ERTMS UNIT

BASELINE 2
REQUIREMENTS FOR IMPLEMENTATION OF BRAKING CURVES FUNCTIONALITY

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AMENDMENT RECORD

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0.3	08/03/10	All	Revision according to Braking aspects engineering Workshop 10/02/10 and to release of SRS 3.1.0	AH
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2.0	19/06/12	3 4	Alignment of chapter 3 and chapter 4 with SUBSET-026 v3.3.0 and SUBSET-040 v3.2.0, respectively Release version	AH

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1. INTRODUCTION

1.1 Context and purpose

1.1.1.1 The braking curves function being an open point in the baseline 2, it is up to Member States to notify the National Technical Rules to be applied in this respect. Railway Undertakings and Infrastructure Managers must then apply those requirements to obtain the authorisation by the National Safety Authority.

1.1.1.2 For cross border trains, it can be easily understood that the implementation of several national solutions in the on-board equipment can induce significantly increased costs (SW design, cross acceptance tests, SW upgrade necessary whenever a national parameter is amended, ..). The aim of this document is therefore to offer a solution that can be adopted in each Member State to stop as soon as possible the proliferation of such national solutions (e.g. on-board tables based on NID_C), and ensure seamless compatibility with Baseline 3 equipped trains.

1.1.1.3 A comprehensive solution of the ERTMS/ETCS braking curves functionality has now been established by the Agency, in the frame of the baseline 3 definition and consolidation.

1.1.1.4 This has been formalised through the implementation of several Change Requests into the SRS 3.3.0.

1.1.1.5 This document shall be used as a reference by baseline 2 based projects, for which it would be desired to implement the ERTMS/ETCS braking curves functionality.

1.2 Scope

1.2.1.1 This document mainly specifies for both the Infrastructure Managers and the Railway Undertakings what shall be implemented in the ERTMS/ETCS products.

1.2.1.2 This document also aims at giving directions about how the on-board equipment will interact with the trackside, in the context of the braking curves function and the different possible combinations of on-board and trackside implementations: pure 2.3.0d, 2.3.0d with the braking curves add-on, baseline 3.

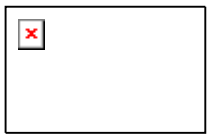
2. REFERENCE DOCUMENTS

Table 1 : reference documents

Ref. N°	Document Reference	Title	Version
[1]	2008/232/EC	Technical Specification for the Interoperability of the Trans-European High Speed rail system, Rolling Stock subsystem	21/02/2008
[2]	2011/291/EU	Technical Specification for the Interoperability of the Trans-European Conventional rail system, Rolling Stock subsystem – locomotives and passenger rolling stock	26/04/2011
[3]	SUBSET-026	ERTMS/ETCS System Requirements Specification	2.3.0
[4]	SUBSET-108	Interoperability-related consolidation on TSI annex A documents	1.2.0
[5]	SUBSET-040	Engineering rules	2.3.0
[6]	UIC 544-1	Brakes – Braking power	4th edition
[7]	EN15595	Railway applications - Braking - Wheel Slide Protection	2009

3. APPLICABLE SRS MODIFICATIONS

3.1.1.1 The braking curve functionality shall be implemented according to the modifications to document [3], which are detailed in the document embedded here below. The amended sections of the SRS are mostly applicable to the ERTMS/ETCS on-board equipment, but some SRS requirements are also relevant for trackside (e.g. structure of the new packet enclosing the National Values for braking curves).



3.1.1.2 The following provisions shall also apply in case of reception of a message including the packet 3 by the ERTMS/ETCS on-board equipment:

a) if the packet 203 is received in the same message, the National Values included in the packet 203 shall be appended to the packet 3 received in the same message, in order to form a single set of National Values, to which apply the distance to start of validity and the list of national area identifiers given in the packet 3.

b) if the packet 203 is not received in the same message, the National Values for braking curves Q_NVGUIPERM, Q_NVSBFBPERM, Q_NVINHSMICPERM, M_NVAVADH, M_NVEBCL, A_NVP12, A_NVP23, V_NVKVINT, M_NVKVINT, L_NVKRINT, M_NVKRINT, M_NVKTINT, A_NVMAXREDADH1, A_NVMAXREDADH2, A_NVMAXREDADH3 (introduced in system version number X.Y = 1.1), if already stored on-board and applicable, shall not be affected by the content of the packet 3 (i.e. if the National Values for braking curves were already applicable, they shall remain applicable with their country identifier(s) previously stored).

3.1.1.2.1 Note for b): if a mismatch is detected between the country identifier read from the balise group transmitting the packet 3 without the packet 203, and the corresponding identifier(s) with which the applicable set of National Values for braking curves was received and stored, the default values will be used for the National Values for braking curves (refer to 3.18.2.5 in the modified SRS as specified in this section 3).

4. ENGINEERING RULES

4.1 Emergency brake characteristics

4.1.1 Introduction

4.1.1.1 In order to allow the Infrastructure Manager to properly set the National Values for braking curves, it is necessary to define the conditions under which the nominal emergency brake deceleration and build up time are determined for the rolling stock.

4.1.1.2 If the braked weight percentage is acquired as Train Data by the ERTMS/ETCS on-board equipment and if the conversion model is applicable (i.e. the train is said to be a “Lambda” train), the speed dependent deceleration profile and the brake build up time, which are obtained from the Conversion Model, are to be considered as the nominal emergency brake deceleration and build up time. Note: the conversion model has been designed assuming that all the provisions laid down in the document [6], with the exception of sections 9.1.2 and 9.2.2, apply for the acquired braked weight percentage.

4.1.1.3 Otherwise, the nominal emergency brake deceleration profile(s) and build up time(s) are preconfigured and acquired as ETCS Train Data by the ERTMS/ETCS on-board equipment (i.e. the train is said to be a “Gamma” train”), and the rules specified here after (sections 4.1.2 to 4.1.5 inclusive) shall apply.

4.1.1.3.1 Note: these rules are applicable for one set of emergency brake deceleration profile, brake build up time and rolling stock correction factors belonging to a given set of ETCS Train Data, regardless of whether this latter covers one or more train formations.

4.1.2 Nominal emergency brake deceleration profile

4.1.2.1 Environmental conditions

4.1.2.1.1 The nominal emergency brake deceleration shall be based on the following environmental conditions: for conventional trains according to appendix F1.1 of document [6], for high speed trains according to case A of document [1].

4.1.2.2 Humidity of friction elements

4.1.2.2.1 The nominal emergency brake deceleration shall be based on dry friction elements.

4.1.2.3 Track profile

4.1.2.3.1 If field tests are carried out to define the nominal emergency brake deceleration, they shall be performed on straight and as level as possible track. The deceleration shall be corrected to level track.

4.1.2.4 Load

4.1.2.4.1 Passenger trains without automatic loading device

4.1.2.4.1.1 The nominal emergency brake deceleration shall be valid for normally loaded vehicles. (see clause 4.2.3.2 of document [1] and clause 4.2.2.10 of document [2]).

4.1.2.4.2 Passenger trains with automatic loading device

4.1.2.4.2.1 For vehicles with automatic loading device the nominal emergency brake deceleration shall be defined as the lowest deceleration from the whole loading range (from empty to exceptional load) and if the lowest deceleration is obtained by several loads then the greatest load shall be taken into account as the nominal loaded condition.

4.1.2.5 Use of special brake systems

4.1.2.5.1 Note: All installed brake systems can be considered by a Railway Undertaking in the nominal emergency brake deceleration, based on a reliability/availability study.

4.1.2.5.2 In case special brake system(s) (regenerative brake, magnetic shoe brake or eddy current brake) is/are considered by a Railway Undertaking in the nominal emergency brake deceleration and if the train is running on lines where a certain special brake system is not permitted or must be inhibited at certain locations (through the track condition “Inhibition of special brakes”), further nominal deceleration profiles without the contribution of the concerned special brake system shall be defined.

4.1.2.5.3 In case the dynamic brake not independent from the presence of voltage in the catenary (i.e. regenerative brake not backed up by a rheostatic brake) is included in the nominal emergency brake deceleration, further nominal deceleration profile(s) without the contribution of this brake shall be defined. Justification: the train will always encounter a powerless section (through the track condition “powerless section”) wherever it will operate.

4.1.2.6 Wheel Diameter

4.1.2.6.1 The nominal deceleration shall be based on new wheel diameter.

4.1.3 Emergency brake build up time

4.1.3.1 The nominal brake build up time shall be the equivalent brake build-up time as specified in section 3.13.2.2.3.2 of the modified SRS as specified in chapter 3 herein).

4.1.4 Rolling stock correction factor Kdry_rst

4.1.4.1 Kdry_rst(V,EBCL) shall be established for each confidence level that can be required by trackside (refer to sections 3.13.2.2.9.1.2, 3.13.2.2.9.1.3, 3.13.2.2.9.1.4 and variable M_NVEBCL in the modified SRS as specified in chapter 3 herein). For the dry rail reference conditions, see section 4.1.2.1.

4.1.4.2 Note: The Monte Carlo methodology has shown to be suitable for the determination of the Kdry_rst values. However the Railway Undertaking is free to choose another methodology, provided that it is able to demonstrate that the required confidence levels are achieved.

4.1.5 Rolling stock correction factor Kwet_rst

4.1.5.1 Trains fitted with Wheel Slide Protection system

4.1.5.1.1 In order to determine the correction factor Kwet_rst(V), field tests shall be made according to the provisions laid down in the following sections of the document [7]:

- 6.1.2 (ambient temperature condition),
- 6.2.3 table 5 tests 1&3 and 2&4 (test programme for initial speed 120 km/h and maximum train speed, respectively)
- 6.4.2.1 (generation of reduced adhesion)
- 6.4.3.5 (spraying conditions for tests at speed higher than 200 km/h)
- 6.4.4.1 (correction of the measured stopping distance)
- 6.4.4.2 (number and validity of tests on dry rails)
- 6.4.4.3.(evaluation of validity of tests on wet rails)

4.1.5.1.2 For each pair of deceleration distances (on dry rail and with reduced adhesion) obtained from the tests 1&3 and 2&4, the increase of deceleration distance (in %) obtained from the tests shall be used as follows to determine the correction factor: Kwet_rst = 100/(100+ increase of deceleration distance (in %)), with the deceleration distance resulting from tests 3 & 4 being the mean of the valid tests.

4.1.5.1.3 The deceleration distance is defined as the total distance travelled from the triggering of brake command to the train stop, minus the distance travelled from this triggering to the elapsing of the equivalent brake build up time.

4.1.5.1.4 In case a unique Kwet_rst (i.e. valid for all speeds) is defined by the Railway Undertaking, the maximum increase of stopping distance between the tests 1&3 and 2&4 shall be retained.

4.1.5.1.5 Note: supplementary tests at other initial speeds (e.g. low speed) may be performed according to the same requirements, e.g. depending on a particular braking system configuration.

4.1.5.2 Trains not fitted with Wheel Slide Protection system

4.1.5.2.1 For trains where the first four braked wheelsets are not fitted with a WSP system (without which the reference wheel/rail adhesion condition cannot be validated) the field tests specified in document [7] cannot be used and the rules of §4.1.5.1 shall not be applied

4.1.5.2.2 Note: For such trains, any value lower than or equal to 1 for the rolling stock correction factor Kwet_rst may be used.

4.2 National values for braking curves (packet 203)

4.2.1.1 The implementation of the ETCS braking curve model leads to the definition of new parameters, which are transmitted by trackside as National Values. It shall be possible

to transmit the packet 203 (National Values for braking curves) from balise or from RBC, according to the following rules.

4.2.1.2 All the telegrams of a balise group message, which includes the packet 203, shall be marked with the system version number 1.1.

4.2.1.3 An RBC that uses the packet 203 shall transmit a system version number equal to 1.1, when establishing the communication session.

4.2.1.4 A balise group or RBC message including the packet 203 shall also include the packet 3 (i.e. in a message, the packet 203 cannot be transmitted without the packet 3).

4.2.1.5 Note 1: to allow the transmission of the packet 203 over the RBC-RBC interface is not deemed necessary.

4.2.1.6 Note 2: the transmission of packet 3 as infill information is not permitted (see clause 4.2.4.5.1 of document [5]); the sending of packet 203 from loop or RIU is not possible since packet 203 together with packet 3 are location based information, which could not be interpreted by the on-board if they are sent as non-infill information by loop or RIU.

4.3 Reduced adhesion profiles (packet 71 – adhesion factor)

4.3.1.1 In baseline 2 implementations, it is possible to send from trackside reduced adhesion information valid for areas where the EBD curve will be locally affected by the clipping of the emergency brake deceleration profile. For ERTMS/ETCS on-board equipment fitted with the ETCS braking curve functionality, the variable M_ADHESION shall however have a different meaning than the one defined in document [3]:

- Value 0 of M_ADHESION means “slippery rail”, in which case the emergency brake deceleration profile shall be clipped by the on-board equipment, with the applicable National Value A_NVMAXREDAH, according to the type of brakes.
- Value 1 of M_ADHESION means “non slippery rail”, in which case no clipping of the emergency brake deceleration profile shall be applied by the on-board equipment.

5. CROSS BORDER TRAFFIC VS BRAKING CURVES FUNCTION

5.1 Handling of correction factors- computation of the EBD&EBI

5.1.1.1 The Table 2 gives an overview of the different possible combinations, which can arise when trains fitted with or without the ETCS braking curve functionality will be operated on a pure 2.3.0d infrastructure or on a 2.3.0d infrastructure where the packet 203 is implemented.

5.1.1.2 The Table 2 focuses on the way the correction factors will be applied to compute the EBD braking curve and the EBI supervision limit, depending on the way the braking performance of the train is captured in the ETCS on-board equipment:

- “Gamma” trains: the emergency braking deceleration profile is preconfigured and captured as ETCS Train Data in the on-board equipment
- “Lambda” trains: the brake percentage is captured through driver data entry AND the conversion model is applicable

On-board / Trackside	Pure 2.3.0d	2.3.0d with ETCS BC function		Baseline 3	
		Gamma	**Lambda**	**Gamma**	**Lambda**
Pure 2.3.0d	Proprietary/ National BC algorithm ↓ EBD	Nominal deceleration profile + RST correction factors + Default values for M_NVEBCL, M_NVAVADH ↓ EBD&EBI	Lambda single value + Conversion model + Default values for integrated corr. factors ↓ EBD&EBI	Nominal deceleration profile + RST correction factors + Default values for M_NVEBCL, M_NVAVADH ↓ EBD&EBI	Lambda single value + Conversion model + Default values for integrated corr. factors ↓ EBD&EBI
2.3.0d with packet 203	Packet 203 is ignored Proprietary/ National BC algorithm ↓ EBD	Nominal deceleration profile + RST correction factors + M_NVEBCL, M_NVAVADH from pck 203 ↓ EBD&EBI	Lambda single value + Conversion model + Integrated corr. factors from pck 203 ↓ EBD&EBI	Nominal deceleration profile + RST correction factors + M_NVEBCL, M_NVAVADH from pck 203 ↓ EBD&EBI	Lambda single value + Conversion model + Integrated corr. factors from pck 203 ↓ EBD&EBI

Table 2: Elaboration of the EBD and EBI in relation to the on-board and trackside possible implementations

5.1.1.3 The Table 2 illustrates an important point: there is no difference of behaviour between a baseline 3 train and a 2.3.0d train with the ETCS Braking Curves add-on, wherever the train is operated.

5.1.1.4 While it is very likely that the notion of correction factors does simply not exist in the current proprietary on-board implementations, the column “pure 2.3.0 on-board” is however shown for completeness reasons.

5.2 Compatibility issues

5.2.1.1 In the frame of the baseline 2.3.0d currently in force, the compatibility between on-board and trackside implementations, for what regards the braking curves functionality, is solved through National Rules, and in case of cross-border operation via bi-lateral agreements.

5.2.1.2 Therefore the compatibility between on-board fitted with the ETCS braking curves and pure 2.3.0d trackside can be guaranteed only after appropriate checks, in particular in terms of performance taking into account the default values for National Values for braking curves. This can be done for instance by benchmarking the current proprietary/national solutions, which have been implemented in the trains already placed into service.

5.2.1.3 In case the default values for the National Values do not allow the train fitted with ETCS braking curves to meet the requirements applicable on a pure 2.3.0d trackside, then the packet 203 must be implemented on the concerned line.

5.2.1.4 Note: the default values for gamma trains are by definition the safest ones, while for lambda trains the following default values are assumed as safe[1]: Kv_int = 0.7, Kr_int = 0.9, Kt_int = 1.1 (see modified SRS as specified in chapter 3 herein).

[1] These default values may be tuned at a later stage, further to some benchmarking with the existing implementations