



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

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



Deutsches Zentrum  
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

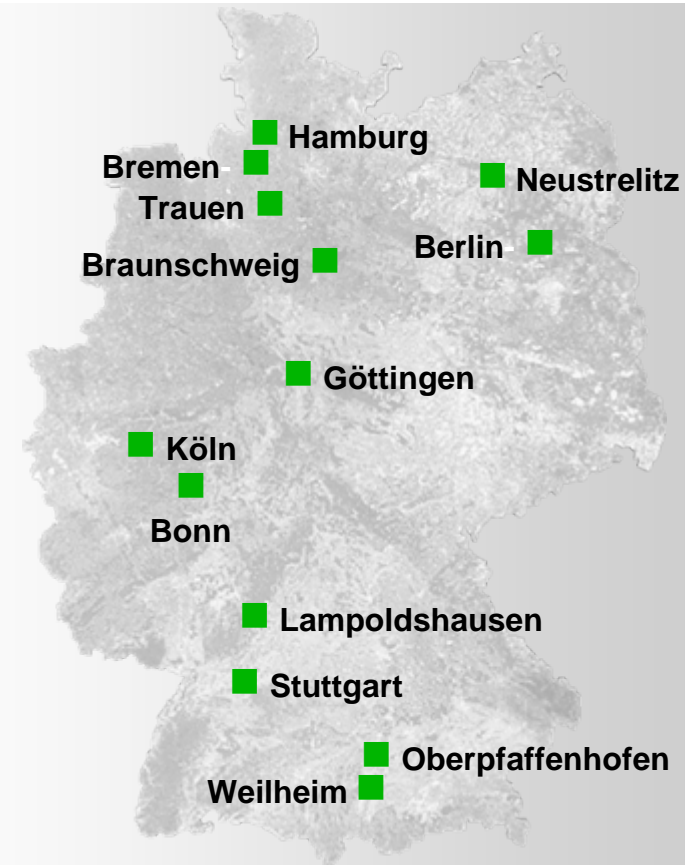
6.200 Mitarbeiterinnen und Mitarbeiter arbeiten in 29 Forschungsinstituten und Einrichtungen in

■ 13 Standorten.

Büros in Brüssel, Paris und Washington.

## Forschungsschwerpunkte

- Raumfahrt
- Luftfahrt
- Energie
- Verkehr



# Institut für Verkehrssystemtechnik

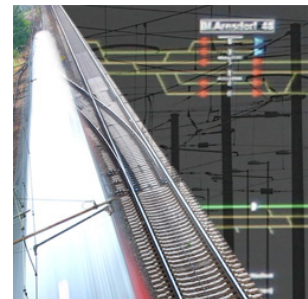
- Sitz: Braunschweig, Berlin
- Seit: 2001
- Leitung: Prof. Dr.-Ing. Karsten Lemmer
- Mitarbeiter: etwa 100 Mitarbeiter aus verschiedenen wissenschaftlichen Bereichen

## Aufgabenspektrum

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

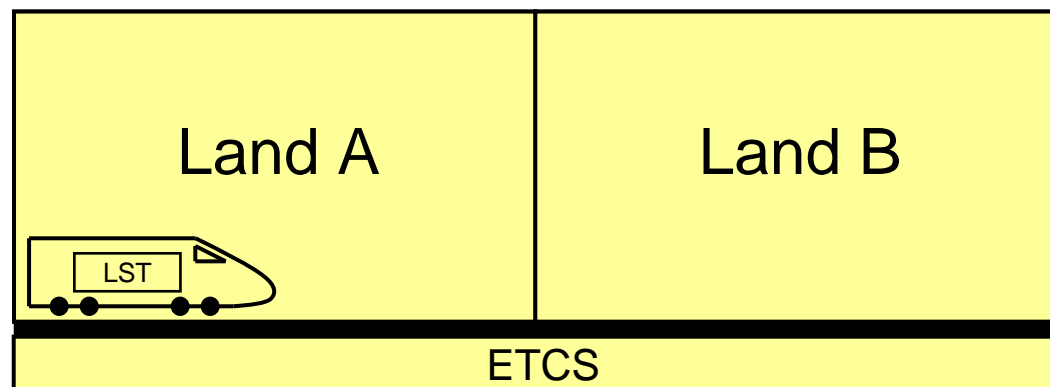
## Forschungsgebiete

- Automotive
- Bahnsysteme
- Verkehrsmanagement



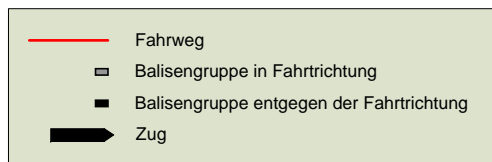
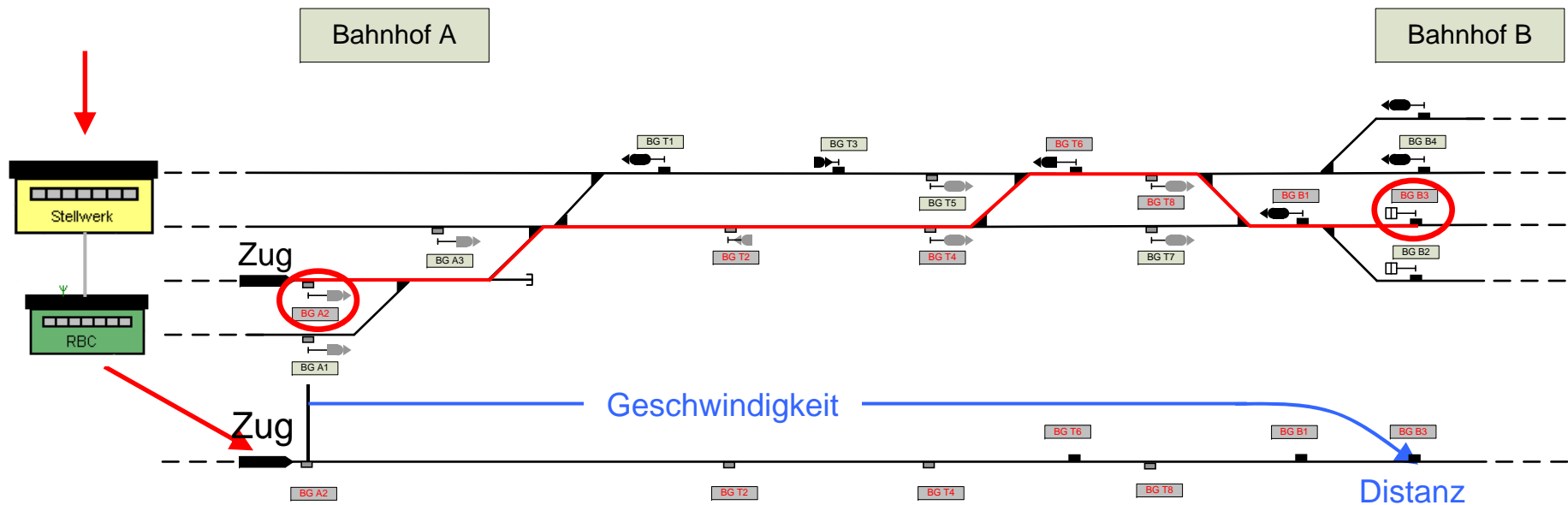
# European Rail Traffic Management System (ERTMS) - European Train Control System (ETCS)

- 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 ermöglichen
- 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

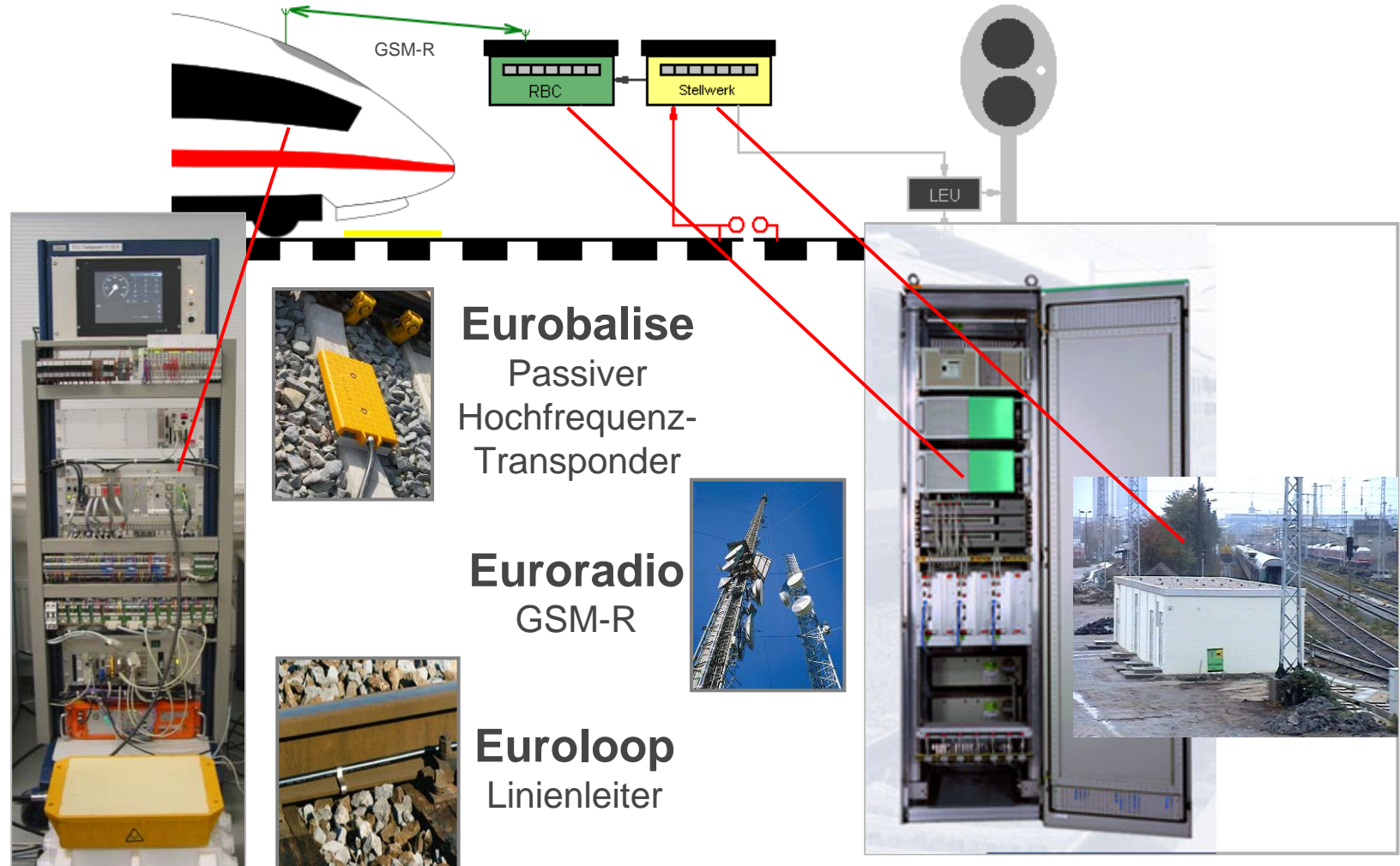
## Beispielhafte Interaktion zwischen Strecke + Zug



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

# ETCS

## Fahrzeugseitige und streckenseitige Komponente



# Eisenbahntechnisches Labor RailSite® - Railway Simulation and Testing



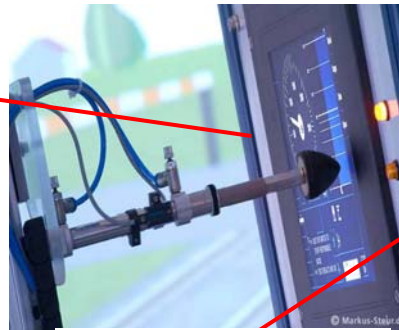
Deutsches Zentrum  
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in der Helmholtz-Gemeinschaft

Effiziente Qualitätssicherung der neuen europäischen Leit- und Sicherungstechnik > 23./24. Mai 2011 > 8  
Institut für Verkehrssystemtechnik > Technologien aus Luft- und Raumfahrt für Straße und Schiene

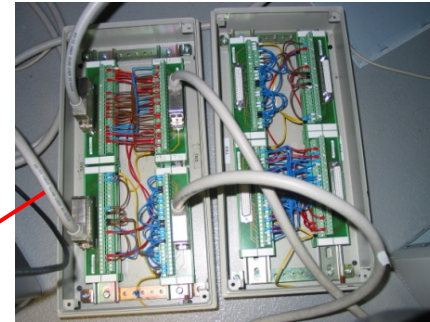
# Schnittstellen zur fahrzeugseitigen ETCS-Einheit



DMI

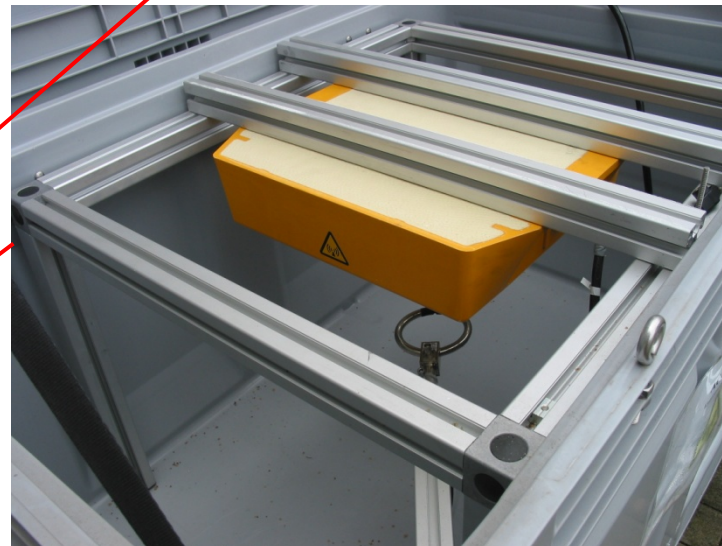


Zugschnittstelle



GSM-R Modem

Fahrdatenschreiber (JRU)

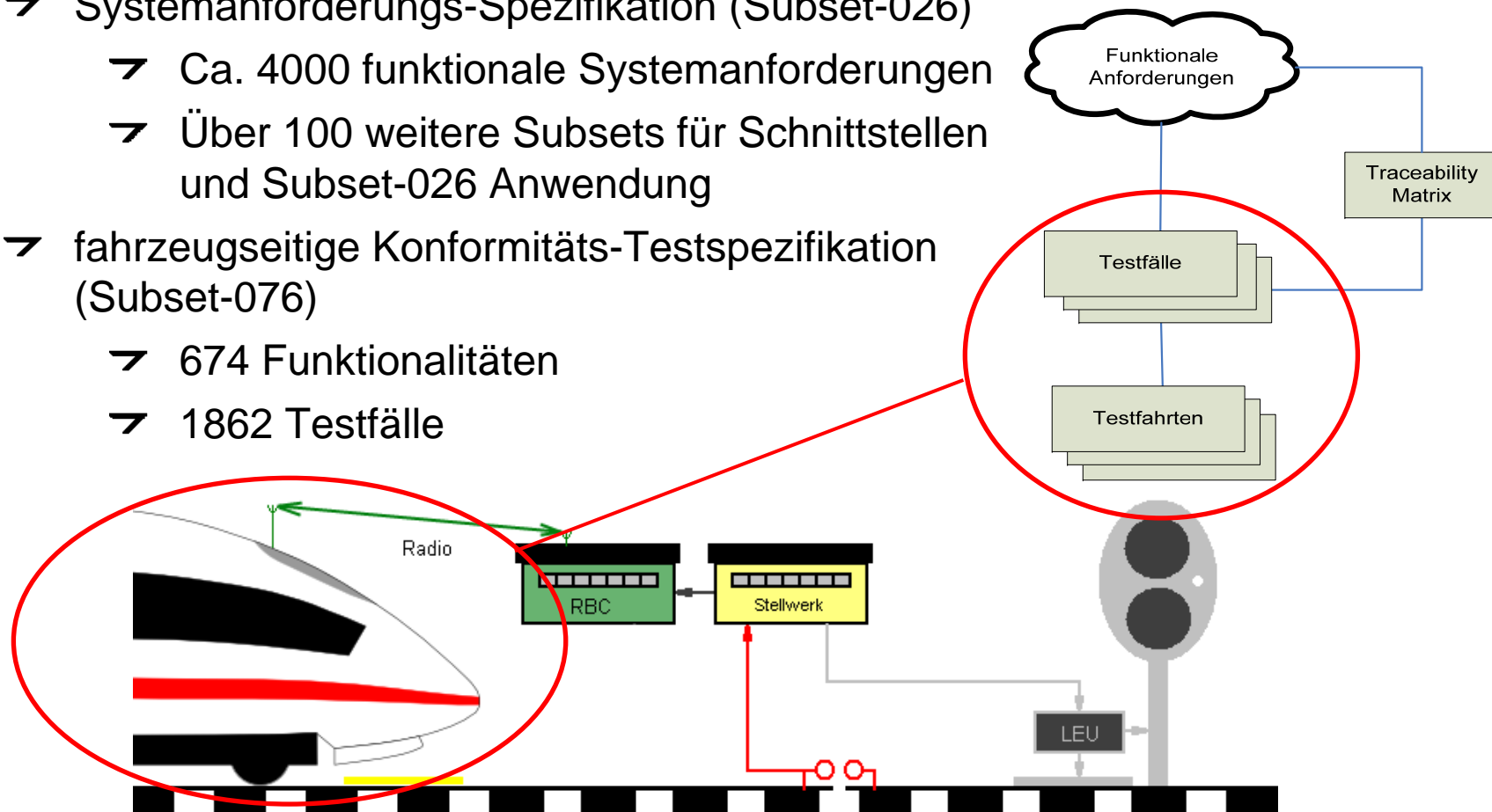


Balisen-/  
Loop-  
signal-  
generator  
des  
RailSiTe

# ETCS Fahrzeugkomponententests - Motivation

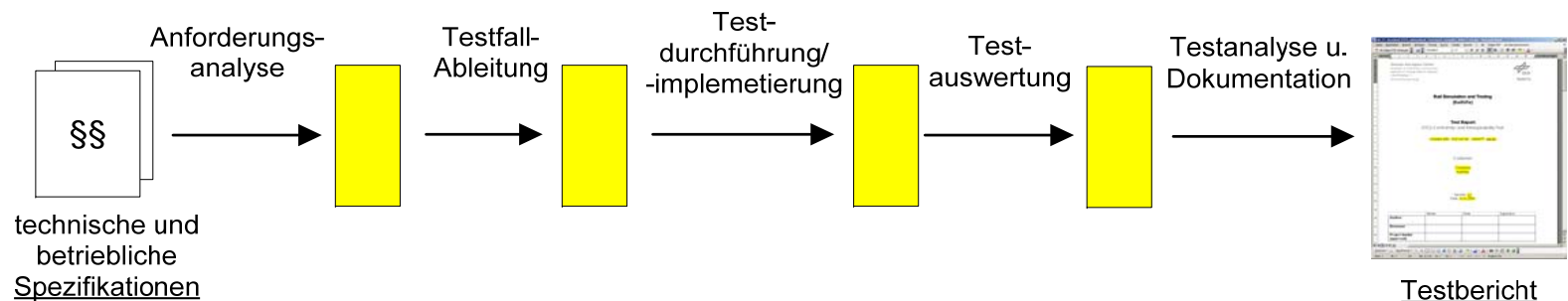
## Konformitäts- und Interoperabilitätstestspezifikation

- 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	Descriptio	Comment	Interface	Direction	Details	User	Index	Sender	Time	Distance	Message	Message	JRU Head	Comment	Variables	Changed	Step Hit	Unique Index
168										165	TBS1	11:12:43:401	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	68
169										166	RTS1	11:12:43:682	'0.0'	654	+0.0000112	-	Transmit r	-	-	-	69
170	25	'0.0'	FT176.TC!	Message	-	RTM	I	Delay	Surr	167	RTM1	11:12:43:747	'0.0'	100	+0.000018(-	-	Transmit r	NID_MES	-	25	70
171										168	JRU	11:12:44:093	'1426.0'	10	9D060000	NID_MES	MESSAG	NID_MES	Original lo	37	88
172										169	JRU	11:12:44:093	'1426.0'	10	9F074000	NID_MES	MESSAG	NID_MES	Original lo	30	89
173	26	'0.0'	FT176.TC!	Message	-	JRU	O	Delay	Surr	160	JRU	11:12:44:093	'1426.0'	9	2002C000	NID_MES	MESSAG	NID_MES	Original lo	26	90
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	161	RTM1	11:12:44:886	'0.0'	101	+0.000036	-	Receive r	NID_MES	-	29	71
177	30	'0.0'	FT176.TC!	Message	-	JRU	O	Delay	Surr	see index	JRU										
178	31	'0.0'	FT176.TC!	Communi	-	none	none	Delay	Surr												
179										162	RTS1	11:12:44:952	'0.0'	655	+0.000029	-	Receive r	-	-	-	72
180	36	'0.0'	FT631.TC!	Onboard r	MESSAG	RTM	O	Delay	Surr	163	RTM1	11:12:45:293	'0.0'	101	+0.000031(-	-	Receive r	NID_MES	-	36	73
181	37	'0.0'	FT631.TC!	Message	-	JRU	O	Delay	Surr	see index	JRU										
182										164	RTS1	11:12:45:377	'0.0'	655	+0.000024	-	Receive r	-	-	-	74
183										165	RTS1	11:12:46:439	'0.0'	654	+0.0000102	-	Transmit r	-	-	-	75
184	38	'0.0'	FT631.TC!	RBC is ab	Message	RTM	I	Delay	Surr	166	RTM1	11:12:46:491	'0.0'	100	+0.000017(-	-	Transmit r	NID_MES	-	38	76
185										167	JRU	11:12:46:793	'1426.0'	15		NID_MES	PREDEFI	-	Original lo	-	91
186	39	'0.0'	FT631.TC!	Message	-	JRU	O	Delay	Surr	168	JRU	11:12:46:793	'1426.0'	9	2B028000	NID_MES	MESSAG	NID_MES	Original lo	39	92
187	42	'0.0'	FT256.TC!	The driver	Starting o	DMI	O	Delay	Surr	see DMI v DMI		11:12:48:000									
188	43	'0.0'	FT256.TC!	It is not pc	-	DMI	O	Delay	Surr	see DMI v DMI		11:12:52:000									
189	44	'0.0'	FT256.TC!	The driver	User Com	DMI	I	Delay	Surr	see DMI v DMI		11:12:56:000									
190	45	'0.0'	FT256.TC!	The driver	-	DMI	O	Delay	Surr	see DMI v DMI		11:12:57:000									
191										169	TBS1	11:12:48:443	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	77
192										170	JRU	11:12:51893	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	93
193										171	TBS1	11:12:53:504	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	78
194	46	'0.0'	FT256.TC!	The driver	-	JRU	O	Delay	Surr	172	JRU	11:12:55:943	'1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	46	94
195	47	'0.0'	FT256.TC!	The EVC s	only if tra	none	none	Delay	Surr												
196	49	'0.0'	FT256.TC!	The on-bc	Starting o	DMI	O	Delay	Surr	see DMI v DMI		11:12:57:000									
197	50	'0.0'	FT256.TC!	The driver	-	DMI	I	Delay	Surr	see DMI v DMI		11:13:00:000									
198	51	'0.0'	FT256.TC!	The driver	The on-bc	DMI	O	Delay	Surr	see DMI v DMI		11:13:04:000									
199	55	'0.0'	FT256.TC!	the driver	Pressure	DMI	I	Delay	Surr	see DMI v DMI		11:13:04:000									
200										173	TBS1	11:12:58:544	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	79
201										174	JRU	11:13:01043	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	95
202										175	TBS1	11:13:03:605	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	80
203	56	'0.0'	FT256.TC!	the drivers	-	JRU	O	Delay	Surr	176	JRU	11:13:04:393	'1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	56	96
204	57	'0.0'	FT256.TC!	the compl	-	JRU	O	Delay	Surr	177	JRU	11:13:05:093	'1426.0'	2		NID_MES	DATA EN	-	Original lo	-	97
205										178	JRU	11:13:05:443	'1426.0'	10	810A4000	NID_MES	MESSAG	NID_MES	Original lo	59	98
206	58	'0.0'	FT256.TC!	the On-bo	-	RTM	O	Delay	Surr	179	RTM1	11:13:06:302	'0.0'	101	+0.000048	-	Receive r	NID_MES	-	58	81
207	59	'0.0'	FT256.TC!	On-board	-	JRU	O	Delay	Surr	see index	JRU										
208										180	RTS1	11:13:06:398	'0.0'	655	+0.000041(-	-	Receive r	-	-	-	82
209										181	RTS1	11:13:07:444	'0.0'	654	+0.000014(-	-	Transmit r	-	-	-	83
210	60	'0.0'	FT256.TC!	the Onboz	-	RTM	I	Delay	Surr	182	RTM1	11:13:07:517	'0.0'	100	+0.000021(-	-	Transmit r	NID_MES	-	60	84
211										183	JRU	11:13:07:793	'1426.0'	15		NID_MES	PREDEFI	-	Original lo	-	99
212	61	'0.0'	FT256.TC!	On-board	-	JRU	O	Delay	Surr	184	JRU	11:13:07:793	'1426.0'	9	08038000	NID_MES	MESSAG	NID_MES	Original lo	61	100
213	62	'0.0'	FT268.TC!	the DMI al	-	DMI	O	Delay	Surr	see DMI v DMI		11:13:10:000									
214	64	'0.0'	FT262.TC!	T s r? The	-	DMI	I	Delay	Surr	see DMI v DMI		11:13:10:000									
215										185	TBS1	11:13:08:645	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	85
216										186	JRU	11:13:10:493	'1426.0'	10	84060000	NID_MES	MESSAG	NID_MES	Original lo	63	101
217	65	'0.0'	FT262.TC!	Driver's si	-	JRU	O	Delay	Surr	187	JRU	11:13:10:493	'1426.0'	11	M_DRIVE	NID_MES	DRIVER'S	-	Original lo	65	102
218	68	'0.0'	FT268.TC!	T s r? The	if T_CYCF	RTM	O	Delay	Surr	188	RTM1	11:13:11:293	'0.0'	101	+0.000031(-	-	Receive r	NID_MES	-	68	86
219	69	'0.0'	FT268.TC!	The radio	-	JRU	O	Delay	Surr	see index	JRU										
220										189	RTS1	11:13:11:386	'0.0'	655	+0.000024	-	Receive r	-	-	-	87
221										190	TBS1	11:13:13:706	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	88
222										191	JRU	11:13:15:543	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	103
223										192	TBS1	11:13:18:748	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	89
224										193	JRU	11:13:20:643	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	104
225										194	TBS1	11:13:23:809	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	90
226										195	JRU	11:13:25:693	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	105
227										196	TBS1	11:13:28:849	'0.0'	250	+0.00-000.	-	Odometric	-	-	-	91
228										197	JRU	11:13:30:793	'1426.0'	1		NID_MES	GENERAL	-	Original lo	-	106



# Automatisierte Testauswertung und Dokumentation

Microsoft Excel - AU\_TS\_TSEval2\_TS030\_100913.xls

Microsoft Excel - AU\_TS\_TSEval2\_Manual\_Result\_TS030.xls

Automatisierung hängt von der Schnittstelle ab!

- Zugang und Formalität

Test	TCS	Distance	FT	NL	TC	ST	TS	TS	DESCRIPTION	UserComment	TEST ID	TEST COMMENT	result	result comment	Result Type
6	1	0	541	1	1	1	1	1	The power of the on-board is switched on. The on-board equipment is switched on.	<CEDEX> This step is not recorded on JRU.	O	JRU	no		not to be evaluated
7	2	0	541	1	2	2	2	2	The new current mode SB is RECORDED on JRU.		O	JRU	yes		automatic
8	9	0	523	1	1	1	1	1	SB mode is permanently displayed to the driver when the on-board equipment is switched on.		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	1	1	The on-board equipment requires the driver to enter a Driver ID.		O	DMI	Starting condition	time: 11:12:29	manual
10	11	0	257	1	2	2	2	2	The on-board equipment prevents the driver from performing any other action.		I	DMI	yes	time: 11:12:32	manual
11	12	0	257	1	3	3	3	3	The driver enters a correct Driver ID.		I	DMI	yes	time: 11:12:34	manual
12	13	0	257	1	4	4	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	5	5	The driver validates the Driver Id.		I	DMI	yes	time: 11:12:34	manual
14	15	0	257	1	6	6	6	6	Driver's validation action is recorded on the JRU. The validated Driver ID is recorded.		O	JRU	no	time: 11:12:34 jru-index: 86 Driver confirmation of data not recorded.	manual
15	16	0	257	1	7	7	7	7	Driver ask for review the value entered.		I	DMI	yes	time: 11:12:50	manual
16	17	0	257	1	8	8	8	8	Driver action is RECORDED.		O	JRU	no	time: 11:12:50 The request to review the Driver ID is not recorded.	manual
17	18	0	257	1	9	9	9	9	Driver ID is displayed correctly.		O	DMI	yes	time: 11:12:51	manual
18	19	0	176	5	2	1	1	1	Train tries to set up a safe connection.		O	RTM	yes		automatic
19	22	0	176	5	3	2	2	2	Setting up of a safe connection is successful.		I	RTM	setting up		automatic
20	23	0	176	5	4	3	3	3	Message 155: Initiation of a communication session is SENT.		O	RTM	yes		automatic
21	24	0	176	5	5	4	4	4	Message 155: Initiation of a communication session is RECORDED.		O	JRU	yes		automatic
22	25	0	176	5	6	5	5	5	Message 32: Configuration Determination is RECEIVED.		I	RTM	yes		automatic
23	26	0	176	5	7	6	6	6	Message 32: Configuration Determination is RECORDED.		O	JRU	yes		automatic
24	27	0	176	5	8	7	7	7	System versions are compatible.		no	none	4_VERSION		not to be evaluated
25	28	0	176	5	9	8	8	8	Communication session established for on-board.		no	none			not to be evaluated
26	29	0	176	5	10	9	9	9	Message 159: Session established is SENT.		O	RTM	yes		automatic
27	30	0	176	5	11	10	10	10	Message 159: Session established is RECORDED.		O	JRU	yes		automatic
28	31	0	176	5	12	11	11	11	Communication session established for trackside.		no	none			not to be evaluated
29	36	0	631	1	3	2	2	2	Onboard reports invalid position to RBC (A34).		O	RTM	MESSAGE		automatic
30	37	0	631	1	4	3	3	3	Message recorded		O	JRU	yes		automatic
31	38	0	631	1	5	4	4	4	RBC is able to confirm position (D33), it reports valid position (A35).		I	RTM	Message 4		automatic
32	39	0	631	1	6	5	5	5	Message RECORDED		O	JRU	yes		automatic
33	42	0	256	8	2	1	1	1	The driver can select either SH or NL or 'Train Data Entry' or 'change of position'.		O	DMI	Starting condition	time: 11:12:48 Menu data was not selected for availability of menu Level and menu Train Data. For availability of the menu see test sequence 6 step 37.	manual
34	43	0	256	8	3	2	2	2	It is not possible to select 'Override EoA', since the train data is invalid.		O	DMI	yes	time: 11:12:52	manual
35	44	0	256	8	4	3	3	3	The driver selects either SH or NL or 'Train Data Entry' or 'change of position'.		I	DMI	yes	time: 11:12:56	manual
36	45	0	256	8	5	4	4	4	The driver's selection action is displayed on the DMI.		O	DMI	yes	time: 11:12:57	manual



# Automatisierte Testauswertung und Dokumentation

The image displays three overlapping screenshots of Microsoft Word documents, all titled "AU\_TS\_ETCS\_OnboardUnit\_Testreport\_xxyzz\_00.doc - Microsoft Word".

The leftmost screenshot shows a sidebar with a DLR logo and a table with the following content:

Author
Project leader (technical review)
Responsible Authority (approval)

The middle screenshot shows a "Test Report" for "RailSiTe" with the DLR logo. It includes a section "4.2 Error Report" and "4.2.1 Test Sequence 001". Below this is a table titled "Summary of failed Test steps:" with columns "TS 001 Step", "FT.TCS step", "Description", "Interface", and "Cat".

TS 001 Step	FT.TCS step	Description	Interface	Cat
11	FT257.TC1.1	S8 mode is permanently deployed to the driver when the on-board equipment is in S8 mode.	DMI	OBL
17	FT257.TC1.6	Driver's validation action is recorded on the JRU. The validated Driver ID is recorded on the JRU. Comment: Triggered by: The driver acts on the on-board MML. Triggered by: Data Entry completed	JRU	OBL
18	FT257.TC1.7	Driver ask for review the value entered	DMI	Seque
19	FT257.TC1.8	Interaction is RECORDED	JRU	Follow
41	FT631.TC1.3	Onboard reports invalid position to RBC (A34). Comment: MESSAGE 157, SoM position report	RTM	OBL

Below the table is a note: "This document is confidential and restricted." and the file path "AU\_TS\_ETCS\_OnboardUnit\_Testreport\_xxyzz\_00.doc".

The rightmost screenshot shows a "Certificate" from "BUREAU VERITAS Certification" awarded to "DLR". The certificate text states: "German Aerospace Center Quality and Product Assurance 51147 Köln Germany". It certifies that the Management System of the above organization has been assessed and found to be in accordance with the requirements of the standards detailed below.

**Standard**  
DIN EN ISO 9001:2008  
Scope of supply

The configuration and operation of the DLR quality management process and:

- the product assurance management in national space projects
- the management of EEE-component qualifications as well as
- the participation in standardization and component bodies and working groups
- the management of the Quality and Product Assurance organisation

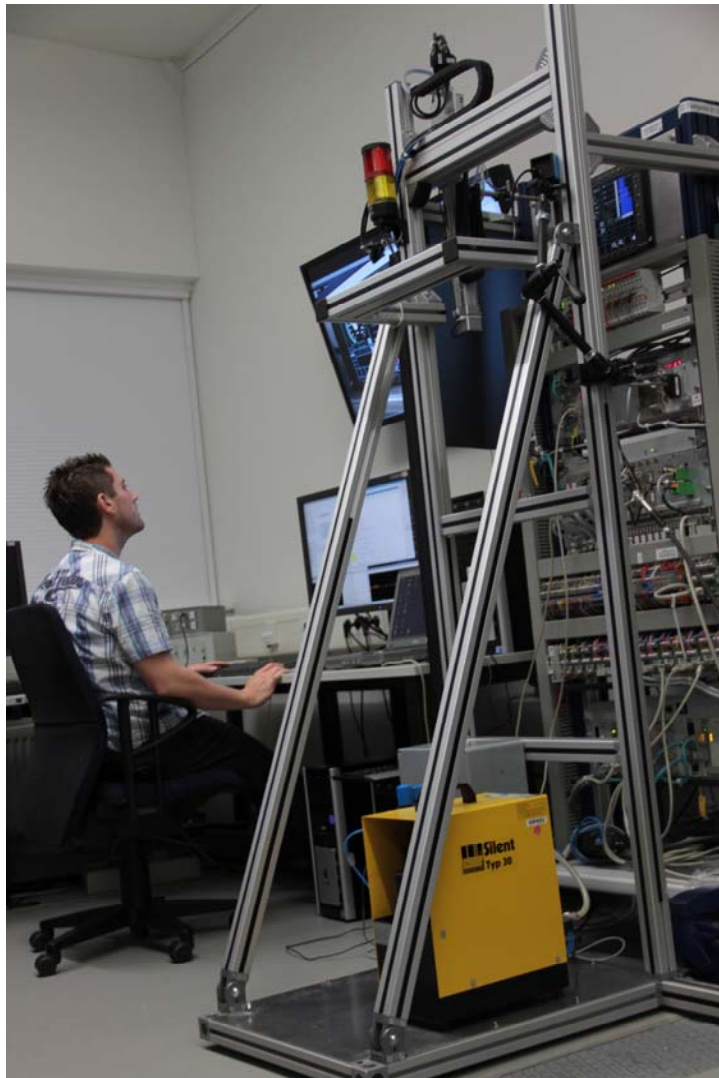
Original approval date: 28.07.2006  
Date of audit: 06.03.2009  
Date of recertification: 05.03.2012  
Subject to the central satisfactory operation of the organization's Management System, this certificate is valid from:  
Date of expiration: 03.04.2009  
Valid until: 02.04.2012

The certificate is signed by "Kette Ritz" on 28.05.2009. The certificate number is "DE9000016018". The Bureau Veritas Certification Germany GmbH is located at "Vitalstraße 1 | D-20079 Hamburg".

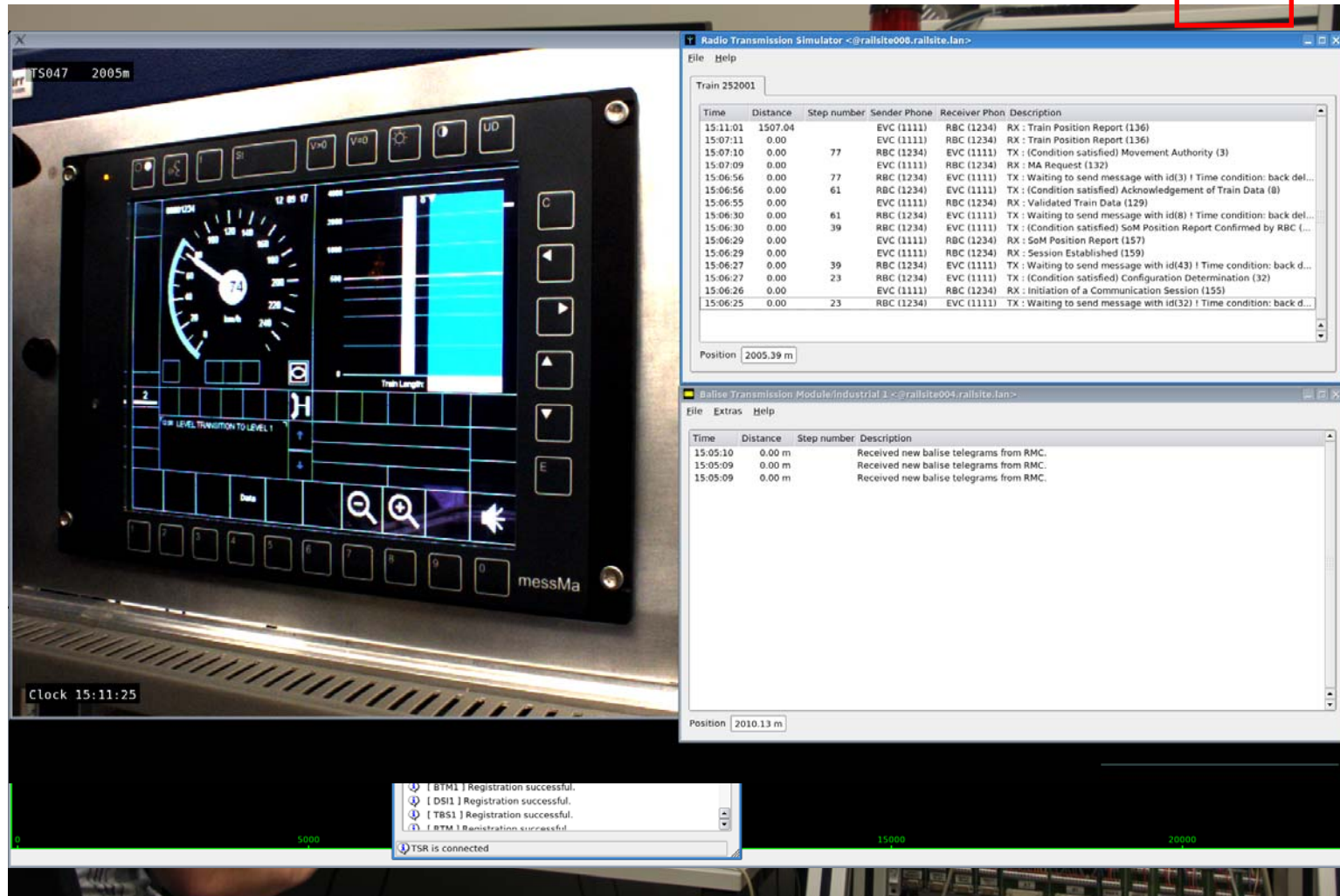
Below the certificate is a note: "This document is confidential and restricted." and the file path "AU\_TS\_ETCS\_OnboardUnit\_Testreport\_xxyzz\_00.doc".



# Automatisierte Testdurchführung



# Automatisierte Testdurchführung Touch-Screen-Eingaben (Roboter)



# Automatisierte Testdurchführung

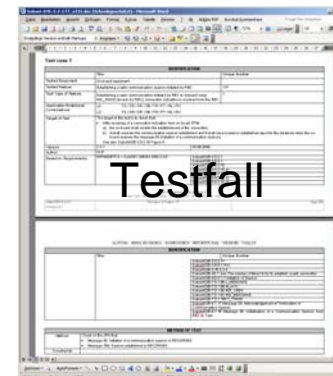
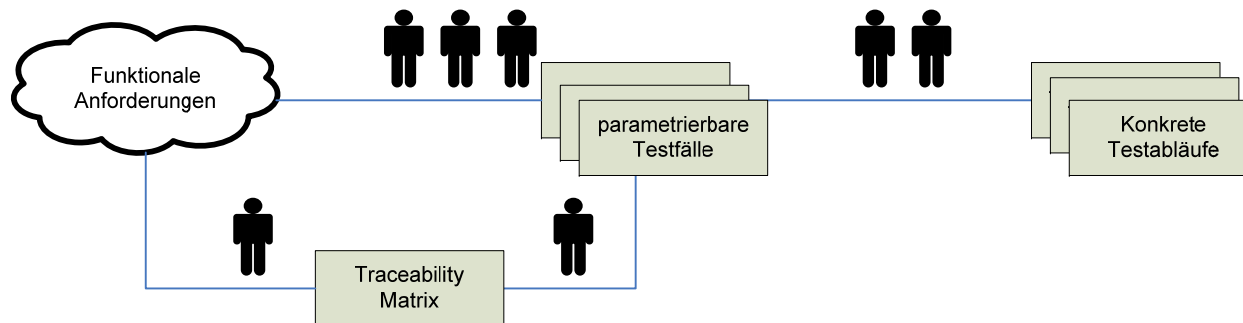
## Touch-Screen-Ausgaben (Bildererkennung)



# Automatisierte Testerstellung

## ➤ Herkömmliche, klassische Testfallableitung

Anforderung → Funktionalität → positive/negative Testfälle → Testabläufe



# Automatisierte Testerstellung

**SUBSET-026-5 v320.doc - Microsoft Word**

ERA \* UNISIG \* EEIG ERTMS USERS GROUP

Seite 17 Ab 1 17/86 Bei 2,9 cm Ze 1 Sp 5 MAK AND ERW UB Englisch (Gr)

**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	0/1/2/6/7/8/11/12/13/14	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	-	ITM	

powerOn

```

stateDiagram-v2
    [*] --> a_changeModeToSB
    a_changeModeToSB: do: setMode; Exit/jru.recordNewMode(SB);
    a_changeModeToSB --> s_SB
    s_SB --> e_openDriverDesk
    e_openDriverDesk --> a_activateDriverDesk
    a_activateDriverDesk: a_displayNewMode; Entry/dmi.displayNewMode(SB);
    a_activateDriverDesk --> a_performSelfTest
    a_performSelfTest: do: performSelfTest;
    a_performSelfTest --> s_S0
    s_S0 --> s_S1
    s_S1 --> dmi_displayDriverIdEntryRequest
    dmi_displayDriverIdEntryRequest --> [*]
    
```

10. Message 136 'Train position report' is RECORDED

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	
MT_ACK	1	1	
NID_LRB0	10 + 14	UNKNOWN	

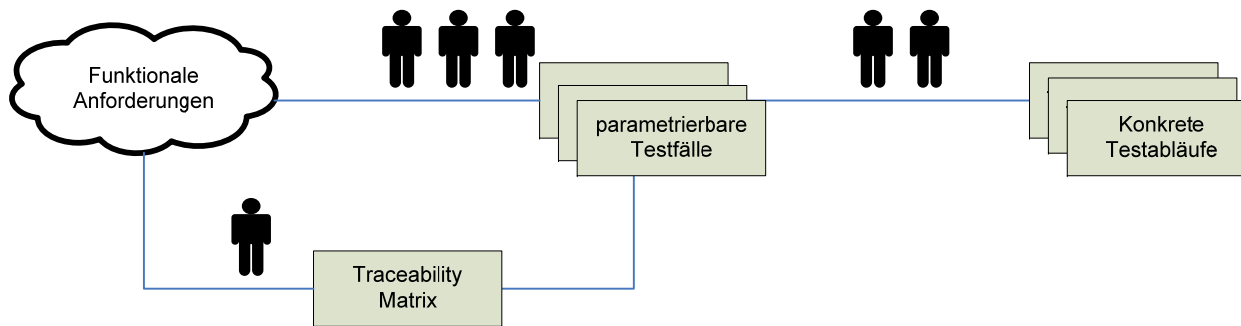
Step 6: Message 159: Session established

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

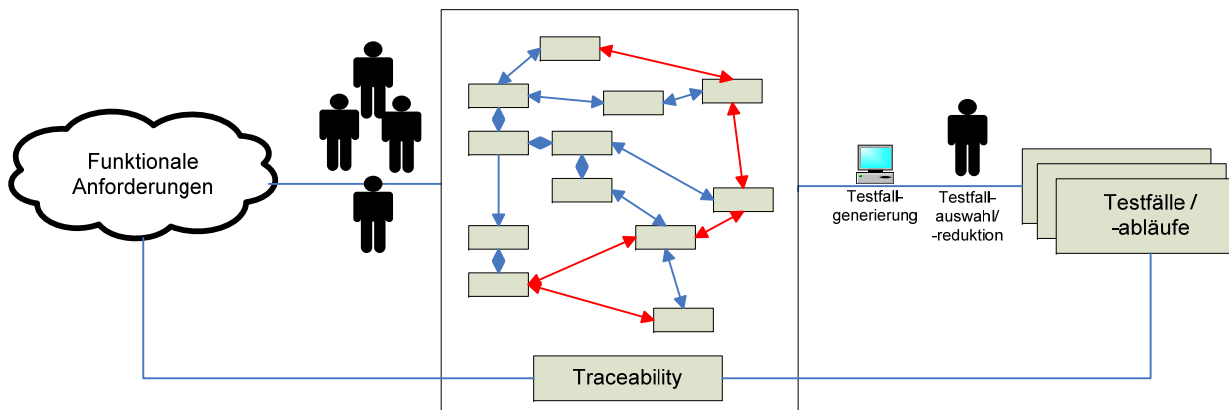
Seite 6 Ab 1 6/22 Bei 2,7 cm Ze 1 Sp 1 MAK AND ERW UB Englisch (Gr)

# Automatisierte Testerstellung

## ➤ Herkömmliche, klassische Testfallableitung

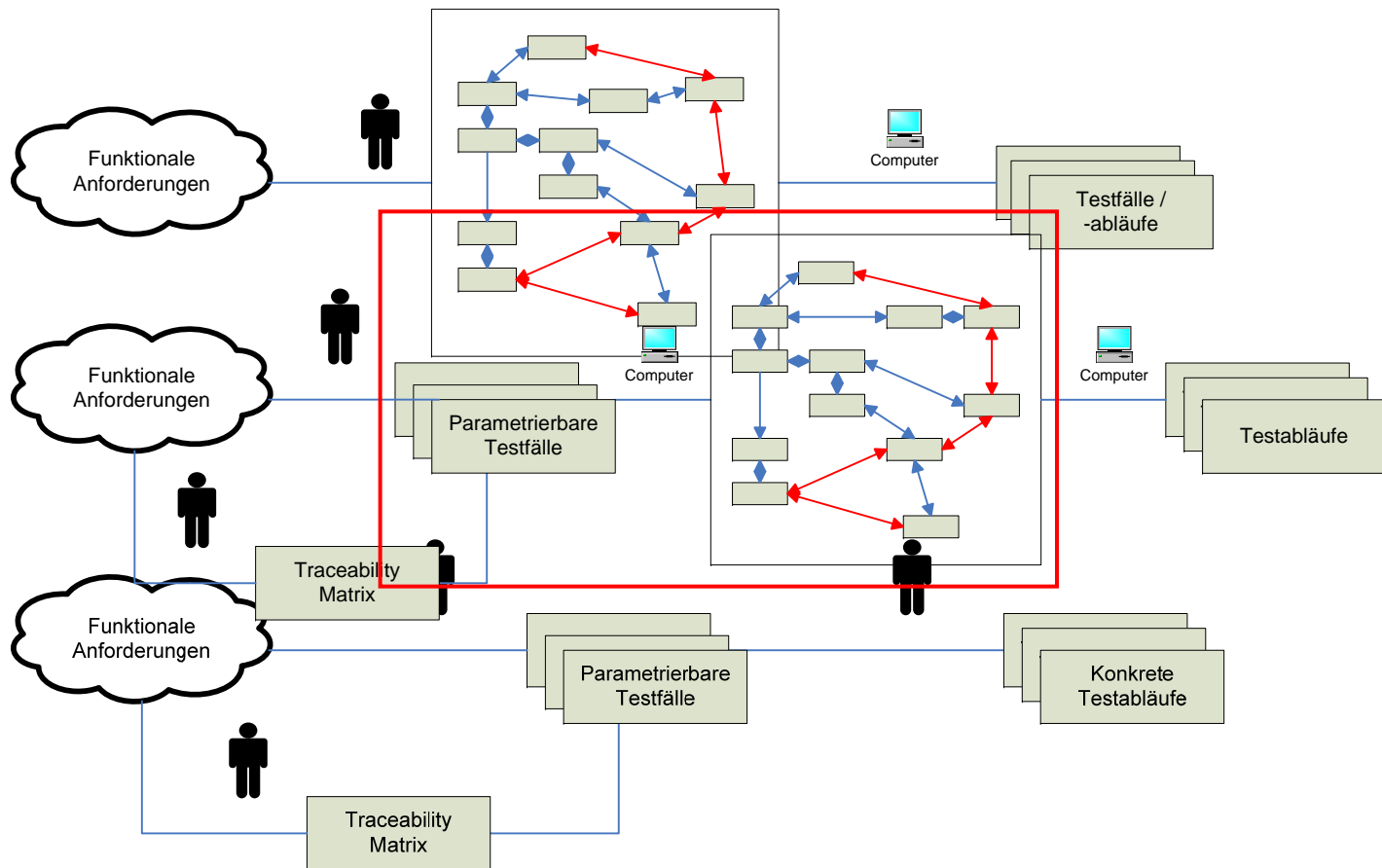


## ➤ Testfallgenerierung über Modell-based Testing



# Automatisierte Testerstellung

## Kombination der beiden Ansätze



# Zusammenfassung

## Effiziente Qualitätssicherung

➤ Automatisierung der Berichtgenerierung



➤ Automatisierung der Testauswertung



➤ Automatisierte Testdurchführung



➤ Automatisierte Testerstellung



## Effizienz- + Effektivitätssteigerungspotentiale

# Verification

## White box

**+**  
**VS.**

## Validation

## Black box

## = „win-win“!?

