MODURBAN

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MODONBOARD SUBPROJECT

– DELIVERABLE REPORT –

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v1C	2005-10-12	Elaboration of sections 2.1 and 2.3.	Alstom
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V4.1	2009-03-26	Glossary updated	Bombardier

SECTION I – DELIVERABLE SUMMARY

Transit version of the EUROBALISE specifications

Deliverable ID , associated WP & Subproject	*D14 MODONBOARD / WP3*
Type of Deliverable	*Reference document*
Input / Starting stage	
Output / Final stage	

Lead partner(s)	Bombardier
Achievement to date (%)	*100 %*
Expected date of achievement	*Month 12*
Type of exploitation	*Basic input for other MODURBAN WPs*
Exploitation potential	
Protection	*Not relevant*
Protection date	*Not relevant*

IP's	***Partners, (type, identification, date)***
Pre-existing Know-How	
Exploitation Rights	

Associated Risk analysis	***Type, solution envisaged, action, actors***	***Actual Reduction***
Before start		
During task implementation		

Transit version of the EUROBALISE specifications

Deliverable Abstract

The goal of the work package 3 is to analyse the possibility to reuse some ERTMS modules, and, if necessary, to propose some adaptations in order to fit with the mass transit constraints. This document aims to analyse the possibility to re-use the ERTMS Eurobalise system in the mass transit environment.

The underlying principle is to take profit of the experience of ERTMS that has permitted to define a standard for punctual transmissions. The gain for operators will be the use of a single type of punctual transmission through the reuse of service proven components.

Associated Milestone (if relevant):

Related to milestones M9 and M10.

Contribution to MODURBAN Objectives as mentioned in the Description of Work		
Objective Definition	***Comments***	***Quantification***
Objective 1 - Analyse the possibility to reuse some ERTMS modules		
Objective 2 –		
Objective 3 …		
Objective 4 …		

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SECTION 2 – DELIVERABLE DETAILED DESCRIPTION

1 INTRODUCTION

1.1 Objectives

The goal of the work package 3 is to analyse the possibility to reuse some ERTMS modules, and, if necessary, to propose some adaptations in order to fit with the mass transit constraints. This document aims to analyse the possibility to re-use the ERTMS Eurobalise system in the mass transit environment.

The underlying principle is to take profit of the experience of ERTMS that has permitted to define a standard for punctual transmissions. The gain for operators will be the use of a single type of punctual transmission through the reuse of service proven components.

Included is the re-usability analysis of the Eurobalise spot transmission:

- To assess the accuracy of the re-localisation.
- To analyse the initialisation.
- Review suitable On-board interfacing of the spot transmission sub-system.

Following recent comments and meetings, the re-usability analysis of Eurobalise spot transmission with respect to a so far undefined wheel calibration function shall also be addressed. This will be done in a next version of this document taking into account applicable additional performance requirements (if any) once defined by MODSYSTEM.

The following principles apply:

- Take profit from the experience of the Eurobalise system used within ERTMS in order to extend the use of this standardised transponder to mass transit.
- The gain for operators will be the usage of a proven and standardised type of punctual transmission, better reliability, and long technical lifetime expected from an open standard and large mainline applications.

1.2 References

Ref. No	Document no	Title
1	UNISIG SUBSET-036, issue 2.3.0	FFFIS for Eurobalise
2	MODURBAN WP1 – D1, v2B, November 8, 2005 [1]	ATP Onboard Specification and Interfaces with MODWAYSIDE

[1] D1 was not released when used as input to D14, so D14 might need revising to take into account any relevant changes made to D1 after v2B.

1.3 Abbreviations

Abbreviation	Explanation
ATO	Automatic Train Operation
ATP	Automatic Train Protection
BTM	Balise Transmission Module (ERTMS function)
CC	Carborne Controller
ERTMS	European Railway Traffic Management System
FFFIS	Form Fit Function Interface Specification
GOA1a	Non-automated train operation, with intermittent supervision by the system
GOA1b	Non-automated train operation with continuous supervision
GOA4	Unattended train operation
MU_BTM	MODURBAN BTM Function
SPTS	Spot Transmission Sub-system
SRS	System Requirements Specification

1.4 Definitions

Term	Explanation
Grade of Automation	Automation level of train operation, in which Urban Guided Transport can be operated, resulting from sharing responsibility for given basic functions of transport management between operations staff and system.
Eurobalise Technology	The air gap definition and the functionality as defined by FFFIS for Eurobalise (Ref. [1]).
MODURBAN BTM Function	The ERTMS On-board BTM functionality as specified in FFFIS for Eurobalise (Ref. [1]), possibly adapted in order to comply with some more demanding MODURBAN requirements as specified herein.
NID_C	ERTMS variable including the code used to identify the country or region in which the Balise Group, the RBC, or the RIU is situated. This needs not necessarily follow administrative or political boundaries.
NID_BG	ERTMS variable including the identity number of a Balise Group or loop within the country or region defined by NID_C.

1.5 Overall Architecture

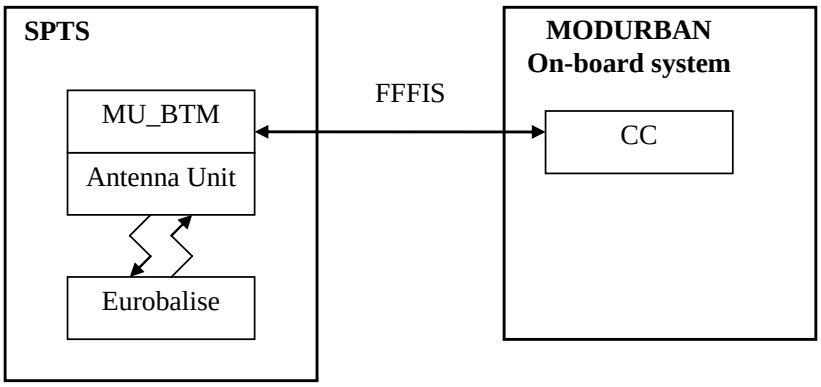

Figure 1 : MODURBAN SPTS Architecture

2 REQUIREMENTS APPLICABLE TO MODURBAN

2.1 General Requirements

2.1.1 General

Requirements applicable to the MODURBAN Eurobalise are provided through the D1 document "ATP Onboard Specification and Interfaces with MODWAYSIDE" elaborated by the WP1 group (see Ref. [2]).

The following requirements apply to the MODURBAN Eurobalise system.

2.1.2 Localisation Process

The CC initializes the position of the train by correctly reading two consecutive transponders (refer to section 3.2.8 of Ref. [2]).

For the stationary initialisation function, there is no requirement on the use of the Eurobalise system (refer to section 3.2.2 of Ref. [2]).

Reference in Ref. [2] to possible use of transponders in stationary initialisation shall not apply to Eurobalise. This was agreed at MODONBOARD sub-project meeting of September 7, 2005, (topic 3) in recognition that Eurobalise is not designed to be read at a distance.

2.1.3 Re-localisation Process

When passing over a transponder, the train shall be able to acquire the Balise identification number (variables NID_C and NID_BG). Because this identification number is unique in the static guide way database, the ATP is able to precisely determine its coordinates along the line (refer to section 3.2.1 of Ref. [2]).

2.1.4 Train Orientation Determination

Based on the train travel direction and the order of reading two successive transponders the CC is able to determine the train orientation. Therefore, as it is a CC functionality, there is no specific requirement applicable to the Eurobalise (refer to section 3.2.6 of Ref. [2]).

2.1.5 Precision Stop Accuracy

The use of the Eurobalise transmission system shall facilitate an overall system localisation accurate enough for an ATO to fulfil the system requirement on stopping accuracy in stations. The current working hypothesis is that this accuracy should be better than ±30 cm (see section 2.2 for further details).

2.1.6 Others

For levels of automation GOA1b to GOA4, the spot transmission system is only intended to provide the unique Balise identification number (variables NID_C and NID_BG) and all the data required for localisation purposes (e.g., time stamp of Balise passage).

As the MODURBAN project addresses also GOA1a level of automation, the Eurobalise spot transmission system shall also provide more information as defined in Ref. [1].

2.2 Proposed Apportionment of Accuracy for Eurobalise Localisation

2.2.1 General

In general, there are three different aspects that should be addressed for the purpose of localisation accuracy in MODURBAN applications. These are:

- General availability related accuracy for transponders used for re-localisation in open lines
- Availability related accuracy for transponders used for precise stopping in stations
- Vital localisation accuracy

These aspects are further explored in the succeeding sections.

This section (2.2) solely focuses on the pure transmission system and refers to localisation accuracy with respect to the reference mark of the Balise (i.e., excludes the inaccuracy related to the physical installation of the Balise, time/odometer inaccuracy, inaccuracy from On-board processing algorithms, etc.).

2.2.2 Re-localisation in Open Lines

When the train is travelling in all normal areas where there is no requirement on approaching a precision stop, the standardised Eurobalise accuracy for ERTMS is suggested being sufficient for MODURBAN applications.

For the purpose of the pure transmission system, the standardised accuracy shown in Figure 2 below applies (see Ref. [1], UNISIG SUBSET-036).

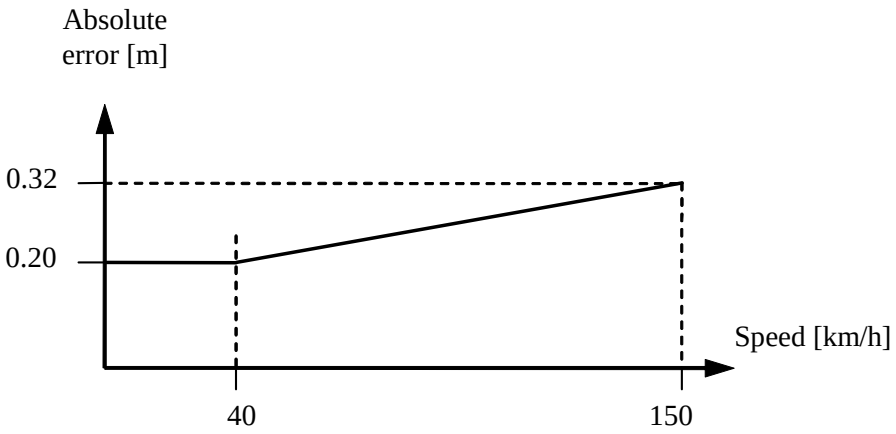

Figure 2 : Standardised Eurobalise Localisation Accuracy (non-vital)

The standardised confidence in reaching the accuracy after the Balise passage is 99.8 %.

2.2.3 Precise Stopping in Stations

In general, the characteristics defined in section 2.2.2 are provided by the standardised Eurobalise transmission system without further considerations.

If the standardised Eurobalise localisation accuracy is deemed not being sufficient when the train is approaching a precision stop, the standard Eurobalise technology may provide better accuracy under the following assumptions:

- The speed is low (less than approximately 10 km/h).
- Permitting Balises to operate during almost nominal environmental conditions regarding debris conditions and cases.
- Metallic objects that constitute unsymmetrical conditions for the Balise should be avoided.
- Additional constraints on allowed pitching of the Balise should be introduced
- The vertical installation range of the Balise should be reduced.
- The existing Eurobalise On-board design may, if required, be suitably adapted (but still fulfilling SUBSET-036 and the specifics of this document) for the purpose of MODURBAN.

Based on experience from various Eurobalise test campaigns and projects, it is judged realistic that a localisation accuracy of better than ±5 cm after the completed Balise passage should be feasible for the purpose of the pure transmission system.

Due to the different implementation of the on-board equipment by different manufacturers, it is not guaranteed that all currently existing On-board designs fulfil the more demanding targets requested by MODURBAN.

2.2.4 Vital Localisation Accuracy

For the purpose of the pure transmission system, the standardised vital accuracy is better than ±1 m after the passage of the Balise (see Ref. [1], UNISIG SUBSET-036).

2.2.5 Parameters Impacting the Eurobalise Localisation Accuracy

It has been identified that the following parameters impact the localisation accuracy of the pure Eurobalise transmission system:

- The train speed.
- The vertical installation range for the Balise.
- The allowed pitching of the Balise.
- Debris conditions (in case these constitute unsymmetrical conditions).
- Presence of metallic objects in the infrastructure in case these constitute unsymmetrical conditions.

2.3 Initialisation

2.3.1 General

In general, there are two different aspects that should be addressed for the purpose of localisation initialisation in MODURBAN applications:

- Initialisation when the train is stationary.
- Initialisation and re-initialisation when the train is moving.

2.3.2 Stationary Initialisation

The MODURBAN requirement is the capability to initialise the train localisation when stationary after the awakening process launched by the ATS or the operator.

The MODURBAN Eurobalise spot transmission system is not required to support initialisation when the train is stationary.

2.3.3 Moving Train Initialisation

The Eurobalise spot transmission system can be used to (re-) initialise a moving train. When passing over two consecutive transponders, the MODURBAN ATP shall dynamically initialise the position of the train:

- Initialise the relative position after reading the first transponder.
- Calibrate the On-board odometer by comparing the measured distance between the two consecutively read transponders with the distance provided by the On-board static database.

Constraints to (re-) initialise the train localisation are identical as those from the re-localisation (refer to section 2.2.2).

3 EXAMINATION OF PREVIOUS EXPERIENCE OF EUROBALISE

The test results from the Eurobalise EMSET tests, and from the EEIG Eurobalise test campaign at CEDEX, were examined by at least one manufacturer. The focus was to judge the actual localisation accuracy for the Eurobalise technology during the specific conditions that are applicable to precision stop areas.

The opinion of at least one partner is that the Eurobalise technology allows better accuracy, in the range of ±5 cm, but that adaptations to existing On-board designs for reading the Eurobalise could be necessary due to the fact that some more demanding On-board performance is required compared to the existing Eurobalise reader specifications.

Another partner expressed that it is feasible to achieve an accuracy of ±10 cm with the less demanding conditions of MODURBAN in existing designs, considering the less demanding MODURBAN conditions and also the more demanding MODURBAN availability requirements.

The remaining two MODURBAN involved Eurobalise partners confirmed that the Eurobalise technology does support the overall system target on stopping accuracy in precision stop areas.

At least one manufacturer has already got experience that the Eurobalise technology is suitable for driverless mass transit applications with partly adapted On-board design (MU_BTM). Other partners have the same experience using Balise systems similar to Eurobalise.

4 ASSESSMENT OF EXISTING ERTMS SPECIFICATIONS

4.1 General

In general, the existing ERTMS Eurobalise specification (see Ref. [1], UNISIG SUBSET-036) should be applicable also to mass transit applications. However, there is a need for a few additions/modifications/clarifications further detailed in this chapter.

4.2 Localisation Accuracy

There is a need for an additional specification of the mounting of the Eurobalise for enhanced localisation accuracy in precision stop areas.

4.3 Balise Mounting

It was identified that the MODURBAN infrastructure in general requires the Eurobalises to be mounted higher up in the track in order not to come in conflict with nearby metallic objects (re-enforcement in concrete tracks).
To achieve this it will be necessary to limit the vertical installation range compared to the Eurobalise specification in precision stop areas in order to obtain better localisation accuracy, using only the upper part.

It was also identified that tighter tolerances on allowed pitching of the Balise should be necessary in precision stop areas.

4.4 Delay in Reporting

From a system perspective, it should be considered if the standardised reporting mechanisms in Eurobalise imply any constraints. According to UNISIG SUBSET-036 (see Ref. [1] §4.2.9), the time delay between the end of transmission of a Balise (that is 1.3 m after the passage of the Balise Reference Mark) and the availability of data to be forwarded to the CC shall be less than 100 ms.

There is also a possibility to optionally get repetitive preliminary reports each 50 ms to 600 ms during very low speed Balise passages, but this mechanism is not mandatory, and the reports can not be used for precise localisation of the train.

4.5 Time/Odometer Information

It should be clarified that it is allowed that time/odometer information is not coming from the CC (ERTMS “Kernel”) but from somewhere else in the On-board system. The exact wording in SUBSET-036 might be misleading, but the ERTMS SRS leaves implementation flexibility in this respect.

5 RELEVANT ADAPTATIONS IN ORDER TO FIT WITH THE MASS TRANSIT CONSTRAINTS

The following MODURBAN adaptations should apply with respect to the currently available Eurobalise specification (Ref. [1], UNISIG SUBSET-036) for using and mounting of the Eurobalise:

- There is a need for an additional application specification titled “Accuracy in precision stop areas”. The contents should read:
  ”The localisation in precision stop areas shall be better than ±5 cm after the completed Balise passage. The speed shall not exceed approximately 10 km/h when passing the last Balise in order to reach the specified accuracy. Unsymmetrical debris conditions are not allowed, and the debris condition “Iron Ore” is not applicable. Debris Class A is out of scope for the purpose of this requirement. Unsymmetrical metallic objects in the infrastructure are not allowed (e.g., metallic plates in accordance with the specification that are only partially in the vicinity of the Balise.”

- There is a need for an additional mounting specification titled “Installation in precision stop areas”. The contents should read:
  The highest position of any Balise shall be 93 mm below the top of rail.
  The lowest position of a Standard Size Balise shall be 103 mm below the top of rail.
  The lowest position of a Reduced Size Balise shall be 103 mm below the top of rail.
  The maximum allowed pitching of the Standard Size Balise shall be ±2 °.
  The maximum allowed pitching of the Reduced Size Balise shall be ±2 °.
  The position of the Balise refers to the Reference Mark of the Balise.

6 CONCLUSIONS

It can be concluded that the Eurobalise technology as specified in UNISIG SUBSET-036 (Ref. [1]) is well suited also for MODURBAN application provided that the few adaptations to its use and mounting detailed in this document are implemented.

Since the specification adaptations to some extent imply more demanding requirements than in ERTMS, it can not be guaranteed that all currently existing On-board implementations comply with the new requirements without suitable adaptations, depending on different implementations. However, there is no technological limitation.

There is already experience that the Eurobalise technology is suitable for driverless mass transit applications with partly adapted On-board design (MU_BTM).