



ECUC

Eddy Current Brake Compatibility

Second Interim Report

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Coordinator: CEIT

Index

1. PUBLISHABLE SUMMARY	5
2. CORE OF THE REPORT FOR THE PERIOD	11
2.1 Overview of general project objectives	11
2.2 Objectives for the reporting period	11
2.3 Budget follow up table	13
3. WORK PROGRESS AND ACHIEVEMENTS DURING THE PERIOD	20
3.1 WP2: Identification of the Performance Requirements, Design Parameters, and their Relationships	20
3.2 WP3: Eddy Current Brake Compatibility Model design and Implementation	22
WP4: Definition of Representative Worst Case Conditions	29
3.3 WP5: Test Site, Test procedure and Test Setup Design and Implementation	35
3.4 WP6: Technical Recommendations and Design, Engineering and Operational Guidelines	40
3.5 WP7: Exploitation and Dissemination	53
4. PROJECT MANAGEMENT	57
4.1 Introduction	57
4.2 Consortium management tasks and achievements	58
4.2.1. Problems which have occurred and how they were solved or envisaged solutions	60
4.2.2. Changes in the consortium	60
4.2.3. Changes to the legal status of any of the beneficiaries	61
4.3 Project planning and status	61
4.3.1. Impact of possible deviations from the planned milestones and deliverables	61
4.4 List of project meetings	65
4.4.1. Consortium Meetings	65
4.5 Use of foreground and dissemination activities during this period	66
4.5.1. Development of the project website and rss	66
4.5.2. Media	66
4.5.3. Participation in conferences	67
4.5.4. Publications	67
4.5.5. Newsletters and Flyer	67
4.5.6. Analysis of the web site impact	67
4.5.7. General Dissemination Roadmap	69
4.6 Deliverables and milestones tables	70
4.6.1. Deliverables (excluding the periodic and final reports)	70
4.6.2. Milestones	73

LIST OF ANNEXES

- Annex A.1:** [4th Steering Committee Meeting](#)
Annex A.2: [4th Scientific Committee Meeting](#)
Annex A.3: [1st Advisory Board Meeting](#)
Annex A.4: [5th Steering Committee Meeting](#)
Annex A.5: [5th Scientific Committee Meeting](#)
Annex A.6: [6th Scientific Committee Meeting](#)
Annex A.7: [2nd Advisory Board Meeting](#)
Annex A8: [6th Steering Committee Meeting](#)
Annex A.9: [Summary of the Dissemination Activities](#)

LIST OF CHANGES

Version	Date	Contributors	Section Affected
1	26/10/2015	ALL	ALL
2	27/10/2015	CEIT	ALL
3	28/10/2015	CEIT	4.2.1

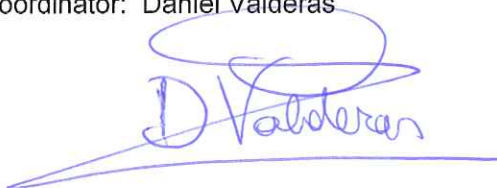
Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) ¹:
 - has fully achieved its objectives and technical goals for the period;
 - has achieved most of its objectives and technical goals for the period with relatively minor deviations.
 - has failed to achieve critical objectives and/or is not at all on schedule.
- The public website, if applicable
 - is up to date
 - is not up to date
- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Daniel Valderas

Date: 30/ 10/ 2015



For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism.

¹ If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

1. PUBLISHABLE SUMMARY

List of Beneficiaries

No	Name	Short name	Country	Project entry month	Project exit month
1	CENTRO DE ESTUDIOS E INVESTIGACIONES TECNICAS	CEIT	Spain	1	36
2	KNORR-BREMSE SYSTEME FUR SCHIENENFAHRZEUGE GMBH*KB	KB	Germany	1	36
3	ALSTOM TRANSPORT S.A	ALSTOM	France	1	36
4	SOCIETE NATIONALE DES CHEMINS DE FER FRANÇAIS	SNCF	France	1	36
5	DEUTSCHE BAHN AG	DB	Germany	1	36
6	NETWORK RAIL INFRASTRUCTURE LTD	NRIL	United Kingdom	1	36
7	FRAUSCHER SENSORTECHNIK GMBH	FRAUSCHER	Austria	1	36
8	UNION DES INDUSTRIES FERROVIAIRES EUROPEENNES - UNIFE	UNIFE	Belgium	1	36

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Summary description of project objectives

The project Eddy Current Brake Compatibility (ECUC) aims to prove that linear Eddy Current Brake (ECB) is a highly effective and applicable solution for increasing the braking capacity of new high-speed trains. While shortening the stopping distance, no wearing, no smell and no fine-dust are produced by ECB. Moreover, as it is independent of adhesion between wheel and rail, it leads to an improved safety. Its ability to perform most service brake applications without using the friction brake results in a reduction of maintenance costs. In addition, if the excitation power supply is independent of the catenary supply, ECB is a reliable safety device which can be used for emergency brake applications. Nevertheless, some issues have been detected. On one hand, some signalling systems such as axle counters are disturbed by ECBs. On the other hand, the derived elevated rail head temperatures can lead to the buckling of the rail. In this manner, ECUC has proposed recommendations to overcome these drawbacks and pave the way for future developments.

The following objectives have been achieved in ECUC project:

- Improvement of the understanding of the interaction between the eddy-current brake and the track and trackside signalling equipment.
- Design of a test setup and test site that contribute to the approval tests for ECBs.
- Definition of a test procedure according to representative worst-case conditions.
- Development of new design, engineering and operational guidelines for eddy-current brakes and trackside signalling equipment.
- Improvement of the standardisation process of ECB.

The study has been performed in two domains: electromagnetic and thermo-mechanical. In its last stages ECUC has defined project technical recommendations for the correct interoperable functioning of the ECB in a complex railway system and input for revisions to Technical Specifications for Interoperability.

In order to ensure that the research and innovation objectives of ECUC project are achieved, the work program has been divided in five technical work packages and two work packages dedicated to management and dissemination. The results of WP2 contains the definition of the design parameters and requirements of ECB based on the analysis of all the actors involved in this project (ECB, rolling stock, track, trackside equipment). WP3 sets computer models for the interaction between ECB and the track and trackside equipment and describes a new generation ECB. WP4 defines the conditions that maximize the emitted interferences created by the ECB system. WP5 defines the test site, test procedure and test setup for the measurement of the ECB emissions and thermo-mechanical behaviour and carries out extensive testruns on track and laboratory measurements. They also served as validation purposes for the computer models set to predict worst case interoperability impact. WP6 defines the design, engineering and operational guidelines of the operational ECB, its installation, the tracks and the signalling systems. Furthermore, it provides an input Project Technical Recommendations for the ECB and the infrastructure that is set in WP7.

Work performed and main results achieved

The first period of the project has been dedicated to the following activities in each WP.

WP1: MANAGEMENT

CEIT, as project coordinator, has the main responsibilities in such matters of the first work package: administrative, financial, legal and IPR activities. Therefore, only CEIT has Person-Months dedicated to the Management activities.

WP2: IDENTIFICATION OF THE PERFORMANCE REQUIREMENTS, DESIGN PARAMETERS, AND THEIR RELATIONSHIPS

No efforts have been dedicated to this WP in the second period of the project.

WP3: EDDY CURRENT BRAKE COMPATIBILITY MODEL DESIGN AND IMPLEMENTATION

In this work package finite element models were developed to simulate the interactions between ECBs, sensing systems and the track infrastructure.

The implementation of the model of the interaction between ECB and the infrastructure is divided in two main parts: an electromagnetic model and a thermo-mechanical model.

Based on the results of WP2, the electromagnetic model focuses on the interaction between ECB and axle counters where different effects are being analysed. Not only the EM field radiated by the ECB is a problem, but also the passive effect of the metallic mass that represents the brake. Moreover, EM fields are divided depending on the radiated signal frequency and low frequency and high frequency interferences have been studied. In this work package two Frauscher wheel sensors

were simulated and verified in the laboratory. Furthermore, the electrical characteristics of the eddy current brakes were measured and used to test and verify the electromagnetic 3D model of the principle parts of an ECB. Additionally, the ground paths and parasitic effects of the mounted ECB in the bogie were measured in WP5 and incorporated into the electronic schematic. These individual models were then combined to generate a holistic model which was then used to investigate the different interactions between ECB and wheel sensor.

The thermo-mechanical model focuses on studying the temperature increase in the tracks due to the use of the ECB and the influence that it could have on the infrastructure, mainly concerning lateral buckling of tracks.

The model has proved to be a powerful tool to predict temperature increases in rails due to the use of ECBs.

The models, once verified using data gained from the laboratory or track tests (see WP5), were used to investigate worst case situations in order to help define limits and recommendations in WP6.

Based on the compilation of information, requirements and enhanced properties of ECB, KB developed a concept for a new generation of ECB specifically with the focus on signaling compatibility.

WP4: DEFINITION OF REPRESENTATIVE WORST CASE CONDITIONS

The main objective of this task was to define the worst case conditions produced by an ECB regarding rolling stock. Through a thorough understanding of the information gained in WP2, worst case scenarios were defined for operational conditions of the ECB, signaling systems, the rail head and rolling stock. These scenarios were analysed and used as inputs for the requirements for the test setup and test procedure as defined in WP5.

Regarding operational conditions the worst cases include infrastructure aspects as track or rail heating, forces on track/rail, gauge, EMC etc. Regarding train operation the worst cases have to respect the operation cycle, the environment and the approval for use. Regarding the train itself the ECB design has to take in account the speed, the kind of power supply/consumption, the thermal limits and the mechanical forces. For maintenance the adjustment of the air gap is relevant. Regarding signalling systems the worst cases have to take in account the influenced systems (axle counters, wheel sensors, speed detection), all non influenced systems and the possibly influenced systems. For the rail head, the modelled conditions such as track temperature limits, maximum brake power per trainset, succession of trains, speed limit, material of rail and weather conditions were taken into account. Worst cases result also from track limitations (ballasted or non ballasted). The worst cases regarding rolling stock are the design of the bogie and (brake) control systems. The potential hazard of affecting signalling track circuits using insulated rail joints (IRJ) to differentiate the boundary between adjacent block sections was identified. The application of ECB over IRJ may lead to a differential voltage on both sides and potential reliability issues of the train detection system.

WP5: TEST SITE, TEST PROCEDURE AND TEST SETUP DESIGN AND IMPLEMENTATION

This work package is divided into two main parts. tests in the laboratory and track tests

As far as laboratory tests concerned, the interaction between ECB and signalling systems have been measured. Passive effects and HF emissions have been the effects analysed during these measurements. In this period the laboratory tests were extended to include measurements on a new generation of ECB with shielding plates which reduced the influence on wheel sensors.

Regarding tests with trains equipped with ECBs, they have been carried out on the track also within this period. Extensive line tests with an ICE 3 train have been carried out on the high speed line Nürnberg – Ingolstadt. The used ICE 3 train was equipped with different eddy current brake types

(ICE 3 type, Velaro D type, and PWB (permanent magnetic type, only the housing)) and an additional onboard measurement system which measured the current in the electrical path of the eddy current brakes. The planning phase carefully detailed which sensors and measurement probes were to be used as well as the speeds, brakes forces and air gap to be set for each test run. On track side numerous axle counters, wheel sensors, magnetic field sensors, temperature sensors and force sensors were installed along the test track section. These sensors were then mounted and tested before the actual test runs could be conducted. The test runs (over 80 test runs with different operational parameters) and the measurements have been carried out successfully in October / November 2014. As it was not possible to measure the influence of an active ECB on track circuits (track circuits with insulated rail joints) at the first measurement campaign a second – very short – test campaign was realized on another line section of the high speed line in 08/2015.

Temperatures and stresses have been also recorded at different points of the cross-section in three different locations in a rail profile UIC60. Temperature was recorded before, during and after the test-run, so that enough data to compare with simulations was obtained. These temperature measurements are focused on providing data to validate the thermal model developed in WP5. The numerous measurement data – which have been used for the verification and validation of the simulation models as well as for the deviation of future technical solutions - were prepared, analyzed and evaluated

WP6: TECHNICAL RECOMMENDATIONS AND DESIGN, ENGINEERING AND OPERATIONAL GUIDELINES

From the holistic model generated in WP3 and the laboratory and test run data obtained from WP5 is has been possible to set a number of recommendations for ECBs, installation, signalling devices and track. These include design guidelines for both ECBs and for wheel sensor manufacturers in order that mutual compatibility is achieved. Therefore, based on the simulation and measurement results of the former work packages the steps for future authorization processes for ECB, axle counters and vehicles equipped with an ECB have been defined. Interference relevant design parameters of ECB and axle counter were defined and the associated standards could be specified.

Concerning track lateral stability, a collection of simulation results (temperature increase results) have been obtained from the model, as a function of braking force and frequency of trains (time interval between consecutive trains braking at the same point). Those values are to be used as a guideline to define the braking strategy of ECB equipped trains from track safety point of view, especially to prevent lateral buckling. Therefore, design rules for future ECBs as well as operational guidelines for operators stipulate the minimum allowable train period for a given brake force.

WP7: EXPLOITATION AND DISSEMINATION

In the second part of the project, the dissemination activities focused on a wide promotion of the latest developments of ECUC. This campaign included an Open Workshop, participation of several EU-level events on brakes, publications on International magazines, two project newsletters and a Final Conference with technical visit at the end of August 2015.

A detailed summary of the main communication and dissemination activities has been developed in Section 3 of this document.

Among dissemination activities, the mid-term and the final events were particularly successful. The events took place on time enabling the consortium partners to introduce the attendants the progress and the results of the ECUC project.

Another important part of this T7 is the production of technical recommendations (D7.7) to be proposed to the authorities. These recommendations are aimed at enabling the ERA to close pending open points of the TSIs and proposing CEN/CENELEC material for further work on integrating results of the ECUC project in new EN standards.

Expected final results

The project has successfully expanded understanding of the interactions between ECBs, the track and trackside signalling equipment. ECUC partners have identified critical electromagnetic design parameters for ECBs and axle counters and thermomechanical aspects for the infrastructure resulting from ECB use by using 3D computer modelling systems

As a consequence new design, engineering and operational guidelines for ECBs and trackside signalling equipment are developed.

Another key feature of the project is the design and implement of state-of-the-art testing ECB sites and procedures for interoperability under real-world conditions. The test procedure has been extended to on track measurements than can be applied for future tests. However, this solution is not recommended by the amount of expenses involved and its relevant difficulty. This is the reason why the proposed laboratory procedures and methods along with the proposed 3D simulation will pave the way for further developments in a more effective way.

Over these lines, ECUC has produced a new set of requirements for ECBs, as well as design and installation guidelines and operational recommendations for ECBs (D6.1), installation on the vehicle (D6.2), signalling systems (D6.3) and tracks (D6.4) (due to observed and projected temperature increases in rails due to ECB brake forces). The **Project Technical Recommendations (PTR)** (D6.5, D6.6 and D7.7) are aimed at enabling the ERA to close pending open points of the TSIs and proposing CEN/CENELEC material for further work on integrating results of the ECUC project in new EN standards. This will lead at the end of the process to a revision of the compatibility limits and frequency management set by standards like CLC/TS 50238-3.

New ECB design and development and specific truck design parameters will also mark the trend for the promising future of interoperable ECBs: that will help to integrate a safer, more reliable and comprehensive brake system.

Potential impact and use

The goal of ECUC project is, among others, to address concerns raised by infrastructure managers regarding the interoperability between linear eddy current brakes and the infrastructure. The recommendations presented pave the way for approved acceptance of this brake type by highlighting an understanding of the origin of these concerns and by proposing methods for infrastructure manager, brake manufacturer and wheel sensor manufacturer to overcome, or at least diminish, their effects.

The first economic impact is based on the infrastructure capacity, which can be a consequence of the spread of the ECB's use: the capacity of railway infrastructure is directly linked to the braking performances of the rolling stock which allows shortening the stopping sequences and therefore to bring the trains closer. One advantage of a ECB magnet system is to have its performance decoupled from the wheel/rail adhesion. Difficult conditions (humidity, leaf deposition...) reduce travelling speeds of trains which culminate in delays. These instances could be greatly reduced by ECB usage. As a consequence, track efficiency and train punctuality for paying customers will be highly improved. Therefore, ECB brings braking performances over the level allowed by wheel contact braking systems.

The enhanced operation of ECB as a service brake on conventional tracks and ballasted high speed lines can help to reduce the effort of maintenance for conventional friction-based systems. In this manner, there are also benefits regarding the rolling stock operation because the ECB magnet system is wearless and costs due to friction pads are very high in the whole life of a train.

The extension of the usage of ECBs that ECUC results promote will translate into higher quality standards of travelling by train: the fact that the ECB generates no noise, no dust and no smell in operation will enhance the quality of experience of the passenger.

Another advantage is to have a high constant brake power for a wide range of speeds, including an additional braking force at both high speeds and during emergency braking. Again, safety is increased while travelling at higher speeds. The high brake performance of ECB allows to accept higher gradients in new lines, which in turn would reduce high costs of infrastructure. The advantages of increased safety, reduced travel times and trains arriving at their destinations punctually would increase the popularity of travelling by rail thereby increasing passenger numbers. Shorter travel time and reduced costs are key issues for improvement of rail mobility.

The insights and knowledge gained from ECUC project will be implemented in the development of new generations of ECBs and wheel sensors immune to ECBs thereby securing jobs within Europe and the rail sector. Once these sensors have an established position within the market, ECBs can be broadly introduced to the infrastructure therefore strengthening the position of ECB manufacturers and once again securing jobs in their region. At the same time, providing information about rail temperature increase due to ECB performance will help infrastructure managers to set a comprehensive strategy for the definition of ECB-compatible lines.

An easier recycling of the product at the end of its lifetime based on the concept of modularisation of the new generation ECB is another advantage. Hence the ECB fulfils the aspects of a "green" product to a high degree. Business opportunities are open up by paving the way for future ECB developments, contributing to European leadership in the railway sector.

If introducing ECBs into more railway sectors increases the number of passengers travelling, then there is not just a direct impact on the manufacturers of both ECBs and compliant signalling systems to supply these systems, but also on the railway operator, railway stations and an indirect impact on services and transport systems to and from railway stations.

Furthermore, potentially introducing a new all electric rolling stock brakes will make the railway transport system more affordable as additional systems to overcome poor adhesion are ruled as unnecessary.

Besides, the decision for developing very high speed railway projects (those whose speed can reach more than 300 km/h) remains at high political level. The balance to be hit is the combination of the overall growth of European activity that is achieved and the required investment on a better transportation capacities in large territories, which should overcome interoperability issues. ECUC results are geared to pave the way of the interoperability between a high quality brake system at one end, and signalling devices and infrastructure at the other.

Project logo and website



<http://www.ecuc-project.eu/>