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# ATLAS: The road to Baseline3

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**Abstract**

European Rail Traffic Management System (ERTMS) development started several years ago, with some rail manufacturers, infrastructure managers and trains operators, and the European Union.

Alstom was present from the beginning in this process, being the first to put in service the ATLAS solution for ERTMS in a High Speed Line (HSL) in Italy, the first freight line in The Netherlands, and the first high-density line with short headway in Switzerland.

The first set of ERTMS specification, stable and complete, is based in subset 026 with version called "2.3.0 D", also known as Baseline 2. This Baseline 2 was used in most of the European projects today in commercial operation, and in Spain in all the Adif (Administrador de Infraestructuras Ferroviarias), and Renfe (Public train operator) projects.

About Spain, there are several Adif lines in operation (Madrid-Barcelona, Madrid-Valencia, Madrid-Valladolid, etc…), and also Albacete-Alicante, the first to enter in commercial operation with ERTMS level 2, without fall back of level 1, in May 2014.

Also Renfe has installed in some of their trains the ERTMS baseline 2, in High Speed, regional and commuter train types.

Alstom has installed its ATLAS solution in Renfe S-100, S-104, S-114 and different type of CIVIA trains for commuter lines. Asltom has demonstrated experience in the ERTMS onboard equipment, with more than 5450 trainsets of 115 different types running with ATLAS solution.

*Keywords: atlas, ERTMS, infraestructures,lines*

## 1. ATLAS: The road to Baseline3 - (artículo de 10 páginas – versión 170913a)

European Rail Traffic Management System (ERTMS) development started several years ago, with some rail manufacturers, infrastructure managers and trains operators, and the European Union.

From that time, several projects have been deployed across Europe, and there are several high speed, regional, and freight traffic lines in operation, and hundreds of trains running with ERTMS in commercial operation. Alstom was present from the beginning in this process.

Alstom was the first to put in service the ATLAS solution for ERTMS in a High Speed Line (HSL) in Italy. After Alstom did it again for the first freight line in The Netherlands, and the first high-density line with short headway in Switzerland:

| Date | Country | Line | Operational Speed | ERTMS Baseline | Line (km) |
|---|---|---|---|---|---|
| 2005 | Italy | Roma-Napoli | 300 km/h | 2.3.0D | 220 D |
| 2006 | Switzerland | Maastesten Rothrist | 200 km/h | 2.2.2+ | 40 D + 10 S |
| 2007 | The Netherlands | Betuwe Route (Freight only) | 120 km/h | 2.3.0D | 90 D |

(S: single line; D: Double line)

The first set of ERTMS specification, stable and complete, is based in subset 026 with version called “2.3.0 D”, and it is also known as Baseline 2. The complete list of documents and applicable versions can be found at:

http://www.era.europa.eu/Core-Activities/ERTMS/Pages/Set-of-specifications1.aspx

This Baseline 2 was used in most of the European projects today in commercial operation, and in Spain in all the Adif (Administrador de Infraestructuras Ferroviaras, Infraestructure manager), and Renfe (Public train operator) projects.

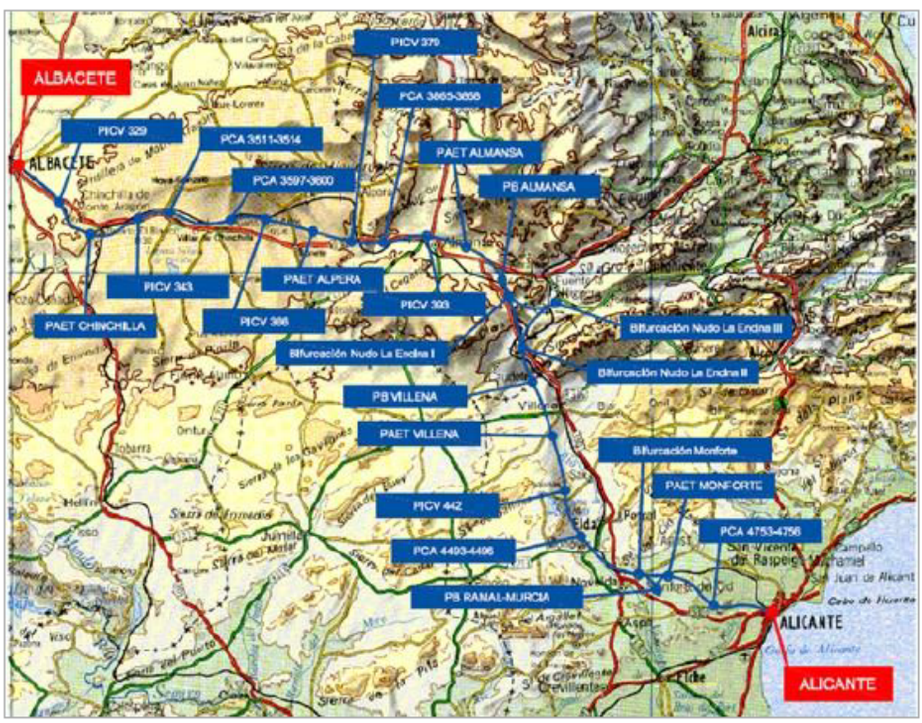
Here is the list of the most relevant European projects with ERTMS level 2, in commercial operation (in **bold** what is ATLAS solution from Alstom):

| Date | Country | Line | Operational Speed |
|---|---|---|---|
| **2005** | **Italy** | **Roma-Napoli** | **300 km/h** |
| 2006 | Italy | Torino-Milano | 300 km/h |
| 2008 | Italy | Milano-Bologna | 300 km/h |
| **2009** | **Italy** | **Bologna-Firenze** | **300 km/h** |
| **2007** | **Belgium** | **L3** | **260 km/h** |
| **2009** | **Belgium** | **L4** | **300 km/h** |
| 2011 | Spain | Madrid Lleida | 350 km/h |
| 2012 | Spain | Madrid Valencia | 350 km/h |
| **2014** | **Spain** | **Albacete Alicante** | **300 km/h** |
| 2009 | The Netherlands | HSL Zuid | 300 km/h |
| **2012** | **The Netherlands** | **Hanzelijn** | **200 km/h** |
| **2006** | **Switzerland** | **Maastesten Rothrist** | **200 km/h** |
| 2007 | Switzerland | Loetschberg tunnel | 250 km/h |

About Spain, there are several Adif lines in operation, some included in the table above, but I would like to highlight Albacete-Alicante, the first to enter in commercial operation with ERTMS level 2, without fall back of level 1.

**Línea de Alta Velocidad Albacete-Alicante**

Albacete – Alicante line belongs to Madrid – Levante HSL, and it is in commercial operation since May 2014. The most relevant characteristics of the line are:




- 160 km length with double track, from KP. 326,261 to KP 486,123 at Alicante terminal station.
- Maximum operational speed, tested with commercial trains is 300 km/h, even if the line is designed for 350km/h. With ASFA the maximum speed is only 200km/h.
- There are 22 technical buildings along the line to locate three main electronic interlockings Smartlock, in Bonete, La Oliva and Monforte del Cid, and two Radio Block Center (RBC), located at Bonete and Monforte del Cid.

Renfe installed in some of their trains the ERTMS baseline 2, in High Speed trains, but also in regional and commuter trains.

Renfe has also ERTMS installed in all the HS trains they have: S-102, S-103, S120, S-121, S-130 and S-730.

Alstom has installed its ATLAS solution in Renfe S-100, S-104, S-114 and different type of CIVIA trains for commuter lines.

**ERTMS on board of CIVIA Renfe trains**

Project includes the installation and commissioning of 123 trains to be used in Cercanías Madrid commuter lines. First train is in operation with ERTMS level 1 since Feb 2012.

*The trains to be equipped were: 8 CIVIA I (in commercial operation), 34 CIVIA II (in commercial operation), 40 CIVIA III (in commercial operation), and 11 CIVIA III and 30 CIVIA IV under manufacturing at the time of the project.*

*Central car with new rack installed, cabling between cars, cabin and driver desks were modified:*

*Today, all units are ready for ERTMS commercial operation.*

At the end, Alstom has demonstrated a big experience in the ERTMS onboard equipment, the integration in several train types, and the management of other national ATPs when required. In total there are more than 5450 trainsets of 115 different types running with an Alstom ERTMS onboard.

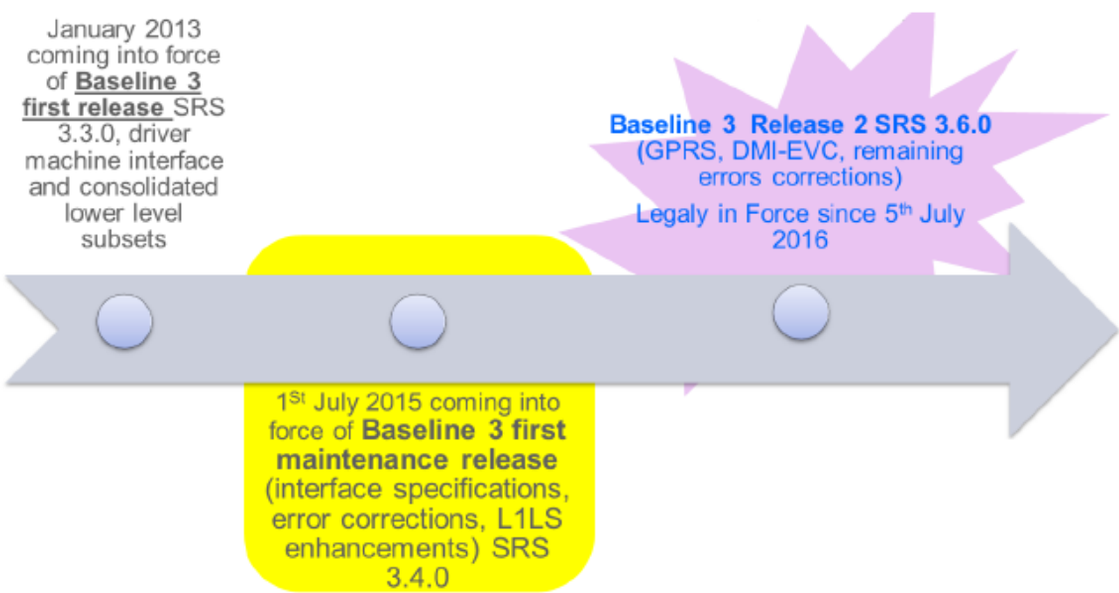
In the first implementations, Adif, Renfe and the Ministerio de Fomento created some functions (called National Functions) to cover Spanish specificities not included in the ERTMS standard. I mean, new functions not against the standard, but needed considering operational rules. This was a must because Spain was (and is) one of the European countries with more km of line and trains in commercial operation with ERTMS.

A short list of these National Functions is (first version of this specification was created in 2003):

- Función 20: Gestión separada de limitaciones temporales de velocidad según el nivel
- Función 24: Gestión del mensaje por defecto de eurobaliza

- Función 27: Gestión ERTMS del equipamiento ASFA independiente
- Función 77: Transición degradada desde nivel 2 a nivel 1 por pérdida de comunicación.
- Función 121: Inhibición de niveles disponibles (via external switch)
- Función 124: Gestión de la reacción de enlace
- Función 125: Operación en áreas ERTMS fuera de servicio

From those first implementations, the ERTMS specification has evolved to improve defects or misunderstandings found, and to implement new functionalities requested by Infrastructure Managers and Train Operators. The release 2.3.0 D evolved to version 3.0.0, 3.1.0, 3.2.0 and 3.3.0, and after:




The Baseline 3 compared with version 2.3.0 D includes:

- 22 new functions and 32 Errors Change Requests (CRs) in SRS 3.0.0 (due to finalisation of Subset 108)
- 46 Errors CRs with SRS 3.1.0
- 73 CRs with SRS 3.2.0
- 30 CRs added and 2 removed with SRS 3.3.0

The major evolutions are the system version management, harmonised braking curves, the Limited Supervision, and the Level crossings management.

But other functions have been also included like:

- Speed restriction to ensure a given permitted braking distance
- Inhibition of revocable TSRs from balises in Level 2 or 3
- Redefinition of international train categories

- Shunting in level NTC areas
- Supervision of the safe radio connection
- Non-Leading input signal
- Cold movement detection
- Door control supervision
- Inhibition of the BG message consistency reaction
- Passive Shunting mode
- Lines under construction (Virtual Balise Cover)
- Changing Train Data from sources different from the driver
- Etc…

From release 3.3.0, the specifications evolved to 3.4.0 in 2015, also called **Baseline 3 Maintenance Release 1** (MR1). This MR1 includes:

- 28 CRs, with 21 error corrections and 7 enhancements
- 25 subsets of specifications affected
- Key changes on: L1 Limited Supervision (CR 1223) with toggle function to Select Swiss / Other countries; Increased SIL requirements on some DMI features

The changes implemented consider the following CRs:

| Id number | Headline |
|---|---|
| 0944 | Data unit/resolution/size |
| 1088 | Subset-039 upgrade to Baseline 3 |
| 1104 | Subset-094 upgrade to baseline 3 |
| 1109 | error non-stopping areas (Follow-up CR 1015) |
| 1124 | Findings on SRS section 3.13 “Speed and distance monitoring” |
| 1127 | Non convergence of the release speed calculated on-board |
| 1147 | DMI text message handling |
| 1148 | Trigger of specific NTC data entry |
| 1149 | Alignment of PBD SR requirements with the new braking curve model |
| 1150 | Incomplete V_MRSP definition vs train position |
| 1151 | Error in Subset-037 Table 11 |
| 1153 | Train interface passive shunting input simplification |
| 1154 | Train interface - clarification of isolation output |
| 1155 | CR712 follow-up: packets sent as non-infill information from infill device |
| 1157 | SUBSET-076 upgrade to Baseline 3 |
| 1158 | SUBSET-074 upgrade to Baseline 3 |
| 1159 | Missing train-to-track message specification for RBC X=1 |
| 1168 | Unspecified ACC RBC behavior when receiving new pre-announcement messages in ongoing transaction |
| 1173 | Miscellaneous problems with STM specifications |

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|---|---|
| 1176 | Feedback on SRS chapter 6 from Baselines compatibility assessment |
| 1183 | Unclear use of telegram header info when a balise telegram or BG message is ignored/rejected |
| 1185 | Miscellaneous editorial findings in SRS&DMI spec 3.3.0 |
| 1223 | Display in Limited Supervision |
| 1231 | Miscellaneous editorial findings in SUBSET-027 v3.0.0 |

A year after, in 2016, the specifications evolved to 3.6.0, also called **Baseline 3 Release 2** (R2). This R2 includes:

- 55 CRs, with 39 error corrections and 16 enhancements
- 25 subsets of specifications affected
- Key changes on: GPRS; Key management; ATO (finally postponed…), and Low adhesion factor.

The changes implemented consider the following CRs:

| ID number | Headline |
|---|---|
| 0239 | Train data on TIU |
| 0299 | Version compatibility check |
| 0539 | Set speed indication for driver |
| 0740 | Unclear requirements concerning functions active in L2/L3 only |
| 0741 | Packet data transmission for ETCS |
| 0852 | Definition of level 2/3 area and level transition border |
| 0933 | Storing of RBC contact information |
| 1014 | Duplicated balises ambiguities |
| 1033 | Disable Start in SR if no safe connection |
| 1084 | Target speed masking |
| 1086 | Unknown L1 LRBG reported to RBC |
| 1087 | Manual network selection |
| 1089 | Ack for text messages in NL mode |
| 1091 | Insufficient driver information in OS |
| 1094 | Unclear stop conditions for display of some DMI objects |
| 1107 | Status planning information on the DMI in FS mode |
| 1117 | Reception of an order to terminate a communication session while session is being established |
| 1122 | Communication session establishment to report change to SL mode |
| 1125 | Clarification of human role in ETCS safety analysis |
| 1129 | DMI indication of level announcement in SB |
| 1152 | Avoid increase of permitted speed and target distance |
| 1163 | Train interface – Track conditions related outputs to be harmonized |
| 1164 | Ambiguity in assignment of coordinate system |
| 1167 | Juridical data for the equivalent brake build-up time |
| 1169 | Ambiguity about the variable L_STMPACKET in juridical data STM INFORMATION |

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|---|---|
| 1172 | Problems related to level crossing supervision |
| 1180 | Guard rails and cables in the vicinity of balises |
| 1184 | Missing requirement for the number of communication sessions an OBU must be capable to handle simultaneously |
| 1187 | Indication marker inconsistency |
| 1188 | Balises in Multi-Rail Track |
| 1190 | UES text message end condition |
| 1197 | Ambiguity regarding the temporary EOAs and SvLs |
| 1213 | SUBSET-091 upgrade to Baseline 3 Release 2 (B3R2) |
| 1221 | Availability of Override and Start buttons |
| 1222 | Inconsistency regarding list of BGs for SH area |
| 1229 | Age requirement for estimated speed |
| 1236 | Criteria for Levels in train unclear |
| 1237 | KMS evolution |
| 1242 | Several problems with STM specifications |
| 1245 | Display of ETCS override in level NTC |
| 1249 | Problems with pre-indication |
| 1250 | Incorrect description in gradient profile |
| 1254 | Session establishment attempts to report mode change |
| 1255 | Impossibility to transmit unknown values in the message “Additional data” |
| 1260 | Inconsistent set of clauses regarding the service brake interface in SH mode |
| 1262 | Issues related to the initiation of a communication session by an RBC |
| 1265 | Miscellaneous editorial findings in B3 MR1 |
| 1266 | Classification of SRS clauses |
| 1273 | Impact of UIC 544-1 new version |
| 1275 | Eurobalise transmission susceptibility requirements not linked to interoperability |
| 1277 | D7 of SoM procedure is reached while no Mobile Terminal is registered yet |
| 1278 | SUBSET-074 upgrade to Baseline 3 Release 2 (B3R2) |
| 1280 | System version number increment for B3R2 |
| 1283 | Inconsistent use of the terms EOA and LOA |
| 1284 | SUBSET-092 upgrade to Baseline 3 Release 2 (B3R2) |

The complete list of documents and versions can be found at

http://www.era.europa.eu/Core-Activities/ERTMS/Pages/Set-of-specifications3.aspx

Going back to Spanish National functions, some of them have been include in the standard, or can be managed through standard functions and interfaces:

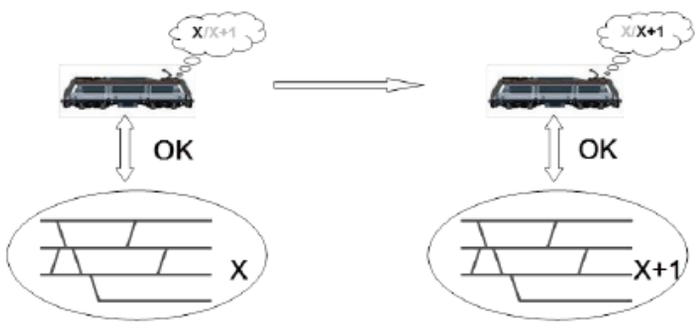
- Función 20: Gestión separada de limitaciones temporales de velocidad según el nivel
- Función 24: Gestión del mensaje por defecto de eurobaliza
- Función 125: Operación en áreas ERTMS fuera de servicio

This three are already included in the Baseline 3 specifications.

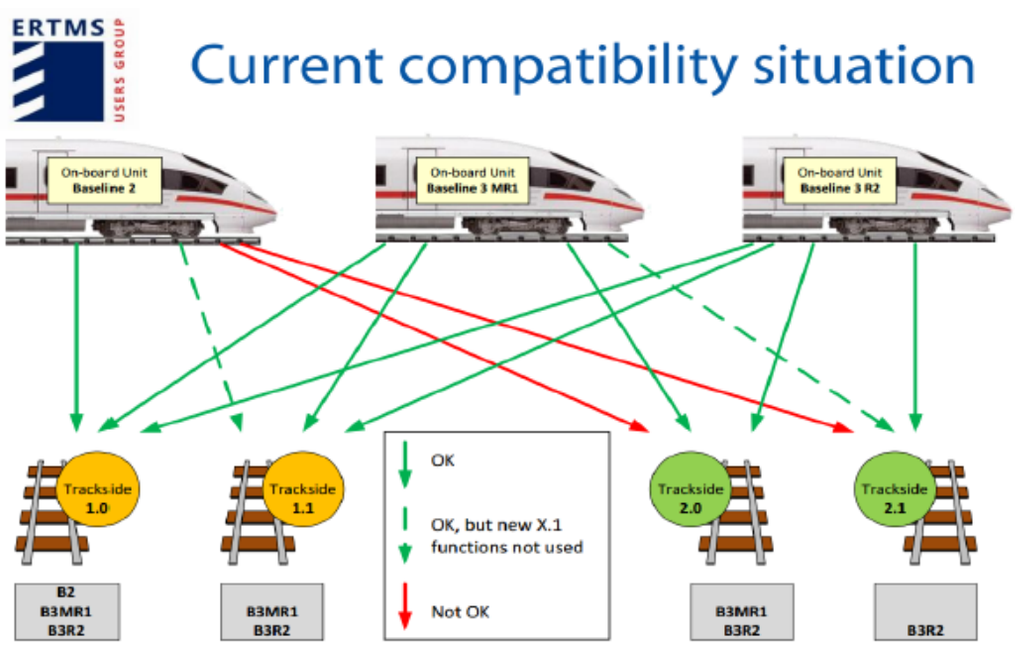
- Función 27: Gestión ERTMS del equipamiento ASFA independiente
- Función 121: Inhibición de niveles disponibles (via external switch)

This two can me managed with Train interface functions integrated in the ERTMS onboard equipment.

And with new Baseline 3 legaly in force, what happen with existing trains /lines in Baseline 2?




The Baseline 3 specifications includes the System version management, to ensure all Baseline 3 trains can operate on lines with at least 2 different versions:



The full picture about compatibility is:

As a summary, Baseline 3:

- offers backward compatibility for baseline 3 trains on baseline 2 infrastructure.
- offers the possibility to upgrade a baseline 2 trackside while keeping most of the existing balises untouched.
- offers the possibility for additional trackside functionalities without losing compatibility with baseline 2 on boards (additional baseline 3 information will be ignored by a baseline 2 train but taken into account by a baseline 3 train)

A detailed document has been released by the European Railway Agency (ERA) together with the Infrastructure Managers and Trains Operators, to identify all the potential interoperability problems between Baseline 2 and 3 subsystems, called Baseline Compatibility Assessment.

The document about Baseline 3 MR1 compatibility can be found in:

http://www.era.europa.eu/Document-Register/Pages/Baseline-Compatibility-Assessment-B3-MR1.aspx

The conclusion, for the evolution from version 2.3.0 D to Baseline 3 MR1, is “vast majority of the 436 analysed Change Requests, the analysis demonstrated that the compatibility objectives for Baseline 3 […]have been achieved and no potential compatibility problems were identified”.

Besides, “some other potential compatibility issues were identified, due to shortcomings or ‘grey areas’ in Baseline 2, for which mitigation measures could be needed to ensure interoperability.”

**(extracts from Baseline Compatibility Assessment - Final Report, Reference EUG_UNISIG_BCA, version 1.0.0)*

This document about Baseline 3 R2 compatibility can be found in:

http://www.era.europa.eu/Document-Register/Pages/Baseline-Compatibility-Assessment-for-B3-R2.aspx

The conclusion is for 50 out of the 55 CRs added in MR2, the compatibility between the baselines has been achieved and no potential compatibility problems were identified. For other 5 CRs (CR 933, 1089, 1184, 1249 and 1262) have been identified mitigation measures.

All these analysis have been performed to facilitate migrations to Baseline 3, and coexistence of both Baselines from a legal but also real point of view.

And together with specifications evolution, the products also evolve.

New generation of ERTMS onboard equipments have:

- reduced HW, with less components and less power consumption
- more functions integrated in the European Vital Computer
- more processing capacities
- and open to other standards /equipments used in other sectors.

New EVC included in the Alstom ATLAS solution, includes:

- 19”, 6U rack with all functions integrated (Radio and Balise Transmission Modules integrated, Juridical Recording function, Diagnostic, …)
- Additional communication modules to integrate EVC in central diagnostic systems.
- Capability to use other communication than GSM-R and Profibus.
- ATO and Eco driving
- Etc…