

## ERTMS/ETCS

### ETCS Application Level 1 - Safety Analysis

#### Part 1 - Functional Fault Tree

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Company	Technical Approval	Management approval
ALSTOM		
AZD		
CAF		
HITACHI RAIL STS		
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THALES		

## 1. MODIFICATION HISTORY

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0.0.2. 17-10-01		Inclusion of CSEE Transport comments (input document subset-088-2 v021 part1.doc)	HB (Editor)
0.0.3 19-02-02		Revised document according to subset-088-2 v030 part1.doc	HB (Editor) Sven Adomeit
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2.0.2. 04-12-02	3.1.1.6, 3.1.1.7, Section 10 Function Table amended	Amended in line with review comments from Ansaldo and Siemens	WLH
2.1.0. 31-01-03		Raised in issue for release to the Users Group.	WLH

2.2.2. 21-03-03		Final release after amendment to reflect the comments in the final report from the ISA's version 1.1 dated 07-03-03 as proposed via the Unisig consolidated review comments on the ISA report v 0.0.2 March 03.	WLH
2.2.3 25-05-04		Modifications on Fault Tree due to new events added during consolidation process - New KERNEL_33 event - New KERNEL_34 event	IS
2.2.4 15-10-04		App B. General. TRANS-events definitions updated according to Part 3 App B. Added Gate 160, explanatory OR-gate between RS and Kernel-34 event	IS
2.2.5 06-07-05		Reference to SRS updated.	DARI
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2.2.11 20-09-07		<ul style="list-style-type: none"> <li>Updated version of reference SUBSET-026 to match baseline 2.3.0</li> <li>Formal changes, corrections of grammar and spelling</li> </ul>	KN
2.3.0 02-04-08		Administrative updates for baseline 2.3.0	DARI
2.3.1 18-12-09	10.1.2	Corrections to match Subset-026, 2.3.0d	DARI

2.3.2 08-04-10	Appendix B	Update with new/changed MMI-x events according to draft version of Subset-079 (updated to 2.3.0)	KN
	10.1	Adaptation to Subset.026, 3.1.0 New modes LS, PS included Speed restriction concerning permitted braking distance added On-board function table corrected to match Subset.026, 3.1.0, column SE deleted  Formal corrections	
2.3.3 04-03-11	10.1.2	Adaptation to Subset.026, 3.2.0 Update with new/changed MMI-x events according to final version of Subset-079 (updated to 2.3.0)	
2.3.4	10.1.2	Adaptation to Subset.026, 3.2.0, Active function table 4.5.2	
2.3.5 17-06-11	Appendix B	Update according to Subset-079: MMI-4A and MMI-4B removed	
2.3.6	Appendix B	Update according to Subset-079: MMI-2j and MMI-4 added, MMI-2i removed	KN
3.0.0	Appendix B	Update according to Subset-079: MMI- 2j and MMI-2k added, MMI-2a split into MMI-2a.1 and MMI-2a.2	KN

3.0.1	Appendix B	Update according to Subset-079: Event description changed, MMI-1g added,	KN
3.1.0		CR1106 considered. Administrative changes for release to ERA.	DR
3.2.0		<ul style="list-style-type: none"> <li>Adaptation to Subset.026, 3.2.1, Active function table 4.5.2</li> <li>Use ETCS Core Hazard as standardized term</li> <li>MMI-6 added</li> </ul>	KN
3.3.0		Update after internal RAMS WP review	KN
3.4.0		Updated during RAMS-meeting	DR
3.5.0		Baseline 3 release version	DR
3.5.1		Appendix B: update for B3 MR1	KN
3.5.3		Formal updates during RAMS-meeting	DARI
3.5.4	10.1.2	Add new function "LSSMA display to the driver"	KN
3.5.5	10.1.2	Adaptation to Subset.026, 3.2.1, Active function table 4.5.2	KN
3.5.6	Appendix B 3.1.1.1, 10.1.2	update for BL3 R2 Formal Corrections	KN
3.5.7	Appendix B	Embedded files for FT added	KN
3.6.0 2016-06-20	No change	Baseline 3 2 <sup>nd</sup> release version	RAMS WP
3.6.1	Appendix B	Formal Corrections (remove not openable object, remove overlay page 15)	KN
3.6.2	Appendix B	Formal corrections	KN
3.7.0	No change	Release version	RAMS WP

3.7.1	Appendix B	ODO-5: this new base event is introduced in connection with analysis of CR1345 for cold movement functionality	KN
3.7.2		New template	KN
3.7.3	3.1.1.6	New mode SM Level 2 exchanged with Level R	KN
3.7.4	No change	Internal RAMS Baseline	RAMS WP
3.7.5	Appendix C	Update based on Subset-026 3.9.2  First 2 digits of the version aligned to SUBSET 026 version number	KN
3.7.6	All Appendix C	Editorial changes MMI-1j and MMI-2m added	KN
3.7.7	All	Level R exchanged with Level 2	KN
3.7.8	All	Editorial changes, Kernel-35 and Kernel-36 added  Note: A previous edition was used to update and finalise SUBSET-091 (ed. 4.0.0). In the meantime, this document was also completed and the updated edition of this document does not affect the content of SUBSET-091	RAMS WP
3.8.0 06-05-24	Cover page, footer, 3.1.1.1, 3.1.1.6, 5.1.1.2, 7.1.1.2, 10.1.1.1, 10.1.3	Application of quality checks proposed by SG Baseline 4 release version	KN



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### 3. INTRODUCTION

- 3.1.1.1 This document contains the functional fault tree for ETCS application level 1 based on the failure modes of the ETCS macro functions. These macro functions are derived from UNISIG SRS version 4.0.0 (please refer to Appendix C). This fault tree does not imply or mandate a specific system implementation and neither is it related to specific system mode.
- 3.1.1.2 The function table of Appendix C contains references to related Fault Tree gates.
- 3.1.1.3 The objective of producing the generic functional fault tree is to provide a system wide view of functional interactions so that the migration of base events that have been identified as being potentially catastrophic can be analysed. The base events were identified by the FMEA analyses of the mandatory interfaces.
- 3.1.1.4 The detailed analysis against specific modes is undertaken in Part 2 of this suite of documents.
- 3.1.1.5 The analysis is undertaken separately in Part 2 because of the difficulty in accounting for the degree of failure necessary to result in the occurrence of the ETCS Core Hazard in the confines of a diagrammatic representation. The analysis identifies the criticality of base events and ETCS functions.
- 3.1.1.6 The system fault trees form the starting point for the documented analysis in part 2 for the different grades of protection available to an ETCS fitted train, the relevant operational modes being, Full Supervision (FS), On Sight (OS), Limited Supervision (LS), Staff Responsible (SR), Reversing (RV), Shunting (SH), Automatic Driving (AD) and Supervised Manoeuvre (SM).
- 3.1.1.7 The functional fault tree puts the macro function failure modes into a hierarchy leading up to the ETCS Core Hazard:
- Exceedance of the safe speed or distance limits as advised to ETCS.
- Note: The hierarchy is generic and not mandatory for a product design. It is developed to provide a static view of functional interaction.
- 3.1.1.8 The functional fault tree provides full traceability to the set of system macro functions as defined in the SRS, whether or not the failure leads to a catastrophic event.
- 3.1.1.9 The general hierarchy for the system fault tree is given in Appendix A.
- 3.1.1.10 Appendix B gives the detailed system fault tree from the perspective of a single system.



## 4. KEY TO THE FAULT TREE SYMBOLS

4.1.1.1 The fault tree tool adopted for the analysis work is Isograph Reliability Workbench 13.0.1 where the following symbols are used in the fault tree modelling:

### 4.2 Gate Symbols



OR Gate: Gate event occurs if any one of the input events occurs.



AND Gate: Gate event occurs if all of the input events occur.

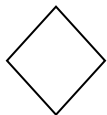


TRANSFER Gate The output is used as part of a lower level tree on page n.

### 4.3 Primary Event Symbols



Basic Event: Event using a Primary Event Failure Model.



Undeveloped Event: Event that is yet to be developed.

### 4.4 Gate / Event Description Symbol



Description Symbol: Text describing the logical result of the gate or event.



## **5. CONCEPTUAL FAULT TREE**

### **5.1 Purpose**

- 5.1.1.1 The Conceptual Fault Tree is intended to provide an overview of the principle behind the construction of the detailed fault tree. The hierarchy is developed from a purely functional standpoint linking to the top level ETCS Core Hazard as identified in document Part 0.
- 5.1.1.2 The functional development of the fault tree stems from the definition of the UNISIG ETCS within an operational railway environment. This definition is given in Part 0 as To provide the driver with information to allow him to drive the train safely and to enforce respect of this information to the extent advised to ETCS.

### **5.2 Structure**

- 5.2.1.1 From the system definition, the system splits naturally into two parts
  - a) The provision of information to the driver that keeps him informed of limits, in terms of speed and distance that he must observe in order to maintain safety.
  - b) The enforcement function that protects the train from breaching a safe speed and distance envelope by intervening with a request for a pre-emptive brake application.
- 5.2.1.2 Both the provision of information and enforcement functions are dependent upon knowing the safety parameters in terms of allowed movements and permissible speeds and then relating this to the capability of the train. This information is then used to supervise the passage of the train by continuously comparing actual performance against that required such that a decision about intervention can be made.
- 5.2.1.3 The speed profile for a route is represented by the Most Restrictive Speed Profile. This in turn is modified by the Movement Authority authorisations to create the Dynamic Speed Profile. The Dynamic Speed Profile is the embodiment of the safety parameters as it contains both the speed and distance limits.
- 5.2.1.4 This simplified operational view based on the major functionality of ETCS is used to create the conceptual fault tree.

Note: Being based on the major functions the event names do not match those of the macro functions used in Appendix B

### **5.3 Fault Tree Diagram**

- 5.3.1.1 The conceptual fault tree is given in Appendix A.



## 6. DETAILED, GENERIC LEVEL 1 FAULT TREE

### 6.1 Concept

- 6.1.1.1 This fault tree is a detailed development based on the principles of the conceptual tree given in Appendix A.
- 6.1.1.2 The tree provides a complete deployment of the functions as given in the Function List but not necessarily in the same groupings.
- 6.1.1.3 The tree provides a complete picture of the functional hierarchy of the UNISIG system when being operated in application level 1.
- 6.1.1.4 This fault tree is given in Appendix B. This fault tree is developed on Isograph Reliability Workbench 13.0.1

### 6.2 Comparison between level 1 and level 2 fault tree

#### 6.2.1.1 Table of modifications

gate / event	level 2 fault tree	level 1 fault tree
gate 18	existing	modification of description
gate 64 below gate 18	existing	Cut
gate 76 under gate DATA	existing	modification of description
gate 89 below gate 80	existing	Cut
gate 94 under gate 80	existing	modification of description
gate 109 below gate 18	existing	Cut
gate 110 below gate 94	existing	modification of description
gate 125 below gate 121	existing	Cut
gate 126-1 below gate 54	-	New
gate 126-2 below gate 159	-	New
gate 127 below gate 121	existing	Cut
gate 156 below gate 94	-	New
gate 159 below gate DATA	-	New
event KERNEL-18 below gate 82	existing	Cut
event KERNEL-32 below gate 156	-	New
event TRANS-OB/RADIO-2 below gate 113	existing	Cut
event TRANS-6 below gate 128	existing	Cut
event TRANS-LOOP1 below gate 126-2	-	New



## **7. PRELIMINARY SAFETY RELATED COMMENTS**

### **7.1 General Comments.**

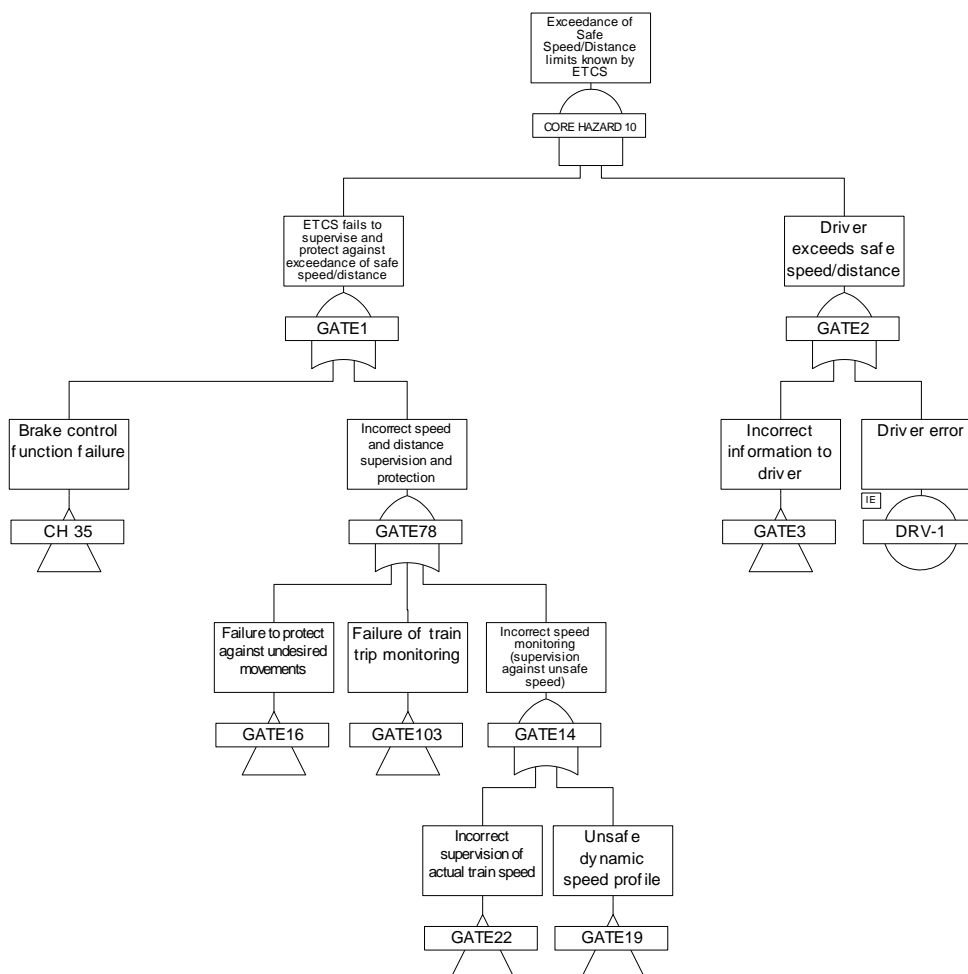
- 7.1.1.1 Even at this initial stage, comments on the safety aspects of the system design can be made following examination of the functional fault tree. Many of the issues noted will in practice be affected by the magnitude (too large or too small) of the error and the direction (high or low) of the error. This analysis, along with the effect of different modes of operation, is the subject of Part 2 of this suite of documents.
- 7.1.1.2 The role of the ETCS system has been defined in Part 0 as being:  
To provide the driver with information to allow him to drive the train safely and to enforce respect of this information to the extent advised to ETCS.  
Associated with this role is the ETCS Core Hazard, also defined in Part 0:  
Exceedance of safe speed or distance limits as advised to ETCS.
- 7.1.1.3 Working down the fault tree from the top hazard (ETCS Core Hazard) it is clear that due to the need to keep the display to the driver and the supervision parameters co-incident, there will be major common mode issues within the system. This is borne out by the functional fault tree.
- 7.1.1.4 From a safety perspective this need for co-incidence means, if the information provided to the train carried system is incorrect in terms of a safe speed and distance, then the driver will be shown the wrong targets. If he drives to these incorrect targets he will be allowed to do so without being protected from making an unsafe move by the ETCS supervision and intervention functions.
- 7.1.1.5 There are benefits however, which act to reduce the integrity requirements on the display to the driver. This is because, assuming the supervision function is correctly functioning, the driver is protected against a failure of the display.
- 7.1.1.6 The most important common mode issue external to ETCS is the function of Data Entry whereby the length and capability of the train are provided to the ETCS. This information affects the calculation of the Most Restrictive Speed Profile (MSRP) and separately, the braking algorithm calculation.
- 7.1.1.7 There is nothing that ETCS can do if a driver confidently enters and acknowledges erroneous data. Thus rigorous checks outside ETCS will be essential, particularly if data is modified during a journey or under emergency conditions where an independent check may be difficult to initiate.



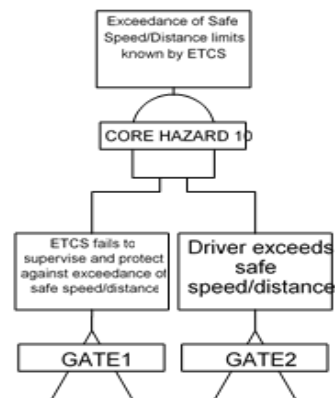
- 7.1.1.8 Internal to ETCS there are several common mode issues which may affect the internal assignment of integrity levels. In this respect the primary base event would be that of speed and position which will impact on the Dynamic Speed Profile calculation.
- 7.1.1.9 Another source of common mode error would be incorrect track topography and/or incorrect placing of balises. Again this error would affect both the supervision and the display functions.

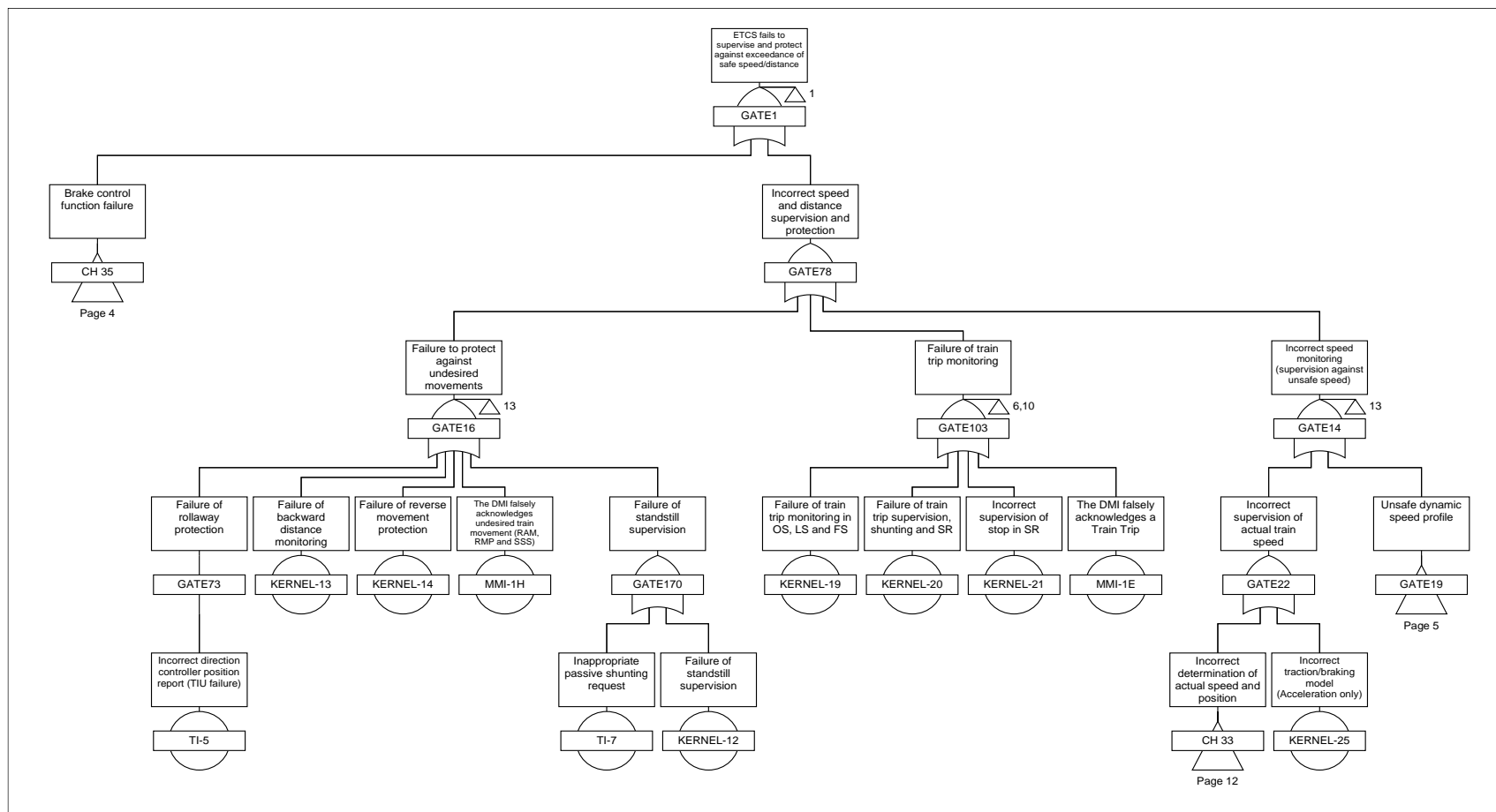
## 8. APPENDIX A

### 8.1 Conceptual Fault Tree

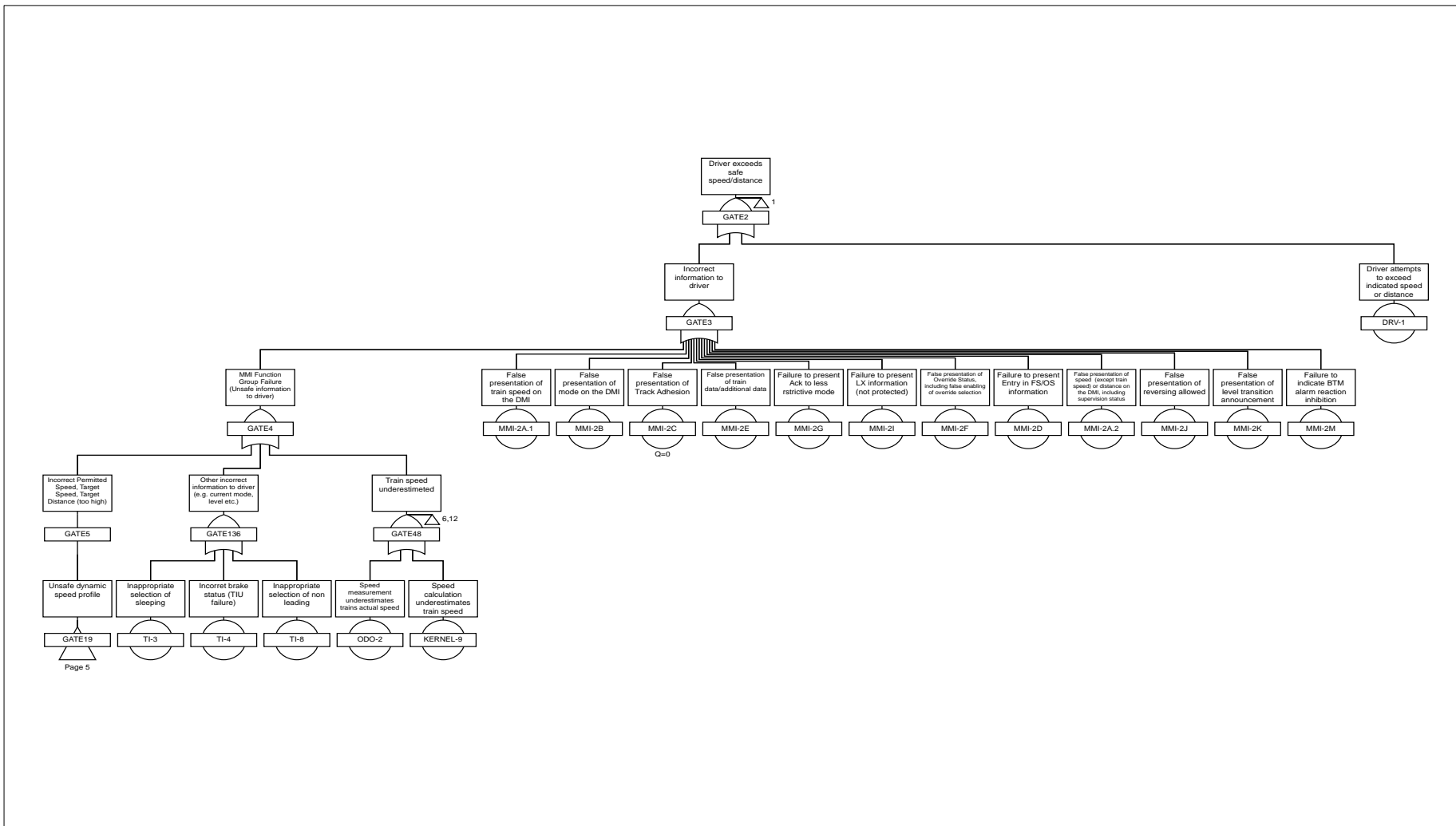


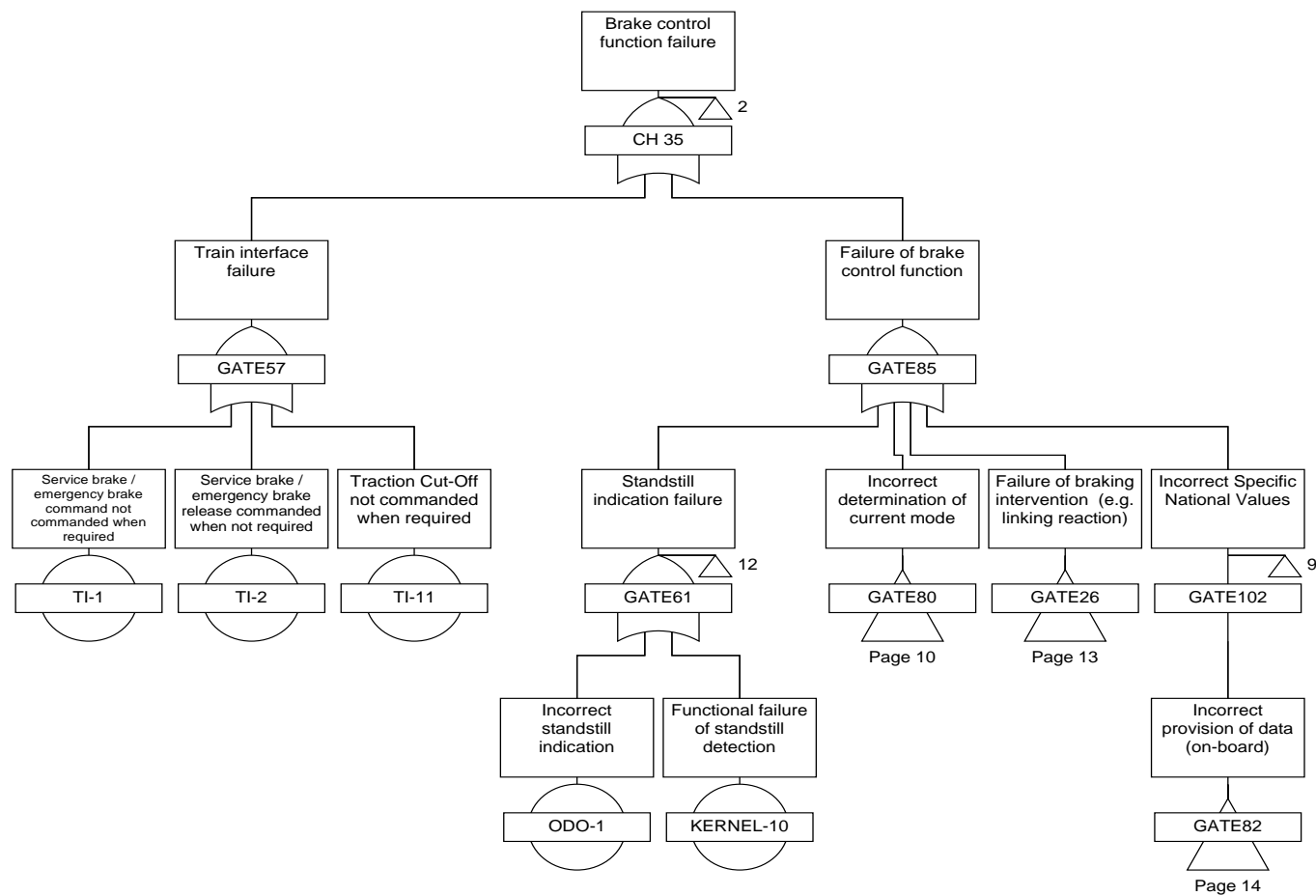
## 9. APPENDIX B - DETAILED SYSTEM LEVEL FAULT TREE

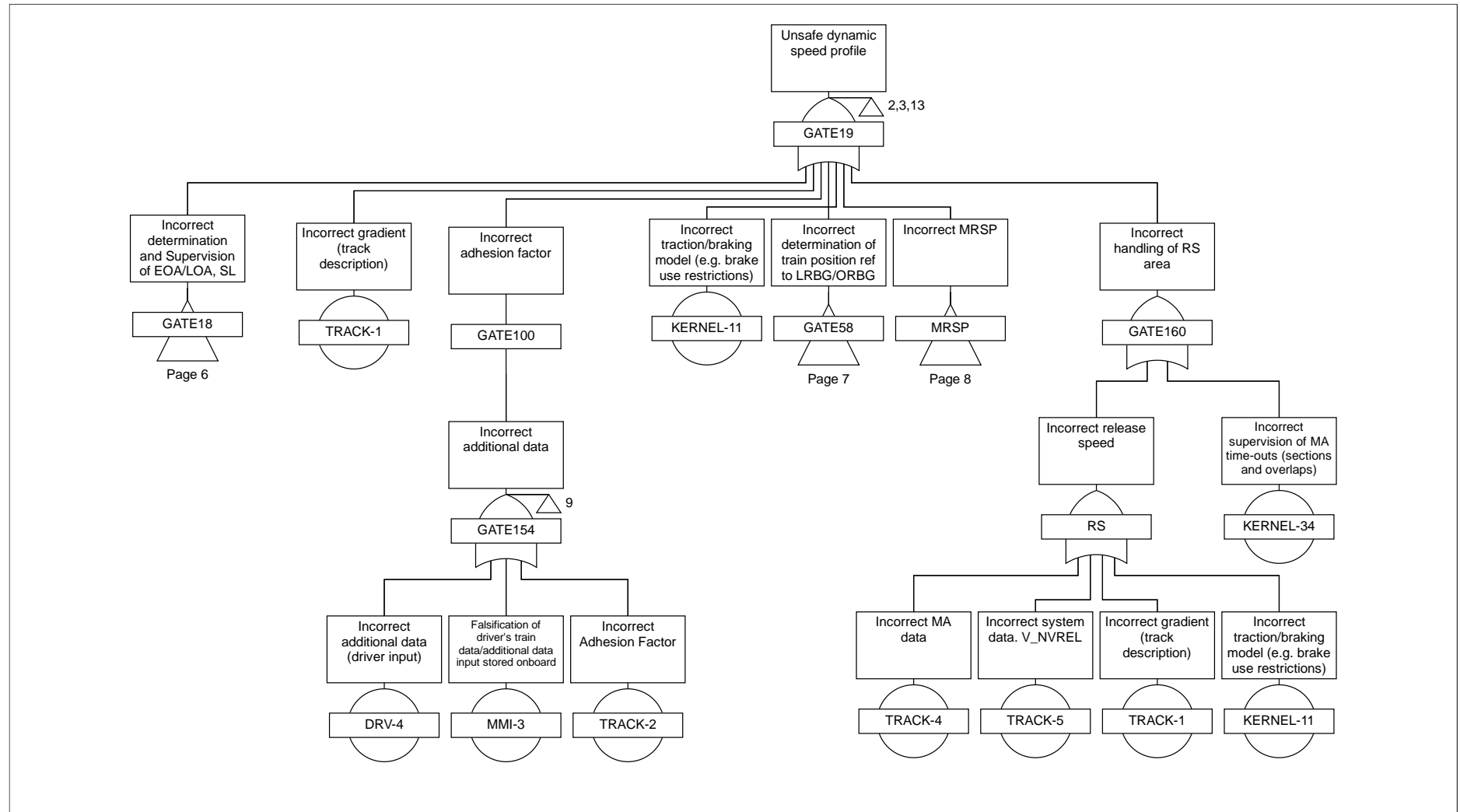


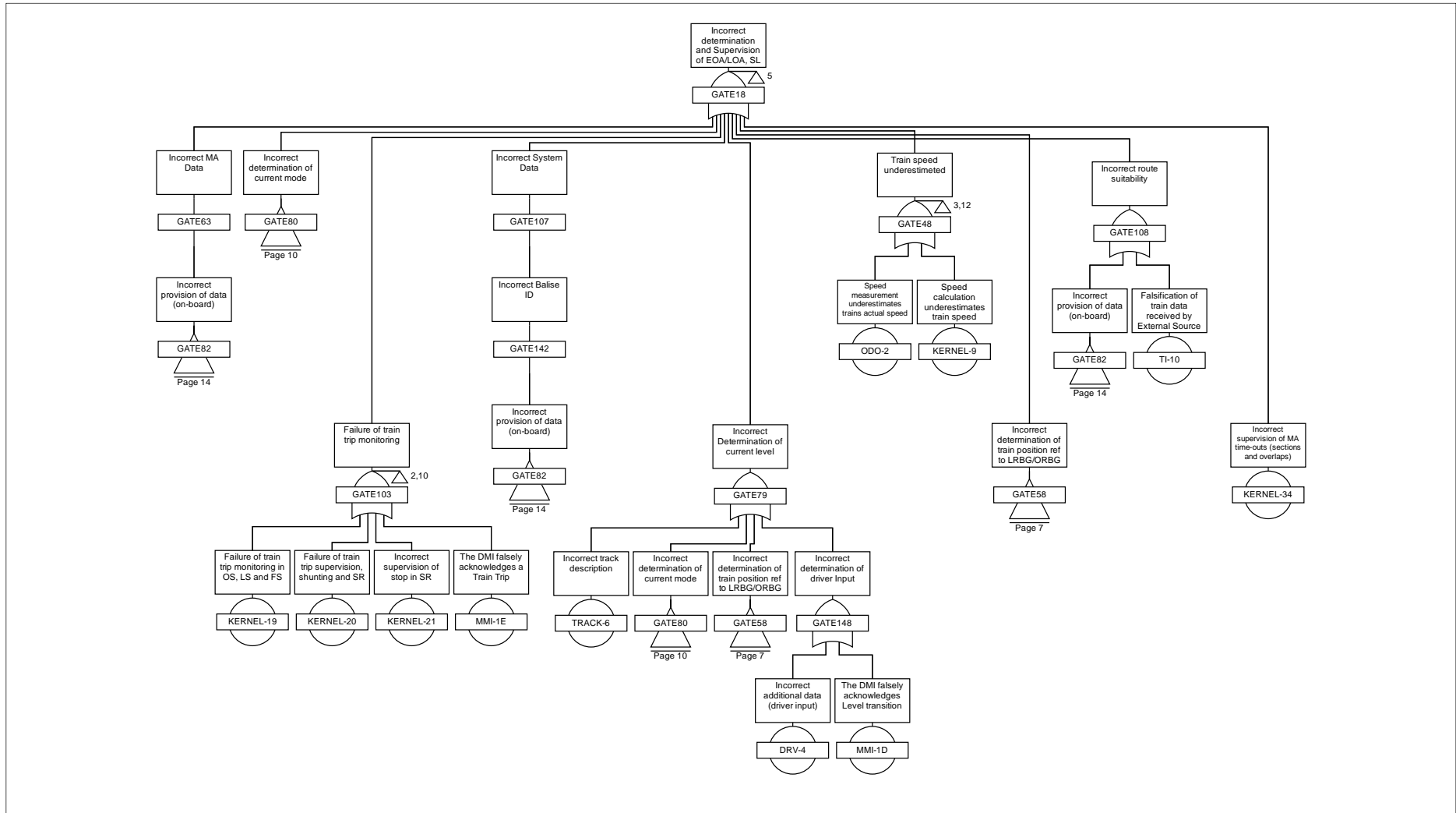




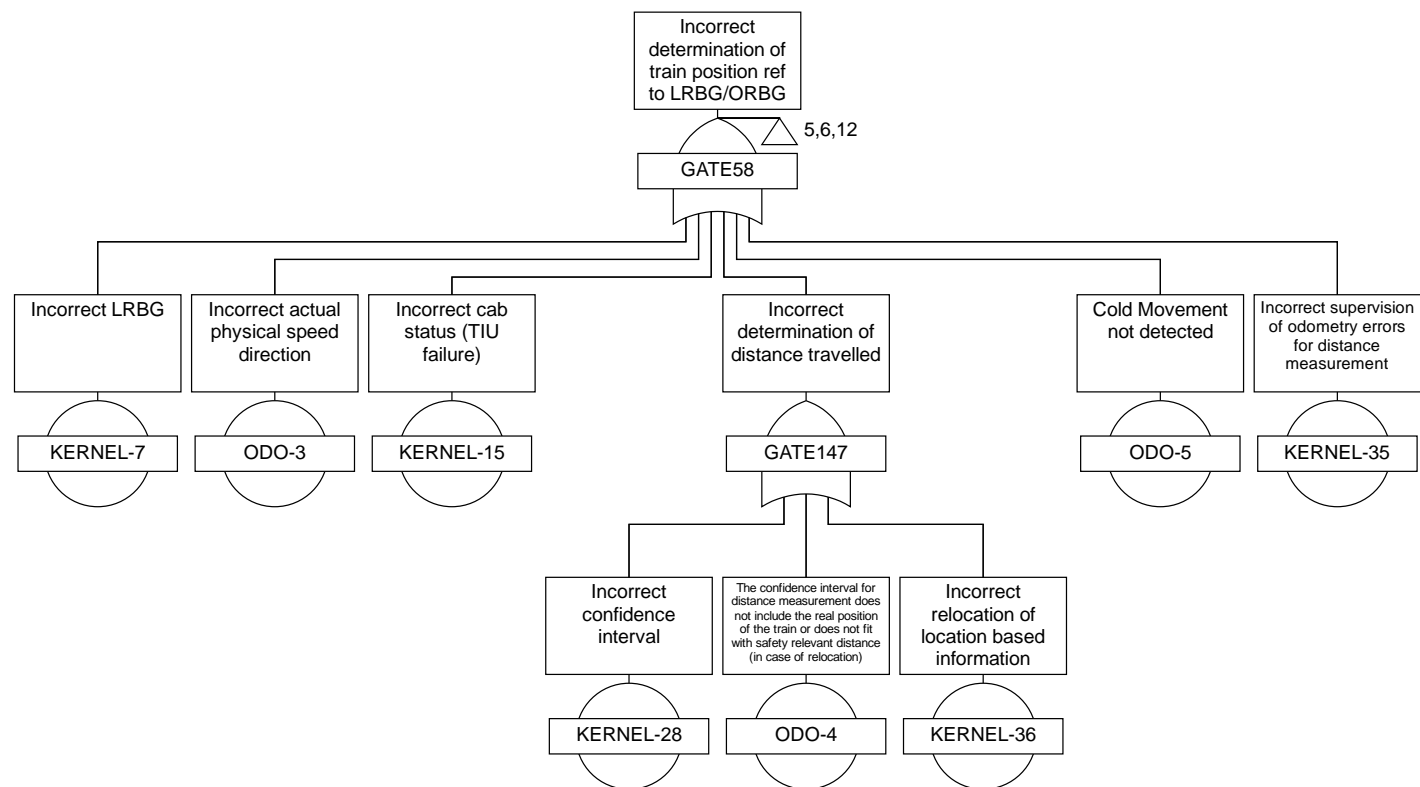


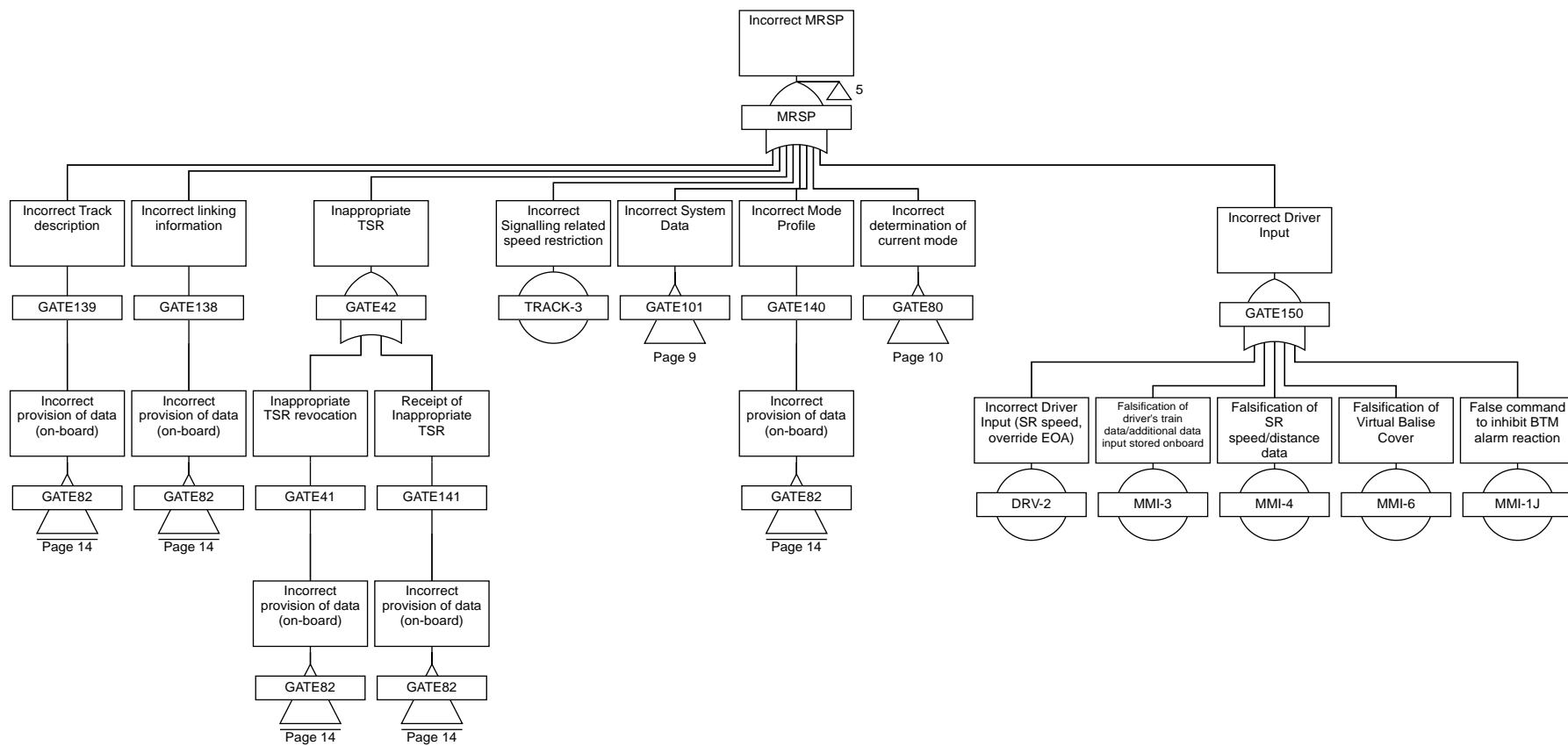


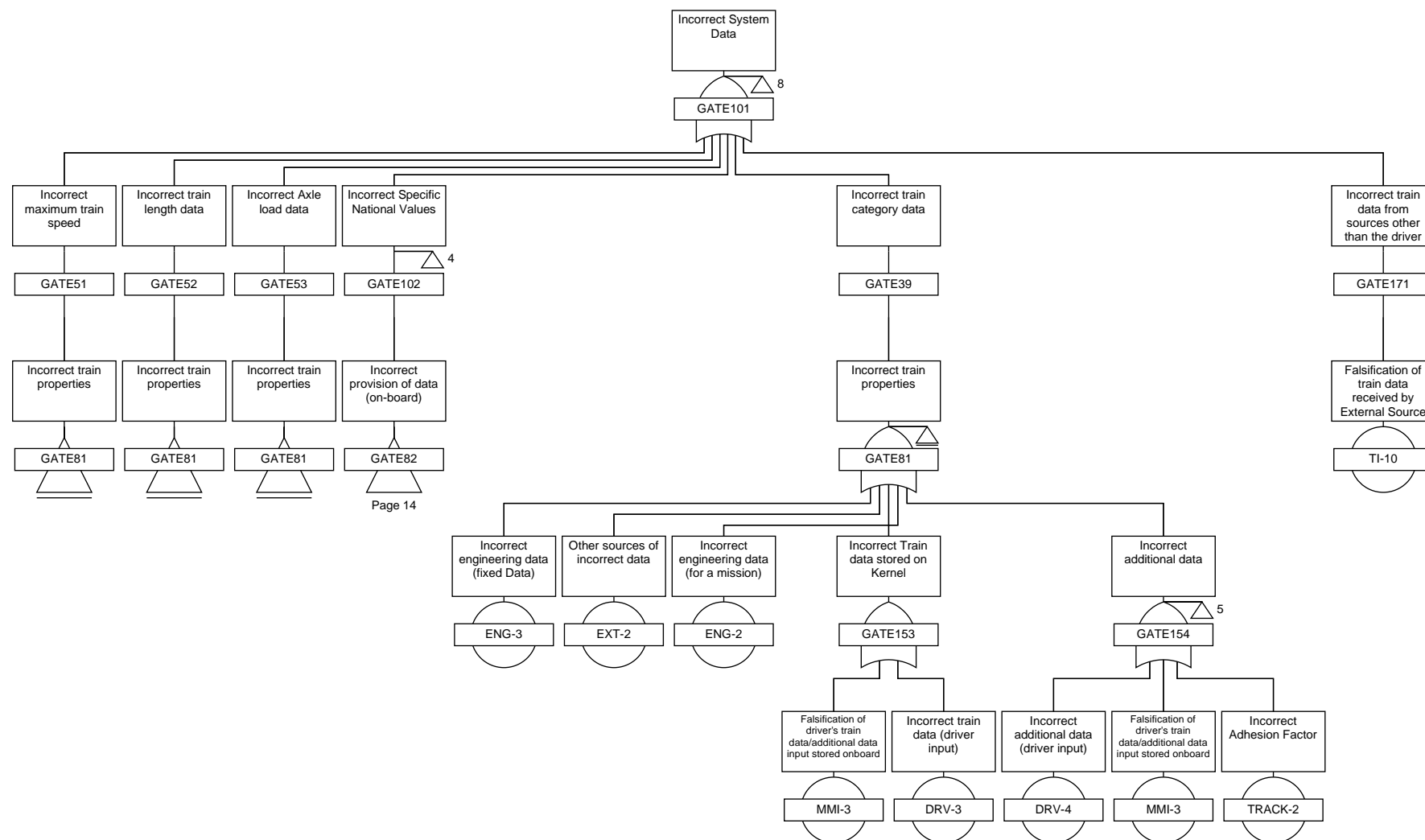


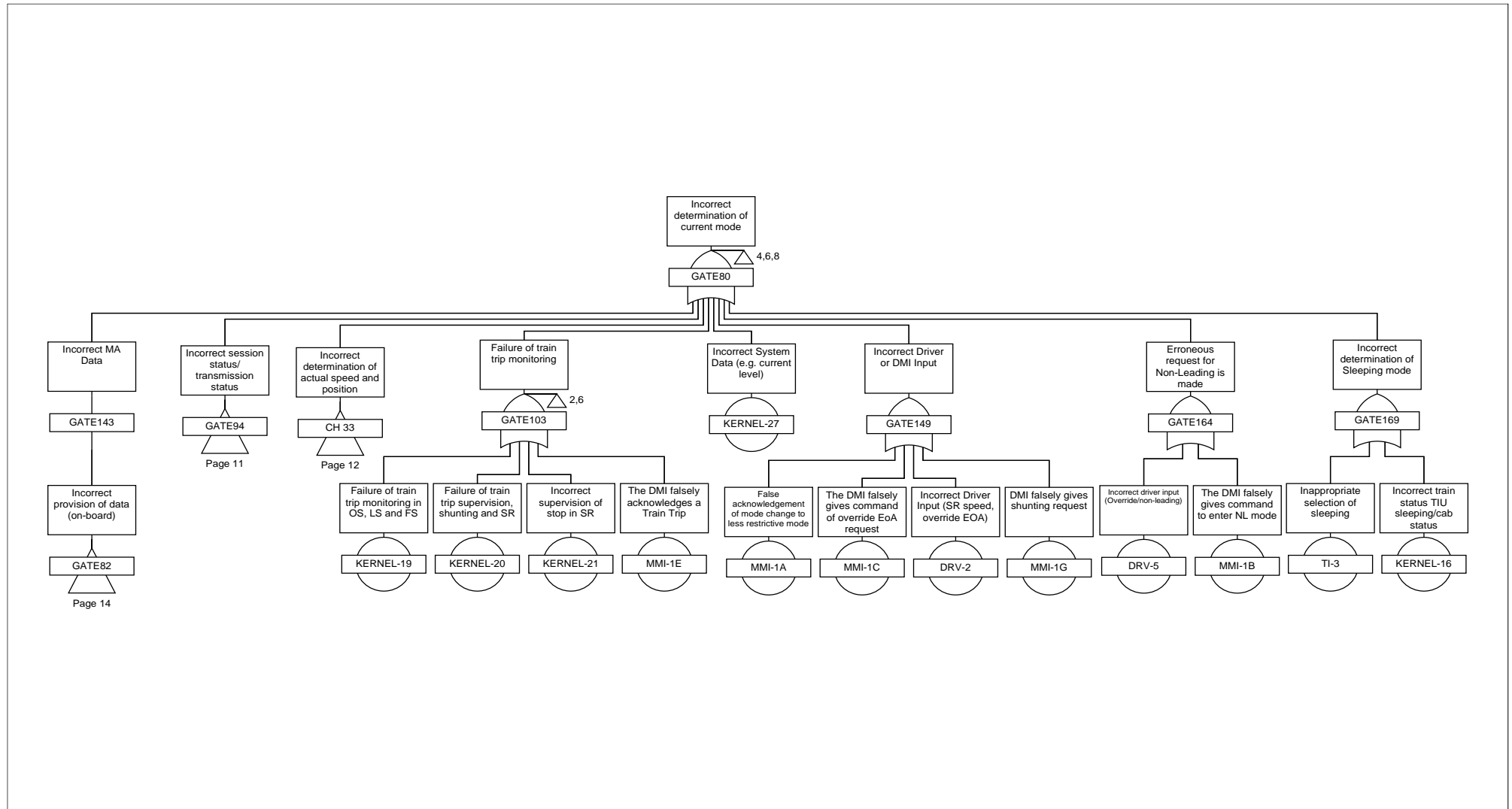


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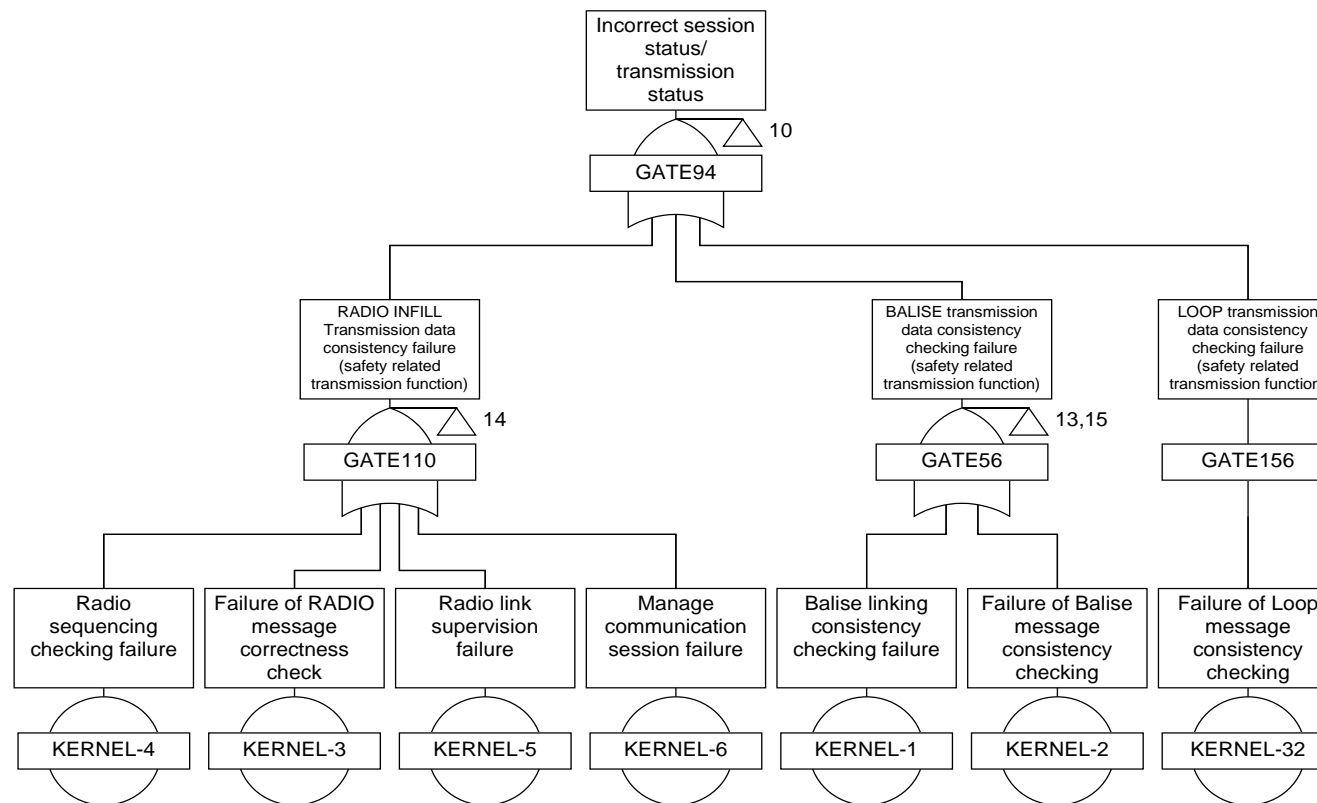


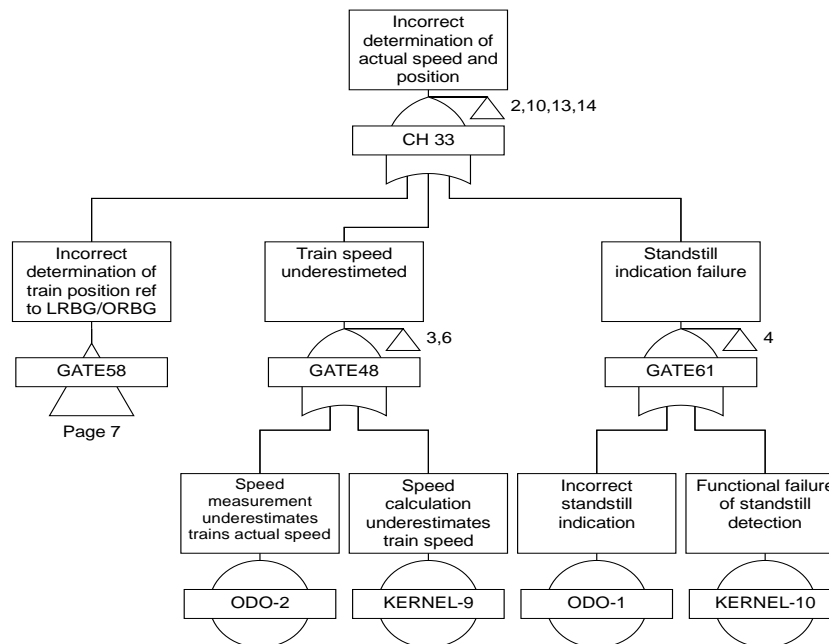


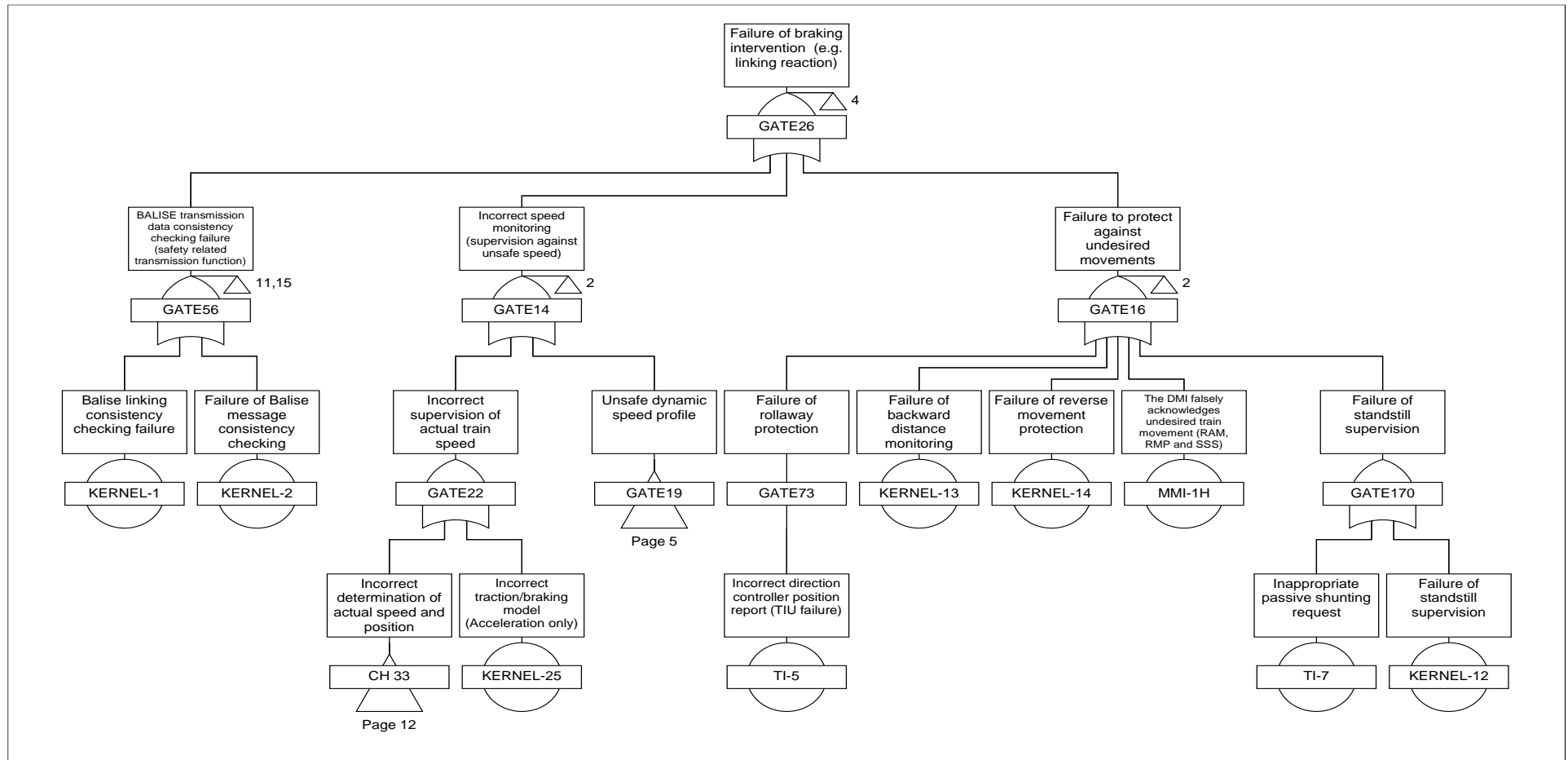


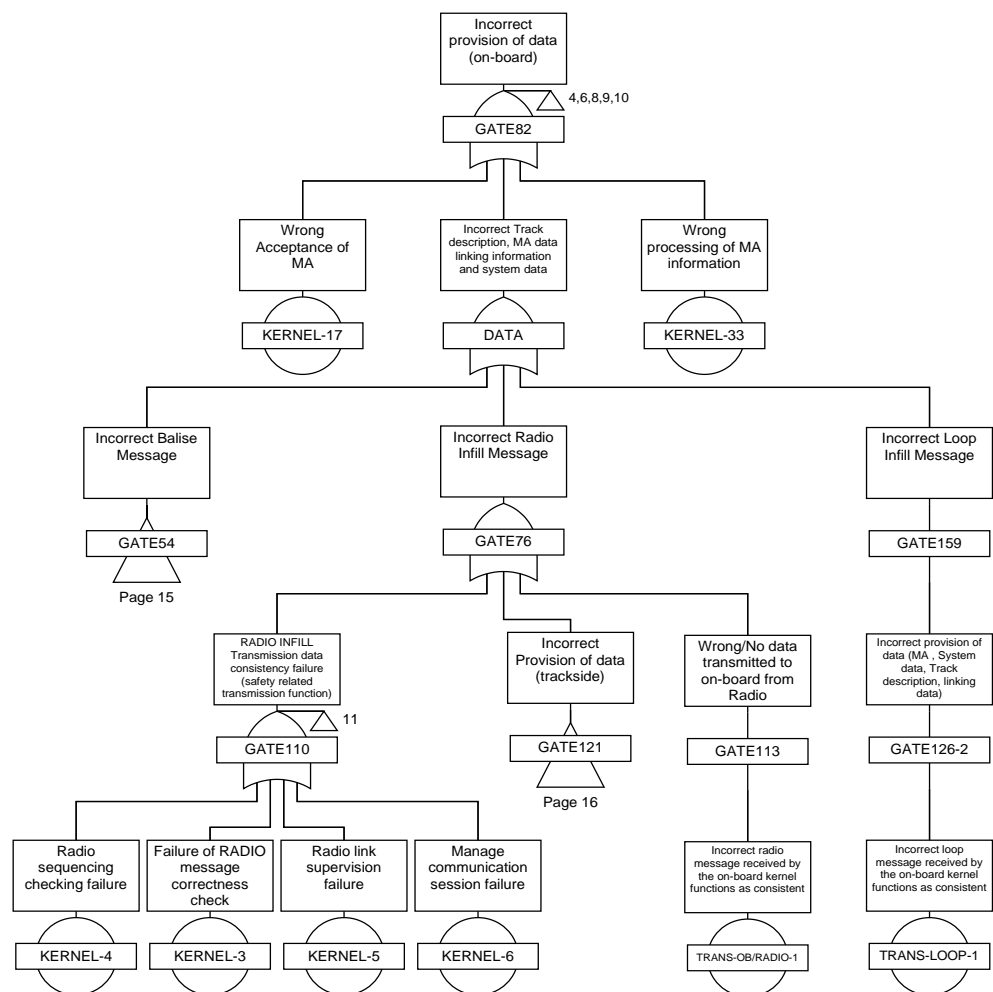


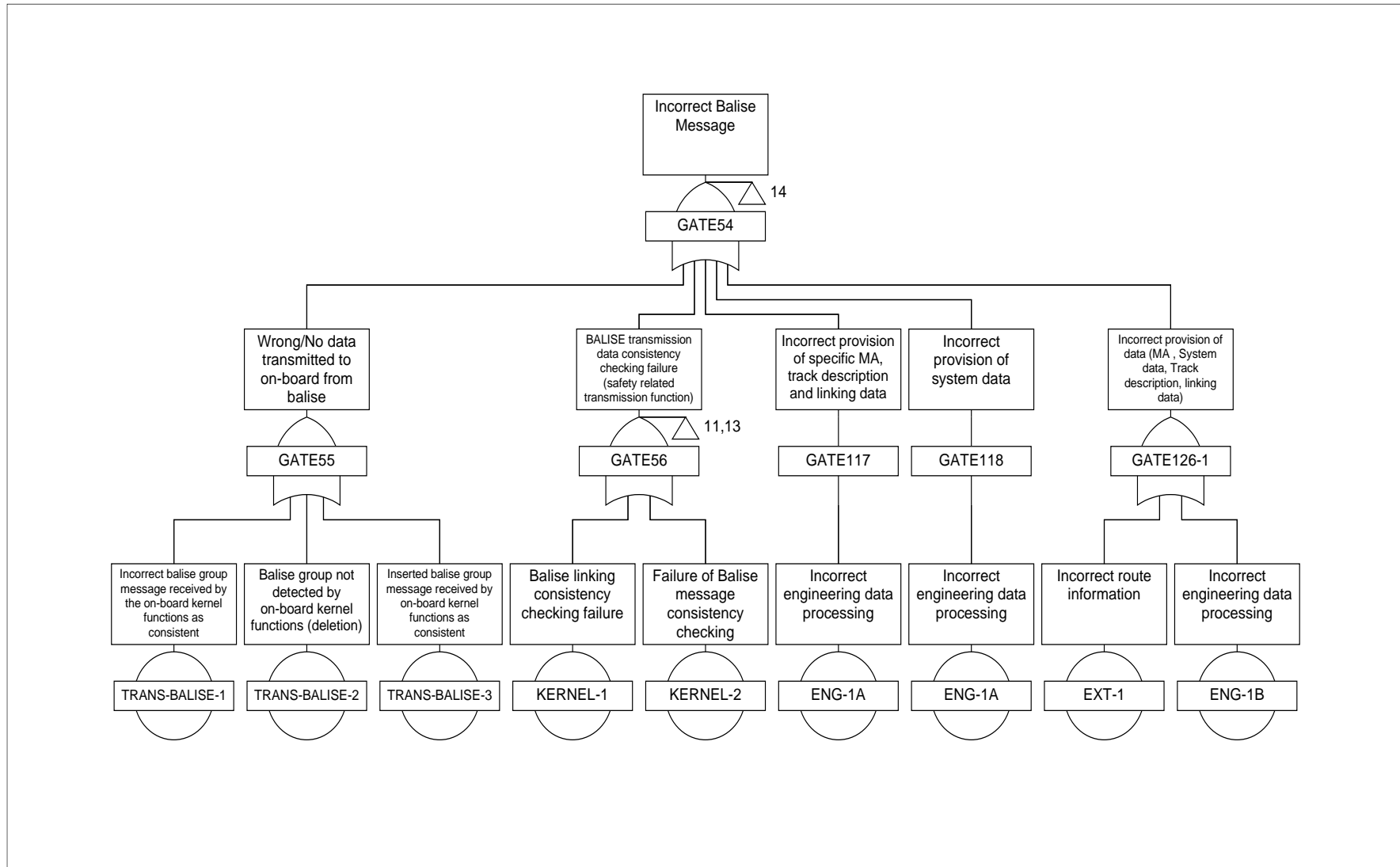


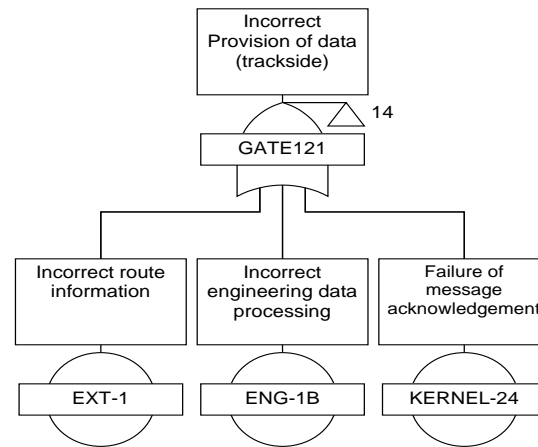












## **10. APPENDIX C**

### **10.1 Modes and on-board Functions in Level 1**

#### **10.1.1 Introduction**

- 10.1.1.1 The table in 10.1.2 is based on Subset-26, chapter 4.5 'Modes and on-board Functions'. It specifies which modes the on-board functions are active or not. Compared to previous versions of Subset-026 some parts were removed in version 4.0.0 because they can be derived from other explicit mode specific provision in the specifications. As the table in 10.1.2 was used to enable the creation of the fault tree these parts are kept. The functions are described in detail in the SRS with the appropriate reference being given in the fourth column of the table under 'Related SRS paragraph'. In addition, references to the gates in the fault tree are provided.
- 10.1.1.2 The resulting hierarchy is generic and not mandatory for the design of a product. It is developed to provide a static view of functional interaction.
- 10.1.1.3 Note: Modes are not the only thing that can influence an on-board function. Therefore this table is not enough in itself to understand all the ERTMS/ETCS on-board behaviour. It must be understood as a complement to all other SRS chapters (especially SRS chapters 4.7, 4.8, 4.9 and 4.10).
- 10.1.1.4 Note: for DMI depending on modes, refer to SRS chapter 4.7.

#### **10.1.2 Active Functions – On-board Function Table**

- 10.1.2.1 X = functions shall be active, i.e. their corresponding on-board requirements and/or definitions shall apply  
Empty case = functions shall be inactive, i.e. their corresponding on-board requirements and/or definitions shall not apply  
NR = Not Relevant: This concerns the modes SF and IS in which the on-board behaviour cannot be harmonised

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sup>1</sup>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
1	Check data consistency																					
1.1	Balise Message Consistency	Gate 54																				
1.1.1	Check balise linking consistency	Gate 54 56	3.16.2.3 3.4.4.2.1.1 3.4.4					X	X	X	X		X						N R	N R		
1.1.2	Check message consistency for balise groups announced by linking and for other balise groups marked as linked while the linking consistency is checked	Gate 54 56	3.16.2.4.1 3.16.2.4.23.1 6.2.4.3 3.16.2.4.3.1					X	X	X	X		X						N R	N R		
1.1.3	Check Balise Group Message Consistency (if no linking consistency is checked) (because no linking information is available and/or because the function "check linking consistency" is not active)	Gate 54 56	3.16.2.4.4		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X

<sup>1</sup> Only used in Level 2



	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
1.1.4	Check Unlinked Balise Group Message Consistency	Gate 54 56	3.16.2.5		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
1.1.5	System Version Management	Gate 54 56	3.17		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
<b>1.2</b>	<b>Radio Message Consistency</b>	Gate 76																				
1.2.1	Check correctness of radio messages	Gate 76 110	3.16.3.1		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
1.2.2	Check radio sequence	Gate 76 110	3.16.3.3		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
1.2.4	Manage Communication Session	Gate 76 110	3.5		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
<b>1.3</b>	<b>Check Loop Message Consistency</b>		3.8.4.6  there is no reference in the SRS chapter 3.16						X													

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
<b>2</b>	<b>Determine Train Speed and Position:</b>	CH 33																				
2.1	Determine train position referenced to LRBG	Gate 58	3.6.1 3.6.4		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
2.2	Determine train speed, train acceleration, train standstill	Gates 48 61	None		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
2.3	Determine current on-board-LRBG	Event "Kernel - 7"	3.4.4, 3.6.1.4, 3.6.2.2.2		X		X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
2.4	Check of odometer accuracy thresholds	Gate 54	3.6.8.5, 3.6.8.6, 3.6.8.7					X	X	X	X	X	X						N R	N R		
2.5	Storage of accumulated underestimation / overestimation in measuring the movements over a defined total distance	Gate 54	3.6.8.2 to 4			X	X	X	X	X	X	X	X	X	X	X	X	X	N R	N R	X	X
<b>3</b>	<b>Handle Train Properties</b>	Gate 81																				
3.1	Manage change of Train Data from external sources	Gate 81 153	3.18.3, 5.17, 5.4.3		X				X		X	X	X			X	X	X	N R	N R	X	
3.2	Report Validated Train Data	Gate 81	3.18.3.4		X														N R	N R		

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
3.3	Report Train Position :	Gate "CH33"	3.6.5.																N R	N R		
3.3.1	Report train position when train reaches or leaves standstill	Gate 58 & 48	3.6.5.1.4 a) 3.6.5.1.4 i)		X			X	X	X	X	X	X						N R	N R		X
3.3.2	Report train position when mode changes to ...	Gate 58 & 48	3.6.5.1.4 b)		X		X	X	X	X	X	X	X	X	X	X	X	X	N R	N R	X	X
3.3.3	Report train position when train integrity confirmed by driver	Gate 58 & 48	3.6.5.1.4 c)		X		X	X	X	X	X	X	X			X		X	N R	N R	X	
3.3.4	Report train position when loss of train integrity is detected	Gate 58 & 48	3.6.5.1.4 d)		X			X	X	X	X	X	X			X	X	X	N R	N R	X	X
3.3.5	Report train position when train front/rear passes an RBC/RBC border	Gate 58 & 48	3.6.5.1.4 e) 3.6.5.1.4 k)					X	X	X	X	X	X	X	X		X		N R	N R		
3.3.6	Report train position when train rear passes a level transition border (from level 2 to 0, NTC, 1)		3.6.5.1.4 f)					X	X	X	X	X	X	X	X		X		N R	N R	X	
3.3.7	Report train position when change of level due to trackside order	Gate 58 & 48	3.6.5.1.4 g)					X	X	X	X	X	X	X	X		X		N R	N R		

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
3.3.8	Report train position when change of level due to driver request	Gate 58 & 48	3.6.5.1.4 g)		X			X	X	X	X	X	X		X				N R	N R		
3.3.9	Report train position when establishing a session with RBC	Gate 58 & 48	3.6.5.1.4 h)		X		X	X	X	X	X	X	X	X	X	X	X	X	N R	N R	X	X
3.3.10	Report train position when a data consistency error is detected	Gate 58 & 48	3.6.5.1.4 I)		X			X	X	X	X	X	X	X	X	X	X	X	N R	N R	X	X
3.3.11	Report train position at every passage of an LRBG compliant balise group	Gate 58 & 48	3.6.5.1.4 j)		X			X	X	X	X	X	X	X	X	X	X	X	N R	N R	X	X
3.4	Provide Date and Time	no impact to safety	3.18.5		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
<b>4</b>	<b>Determine Mode and Level</b>	-																				
4.1	Determine ERTMS/ETCS Mode	Gate 80	3.12.4, 4.6	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X
4.1.1	Inhibit Trip (Override function)	Gates 143 149	5.8				X				X				X				N R	N R	X	
4.2	Determine ERTMS/ETCS level	Gate 79	5.10		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R X	X	X

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
5	Manage Emergencies	Only Level 2	3.10																			
6	Provide Data																					
6.1	Handle Data	Gate 82																				
6.1.1	Accept MA	Event "Kernel- 17"	3.7.2 3.8.5 4.8.4		X				X		X	X	X			X		X	N R	N R	X	
6.1.2	Delete Track Description, Linking Information and MA data	Gates "DATA" 139 138 63	3.7.3.3 4.9 4.10	X	X		X		X		X	X	X	X	X	X	X	X	X	X	X	X
6.1.3	Delete Revoked TSR	Gate 41	3.11.5.5		X				X		X	X	X			X	X	X	N R	N R		
6.2	Provide Fixed Values, and Default/National Values	Gate 118	3.18.1 3.18.2		X	X	X		X		X	X	X	X	X	X	X	X			X	X
7	Supervise and Protect	-																				
7.1	Determine EOA/LOA SvL Shortening of MA																					
7.1.1	Determine EOA/LOA, SvL, Danger Point etc.	Gates 18, 160	3.8.4 3.8.5					X	X	X	X		X						N R	N R		

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
7.1.2	Supervise “danger for shunting” information and list of expected balises for shunting	Event “Kernel- 20”	4.4.8.1.1 b) and c)				X												N R	N R		
7.1.3	Supervise “Stop if in SR” information and list of expected balises for Staff Responsible	Event “Kernel- 21”	4.4.11.1.3 c) and d)									X							N R	N R		
7.1.4	Supervise passing EOA/LOA	Gate 18  Event “Kernel- 34”	3.13.8						X		X	X <sub>2</sub>	X						N R	N R		
<b>7.2</b>	<b>Monitor Speed</b>	Gate 14																				
7.2.1	Determine Most Restrictive Speed Profile	Gate “MRSP”																	N R	N R		
7.2.1.1	Calculate SSP	Gate “MRSP”	3.13.7.2 3.11.2.2 a)					X	X	X	X		X						N R	N R		
7.2.1.2	Calculate ASP	Gate “MRSP”	3.13.7.2 3.11.2.2 b)					X	X	X	X		X						N R	N R		
7.2.1.3	Calculate TSR	Gate “MRSP”	3.13.7.2 3.11.2.2 c)					X	X	X	X	X	X			X			N R	N R		

<sup>2</sup> In SR mode the end of the SR Authorization is supervised.

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
7.2.1.4	Signalling related speed restriction SR when evaluated as a speed limit	Gate "MRSP"	3.13.7.2 3.11.2.2 e)						X	X	X		X						N R	N R		
7.2.1.5	Calculate (or enter) Mode related speed restriction	Gate "MRSP"	3.13.7.2 3.11.2.2 f)				X	X			X	X	X			X			N R	N R		X
7.2.1.6	Calculate (or enter) Train related speed restriction	Gate "MRSP"	3.13.7.2 3.11.2.2 d)					X	X	X	X	X	X			X			N R	N R		X
7.2.1.7	STM max speed	Gate "MRSP"	3.13.7.2 3.11.2.2 g)						X	X	X	X	X			X			N R	N R	X	
7.2.1.8	STM system speed	Gate "MRSP"	3.13.7.2 3.11.2.2 h)						X	X	X	X	X			X			N R	N R		
7.2.1.9	LX speed	Gate "MRSP"	3.13.7.2 3.11.2.2 i)					X	X	X	X		X						N r	N R		
7.2.1.10	Speed restriction to ensure a given permitted braking distance	GATE "MRSP"	3.13.7.2 3.11.2.2 k)					X	X	X	X		X						N R	N R		
7.2.1.11	Override related speed restriction	GATE "MRSP"	3.13.7.2 3.11.2.2 j)				X					X				X			N R	N R		
7.2.2	Determine Dynamic Speed Profile	Gate 19	3.8.2 3.12.3.1 3.13						X		X		X						N R	N R		
7.2.2.1	Calculate Release Speed	Gate "RS"	3.13.9						X		X		X						N R	N R		

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
7.2.3	Supervise Train Speed	Gate 14	3.13.4																N R	N R		
7.2.3.1	Monitor Speed and Distance based on MRSP (Dynamic Speed Profiles), MA, release speed, gradient, mode profile,,non protected LX start location, and route unsuitability location	Gate 14	3.13 5.9.3.5 5.7.3.4 3.12.2.8 3.12.5.4						X	X	X		X						N R	N R		
7.2.3.3	Monitor Speed and Distance based on MRSP	Gate 14	3.13.7				X	X	X	X	X	X	X			X			N R	N R	X	X
7.2.3.4	Monitor Speed and Distance based on MRSP (Dynamic Speed Profiles), allowed distance to run in SR mode	Gate 14	3.13.2.3.6.1 b) 3.13.8.2.1 d) 3.13.10.4.13									X							N R	N R		
7.2.3.5	Monitoring Ceiling Speed (no braking curve) based on MRSP	Gate 14	4.4.8.1.1 a) 4.4.18.1.3 a)				X												N R	N R	X	X



	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
7.2.4	Request MA on reception of "track ahead free up to the level 2 transition location"	no impact to safety	3.8.2.7.1		X				X	X	X	X	X			X	X	X	N R	N R	X	
<b>7.3</b>	<b>Protect against undesirable Train Movements</b>	Gate 16																				
7.3.1	Protect against Backwards Distance movement	Event "Kernel-13"	4.4.14, 4.4.18															X	N R	N R		X
7.3.2	Protect against Roll Away	Gate 73	3.14.2				X	X	X	X	X	X	X			X		X	N R	N R		X
7.3.3	Unauthorised Direction Movement Protection	Event "Kernel-14"	3.14.3					X	X	X	X	X	X					X	N R	N R		X
7.3.4	Supervise Standstill	Event "Kernel-12"	3.14.4 4.4.7.1.5		X														N R	N R		
7.3.5	Supervise signalling related speed restriction when evaluated as a trip order	Gate "MRSP"	3.11.6.4						X		X	X	X						N R	N R		
<b>7.4</b>	<b>Control Brakes</b>	Gate 85	3.13 3.14.1	X	X		X		X		X	X	X			X	X	X	X	N R		X
7.4.1	Command Emergency Brake	Gate 85	4	X												X		X	N R			

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
7.5	Protection functions																					
7.5.1	Manage Track Conditions excluding Sound Horn, Non Stopping Areas, Tunnel Stopping Areas and Big Metal Masses	no impact to exceed safe speed and distance	3.12.1						X		X		X		X		X	X	N R	N R		
7.5.1.1	Manage Track Condition Big Metal Masses	no impact to exceed safe speed and distance	3.12.1		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	
7.5.1.2	Manage Track Conditions Sound Horn, Non Stopping Areas, Tunnel Stopping Areas	no impact to exceed safe speed and distance	3.12.1						X		X		X						N R	N R		
7.5.2	Manage Route Suitability	Gate 108	3.12.2						X		X		X						N R	N R		
7.5.3	Manage Text Display to the driver	no impact to safety	3.12.3		X				X		X	X	X		X	X	X	X	N R	N R		X
8	Other functions																					
8.1	Determine Geographical Position	Gate 4	3.6.6		X				X		X	X	X		X	X	X	X	N R	N R		

	ON-BOARD FUNCTIONS	Related Fault Tree Gates	Related SRS paragraph	N P	S B	P S	S H	S M <sub>1</sub>	F S	A D	L S	S R	O S	S L	N L	U N	T R	P T	S F	I S	S N	R V
8.3	Request Radio Infill	no impact to safety	3.9.6						X		X								N R	N R		
8.5	Provide Juridical Data	no impact to safety	3.20		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
8.6	Continue Shunting on desk closure (Enabling transition to Passive Shunting mode)	no impact to safety	5.12.4				X												N R	N R		
8.7	Manage “Stop Shunting on desk opening” information	Gate 80	4.4.20.1.8 4.4.20.1.9			X													N R	N R		
8.8	Cold Movement Detection	Gate 58	3.15.8	X															N R	N R		
8.9	Advance display of route related information	no impact to safety	3.15.10						X										N R	N R		
8.10	Virtual Balise Cover	MRSP	3.15.9		X	X	X		X		X	X	X	X	X	X	X	X	N R	N R	X	X
8.12	Manage LSSMA display to the driver	no impact to exceed safe speed and distance	4.4.19.1								X								N R	N R		

### 10.1.3 Trackside Function Table

10.1.3.1 The following table specifies the trackside functions. The functions are described in more detail in the SRS chapter referenced in the fourth column of the table.

	TRACKSIDE-FUNCTIONS	Related Fault Tree Gates	RELATED SRS paragraph
<b>1</b>	<b>Define Balise configuration and linking</b>	Gate 54	
1.1	<p>Define Balise group</p> <p><i>It is the trackside responsibility to take care that the number of balises in a group and that their identification within the group is correct.</i></p> <p><i>Variables in the balise message may be affected by basic message errors during transmission (mitigations: safety code)</i></p>	Gate 54	3.4.1
1.2	<p>Define Balise co-ordinate system</p> <p><i>It is the trackside responsibility to take care that orientation information and the installation of a balise group is correct.</i></p> <p><i>Variables in the balise message may be affected by basic message errors during transmission (mitigations: safety code, groups of more than one balise)</i></p>	Gate 54	3.4.2
1.3	<p>Define Linking</p> <p><i>It is the trackside responsibility to take care that linking information is correct.</i></p> <p><i>Variables in the message may be affected by basic message errors during transmission (mitigations: safety code)</i></p>	Gate 54	3.4.4
<b>2</b>	<b>Manage radio communication</b>	Gate 128 (only Level 2)	
2.1	<p>Establish a communication session</p> <p><i>It is the trackside responsibility to order an on-board to initiate the establishment of a communication session.</i></p> <p><i>It is also the trackside responsibility to send the correct system version.</i></p>	not detailed further	3.5.3
2.2	<p>Maintain a communication session</p> <p><i>The trackside shall not attempt to re-establish a connection accidentally lost.</i></p>	not detailed further	3.5.4
2.3	<p>Terminate a communication session</p> <p><i>It is the trackside responsibility to order an on-board to terminate a communication session.</i></p>	not detailed further	3.5.5

	TRACKSIDE-FUNCTIONS	Related Fault Tree Gates	RELATED SRS paragraph
<b>3</b>	<b>Transmit location specific data</b>		
3.1	<p>Transmit location specific data from balise</p> <p><i>It is the trackside responsibility to send location and profile data correctly referred to balise location and to install appropriately the balise groups.</i></p> <p><i>Variables in the balise message may be affected by basic message errors during transmission (mitigations: safety code, groups of more than one balise,...)</i></p>	Gate 117	3.6.2.1
3.3	Transmit location specific data from in-fill device	Gate 117	3.6.2.3
<b>4</b>	<b>Determine Train position</b>	Gate 125 (only Level 2)	
4.1	<p>Validate direction of transmitted information</p> <p><i>It is the trackside responsibility to identify correctly the direction of validity of information sent to the on-board.</i></p> <p><i>Variables in the message may be affected by basic message errors during transmission (mitigations: safety code,...)</i></p>	Gate 125	3.6.3
4.2	<p>Estimate of train location based on position report</p> <p><i>It is the trackside responsibility to use position reports received from the train, to select the correct information to send (e.g., a wrong MA could be sent to a train).</i></p> <p><i>Errors in this function may depend on internal RBC operations or on error in data configuration (trackside design).</i></p>	Gate 125	3.6.5

	TRACKSIDE-FUNCTIONS	Related Fault Tree Gates	RELATED SRS paragraph
<b>5</b>	<b>Check Completeness of data</b>	-	
5.1	<p>Check completeness of data</p> <p><i>It is the trackside responsibility to send MA only when all necessary information are received by the on-board and to send additional information when needed (e.g., emergency messages).</i></p> <p><i>Errors in this function may depend on trackside design errors (especially in level 1) internal operation of RBC or on errors at the interface with other trackside equipment (e.g., alarm detectors).</i></p> <p><i>(mitigations: on-board does not accept MA if SSP, gradient, etc. are not available for its length).</i></p> <p><i>Messages may be affected by basic message errors during transmission (mitigations: safety code, ack procedures,...)</i></p>	Gate 126 (only Level 2)	3.7.2
<b>6</b>	<b>Manage Movement Authorities</b>	Gate 126 (only Level 2)	
6.1	<p>Structure MA</p> <p><i>It is the responsibility of trackside to send MA complying with ERTMS language and corresponding to trackside state.</i></p> <p><i>Messages may be affected by basic message errors during transmission (mitigations: safety code,...)</i></p>	Gate 125 and 126 (only Level 2)	3.8.1, 3.8.3
6.2	<p>Manage MA</p> <p><i>Correctness of the engineering process in providing balise data and positioning balises correctly.</i></p>	Event "ENG-1A"	
<b>7</b>	<b>Transmit in-fill data (level 1 only)</b>	-	3.8.4.6; 3.9

<b>8</b>	<b>Manage Emergency messages</b>		
<b>9</b>	<b>Manage Track description data</b>	Gate 126 (only Level 2)	
9.1	<p>Structure message</p> <p><i>It is the responsibility of trackside to send messages complying with ERTMS language.</i></p> <p><i>Messages may also be affected by basic message errors during transmission (mitigations: safety code, ...)</i></p>	Gate 125  and 126 (only Level 2)	3.11, 3.12
9.2	<p>Manage Temporary speed restrictions</p> <p><i>It is the responsibility of trackside to send correct messages when needed to the appropriate train.</i></p> <p><i>Messages may also be affected by basic message errors during transmission, as deletion, repetition, insertion. (mitigations: safety code, ack procedures...)</i></p>	Gate 126 (only Level 2)  or  117	3.11.5
9.3	<p>Send Text messages</p> <p><i>It is the responsibility of trackside to send correct messages when needed to the appropriate train.</i></p> <p><i>Messages may also be affected by basic message errors during transmission, as deletion, repetition, insertion. (mitigations: safety code, ack procedures...)</i></p>	Gate 126 (only Level 2)  or  117	3.12.3
<b>10</b>	<p><b>Handle trains with NL engines</b></p> <p><i>The trackside may be informed on the location of NL engines, possibly used if they initiate a mission.</i></p>		<b>3.15.2</b>
<b>11</b>	<b>Splitting/joining</b>		<b>3.15.3</b>
<b>12</b>	<p><b>Manage Reversing</b></p> <p><i>It is trackside responsibility to send reversing area information.</i></p> <p><i>Message may be affected by basic message errors during transmission (mitigations: safety code, ack procedures, ...)</i></p>	Gate 126 (only Level 2)	<b>3.15.4</b>

<b>13</b>	<b>Request Track status (Track ahead free request)</b>  <i>It is the responsibility of the trackside to ask for information and use information received from the on-board to send MAs.</i>  <i>Input: information from trackside, train position.</i>  <i>Output: decision to send MA message.</i>  <i>Messages may be affected by basic message errors during transmission (mitigations: safety code, ack procedures,...)</i>		<b>3.15.5</b>
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<b>14</b>	<b>Manage Data consistency</b>		
14.1	Prepare of balise and Loop messages  <i>Correctness of the engineering process in providing balise data and positioning balises correctly.</i>	Event “ENG-1A”	3.16.2
14.2	Prepare of radio messages  <i>It is responsibility of trackside to prepare radio messages complying with ERTMS language.</i>  <i>Messages may also be affected by basic message errors during transmission. (mitigations. Safety code, time stamping, ...)</i>	Gate 128 (only Level 2)	3.16.3
14.3	Check received radio messages  <i>It is the responsibility of trackside to reject a corrupted message and to avoid errors due to delayed, resequenced, masqueraded, etc. messages.</i>	Gate 121	3.16.3
<b>15</b>	<b>Manage System Version</b>  <i>Correctness of data from the engineering process.</i>	Event “ENG-1B”	<b>3.17</b>
<b>16</b>	<b>Manage System data</b>	Gate 126 (only Level 2)	
16.1	Manage National values  <i>It is the responsibility of trackside to send correct national values when necessary.</i>  <i>Messages may also be affected by basic message errors during transmission. (mitigations: safety code,...)</i>	Gate 126 (only Level 2) or 118	3.18.2



16.2	<p>Manage Train data</p> <p><i>It is the trackside responsibility to use train data received from on-board to select appropriate information for the train (e.g., SSP).</i></p> <p><i>Messages may also be affected by basic message errors during transmission. (mitigations: safety code,...)</i></p>	<p>Gate 125 (only Level 2)</p>	3.18.3
16.3	<p>Manage Additional data</p> <p><i>It is the trackside responsibility to use additional data received from on-board, e.g., to inform a supervision system outside ERTMS.</i></p> <p><i>Messages may also be affected by basic message errors during transmission. (mitigations: safety code,...)</i></p>	<p>Gate 126 (only Level 2)</p>	3.18.4