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Operational temporary speed reductions on the ETCS-DMI

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Abstract

Dealing with a congested railway area becomes an important topic in railway operation management. Significant efforts are made to develop a Driver Advisory System (DAS) in connection with the trackside Train Management System (TMS). Many advantages are expected from smoothing train dynamic speed profiles: timetable resilience, significant reduction of both the energy consumption and the wear and tear and, finally, positive impacts on the comfort for passengers. Today, on the one hand, only a few Centrally Guided Train Operation Systems (CGTO) are already in operation on European major railways. On the other hand, the European Train Control System (ETCS) spreads rapidly. Such combination offers a great opportunity to promote a European standard CGTO system using the ETCS-DMI opportunities.

The present paper describes many options using either the "Monitoring" area, or the "Supplementary Driving Info" area, or the "Planning" area, or the "Speed Info" area; or a combination of them on the ETCS Diver Machine Interface (DMI). Some of them give only advices or guidance but some of them indicate operational temporary speed reductions (O_TSR) that are mandatory.

Historical research, current experiments, and dispatching concepts in bottlenecks areas militate in favour of the compulsory character of temporary speed limits due to congestion. Therefore, the last option presented here should be more examined more in depth.
Keywords: ETCS, DMI, DAS, CGTO, speed guidance, operational TSRs.

1 Introduction

On the one hand, the Driver Advisory Speed (DAS) concept has already a long history. Specific lateral signals were used in many rail networks to order drivers

to speed up or slow down the train preventively due to a potential conflict situation far ahead. Such signalling combines positive aspects: minimising the global delay of trains, reducing energy consumption as well as tear and wear.

On the other hand, the ETCS-DMI has a long future ahead. It becomes therefore important to introduce, as soon as possible, a common standard for the connection of a DAS to the ETCS-DMI, in order to provide information from the Train Management System (TMS) to the driver.

However, what is the final goal of a Centrally Guided Train Operation System (CGTO)? Only giving information or guidance? Or giving speed orders that must be obeyed?

This paper proposes some options to develop a standard CGTO and to answer to the question above.

2 Speed representations in the ETCS-DMI and human factors

The default window of ETCS-DMI is divided in many rectangular areas. The "Supervised Distance Info" (A), "Speed Info" (B), "Supplementary Driving Info" (C), "Planning" (D) and "Monitoring" (E) areas are concerned by this study.

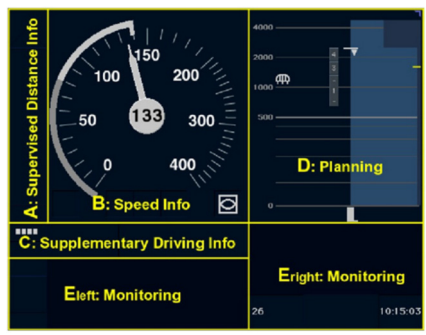

Figure 1: Respective positions of the areas of a ETCS-DMI display.

These areas are used for speed and supervision information. The main focus of the driver is on the "Speed info" area, which displays namely the actual speed, the speed limit, and the level of speed supervision. As soon as the train approaches a speed reduction, the driver widens slightly its focus to encompass the "Supervised Distance Info" area, which gives some information needed for convenient braking. The peripheral view can also catch what is displayed by the "Supplementary Driving Info" area, like the red symbol of a system brake intervention or the yellow symbol of the announcement of a tunnel that is a non-stopping area.

Before choosing ETCS-DMI Speed Advice or Speed Guidance colours, it is necessary to take into account both the ETCS colour philosophy and the way the drivers react to colours displayed on the ETCS-DMI, in particular those appearing in the "Speed Info" area.

2.1 Colour and sound philosophy

"Grey" is the colour of normality. The Ceiling Speed Monitoring (CSM) is the normal driving situation as long as a compulsory speed reduction isn't foreseen. The Circular Speed Gauge (CSG) is "dark grey" and the speed pointer is "grey". These colours stay unchanged in the Target Speed Monitoring (TSM) situation as long as there is no need to notify the reduction of the actual speed of the train.

"Yellow" is the colour of a speed reduction warning. This colour appears in the TSM situation when, according to the actual speed of the train, speed reduction has to be proceeded. Upon entering this status, the audible information Sinfo is played.

"Orange" is the colour of overspeed warning. This colour is used as soon as the actual speed of the train is higher than the Most Restrictive Dynamic Speed Profile (MRDSP). Upon entering this status, the audible information S1_toofast info is played. When the "Orange" colour is near changing to "Red" the audible information S2_warning info is played.

"Red" is the colour of system intervention. This colour indicates, in speed topics, the overtaking of the overspeed tolerance. In this situation, the system brakes the train by itself.

Table 1: Conditions for display and colour of the speed pointer in FS mode when Vrelease does not exist [1].

Supervision Status	$0 \leq$ pointer $\leq V_{perm}$	$0 \leq$ pointer $< V_{target}$	$V_{target} \leq$ pointer $\leq V_{perm}$	pointer $> V_{perm}$
CSM – NoS	Grey	–	–	–
CSM – OvS/WaS	–	–	–	Orange
CSM – IntS	Grey	–	–	Red
TSM – IndS	–	Grey	Yellow	–
TSM – OvS/WaS	–	–	–	Orange
TSM – IntS	–	Grey	Yellow	Red

Table 2: Conditions for display and colour of CSG in FS mode when Vrelease does not exist [1].

Supervision Status	$0 \leq$ CSG $\leq V_{perm}$	$0 \leq$ CSG $< V_{target}$	$V_{target} \leq$ CSG $\leq V_{perm}$	$V_{perm} <$ CSG $\leq V_{SBI}$
CSM – NoS	Dark Grey	–	–	–
CSM – OvS/WaS	Dark Grey	–	–	Orange
CSM – IntS	Dark Grey	–	–	Red
TSM – IndS	–	Dark Grey	Yellow	–
TSM – OvS/WaS	–	Dark Grey	Yellow	Orange
TSM – IntS	–	Dark Grey	Yellow	Red

Table 3: Definition of ETCS-DMI (*left*) and NTC (*right*) additional colours (Red/Green/Blue) [1].

Colour name		Red/Green /Blue
Yellow		223/223/0
Orange		234/145/0
Red		191/0/2
Dark Blue		3/17/34
Shadow		8/24/57
PASP dark		33/49/74
PASP light		41/74/107
White		255/255/255
Grey		195/195/195
Medium Grey		150/150/150
Dark Grey		85/85/85
Black		0/0/0

Colour name		Red/Green /Blue
Blue		0/0/234
Green		0/234/0
Light Red		255/96/96
Light Green		96/255/96
SBB (2006):		
Very Light Grey		215/251/215
Dark Yellow		105/105/0
Magenta		255/0/255
SNCF (2015):		
NExTEO Blue		63/173/255

2.2 Driving styles

The Target Speed Monitoring (TSM) is the situation when the speed limit of the train has to be reduced. Depending on the speed of the train at that time and the driving style taught to the drivers, drivers will react very differently. According to table 4, three main driving styles can be distinguished. In this paragraph, no energy saving consideration is taken into account.

Table 4: Colour and driving style.

Driving style before/during a speed reduction	Alternate driving style description	Subjective appreciation	Consequence
"dark grey"	–	over-cautious	significant loss of time
"yellow"	"indication"	standard	–
"yellow hook"	"limit"	limit	risk of overspeeding

The "dark grey" driving style is over-cautious. The goal of such kind of driver is to always run with "dark grey" CSG and grey speed pointer. Such drivers anticipate the speed reduction order and reduce pro-actively the speed of their train.

The "yellow" driving style is adequate with the ERTM/ETCS braking curve philosophy. The driver reduces significantly the speed of the train only when the

yellow colour is displayed and the Sinfo sound is played. When applying this driving style, the actual speed stays slightly under the permitted speed until the target speed is reached.

The "yellow hook" driving style is not a good practice. Running at "yellow hook" means to run at the decreasing permitted speed. It isn't a safe way to drive; if adhesion situation is weaker than expected, the deceleration effort may not be sufficient, and the orange colour could rapidly turn into the red one, indicating a system brake intervention.

3 Some options to display Speed Advice/Guidance on the ETCS-DMI

The purpose of speed advices or speed guidance is not to distract drivers from safety information.

Therefore, speed advices or guidance must not be shown as soon as the ETCS-DMI displays an "Indication" (Yellow) or a "Overspeed/Warning" (Orange) status. In this paper the "DAS colour" is supposed to be Green (cf. figure 3).

The AG1 option is already in use today [2]. It uses a text indication presented in the Monitoring Area (ETCS-DMI – E-Area).

The AG2 option was presented with some making variants in [3]. Advice/Guidance is presented in the Supplementary Speed Info Area (figure 2).

Colour and meaning	"grey_shade" option	"grey-white" option
no advice	Dark blue (background)	Dark blue (background)
Speed to be gradually reached	Medium Grey	Grey
Speed to be rapidly reached	Grey	White
Speed to be maintained	Dark Grey	Medium Grey

Figure 2: Option AG2 – CGTO – Example: 120 km/h to be reached rapidly ("grey-white" option / Advice from TMS / ETCS L1 FS).

Unfortunately, in ETCS baseline 3, the Supplementary Driving Info Area has no place anymore to present speed advice/guidance [1].

The AG3 option uses O_TSR displayed in the Planning area (ETCS-DMI – D-Area). Advice – or even guidance – is transmitted from TMS to DMI (cf. figure 3).

Like AG3, the AG4 option uses O_TSR displayed in the Planning area (ETCS-DMI – D-Area). O_TSR is also displayed in the Speed info area (ETCS-DMI – C-Area) by painting in green the CSG from bottom to V_OTSR as long as the train is under the CSM NoS supervision or the TSM IndS supervision with actual speed under Vtarget.

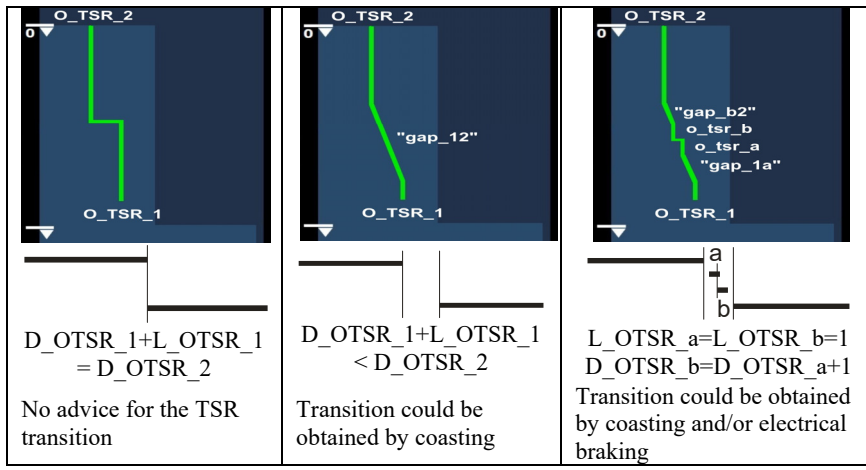

Figure 3: Option AG3 –advice/guidance in the ETCS-DMI PASP part.

4 Tentative of displaying Operational Speed Order on the ETCS-DMI

In this last family of options, O_TSR are considered to draw the ETCS Static and Dynamic Speed Profiles and then to build the braking curves. These following options differ only on the information given to the driver.

Within the O5 option the driver cannot distinguish O_TSR from TSR due to safety reasons.

Within the O6 option the driver can distinguish O_TSR from other TSR only in the Planning area (cf. figure 3).

Within the O7 option the driver can distinguish O_TSR from other TSR in the Planning area like option O6 (cf. figure 3, left). O_TSR is also displayed in the Speed info area by painting in green the CSG from bottom to V_OTSR as long as the train runs with the Normal status (NoS).

5 Implementation for speed advice, guidance or order

As mentioned earlier, O_TSR is the means to transmit speed advice, guidance or order. The ERTMS on-board system must then distinguish two new “messages”: “Operational Temporary Speed Restriction” and “Operational Temporary Speed Restriction Revocation”.

The first will be similar, in structure, to the ETCS packet 65 “TSR” and the last similar to the ETCS packet 66 “TSR revocation”.

5.1 Attempt with ERTMS baseline 3

Packets 65 (TSR) and 66 (TSR Revocation) use the identity number of the TSR NID_TSR (8 bit length). It could be possible to reserve specific values of NID_TSR to transmit O_TSR, by example [11000001-11110111]=[193-239].

If the onboard system is not able to distinguish between TSR and O_TSR, both will be considered as TSR and safety is ensured.

However, it is quite important that the Traffic Management System (TMS) is aware that specific NID_TSR are used for O_TSR and not for standard TSR in order not to send a TSR which will be interpreted on board as an O_TSR. One possible mechanism to inform the onboard unit the TMS consciously uses O_TSR is to send a very particular and illogical TSR just before an O_TSR in the same message. For example, this TSR could contain V_TSR=[1110001]=[113] which mean a TSR at 565 km/h.

5.2 Alternative attempt with a future ERTMS baseline

The easiest way is to create two new packets (cf. SUBSET-026-7 v300); packets 165 and 166 (cf. table 5) for example.

Table 5: O_TSR – new ETCS packets 165 and 166.

Transmission of temporary speed restriction (packet 165)	
Variable	Length
NID_PACKET	8
Q_DIR	2
L_PACKET	13
Q_SCALE	2
NID_OTSR	8
D_OTSR	15
L_OTSR	15
Q_FRONT	1
V_OTSR	7

Transmission of temporary speed restriction revocation (packet 166)	
Variable	Length
NID_PACKET	8
Q_DIR	2
L_PACKET	13
NID_OTSR	8

6 Short and very specific glossary, abbreviations and acronyms

Centrally Guided Train Operation Systems: Driver Advice Systems (DAS) receiving Speed Advice continuously or semi-continuously from the track-side Traffic Management System (TMS). This term was used in the FP7 European Research Project "ON TIME" [4].

Operational Temporary Speed Restrictions: Speed Restrictions varying rapidly in space and time. They are not given for safety raisons but mainly for more fluid traffic.

Speed Advice: Discrete speed indication given in advance to the driver. The driver can decide freely how to comply with the advice. No system intervention is foreseen if the driver ignores the advice.

Speed Guidance: Speed indications given in advance to the driver. The guidance can be continuous or semi-continuous (target speed and tactic to reach it). No system intervention is foreseen if the driver ignores the guidance as long as the train runs under the safe speed profile.

Speed Order: Speed indications given in advance to the driver. The order shall be obeyed by the driver. If not, a system intervention brakes the train.

Table 6: Abbreviations and acronyms.

ATO	Automatic Train Operation	MRDSP	Most Restrictive Dynamic Speed Profile
ATP	Automatic Train Protection	NoS	Normal Status
CGTO	Centrally Guided Train Operation System	NTC	National Train Control System
CSG	Circular Speed Gauge	OvS	Overspeed Status
CSM	Ceiling Speed Monitoring	O_TSR	Operational Temporary Speed Restriction
DMI	Driver Machine Interface	P	Permitted Speed/Decel. (braking curve)
EBI	Emergency Brake Intervention (brak. curve)	PASP	Planning Area Speed Profile
EoA	End of Authority (ETCS)	RBC	Radio Block Centre (GSM-R)
ERTMS	European Railway Train Management System (=ETCS+GSM-R+ETML)	RS	Rolling Stock
		RSM	Release Speed Monitoring section
ETCS	European Train Control System	RU	Railway Undertaking
ETML	European Train Management Layer	SATO	Semi-Automatic Train Operation
EVC	European Vital Computer (on-board)	SBMD	System Brake Maximal Deceleration (braking curve)
FS	Full Supervision		
GSM-R	Global System for Mobile communications – Railways	Sinfo	Standardised information sound (2 identical short and close sounds)
GUI	Guidance Speed/Decel. (braking curve)	SvL	Supervised Location (ETCS)
HS	High Speed	TMS	Traffic Management System
HSL	High Speed Line		
I	Indication Curve	TSI	Technical Specification for Interoperability
IM	Infrastructure Manager		
IndS	Indication Status	TSR	Temporary Speed Restriction
IntS	Intervention Status		
IXL	Interlocking	TSM	Target Speed Monitoring
KVB	Contrôle de Vitesse par Balise	WaS	Warning Status
		ZUB	ZUg Beeinflussung
MRSP	Most Restrictive static Speed Profile		

7 Conclusion

AG3, AG4 as well as O7 options are simple to implement. Information about O_TSR is simple and mainly given in the ETCS-DMI Planning area.

Those implementation propositions can likely by adopted by Railway Undertakings and Infrastructure Managers at a European wide level.

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