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Work-Package 2: Requirements

Methods and tools benchmarking methodology

WP2 D2.5

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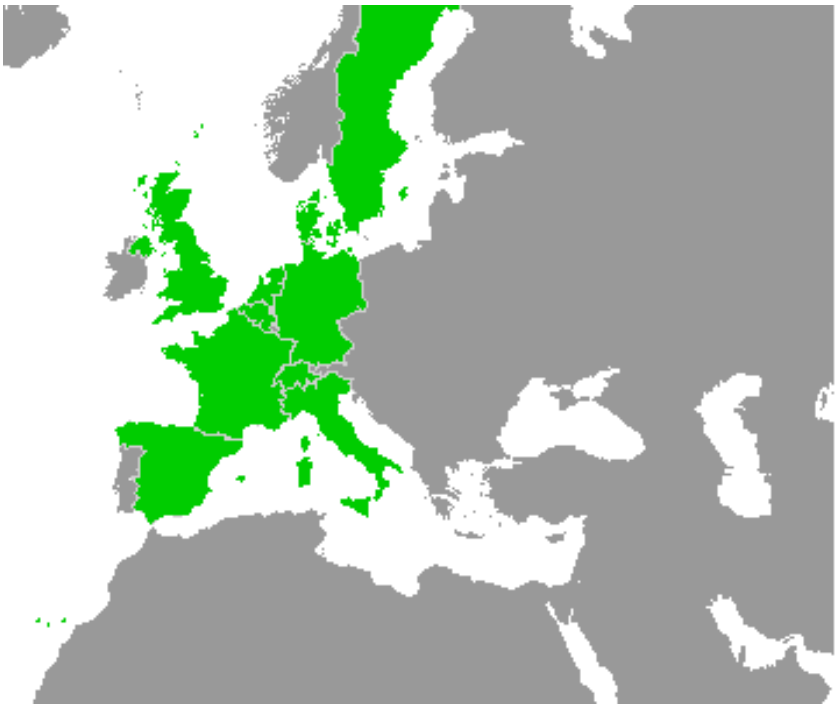

Methods and tools benchmarking methodology

WP2 D2.5

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Requirements

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Abstract: This document is the deliverable of the WP2 D2.5 task, it defines the subset of SRS SUBSET-026 that should be used to evaluate formal modelling tools.

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1 Introduction

The purpose of this document is to define the methodology for the methods and tools benchmarking activities.

WP2 D2.1 has shown that several methods and tools are available to make the formal model of the On Board Unit in WP3. In order to evaluate them in WP7, WP2.D2.5 need to define a representative part of the SUBSET-026 that would be modelled by each candidate, therefore allowing comparing the tools on the same basis.

A formal model is composed of two different aspects:

- the modelisation of functionalities in a non ambiguous language/semantics (allowing refinements to the code or code generation), that we will call the *modelisation* aspect;
- the proofs of safety properties, that we will call the *proof* aspect.

For the modelisation aspect, the idea is to cover all the different means of description needed for SUBSET-026 in order to highlight the strong points and weak points of a potential language/semantic. Moreover, there is the need of having a sufficient and self content part of a functionality for the proof aspect in order to verify the proof capability of the method/tool.

This document is initiated as a preliminary version. The final version is planned for the end of May 2013.

2 Reference documents

SUBSET-026 3.3.0 — *System Requirement Specification*

SUBSET-058 3.0.0 — *STM Application layer*

SUBSET-091 3.2.0 — *Safety Requirements for the Technical Interoperability of ETCS in Levels 1 & 2*

3 Glossary

EBD Emergency Brake Deceleration curve

EBI Emergency Brake Intervention curve

EOA End Of movement Authority

FLOI First Line Of Intervention

FS Full Supervision mode

FTA Fault Tree Analysis

IS ISolated mode

MA Movement Authority

MRDT Most Restrictive Displayed Target

MRSP Most Restrictive Speed Profile

OBU On Board Unit

OS On Sight mode

SB Stand By mode

SH SHunting mode

SRS System Requirement Specification

STM Specific Transmission Module

TSR Tempory Speed Restriction

WP Work Package

4 Content of the benchmarking

4.1 Modelisation aspect

The following paragraphs of SUBSET-026 are representative of the diversity of means of description used in the SRS and should be used in the benchmark. These paragraphs are divided into two sections: a high priority one that should be modelled first and a lower priority that should be modelled if time permits.

In Appendix A, there is a list of standardised variables for each SRS paragraph chosen for the benchmark. It will facilitate the review of the different models.

4.1.1 State machines

The modelisation of state charts will indicate if the review of this modelisation is easy or not according to the SRS. There are several state charts in chapter 5 and some of them are huge, especially the first one "start of mission".

HIGH PRIORITY **§5.9 Procedure On-Sight** State chart which contains a timer and is not too long.

4.1.2 Time-outs

The OBU is in interface with the trackside and it means that time-outs management is needed.

HIGH PRIORITY **§3.5.3 Establishing a communication session**

4.1.3 Arithmetics and Braking curves

The OBU must calculate several braking curves to determine if it will not exceed the safe speed / distance. These curves are defined in baseline 3, chapter 3.13 of SUBSET-026. Braking curves represent a big challenge for formal models. Indeed it is not always possible to do it in the high level modelisation language, but rather in low level language like C or ADA. The following examples take into account different aspects of this problematic.

HIGH PRIORITY **§3.13.4 (Acceleration / Deceleration due to gradients)**

HIGH PRIORITY **§3.13.6.2 Emergency brake** and more particularly:

- §3.13.6.2.1.3 (calculation of A_safe, function of V and d, depending on the gradient profile, braking models of the train, several correction factors etc; this is the basis of the EBD curve, see Figure 38)

HIGH PRIORITY **§3.13.7 Determination of Most Restrictive Speed Profile (MRSP)** Combine for example several TSR and LX restrictions

HIGH PRIORITY **§3.13.8.3 Emergency Brake Deceleration curves (EBD)**

***HIGH PRIORITY* §3.13.9.3.3.9 Computation of d_FLOI, using d_SBI2_MREBDT** (MREBDT: Most Restrictive Target amongst the EBD based targets)

***HIGH PRIORITY* §3.13.9.4 Release speed supervision limits** and more particularly:

- §3.13.9.4.7 (computation of different release speed supervision limits)
- §3.13.9.4.8 (computation of the most restrictive value at the Trip location related to the EOA, amongst several EBI supervision limits)
- 3.13.9.4.8.2 (iterative computation of the release speed)
- §3.13.9.4.9 (using of the most restrictive MRSP value instead of the release speed)

***HIGH PRIORITY* §3.13.10.4.2 Calculation of the MRDT**

4.1.4 Truth Tables and Logical Statements

SUBSET-026 can be considered as a tool box and there is also a lot of modes / information / functionality available. All these possibilities are combined into big truth tables representing hundreds of cases. The modelisation of these tables will indicate if the review of this modelisation is easy or not according to the SRS.

***HIGH PRIORITY* §4.6.2 (Transitions Table) and §4.6.3 (Transitions Condition table)** Only transitions:

1. from SB to SH
2. from SB to FS
3. from SB to IS

Having transitions at different priority level is important to look at priority issues and exclusion issues at the same priority level.

***Low priority* §4.8.3.2 From National System X (through STM interface)** Model a small table.

4.1.5 Data structure

SUBSET-026 defines the format and content of messages for ERTMS/ETCS functions. The ERTMS/ETCS language (refer to SUBSET-026 chapter 7 and 8) is used for transmitting information over the radio, balise and loop airgaps and the STM interface. It is based on variables, packets, messages and telegrams.

***Low priority* §3.6.3.2 Location, Continuous Profile Data and Non-Continuous Profile Data** Example of complex generic data structure.

***Low priority* §3.8.3 Structure of Movement Authority and §3.8.5 Update of Movement Authority** Example of complex procedure, with complex data.

***Low priority* §3.11.3 Static Speed Profile and §3.11.12 Gradients** Example of data structure, referring to §3.6.3.2 and used by §3.13.4.

***Low priority* §8.7.2 Movement Authority message** This includes reference to Packet 15 (§7.4.2.4). That would be a perfect use case for tools able to model things down to bit level.

4.2 Proof aspect

From the previous list, only §3.5.3 (Establishing a communication session), §4.6.2 (Transitions Table) and §5.9 (Procedure On-Sight) would be considered in this section. The others are not sufficiently self content.

Since the safety process is not precisely defined at the moment, **the following paragraph must not be used as reference for the future safety activities. There is no guarantee of completeness or correctness.**

The objective is only to give some examples of safety requirements that can be used for testing the proof capability of a tool / method. SUBSET-091 will then be considered as the basis.

IMPORTANT NOTE: In SUBSET-026, all the requirements related to one function are not gathered in the same paragraph. They are in different sections. So there is a risk that it can be difficult or impossible to prove some safety requirements because a part of the proof needs more information than what is specified in the chosen paragraph.

4.2.1 §3.5.3 Establishing a communication session

Safety requirements will be proposed according to the following SUBSET-091 items:
KERNEL-5 Radio link supervision function failure
KERNEL-6 Manage communication session failure

Without trying a FTA or FMECA approach, a simple property comes directly in mind:

PROPERTY_3.5.3_01 OBU shall never have two different communication sessions established at the same time (with the same RBC or with two different)

4.2.2 §4.6.2 Transitions Table

Safety requirements will be proposed according to the following SUBSET-091 item:
KERNEL-27 Incorrect System Data

Most of the safety behavior is yielded by the model itself and it is difficult to produce a set of declarative properties, and to avoid paraphrase. In Isolation mode, OBU has no more responsability and is isoled from the brakes, we can consider that the transition to or from this mode is safety relevant.

PROPERTY_4.6.2_01 OBU shall never enter in isolated mode if not requested by the driver

PROPERTY_4.6.2_02 OBU shall never leave Isolated mode (no transition from Isolation is specified)

4.2.3 §5.9 Procedure On-Sight

Safety requirements will be proposed according to the following SUBSET-091 item:
KERNEL-19 Failure of train trip supervision in OS, LS and FS

Let's try a FTA approach *(Figure 1)*.

The result is three safety requirements.

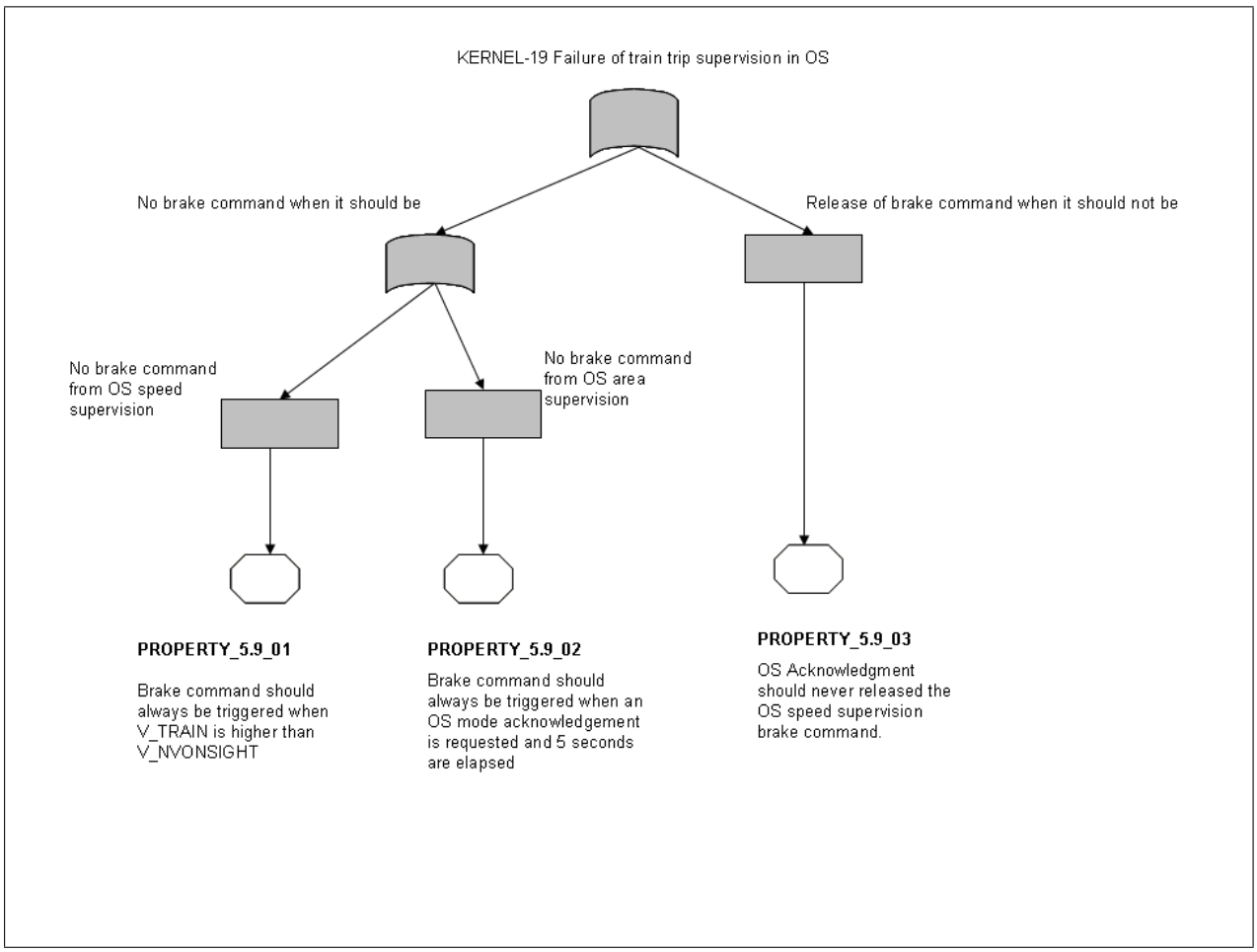

Figure 1. FTA of Kernel 19

PROPERTY_5.9_01 Brake command should always be triggered when V_TRAIN is higher than V_NVONSIGHT

PROPERTY_5.9_02 Brake command should always be triggered when an OS mode acknowledgement is requested and 5 seconds are elapsed

PROPERTY_5.9_03 OS Acknowledgment should never released the OS speed supervision brake command.

5 Methodology of the benchmarking and role of WP7

WP2 is in charge of the definition of the benchmark (this document).

WP7 is in charge of the realisation of the benchmark. The evaluation matrix will be created by WP7, based on the deliverables of WP2.

The evaluation shall be done by independant persons from those who has done the modelisation and from the provider of the means or tools.

Appendix A: ERTMS/ETCS Language

The purpose of this appendix is to propose common variables / packets / messages for the models.

Variables shall be used to encode single data values. Variables cannot be split in minor units. The whole variable has one type (meaning)
Packets are multiple variables grouped into a single unit, with a defined internal structure.
A message (Euroradio/Euroloop) or telegram (Eurobalise) shall be composed of one Header, when needed, a predefined set of variables (only for Radio), when needed, a predefined set of Packets (only for Radio), optional Packets as needed by application.

All the variables are not defined since it could depend on modelisation choices (especially internal variables of the OBU which are not defined in the SUBSET-026). It is also mainly focussed on chapter 7 and 8 of SUBSET-026.

The following lists are surely not complete but it is a good basis.

A.1 §3.5.3 Establishing a communication session

Packet Train to Track : SUBSET-026 §7.4.3.3 Packet number 3 Onboard telephone numbers

Message Train to Track : SUBSET-026 §8.6.13 Message 155 Initiation of a communication session

Message Train to Track : SUBSET-026 §8.6.14 Message 155 Termination of a communication session

Message Train to Track : SUBSET-026 §8.6.17 Message 159 Session established

Packet Track to Train : SUBSET-026 §7.4.2.1 Packet number 2 System Version order

Packet Track to Train : SUBSET-026 §7.4.2.10 Packet number 42 Session Management

Packet Track to Train : SUBSET-026 §7.4.2.11.1 Packet number 45 Radio Network registration

Packet Track to Train : SUBSET-026 §7.4.2.27 Packet number 131 RBC transition order

Packet Track to Train : SUBSET-026 §7.4.2.37.1 Packet number 143 Session Management with neighbouring Radio Infill Unit

Message Track to Train : SUBSET-026 §8.7.12 Message 32 RBC/RIU System Version

Message Track to Train : SUBSET-026 §8.7.16 Message 38 Initiation of a communication session

Message Track to Train : SUBSET-026 §8.7.17 Message 39 Acknowledgement of termination of a communication session

A.2 §5.9 Procedure On-Sight

Variable : SUBSET-026 §7.5.1.72 M_MODE

Variable : SUBSET-026 §7.5.1.65 M_LEVEL

Variable : SUBSET-026 §7.5.1.162 V_NVONSIGHT

Variable : SUBSET-026 §7.5.1.172 V_TRAIN

Message Train to Track : SUBSET-026 §8.6.7 Message 146 Acknowledgement

Message Train to Track : SUBSET-026 §8.6.9 Message 149 Track ahead free granted

Packet Track to Train : SUBSET-026 §7.4.2.26 Packet number 80 Mode profile

Packet Track to Train : SUBSET-026 §7.4.2.26.2 Packet number 90 Track Ahead Free up to level 2/3 transition location

Message Track to Train : SUBSET-026 §8.7.14 Message 34 Track Ahead Free request

A.3 §3.13 Braking curves

Variable : SUBSET-026 §7.5.0.1 A_NVMAXREDADH1

Variable : SUBSET-026 §7.5.0.2 A_NVMAXREDADH2

Variable : SUBSET-026 §7.5.0.3 A_NVMAXREDADH3

Variable : SUBSET-026 §7.5.0.4 A_NVP12

Variable : SUBSET-026 §7.5.0.5 A_NVP23

Variable : SUBSET-026 §7.5.1.1 D_ADHESION

Variable : SUBSET-026 §7.5.1.4 D_DP

Variable : SUBSET-026 §7.5.1.13 D_LRBG

Variable : SUBSET-026 §7.5.1.19.1 D_PBD

Variable : SUBSET-026 §7.5.1.19.2 D_PBDSR

Variable : SUBSET-026 §7.5.1.37 G_A

Variable : SUBSET-026 §7.5.1.37.1 G_PBDSR

Variable : SUBSET-026 §7.5.1.38 G_TSR

Variable : SUBSET-026 §7.5.1.48.1 L_NVKRINT

Variable : SUBSET-026 §7.5.1.49.1 L_PBDSR

Variable : SUBSET-026 §7.5.1.56 L_TRAIN

Variable : SUBSET-026 §7.5.1.57 L_TRAININT

Variable : SUBSET-026 §7.5.1.65 M_LEVEL

Variable : SUBSET-026 §7.5.1.73.1 M_NVAVADH

Variable : SUBSET-026 §7.5.1.75.1 M_NVEBCL

Variable : SUBSET-026 §7.5.1.75.2 M_NVKRINT

Variable : SUBSET-026 §7.5.1.75.3 M_NVKTINT

Variable : SUBSET-026 §7.5.1.75.4 M_NVKVINT

Variable : SUBSET-026 §7.5.1.110 Q_GDIR

Variable : SUBSET-026 §7.5.1.115 Q_LOCACC

Variable : SUBSET-026 §7.5.1.123.2 Q_NVINHSMICPERM

Variable : SUBSET-026 §7.5.1.123.3 Q_NVKINT

Variable : SUBSET-026 §7.5.1.123.4 Q_NVKVINTSET

Variable : SUBSET-026 §7.5.1.126.1 Q_PBDSR

Variable : SUBSET-026 §7.5.1.155 V_AXLELOAD

Variable : SUBSET-026 §7.5.1.156 V_DIFF

Variable : SUBSET-026 §7.5.1.157 V_LOA

Variable : SUBSET-026 §7.5.1.157.1 V_LX

Variable : SUBSET-026 §7.5.1.158 V_MAIN

Variable : SUBSET-026 §7.5.1.159 V_MAMODE

Variable : SUBSET-026 §7.5.1.160 V_MAXTRAIN

Variable : SUBSET-026 §7.5.1.161 V_NVALLOWOVTRP

Variable : SUBSET-026 §7.5.1.161.1 V_NVKVINT

Variable : SUBSET-026 §7.5.1.161.2 V_NVLIMSUPERV

Variable : SUBSET-026 §7.5.1.162 V_NVONSIGHT

Variable : SUBSET-026 §7.5.1.163 V_NVSUPOVTRP

Variable : SUBSET-026 §7.5.1.164 V_NVREL

Variable : SUBSET-026 §7.5.1.165 V_NVSHUNT

Variable : SUBSET-026 §7.5.1.166 V_NVSTFF

Variable : SUBSET-026 §7.5.1.167 V_NVUNFIT

Variable : SUBSET-026 §7.5.1.168 V_RELEASEDP

Variable : SUBSET-026 §7.5.1.169 V_RELEASEOL

Variable : SUBSET-026 §7.5.1.170 V_REVERSE

Variable : SUBSET-026 §7.5.1.171 V_STATIC

Variable : SUBSET-026 §7.5.1.172 V_TRAIN

Variable : SUBSET-026 §7.5.1.173 V_TSR

Packet Track to Train : SUBSET-026 §7.4.2.6 Packet number 21 Gradient Profile

Packet Track to Train : SUBSET-026 §7.4.2.37 Packet number 141 Default Gradient for Temporary Speed Restriction

A.4 §4.6.2 and 4.6.3 Transition table

Variable : SUBSET-026 §7.5.1.13 D_LRBG

Variable : SUBSET-026 §7.5.1.72 M_MODE

Variable : SUBSET-026 §7.5.1.65 M_LEVEL

Variable : SUBSET-026 §7.5.1.172 V_TRAIN

Message Train to Track : SUBSET-026 §8.6.2 Message 130 Request for Shunting

Message Train to Track : SUBSET-026 §8.6.7 Message 146 Acknowledgement

Packet Track to Train : SUBSET-026 §7.4.2.3 Packet number 12 Level 1 Movement Authority

Packet Track to Train : SUBSET-026 §7.4.2.4 Packet number 15 Level 2/3 Movement Authority

Packet Track to Train : SUBSET-026 §7.4.2.6 Packet number 21 Gradient Profile

Packet Track to Train : SUBSET-026 §7.4.2.7 Packet number 27 International Static Speed Profile

Packet Track to Train : SUBSET-026 §7.4.2.37 Packet number 141 Default Gradient for Temporary Speed Restriction

Packet Track to Train : SUBSET-026 §7.4.2.26 Packet number 80 Mode profile

Message Track to Train : SUBSET-026 §8.7.2 Message 3 Movement Authority

Message Track to Train : SUBSET-026 §8.7.10 Message 27 SH Refused

Message Track to Train : SUBSET-026 §8.7.11 Message 28 SH Authorised

A.5 §4.8.3.2 From National System X

Variable : SUBSET-026 §7.5.1.65 M_LEVEL

Packet Track to Train : SUBSET-026 §7.4.2.9 Packet Number 41 Level Transition Order

Packet STM to Train : SUBSET-058 §7.2.8 Packet STM-16 Transition variables STM max speed from STM

Packet STM to Train) : SUBSET-058 §7.2.9 Packet STM-17 Transition variables STM system speed and distance from STM

A.6 §3.6.3.2 Location, Continuous Profile Data and Non-Continuous Profile Data

Variable : SUBSET-026 §7.5.1.13 D_LRBG

Variable : SUBSET-026 §7.5.1.22 D_REF

Variable : SUBSET-026 §7.5.1.90 NID_LRBG

Variable : SUBSET-026 §7.5.1.94 NID_PRVLRBG

Variable : SUBSET-026 §7.5.1.103 Q_DIR

Variable : SUBSET-026 §7.5.1.104 Q_DIRLRBG

Variable : SUBSET-026 §7.5.1.105 Q_DIRTRAIN

Variable : SUBSET-026 §7.5.1.106 Q_DLRBG

Packet Track to Train : SUBSET-026 §7.4.2.5 Packet number 16 Repositioning Information

Message Track to Train : SUBSET-026 §8.7.13 Message 33 MA with Shifted Location Reference

A.7 §3.8.3 Structure of Movement Authority and §3.8.5 Update of Movement Authority

Packet Track to Train : SUBSET-026 §7.4.2.3 Packet number 12 Level 1 Movement Authority

Packet Track to Train : SUBSET-026 §7.4.2.4 Packet number 15 Level 2/3 Movement Authority

Packet Track to Train : SUBSET-026 §7.4.2.32 Packet number 136 Infill location reference

Message Track to Train : SUBSET-026 §8.7.2 Message 3 Movement Authority

Message Track to Train : SUBSET-026 §8.7.13 Message 33 MA with Shifted Location Reference

Message Track to Train : SUBSET-026 §8.7.15 Message 37 Infill MA

A.8 §3.11.3 Static Speed Profile and §3.11.12 Gradients

Packet Track to Train : SUBSET-026 §7.4.2.6 Packet number 21 Gradient Profile

Packet Track to Train : SUBSET-026 §7.4.2.7 Packet number 27 International Static Speed Profile

Packet Track to Train : SUBSET-026 §7.4.2.37 Packet number 141 Default Gradient for Temporary Speed Restriction

A.9 §8.7.2 Movement Authority message

Packet Track to Train : SUBSET-026 §7.4.2.4 Packet number 15 Level 2/3 Movement Authority

Message Track to Train : SUBSET-026 §8.7.2 Message 3 Movement Authority

