



Entwurfsverfahren

Das atomare Element als Meta-Modell zur tabellarischen Verhaltensbeschreibung von Echtzeitsystemen

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04. November 2011

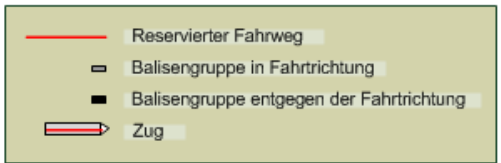
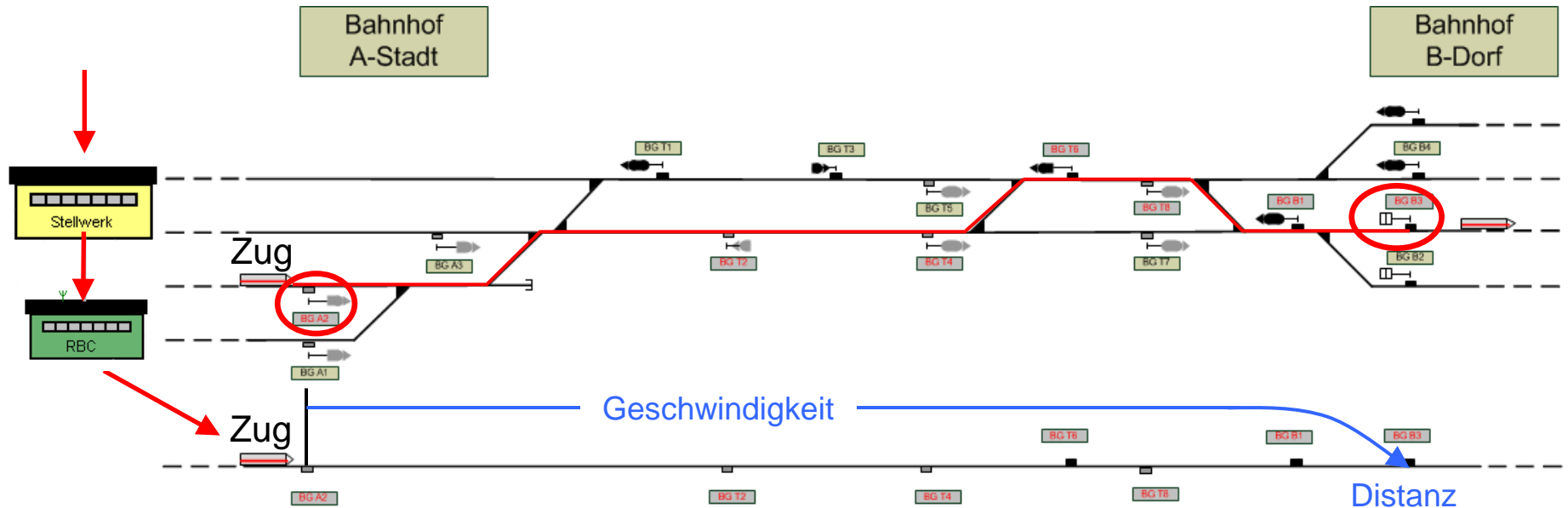


Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft



Echtzeitbetrieb im Schienenverkehr

Strecken und fahrzeugseitige Fahrwegsicherung



1. Fahrstraße wird eingestellt (Stellwerk-STW)
2. Fahrstraße wird übermittelt (STW -> RBC)
3. Fahrerlaubnis wird angezeigt und überwacht (OBU)



Ausnahmesituation: Zugvereinigung Zwei Züge in einem Blockabschnitt





Zugfahrt durch Bahnhof

Weichenumstellung - nach dem Zug und vor dem Zug!







Ausfahrt eines ICE

Umschaltvorgang des Ausfahrtsignals





Echtzeitbetrieb im Schienenverkehr ist komplex und kompliziert





Validierung neuer Leit- und Sicherungstechnik durch technische und betriebliche Simulation tut not!





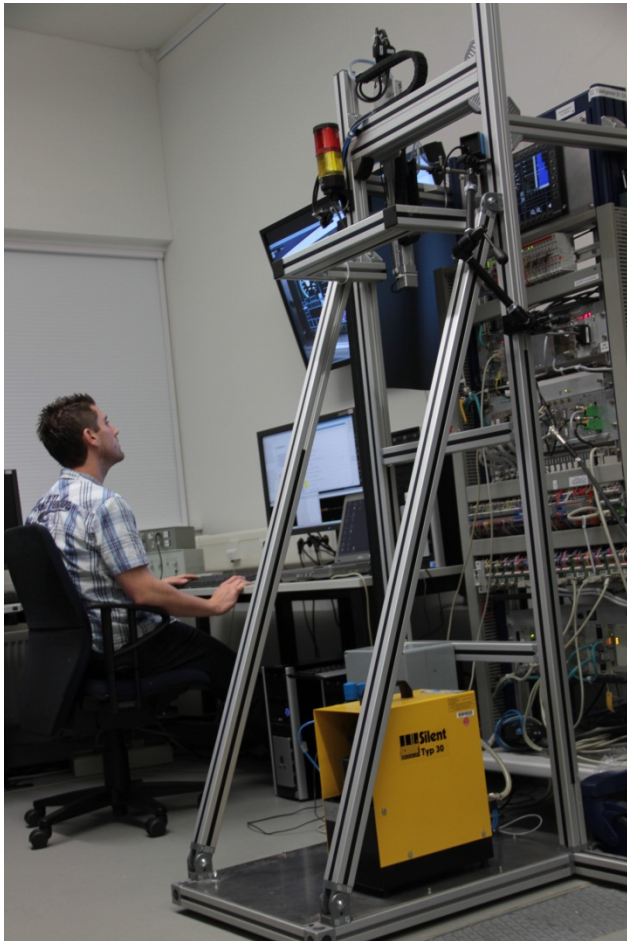
Eisenbahntechnisches Versuchslabor RailSiTe®

Railway Simulation and Testing laboratory

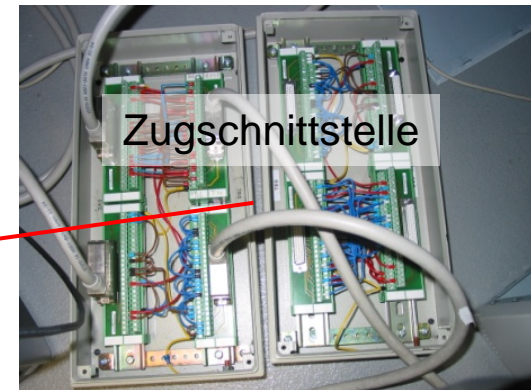
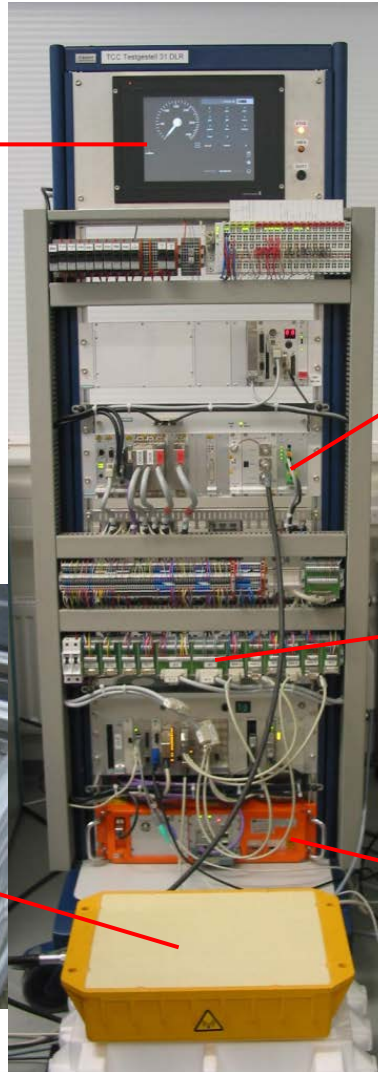
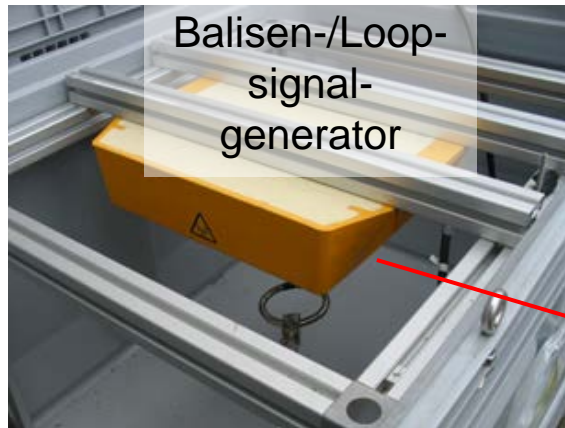
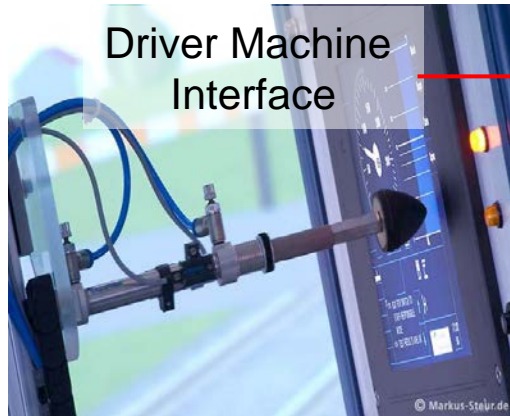




Überprüfung fahrzeugseitiger Komponenten im Labor



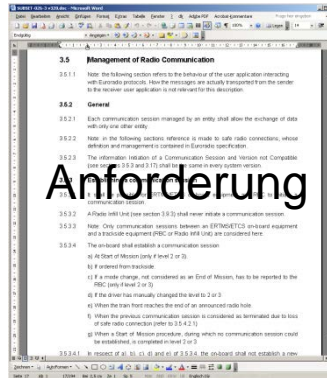
Schnittstellen der fahrzeugseitigen ETCS-Einheit



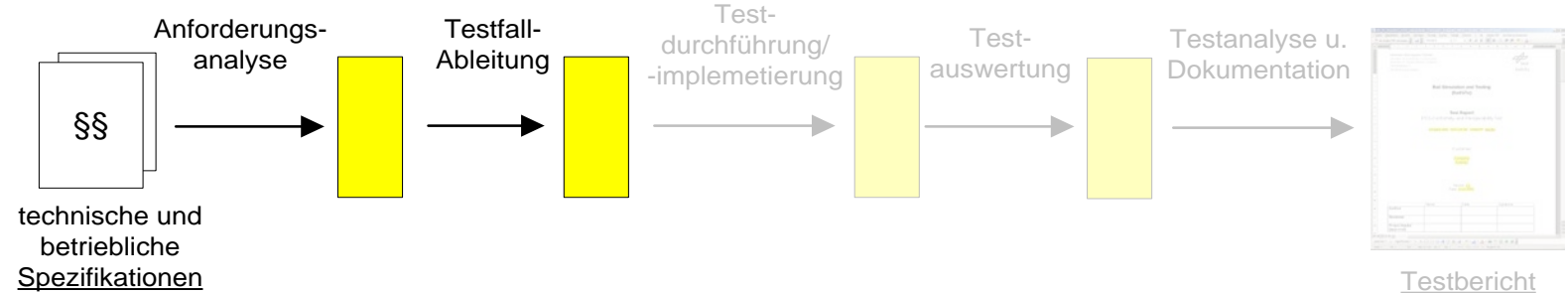
GSM-R Modem

Fahrdaten-schreiber

Von der Systemanforderung zum getesteten System Gesucht: Das Sollverhalten



Anforderung → Funktionalität → positive/negative Testfälle → Testabläufe/-fahrten

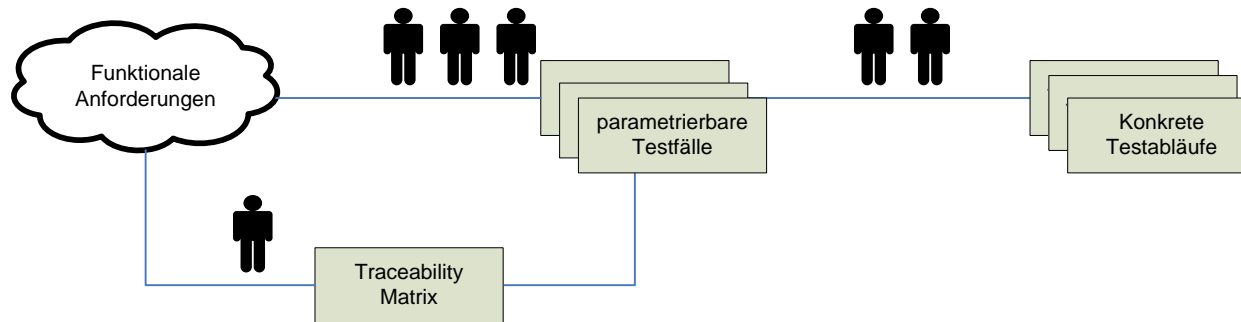




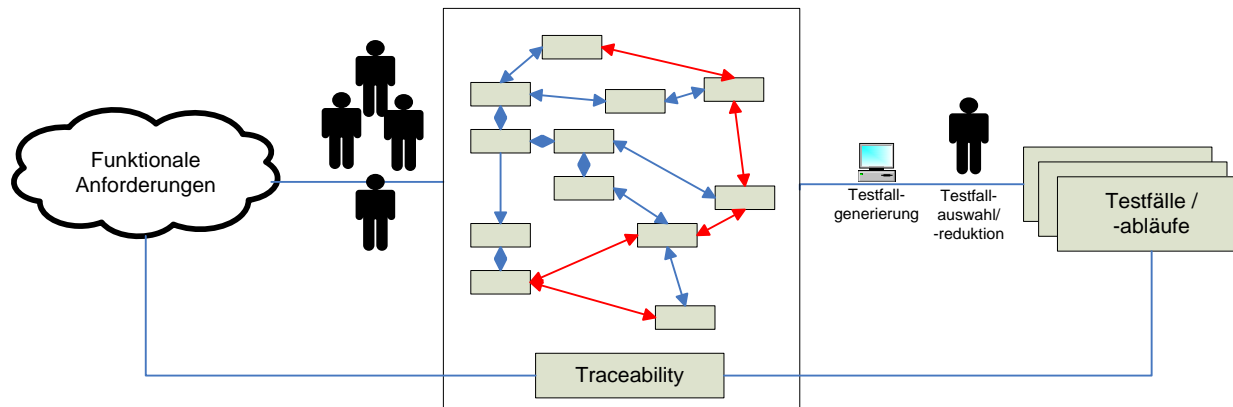
Testfallableitung

2 Wege

1. Testfallerstellung direkt von der Anforderung zum Testfall

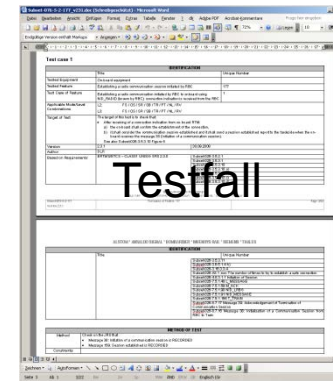
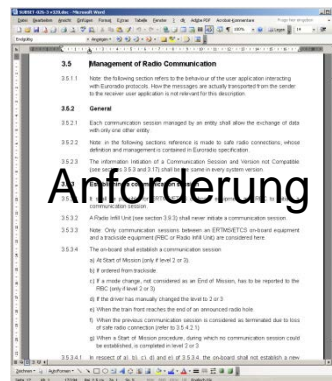
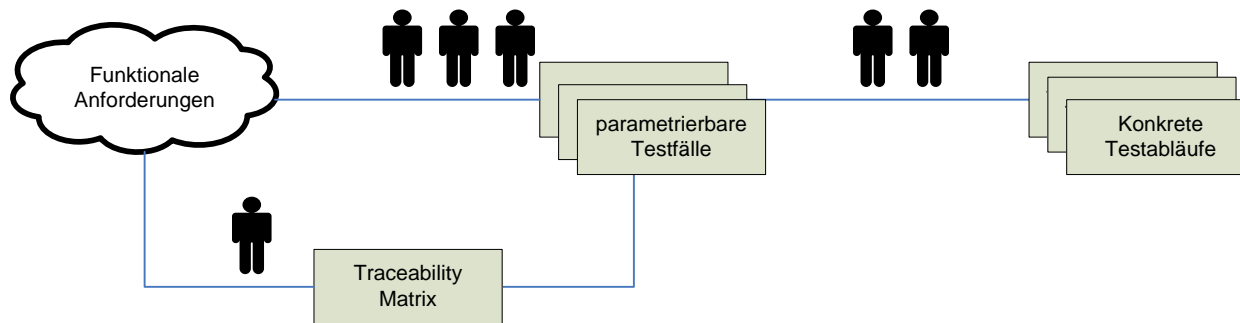


2. Testfallgenerierung indirekt über ein funktionales Modell

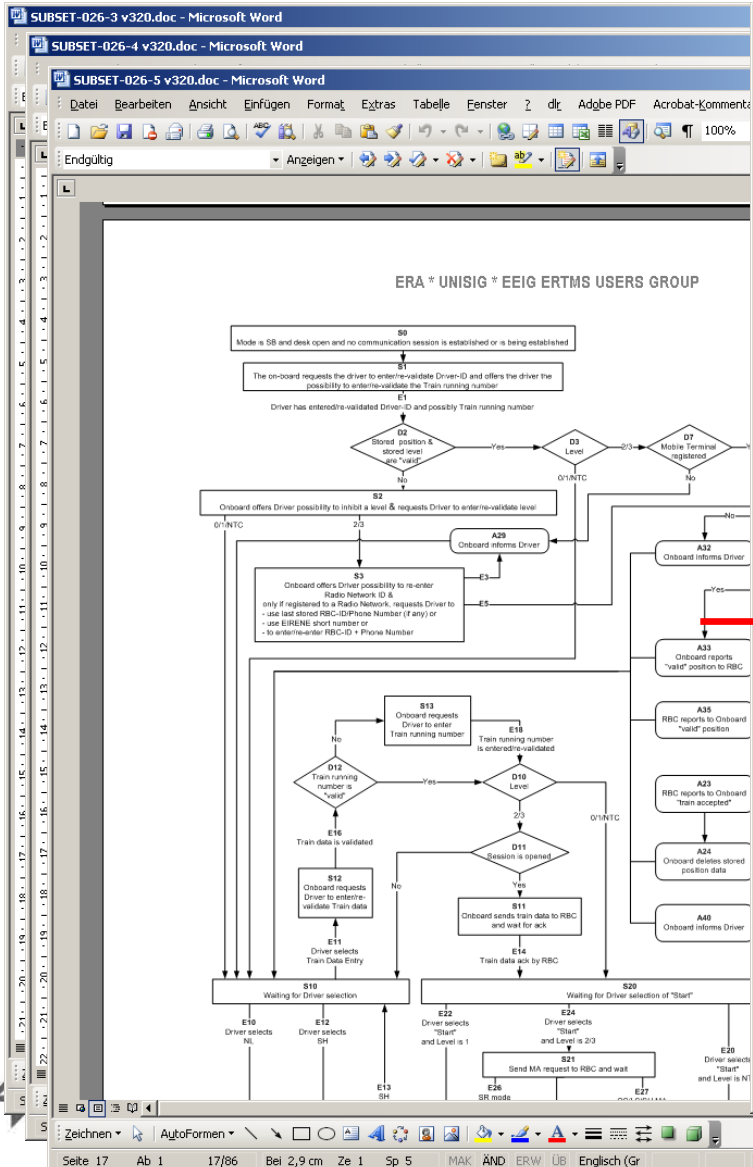


1. Direkte Testfallerstellung

Anforderung → Funktionalität → positive/negative Testfälle → Testabläufe



1. Direkte Testfallerstellung



Subset-076-5-2-177_v231.doc (Schreibgeschützt) - Microsoft Word

Subset-076-5-2-177_v231.doc (Schreibgeschützt) - Microsoft Word

STARTING CONDITIONS (INTERNAL STATES)

States of ERTMS/ETCS variables	Value	Description
M_LEVEL	3/4	L2/L3*)
M_MODE	01/12/6/7/8/11/12/13/14	FS / OS / SR / SB / TR / PT / NL / RV*)
Radio communication session	TERMINATED	Refers only for the session to the "calling" RBC

*) one of the applicable Mode-Level combinations

REQUIRED STARTING CONDITIONS ON INTERFACES

State of interfaces	I/O	Interface	Comments
Radio link is DISCONNECTED	-	RTM	Refers only for the link to the "calling" RBC
NOT RELEVANT	-	TIU	
NOT RELEVANT	-	DMI	
NOT RELEVANT	-	BTM	
NOT RELEVANT	-	LTM	
NOT RELEVANT	-	JRU	

SEQUENCE OF TEST

Step	Description of Events	I/O	Interface	Comments	Test Result
1.	Receive of connection indication from RTM Parameter: called ETCS-ID, Calling ETCS-ID, application type	I	RTM	The on-board equipment has to compare the called ETCS-ID with its own ETCS-ID.	
2.	Send an acceptance of the incoming connection to the RTM	O	RTM	A safe connection is now set-up	
3.	Message 38: Initiation of a communication session is RECEIVED	I	RTM		
4.	Message 38: Initiation of a communication session is RECORDED	O	JRU		
5.	Communication session established for on-board				
6.	Message 159: Session established is SENT	O	RTM		
7.	Message 159: Session established is RECORDED	O	JRU		
8.	Communication session is established for RBC				
9.	On-board system sends message 130 'Train position report' to the RBC	O	RTM		
10.	Message 130 'Train position report' is RECORDED	O	JRU		

Step 3: Message 38: Initiation of a communication session

Variable	Length	Value	Comment
NID_MESSAGE	8	38	
L_MESSAGE	10	75	
T_TRAIN	32	UNKNOWN	
M_ACK	1	1	
NID_LRBC	10 + 14	UNKNOWN	

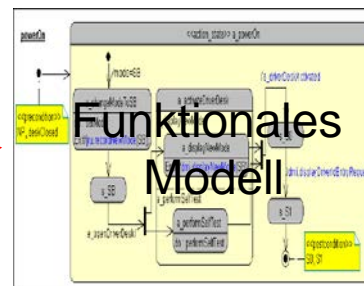
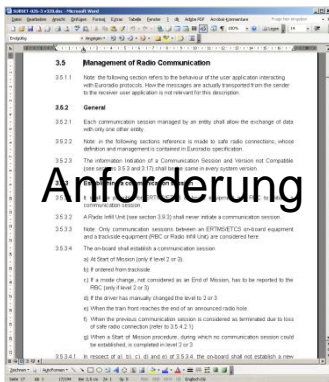
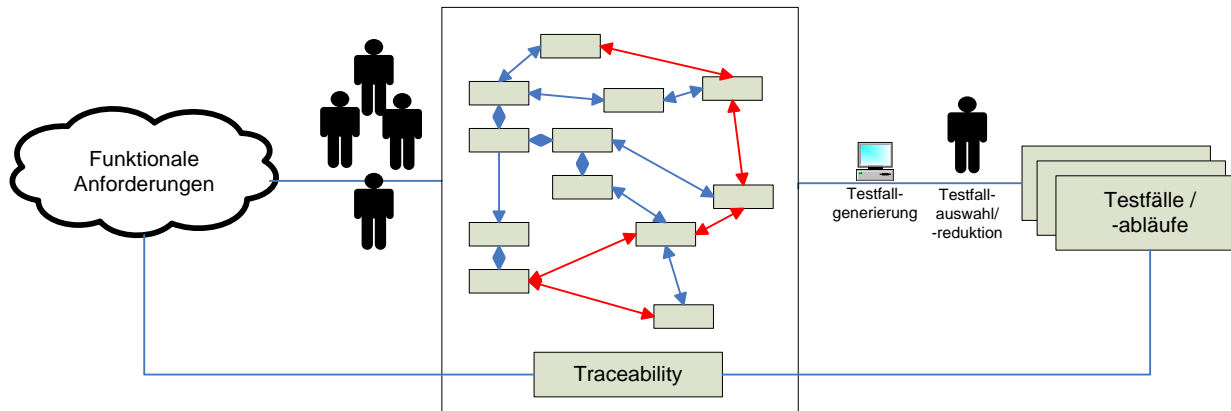
Step 6: Message 159: Session established

Variable	Length	Value	Comment
NID_MESSAGE	8	159	
L_MESSAGE	10	74	
T_TRAIN	32	FINITE VALUE	Time of the train
NID_ENGINE	24	FINITE VALUE	ETCS-ID of the Train



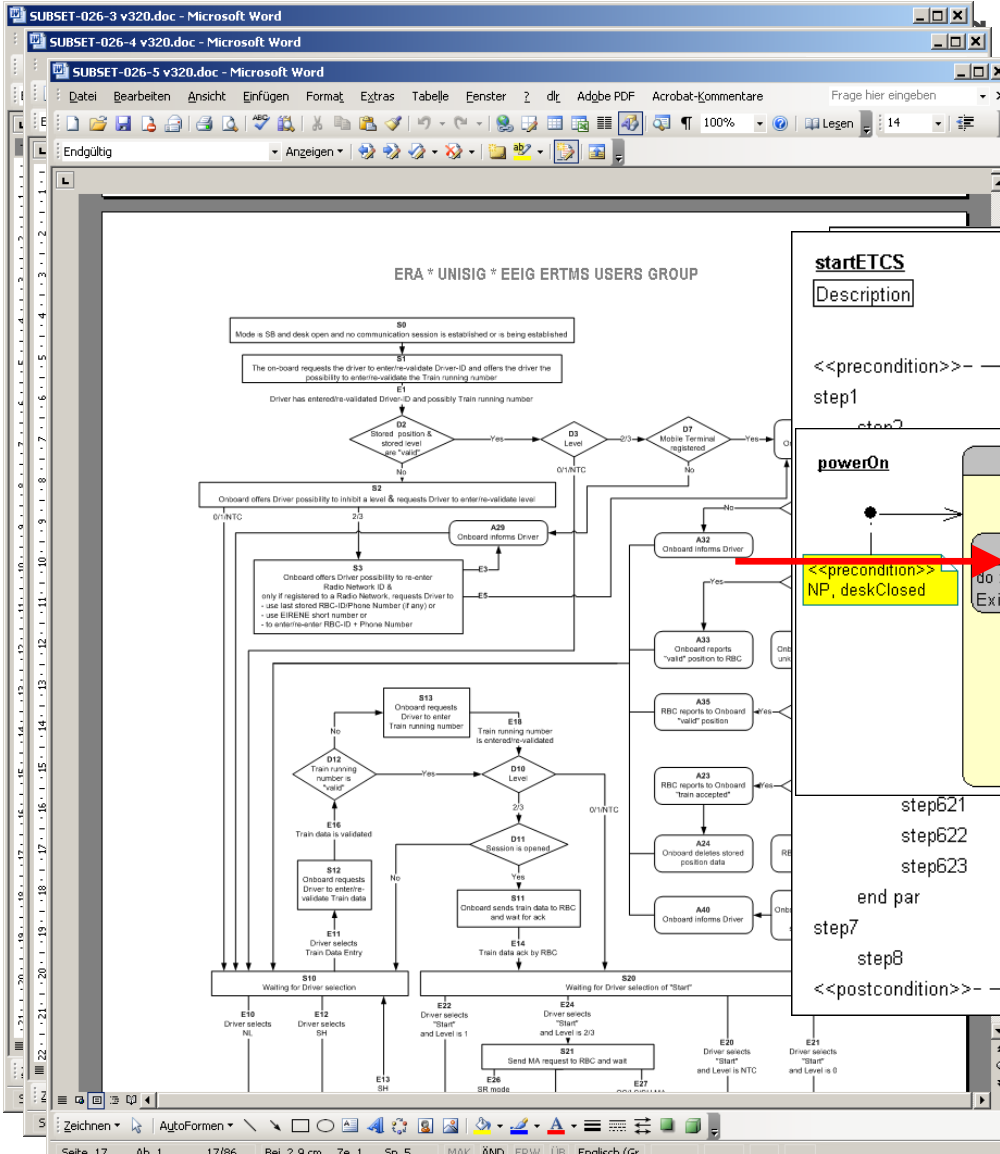
2. Indirekte Testgenerierung Modellbasierte Testableitung

Anforderung → funktionales Modell → Testabläufe/-fahrten

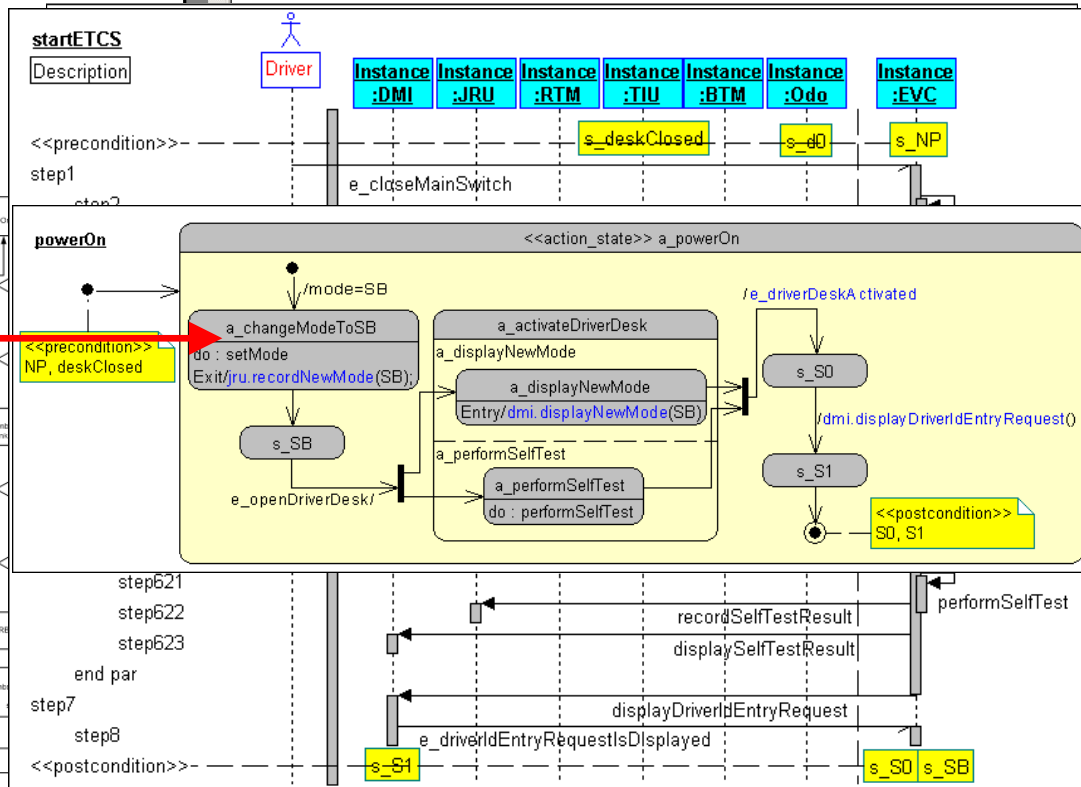


Testabläufe /-fahrten

2. Indirekte Testgenerierung

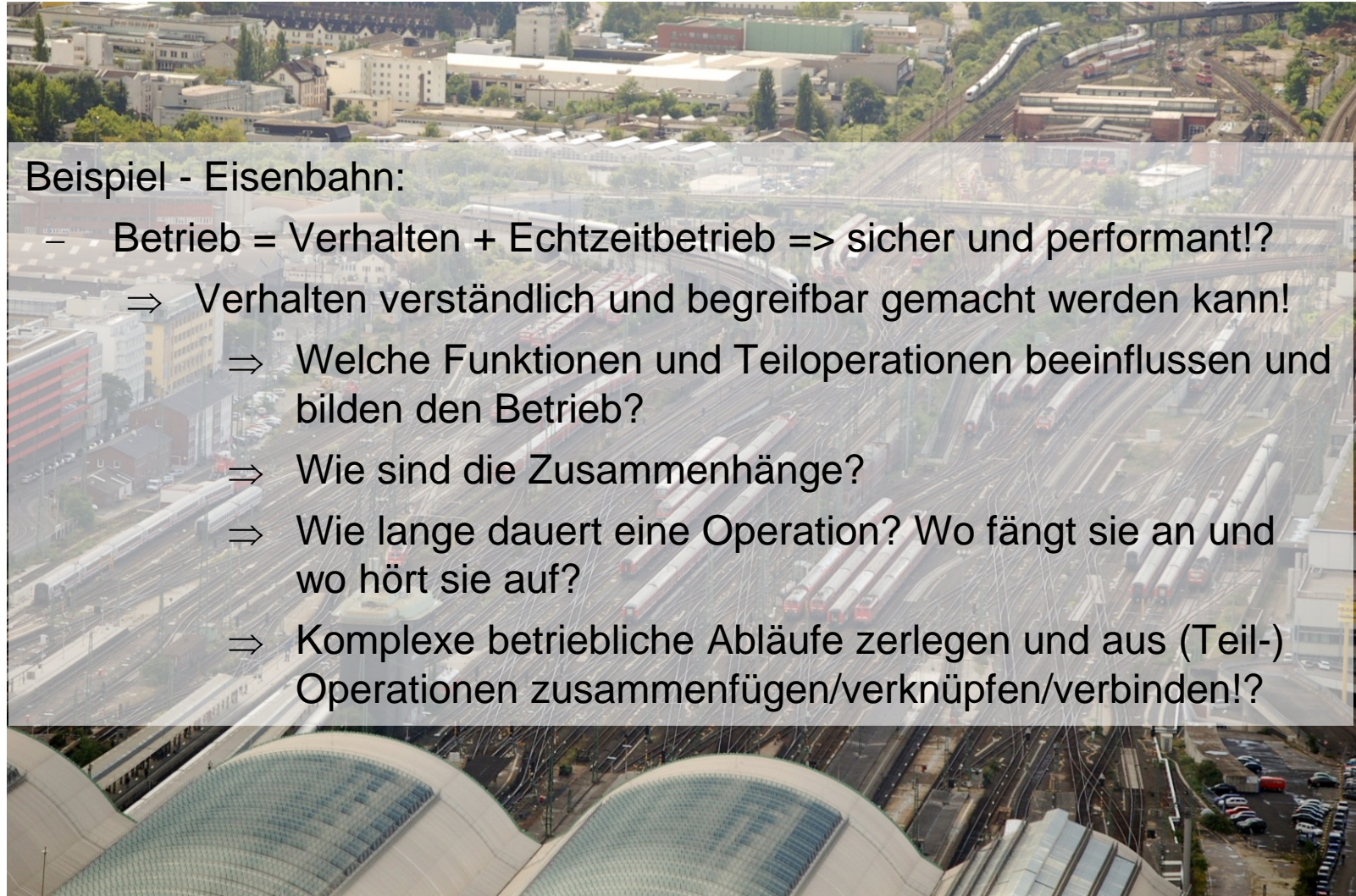


Modell → Testabläufe/-fahrten





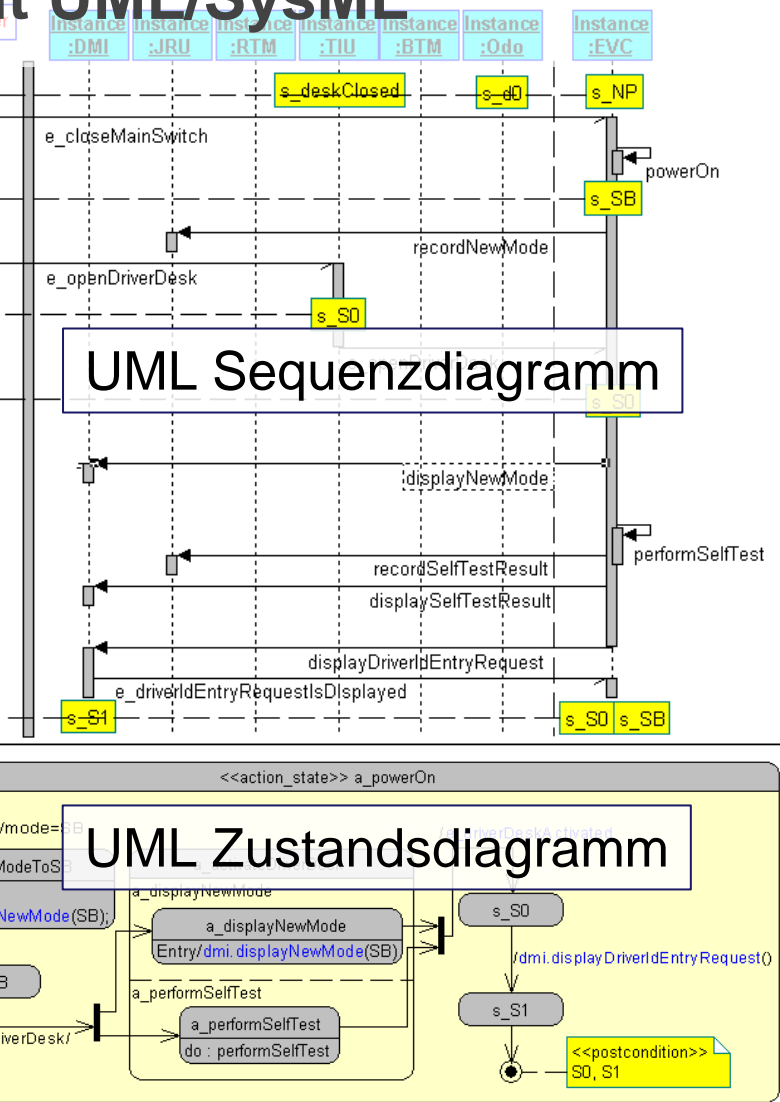
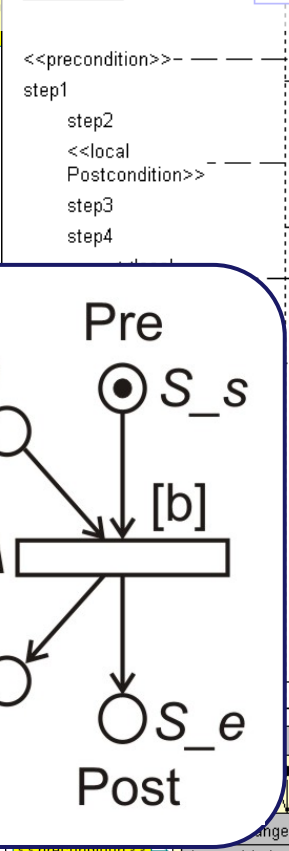
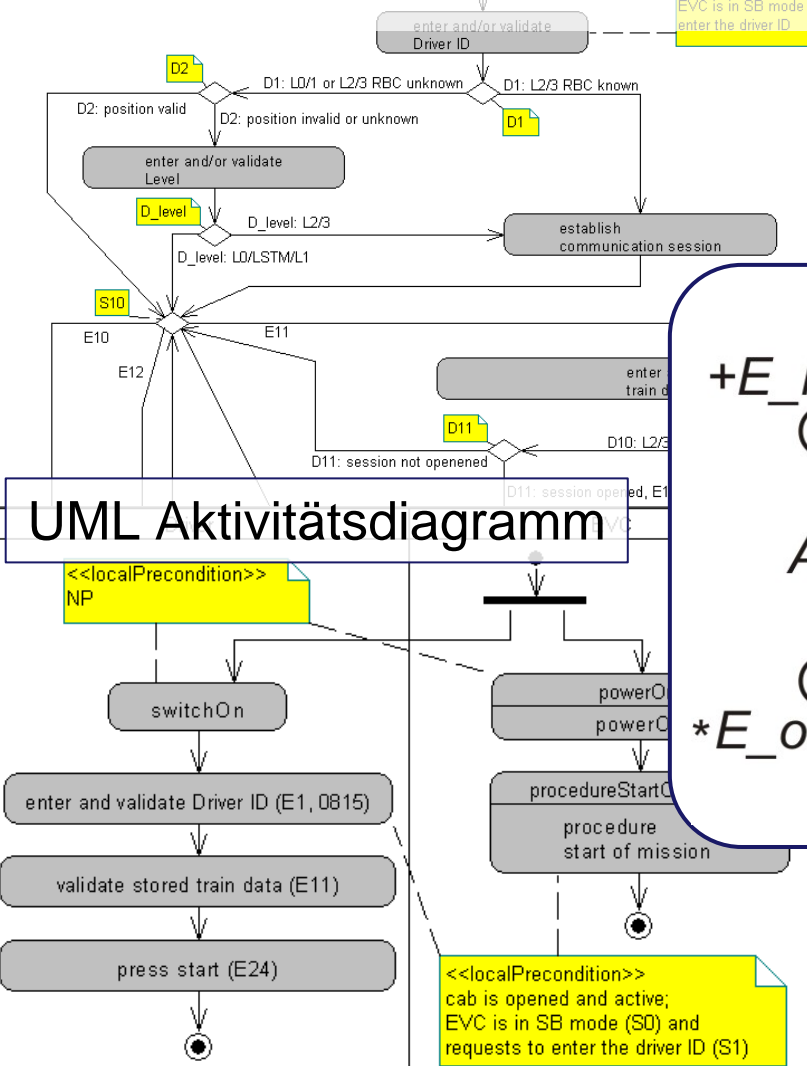
Herausforderungen durch Echtzeitbetrieb



Beispiel - Eisenbahn:

- Betrieb = Verhalten + Echtzeitbetrieb => sicher und performant!?
- ⇒ Verhalten verständlich und begreifbar gemacht werden kann!
 - ⇒ Welche Funktionen und Teiloperationen beeinflussen und bilden den Betrieb?
 - ⇒ Wie sind die Zusammenhänge?
 - ⇒ Wie lange dauert eine Operation? Wo fängt sie an und wo hört sie auf?
 - ⇒ Komplexe betriebliche Abläufe zerlegen und aus (Teil-) Operationen zusammenfügen/verknüpfen/verbinden!?

1. Alternative: Modellierung mit UML/SysML



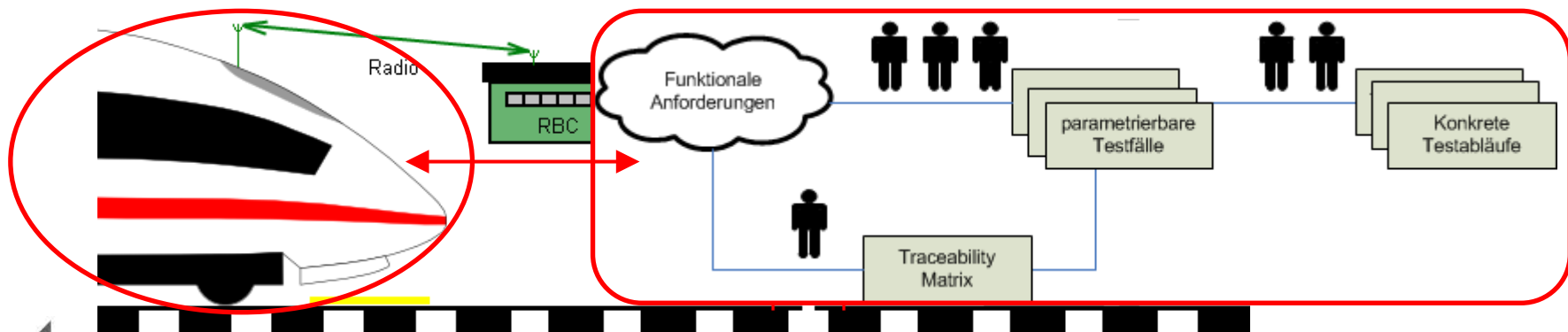
2. Alternative: Tabellarische Verhaltensbeschreibung Sollverhalten als Folge von Schnittstelleneignissen

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231_orig.mdb) Version 3.0; DataVersion 1.8											
Ord...	FT/TC	Step	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M	Comments
1	9999...	single step	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP	
2	541.1	1	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB	
3	541.1	2	L2/SB		0	0		JRU	The new current mode SB is RECORDED on JRU	L2/SB	
4	541.1	Followed by	L2/SB		0	0			Feature #522 'Indication of Auto-tests results to the dri...	L2/SB	
5	522.1	Preceded by	L2/SB		0	0			Feature #541 The ETCS on-board system is powered (T...	L2/SB	mode transition from NP to S...
6	522.1	1	L2/SB		0	0		TIU	Driver opens desk	L2/SB	Recording this TIU input is not...
7	522.1	2	L2/SB		0	0		DMI	The actual mode SB is DISPLAYED	L2/SB	The SB indication after openin...
8	522.1	3	L2/SB		0	0		DMI	After finishing the tests (self test and test of external d...	L2/SB	With switch on of power the s...
9	522.1	4	L2/SB		0	0		JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB	
10	523.1	1	L2/SB		0	0		DMI	SB mode is permanently displayed to the driver when t...	L2/SB	
11	257.1	1	L2/SB		0	0		DMI	The on-board equipment requires the driver to enter a ...	L2/SB	Starting conditions : There is ...

Properties						
Type	Var_Name	Var_Value	Var_Len	Name	Description	
StepExtra	Distance	0				
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination	
Header	L_MESSAGE	11 d	10	Message length	L_MESSAGE indicates the length of the message in byte...	
Header	T_TRAIN	t_train_1	32	Trainborne clock	Time, according to trainborne clock, at which message i...	
Header	M_ACK	0 b	1	Qualifier for acknowledgement request	Indicates whether the telegram must be acknowledged ...	
Header	NID_LRBG	16777215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number ...	
Header	M_VERSION	0010000 b	7	Version of the ETCS language	This gives the version of the ETCS languageEach part in...	

Konformitäts- und Interoperabilitätstestspezifikation der neuen europäischen Leit- und Sicherungstechnik

- Systemanforderungs-Spezifikation (Subset-026)
 - Ca. 4000 funktionale Systemanforderungen
 - Über 100 weitere Subset's für Schnittstellen-Spezifikationen
- Konformitäts-Testspezifikation für Zugsicherungseinheit (Subset-076)
 - Von Bahnexperten manuell Toolgestützt erstellt
 - Großer Umfang und hoher Detaillierungsgrad der Tests:
 - 674 Funktionalitäten, 1862 Testfälle, ca. 35.000 Testschritte
 - Detaillierte Datenstrukturen für Nachrichten und Variablen



Tabellarischer Testablauf/-fahrt

Sollverhalten als Folge von Schnittstellenergebnissen

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231_orig.mdb) Version 3.0; DataVersion 1.8

Ord...	FT/TC	Step	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M	Comments
1	9999...	single step	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP	
2	541.1	1	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB	
3	541.1	2	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB	
4	541.1	Followed by	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB	
5	522.1	Preceded by	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB	mode transition from NP to S...
6	522.1	1	L2/SB		0	0	⊙	TIU	Driver opens desk	L2/SB	Recording this TIU input is not...
7	522.1	2	L2/SB		0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB	The SB indication after openin...
8	522.1	3	L2/SB		0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB	With switch on of power the s...
9	522.1	4	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB	
10	522.1	5	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB	
11	257.1	1	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB	Starting conditions : There is ...

Type	Var. Name	Var. Value	Var. Unit	Name	Description
StepExtra					
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination
Header	L_TRAIN	32	32	Trainborne clock	Time, according to trainborne clock, at which message i...
Header	NID_LRBG	1677215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number ...
Header	Version	1		Version of the ETCS language	This gives the version of the ETCS languageEach part in...

Problem

- Wo fängt eine Funktion an?

- Wo hört sie auf?

- Zustände als Referenzpunkte für das Systemverhalten sind

nur implizit aufgeführt

Funktionalität durch mehrere 100 bis über 1000 Schritte /

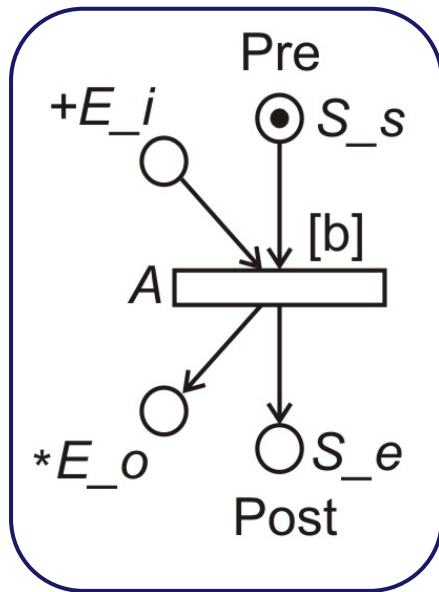
Schnittstellenergebnisse schwer überschaubar und

nachvollziehbar

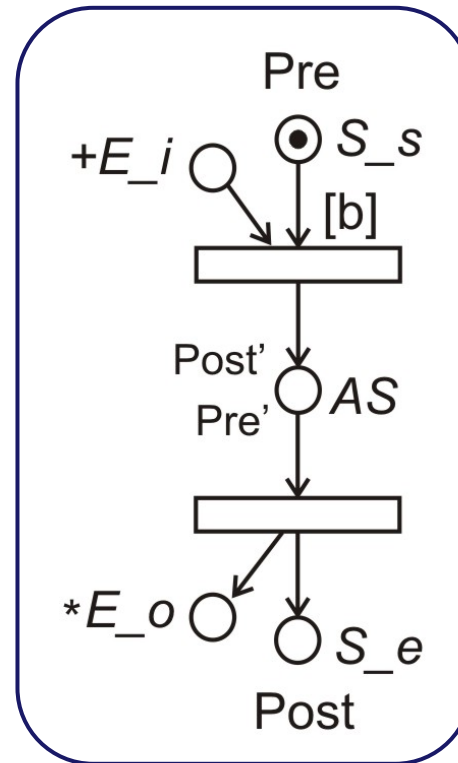


Das atomare Element

Meta-Modell für Echtzeitverhalten



kompakt

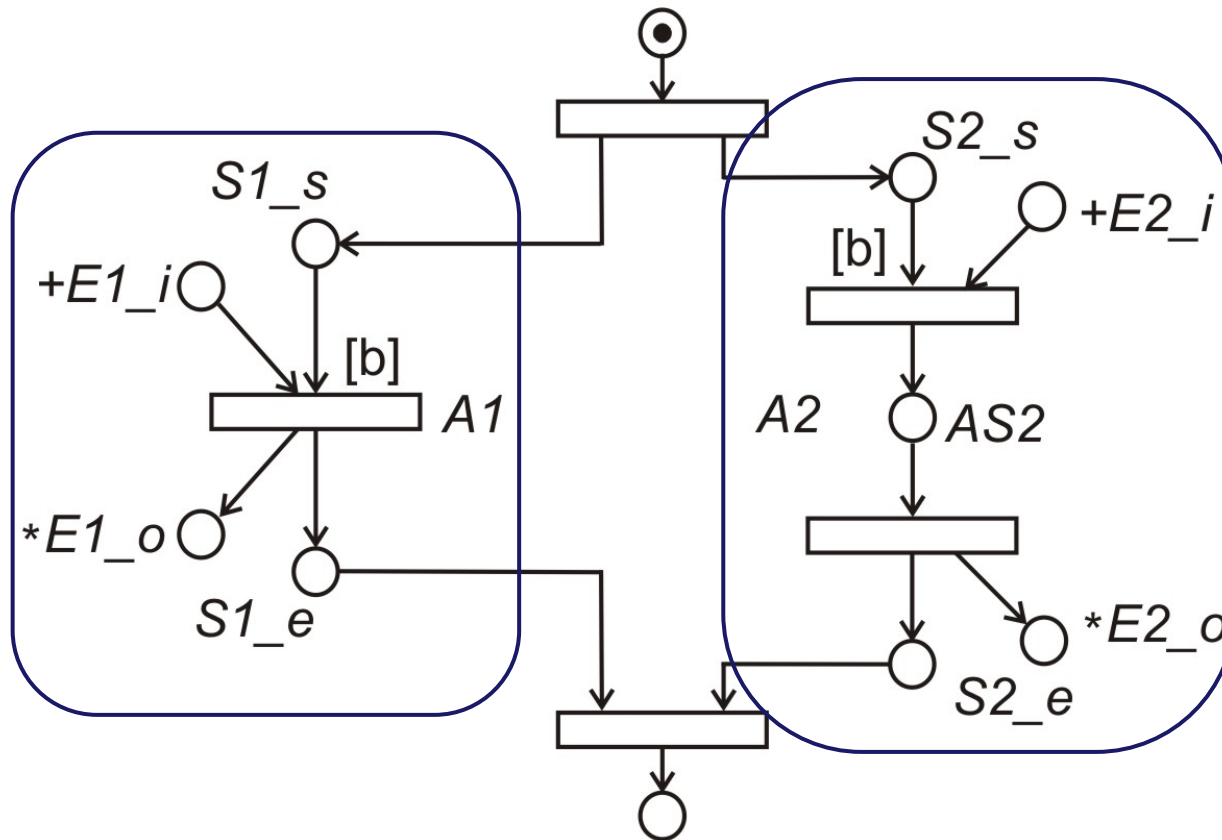


entfaltet



Das atomare Element bei nebenläufigen Aktivitäten

Meta-Modell für Echtzeitverhalten



Verhaltensbeschreibung - Testfallebene (mikroskopisch) auf Basis des atomaren Elements als Meta-Modell

SC_ITEM	SC_VALUE	SC_DESCRIPTION	SC_NOTE
M_LEVEL	0/ 1/ 2/ 3/ 4	L0/ LSTM/ L1/ L2/ L3 *)	
M_MODE	6	SB	

Start Conditions

SC_STATE	SC_INTERFACE	SC...
NOT RELEVANT	RTM	-
All driver desks are closed	TIU	I
NOT RELEVANT	DMI	-
NOT RELEVANT	BTM	-
NOT RELEVANT	LTM	-
NOT RELEVANT	JRU	-

Step

FT...	TC...	S...	ST_STEP	ST_PREV_...	ST_PREV_...	ST_DESCRIPTION
522	1	1	Preceded by	-	-	Feature #541 The ETCS on-board system is powered (Transi
522	1	2	Pre-condition	-	-	Starting state
522	1	3	-	-	-	Driver opens desk
522	1	4	Action	L0/ LSTM/ ...	SB	Activate driver desk A
522	1	5	-	-	-	The actual mode SB is DISPLAYED
522	1	6	-	-	-	After finishing the tests (self test and test of external devices) t
522	1	7	-	-	-	The text message 'TEST RESULTS ARE OK' (Or similar) is R
522	1	8	Post-condition	-	-	End state

Test Case

End Conditions

EC_STATE	EC_INTERFACE	EC...
NOT AFFECTED	RTM	-
One driver desk is open	TIU	I
Predefined text message 'TEST RESULTS A...	DMI	O
NOT AFFECTED	BTM	-
NOT AFFECTED	LTM	-
Predefined text message 'TEST RESULTS A...	JRU	O

EC_Internal

EC_ITEM	EC_VALUE	EC_NOTE	EC_DESCRIPTION
M_LEVEL	0/ 1/ 2/ 3/ 4	UNCHANGED	L0/ LSTM/ L1/ L2/ L3 *)
M_MODE	6	UNCHANGED	SB

The diagram illustrates a state transition model. It starts with a state labeled 'Pre'. An event $+E_i$ (represented by a circle with an arrow) and a state S_s (represented by a circle with a dot) lead to a transition box labeled '[b]'. This transition leads to a state labeled 'Post''. From 'Post'', an event AS (represented by a circle with a dot) leads to another transition box. This transition leads to a state labeled 'Post'. From 'Post', two events emerge: $*E_o$ (represented by a circle with an arrow) and S_e (represented by a circle with a dot).

Verhaltensbeschreibung - Testablaufebene(makroskopisch) auf Basis des atomaren Elements als Meta-Modell

entfaltet

Ord...	FT/TC	Step	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1					S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2					S	L2/NP		0	0			Starting state	L2/NP
3					E	L2/NP		0	0			The power of the on-board is switched on.The on-board...	L2/SB
4					A	L2/SB		0	0			Boot system, start all devices and perform self test	L2/SB
5					E	L2/SB		0	0		JRU	The new current mode SB is RECORDED on JRU	L2/SB
6					S	L2/SB		0	0			End state	L2/SB
7					-	L2/SB		0	0			Feature #522 'Indication of Auto-tests results to the dri...	L2/SB
8					-	L2/SB		0	0			Feature #541 The ETCS on-board system is powered (1...	L2/SB
9					S	L2/SB		0	0			Starting state	L2/SB
10					E	L2/SB		0	0		TIU	Driver opens desk	L2/SB
11					E	L2/SB		0	0		DMI	The actual mode SB is DISPLAYED	L2/SB
12					E	L2/SB		0	0		DMI	After finishing the tests (self test and test of external d...	L2/SB
13					E	L2/SB		0	0		JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14					S	L2/SB		0	0			End state	L2/SB
15					S	L2/SB		0	0			Starting state	L2/SB
16					E	L2/SB		0	0		DMI	SB mode is permanently displayed to the driver when t...	L2/SB
17					S	L2/SB		0	0			End state	L2/SB
18					E	L2/SB		0	0		DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19					E	L2/SB		0	0		DMI	The on-board equipment prevents the driver from perf...	L2/SB

Properties				Name	Description	UserComm...
StepExtra	distance	0				
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination	
Header	L_MESSAGE	11 d	10	Message length	L_MESSAGE indicates the length of the message in bytes, incl...	
Header	T_TRAIN	t_train_1	32	Trainborne clock	Time, according to trainborne clock, at which message is sent	
Header	M_ACK	0 b	1	Qualifier for acknowledgement request	Indicates whether the telegram must be acknowledged or not	
Header	NID_LRBG	16777215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number of last...	
Header	M_VERSION	0010000 b	7	Version of the ETCS language	This gives the version of the ETCS languageEach part indicate...	



Verhaltensbeschreibung - Testablaufebene/makroskopisch auf Basis des atomaren Elements als Meta-Modell

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8

Ord...	FT/TC	Step	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M	
1	9999...	single step	Start of Mission	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP	
2	541.1	Pre-condition	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP	
3	541.1	1	Start of Mission	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB	
4	541.1				A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB	
5	54				E	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB	
6	54				S	L2/SB		0	0	-	-	End state	L2/SB	
7	54				-	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB	
8	54				er dri...	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (1...	L2/SB	
9	54				er dri...	S	L2/SB		0	0	-	Starting state	L2/SB	
10	54				er dri...	E	L2/SB		0	0	⊙	TJU	Driver opens desk	L2/SB
11	54				er dri...	E	L2/SB		0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB
12	54				er dri...	E	L2/SB		0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB
13	54				er dri...	E	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14	54				er dri...	S	L2/SB		0	0	-	-	End state	L2/SB
15	54				er dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
16	54				er dri...	E	L2/SB		0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB
17	54				er dri...	S	L2/SB		0	0	-	-	End state	L2/SB
18	24				er dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19	24				er dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB

Pre

+E_i

○ S_s

○ [b]

A

○ *E_o

○ S_e

Post

kompakt

Type	Var_Name	Var_Value	Var_Len	Name	Description	UserComm...
StepExtra	Distance	0				
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination	
Header	L_MESSAGE	11 d	10	Message length	L_MESSAGE indicates the length of the message in bytes, incl...	
Header	T_TRAIN	t_train_1	32	Trainborne clock	Time, according to trainborne clock, at which message is sent	
Header	M_ACK	0 b	1	Qualifier for acknowledgement request	Indicates whether the telegram must be acknowledged or not	
Header	NID_LRBG	16777215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number of last...	
Header	M_VERSION	0010000 b	7	Version of the ETCS language	This gives the version of the ETCS languageEach part indicate...	



Verhaltensbeschreibung - Testablaufebene/makroskopisch auf Basis des atomaren Elements als Meta-Modell

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8													
Ord...	FT/TC	Step	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1	9099...	single step	Start of Mission	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2	541.1	Pre-condition	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP
3	541.1	1	Start of Mission	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB
4	541.1	Action	Start of Mission	Power on	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB
5	541.1	2	Start of Mission	Power on	E	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB
6	541.1	Post-condition	Start of Mission	Power on	S	L2/SB		0	0	-	-	End state	L2/SB
7	541.1	followed by	Start of Mission	Power on	S	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB
8	522.1	Pre-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
9	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	TRU	Driver opens desk	L2/SB
10	522.1	2	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMR	The actual mode SB is DISPLAYED	L2/SB
11	522.1	3	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMR	After finishing the tests (self test and test of external d...	L2/SB
12	522.1	4	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMR	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
13	522.1	Post-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
14	523.1	Pre-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
15	523.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB
16	523.1	Post-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
17	257.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB
18	257.1	2	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB

Properties						
Type	Var_Name	Var_Value	Var_Len	Name	Description	UserComm...
StepExtra	Distance	0				
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination	
Header	L_MESSAGE	11 d	10	Message length	L_MESSAGE indicates the length of the message in bytes, incl...	
Header	T_TRAIN	t_train_1	32	Trainborne clock	Time, according to trainborne clock, at which message is sent	
Header	M_ACK	0 b	1	Qualifier for acknowledgement request	Indicates whether the telegram must be acknowledged or not	
Header	NID_LRBG	16777215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number of last...	
Header	M_VERSION	0010000 b	7	Version of the ETCS language	This gives the version of the ETCS languageEach part indicate...	

Das atomare Element ermöglicht makroskopisch

1. Vertikale Differenzierung
2. Horizontale De-/Komposition



1. Vertikale funktionale Differenzierung

Schrittcontext: Funktions- und Testfallzugehörigkeit

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8

Ord.	FT/TC	In L/M	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1	9999...	L2/NP	0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2	541.1	L2/NP	0	0	-	-	Starting state	L2/NP
3	541.1	L2/NP	0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB
4	541.1	L2/NP	0	0	-	-	Boot system, start all devices and perform self test	L2/SB
5	541.1	L2/SB	0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB
6	541.1	L2/SB	0	0	-	-	End state	L2/SB
7	541.1	L2/SB	0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB
8	522.1	L2/SB	0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB
9	522.1	L2/SB	0	0	-	-	Starting state	L2/SB
10	522.1	L2/SB	0	0	⊙	TIU	Driver opens desk	L2/SB
11	522.1	L2/SB	0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB
12	522.1	L2/SB	0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB
13	522.1	L2/SB	0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14	522.1	L2/SB	0	0	-	-	End state	L2/SB
15	523.1	L2/SB	0	0	-	-	Starting state	L2/SB
16	523.1	L2/SB	0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB
17	523.1	L2/SB	0	0	-	-	End state	L2/SB
18	257.1	L2/SB	0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19	257.1	L2/SB	0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB

1. Vertikale funktionale Differenzierung

Schrittkontext: Typ und Bezeichner/ID

Test Steps (D:\daten\workspace\subet-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8													
Ord...	FT/TC	Step	Type	In L/M	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M			
1	9999...	single step	S	L/NP	0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP			
2	541.1	Pre-condition	S	L/NP	0	0	-	-	Starting state	L2/NP			
3	541.1	1	E	L/NP	0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB			
4	541.1	Action	A	L/NP	0	0	-	-	Boot system, start all devices and perform self test	L2/SB			
5	541.1	2	E	L/SB	0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB			
6	541.1	Post-condition	S	L/SB	0	0	-	-	End state	L2/SB			
7	541.1	Followed by	-	L/SB	0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB			
8	522.1	Preceded by	-	L/SB	0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB			
9	522.1	Pre-condition	S	L/SB	0	0	-	-	Starting state	L2/SB			
10	522.1	1	E	L/SB	0	0	⊙	TIU	Driver opens desk	L2/SB			
11	522.1	2	E	L/SB	0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB			
12	522.1	3	E	L/SB	0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB			
13	522.1	4	E	L/SB	0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB			
14	522.1	Post-condition	S	L/SB	0	0	-	-	End state	L2/SB			
15	523.1	Pre-condition	S	L/SB	0	0	-	-	Starting state	L2/SB			
16	523.1	1	E	L/SB	0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB			
17	523.1	Post-condition	S	L/SB	0	0	-	-	End state	L2/SB			
18	257.1	1	E	L/SB	0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB			
19	257.1	2	E	L/SB	0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB			

- Bezeichner:
- Pre-Condition
 - Post-Condition
 - Action
 - <Nr>
- Typ:
- „S“ = Zustand
 - „E“ = Ereignis
 - „A“ = Action

1. Vertikale funktionale Differenzierung

Schrittkontext: Fahrtrichtung des Zuges

Test Steps (D:\daten\workspace\subet-076\T5003\Subet-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8													
Ord...	FT/TC	Step	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M		
1	9999...	single step	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP		
2	541.1	Pre-condition	S	L2/NP		0	0	-	-	Starting state	L2/NP		
3	541.1	1	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB		
4	541.1	Action	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB		
5	541.1	2	E	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB		
6	541.1	Post-condition	S	L2/SB		0	0	-	-	End state	L2/SB		
7	541.1	Followed by	-	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB		
8	522.1	Preceded by	-	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB		
9	522.1	Pre-condition	S	L2/SB		0	0	-	-	Starting state	L2/SB		
10	522.1	1	E	L2/SB		0	0	⊙	TIU	Driver opens desk	L2/SB		
11	522.1	2	E	L2/SB		0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB		
12	522.1	3	E	L2/SB		0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB		
13	522.1	4	E	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB		
14	522.1	Post-condition	S	L2/SB		0	0	-	-	End state	L2/SB		
15	523.1	Pre-condition	S	L2/SB		0	0	-	-	Starting state	L2/SB		
16	523.1	1	E	L2/SB		0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB		
17	523.1	Post-condition	S	L2/SB		0	0	-	-	End state	L2/SB		
18	257.1	1	E	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB		
19	257.1	2	E	L2/SB		0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB		

1. Vertikale funktionale Differenzierung

Schrittcontext: Zugehörige und übergeordnete Funktion

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8													
Ord...	FT/TC	Step	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1	9999...	single step	Start of Mission	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2	541.1	Pre-condition	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP
3	541.1	1	Start of Mission	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB
4	541.1	Action	Start of Mission	Power on	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB
5	541.1	2	Start of Mission	Power on	E	L2/SB		0	0		JRU	The new current mode SB is RECORDED on JRU	L2/SB
6	541.1	Post-condition	Start of Mission	Power on	S	L2/SB		0	0	-	-	End state	L2/SB
7	541.1	Followed by	Start of Mission	Power on	-	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB
8	522.1	Preceded by	Start of Mission	Open desk and enter dri...	-	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB
9	522.1	Pre-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
10	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		TIU	Driver opens desk	L2/SB
11	522.1	2	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		DMI	The actual mode SB is DISPLAYED	L2/SB
12	522.1	3	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		DMI	After finishing the tests (self test and test of external d...	L2/SB
13	522.1	4	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14	522.1	Post-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
15	523.1	Pre-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
16	523.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		DMI	SB mode is permanently displayed to the driver when t...	L2/SB
17	523.1	Post-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
18	257.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19	257.1	2	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0		DMI	The on-board equipment prevents the driver from perf...	L2/SB

2. Horizontale funktionale De-/Komposition Zugehörige Funktion

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8												
Ord...	FT/TC	Step	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1	9999...	single step	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2	541.1	Pre-condition	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP
3	541.1	1	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB
4	541.1	Action	Power on	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB
5	541.1	2	Power on	E	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB
6	541.1	Post-condition	Power on	S	L2/SB		0	0	-	-	End state	L2/SB
7	541.1	Followed by	Power on	S	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB
8	522.1	Preceded by	Open desk and enter dri...	S	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB
9	522.1	Pre-condition	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
10	522.1	1	Open desk and enter dri...	E	L2/SB		0	0	⊙	TIU	Driver opens desk	L2/SB
11	522.1	2	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB
12	522.1	3	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB
13	522.1	4	Open desk and enter dri...	E	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14	522.1	Post-condition	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
15	523.1	Pre-condition	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
16	523.1	1	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB
17	523.1	Post-condition	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB
18	257.1	1	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19	257.1	2	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB

2. Horizontale funktionale De-/Komposition Übergeordnete Funktion

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8												
Ord...	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M	
1	Start of Mission	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP	
2	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP	
3	Start of Mission	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB	
4	Start of Mission	Power on	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB	
5	Start of Mission	Power on	E	L2/SB		0	0	⊙	JRU	The new current mode SB is RECORDED on JRU	L2/SB	
6	Start of Mission	Power on	S	L2/SB		0	0	-	-	End state	L2/SB	
7	Start of Mission	Power on	-	L2/SB		0	0	-	-	Feature #522 'Indication of Auto-tests results to the dri...	L2/SB	
8	Start of Mission	Open desk and enter dri...	-	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (T...	L2/SB	
9	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB	
10	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	TIU	Driver opens desk	L2/SB	
11	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The actual mode SB is DISPLAYED	L2/SB	
12	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	After finishing the tests (self test and test of external d...	L2/SB	
13	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	JRU	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB	
14	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB	
15	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB	
16	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	SB mode is permanently displayed to the driver when t...	L2/SB	
17	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	End state	L2/SB	
18	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment requires the driver to enter a ...	L2/SB	
19	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	⊙	DMI	The on-board equipment prevents the driver from perf...	L2/SB	

Verhaltensbeschreibung auf Basis des atomaren Elements als Meta-Modell

Test Steps (D:\daten\workspace\subset-076\T5003\Subset-076-6-3-003_v231.mdb) Version 3.0; DataVersion 1.8													
Ord...	FT/TC	Step	Group Fct	Group SubFct	Type	In L/M	Direction	Dist.	Rel. ...	I/O	Inter...	Description	Out L/M
1	9099...	single step	Start of Mission	Power on	S	L2/NP		0	0	-	ODO	Train speed is 0.0 km/h, stop time is 0.0 s.	L2/NP
2	541.1	Pre-condition	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP
3	541.1	1	Start of Mission	Power on	E	L2/NP		0	0	-	-	The power of the on-board is switched on.The on-boar...	L2/SB
4	541.1	Action	Start of Mission	Power on	A	L2/NP		0	0	-	-	Boot system, start all devices and perform self test	L2/SB
5	541.1	2	Start of Mission	Power on	E	L2/SB		0	0	-	-	The new current mode SB is RECORDED on J...	L2/SB
6	541.1	Pre-condition	Start of Mission	Power on	S	L2/NP		0	0	-	-	Starting state	L2/NP
7	544.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	Feature #522 Indication of Auto-tests results to the dri...	L2/SB
8	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	Feature #541 The ETCS on-board system is powered (1...	L2/SB
9	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	Starting state	L2/SB
10	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	DMI	Driver opens desk	L2/SB
11	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	SB mode is DISPLAYED	L2/SB
12	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	After finishing the tests (self test and test of external d...	L2/SB
13	522.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	DMI	The text message 'TEST RESULTS ARE OK' (Or similar)...	L2/SB
14	522.1	Post-condition	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	End state	L2/SB
15	523.1	Pre-condition	Start of Mission	Open desk and enter dri...	S	L2/SB		0	0	-	-	Starting state	L2/SB
16	523.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	SB mode is permanently displayed to the driver when t...	L2/SB
17	523.1	Post-condition	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	-	End state	L2/SB
18	257.1	1	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	DMI	The on-board equipment requires the driver to enter a ...	L2/SB
19	257.1	2	Start of Mission	Open desk and enter dri...	E	L2/SB		0	0	-	DMI	The on-board equipment prevents the driver from perf...	L2/SB

Properties						
Type	Var_Name	Var_Value	Var_Len	Name	Description	UserComm...
StepExtra	Distance	0				
Header	NID_MESSAGE	32	8	Message identifier	Configuration Determination	
Header	L_MESSAGE	11 d	10	Message length	L_MESSAGE indicates the length of the message in bytes, incl...	
Header	T_TRAIN	t_train_1	32	Trainborne clock	Time, according to trainborne clock, at which message is sent	
Header	M_ACK	0 b	1	Qualifier for acknowledgement request	Indicates whether the telegram must be acknowledged or not	
Header	NID_LRBG	16777215 d	24	Identity of last relevant balise group	Country/region identity (NID_C) + balise identity number of last...	
Header	M_VERSION	0010000 b	7	Version of the ETCS language	This gives the version of the ETCS languageEach part indicate...	

Deutliche Steigerung der Transparenz, des Verständnisses sowie der Konsistenz durch:

- Horizontale De-/Komposition

- Vertikale Differenzierung anwendungs-

spezifischer Informationen

=> Sicherheit und Vertrauen!





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