Effiziente Qualitätssicherung der neuen europäischen Leit- und Sicherungstechnik - Automatisierte Testerstellung, Testdurchführung, Testauswertung und Testberichtgenerierung

Lars Ebrecht

ATAMI 2011 - Advances in Testing: Academia meets Industry
23./24. Mai 2011 Berlin

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

Gliederung

- DLR - Institut für Verkehrssystemtechnik
- Kontext:
  - ETCS
  - Konformitätstests für ETCS-Fahrzeug-Einheit
- Motivation für die Testautomatisierung
  - Testauswertung und Dokumentation
  - Testdurchführung
  - Testerstellung
- Zusammenfassung und Schlussfolgerungen

DLR – Deutsches Zentrum für Luft- und Raumfahrt

6.200 Mitarbeiterinnen und Mitarbeiter arbeiten in 29 Forschungsinstituten und Einrichtungen in

- 13 Standorten.

Büros in Brüssel, Paris und Washington.

Forschungsschwerpunkte

- Raumfahrt
- Luftfahrt
- Energie
- Verkehr

Institut für Verkehrssystemtechnik

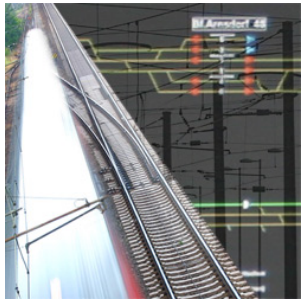
- Sitz: Braunschweig, Berlin
- Seit: 2001
- Leitung: Prof. Dr.-Ing. Karsten Lemmer
- Mitarbeiter: etwa 100 Mitarbeiter aus verschiedenen wissenschaftlichen Bereichen

Aufgabenspektrum

- Grundlagenforschung
- Erstellen von Konzepten und Strategien
- Prototypische Entwicklungen
- Betreiben von Großforschungsanlagen

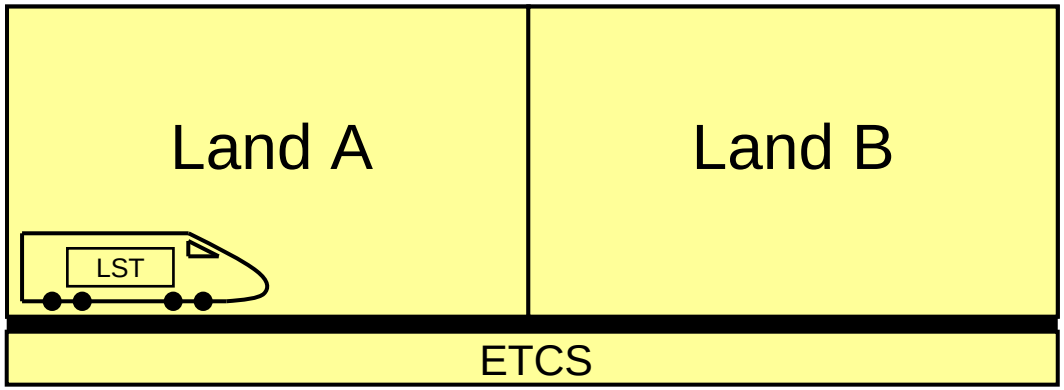
Forschungsgebiete

- Automotive
- Bahnsysteme
- Verkehrsmanagement



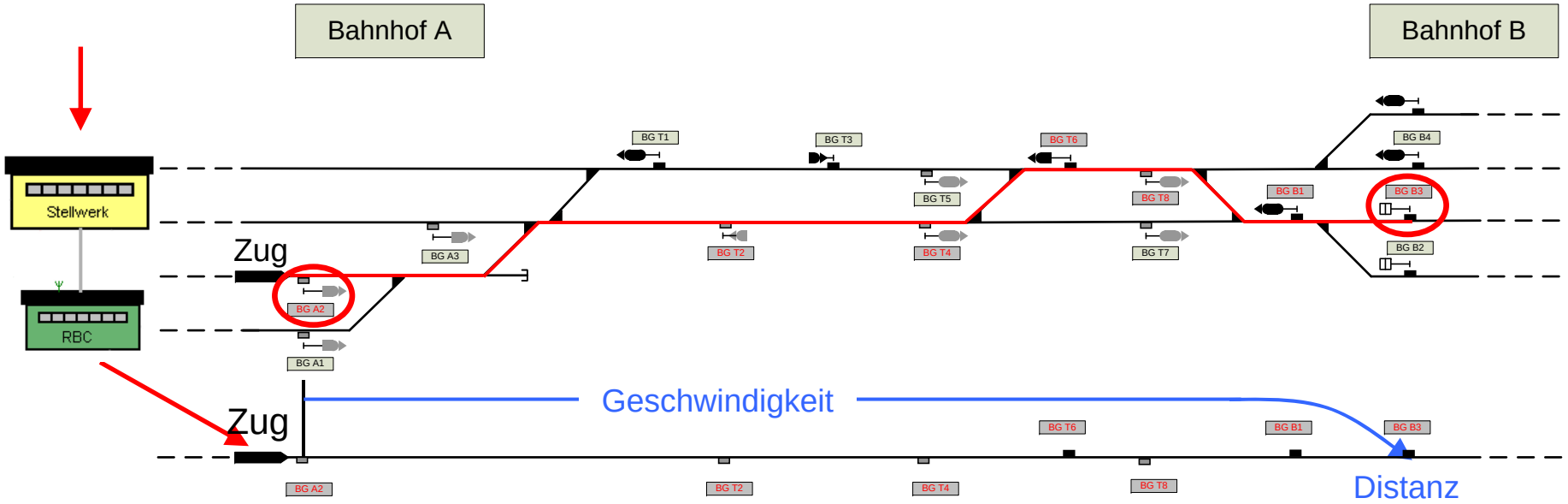
European Rail Traffic Management System (ERTMS) - European Train Control System (ETCS)

- In Europa sind über 20 verschiedene Leit- und Sicherungssystem im Einsatz
- Ein einheitliches System (ETCS) soll diese ablösen und einen nahtlosen Grenzüberschreitenden Verkehr mit einem einzigen System ermgöglichen
- Von verschiedenen Herstellern produzierte fahrzeug- und streckenseitige Komponenten sollen in Kombination verwendet werden können
- Das einheitliche Verhalten der Fahrzeuge ist hierbei von essentieller Bedeutung



Fahrwegssicherung

Beispielhafte Interaktion zwischen Strecke + Zug

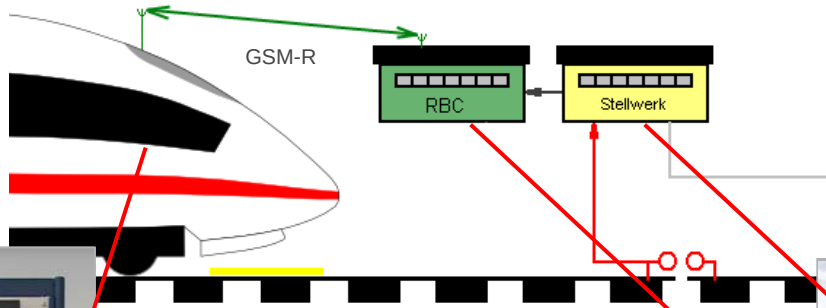


Fahrweg
Balisengruppe in Fahrtrichtung
Balisengruppe entgegen der Fahrtrichtung
Zug

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

ETCS

Fahrzeugseitige und streckenseitige Komponente



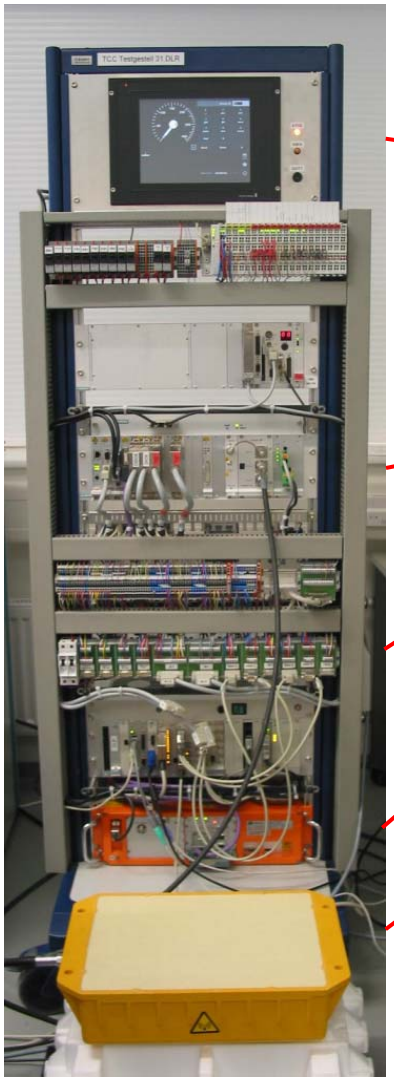
Eurobalise
Passiver Hochfrequenz-Transponder

Euroradio
GSM-R

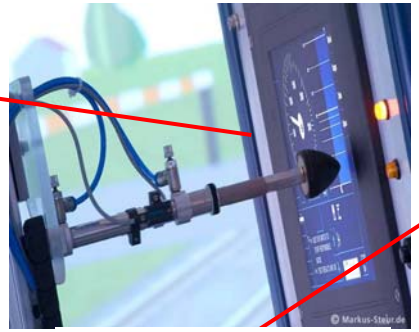
Euroloop
Linienleiter

Eisenbahntechnsiches Labor RailSite® -
Railway Simulation and Testing

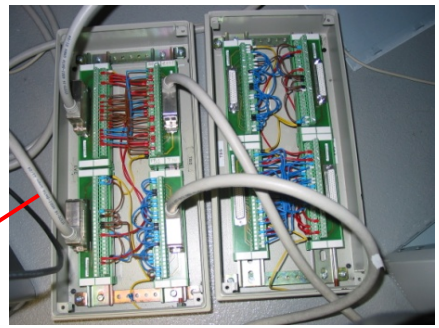
Schnittstellen zur fahrzeugseitigen ETCS-Einheit



DMI

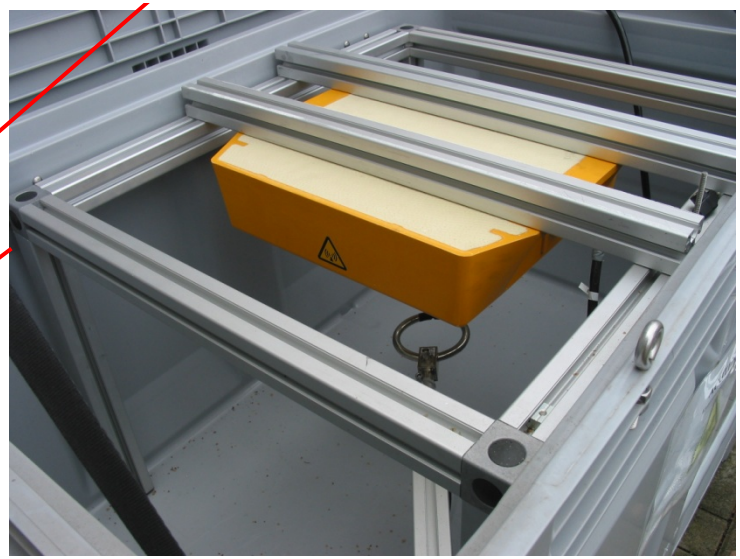


Zugschnittstelle



GSM-R Modem

Fahrdatenschreiber (JRU)

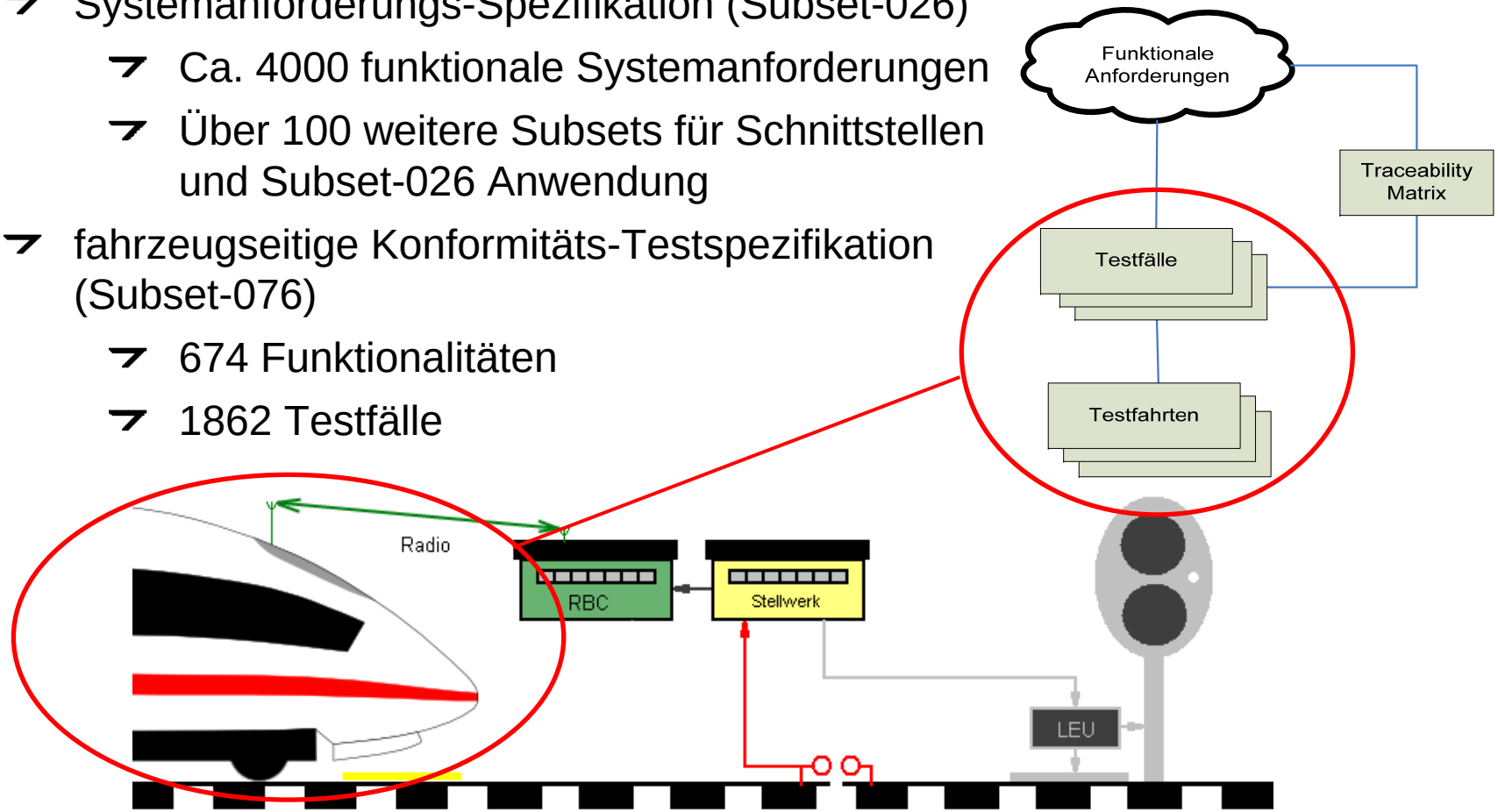


Balisen-/ Loop-signal-generator des RailSiTe

ETCS Fahrzeugkomponententests - Motivation

Konformitäts- und Interoperabilitätstestspezifikation

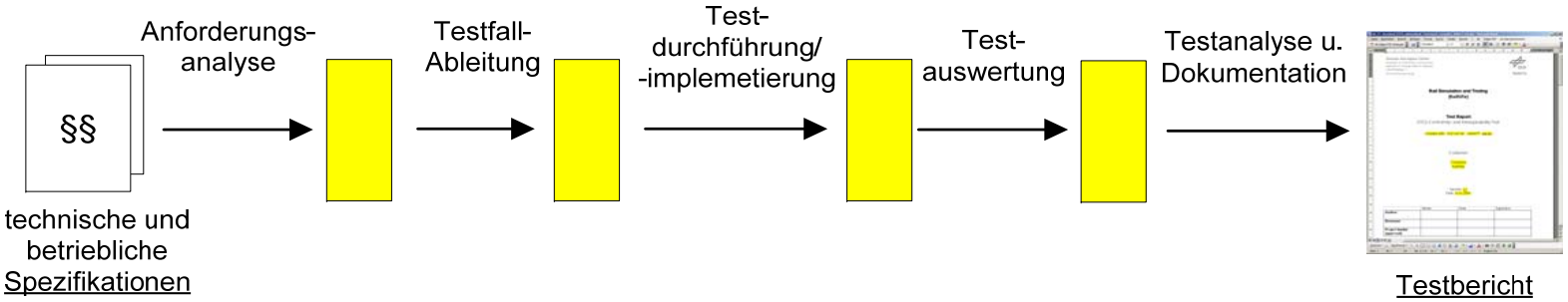
- Systemanforderungs-Spezifikation (Subset-026)
  - Ca. 4000 funktionale Systemanforderungen
  - Über 100 weitere Subsets für Schnittstellen und Subset-026 Anwendung
- fahrzeugseitige Konformitäts-Testspezifikation (Subset-076)
  - 674 Funktionalitäten
  - 1862 Testfälle



Effiziente und verlässliche Qualitätssicherung der neuen europäischen Leit- und Sicherungstechnik

- Großer Umfang und hoher Detaillierungsgrad der Tests:
  - Ca. 35.000 Testschritte für den Fahrzeug-Konformitätstest
  - Detaillierte Datenstrukturen für Nachrichten und Variable

- Wiederholbare, genaue, verlässliche und equivalente Testergebnisse
  - Reduktion von Abweichungen und Fehlern manueller Tätigkeiten



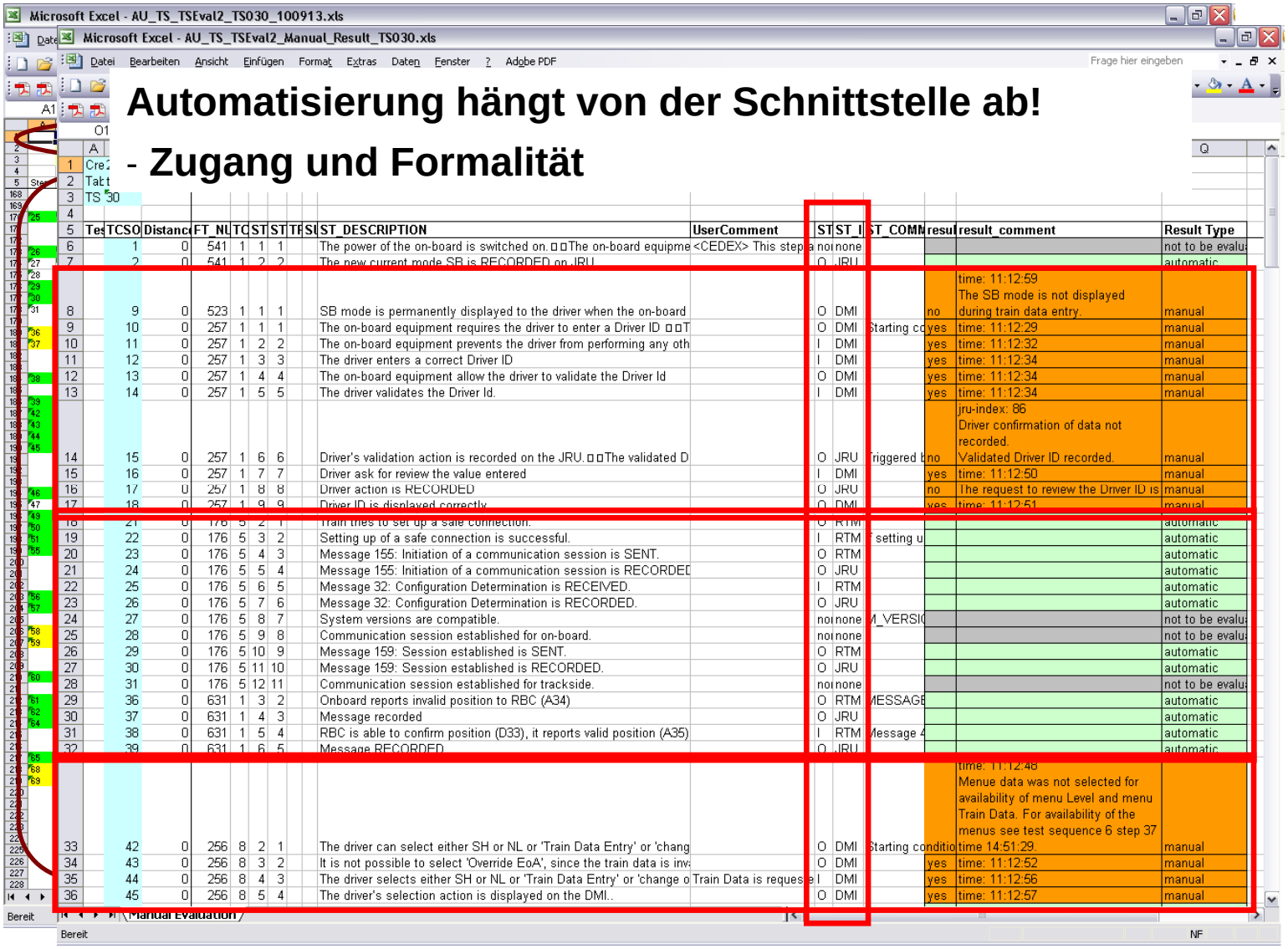
=> Testautomatisierung?!

Automatisierte Testauswertung und Dokumentation

5	Step	Distance	FT.TC.Ste	Descriptic	Comment	Interface	Direction	Details	User
168									
169									
170	25	0.0	FT176.TC!	Message	-	RTM	I	Delay Surr	
171									
172									
173	26	0.0	FT176.TC!	Message	-	JRU	O	Delay Surr	
174	27	0.0	FT176.TC!	System ve	M_VERSI	none	none	Delay Surr	
175	28	0.0	FT176.TC!	Communi	-	none	none	Delay Surr	
176	29	0.0	FT176.TC!	Message	-	RTM	O	Delay Surr	
177	30	0.0	FT176.TC!	Message	-	JRU	O	Delay Surr	
178	31	0.0	FT176.TC!	Communi	-	none	none	Delay Surr	
179									
180	36	0.0	FT631.TC	Onboard r	MESSAG	RTM	O	Delay Surr	
181	37	0.0	FT631.TC	Message	-	JRU	O	Delay Surr	
182									
183									
184	38	0.0	FT631.TC	RBC is ab	Message	RTM	I	Delay Surr	
185									
186	39	0.0	FT631.TC	Message	-	JRU	O	Delay Surr	
187	42	0.0	FT256.TC	The driver	Starting c	DMI	O	Delay Surr	
188	43	0.0	FT256.TC	It is not pc	-	DMI	O	Delay Surr	
189	44	0.0	FT256.TC	The driver	User Com	DMI	I	Delay Surr	
190	45	0.0	FT256.TC	The driver	-	DMI	O	Delay Surr	
191									
192									
193									
194	46	0.0	FT256.TC	The driver	-	JRU	O	Delay Surr	
195	47	0.0	FT256.TC	The EVC s	only if train	none	none	Delay Surr	
196	49	0.0	FT256.TC	The on-bc	Starting c	DMI	O	Delay Surr	
197	50	0.0	FT256.TC	The driver	-	DMI	I	Delay Surr	
198	51	0.0	FT256.TC	The driver	The on-bc	DMI	O	Delay Surr	
199	55	0.0	FT256.TC	the driver	Pressure	DMI	I	Delay Surr	
200									
201									
202									
203	56	0.0	FT256.TC	the drivers	-	JRU	O	Delay Surr	
204	57	0.0	FT256.TC	the compl	-	JRU	O	Delay Surr	
205									
206	58	0.0	FT256.TC	the On-bo	-	RTM	O	Delay Surr	
207	59	0.0	FT256.TC	On-board	-	JRU	O	Delay Surr	
208									
209									
210	60	0.0	FT256.TC	the Onboa	-	RTM	I	Delay Surr	
211									
212	61	0.0	FT256.TC	On-board	-	JRU	O	Delay Surr	
213	62	0.0	FT256.TC	the DMI al	-	DMI	O	Delay Surr	
214	64	0.0	FT262.TC	T = t?	The	DMI	I	Delay Surr	
215									
216									
217	65	0.0	FT262.TC	Driver's s	-	JRU	O	Delay Surr	
218	68	0.0	FT268.TC	T = t?|The	If T_CYCF	RTM	O	Delay Surr	
219	69	0.0	FT268.TC	The radio	-	JRU	O	Delay Surr	
220									
221									
222									
223									
224									
225									
226									
227									
228									

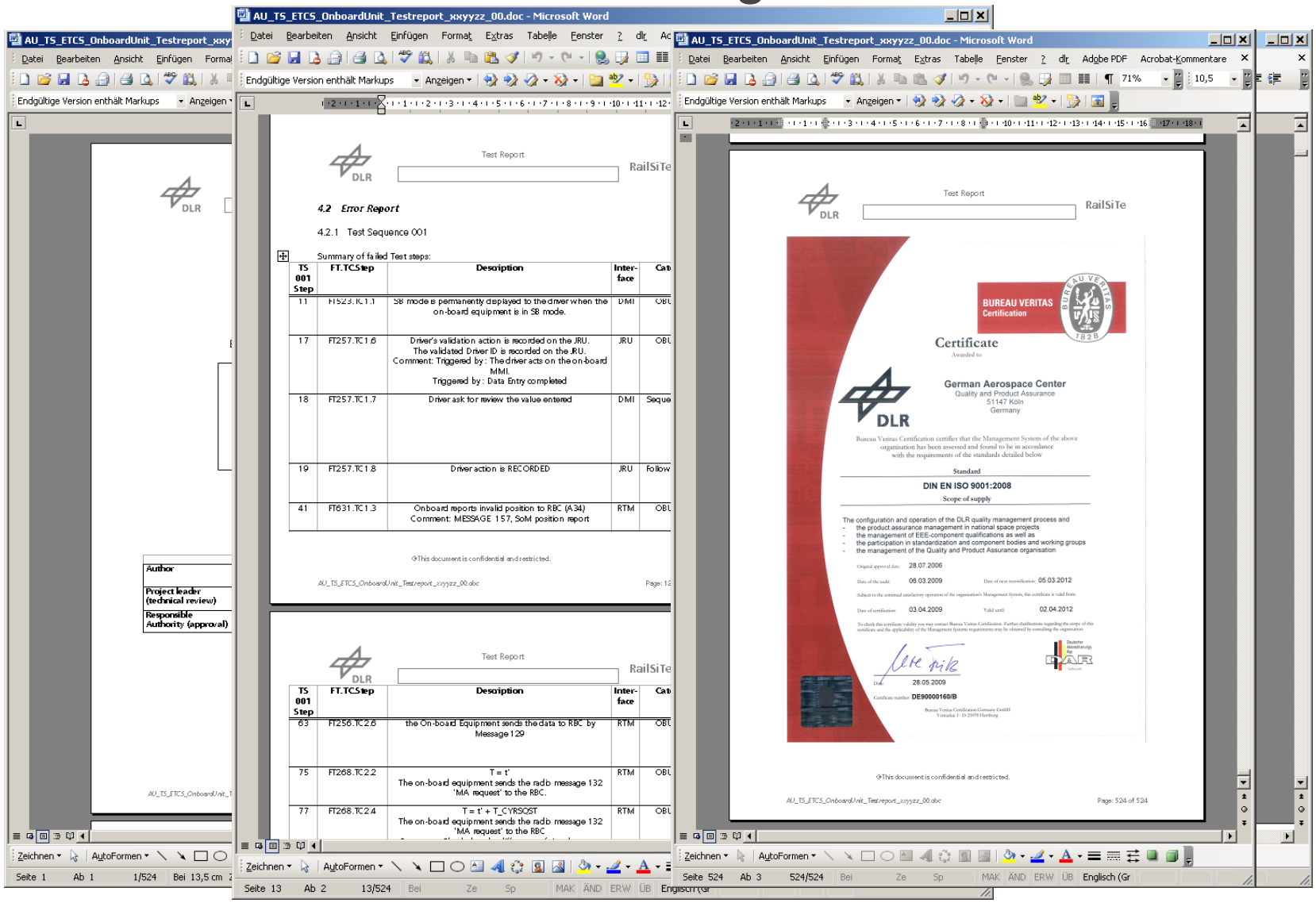
Index	Sender	Time	Distance	Message	Message	JRU Head	Comment	Variables	Changed	Step Hit	Unique Index
155	TBS1	11:12:43:401	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-68
156	RTS1	11:12:43:682	0.0'	654	+0.0000112	-	Transmit r	-	-	-	-69
157	RTM1	11:12:43:747	0.0'	100	+0.0000180	-	Transmit r	NID_MES	-	25	-70
158	JRU	11:12:44:093	1426.0'	10	9D060000	NID_MES	MESSAG	NID_MES	Original lo	37	88
159	JRU	11:12:44:093	1426.0'	10	9F074000	NID_MES	MESSAG	NID_MES	Original lo	30	89
160	JRU	11:12:44:093	1426.0'	9	2002C000	NID_MES	MESSAG	NID_MES	Original lo	26	90
161	RTM1	11:12:44:886	0.0'	101	+0.000036	-	Receive ra	NID_MES	-	29	-71
see index	JRU										
162	RTS1	11:12:44:952	0.0'	655	+0.000029	-	Receive ra	-	-	-	-72
163	RTM1	11:12:45:293	0.0'	101	+0.0000310	-	Receive ra	NID_MES	-	36	-73
see index	JRU										
164	RTS1	11:12:45:377	0.0'	655	+0.000024	-	Receive ra	-	-	-	-74
165	RTS1	11:12:46:439	0.0'	654	+0.0000102	-	Transmit r	-	-	-	-75
166	RTM1	11:12:46:491	0.0'	100	+0.0000170	-	Transmit r	NID_MES	-	38	-76
167	JRU	11:12:46:793	1426.0'	15		NID_MES	PREDEFI	-	Original lo	-	91
168	JRU	11:12:46:793	1426.0'	9	2B028000	NID_MES	MESSAG	NID_MES	Original lo	39	92
see DMI v	DMI	11:12:48:000									
see DMI v	DMI	11:12:52:000									
see DMI v	DMI	11:12:56:000									
see DMI v	DMI	11:12:57:000									
169	TBS1	11:12:48:443	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-77
170	JRU	11:12:51:893	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	93
171	TBS1	11:12:53:504	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-78
172	JRU	11:12:55:943	1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	46	94
see DMI v	DMI	11:12:57:000									
see DMI v	DMI	11:13:00:000									
see DMI v	DMI	11:13:04:000									
see DMI v	DMI	11:13:04:000									
173	TBS1	11:12:58:544	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-79
174	JRU	11:13:01:043	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	95
175	TBS1	11:13:03:605	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-80
176	JRU	11:13:04:393	1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	56	96
177	JRU	11:13:05:093	1426.0'	2		NID_MES	DATA EN	-	Original lo	-	97
178	JRU	11:13:05:443	1426.0'	10	810A4000	NID_MES	MESSAG	NID_MES	Original lo	59	98
179	RTM1	11:13:06:302	0.0'	101	+0.000048	-	Receive ra	NID_MES	-	58	-81
see index	JRU										
180	RTS1	11:13:06:398	0.0'	655	+0.0000418	-	Receive ra	-	-	-	-82
181	RTS1	11:13:07:444	0.0'	654	+0.0000140	-	Transmit r	-	-	-	-83
182	RTM1	11:13:07:517	0.0'	100	+0.0000210	-	Transmit r	NID_MES	-	60	-84
183	JRU	11:13:07:793	1426.0'	15		NID_MES	PREDEFI	-	Original lo	-	99
184	JRU	11:13:07:793	1426.0'	9	08038000	NID_MES	MESSAG	NID_MES	Original lo	61	100
see DMI v	DMI	11:13:10:000									
see DMI v	DMI	11:13:10:000									
185	TBS1	11:13:08:645	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-85
186	JRU	11:13:10:493	1426.0'	10	84060000	NID_MES	MESSAG	NID_MES	Original lo	69	101
187	JRU	11:13:10:493	1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	65	102
188	RTM1	11:13:11:293	0.0'	101	+0.0000310	-	Receive ra	NID_MES	-	68	-86
see index	JRU										
189	RTS1	11:13:11:386	0.0'	655	+0.000024	-	Receive ra	-	-	-	-87
190	TBS1	11:13:13:706	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-88
191	JRU	11:13:15:543	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	103
192	TBS1	11:13:18:748	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-89
193	JRU	11:13:20:643	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	104
194	TBS1	11:13:23:809	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-90
195	JRU	11:13:25:693	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	105
196	TBS1	11:13:28:849	0.0'	250	+0.00+000.	-	Odometric	-	-	-	-91
197	JRU	11:13:30:793	1426.0'	1		NID_MES	GENERAI	-	Original lo	-	106

Automatisierte Testauswertung und Dokumentation

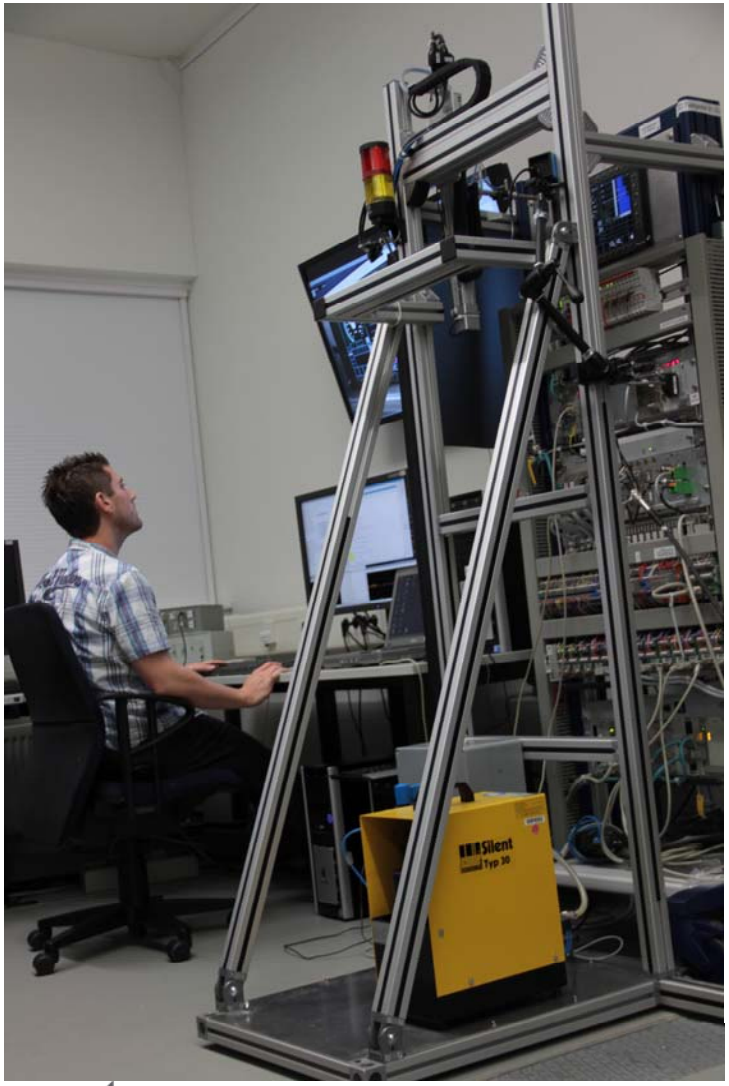


Tes	TCSO	Distanc	FT_NL	TC	ST	ST	TF	SI	ST_DESCRIPTION	UserComment	ST	ST_I	ST_COMM	resul	result_comment	Result Type
6	1	0	541	1	1	1			The power of the on-board is switched on. □□The on-board equipme	<CEDEX> This step a	no	none				not to be evalu
7	2	0	541	1	2	2			The new current mode SB is RECORDED on JRU		O	JRU				automatic
8	9	0	523	1	1	1			SB mode is permanently displayed to the driver when the on-board		O	DMI		no	time: 11:12:59 The SB mode is not displayed during train data entry.	manual
9	10	0	257	1	1	1			The on-board equipment requires the driver to enter a Driver ID □□T		O	DMI	Starting co	yes	time: 11:12:29	manual
10	11	0	257	1	2	2			The on-board equipment prevents the driver from performing any oth		I	DMI		yes	time: 11:12:32	manual
11	12	0	257	1	3	3			The driver enters a correct Driver ID		I	DMI		yes	time: 11:12:34	manual
12	13	0	257	1	4	4			The on-board equipment allow the driver to validate the Driver Id		O	DMI		yes	time: 11:12:34	manual
13	14	0	257	1	5	5			The driver validates the Driver Id.		I	DMI		yes	time: 11:12:34	manual
14	15	0	257	1	6	6			Driver's validation action is recorded on the JRU. □□The validated D		O	JRU	Triggered b	no	jru-index: 86 Driver confirmation of data not recorded. Validated Driver ID recorded.	manual
15	16	0	257	1	7	7			Driver ask for review the value entered		I	DMI		yes	time: 11:12:50	manual
16	17	0	257	1	8	8			Driver action is RECORDED		O	JRU		no	The request to review the Driver ID is	manual
17	18	0	257	1	9	9			Driver ID is displayed correctly		O	DMI		yes	time: 11:12:51	manual
18	21	0	176	5	2	1			Train tries to set up a safe connection.		O	RTM				automatic
19	22	0	176	5	3	2			Setting up of a safe connection is successful.		I	RTM	f setting u			automatic
20	23	0	176	5	4	3			Message 155: Initiation of a communication session is SENT.		O	RTM				automatic
21	24	0	176	5	5	4			Message 155: Initiation of a communication session is RECORDED		O	JRU				automatic
22	25	0	176	5	6	5			Message 32: Configuration Determination is RECEIVED.		I	RTM				automatic
23	26	0	176	5	7	6			Message 32: Configuration Determination is RECORDED.		O	JRU				automatic
24	27	0	176	5	8	7			System versions are compatible.		no	none	M_VERSIO			not to be evalu
25	28	0	176	5	9	8			Communication session established for on-board.		no	none				not to be evalu
26	29	0	176	5	10	9			Message 159: Session established is SENT.		O	RTM				automatic
27	30	0	176	5	11	10			Message 159: Session established is RECORDED.		O	JRU				automatic
28	31	0	176	5	12	11			Communication session established for trackside.		no	none				not to be evalu
29	36	0	631	1	3	2			Onboard reports invalid position to RBC (A34)		O	RTM	MESSAGE			automatic
30	37	0	631	1	4	3			Message recorded		O	JRU				automatic
31	38	0	631	1	5	4			RBC is able to confirm position (D33), it reports valid position (A35)		I	RTM	Message A			automatic
32	39	0	631	1	6	5			Message RECORDED		O	JRU				automatic
33	42	0	256	8	2	1			The driver can select either SH or NL or 'Train Data Entry' or 'chang		O	DMI	Starting conditio		time: 11:12:48 Menue data was not selected for availability of menu Level and menu Train Data. For availability of the menus see test sequence 6 step 37 time 14:51:29.	manual
34	43	0	256	8	3	2			It is not possible to select 'Override EoA', since the train data is inv		O	DMI		yes	time: 11:12:52	manual
35	44	0	256	8	4	3			The driver selects either SH or NL or 'Train Data Entry' or 'change o	Train Data is reques	I	DMI		yes	time: 11:12:56	manual
36	45	0	256	8	5	4			The driver's selection action is displayed on the DMI..		O	DMI		yes	time: 11:12:57	manual

Automatisierte Testauswertung und Dokumentation

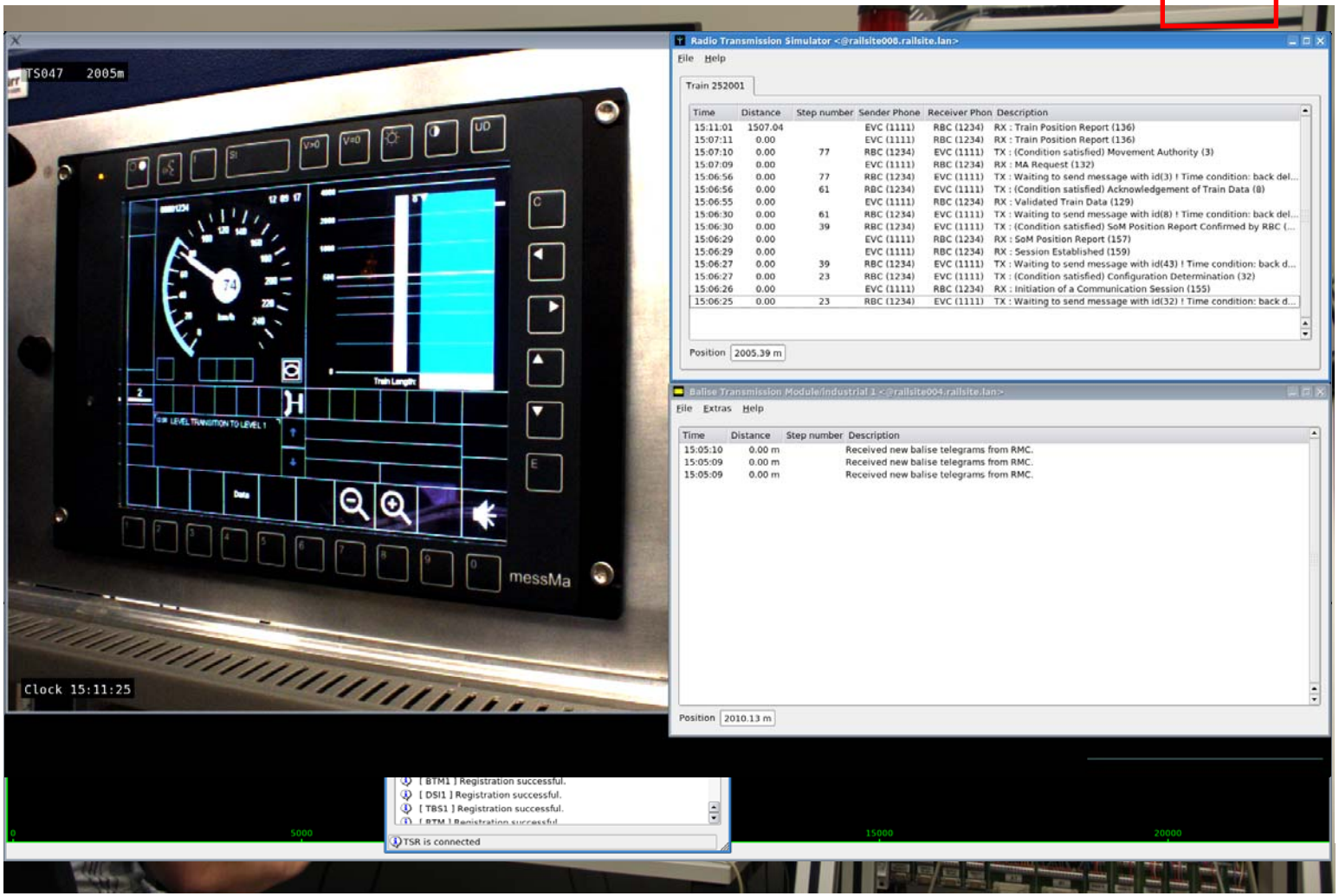


Automatisierte Testdurchführung



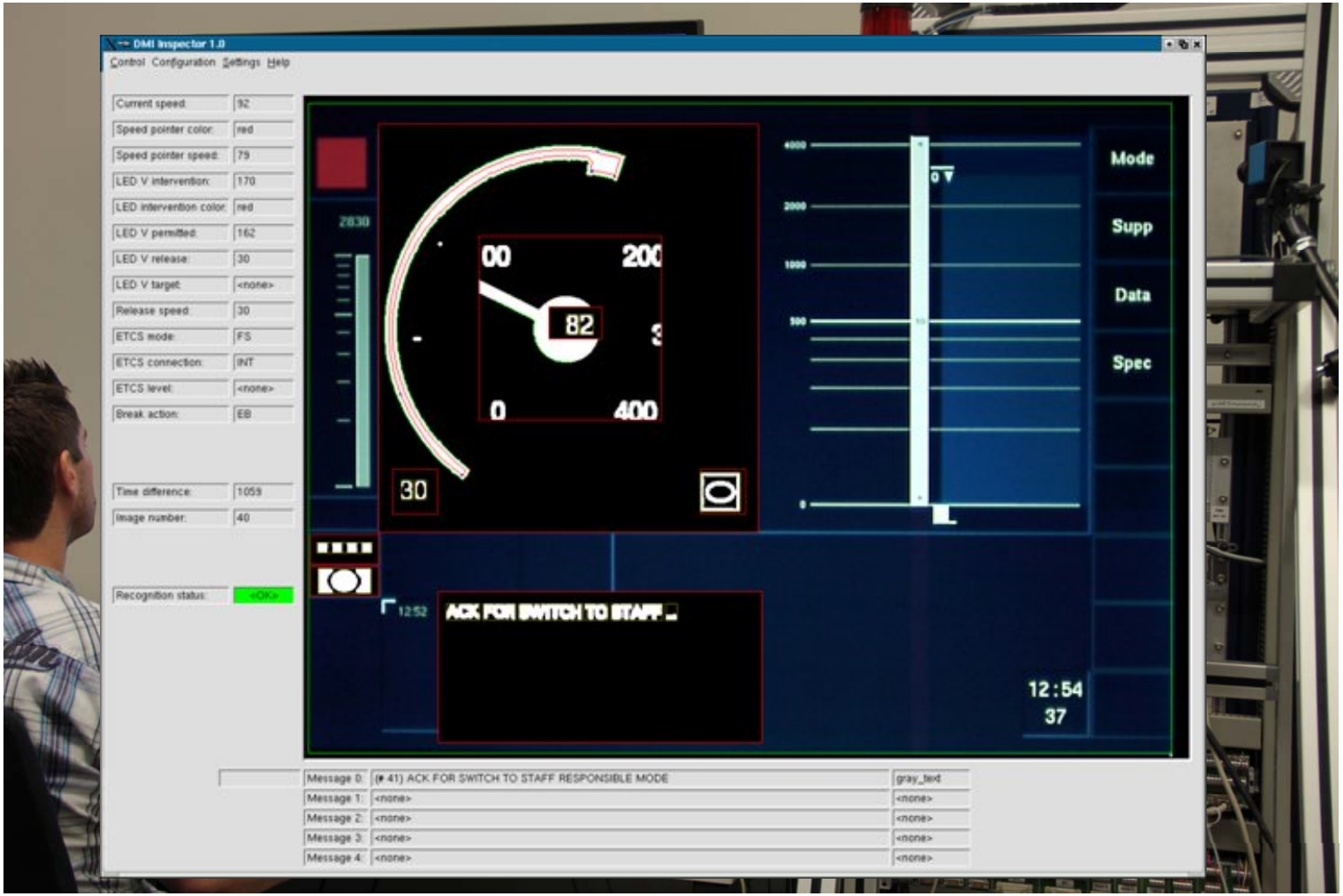
Automatisierte Testdurchführung

Touch-Screen-Eingaben (Roboter)



Automatisierte Testdurchführung

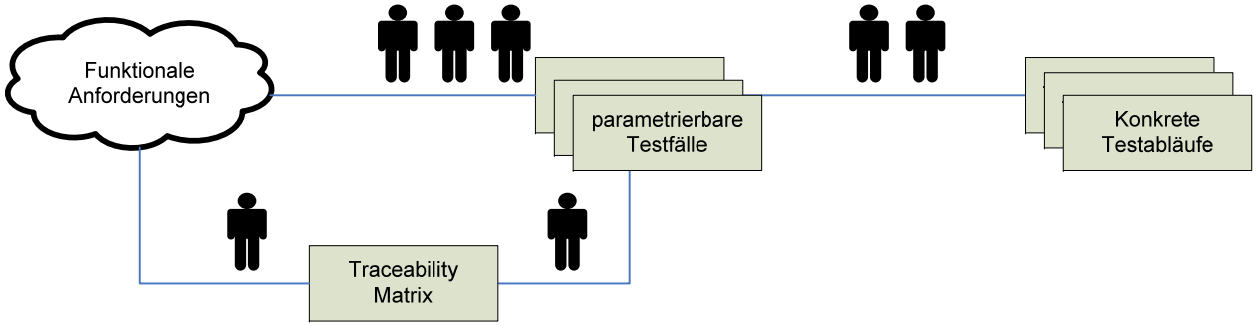
Touch-Screen-Ausgaben (Bilderkennung)



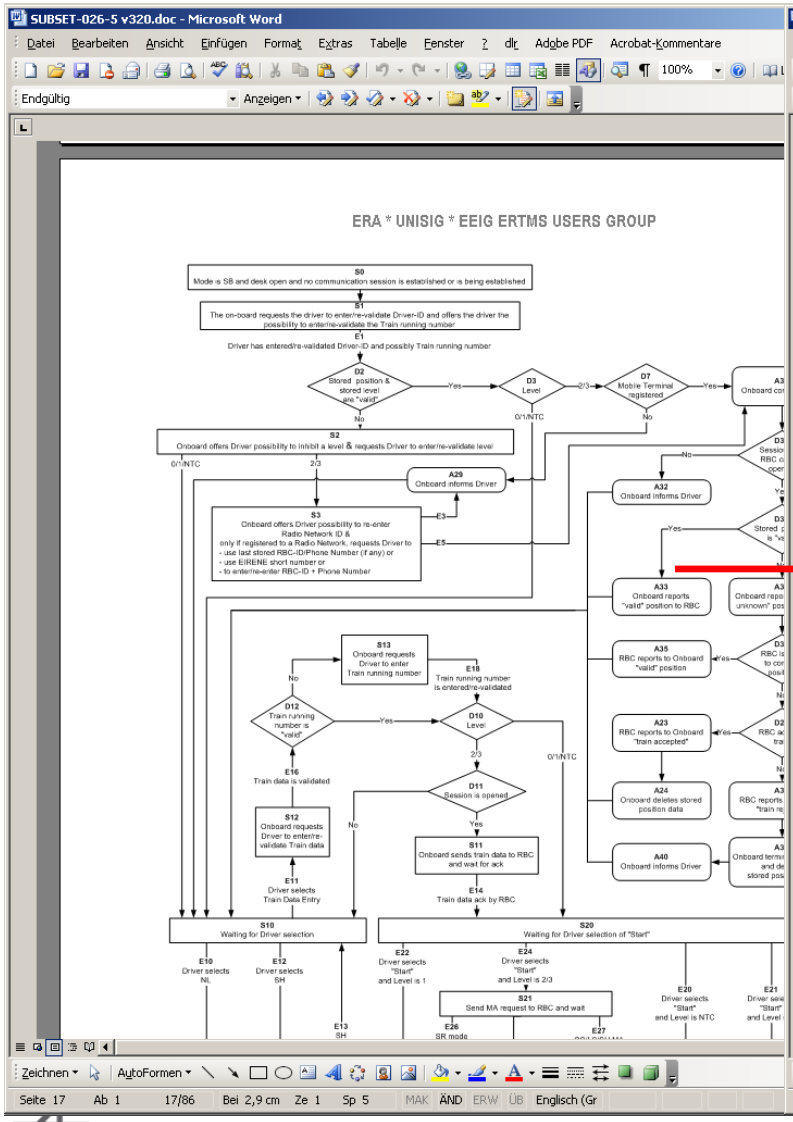
Automatisierte Testerstellung

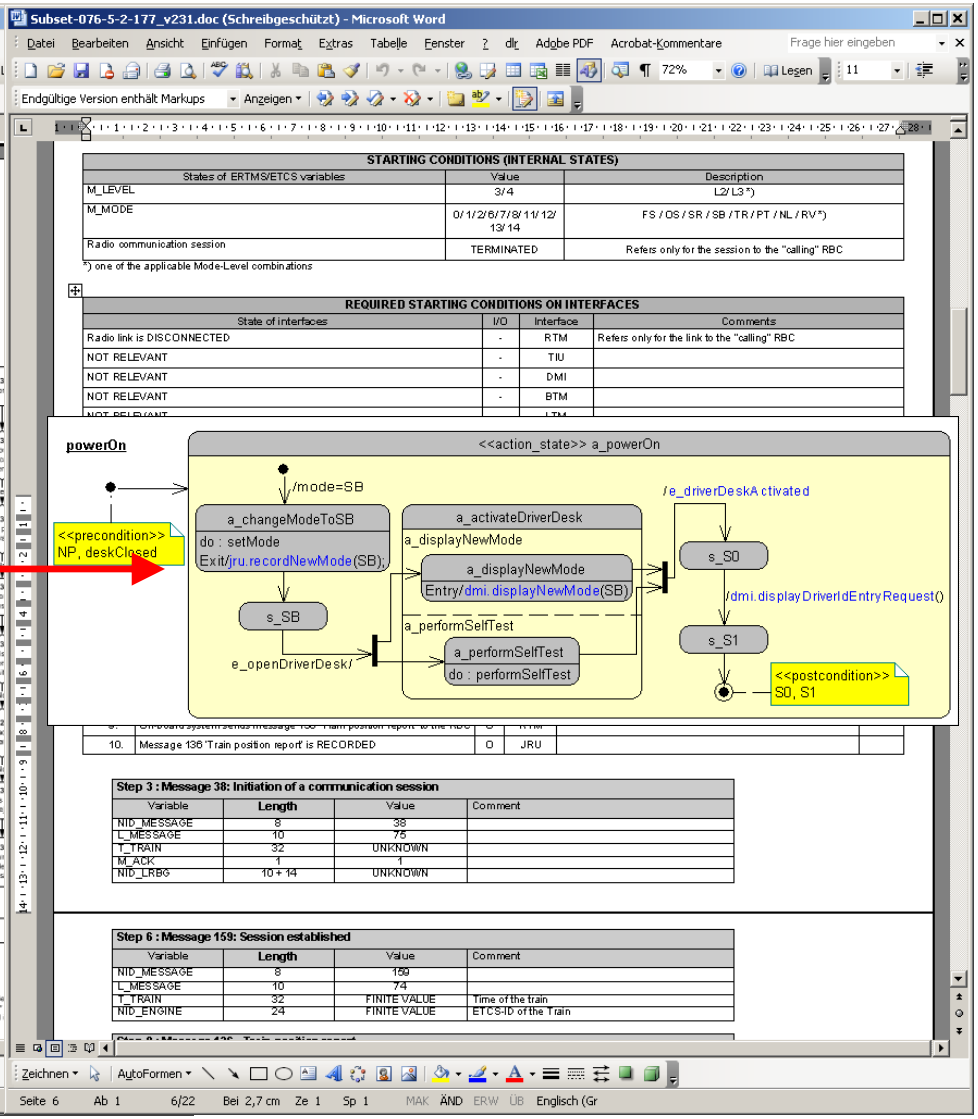
- Herkömmliche, klassische Testfallableitung

  Anforderung → Funktionalität → positive/negative Testfälle → Testabläufe



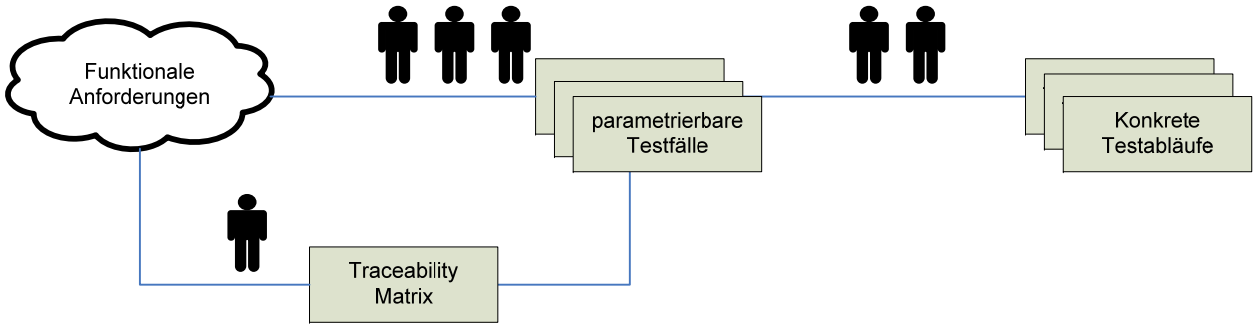
Automatisierte Testerstellung



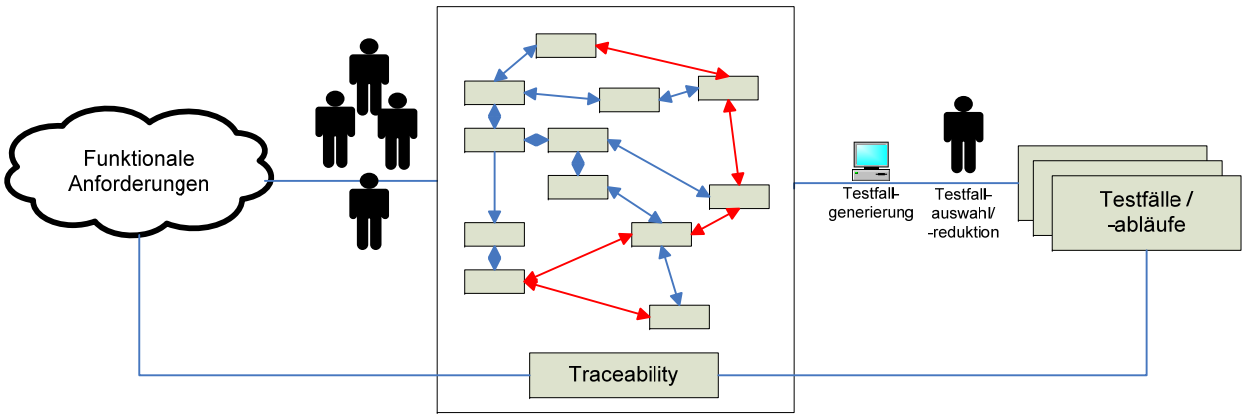


Automatisierte Testerstellung

- Herkömmliche, klassische Testfallableitung

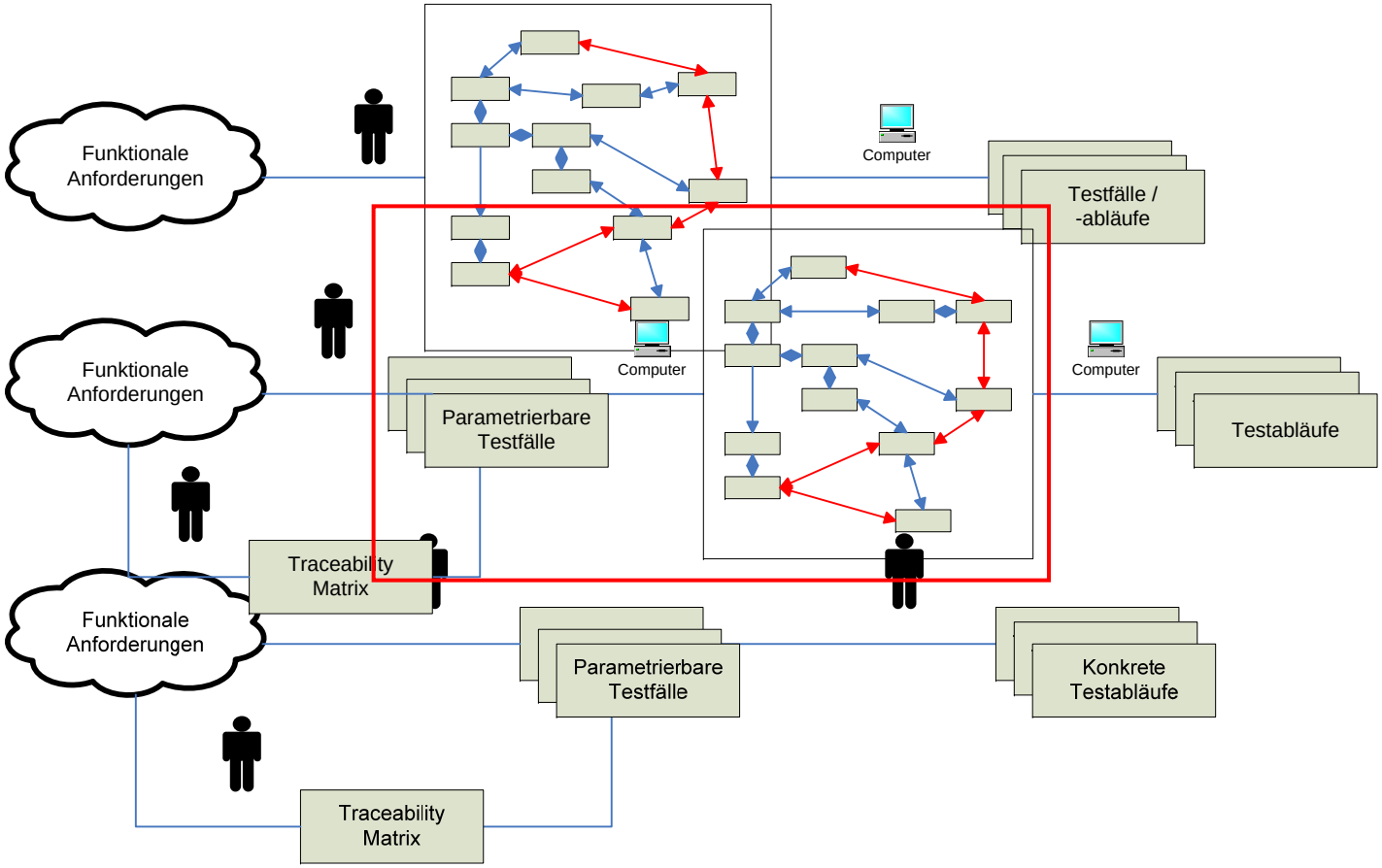


- Testfallgenerierung über Modell-based Testing



Automatisierte Testerstellung

Kombination der beiden Ansätze



Zusammenfassung
Effiziente Qualitätssicherung

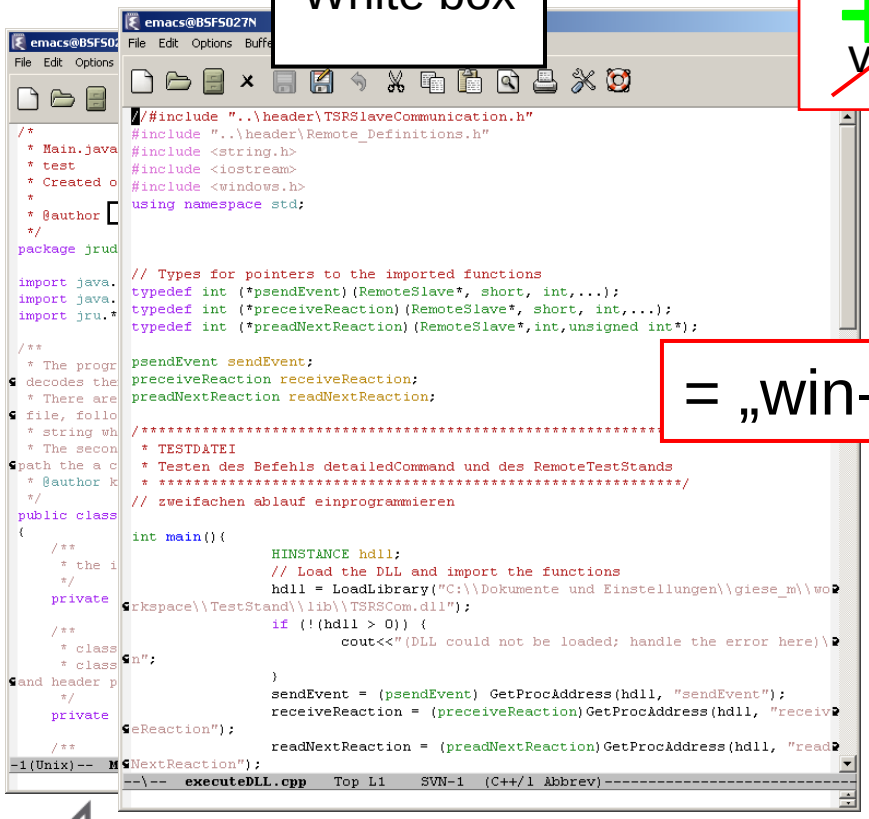
- Automatisierung der Berichtgenerierung 
- Automatisierung der Testauswertung 
- Automatisierte Testdurchführung 
- Automatisierte Testerstellung 

Diskussion

Effizienz- + Effektivitätssteigerungspotentiale

Verification

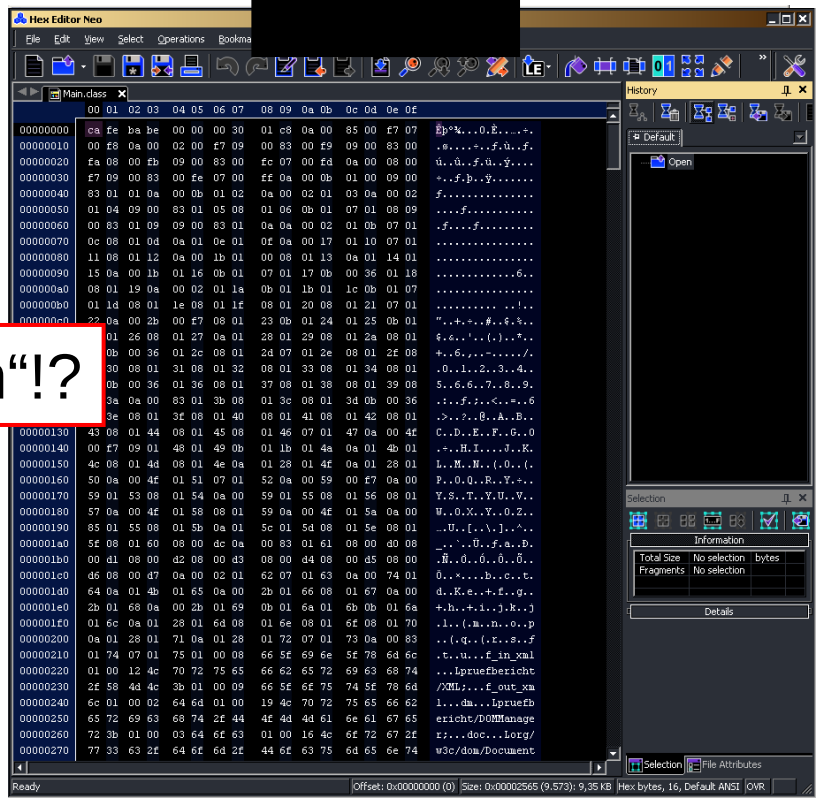
White box



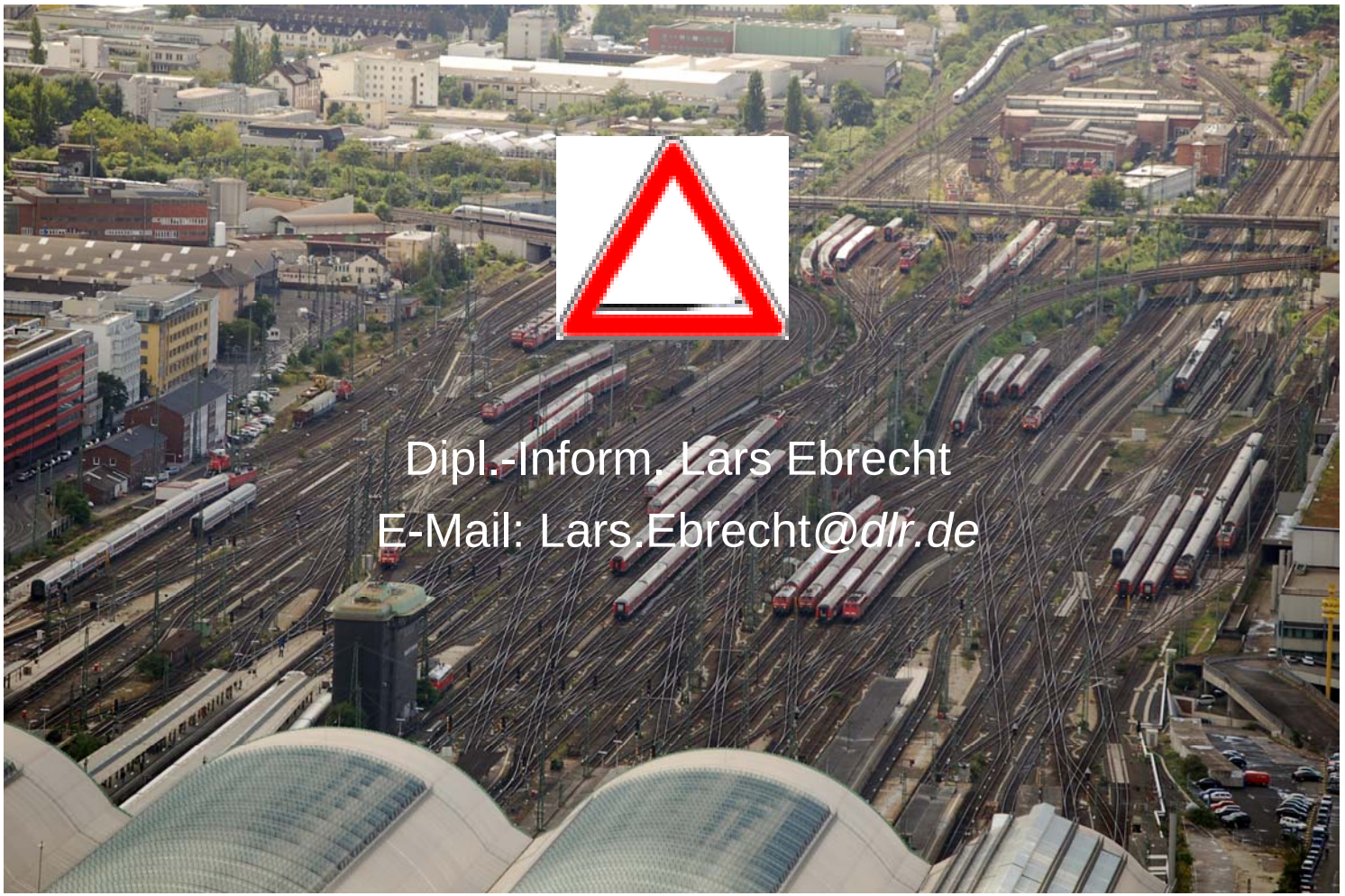
vs.

Validation

Black box



= „win-win“!?



Dipl.-Inform. Lars Ebrecht
E-Mail: Lars.Ebrecht@*dlr.de*