concern that removing the pre-indication could lead to more frequent brake interventions if the service brake is inhibited in Target Speed Monitoring. This would result in less performance and higher wear.

With the change described in section 9 the restored relation between brake build-up time and indication time prevents very short indications times. There is sufficient time to brake and avoid an intervention.