CEDEX Rail interoperability Lab (RIL)
Main activities and tests performed

September 2017

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Summary

1. CEDEX: A Public Research Centre for Civil Engineering
2. ERTMS creation
3. Rail Interoperability lab (RIL) presentation
4. ERTMS in Spain and main pending challenges worldwide
5. Train-Track integration Tests (Operational tests). Remote tests
   • How do we integrate the track and onboard subsystems at lab?
6. On-site tests vs. laboratory tests: lab validation
7. Eurobalise laboratory: Eurobalise and Antenna/BTM certification
8. Eurocab laboratory: EVC certification tests (Subset-076)
9. Spanish procedure of placing in service
10. Current international activities at RIL
11. Conclusions.
2. ERTMS Creation
1. Signaling: A lot of systems in Europe

An Unique Multi-Supplier Signaling System

Full Open Market:
No more captive markets

EBICAB 700/1000
EBICAB 900
ZUB 123
KHP
INDUSI/LZB
INDUSI/LZB
EVM
European Process. ERTMS creation. (European Rail Traffic Management System)

- **European Rail Transport Policy (Directive 91/440/EEC):** Opening rail market
- **Creation of Trans-European Transport Network (Decision 1692/1996/EC).**
- **Directive 96/48/EC on interoperability of the European high-speed railway system.**
- **Directive 2001/16/EC on interoperability of the European conventional railway system.**
- **COMMISSION REGULATION (EU) 2016/919 of 27 May 2016 on the technical specification for interoperability relating to the 'control-command and signalling' subsystems of the rail system in the European Union.**

**Set of Specifications # 1 (ETCS baseline 2 and GSM-R Baseline 1) (2.3.0.d.)**

**Set of Specifications # 2 (ETCS baseline 3 and GSM-R Baseline 1) (3.4.0.)**

**Set of Specifications # 3 (ETCS baseline 3 and GSM-R Baseline 1) (3.6.0.)**

**Interoperability means the ability of the Trans-European rail system to allow the safe and uninterrupted movement of trains which accomplish the specified levels of performance.**
<table>
<thead>
<tr>
<th>Title</th>
<th>Identification</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>System Requirement Specification</td>
<td>UNISIG Subset-026</td>
<td>Version 2.3.0 d</td>
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<td>FFFIS Juridical Recorder-Downloading Tool</td>
<td>UNISIG Subset-027</td>
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<td>Version 2.1.1</td>
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<td>FFFIS for Eurobalise</td>
<td>UNISIG Subset-036</td>
<td>Version 2.4.1</td>
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<td>Euroradio FIS</td>
<td>UNISIG Subset-037</td>
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<td>UNISIG Subset-038</td>
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<td>FIS for the RBC/RBC Handover</td>
<td>UNISIG Subset-039</td>
<td>Version 2.3.0</td>
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<td>Dimensioning and Engineering rules</td>
<td>UNISIG Subset-040</td>
<td>Version 2.3.0</td>
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<tr>
<td>Performance Requirements for Interoperability</td>
<td>UNISIG Subset-041</td>
<td>Version 2.1.0</td>
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<td>FFFIS for Euroloop sub-system</td>
<td>UNISIG Subset-044</td>
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<td>UNISIG Functional Requirements for an On-Board reference Test Facility</td>
<td>UNISIG Subset-094</td>
<td>Version 2.0.2</td>
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<td>Test cases related to features</td>
<td>UNISIG Subset-0076-5-2</td>
<td>Version 2.3.3</td>
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<td>Test sequences</td>
<td>UNISIG Subset-0076-6-3</td>
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<td>ERTMS EuroRadio Conformance Requirements</td>
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<td>Test Specification for Eurobalise FFFIS</td>
<td>UNISIG Subset-085</td>
<td>Version 2.2.2</td>
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<tr>
<td>Test specification for EUROLOOP</td>
<td>UNISIG Subset-108</td>
<td>Version 1.0.0</td>
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<tr>
<td>Methodology of testing</td>
<td>UNISIG SUBSET-076-3</td>
<td>Version 2.3.1</td>
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<tr>
<td>ERTMS/ETCS Driver Machine Interface</td>
<td>ERA-ERTMS-015560</td>
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<td>UNISIG SUBSET-099</td>
<td>Version 1.0.0</td>
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</tbody>
</table>
ERTMS = ETCS + GSM-R
ERTMS Reference Architecture (TSI)

- **ETCS Onboard**
  - Train
  - Driver
  - STM
  - TIU
  - MMI
  - Kernel
  - BTM
  - LTM
  - EURORADIO
  - JRU Downloading tool
  - Jur. Recording
  - Odometry

- **ETCS Trackside**
  - National System
    - EUROBALISE
    - EUROLOOP
  - Interlocking and LEU
  - Control Centre
  - RBC 1
  - RBC 2
  - Key Management Centre
  - GSM-Mobile
  - GSM fixed network
  - Radio infill unit
  - EURORADIO
• CEDEX Rail Interoperability Lab is the first laboratory in the world accredited for certifying ERTMS components and for testing ERTMS lines.

• The laboratory was created in 2000. It is has been the pioneer on testing ETCS components and subsystems and it has tested equipments from almost all ERTMS worldwide suppliers.

• The laboratory has actively participated in the process of placing in service ERTMS in the Spanish High Speed and Conventional Lines (Madrid commuter lines).

• The laboratory has designed, together with Adif, Renfe and the Ministry of Fomento, the set of INT tests (around 200 tests) which really guarantee full interoperability.
4. ERTMS in Spain and main pending challenges worldwide
ERTMS in Spain

3200 Kms in commercial operation with ERTMS with 17 interoperability cases tested. L2 already in operation

Orense-Santiago Thales L1 2011 /
Olmedo-Zamora Thales/Siemens L2 2016

Madrid-Valladolid Thales L1 2007 /

La Sagra-Toledo Thales L1 2008

Madrid commuter lines Dimetronic-Thales L1 2012- L2 2016

The longest (1250 Kms) interoperable HSL from Barcelona to Malaga: Paradigm of interoperability (3 ETCS suppliers plus STM LZB on track and a different supplier for the EVC)

Córdoba-Malaga Siemens L1 2007 / L2 2016


Valladolid-León-Burgos Alstom/Bombardier L2-2016

Zaragoza-Huesca / Alstom L1- 2009

Madrid-Lleida / Ansaldo L1 2006 / L2 Oct 2011

Madrid-Valladolid-León-Burgos-Valladolid-León-Burgos

Olmedo-Zamora Thales/Siemens L2 2016


La Lleida-Barcelona Thales L1 2008 / L2 2016

Madrid-Valladolid Thales L1 2007 /

Figueras-Perpignan Ansaldo L1 2010 / L2 2016

Madrid-Lleida / Ansaldo L1 2009

Bna-Figueras Thales L1 2012 / L2 2016

Valladolid-León-Burgos-Valladolid-León-Burgos

La Sagra-Toledo Thales L1 2008

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ERTMS in Spain

The longest (1250 Kms) interoperable HSL from Barcelona to Malaga: Paradigm of interoperability (3 ETCS suppliers plus STM LZB on track and a different supplier for the EVC)
## HIGH SPEED/ LONG DISTANCE/ MEDIUM DISTANCES TRAINS

<table>
<thead>
<tr>
<th>Train supplier</th>
<th>Alstom</th>
<th>Talgo</th>
<th>Siemens</th>
<th>Alstom</th>
<th>CAF (Variable Gauge)</th>
<th>Talgo (Variable Gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>renfe trainset</td>
<td><img src="image1" alt="Train" /></td>
<td><img src="image2" alt="Train" /></td>
<td><img src="image3" alt="Train" /></td>
<td><img src="image4" alt="Train" /></td>
<td><img src="image5" alt="Train" /></td>
<td><img src="image6" alt="Train" /></td>
</tr>
<tr>
<td>Class</td>
<td>100 + 101</td>
<td>102 + 112</td>
<td>103</td>
<td>104</td>
<td>114</td>
<td>120 + 120.050</td>
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<tr>
<td>Fleet</td>
<td>24</td>
<td>46</td>
<td>26</td>
<td>20</td>
<td>13</td>
<td>28</td>
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<tr>
<td>Signalling</td>
<td>ETCS N1/N2 Lzb ASFA</td>
<td>ETCS N1/N2 Lzb ASFA</td>
<td>ETCS N1/N2 Lzb ASFA</td>
<td>ETCS N1/N2 Lzb ASFA</td>
<td>ETCS N1/N2 ASFA</td>
<td>ETCS N1/N2 Lzb ASFA</td>
</tr>
<tr>
<td>ERTMS Supplier</td>
<td>Alstom</td>
<td>Siemens</td>
<td>Siemens</td>
<td>Alstom</td>
<td>Alstom</td>
<td>Ansaldo - CSEE Transport</td>
</tr>
<tr>
<td>ETCS SRS Version</td>
<td>2.3.0.d compatible</td>
<td>2.2.2 + CR</td>
<td>2.2.2 + CR</td>
<td>2.3.0.d compatible</td>
<td>2.2.2 + CR</td>
<td>2.2.2 + CR</td>
</tr>
</tbody>
</table>
## Interoperability cases: Cross ERTMS Interoperability table

<table>
<thead>
<tr>
<th>CROSS INTEROPERABILITY IN SPAIN</th>
<th>TRACK EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ON BOARD EQUIPMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Alstom S-100/104/114- 465</td>
<td>15</td>
</tr>
<tr>
<td>Ansaldo S-120/121</td>
<td>7</td>
</tr>
<tr>
<td>Bombardier S-130/730</td>
<td>9</td>
</tr>
<tr>
<td>Dimetronic 450/446/447</td>
<td>18</td>
</tr>
<tr>
<td>Siemens S-102/103- 252</td>
<td>14</td>
</tr>
<tr>
<td>Thales</td>
<td>No On Board Unit from Thales in Spain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRACK EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alstom</strong></td>
</tr>
<tr>
<td><strong>Bombardier</strong></td>
</tr>
<tr>
<td><strong>Thales</strong></td>
</tr>
</tbody>
</table>

- **15** Alstom
- **7** Ansaldo
- **9** Bombardier
- **18** Dimetronic
- **14** Siemens
- **10** Thales
- **Ansaldo S-120/121**
- **Bombardier S-130/730**
- **Pilot line** Dimetronic 450/446/447
- **Mad. Comm.** Siemens S-102/103- 252
- **No On Board Unit from Thales in Spain**
ERTMS works!!!

ERTMS in Spain

ERTMS reliability and punctuality in Madrid-Barcelona HSL

Kms between incidences

* L2 started in October 2011
* Line was extended in L1 up to Barcelona
** Line was extended in L1 up to French border

Punctuality (delay <5')
CURRENT SITUATION: POSITIVE MESSAGES

1. ERTMS will be the worldwide standard for rail signaling for the next decades

2. ERTMS will be deployed in European core and comprehensive corridors

3. ERTMS Specifications are stable enough and properly managed by ERA

- Baseline 2 (2.3.0.d) is an stable version in successful commercial operation in many European and non-European countries (Spain, Italy, Switzerland, The Netherlands, China...)
- Baseline 3 has been already published into the TSI (3.3.0) and it includes some added functionality (braking curves, crossing supervision...) as well as bugs debugging.
**MAIN PENDING CHALLENGES: TIME AND MONEY**

**1. ERTMS costs are too high**

- Increase market scale ✓
- Increase competition (multiple suppliers) ✓
- Increase system complexity

**2. Too long process to place in service**

Operational and train-track integration tests on lab:
- Reduce time
- Reduce cost
- Increase system reliability
- Advance “last minute problems” (always appeared in the signaling world).

Very high deployment costs (tests on track)
5. Train-Track integration Tests (Operational tests): Remote tests
SYSTEM AUTHORITY AND INTEROPERABILITY (IOP) TESTS

- Within the new European frame where the operators and infrastructure are separated, it is essential the existence of a System Authority to manage the interoperability problems.
- MFOM has played this role in the Spanish ERTMS projects.
- The group led by MFOM (ADIF, RENFE, CEDEX and INECO) has created the validation procedure that allows the opening of railway lines with full warranties of interoperability.

NATIONAL AUTHORITY:
Ministry of Fomento (Public Works)

INDEPENDENT ASSESSMENT
CEDEX

OPERATIONAL TESTS

INFRASTRUCTURE MANAGER

OPERATOR
Operational Tests. Main Tested Functionality

- Speed supervision and braking curves
- Level transitions
- Mode changes
- TSR Managing
- Managing of MA timers
- Odometry
- Track conditions
- Train Interface unit
- ATO and preset speed
- DMI
- National Functions
- Maximum Speed for exploitation with free route ahead
- Degraded situations (loss of communications, balise group lost, etc)
- EoA override
- RBC Handover
To achieve full interoperability two options are possible:

1. Performing OP tests once the whole system is installed on the track.

2. Advance interoperability issues by performing OP tests in a lab and after solving the problems appeared, running OP tests on track.

This is the selected way in Spanish Projects.
• How do we integrate the track and onboard subsystems at lab?
The real track data and configuration is introduced into the real Radio Block Center (RBC).......

Track layout, switches, signals, track circuits...
And the real RBC is connected to the laboratory
The real train data are introduced into the real On Board Unit (EVC).....
And the real On Board Unit is connected to the laboratory
RBC and OBU are integrated and tested in the lab connected to all the simulators reproducing: a) the real train dynamics and b) track circuits occupancy, interlocking selected routes and balise telegrams.
Robot Remote Control DMI
EVC test bench: DLR  DMI Robot
6. On-site tests vs. laboratory tests: lab validation.
DEFINITION OF THE OPERATIONAL SCENARIO FOR LABORATORY VALIDATION

Trip between Valdemoro y Villarubia stations
Trackside: Dimetronic / Onboard: Siemens

Testing the line in the laboratory.
Laboratory validation
COMPARISON OF THE CALCULATION OF PERMITTED SPEEDS (L1)

Testing the line in the laboratory.
Laboratory validation
Testing the line in the laboratory. Laboratory validation

COMPARISON OF BRAKING CURVES: TRACK; LABORATORY & LIF & ERA MODELS
DEFINITION OF THE OPERATIONAL SCENARIO FOR LABORATORY VALIDATION

Validation trip in LEVEL 2
Trip between Nuevos Ministerios and Atocha commuter stations

Trackside: Thales / Onboard: Alstom

Level 2 Laboratory validation operational scenario for the commuter lines of Madrid:

❖ Train starting at the Balise Group 8102 (associated to signal S2/6M).
❖ Track free until signal S32 (Balise Group 8102) that will take free aspect when train approaches.
❖ Once S32 shows green aspect the signaling system will allocate track free until Atocha
❖ Atocha entry signal E6 shows non proceed aspect
Testing the line in the laboratory.
Laboratory validation

Validation trip in LEVEL 2

Permitted Speed
Lab
Track
BG Track
BG Lab
Track MA
Lab MA
P24 Lab
P24 Track
P136 Lab
P136 Track

SB → SR
7. Eurobalise laboratory
European Test Specifications (SS 085) were debugged at CEDEX lab (2004)
Eurobalise lab description

- European Eurobalise Test campaign, promoted by ERTMS-EEIG Users Group to debug the official Eurobalise test specifications (2003-2005): all the Eurobalise and antenna-BTM manufacturers from UNISIG at that moment were tested at the lab.

- Recognized as Reference Laboratory by the European Commission (ERA), UNISIG, Users Group

- Eurobalise Lab can perform in a neutral way the Certification tests required by the NOBO’s.

- Eurobalise lab is reference laboratory for the component certification: First certification of an Eurobalise in an industry independent lab.

- The Lab is accredited by ENAC according to norm UNE-EN ISO/IEC 17025, accreditation number 465/LE1003
Eurobalise lab main activities

- Eurobalise tests (TSI-Subset-085)
- Antenna-BTM tests (TSI-Subset-085)
- Euroloop tests (TSI-Subset-103)
- Noise Immunity tests
- Several investigations and specific studies related to Eurobalise, working for ADIF, RENFE, Ministry of Fomento and private companies.
- Tests for different manufacturers since 2005: new manufacturers from Europe, China, Japan, Korea...
Free-air debris balise Test
Preparation for the Reference Loop Calibration under clear water debris
Debris Box filling-up for the Balise Clear-Water Tests
Balise Test under the Metallic-Plate Debris Condition
Preparation of Iron-Ore debris Balise Test
ERTMS & Interoperability Tests Laboratory (LIF)

Test on the Balise under Iron-Ore Debris condition
Tested Balises from the four suppliers (ANS, BTS, ALS, SIE)
8. Eurocab laboratory:

- Tests for placing in service new lines and trains
- EVC certification tests (Subset-076)
Operational Test Cases (OTCs) to test new lines and train-track integration are currently performed first at lab in Spanish ETCS lines.

Every new ETCS line is tested against 3 different EVCs and every EVC is tested over 3 ETCS lines.

HO between different RBC suppliers have been successfully tested.

Integration of both RBC and IxL (or IxL simulator) makes easier the interface between RBC (or IxL in this case) and the lab. (Track circuits occupancy, aspect of the signals and status of the switches)
TEST LAY-OUT TO TEST THE LEVEL 2 ON THE COMMUTER LINES OF MADRID (MINISTRY OF FOMENTO)

European Cross Tests are being run at CEDEX lab

THALES RBC
DIMETRONIC / SIEMENS RBC
ALSTOM EVC

TRAFFIC SIMULATION LABORATORY
Different labs at Rail Interoperability lab -CEDEX

- **Eurocab Laboratory**
  - European Test campaigns
  - Alstom
  - Ansaldo
  - Bombardier
  - Dimetronic
  - Siemens
  - CAF
  - Indra*

- **Traffic Simulation Laboratory**
  - Level 1:
    - Ansaldo
    - Thales
    - Siemens (Dimetronic)
    - Alstom
    - Bombardier
  - Level 2:
    - Thales
    - Siemens (Dimetronic)
    - Alstom
    - Bombardier
    - CAF
    - Ansaldo*
  - Infrabel
  - European Cross tests

- **Eurobalise and BTM Laboratory**
  - European Test campaigns
  - Alstom
  - Ansaldo
  - Bombardier
  - Siemens
  - Thales
  - Digitek
  - Beijing Microunion
  - Hitachi
  - Nippon Signal

- **Energy Laboratory CEDEX-CIEMAT**
  - Kyosan (Japan)
  - Shingwooeng (Korea)
  - CARS (China Academy of Railways Science)
  - Beijing Hollysys (China)
  - Beijing Jioda Signal
  - Beijing Railway Signal
  - Lanxin (China)
  - Casco (China)
  - CAF
  - Shenyang Railway Signal

* In the near future
### EVCs and RBCs tested or being tested at RIL

#### EVCs

<table>
<thead>
<tr>
<th>Line</th>
<th>RBC supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madrid commuter lines</td>
<td>Thales ~ Dimetronic (Siemens)</td>
</tr>
<tr>
<td>Madrid _Valencia HSL</td>
<td>Dimetronic (Siemens)</td>
</tr>
<tr>
<td>Valladolid-León-Burgos</td>
<td>Alstom and Bombardier</td>
</tr>
<tr>
<td>Olmedo-Zamora</td>
<td>Thales</td>
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#### BOMBARDIER

<table>
<thead>
<tr>
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<td>Valladolid-León-Burgos</td>
<td>Alstom and Bombardier</td>
</tr>
<tr>
<td>Olmedo-Zamora</td>
<td>Thales</td>
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#### CAF

<table>
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<th>Line</th>
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<tbody>
<tr>
<td>Olmedo-Zamora</td>
<td>Thales</td>
</tr>
<tr>
<td>Valladolid-León-Burgos</td>
<td>Bombardier and Alstom</td>
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#### SIEMENS

<table>
<thead>
<tr>
<th>Line</th>
<th>RBC supplier</th>
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<tbody>
<tr>
<td>Madrid Commuter Lines</td>
<td>Alstom</td>
</tr>
<tr>
<td>Olmedo- Zamora</td>
<td>Alstom, Bombardier and CAF. Siemens (in progress)</td>
</tr>
<tr>
<td>Madrid-Valencia</td>
<td>Alstom and Bombardier</td>
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#### ANSALDO

<table>
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<th>Line</th>
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<tr>
<td>Madrid Commuter Lines</td>
<td>Alstom</td>
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<tr>
<td>Madrid-Valencia</td>
<td>Alstom and Bombardier</td>
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<tr>
<td>Meca-Medina HSL</td>
<td>Alstom</td>
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Cost and duration reduction by performing Operational Tests on lab

<table>
<thead>
<tr>
<th>Scenario . Test campaign with 3 OBUs</th>
<th>Cost (k€)</th>
<th>Duration (months)</th>
<th>Duration after construction end</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.- Test campaign only on track</td>
<td>1,328</td>
<td>10,5</td>
<td>10,5</td>
</tr>
<tr>
<td>2.- Test campaign only at lab</td>
<td>180 (13%)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>3.- Test campaign first in the lab (debugging) and later on track</td>
<td>824 (62%)</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>
ERTMS PLACE IN SERVICE PROCEDURE

1. It is needed to harmonize the procedure of placing in service ERTMS, including the role of the neutral (proposal sent from CEDEX to the AESF Dic 2015)

2. ADIF has included a clause in the tender documents regulating the tests to be run by the RBCs in a neutral lab with at least 3 EVCs.

3. Renfe Operadora has also recently included a clause requesting the EVCs to run test in a neutral lab to assure route compatibility.

4. RIL proposal: Integration in the lab of all RBCs installed in Spanish lines, as well as all the EVCs to be run over the Spanish lines.
10. Current international activities at RIL
CURRENT INTERNATIONAL ACTIVITY AT RIL

1. Leader of European working group writing ETCS Test Specifications (SS-076).

2. ETCS tests for Haramain project (HSL in Saudi Arabia) (Alstom EVC/ Siemens RBC).

3. ETCS tests for ISR (Israel Railways).

4. Tendering for the creation of a similar ETCS lab for Network Rail ERTMS program.

5. Definition and execution of operational tests for Danish ERTMS program.


7. Participation in the Project VITE (Virtual Test of ERTMS), financed by the European Commission through the initiative Shift to Rail.

8. Participation in the Project ERSAT, Galileo satellite application for ERTMS, financed by the European Commission.

9. Testing ERTMS L2 in Senegal (Dakar commuter lines) in the near future.
ALIANCES AND NETWORKING

Deployment of European Freight corridors

Laboratories network: Consolidation

National Projects: Putting in service

European Commission
European Railway Agency
DLR
Multitel
RINA
CITEF
CEDEX
ADIF
RENFE

MINISTERIO DE AGRICULTURA ALIMENTACIÓN Y MEDIO AMBIENTE
GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

Tools development

European Rail Software Applications
11. Conclusions
CONCLUSIONS: USING THE LAB TO HELP ERTMS DEPLOYMENT

- Conforms with CCS TSI requirements (efficient assessment/certification)
  - CEDEX lab is accredited for certifying Eurobalises, Antennas-BTM (SS-85), Euroloop (SS-103) and EVCs (SS-076).
  - Operational lab test can be used as a powerful tool, not only for Placing in Service new lines but also for certifying the ETCS line (IOP successful tests of a certified OBU over a line, would be enough to certify the line).
  - CEDEX IOP tests are based on real data and are supported by a technical staff with the highest experience in ETCS lines testing and deployment

- Maximising Lab based testing (reduced time/cost)
  - CEDEX experience demonstrates that IOP tests at lab achieve a strong reduction of test onsite (from 10.5 to 3 months for 3 EVCs and around 8 times less cost), as well as avoid “last minute problems”.
  - CEDEX lab has been pioneer in executing IOP tests in Europe. Comparison between onsite tests and lab tests have been USED TO VALIDATE THE LAB.
  - A similar strategy can be used in Europe and mainly for the European corridors

- International presence
  - CEDEX is the WP leader of SS-76 ETCS Test Specifications
  - CEDEX-RIL is proposing this strategy to many foreign countries as England, Denmark, as well as offering his installations to test ERTMS projects in Saudi Arabia, India, China, Senegal etc....
Thank you very much for your kind attention

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