"ERTMS accredited labs: A powerful tool for performing Components and System Compatibility Tests"

ERTMS Accredited Laboratories (EAL)

CEDEX CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS

DLR

SNCF Rapprochons-nous Ingénierie du Matériel

LEF: *Laboratoire ERTMS France*

Multitel INNOVATION CENTRE

RINA

Dr. Eng. I.J. Iglesias

Type of Tests performed at EAL labs

1.- Components:

- **On-board Conformity Tests** - According to TSI standard specifications (Subset-076, Subset-094,…)- BTM, EVC
- **Trackside Conformity Tests** – According to TSI standard specifications (Subset-085, Subset-103,…)- Eurobalise, Euroloop
- **Other developments - "Subset -TRK":** covering requirements from trackside constituents (RBC - IXL)

Lab Testing in the frame of (EU) 2016/919 CCS TSI (amended by EU 2019/776)

2.- System Tests:

- **Operational Tests Scenarios (OTS)–** Operational test scenarios based on Engineering Rules of the ETCS trackside as part of trackside subsystem EC Verification/certification process.
- **ESC Tests –** To increase system confidence and assure ETCS system compatibility between trackside and a new On-board Subsystem to operate in a certified line.

Lab Testing in the frame of 2016/919 EU CCS TSI (amended by EU 2019/776)

*(10) "Even a successful certification process cannot always exclude that, when an on-board CCS subsystem interacts with a trackside CCS subsystem, one of the subsystems repeatedly fails to function or perform as intended under certain conditions…….. Therefore, checks might need to be carried out to demonstrate the technical compatibility ……. **The possibility of executing those checks in a laboratory** representing the trackside configuration to be made available by the Infrastructure Manager **should be prioritized**"*

- **Examples of ETCS System Compatibility checks**
  - MRSP Supervision
  - Braking Curves supervision
  - Baseline Compatibility Assessment (BCA)
  - SPAD
  - Commercial itineraries
  - Level Transitions
  - Mode Transitions
  - TSR management
  - MA (EoA, Timers in L1…)
  - Track Conditions
  - Confidence interval impact.
  - Driver operational actions
  - Maximum permitted speed in the line.
  - Degraded conditions
  - Handover

Representative Configuration of the On-Board Unit

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Lab Testing – OTS & ESC Tests

- **Facility** – It operates as a Test Center contracted by the IM and/or in agreement to OB|TS suppliers
- **Test architecture -** Modular approach - Precision, flexibility and credibility of the lab structure – All labs are compatible with SS-094 architecture. Capability to be adapted to different architectures (e.g. SS-111) as well as different track data formats (S-112, RailML…)
- **Test Procedure** – Defines the process to be followed

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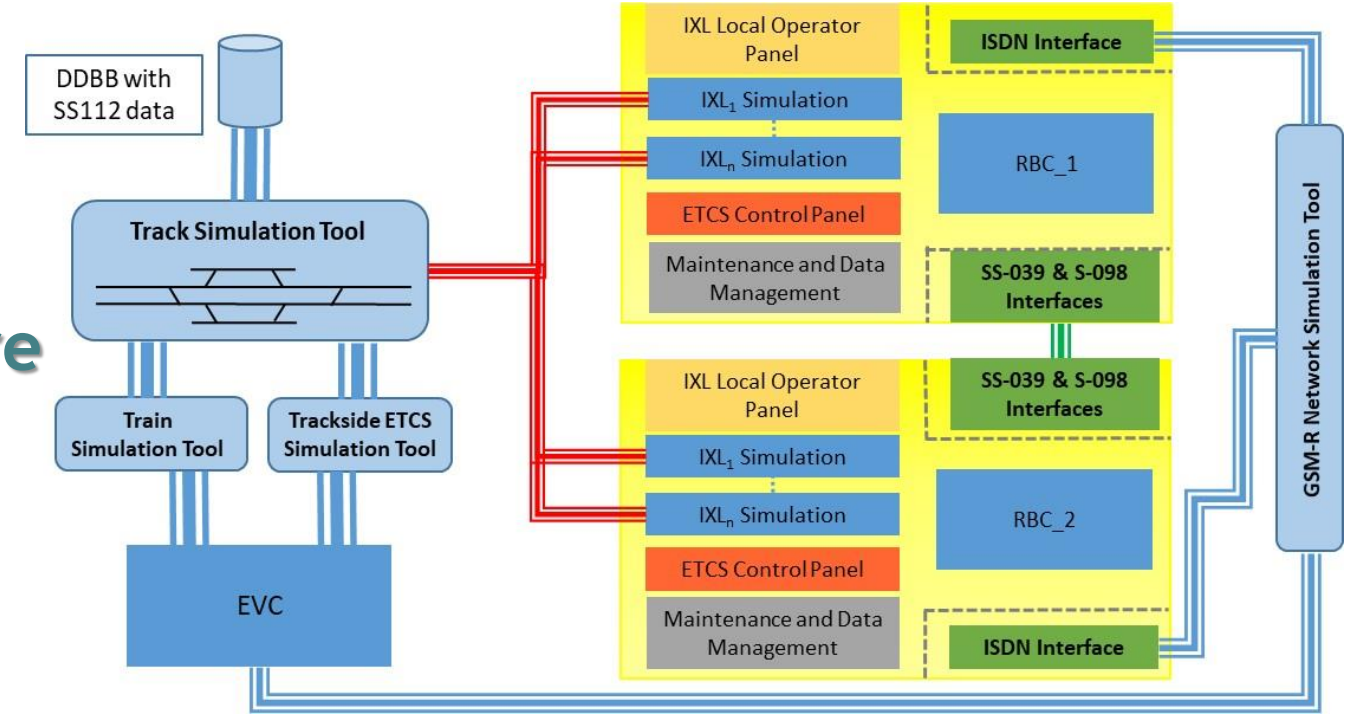
Lab Testing – OTS & ESC Tests

Test Architecture



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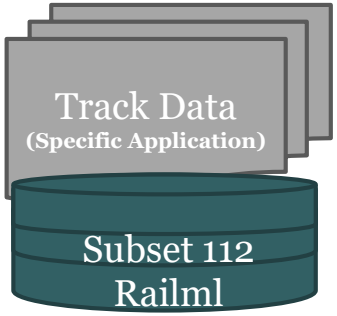
Lab Testing – OTS & ESC Tests

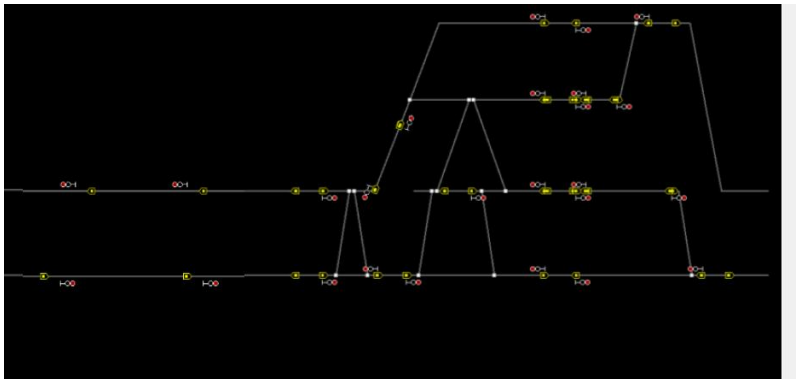
- **Test Procedure** – Preparation phase: **Track data Importation**



Database Storage

Project Track Data Loading into Test Bench

- Topology
- Set of Routes
- Track elements



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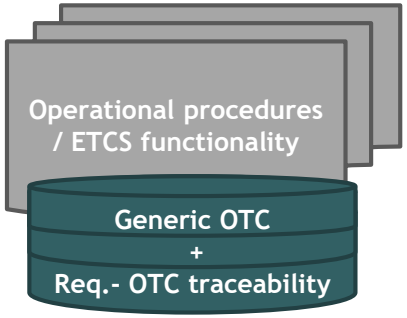
Lab Testing – OTS & ESC Tests

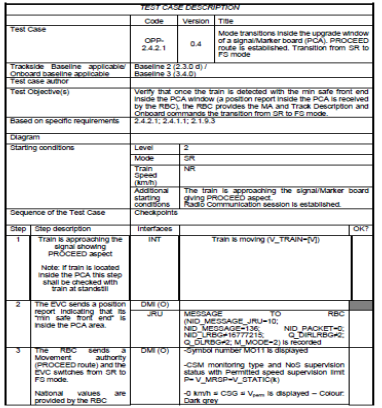
- **Test Procedure** – Preparation phase: **OTC (Generic application)**

Operational Test Cases



- Set of OB and TS events reproducing the expected operational behavior according to applicable Project Engineering Rules/ETCS functionality.
- Traceability OTC – Engineering rules requirements to verify the proper fulfilment.

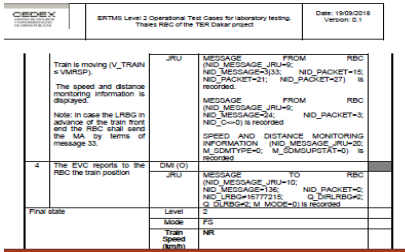
Database Storage



TEST CASE DESCRIPTION

Test Case	Code: OPP-2.4.2.1	Version: 0.4	Title: Mode transitions inside the upgrade window of a signal/Marker board (PCA). PROCEED route is established. Transition from SR to FS mode
Trackside Baseline applicable/ Onboard baseline applicable	Baseline 2 (2.3.0 d) / Baseline 3 (3.4.0)		
Test case author			
Test Objective(s)	Verify that once the train is detected with the min safe front end inside the PCA window (a position report inside the PCA is received by the RBC), the RBC provides the MA and Track Description and Onboard commands the transition from SR to FS mode.		
Based on specific requirements	2.4.2.1; 2.4.1.1; 2.1.9.3		
Diagram			
Starting conditions	Level: 2		
	Mode: SR		
	Train Speed (km/h): NR		
	Additional starting conditions: The train is approaching the signal/Marker board giving PROCEED aspect. RadIO communication session is established.		
Sequence of the Test Case	Checkpoints		

Step	Step description	Interfaces		OK?
1	Train is approaching the signal showing PROCEED aspect Note: If train is located inside the PCA this step shall be checked with train at standstill	INT	Train is moving (V_TRAIN>[V])	
2	The EVC sends a position report indicating that its "min safe front end" is inside the PCA area.	DMI (O)		
		JRU	MESSAGE FROM RBC (NID_MESSAGE_JRU=10; NID_MESSAGE=136; NID_PACKET=0; NID_LRBG=16777215; Q_DIRLRBG=2; Q_CLRBG=2; M_MODE=2) is recorded	
3	The RBC sends a Movement authority (PROCEED route) and the EVC switches from SR to FS mode. National values are provided by the RBC	DMI (O)	-Symbol number M011 is displayed -CSM monitoring type and NID supervision status with Permitted speed supervision limit P= V_MRSP=V_STATIC(a) -0 km/h < CSG = V_{perm} is displayed – Colour: Dark grey	



ERTMS Level 2 Operational Test Cases for laboratory testing. Thales RBC of the TER Dakar project — Date: 19/09/2018 Version: 0.1

	Train is moving (V_TRAIN > VMRSP). The speed and distance monitoring information is displayed. Note: In case the LRBG in advance of the train front end the RBC shall send the MA by terms of message 33.	JRU	MESSAGE FROM RBC (NID_MESSAGE_JRU=5; NID_MESSAGE=133; NID_PACKET=15; NID_PACKET=21; NID_PACKET=27) is recorded. MESSAGE FROM RBC (NID_MESSAGE_JRU=5; NID_MESSAGE=24; NID_PACKET=3; NID_C=~0) is recorded SPEED AND DISTANCE MONITORING INFORMATION (NID_MESSAGE_JRU=20; M_DOMTYPE=0; M_SDMSUPSTAT=0) is recorded	
4	The EVC reports to the RBC the train position	DMI (O)		
		JRU	MESSAGE TO RBC (NID_MESSAGE_JRU=10; NID_MESSAGE=136; NID_PACKET=0; NID_LRBG=16777215; Q_DIRLRBG=2; Q_CLRBG=2; M_MODE=0) is recorded	
Final state		Level: 2		
		Mode: FS		
		Train Speed (km/h): NR		

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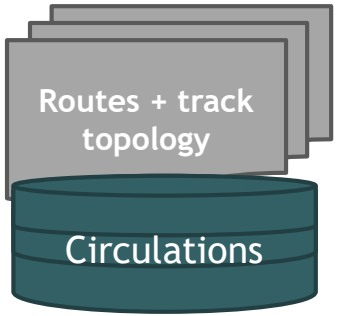
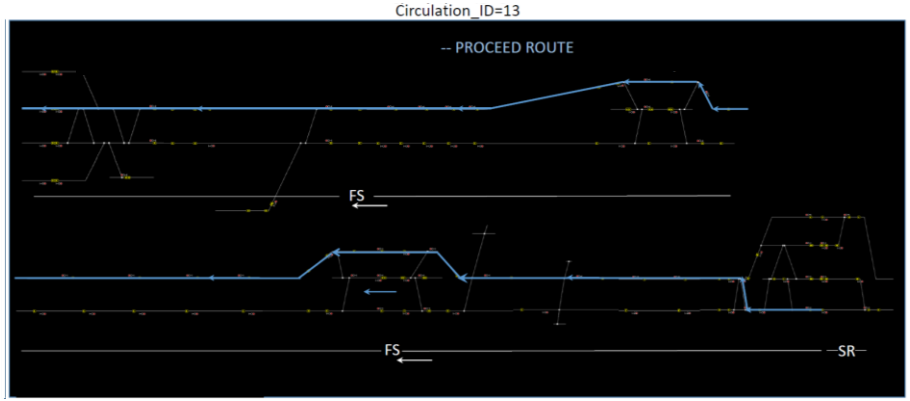
Lab Testing – OTS & ESC Tests

- **Test Procedure** – Preparation phase: **Circulations**



Database Storage

- ✓ Set of route combination (PROCEED, OS, SH…)
- ✓ Operational actions
  - DMI inputs (Driver)
  - Signalman
  - Relevant driving actions (SPAD / Overspeed, Stop…)



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Lab Testing – OTS & ESC Tests

- **Test Procedure** – Preparation phase: **OTS (Specific application)**

OTS_Name	Circulation_ID	OTC_CODE	TrackElementType(S)	TrackElement_ID(S)	Offset(S)	TrackElementType(E)	TrackElement_ID(E)
LIN_Supervission	10	OPP-2.1.7	Balise Group	1338	0	Balise Group	1338
SSP_Supervision	10	2.3	Point	5003a	0	Point	5003a
SSP_Supervision	10	24.1_c	Point	505b	0	Point	505b
PCA_SAD_FS	10	OPP-2.4.3	Signal	S5035	0	Signal	S5035
EoA_Supervision	10	OPP-2.6.2.2	Signal	S5035	0	Signal	S5035
SoM_SB_SR	11	OPP-2.2.1.2.1/OPP-2.13.2.3_b	Signal	SRP2013	-	Signal	SRP2013
PCA_SR_FS	11	OPP-2.4.2.1	Signal	S2013	-50	Signal	S2013
PCA_CES	11	OPP-2.4.4	Signal	S2013	25	Signal	S2013
TSR_80_FS	11	OPP-2.1.8_d	TSR	Kp 0.500	0	TSR	KP 1.500
SSP_Supervision	11	24.1_b	Speed Change	KP 5.232	0	Speed Change	KP 5.232
SSP_Supervision	11	2.3	Speed Change	KP 8.318	0	Speed Change	KP 8.318
SSP_Supervision	11	24.1_b	Speed Change	KP 11.232	0	Speed Change	KP 11.232
SSP_Supervision	11	2.3	Speed Change	KP 14.100	0	Speed Change	KP 14.100
SSP_Supervision	11	2.3	Speed Change	KP 16.710	0	Speed Change	KP 16.710
SSP_Supervision	11	24.1_b	Speed Change	KP 17.702	0	Speed Change	KP 17.702
SSP_Supervision	11	2.3	Speed Change	KP 27.061	0	Speed Change	KP 27.061
SSP_Supervision	11	24.1_b	Speed Change	KP 27.292	0	Speed Change	KP 27.292
SSP_Supervision	11	2.3	Speed Change	KP 30.510	0	Speed Change	KP 30.510

Operational Test Scenarios

- Placing OTC's on specific locations in the line where they can be tested according to the selected Circulation

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Lab Testing – OTS & ESC Tests

Test Procedure – Execution & Analysis phase

After integrating real EVC and real RBC at lab, test are executed

Video of a Test execution

Logs registering DMI, TIU, TMS and JRU

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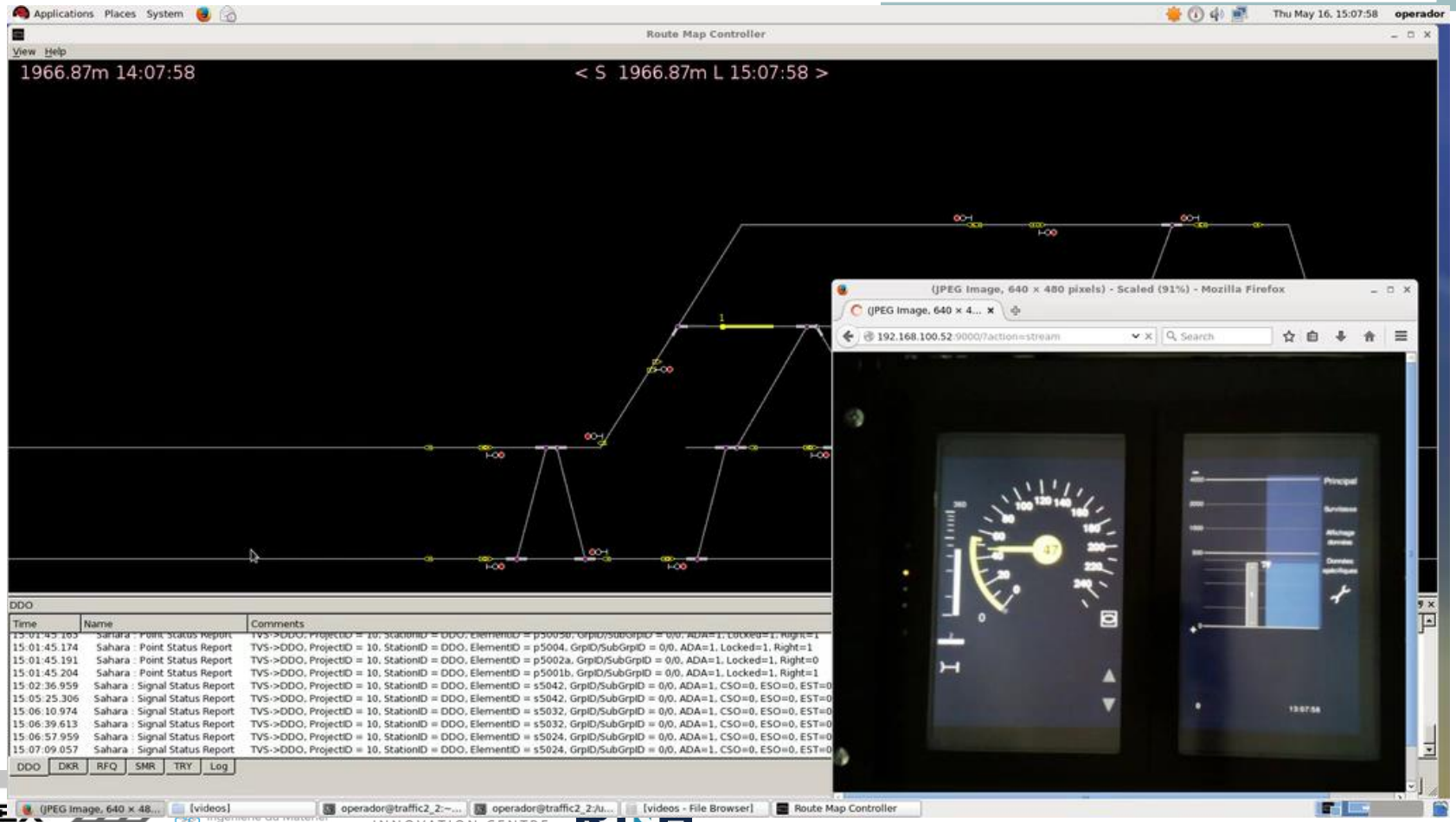
Applications Places System
Thu May 16, 15:07:58 operador
Route Map Controller
View Help
1966.87m 14:07:58
< S 1966.87m L 15:07:58 >
(JPEG Image, 640 × 480 pixels) - Scaled (91%) - Mozilla Firefox
(JPEG Image, 640 × 4...
192.168.100.52:9000/?action=stream
Search
DDO
Time
Name
Comments
15:01:45.174 Sahara : Point Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = p5004, GrpID/SubGrpID = 0/0, ADA=1, Locked=1, Right=1
15:01:45.191 Sahara : Point Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = p5002a, GrpID/SubGrpID = 0/0, ADA=1, Locked=1, Right=0
15:01:45.204 Sahara : Point Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = p5001b, GrpID/SubGrpID = 0/0, ADA=1, Locked=1, Right=1
15:02:36.959 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5042, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
15:05:25.306 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5042, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
15:06:10.974 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5032, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
15:06:39.613 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5032, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
15:06:57.959 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5024, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
15:07:09.057 Sahara : Signal Status Report TVS->DDO, ProjectID = 10, StationID = DDO, ElementID = s5024, GrpID/SubGrpID = 0/0, ADA=1, CSO=0, ESO=0, EST=0
DDO DKR RFQ SMR TRY Log
(JPEG Image, 640 × 48...
[videos]
operador@traffic2_2:~...
operador@traffic2_2:/u...
[videos - File Browser]
Route Map Controller

Lab Testing - OTS & ESC Tests

Test Procedure – Execution & Analysis phase

OTS_Name	Circulation_Id	OTC_CODE	TrackElementType	TrackElement_ID	TrackElementType(E	TrackElement_ID(	Test Resu
SoM_SB_SR	8	OPP-2.2.1.2.1/OPP-2.13.2.3_b	Signal	SRP2017	Signal	SRP2017	OK
PCA_SR_FS	8	OPP-2.4.2.1	Signal	S2017	Signal	S2017	OK
PCA_CES	8	OPP-2.4.4	Signal	S2017	Signal	S2017	OK
SSP_Supervision	8	2.3	Point	2004	Point	2004	OK
SSP_Supervision	8	24.1_b	Point	2004	Point	2004	OK
SSP_Supervision	8	2.3	Point	2006a	Point	2006b	OK
SSP_Supervision	8	24.1_b	Point	2006b	Point	2006b	OK
SSP_Supervision	8	24.1_b	Speed Change	KP 5.232	Speed Change	KP 5.232	OK
SSP_Supervision	8	2.3	Speed Change	KP 8.318	Speed Change	KP 8.318	OK
SSP_Supervision	8	24.1_b	Speed Change	KP 11.232	Speed Change	KP 11.232	OK
SSP_Supervision	8	2.3	Speed Change	KP 14.100	Speed Change	KP 14.100	OK
SSP_Supervision	8	24.1_b	Speed Change	KP 14.099	Speed Change	KP 14.099	OK
SSP_Supervision	8	2.3	Speed Change	KP 16.710	Speed Change	KP 16.710	OK
SSP_Supervision	8	24.1_b	Speed Change	KP 17.702	Speed Change	KP 17.702	OK
TCO_Supervision	8	OPP-2.15.1	Powerless Section	KP 21.507	Powerless Section	KP 21.610	OK
TEX_Supervision	8	OPP-2.16.1	Commercial Station	KP 9.547_Thiaorye	Commercial Station	KP 9.547_Thiaorye	OK
TEX_Supervision	8	OPP-2.16.1	Commercial Station	KP 26.670_Rufisque	Commercial Station	KP 26.670_Rufisque	OK
TNV_Supervision	8	OPP-3.1.3.1	Signal	S3001	Signal	S3001	OK
NVA_T_NVCONTACT	8	OPP-2.1.9	Signal	S3001	Signal	S3001	OK
LBG	8	OPP-3.3.1	Balise Group	1103	Balise Group	1105	OK
OVR_FS	8	OPP-2.10.3_a	Balise Group	1105	Balise Group	1105	OK
PCA_SR_FS	8	OPP-2.4.2.1	Signal	S3007	Signal	S3007	OK
PCA_CES	8	OPP-2.4.4	Signal	S3008	Signal	S3008	OK
EOS_FS	8	OPP-2.8.2.1_a	Signal	S4023	Signal	S4023	OK
EoA_Supervision	8	OPP-2.6.2.2	Topera	T_Rufisque	Topera	T_Rufisque	OK
STP_BufferStop	8	OPP-2.11.2	Buffer Stop	T_Rufisque	Buffer Stop	T_Rufisque	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1008	Balise Group	1008	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1013	Balise Group	1013	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1015	Balise Group	1015	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1017	Balise Group	1017	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1019	Balise Group	1019	OK
LIN_Supervission	8	OPP-2.1.7	Balise Group	1029	Balise Group	1029	OK

Report

TEST CASE DESCRIPTION

	Code	Version	Title
Test Case	OPP-2.4.2.1	0.4	Mode transitions inside the upgrade window of a signal/Marker board (PCA). PROCEED route is established. Transition from SR to FS mode
Trackside Baseline applicable/ Onboard baseline applicable	Baseline 2 (2.3.0 d) / Baseline 3 (3.4.0)		
Test case author			
Test Objective(s)	Verify that once the train is detected with the min safe front end inside the PCA window (a position report inside the PCA is received by the RBC), the RBC provides the MA and Track Description and Onboard commands the transition from SR to FS mode.		
Based on specific requirements	2.4.2.1; 2.4.1.1; 2.1.9.3		
Diagram			
Starting conditions	Level	2	
	Mode	SR	
	Train Speed (km/h)	NR	
	Additional starting conditions	The train is approaching the signal/Marker board giving PROCEED aspect. Radio Communication session is established.	
Sequence of the Test Case	Checkpoints		

Step	Step description	Interfaces		OKT
1	Train is approaching the signal showing PROCEED aspect Note: if train is located inside the PCA this step shall be checked with train at standstill	INT	Train is moving (V_TRAIN>[V])	✓
2	The EVC sends a position report indicating that its "min safe front end" is inside the PCA area.	DMI (O) JRU	MESSAGE TO RBC (NID_MESSAGE_JRU=10; NID_MESSAGE=136; NID_PACKET=0; NID_LRBG=16777215; Q_DIRLRBG=2; Q_SCALE=2; M_MODE=0) is recorded	✓
3	The RBC sends a Movement authority (PROCEED route) and the EVC switches from SR to FS mode National values are provided by the RBC	DMI (O)	-Symbol number MA11 is displayed -CSM monitoring type and NoS supervision status with Permitted speed supervision limit P= V_MRSP=V_STATIC(k) -0 km/h < CSG < V_{perm} is displayed – Colour: Dark grey	✓

CEDEX | ERTMS Level 2 Operational Test Cases for laboratory testing. Thales RBC of the TER Dakar project | Date: 19/09/2018 Version: 0.1

	JRU	MESSAGE FROM RBC (NID_MESSAGE_JRU=9; NID_MESSAGE=133; NID_PACKET=16; NID_PACKET=21; NID_PACKET=27) is recorded. MESSAGE FROM RBC (NID_MESSAGE_JRU=9; NID_MESSAGE=24; NID_PACKET=3; NID_C<>0) is recorded SPEED AND DISTANCE MONITORING INFORMATION (NID_MESSAGE_JRU=20; M_SDMTYPE=0; M_SDMSUPSTAT=0) is recorded	✓
4 The EVC reports to the RBC the train position	DMI (O) JRU	MESSAGE TO RBC (NID_MESSAGE_JRU=10; NID_MESSAGE=136; NID_PACKET=0; NID_LRBG=16777215; Q_DIRLRBG=2; Q_SCALE=2; M_MODE=0) is recorded	✓
Final state	Level	2	
	Mode	FS	

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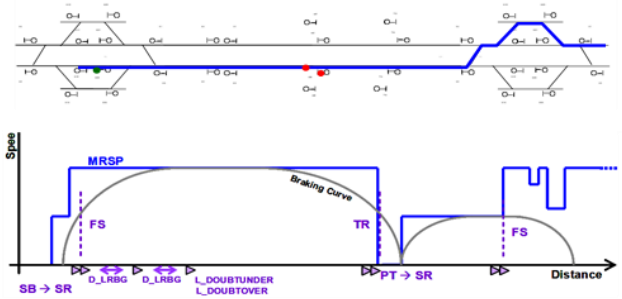
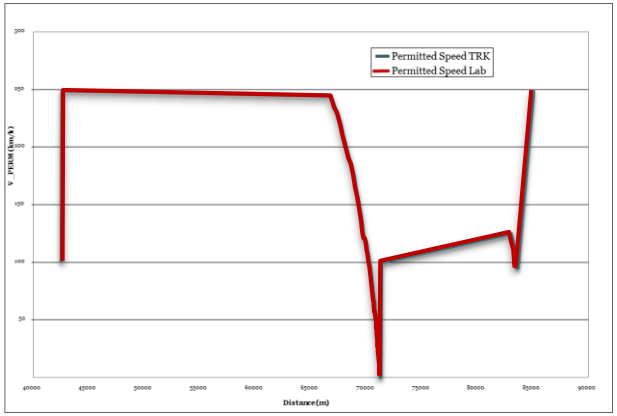
Lab Testing – OTS & ESC Tests

- **Independency** on Test Report from ETCS suppliers, specially relevant if different ETCS TS – OB suppliers
- **Trust and confidence** when transferring tests from track to Lab - **Lab** intercomparisson





- **Experience** more than 16 real L1 and L2 lines already tested at EAL

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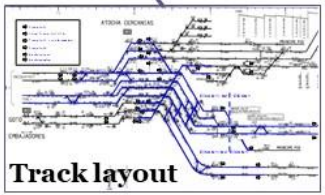
Lab Testing – OTS & ESC Tests

Panoramic view of a EAL: a ESC Test Campaign of a real line with two RBCs and one EVC



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Lab Testing – OTS & ESC Tests

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Conclusions

- Lab Testing is a powerful tool in the "***Digital Transformation of Railways System***"
- Lab testing strongly simplifies the process of executing Operational Test Scenarios and System Compatibility Tests among different On-board and Trackside subsystems suppliers.
- Having a **"Digital Twin" of a ETCS track** in the lab allows in terms of OTS and ESC tests:
  - To be part of a whole **Test process** - Any scenario in nominal or degraded conditions can be reproduced dynamically in the Lab using both TS and OB ETCS subsystems.
  - To set the basis **of Digital Information Exchange System** for the Register and Maintenance of **ETCS RINF** of the (Trans)European Network, ready at any moment to perform ESC Tests when a new On-board of a vehicle is approved.
  - **Flexibility - In Advance Debugging:** compatibility issue detection and change management is fast and does not need the corresponding Safety Case analysis – Avoiding *"last minute"* functionality problems
- Cost of testing will be strongly reduced by executing OTS and ESC tests at lab. It is the only way of addressing this issue in a future European ETCS network.
- EAL has a wide experience in performing OTS and ESC tests at lab. More than 16 real lines have been already tested.

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Thank you for your kind attention

EAL: ERTMS Accredited Labs

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