ECUC

Eddy Current Brake Compatibility

Second Interim Report

Title: Periodic Activity Report 2

Contract number :	314244
Project acronym :	ECUC
Project title :	EDDY CURRENT BRAKE COMPATIBILITY

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Coordinator: CEIT

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LIST OF ANNEXES

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

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	FRAUS CHER	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, TES 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 invloved 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 strengthing 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 rulled 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 qualit brake system at one end, and signalling devices and infrastructure at the other.

Project logo and website

ECUC
www.ecuc-project.eu

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

2. CORE OF THE REPORT FOR THE PERIOD

2.1 Overview of general 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.

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2.2 Objectives for the reporting period

Period 2 covers part of WP1, WP3, WP4 and WP7 and the whole WP5 and WP6. From the aforementioned general objectives, in this period specific objectives have been achieved:

- Definition and validation of Electromagnetic and Thermal models for ECBs-wheel sensors and ECB-infrastructure interoperability. The created heuristic model of ECB enhances the comprehension of different interactions on rolling stock, infrastructure and operation. A worst case can be therefore estimated by simulation.
- New ECB prototype release. The progress of simulation as output of the different workpackages enables a more effective way to start a new ECB design (new train, new line, new track equipment, new brake systems) and to the release of the product. With these exploitations, the ECB will become a common component of brake systems like friction brake or electrodynamic brake systems.
- Extensive testruns definitions either in laboratory setups or in track. The collection of information improves the common knowledge about the ECB in development, service and maintenance.
- Postprocessing of the massive obtained data to validate the model and define worst case conditions for interoperability.
- Proposing Project Technical Recommendations (PTR) to main bodies. The output of the project is the basis for standardisation and closing of open points in many national and European legislative documents.

2.3 Budget follow up table

Budget follow up table details the costs in which the consortium has incurred within Period 2.

Cost Budget Follow-up Table										
Grant Agreement N°:314244								Date:	29/10/2015	
PARTI-CIPANTS	TYPE of EXPENDITURE (as defined by participants)	BUDGET	ACTUAL COSTS (EUR)				Pct. spent		Remaining Budget (EUR)
			Period 1	Adjustment P1	P2	Total	Period 2	Total	
		e	a1			e1	a1/e	a1+b1+c1+d1/e	e-e1
CEIT - RTD	**Total Person-month**	**57,00**	**27,35**		**29,66**	**57,01**	**52%**	**100%**	**-0,01**
	Personnel costs	332.989,06	175.112,77	732,77	193.723,70	369.569,24	58%	111%	-36.580,18
	Travel	16.500,00	7.571,02		6.672,68	14.243,70	40%	86%	2.256,30
	Consumables	60.000,00	26.339,08		17.708,63	44.047,71	30%	73%	15.952,29
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	76.500,00	33.910,10		24.017,81	57.927,91	31%	76%	18.572,09
	Indirect costs	216.442,89	110.986,47	-357,14	117.086,60	227.715,93	54%	105%	-11.273,04
	Total	625.931,95	320.009,34	375,63	335.191,61	655.576,58	54%	105%	-29.644,63
CEIT - MGT	**Total Person-month**	**8,00**	**4,00**		**4,47**	**8,47**	**56%**	**106%**	**-0,47**
	Personnel costs	46.735,31	21.185,14		31.275,01	52.460,14	67%	112%	-5.724,83
	Travel					0,00	-	-	0,00
	IPR Office	9.000,00	4.000,00		5.000,00	9.000,00	56%	100%	0,00
	Audit Costs	1.650,00			1.650,00	1.650,00	100%	100%	0,00
	Web Page	3.000,00				0,00	0%	0%	3.000,00
	Other costs ('the rest')	13.650,00	4.000,00		6.650,00	10.650,00	49%	78%	3.000,00
	Indirect costs	30.377,95	13.427,14		18.902,62	32.329,75	62%	106%	-1.951,80
	Total	90.763,26	38.612,27		56.827,63	95.439,90	63%	105%	-4.676,64
	Total Person-month	**2,00**	**0,70**		**1,84**	**2,54**	**92%**	**127%**	**-0,54**

CEIT - DISS	Personnel costs	11.683,83	4.413,11		9.092,31	13.505,42	78%	116%	-1.821,59
	Consumables	4.000,00	1.625,00		589,00	2.214,00	15%	55%	1.786,00
	Travel	6.000,00	3.862,66		2.334,83	6.197,49	39%	103%	-197,49
	Other costs ('the rest')	10.000,00	5.487,66		2.923,83	8.411,49	29%	84%	1.588,51
	Indirect costs	7.594,49	2.797,03		5.495,39	8.292,42	72%	109%	-697,93
	Total	29.278,32	12.697,79		17.511,53	30.209,33	60%	103%	-931,01
	Total Costs	745.973,53	371.319,40	375,63	409.530,77	781.225,81	55%	105%	-35.252,28
	Requested Contribution	589.490,54	291.317,07	281,73	325.732,87	617.331,66	55%	105%	-27.841,12
KB -RTD	**Total Person-month**	**53,50**	**29,22**	**-0,17**	**30,06**	**59,11**	**56%**	**110%**	**-5,61**
	Personnel costs	448.083,36	232.893,36	-27.687,18	209.863,39	415.069,57	47%	93%	33.013,79
	Travel	8.234,67	3.975,20	-1.119,68	3.398,55	6.254,07	41%	76%	1.980,60
	Consumables	94.690,02	42.690,02	-38.575,00	68.257,10	72.372,12	72%	76%	22.317,90
	Equipment	15.186,87	186,87	20.787,50	28.802,58	49.776,95	190%	328%	-34.590,08
	Subcontracting	212.599,85		174.798,85	28.602,00	203.400,85	13%	96%	9.199,00
	Other costs ('the rest')	118.111,56	46.852,09	-18.907,18	100.458,23	128.403,14	85%	109%	-10.291,58
	Indirect costs	113.238,98	55.949,09	-9.318,87	62.064,32	108.694,54	55%	96%	4.544,44
	Total Costs	892.033,75	335.694,53	118.885,62	400.987,94	855.568,10	45%	96%	36.465,65
KB-MGT	Total Person-month	0,00				0,00	-	-	0,00
	Personnel costs	0,00				0,00	-	-	0,00
	Travel	0,00				0,00	-	-	0,00
	IPR Office	0,00				0,00	-	-	0,00
	Web oage	0,00				0,00	-	-	0,00
	Audit Costs	0,00			5.250,00	5.250,00	-	-	-5.250,00
	Other costs ('the rest')	0,00				0,00	-	-	0,00
	Indirect costs	0,00				0,00	-	-	0,00
	Total Costs	0,00			5.250,00	5.250,00	-	-	-5.250,00
KB -DISS	**Total Person-month**	**1,00**			**1,05**	**1,05**	**105%**	**105%**	**-0,05**
	Personnel costs	7.970,00			8.543,56	8.543,56	107%	107%	-573,56
	Consumables				0,00	0,00	-	-	0,00
	Travel	950,10			70,76	70,76	7%	7%	879,34
	Other costs ('the rest')	950,10			70,76	70,76	7%	7%	879,34
	Indirect costs	1.784,02			1.722,86	1.722,86	97%	97%	61,16
	Total Costs	10.704,12			10.337,18	10.337,18	97%	97%	366,94
	Total Costs	902.737,87	335.694,53	118.885,62	416.575,12	871.155,28	46%	97%	31.582,59

	Requested Contribution	456.721,00	167.847,27	59.442,81	216.081,15	443.371,23	47%	97%	13.349,77
ALSTOM-RTD	**Total Person-month**	**6,50**	**4,00**		**0,90**	**4,90**	**14%**	**75%**	**1,60**
	Personnel costs	49.686,00	40.760,00		9.257,34	50.017,34	19%	101%	-331,34
	Travel	6.400,00	2.230,12		1.391,15	3.621,27	22%	57%	2.778,73
	Consumables					0,00	-	-	0,00
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	6.400,00				0,00	0%	0%	6.400,00
	Indirect costs	24.843,00	20.380,00		4.628,67	25.008,67	19%	101%	-165,67
	Total Costs	80.929,00	63.370,12		15.277,16	78.647,28	19%	97%	2.281,72
AlSTOM-DISS	**Total Person-month**	**0,50**	**0,40**		**0,39**	**0,79**	**78%**	**158%**	**-0,29**
	Personnel costs	3.822,00	4.076,00		3.745,33	7.821,33	98%	205%	-3.999,33
	Travel	1.400,00	457,80			457,80	0%	33%	942,20
	Consumables					0,00	-	-	0,00
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	1.400,00				0,00	0%	0%	1.400,00
	Indirect costs	1.911,00	2.038,00		1.872,67	3.910,67	98%	205%	-1.999,67
	Total Costs	**7.133,00**	6.571,80		5.618,00	12.189,80	79%	171%	-5.056,80
	Total Costs	88.062,00	69.941,92		20.895,16	90.837,08	24%	103%	-2.775,08
	Requested Contribution	47.597,50	38.256,86		13.256,58	51.513,44	28%	108%	-3.915,94
SNCF-RTD	**Total Person-month**	**7,00**	**3,23**		**0,97**	**4,20**	**14%**	**60%**	**2,80**
	Personnel costs	67.200,00	24.904,07		6.710,91	31.614,98	10%	47%	35.585,02
	Travel	6.400,00	3.052,53		93,10	3.145,63	1%	49%	3.254,37
	Consumables					0,00	-	-	0,00
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	6.400,00				0,00	0%	0%	6.400,00
	Indirect costs	37.800,00	7.745,80		2.124,00	9.869,80	6%	26%	27.930,20
	Total Costs	111.400,00	35.702,40		8.928,01	44.630,41	8%	40%	66.769,59
SNCF-DISS	**Total Person-month**	**1,00**	**0,30**		**0,43**	**0,73**	**43%**	**73%**	**0,27**
	Personnel costs	9.600,00	2.079,29		3.156,52	5.235,81	33%	55%	4.364,19
	Consumables					0,00	-	-	0,00
	Travel	1.400,00	116,70		876,37	993,07	63%	71%	406,93
	Other costs ('the rest')	1.400,00				0,00	0%	0%	1.400,00
	Indirect costs	5.400,00	658,10		999,04	1.657,14	19%	31%	3.742,86
	Total Costs	16.400,00	2.854,09		5.031,93	7.886,02	31%	48%	8.513,98

	Total Costs	127.800,00	38.556,49		13.959,94	52.516,43	11%	41%	75.283,57
	Requested Contribution	72.100,00	20.705,29		9.495,94	30.201,22	13%	42%	41.898,78
DB-RTD	**Total Person-month**	**38,50**	**10,08**	**-0,08**	**29,57**	**39,57**	**77%**	**103%**	**-1,07**
	Personnel costs	277.200,00	69.773,47	135,84	193.834,74	263.744,05	70%	95%	13.455,95
	Travel	7.400,00		2.224,71	1.946,73	4.171,44	26%	56%	3.228,56
	Consumables	175.000,00			172.708,35	172.708,35	99%	99%	2.291,65
	Subcontracting	25.000,00				0,00	0%	0%	25.000,00
	Other costs ('the rest')	182.400,00				0,00	0%	0%	182.400,00
	Indirect costs	185.724,00	34.017,36	-2.281,49	85.526,07	117.261,94	46%	63%	68.462,06
	Total Costs	670.324,00	103.790,83	79,06	454.015,89	557.885,78	68%	83%	112.438,22
DB-DISS	**Total Person-month**	**1,50**	**0,54**	**0,00**	**1,03**	**1,57**	**69%**	**105%**	**-0,07**
	Personnel costs	10.800,00	3.915,09	26,08	7.846,16	11.787,33	73%	109%	-987,33
	Consumables					0,00	-	-	0,00
	Travel	1.400,00			753,00	753,00	54%	54%	647,00
	Other costs ('the rest')	1.400,00				0,00	0%	0%	1.400,00
	Indirect costs	7.236,00	1.908,76	7,10	3.608,88	5.524,74	50%	76%	1.711,26
	Total Costs	19.436,00	5.823,85	33,18	12.208,04	18.065,07	63%	93%	1.370,93
	Total Costs	689.760,00	109.614,68	112,24	466.223,93	575.950,86	68%	84%	113.809,14
	Requested Contribution	354.598,00	57.719,27	72,71	239.215,99	297.007,96	67%	84%	57.590,04
NRIL-RTD	**Total Person-month**	**11,50**	**1,35**		**1,90**	**3,25**	**17%**	**28%**	**8,25**
	Personnel costs	155.066,00	22.292,53		34.348,31	56.640,84	22%	37%	98.425,16
	Travel	6.400,00	1.825,06		2.005,14	3.830,20	31%	60%	2.569,80
	Consumables					0,00	-	-	0,00
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	6.400,00				0,00	0%	0%	6.400,00
	Indirect costs	32.293,20	4.823,52		7.270,69	12.094,21	23%	37%	20.198,99
	Total Costs	193.759,20	28.941,11		43.624,14	72.565,25	23%	37%	121.193,95
NRIL-DISS	**Total Person-month**	**1,00**			**0,38**	**0,38**	**38%**	**38%**	**0,62**
	Personnel costs	13.484,00			6.869,66	6.869,66	51%	51%	6.614,34
	Consumables					0,00	-	-	0,00
	Travel	1.400,00	214,80		1.101,37	1.316,17	79%	94%	83,83
	Other costs ('the rest')	1.400,00				0,00	0%	0%	1.400,00
	Indirect costs	2.976,80	42,96		1.594,21	1.637,17	54%	55%	1.339,63

	Total Costs	17.860,80	257,76		9.565,24	9.823,00	54%	55%	8.037,80
	Total Costs	211.620,00	29.198,87		53.189,38	82.388,24	25%	39%	129.231,76
	Requested Contribution	114.740,40	14.728,32		31.377,31	46.105,63	27%	40%	68.634,77
FRAUSCHER-RTD	**Total Person-month**	**16,50**	**9,30**		**6,04**	**15,34**	**37%**	**93%**	**1,16**
	Personnel costs	162.122,07	91.084,32		59.501,95	150.586,27	37%	93%	11.535,80
	Travel	4.800,00	3.754,71		2.207,81	5.962,52	46%	124%	-1.162,52
	Consumables					0,00	-	-	0,00
	Equipment	20.000,00	17.225,53		34.070,00	51.295,53	170%	256%	-31.295,53
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	24.800,00	20.980,24		36.277,81	57.258,05	146%	231%	-32.458,05
	Indirect costs	112.153,24	67.238,73		57.467,86	124.706,59	51%	111%	-12.553,35
	Total Costs	299.075,31	179.303,29		153.247,62	332.550,91	51%		-33.475,60
FRAUSCHER-DISS	**Total Person-month**	**0,50**	**0,09**		**0,67**	**0,76**	**134%**	**152%**	**-0,26**
	Personnel costs	4.912,79	882,60		6.621,85	7.504,45	135%	153%	-2.591,66
	Consumables					0,00	-	-	0,00
	Travel	1.400,00	2.563,61		1.811,36	4.374,97	129%	312%	-2.974,97
	Other costs ('the rest')	1.400,00				0,00	0%	0%	1.400,00
	Indirect costs	3.787,67	2.067,73		5.059,93	7.127,65	134%	188%	-3.339,98
	Total Costs	10.100,46	5.513,94		13.493,14	19.007,08	134%	188%	-8.906,62
	Total Costs	309.175,77	184.817,23		166.740,76	351.557,99	54%	114%	-42.382,22
	Requested Contribution	234.406,94	139.991,41		128.428,85	268.420,26	55%	115%	-34.013,32
UNIFE-RTD	**Total Person-month**					**0,00**			**0,00**
	Personnel costs					0,00	-	-	0,00
	Travel					0,00	-	-	0,00
	Consumables	0,00				0,00	-	-	0,00
	Subcontracting					0,00	-	-	0,00
	Other costs ('the rest')	0,00				0,00	-	-	0,00
	Indirect costs	0,00				0,00	-	-	0,00
	Total Costs	0,00				0,00	-		0,00
UNIFE-DISS	**Total Person-month**	**9,50**	**3,70**		**4,90**	**8,60**	**52%**	**91%**	**0,90**
	Personnel costs	71.250,00	19.913,71		27.807,30	47.721,01	39%	67%	23.528,99
	Consumables	27.250,00	9.235,09		20.753,28	29.988,37	76%	110%	-2.738,37
	Travel	11.700,00	590,86		2.844,72	3.435,58	24%	29%	8.264,42

	Subcontracting	4.000,00	2.660,00		675,00	3.335,00	17%		
	Other costs ('the rest')	42.950,00	12.485,95		24.273,00	36.758,95	57%	86%	6.191,05
	Indirect costs	66.120,00	17.843,80		30.843,18	48.686,98	47%	74%	17.433,02
	Total Costs	180.320,00	50.243,46		82.923,48	133.166,94	46%	74%	47.153,06
	Total Costs	180.320,00	50.243,46		82.923,48	133.166,94	46%	74%	47.153,06
	Requested Contribution	180.320,00	50.243,46		82.923,48	133.166,94	46%	74%	47.153,06

The table below summarises the financial resources that the consortium has allocated within the first period of the project. We can observe that the consortium has spent around 92,05% of the overall budget.

	TYPE of EXPENDITURE	BUDGET	ACTUAL COSTS IN Q1	Adjustmen P1	P2	Total	PER-CENTAGE	REMAINING BUDGET
RTD	**Total Person-month**	**190,50**	**84,53**	**-0,25**	**99,10**	**183,38**	**96,26%**	**7,12 €**
	Personnel costs	1.492.346,49 €	656.820,51 €	-26.818,56 €	707.240,34 €	1.337.242,29 €	89,61%	155.104,20 €
	Travel	56.134,67 €	22.408,64 €	1.105,03 €	17.715,16 €	41.228,83 €	73,45%	14.905,84 €
	Consumables	329.690,02 €	69.029,10 €	-38.575,00 €	258.674,08 €	289.128,18 €	87,70%	40.561,84 €
	Equipment	35.186,87 €	17.412,40 €	20.787,50 €	62.872,58 €	101.072,48 €	287,24%	-65.885,61 €
	Subcontracting	237.599,85 €	0,00 €	174.798,85 €	28.602,00 €	203.400,85 €	85,61%	34.199,00 €
	Other costs ('the rest')	421.011,56 €	108.850,14 €	-18.907,18 €	339.261,82 €	429.204,77 €	101,95%	-8.193,21 €
	Indirect costs	722.495,31 €	301.140,97 €	-11.957,50 €	336.168,22 €	625.351,68 €	86,55%	97.143,63 €
	Total	2.873.453,21 €	1.066.811,61€	119.340,32 €	1.411.272,38€	2.597.424,31€	90,39%	276.028,90 €
MGT	**Total Person-month**	**8,00**	**4,00**	**0,00**	**4,47**	**8,47**	**105,93%**	**-0,47 €**
	Personnel costs	46.735,31 €	21.185,14 €	0,00 €	31.275,01 €	52.460,14 €	112,25%	-5.724,83 €
	Travel	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	#DIV/0!	0,00 €
	IPR Office	9.000,00 €	4.000,00 €	0,00 €	5.000,00 €	9.000,00 €	100,00%	0,00 €
	Audit Costs	1.650,00 €	0,00 €	0,00 €	6.900,00 €	6.900,00 €	418,18%	-5.250,00 €
	Web Page	3.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00%	3.000,00 €
	Other costs ('the rest')	13.650,00 €	4.000,00 €	0,00 €	6.650,00 €	10.650,00 €	78,02%	3.000,00 €
	Indirect costs	30.377,95 €	13.427,14 €	0,00 €	18.902,62 €	32.329,75 €	106,43%	-1.951,80 €
	Total	90.763,26 €	38.612,27 €	0,00 €	62.077,63 €	100.689,90 €	110,94%	-9.926,64 €
DISS	**Total Person-month**	**17,00**	**5,73**	**0,00**	**10,69**	**16,42**	**96,57%**	**0,58 €**
	Personnel costs	133.522,62 €	35.279,80 €	26,08 €	73.682,69 €	108.988,57 €	81,63%	59.839,93 €
	Consumables	31.250,00 €	10.860,09 €	0,00 €	21.342,28 €	32.202,37 €	103,05%	9.907,72 €
	Travel	25.650,10 €	7.806,43 €	0,00 €	9.792,41 €	17.598,84 €	68,61%	15.857,69 €
	Subcontracting	4.000,00 €	2.660,00 €	0,00 €	675,00 €	3.335,00 €	83,38%	3.325,00 €
	Other costs ('the rest')	60.900,10 €	21.326,52 €	0,00 €	27.267,59 €	48.594,11 €	79,79%	33.632,51 €
	Indirect costs	96.809,98 €	27.356,37 €	7,10 €	51.196,16 €	78.559,63 €	81,15%	45.613,82 €
	Total	291.232,70 €	83.962,69 €	33,18 €	156.688,54 €	240.684,40 €	82,64%	134.544,16 €
	Total Costs	**3.255.449,17 €**	**1.189.386,58€**	**119.373,50 €**	**1.630.038,54€**	**2.938.798,61€**	**90,27%**	**316.650,56 €**
	Requested Contribution	**2.050.184,00 €**	**780.808,93 €**	**59.797,25 €**	**1.046.512,16€**	**1.887.118,33€**	**92,05%**	**163.065,67 €**

3. WORK PROGRESS AND ACHIEVEMENTS DURING THE PERIOD

3.1 WP2: Identification of the Performance Requirements, Design Parameters, and their Relationships

Table 1. Work Progress and Achievements of Work Package 2 (WP2)

Work package number	2	**Start date or starting event:**				Month m1			
Work package title	Identification of the performance requirements, design parameters, and their relationships								
Activity type	RTD								
Participant number	1	2	3	4	5	6	7		
Participant short name	CEIT	KB	ALTOM	SNCF	DB	NRIL	FRAUS CHER		
Person-months per participant	4	3,5	3	3	7,5	2,5	2		

Objectives

The objectives of this work package are:

• Establish a common knowledge database that describes all referenced problems of ECB.

• Establish the requirements of the ECB by means of the analysis of the interaction between ECB and the infrastructure (rail head, signalling systems) and rolling stock.

• Establish the design parameters of ECB regarding their functionality.

• Establish the qualitative relationship between the causes and the consequences that enables a common and thorough understanding of the physical phenomena and their effects on availability and safety.

Task 2.1: Systematic collection and analysis of existing information regarding ECB. (Months 1-6 (Sep 2012 – Feb 2013))
Task 2.2: Identification of the performance requirements of the ECB regarding the track, the rolling stock and the signalling systems.(Months 1-15 (Sep 2012- Nov 2013))
Task 2.3: Identification of design parameters of ECB (Months 3-14 (Nov 2012 - Oct 2013))
Task 2.4: Identification of the relationships among the design parameters and the performance requirements. (Months 3-15 (Nov 2012 - Nov 2013))

Progress towards objectives

- This WP belongs to Period 1 of the project

Significant achievements

The results and significant achievements of this task were reported in reporting period 1 document

Any deviations from the project work programme/Annex I (DOW)?
Yes. Explained below

Reasons for deviations, their impact on other tasks and available resources and planning.
WP2 has been longer than planned at the beginning of the project.
The reviewing process of all the documents required more loops than expected. The following work packages WP 2.3 and WP 2.4 effectively together with end of WP2.2. In most of the

partners, more resources were not needed, and regarding ALSTOM and KB, it was a slight difference that it will be compensated by means of the resources of other tasks of the project.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

All the objectives have been achieved, but the documents were finished later than expected. The impact on the rest of the project has been minimized because WP3 started in parallel with WP2. The review process of the documents which postponed the end date of WP2 did not delay the starting date of WP3 because some of the design parameters and main problems were already detected in the first stage of the WP.

Propose corrective actions.
The end of WP2 has been postponed till M14, but the rest of the project continues the scheduling of the project.

3.2 WP3: Eddy Current Brake Compatibility Model design and Implementation

Table 2. Work Progress and Achievements of Work Package 3 (WP3)

Work package number	WP3		**Start date or starting event:**		Month m5					
Work package title	Eddy current brake compatibility model design and implementation									
Activity type	RTD									
Participant number	1	2	5	6	7					
Participant short name	CEIT	KB	DB	NRIL	FRAUSCHER					
Person-months per participant	28	24	3	4	2,5					

Objectives:

The main objective of this WP is to design and verify the Eddy-current Brake Compatibility model that estimates electromagnetic interference levels affecting the functionality of the spot signalling systems and the thermal and mechanical issues affecting the infrastructure. This model is a tool that will enable in WP4 the definition of the representative worst case conditions, which is ultimately a key point to establish the technical specifications for the test setup, procedure and test site (WP5).

Task 3.1 Electromagnetic domain model design and implementation (Months 5-32 (Jan 2013 - April 2015))

Progress towards objectives

In the first period the wheel sensor models were completed (RSR180) or needed to be verified (RSR123). This verification has been completed by Frauscher and both finalised 3D models were shared with CEIT for implementation in the holistic model and further analysis. Similarly to the models developed in the first period, the workflow is based on 3D FEM models in CST generating results for electronic simulations in LTSpice while Matlab automates the analysis and data visualisation. The version control has again been managed by SVN.

In the first

CEIT developed the interaction between ECB and axle counters in the passive case and high frequency emissions of ECB. On one hand, a 3D model of ECB has been implemented and it has been integrated with the model of RSR180 and RSR 123. The complete RSR 180 and RSR 123 electromagnetic models including ECB, wheel sensor, rail and wheel was first of all verified using experimental results from both the laboratory and track tests. In this second period a fine tuning of the model in the passive case interaction was conducted by analyzing the impact of each separate factor (e.g. conductivity of materials, lowest part of the pole core definition etc) in the final results. The comparison was made with the measured results. The results contributed directly to several recommendations in D6.6

On the other hand, CEIT has also analyzed high frequency emissions of ECB. The 3D model of ECB implemented for this task allows to calculate the saturation of the materials due to the effect of ECB. Moreover, **the whole rolling stock power supply is also considered is this period** in the simulations and **the measured parasitic capacitances and inductances of ICE3 train cabling and embarked ECB are embedded now in the model**. In this manner, a **HF transfer function** between ECB input current and output radiated emissions **is now corroborated by comparison with the measurement extracted from WP5 with very good agreement**.

DB went into contact with other axle counter manufacturers (e.g. Siemens) to clarify if they can contribute basic parameters of their axle counters, working in frequency band 1 of the frequency management defined in the TSI CCS interface document, for the generation of appropriate axle counter simulation models and provided – as far as possible - data and information for the generation of the models.

KB placed at the disposal of the consortium the model of three effects of interaction. The passive effect, the low frequency interaction with strong magnetic stray fields in frequency range from 0 up to 1000 Hz and the medium and high frequency interaction in the frequency range described in EN50238. The main part of KB was the simulation of low frequency interaction with a 3D transient FEM model with a new, highly sophisticated, non-commercial software under consideration of different air gaps, speeds of train, variations of current/magnetisation and lateral positions of the Eddy Current Brake. The effort of calculation was significantly higher than expected. The use of a high performance computer with more than 70 clusters was necessary. This simulation was then expanded to wide stray field calculations and to validating by the existing Eddy Current Brake EWB154 R and laboratory stray field measurements. KB documented the results in report D3.1.

Significant achievements

From Frauscher's point of view, the main achievements have been:

3D model of RSR 180 and Spice model thereof

3D model of RSR 123 and Spice model thereof

Workflow software for automation of simulations and calculations

Verification of RSR180 and RSR123 for passive interaction with axles or ECB

From CEIT point of view one of the main achievements is the comprehensive electromagnetic model that is scaled up starting from a pole building block: eight poles make up a magnet, four magnet a complete ECB with its corresponding electric power supply. The integration of all the elements that form a whole system embarked in the train is an important milestone of the project. Another significant achievement of this period is the verification and validation of the simulation models (thermal effect, magnetic interference, passive influence), which have shown a very good correlation with corresponding measurement results generated by laboratory tests and line tests. For the project ECUC this was a very import result for the deviation and definition of (future) interface relevant requirements and parameters (interface between ECB and infrastructure) for ECB and e.g. axle counter.

Due to the intrinsic difficulties to obtain certain parameter values during the measurement campaign, it was necessary to estimate some conditions. For example, this is the case for the lateral displacement of the bogie, the airgap between the ECB and the rail (approximately 5-7 mm and very difficult to determine) and the synchronization of the current signal on board a fast moving train with the output field on a static receiver situated by the track. With these limitations and the knowledge that the model is static while the real event is dynamic, worst case conditions are calculated. They allow higher radiation estimations to be set over real measurements.

Based on the separation in different effects the effects themselves could be more easily simulated. Also worst case conditions were easier to identify. The effects and their superposition can be tested in laboratory. A verification of functionality by consideration of worst case conditions is possible.

Task 3.2: Thermo-mechanical domain model design and implementation (Months 5-32 (Jan 2013 - April 2015))

Progress towards objectives

During this period the thermal model has been completed:

- Convection has been included in the model and a discussion on the value of the heat transfer coefficient has been conducted. There are no experimental results that provide the value of the coefficient in case of air acting on rails and, thus, literature values of air acting on surfaces have been adopted. Values in literature are neither very precise; they just suggest orders of magnitude to be adopted in case of “low speed wind” or “high speed wind”

- Some preliminary calculations have been conducted to study the potential results that could be obtained from the thermal model
- The output of the model is temperature results as function of time in all the cross-section of the rail. It is a powerful transient model that gives very accurate information on gradients of temperatures in the cross-section of rail due to the continuous use of ECBs
- A routine that calculates the average temperature has been programmed, so that a unique value is obtained as a reference value to compare to allowable temperature of track
- The model has been verified by comparing simulation results with measured ones obtained in the measurement campaign in October-November 2014. Correlation is very satisfactory and, thus, we are confident that the model provides accurate predictions of temperature increases due to the use of ECBs
- The structural model has not been further developed, due to the lack of data to correctly represent the ballast and sleeper
- Nevertheless, literature review has shown that previous work was done commissioned by the UIC and ERRI and that maximum critical temperatures of tracks were already calculated (with the help of CWERRI program) and a safety criteria established

Therefore, infrastructure operators already know or could calculate the allowable temperatures for their tracks and a structural model was no further needed in order to establish safety criteria regarding lateral stability of CWR tracks

Significant achievements

- The thermal model is fully developed
- It is a three step model: preprocessing – with a routine in excel -, solver (based on FEM technique) and post-processing It is a three-step model:

1) In a first step thermal inputs due to different parameters are calculated. Considered parameters are: type of rail (cross-section), velocity of trains, braking force, configuration of train (number and position of ECB-equipped bogies), and traffic details (number of trains per hour)
2) FEM calculation, where conduction (propagation of heat through the cross section) and convection (evacuation of heat through lateral surfaces) are evaluated. Within the FEM model the dissipation of heat can be controlled by establishing two parameters: heat transfer coefficient (dependent on the velocity of air acting on the rail) and ambient temperature
3) A post-processing step, where temperatures in the cross-section of the rail are obtained. Temperature evolution in the cross-section and as a function of time is the result provided by the FEM solver; nevertheless, a routine to calculate the average temperature in the cross section has been implemented, in order to obtain a single value for the whole cross-section. Discussions with infrastructure partners led to that average value, which is similar to the value in the middle of the web (the weakest part of the rail concerning lateral buckling)

- Results of the model are temperature values (as a function of time – it is a transient study) at a variety of points in the cross-section of the rail. The model provides lots of information about the evolution of temperatures in time and in the cross-section
- The model has been validated, by comparing simulation results to measurement results of WP5

- A tool that predicts temperature increases due to continuous use of ECBs is now available. Influence of braking force, velocity of trains, train composition, number of ECB-equipped bogies, presence of air cooling the rails and traffic can be considered and evaluated
- Predicted temperature values can be added to other contributions and compared to already known allowable temperatures of tracks in order to evaluate the risk of lateral buckling of CWR

The risk of lateral buckling has not been evaluated by means of a structural model. A structural model, based on Timoshenko beams, was already built, but in order to provide accurate results data to model the ballast was required. A literature research conducted to previous work already developed by the UIC and the ERRI were values of maximum critical temperature and average temperature (together with safety criteria) had already been calculated for different types of tracks. Furthermore, infrastructure operators have already defined which the maximum allowable temperatures in their rails are according to the type of track. Their interest, thus, is focused on temperature increases due to the use of ECBs, that will be added to other temperature increases in their rails (due to solar gain, maintenance jobs, etc) in order to compare the final value with the maximum allowable temperature for a specific track.The thermal model developed has been validated by confronting results from simulations with temperature measurements performed in WP5. Results of the first test-run of each night have been compared, with errors below 1ºC. Moreover, subsequent temperature evolution due to cooling and new test-run has also been successfully predicted by the model.

Task 3.3: Integration and verification of the different domain models into the ECUC holistic model (Months 14-32 (Oct 2013 - April 2015))

Progress towards objectives Significant achievements

The risk of lateral buckling depends on the temperature increases that the use of ECB produces. They have to be seen as a further contribution to the heating of rail, as the rail could already be at temperatures over the stress-free temperature due to atmospheric conditions (sun radiation). It is highly interesting to be able to predict in advance the temperature increases in the rail due to the continuous use of ECBs.

The thermal model developed in task T3.2 allows obtaining the average temperature increases in rails due to the use of ECBs, as a function of train velocity, braking capacity (current ECB and air-gap), train composition and number of trains circulating per hour. Although the model provides temperature field in the section, average temperature seems to be the one that better reflects the possibility of buckling.

Average temperature increases due to the use of ECBs should be added to other contributions and compared to the maximum allowable temperature of each particular track, a value known by the infrastructure operators and that could be tabulated (as it is in United Kingdom).

A particular track has been selected, with a known train circulation (four trains per hour). Different scenarios have been simulated, varying the velocity of trains and the braking capacity.

At the same time, possible interference between ECBs and axle counters can produce false positive readings in the latter. In T3.1, an EM model has been defined to predict worst case interference conditions at high frequencies. By studying the results under same train speed and brake force as in the temperature analysis conclusions can be extracted in a comprehensive way which includes comparisons with the temperature model and highlight the bottle neck for worst case conditions: either temperature or emissions. Given that the corresponding models (thermal and electromagnetic) cannot be run on the same software tool (Abacus and CST respectively), it has been decided to perform the analysis separately under the same operating conditions.

In this task the main purpose of Frauscher was to analyse the simulated parameters generated by CEIT for test cases constructed in the holistic model. These parameters were used in conjunction with an LTSpice model to calculate the wheel sensor currents which could then be used as a direct comparison with track test or laboratory data recorded in WP5.

Significant achievements

In the present task, a comprehensive approach to address worst case conditions is addressed. This comprehensive approach includes thermal and electromagnetic analysis for the same case studies. The case studies are described by speed of the train, braking force (current of the power supply to the ECB), air gap, number of trains per hour and train composition. The last two parameters only affect the thermal outcome on the rail. The first three also affect the electromagnetic interaction. High frequency AC radiation will be analyzed from this point of view. By comparing side by side the outcomes, for each case study, the most critical aspect could be selected.

The highest temperature increase is produced at 120km/h, at full braking capacity. A maximum temperature increase of 18ºC is predicted, which is close to the maximum allowable temperature of the selected track (+25ºC). If atmospheric conditions are such that there is already a rail temperature over the stress-free temperature, the track might be at serious risk of lateral buckling. Braking strategy should limit the braking capacity as a solution, decreasing it to produce more reasonable temperature increases.

From the emissions point of view, even if a particular measurement can indicate tendencies when speed or braking force independently change, the extraction of the values that the model provide for worst cases does not signal any clear evidence about the change in impact on the axle counter that have been studied (ZP43, RSR 180, RSR 123): worst case conditions remain approximately constant with speed and braking force. However further analysis should be performed to extract more detailed recommendations.

The calculation of each effect of interaction now gives engineers the possibility to build a complete model including the superposition of the three effects.

Task 3.4: New generation ECB (Months 14-32 (Oct 2013 - April 2015))

Progress towards objectives

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.

Significant achievements

The concept of a modularized structure of an ECB showed that an easier implementation of an ECB in different types of bogie is then possible. A reduction of the specific mass (ratio mass to performance) of the ECB was achieved. The expected magnetic stray fields were calculated by use of a new method of FEM modelling and solving.

Also the improvement of lower electromagnetic interaction could be shown by 2 examples.

The localisation/position and the type of power supply plays an important role for easier integration of an ECB in rolling stock.

Any deviations from the project work programme/Annex I (DOW)?
External resources were needed to support the design and simulation processes for T3.4 as explained in section 4.2.1.
The following table sets the date of the deliverables in relation to the expected dates

Deliverable	Expected date (initial Dow)	Submission	Comments
D3.1	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.2	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.3	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.4	30.04.2015(*)	30.04.2015	

(*) Date according to the latest version of DoW, amended from initial version

(**) Date according to extension of the latest Dow date agreed with the PO

Reasons for deviations, their impact on other tasks and available resources and planning.

In T3.4, there were difficulties with the design of the new ECB and with internal resource limitations. Impacts on other tasks were minimal

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

Even if the DOW and the project results have not been affected, a comment on the described model in WP3 should be made. The holistic model (Electromagnetic and Thermal) that was described in T3.3 has changed the focus towards modular models. It was observed over the progress of the project that integrating both models into the same software platform was not possible due to incompatibilities between the EM platform (CST) and the thermal one (Abaqus). Therefore electromagnetic and thermal influences were therefore considered separated in a modular wise approach. However, train operational conditions were the common source in the electromagnetic compatibility case and in the rail temperature case and therefore they set which one is the bottle neck for non-interoperability in T3.3. From this point of view, the model can be considered holistic. The impact on schedule, on other tasks as well as on available resources and planning has been negligible.

Propose corrective actions.

The models (Electromagnetic and thermal), although considered running separately, should have the same initial conditions.

WP4: Definition of Representative Worst Case Conditions

Table 3. Work Progress and Achievements of Work Package 4 (WP4)

Work package number	WP4		**Start date or starting event:**			Month M18				
Work package title	Definition of representative worst case conditions									
Activity type	RTD									
Participant number	1	2	3	4	5	6	7			
Participant short name	CEIT	KB	ALSTOM	SNCF	DB	NRIL	FRAUSCHER			
Person-months per participant	7	11	1	3	3	2	3			

Objectives

The main objective of this WP is to define the conditions that maximize the emitted interferences created by the ECB system. The conditions should not only be set on the basis of known worst situations but on a thorough understanding of all the possible situations, by means of the model of WP3. Realistic representative worst case conditions have to be established, and they will then be the inputs for the requirements for the test site, test procedure and test setup, which will be developed and executed in WP5.

Task 4.1: ECB operational conditions: definition of the worst case conditions regarding operational conditions of ECB.(Months 18-26 (Feb 2014 -Oct 2014))

Progress towards objectives

Several meetings have been made to establish the worst case conditions concerning operation of ECBs. Investigations have been performed for the airgap measurement through the partnership with AEF (Agence d’Essais Ferroviaire).Realistic representative worst case conditions have been established, and they are the inputs for the requirements for the test site, test procedure and test setup, which is developed and executed in WP5.

The worst cases regarding operation result from the

- Operation cycle
- Environment
- Approval for use

Regarding maintenance, the worst case is if the air gap is not proper adjusted.

KB supported with its own experience of service, calculations and steps of improvement for ECB.

Significant achievements

Based on the analysis of the functional, mechanical and electrical aspects of using an Eddy Current Brake, worst cases were simulated and described: one part in relation to the collection of loads for a test procedure of a fatigue test considering worst case conditions and others in relation to the infrastructure –split into track and EMC - and rolling stock –split into power supply and bogie interface - from the point of view of operational conditions of ECB.

Once of the main outcomes of this WP is the conclusion of avoiding ballasted tracks for tests. Regarding maintenance the worst case is if the air gap is not proper adjusted.

The identified worst cases led to a well adapted test program, see WP 5.

The collection of worst case condition builds an important basis of requirements, especially for calculation of safety margins and the verification by laboratory tests. They are very useful for the validation of functionality under nominal operation conditions.

Task 4.2: Signalling systems: definition of the worst case conditions for signalling systems. (Months 18-26 (Feb 2014 -Oct 2014))

Progress towards objectives

The outcomes of this task are based on knowledge of known worst case situations and a thorough understanding of all possible situations by means of the information gleaned in WP2 as well as models and simulation results from WP3.

The worst cases for signalling systems are divided in the tree different cases:

- Influenced systems (axle counters, wheel sensors, speed detection)
- Non influenced systems
- Possibly influenced systems

A number of factors depend on ECB operating conditions and can significantly influence axle counters. This may include emitted magnetic fields within the working frequency range of the axle counter in question and also high intensity, low frequency fields which cause local magnetic saturation of the rail or ferromagnetic components of the axle counter. These effects may operate independently or together to corrupt the axle counter signal.

NRIL contributed to the definitions of the worst case scenarios signalling systems by identifying a potential issue with respect the malfunction of track circuits using insulated rail joints under activated ECB.

KB supported with own experience of service, calculations and steps of development of ECB for lower interferences with signaling devices. Based on the analysis of the functional and electrical aspects of using of an Eddy Current Brake, KB simulated and described the conditions of the test of various signaling devices for passive interferences.

DB brought in their knowhow on worst case criteria to different subjects as e.g. mechanical design, brake layout or electromagnetic compatibility with signalling devices. The inputs were based on experience and operational knowhow as well as on technical and physical relations.

Significant achievements

A number of worst case situations could be identified:

High magnetic fields within the working frequency range of axle counters generated by:

- Noise present in the ECB power supply system
- Effects due to parasitic resonances of cabling or the bogie environment, e.g. ECB mounting position and separation
- High transient currents with significant duration
- Short distance between ECB and axle counter

Very high, low frequency magnetic fields which lead to saturation or change of the magnetic characteristics of the rail or components within the axle counter by:

- High operation current of ECB
- Short distance between ECB and axle counter

The additional interaction is relevant to large parts of the European infrastructure, so if resolved, it will help the roll-out of the new technology.

The collection of worst case conditions of interferences with signaling devices build an important basis for requirements and their verification by laboratory tests. They are very useful for the validation of functionality under nominal operation conditions and led to a well adapted test program, see WP 5.

Task 4.3: Rail head: definition of the worst case conditions for rail head (Months 18-26 (Feb 2014 -Oct 2014))

Progress towards objectives

For the infrastructure worst cases regarding

- Track, Rail heating
- Forces on track/rail
- Gauge
- EMC
- Management of rail temperature

Have to be considered

For the worst cases regarding rail head it has to be considered:

- Modelled Conditions (Track temperature limits, Max. brake power / trainset, Succession of trains, Speed limit, material of rail, weather conditions)
- Track limitations (ballasted or non ballasted)
- Test requirements

A battery of simulations with the temperature model developed in Task 3.2 have been conducted in order to identify the parameters that mainly affect the temperature increase in the rails.

Based on the report of design parameters of the Eddy current Brake, the maximum loads of brake and attractive forces which interact with the track were simulated and described. Based on the analysis of the density of Eddy currents in the rail and the physical process of conversion from brake force into heat, worst case conditions of rail heating needed to be defined. It has been established that the worst case conditions are those at which braking forces are the highest and for intense traffic.

Cooling of the rails is an important factor affecting the temperature increases in the rails: if the heat transfer coefficient is high (high speed wind) and time between trains is also high, the rails will cool and temperature increases will be very well under expected limits

Nevertheless, it is unlikely that high speed winds act on the rails as other aspects of stability of the vehicles would be affected, and, thus, the scenario of no wind/very low speed wind should always be adopted. Only the ambient temperature (cooler than that of the rails) affects the evacuation of heat

NRIL contributed to the definition of the worst case scenario for track by providing a report on how to best measure rail stress. In addition, NRIL provided the Operation's guide to Verse – a non destructive method of SFT measurements. NRIL's feedback as an infrastructure manager were taken into account and helped the project's presentation of the model outputs in a more user friendly manner. NRIL was responsible for the report under T4.3, which captured all of the above.

KB supported with the results of magnetic field calculation, especially the density of current in the rail and the magnetic saturation of railhead.

Significant achievements

The identification of the main parameters for a precise model of thermal calculation of rail and the relevance of longitudinal stress of rail are ones of the main outcomes of this task. The following interesting conclusions could be extracted, concerning temperature increment in rails due to the repetitive use of ECBs:

- Increasing braking force has a direct impact in the temperature increment that the rail will suffer. The braking force is also function of speed of train, following a curve that presents maximum braking forces at velocities around 120km/h. Therefore the maximum temperature increments occur at a velocity of 120km/h and decreases slightly till 300km/h.Regarding temperature increments, the model has shown

- The second more influencing parameter in the temperature increments is the frequency of trains. As expected, if frequency of trains is increased the temperature of rails also gets higher, as time for cooling the rail decreases. Nevertheless it is not a linear relationship: the temperature increases very rapidly when the time interval between trains is smaller than 10 minutes (more than 6 trains per hour)

- The air acting on the rail for cooling is also influencing the final temperature. If the speed of wind is very low or still air is considered, the heat transfer coefficient adopts a small value (15 Watts/m^{2}K, according to literature); if high speed air is to be considered, the heat transfer coefficient is an order of magnitude higher (100 Watts/m^{2}K). Differences in temperature increases for different braking forces and traffic estimations are significant. Nevertheless, from worst case point of view, the case of low speed wind/still air should be considered. Furthermore, it is very unlikely to find high speed winds acting on high-speed railway rails, as it could also affect the vehicle and its dynamic behaviour (circulation on track); tracks are almost always insulated against the action of winds

- The rest of parameters, such as train composition are not so critical regarding the temperature increase of rails and could be skipped.

Task 4.4 Rolling stock: definition of the worst case conditions for rolling stock. (Months 18-26 (Feb 2014 -Oct 2014))

Progress towards objectives

The main objective of this task was to define the worst case conditions produced by an ECB regarding rolling stock. The definition of worst case conditions for rolling stock considered operational conditions and interactions with the infrastructure.

The worst cases of train/ECB result from the

- Speed
- Power supply/consumption
- Thermal limits
- Mechanical forces

- Consideration of the design of bogie and the brake control system.

The worst cases for rolling stock have to consider the design of bogie and the design of the brake control system

Based on the output of the previous tasks (mainly tasks 2) a document was proposed by DB integrating all the conditions leading to the possible worst cases. This part has been reviewed by Alstom to complete this analysis from a system integrator's point of view.

Significant achievements

Based on the analysis of the functional, mechanical and electrical aspects of using of an Eddy Current Brake, worst cases were simulated and described.

The Deliverable D4 (integrating D4.1, D4.2, D4.3 and D4.4) has been issued on time.

The output of this tasks are keys for the definition of the engineering guidelines that are the inputs of the tasks of WP 6.

The identified worst cases led to a well adapted test program, see WP 5.

Based on the definition of worst case conditions a safety margin can be defined.

Any deviations from the project work programme/Annex I (DOW)?

Following further discussions within ECUC partners it has been considered that it was worth integrating all the worst case conditions collected for the different parts of the railway system into a single document (deliverable). This decision has been approved by the project officer. The results have been therefore integrated into a complete document covering T4.1, T4.2, T4.3 and T4.4. The Deliverable D4 has been issued on time.

Reasons for deviations, their impact on other tasks and available resources and planning.

It was seen over the course of the WP that it was very difficult to set worst case conditions separately for each of the parts involved: ECB, rolling stock, signalling devices…as some parts have an impact on the others. In order to avoid duplicities, a comprehensive deliverable of this WP was submitted after making the consultation to the project officer. No impact on other tasks and available resources and planning was made.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

The main test runs of these campaigns (WP5) were concluded by November 2014 due to the difficulty to coordinate such an extensive and complicated campaign, with so many agents involved. The time consuming post-processing did not finish before March 2015. In this manner, WP3 had to wait for WP5 results to validate the model. This happened well into 2015 whereas WP4 (the one corresponding to set worst case conditions) was finalized in 2014. WP4 therefore was fed basically by WP2 and WP5 and the impacts of the worst cases were analyzed by WP3.

Propose corrective actions.

Worst cases were set by a combination of experiences and testruns and the model (WP3) contributed to estimate the increase of emissions and temperature that can be achieved by these known worst cases.

3.3 WP5: Test Site, Test procedure and Test Setup Design and Implementation

Table 4. Progress and Achievements of Work Package 5 (WP5)

Work package number	WP5		**Start date or starting event:**		Month M18				
Work package title	Test site, test procedure and test setup design and implementation								
Activity type	RTD								
Participant number	1	2	3	4	5	6	7		
Participant short name	CEIT	KB	SNCF	DB	FRAUSCHER				
Person-months per participant	10	7	1	11,5	4,5				

Objectives:

The main objective of this WP is to define the test site, test procedure and test setup for the measurement of the ECB emissions and thermo-mechanical behaviour and to carry out the relevant laboratory and line tests. These tests will be divided in two main groups. On the one hand, the tests will be carried out in the laboratory and on the other hand, a train equipped with ECB will be tested in the track. In both cases the contributors will need to measure three types of physic parameters: EM signals, temperature and mechanical parameters. An assessment of track geometry before and after the tests is also foreseen, concentrating on the evaluation of the potential geometric defects that ECB might generate.
There will be a short test campaign, mainly in the laboratory, to assure the new generation ECB and a longer one where more parameters will be measured.

Task 5.1: Laboratory tests. Definition and implementation of the test site, test procedure and test setup for the performance of the ECB; realization of the tests. (Months 12-32 (Aug 2013-Apr 2015))

Progress towards objectives

Given the signalling laboratory tests to validate simulation results with parts of existing types of Eddy Current Brakes and also the new generation of Eddy Current Brake, KB, CEIT and Frauscher addressed the task of post processing and comparison with the simulation results in this period 2. The laboratory tests started with the existing ZP43 test bench on which the RSR123 and RSR180 were included in order to test the interaction between ECB and these types of axle counters. An important goal was the validation of simulation results of the EM model of the ECB developed in WP3. In order to do this, transfer functions from several ECB poles were compared with the simulated fields generated in the model. During active braking, the high magnetic fields cause saturation of parts of the ECB itself and the effect this has on the emitted radiation was also compared with simulated results. Another effect evaluated was the low frequency interaction with signaling devices. In laboratory the magnetic stray field density around the ECB was measured with different levels of magnetization. It was verified that by the simulation model developed it is possible to calculate the maximum of magnetic stray field depending on the speed and position of ECB in reference to the rail.

Based on the results of T3.4, a concept prototype for a possible next generation Eddy Current Brake was developed and tested in laboratory. The ECB frame of this next generation of ECB is described by modularization of main parts. For example, the new ECB magnet is built as a self-sustained body modularized by the main part of Integral-beam, angled screw couplings and an integrated support beam.

As an important objective, realization of the test procedures and test sites were developed for electromagnetic and mechanical verification tests. Based on the collection of information from WP2, WP3 and WP4 it was possible to create test procedures to identify of proper function or malfunction of signalling device or subsystems of ECB.

Additionally, the reduction of interference between signalling devices and the magnet body of the existing Eddy Current Brake as well as the new Eddy Current Brake (passive effect) was post-processed in a vast number of cases.

Apart from the tests with signalling devices, KB defined the description of mechanical fatigue tests.

KB supported the partners in preparing and carrying out of laboratory tests. KB split the tests in electromagnetic and mechanical tests.

Significant achievements

The significant achievements in this task have been:

- The transfer function of single and multiple poles of the ECB have been determined in order to validate simulationsThe passive effect of several shielding designs of a new ECB type has been measured
- Postprocessing and selection of results
- Good correlation in the verification of FEM calculation of low-frequency magnetic fields. The possibility to carry out worst case conditions tests in laboratory was proven.
- Reduction of the level of interference between signaling devices and the magnet body of the existing Eddy Current Brake as well as the new Eddy Current Brake concept idea. Based on the learnings, variants of prototypes of shield parts were designed and procured. By laboratory tests a systematic step by step optimization was carried out. The results of these laboratory tests showed a reduction of interference – passive interaction – by the full metal cover of the new Eddy Current Brake. And this reduction was shown to be applicable for both groups of wheel sensors and wheel flange sensors.
- Reduction of interferences (passive effect) was proven between the coils and wheel sensors.

For EM tests, three interactions were tested: passive (disconnected) ECB in the presence of a signalling device that could be detected as a false wheel, low frequency interference (Hz) due to a DC source on the move, and high frequency interference (KHz) due to harmonics coming from the power supply.

For the passive case, the analysed axle counters can be divided in 2 groups.

RSR180 and RSR123 by Frauscher have the magnetic stray field at one side of the rail. They exhibit these common features:

- There is no observable difference between ECB 154 R L4 and ECB 154 R L5
- Changing the value of the impedance loads of an ECB has no effect on interference.
- The ground connection to the ECB magnet is irrelevant.
- The greatest interference appeals in the position of maximum negative latera displacement and the minimum of air gap.

ZP-43 is an example for the other group of sensors that have a magnetic stray field around the rail. In this case:

- The maximum of interference appears in the central position of rail of the ECB magnet.

- The impedance load has an important influence of the level of interference. The design of EWB L5 gives a higher immunity against changes of impedance loads and a greater secure signal-noise ratio.

The new ECB configuration 1-2-3-4 shows with all 3 types of analysed axle counters the lowest level of interference. A common consequence to all ECB is that it is possible to add massive metal bodies surrounding the ECBs to protect signalling devices against disturbing interferences.

For the low frequency interference the worst case conditions of maximum magnetic stray field density are divided in two areas below top of the rail or above top of rail. Based on the magnetic flux density it is possible to define a threshold in frequency range from static up to 500 Hz.

For the high frequency measurements, some conclusions can be extracted:

- The resonant frequencies of poles with iron core are lower than without iron core.
- The resonant frequencies of poles type /L4 (45.0 kHz) are lower than type /L5 (56.5 KHz).
- The peaks for maximum resistance (6 KΩ) and reactance (3 KΩ) are lower than their no-core counterparts by a factor of 6.
- The saturation of the core appears to have little effect on the magnetic stray field intensity from 10 KHz to 1 MHz. A small increase in field intensity with increasing saturation is perceptible and is typically < 2 dB. As a consequence a threshold could be independent from brake force of ECB and could be verified easier.

Fatigue test and attraction force characterization is also described. Based on test of components the concept of new ECB with a self-sustained magnet beam is feasible. As an overall conclusion, defined test sites, test set ups and test procedures can be the starting point to be considered by standardization bodies.

Task 5.2: Track Tests. Definition and implementation of the test site, test procedure and test setup for the performance of the ECB; realization of the tests (Months 15-32 (Nov 2013-Apri 2015))

Progress towards objectives

DB planed, adjusted, organized and executed extensive line tests with an ICE 3 train, equipped with different types of eddy current brakes and an onboard measurement system for recording the current in the electrical path of single eddy current brakes. Numerous testruns with different operating parameters (speed, brake force, ECB air gap) were performed in the high speed line Nürnberg-Ingolstadt, in October-November/2014. DB and Frauscher mounted and recorded data for several different types of wheel sensors on both sides of the rail to measure the influence of the ECB on the specific sensor type. Additionally, Magnetic Noise Receivers (MNR) were placed at typical mounting positions of wheel sensors, as defined in CLC/TS 50238-3, to record high frequency magnetic fields between 10 kHz and 1.3 MHz. Furthermore a significant number temperature sensors and force sensors have been installed along the test track section. The data was then collated, analysed and used in conjunction with measurements from D5.1 to test and verify the models and simulations.

Investigations have been also performed for the airgap measurement through the partnership with AEF (Agence d'Essais Ferroviaire).

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 successfully in August/2015.

The numerous measurement data – which have been used for the verification and validation of the simulation models as well as for the deviation of technical solutions - were prepared, analyzed and evaluated by DB as well as by Frauscher and CEIT.

KB participated in design, planning, implementation and carrying out of running tests. KB prepared eight plus two ECB magnets of EWB154 R /L6 and 4 ECB prototype magnets of the new generation brake. These new generation magnets were only tested with respect to their passive effects.

Significant achievements

The significant achievements during the track tests are:

- The successful coordination and implementation of all test runs
- Wheel sensor data and MNR data collected and analysed
- Recorded data series dependent only on one variable, e.g. speed.
- Results of the running tests showed the comparability between laboratory tests and running test. The measurement results correspond very well with the simulation results.
- The evaluation of the measured magnetic field emissions with the measured axle counter output signals (higher frequency influences in the area of the working frequencies of the single axle counters, lower frequency influences generated by the energized ECB-poles) has shown a very good correlation. This means that in future an authorization process for ECBs/axle counter could be realized by measurement and evaluation of the magnetic field emissions of vehicles equipped with an ECB (low and high frequency range).
- The validation of the function under nominal conditions could be finished. This showed that the procedure consisting of design and simulation by FEM, verification of functionality including worst case conditions and the verification of nominal functions in nominal conditions can be used for an easier and shorter process from the start of the development to the approval for EMC.

Any deviations from the project work programme/Annex I (DOW)?
The following table sets the date of the deliverables in relation to the expected dates

Deliverable	Expected date (initial Dow)	Submission	Comments
D5.1 and D5.2	31.10.2014(*)	23.12.2014(**)	Availability track measurements
D5.3	30.04.2015	25.06.2015(**)	Second public version of the deliverable
D5.4	30.04.2015	31.08.2015(**)	Large amount of data processing

(*) Date according to the latest version of DoW, amended from initial version

(**) Date according to extension of the latest Dow date agreed with the PO

Reasons for deviations, their impact on other tasks and available resources and planning.
The submission date for the deliverables of WP5 are the ones shown in the table above. The processing of a huge amount of data coming from the rail testruns took more than expected and an extension was requested to the project officer. Likewise, the extension granted for D5.4

enabled the chance to include track circuit measurement campaign results (August 2015). This last measurement campaign was difficult to arrange and definitively not possible to merge with the main one in October/November 2014. One of the main challenges that ECUC project had to face was to manage external circumstances, like railway strikes, compatibility of measurements with running services and procedures etc. As WP3 was extended in the first amendment, this WP3 did not suffer particular delays due to the information required from WP5. In this context, from the initial planning of work effort of the project, CEIT required more PM in WP3 and less in WP5. Several modifications of the model of WP3 were done even after the submission of this WP3 deliverables.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

A technical problem arose when several synchronization systems failed in the measurement campaign on track (November 2014). Synchronization systems were studied to assign specific measured signals on board (input) with radiated signal on track (output). Several systems were tested: a time server by UMTS failed due to the low time resolution of the OS of the computer that was used. A laser system (as back up solution) also failed when installed in the train. Furthermore a GPS-based system was also tested with no good results. Furthermore, the time reference embedded in the files was lost when transferred from one storage unit to another and no file to file synchronization was possible either.

Propose corrective actions.
As a contingency plan of the previous event, the model was tested with several non-synchronized signals to check the extent of uncertainty in time. The outcomes showed virtually no variation with time and, therefore, the time interval for the comparison was chosen manually for all cases with very good agreement between simulated and measured results as shown in D6.5.

3.4 WP6: Technical Recommendations and Design, Engineering and Operational Guidelines

Table 5. Work Progress and Achievements of Work Package 6 (WP6)

Work package number	WP6		**Start date or starting event:**			Month m29				
Work package title	Technical Recommendations and design, engineering and operational guidelines									
Activity type	RTD									
Participant number	1	2	3	5	5	7				
Participant short name	CEIT	KB	ALSTOM	DB	NRIL	FRAUSCHER				
Person-months per participant	8	8	2,50	12	3	4,50				

Objectives
This work package will define, by one hand, the design, engineering and operational guidelines of the operational ECB, its installation, the tracks and the signalling systems and, by the other hand, provide an input for the issue of a Project Technical Recommendations for the ECB and the infrastructure (signalling systems, tracks,…).

Task 6.1: Development of the design, engineering and operational guidelines for eddy-current brakes.(Months 29-34 (Jan-Jun 2015))

Progress towards objectives

Based on the heuristic model and the collection of requirements including the worst case conditions an engineering guideline for ECB was created. A common way of description of the interfaces and the requirements was defined. The interfaces were defined to also respect the interaction between rolling stock and infrastructure. As a consequence of the high number of load cases, dependence on functional requirements, different worst case conditions and their combinations, the common requirements were based on nominal values. The overloads were defined to be considered by means of a safety margin. The value of the safety margin should be defined by both parties of the interface. In relation to the safety procedure, all requirements are described by a test case for verification and validation.

The analysis of interactions of signalling devices by the heuristic model of the three general effects (passive interaction, low-frequency and medium- and high-frequency) and their superposition gives the opportunity to complete and optimize the standards of EMC for signalling devices. Furthermore it allows to create thresholds for the design of the ECB itself.

The engineering guideline is oriented towards the structure of EN16207 for magnetic track brakes.

The deliverable D6.1 contains requirements, for design, power supply, monitoring and diagnostics, performance and EMC and the description of interfaces of train and infrastructure. Type test and serial test procedures were explained for verification and validation in this document.

Significant achievements

- The design and definitions of interfaces should be carried out based on nominal values.
- The definitions of the forces of interfaces should respect tolerances of 15%.

- Worst Case conditions should be measured in laboratory as far as possible. Running tests should be applied to evaluate the functionality only at nominal conditions.
- Present evaluations by manufacturers of signaling devices should be prospectively integrated in European Standards and prospectively could build EMC requirements of design of ECB.
- From the other perspective: requirements resulting from the operation of an ECB (e.g. high magnetic fields in the lower frequency range) should be defined for the design of signaling equipment (e.g. axle counter).
- Expansion of the operational area for using ECB as service brake on ballasted tracks with simple temperature management.
- The national infrastructure registers should include information about ECB compatible tracks (signalling devices, type of track and additionally allowed increase of temperature by track brakes, track equipment)

The engineering guideline is oriented towards the structure of EN16207 for magnetic track brakes.

Task 6.2: Development of the design, engineering and operational guidelines for the installation of ECB in the vehicle: (Months 29-34 (Jan-Jun 2015))

Progress towards objectives

All the available information collected during the project has been compiled. Additional information has been provided by DB and KB.

It has been demonstrated that ECB Eddy current brake cannot be considered as a simple product which is easily installable in a train. In fact it is a complete system both at local vehicle level as it requires the combination of the ECB specific parts working together with traditional brake control and the traction systems, but at train level.

Design, engineering aand operational guidelines have been developed that could support the implementation of such sophisticated system in trains designs different from ICE3. These guidelines are set to support the designer work for reminding the critical steps to be studied that involve the interfaces and the design of the main sub systems of the train: Overall system, traction, braking, TCMS train control and monitoring system), and mechanical (bogie) design.

Significant achievements

So far the only existing installation of Eddy Current brake systems has been made on the ICE3 trains of Deutsch Bahn. In order to investigate the compatibility issue of the ECB system, it has been felt that guidelines should be proposed to help the train designer teams to tackle the installation on other trains.

Eddy current brake cannot be considered as a product which is easily installable in a train. In fact it is a complete system both at local vehicle level as it requires the combination of the ECB specific parts working together with traditional brake control and the traction systems, but at train level, and especially when it is intended to use the ECB for service brake, a very sophisticated blending between the different available brakes (electro-dynamic brake, friction brake and eddy current brake) has to be implemented. Therefore it is, in fact, required the complete train brake system to become an eddy current brake system.

The availability of the eddy current brake is a key issue. Obviously this is first due to the availability of the ECB itself that could be impacted due to any failure (even with the best proven design, this can always happen in such a sophisticated system). But there are other reasons that could lead to prevent the use of the ECB:

- restriction due to the track capability to the ECB use,
- restriction due to potential overheating of the rails (due to ECB effect added to a high ambient temperature) that could create a risk of buckling of the track
- too much use leading to overheating of the device,

To cope for all these conditions (some of them being operating rules) the train brake management has to manage the blending between the different brakes to ensure the train braking capability. The dimensioning of the other brakes has to take into consideration additional duties in case of ECB unavailability. The transmission, in a reliable/safe way, of this train braking capability to the signalling (ETCS) system has to be ensured as well.

The proposed guidelines give ideas to build to corresponding blending strategies.

Other guidelines in this task are described for approaching the physical interfaces with the other train subsystems, and working on the monitoring and diagnosis issues.

An easier implementation of ECB is a key issue in future.

Task 6.3: Development of the design, engineering and operational guidelines for signalling systems.(Months 31-36 (Mar 2015- Aug 2015))

Progress towards objectives

Measurement data from the laboratory and track tests along with results from the ECBs and wheel sensors that have been modelled and simulated have been fused to generate a number of recommendations and guidelines. The interactions studied are specific to the ECBs and wheel sensors within the project and are therefore specific to the technologies used. It is therefore difficult to make general extrapolations which are valid for all wheel sensors and ECBs on the market using other technologies. Recommendations have been made regarding magnetic field emissions at frequencies greater than 10 kHz with regard to both braking force and speed based on worst case scenarios. These recommendations focus on methods to reduce the interaction and influence of ECBs on wheel sensors. In addition large, low frequency magnetic fields have been found to cause saturation of both rail and any ferromagnetic components found in the wheels sensors and hence there are recommendations advising against the use of such materials and also extended testing methods for wheel sensors. The link between original DB requirements for axle counters on routes which allowed the use of ECB and design change towards the use of non-ferrite coils is set.

Significant achievements

In the present task, a general overview of the emissions from the Eddy Current Brakes (ECBs) that potentially affect axle counter performance is shown. The transfer function between the AC current (harmonics) in the ECB circuit and the corresponding magnetic field intensity by the trackside is demonstrated to be virtually independent from the level of the magnetic saturation of the tracks and pole cores due to higher braking DC currents. Broadly speaking, the trend in the AC current amplitude is followed by the emissions regardless DC levels. It is observed that the level of emission is reduced with frequency. Therefore axle counters that should be compatible with ECBs are recommended to operate in the higher frequency band (300 KHz to 1.3 MHz). Dependency of emissions on braking force and speed are analyzed. The action of increasing brake current translates in higher emissions in the 100 KHz- 250 KHz band. Axle counters are recommended to be tested at maximum braking force that is applicable to the ECB, if they are to operate within this band. In similar terms, axle counters are recommended to be tested at 120 km/h and 160 Km/h if they operate within this band. Otherwise, the test conditions in braking force and speed are not relevant.

Worst case lateral displacement of the ECB over the axle counter (-17.5 mm) introduces an estimated 5 dB increase of emissions when compared with common close to nominal lateral displacements. These results obtained by the model are set as reference in order to address the task of reducing them by ECB design (D6.5). A post-processing according to CLC/ TS 50238-3 of the worst case leads to the following main conclusions:

- Broadband emissions with ECBs are always exceeded.
- The number of values exceeding the limit neither depends on the speed nor the braking force for the considered axle counters (out of 100 KHz-250 KHz band).
- Within the narrowband analysis, the axle counters allocated in the lower band (10 - 100 KHz) are found to be prone to exceeding the limits. The emissions limits for the higher band axle counters (100 KHz- 1.3 MHz) are not exceeded.
- Three groups of axle counters can be differentiated:
    - Those whose limits are not exceeded by the presence of ECBs (higher band)
    - Those whose limits are highly probable of being exceeded (lower band: ZP 30, ZP 43, ELS 93, ELS 95) ranging from 27 to 48 KHz.
    - Those whose limits are probably of being exceeded (Lower band, D39 X-component, WDD39 X-component, D50 X-component)

If the limits are exceeded, it does not necessarily follow that ECBs and axle counters cannot jointly operate. The aforementioned standard does not refer to ECB emissions and internal electronics of axle counters which filter unwanted signals in current designs. Conversely, phenomenon may occur in which limits are not exceeded but joint operation is not guaranteed (e.g. RSR 180).

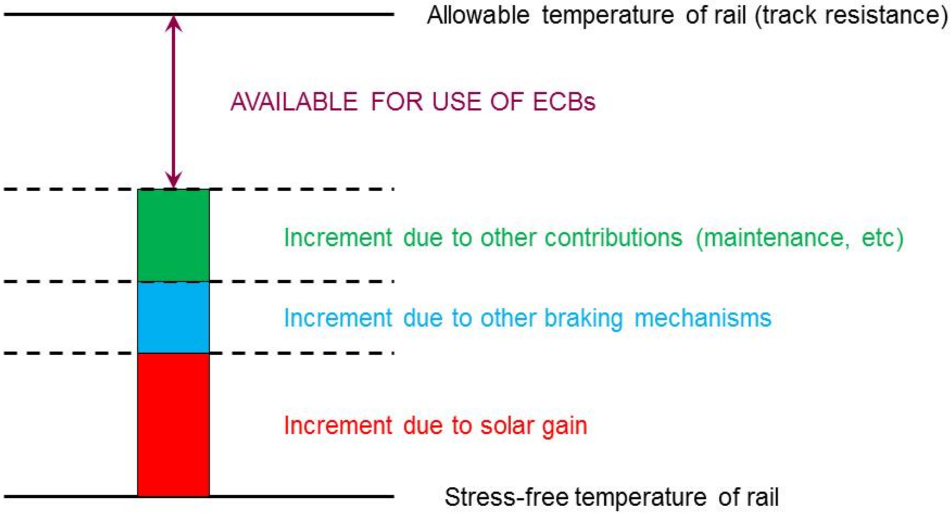
In relation to axle counter design, magnetic parts in systems are not recommended for compatibility with ECBs as they are saturated when the ECB is active and passing over the axle counter. An example of RSR 180 by Frauscher is shown. A distinction between ground dependant wheel sensors and wheel flange detection axle counters is made as the compatibility with ECBs strongly depends on this matter. In any case, compatible axle counters should be immune to an estimated 150 mT magnetic flux density B in the region where they are going to be installed.

The testing provides no evidence that there is an interference mechanism from ECB affecting the track circuits beyond what is already known and used for compatibility requirements in TS50238-2 and EN50617 (for new development).

Task 6.4: Development of the design, engineering and operational guidelines for tracks (Months 31-36 (Mar 2015- Aug 2015))

Progress towards objectives
Allowable temperature is defined as the temperature of rail which provides a margin of safety against a predicted likelihood of track buckling. It is a value already known by track operators for each particular track, dependent on its lateral resistance (type of ballast, sleeper, etc). All contributions to heat the rail above the stress-free temperature (the temperature at which there are no thermal stresses in the rail) increase temperature of rail, a temperature that has to be compared to the allowable temperature in order to be safe against lateral buckling of rails. These contributions have different origin: sun radiation (climatic conditions); maintenance of rails; and, of course, the use of Eddy Current Brakes. Rails are usually installed at their stress-free temperature, so that no initial compressive stresses are present. The procedure suggests to subtract from the allowable

temperature of a particular track temperature increases due to other contributions, not ECB (such as temperature increments due to climatic conditions, maintenance works, other braking systems, etc). Temperature increase due to the use of ECBs could not be over the gap left by the allowable temperature and the temperature of the rail after the rest of contributions are considered.
All guidelines regarding temperature increments in tracks due to the use of ECBs are based on results extracted from simulations with the temperature model developed in Task 3.2.



Temperature increments obtained here are to be used to establish the braking strategy according to the temperature gap described above. They are function of braking force (of whole train) and frequency of trains (traffic). On one hand, for a desired particular traffic situation the limit in the braking force of ECBs could be estimated. On the other hand, the frequency of trains could be determined for a desired particular braking force of ECBs. From safety point of view (as discussed in WP4) low speed wind is considered to be cooling the rails. These results, given in tabular and graphical form, are useful information for infrastructure operators in order to define braking strategies of ECB-equipped bogieIn this way, lateral stability of tracks will be guaranteed.

Other braking systems have not been included in the study and, therefore, the temperature increases are considered as if the train only had a braking system based on ECBs. That is, temperature increases reported here do not take into account the influence of other braking systems applied in the train. They should be considered apart from ECB braking system and their influence in temperature increase calculated separately and considered as an extra temperature increase of the rail (as climatic conditions would be).

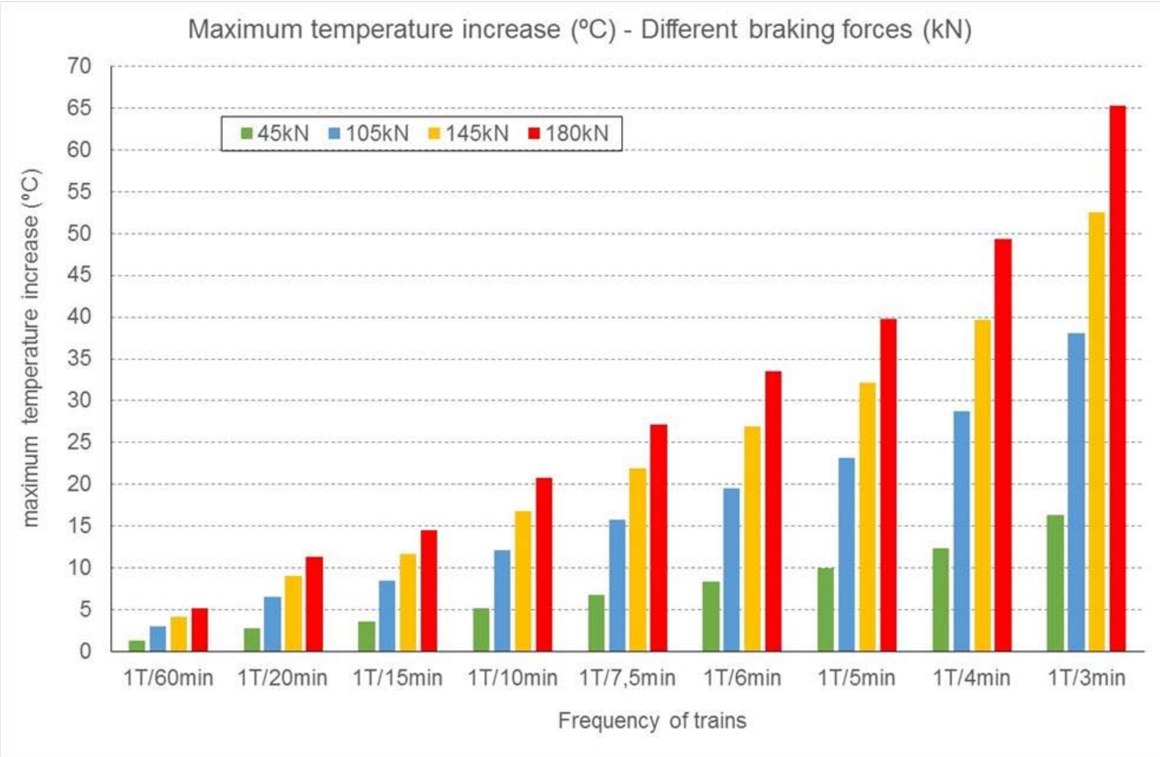
Significant achievements

Regarding temperature increments, the model has shown that increasing braking force has a direct impact in the temperature increment that the rail will suffer. The braking force is also function of speed of train, following a curve that presents maximum braking forces at velocities around 120km/h. Therefore the maximum temperature increments occur at a velocity of 120km/h and decreases slightly till 300km/h.

The second more influencing parameter in the temperature increments is the frequency of trains. As expected, if frequency of trains is increased the temperature of rails also gets higher, as time for cooling the rail decreases. Nevertheless it is not a linear relationship: the temperature increases very rapidly when the time interval between trains is smaller than 10 minutes (more than 6 trains per hour).

The air acting on the rail for cooling is also influencing the final temperature. If the speed of wind is very low or still air is considered, de heat transfer coefficient adopts a small value (15 Watts/m^{2}K, according to literature); if high speed air is to be considered, the heat transfer coefficient is an order of magnitude higher (100 Watts/m^{2}K). Differences in temperature increases for different braking forces and traffic estimations are significant. Nevertheless, from worst case point of view, the case of low speed wind/still air should be considered. Furthermore, it is very unlikely to find high speed winds acting on high-speed railway rails, as it could also affect the vehicle and its dynamic behaviour (circulation on track); tracks are almost always insulated against the action of winds.

- The procedure to evaluate the risk of lateral buckling involves knowledge about allowable temperature of tracks and temperature increases due to different contributions, among which the increase due to ECBs has a significant influence
- Tabular and graphical values of temperature increases due to the use of ECBs have been reported in order to evaluate their impact on lateral stability of tracks, see figure below as an example



- Several easy formulae are also provided in order to interpolate/extrapolate the results to values not in the tables
- Braking strategies should be adopted according to these results:
    - If allowable temperature is overtaken either the braking force or the frequency of trains should be reduced
    - For a desired frequency of trains, braking force should accordingly be reduced, although train operators should be that another braking system should be incorporated
    - For a desired braking force, the number fo trains per hour allowed to brake using ECBs should be reduced, in order to give more time to the rail to evacuate the heat

Task 6.5: Development of the Technical Recommendation regarding ECB new requirements and the test procedure of ECB in the vehicle (Months 31-36 (Mar 2015- Aug 2015))
Progress towards objectives
Based on deliverable D6.1, type and serial test procedures were extracted. The recommendations were separated in a way that is relevant to the TSI and to EN-standards. Furthermore, once worst case ECB emissions were estimated in D6.3, the present task presents ways to reduce the emissions by ECB design. Computations for the emissions in the new hypothetical cases are carried out with the aid of the model defined in D3.1 and improved in D6.3. They are compared with the worst case defined in D6.3. Just the study of a new filtering procedure of the output of the power supply and the ECB-circuit comprises 8 proposals. In relation to the safety procedure all requirements were described by a test case for verification and validation. The type test and the series test procedures, that allow to verify several requirements in the laboratory, were described. Also the technical recommendations related to signalling devices contain detailed proposals to supplement the Standards of EN50238, CLS/TS50238-3 and EN50617-2. The analysis of all deliverables provided the valuable input for the modification and supplementation of TSI requirements and for the filling in of open points in the TSI. Additional aspects were described which expand the opportunity for operation of ECB on conventional lines with ballasted tracks and equipped with ETCS. The recommendations and the test procedures were oriented towards the structure of EN16207 for magnetic track brakes.
Significant achievements

ECB general recommendations are presented below:

- The design and definitions of interfaces should be carried out based on nominal values.
- The definitions of interfaces should respect tolerances of 15%.
- The functionality at nominal conditions should be evaluated and worst case conditions should be measured in laboratory.
- Present evaluations by manufactures of signaling devices should be prospectively integrated in European Standards and could help define EMC requirements in ECB design.
- In the future the standardization group should determine an optimized geometry and position of measurement antenna for low frequency magnetic fields.
- The content of this engineering guideline is oriented towards the structure of EN16207 for magnetic track brakes.

It is also observed that the following techniques can be applied to reduce emissions:

- Improvement of the filter strategy, either by redistributing current filtering on critical points or by adding extra coils (e.g. like the ones corresponding to the actual magnet).
- Extending the cable length that goes from the traction container to the first magnet at each side by, e.g. 4 times.
- Decreasing the parasitic capacitance of the first pair of poles of the first magnet connected to the traction container (e.g. by decreasing the height of the poles).
- Feeding in parallel the aforementioned pair of poles.
- Shielding them by a metallic sheet.

Estimates of the reduction in emissions are presented in each case. For the most significant techniques, computations of the new estimative limits according to CLC/TS 50238-3 are added and the number of times in which limits are exceeded is compared to the previous worst case. Not all proposals are currently practical when addressing implementation, but they set a trend and several guidelines for future developments.

Enhanced recommendations for TSI, CLC/TS50238-3, prEN50592 and prEN50617 part 1 and part 2 are also included in this task.

Task 6.6: Development of Project Technical Recommendations for Interoperability for the rest of the systems disturbed by ECB. (Months 31-36 (Mar 2015- Aug 2015))
Progress towards objectives
It was the aim of the ECUC project to gain an extensive knowledge on the interaction of the ECB with the infrastructure and the physical effects behind and to derive – based on this knowledge and understanding – inputs for the design and the use of ECB as well as for components installed at infrastructure side and to define first requirements for an interoperable authorization of vehicles equipped with an ECB. Therefore within the ECUC project numerous simulations and measurements - in the laboratory, on the train and on the tracks - have been carried out. The measurement results could successfully be used for the validation of the realized simulation models and for the assessment of the influence of eddy current brakes on the infrastructure. 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.
Significant achievements

One significant point is the influence of the ECB on track side installed signalling systems like axle counters and wheel sensors. In the frequency range from 100 kHz up to 1.3 MHz the magnetic field emissions are far below the defined limit levels. Single axle counters and wheel sensors (mainly working within band 1 (27 kHz – 52 kHz) of the frequency management defined in the interface document of the TSI CCS) show higher frequent influences (noise). These influences correlate very well with distinctive magnetic field emissions occur within the frequency bands of the disturbed axle counters (magnetic field emissions near or partly - only for one axle counter type - above the limit levels defined in CLC/TS 50238-3 [3]).

Changes in main parameters as e.g. ECB current or running speed does not have a very significant influence on the magnetic field emission of the ECB in the observed frequency ranges.

The evaluation of the output signal of the axle counters and wheel sensors shows that, based on the high magnetic field emissions generated by each ECB-pole and the corresponding saturation of the rail, the curves of the output signals differ – in the influencing area of the ECB - from the typical shapes. But all investigated axle counters and wheel sensors work correctly.

It is observed that the level of emissions is reduced with frequency. For ECB compatibility **it could therefore be easier for axle counters to operate at higher frequencies as e.g. above 300 kHz**. It was also shown in D6.3 and D5.4 that CLC/TS 50238-3 limits are prone to be exceeded in the lower band axle counters (10 KHz – 100 KHz). However, **if the limits are not complied with, it does not necessarily follows that, in these cases, ECBs and axle counters cannot jointly operate** as the aforementioned standard does not refer to ECB emissions and internal electronics of axle counters filters undesired signals in current designs. The converse phenomenon (limits fulfilled but incompatibility in practice) also occurs in cases that are already known (e.g. RSR 180). Therefore internal technology of axle counters is a factor that should be taken into consideration along with limits study, since the latter as a stand-alone criterion is insufficient to define compatibility.

Dependency of emissions on braking force and speed were also analyzed in D6.3. The action of increasing brake current translates in higher emissions in the 100 kHz- 250 kHz band. **Axle counters are recommended to be tested at maximum braking force that is applicable to the ECB, if they are to operate within this band. Additionally, axle counters are recommended to be tested at 120 km/h and 160 Km/h if they operate within this band. Otherwise, the test conditions in braking force and speed are not relevant**.

Based on the very good correlation of the results of the magnetic field emissions with the evaluated axle counter output signals (higher frequency influences in the area of the working frequencies of the single axle counters, lower frequency influences generated by ECB-poles) the assessment of the compatibility of a vehicle equipped with ECB with axle counters in future can be done by:

a) measurement and evaluation of the low-frequency magnetic field emissions, generated by the very high DC magnetic field of each of the single ECB-pole with the running train; For the evaluation limit levels, the maximum low frequency magnetic field emission have to be defined by axle counter manufacturers, considering the saturation effect of the rail. The fixed limit levels should be included in the EN 50617-2 (specification of axle counters) as well as in a future comparable standard for the (type) specification of ECB (leading to maximum allowed emission of ECB).

b) measurement and evaluation of the middle/higher frequency magnetic field emissions according the frequency management defined in the TSI CCS interface document respectively the future standard prEN 50592 and – for single axle counter types - in the CLC/TS 50238-3 [3] or national rules (e.g. in Germany Regelung EMV 05).

c) measurement and evaluation of the passive effect primary at laboratory in combination with a magnetic field source, generating magnetic fields (frequency sweep) within the working frequency ranges of axle counters (ranges as defined in the frequency management of the TSI CCS [4]) and the full installation of the ECB power supply system; For the evaluation limit levels for the damping of the ECB housing and the resonant coupling (e.g. Q-factor) between the field source (axle counter) and e.g. the coils of the ECB (including their parasitic capacitances) have to be defined by axle counter and ECB manufacturers. These limit levels should be included in a future standard for (type) specification of ECB (see also a).

The definition of the influence of the rail saturation on the interaction with axle counters and wheel sensors as well as the definitions on the passive effect may be the major standardization work which has to be done.

Also in this document, insights into the main factors that influence Eddy Current Brakes (ECBs) EM interaction with axle counters are defined. In D6.3, it was shown that the level of magnetic saturation of the rail due to higher levels of DC current of the ECB does not significantly affect the level of emissions in AC up to 1.3 MHz. The influence of the input DC current of the ECB (and therefore its braking force) is reflected in the level of saturation of the rail by decreasing its relative permeability. As the axle counter is calibrated to a relative permeability corresponding to the unsaturated state, the decreasing of this parameter is the main EMC issue. An estimate of the levels of rail saturation is done by two means in this document:

- By calculating the minimum incremental relative permeability of the rail and ECB pole core when high levels of DC currents are introduced in the ECB in a magnetostatic computation.
- By adjusting the relative permeability of the rail and pole core when comparing the output of RSR 123 axle counter readouts in running test when the ECB was active.

Both cases indicate that a relative permeability of 1 (100% saturation) of the rail and pole cores are representatives of worst case conditions for maximum input DC current. The extra damping of the aforementioned axle counter that could lead to a misreading is calculated as 6% from the unsaturated value and given as a coefficient (Saturation Interference Coefficient SIC). This value is representative of saturation when performing passive unsaturated measurements in the laboratory. Even if the value of 6% is only applicable to RSR 123, the general concept can be extrapolated to any axle counter.

Based on computation, a non-magnetic material, such as aluminium, is recommended to be used as test-bench material for the rail in axle counter fingerprints measurements in the laboratory in active ECB state (magnetic saturation). The higher conductivity of aluminium when compared to rail steel compensates the effect of employing unsaturated pole cores in the experiment when mimicking saturated tests for RSR 123. Instead of using an aluminium solid block for the rail, a thin foil of approximately 0,2 mm thickness could be used due to the reduced penetration of the field into the rail at the axle counter operation frequencies. The recommendations given in this paragraph have not been experimentally demonstrated but there is enough evidence to support the improvement of the ECB-axle counter test benches over these lines.

A critical aspect concerning Continuously Welded Rails (CWR) safety is the temperature to which tracks are subjected. According to UIC720 the stress-free temperature (Tn) is the temperature at which there are no thermal stresses in the rails. When the rail temperature rises from the stress-free temperature high compressive stresses will occur. As the CWR (continuously welded rail) is not allowed to expand in the longitudinal direction, any irregularity in the track, a small lateral force, etc, may trigger the lateral buckling. The use of Eddy-current brakes raises rail temperature further, a rail already heated due to ambient temperature and sunlight radiation. Lateral stability of the track can be seriously affected and the probability of buckling and derailment increases.

ECB-based temperature increments reported in this document have been obtained through simulations carried out with a thermal model of a UIC60 rail, which has been validated by comparing results with experimental measurements carried out in real situations.

Simulation and measurement results show the expected dependency of rail temperature from the ECB braking force and train frequency (trains per hour). While for a braking force of 45 kN and a train frequency of 10 trains/hour the rail temperature increases between 7.6 and 8.4°C, the temperature rises between 30.2 and 33.5 °C by a braking force of 180 kN and the same number of trains per hour.

Relating on the rail temperature considerations have been made to allow - for a line section – the use of an ECB with different braking force levels, depending on the environmental temperature and the knowledge of the application of the ECB by previous trains in this line section.

Any deviations from the project work programme/Annex I (DOW)?
The following table sets the date of the deliverables in relation to the expected dates

Deliverable	Expected date (initial Dow)	Submission	Comments
D6.1 and D6.2	30.06.2015	30.07.2015(**)	Improved quality over the granted month
D6.3 and D6.4	31.08.2015	31.08.2015	
D6.5 and D6.6	31.08.2015	30.09.2015 (**)	Improved quality over the granted month

(*) Date according to the latest version of DoW, amended from initial version

(**) Date according to extension of the latest Dow date agreed with the PO

Reasons for deviations, their impact on other tasks and available resources and planning.

Even if draft versions of D6.5 and D6.6 were submitted by the end of the project (August 2015), a one month extension was applied to review the recommendations by experts involved. In this manner, the final version was submitted by September of 2015 with no extra resources. Another month was granted by the PO for the submission of D6.1 and D6.2. No impact was made in other tasks.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

It was in the interest of the participants to make sure that recommendations were of high quality and that they were under reasonable implementation requirements. That is why a one month extension was granted by the project officer: for review purposes. D7.7, which depended on D6.5 and D6.6, was submitted, in its final and revised version, in September 2015.

Propose corrective actions. *Not applicable*

3.5 WP7: Exploitation and Dissemination

Table 6. Progress and Achievements of Work Package 7 (WP7)

Work package number	WP7		**Start date or starting event:**			Month m1				
Work package title	Exploitation and dissemination									
Activity type	OTHER									
Participant number	1	2	3	4	5	6	7	8		
Participant short name	CEIT	KB	ALSTOM	SNCF	DB	NRIL	FRAUSCHER	UNIFE		
Person-months per participant	2	1	0,50	1	1,5	1	0,50	9,50		

Objectives

The objectives of this WP are namely:

• To set up the dissemination strategy and tools to facilitate wide-spread information transfer among and beyond the members of the consortium;
• To ensure that the research carried out in the project fully exploits existing knowledge and is focused on the aspects of the work. As a whole the project consortium incorporates a significant portion of the knowledge on the state-of-the-art which will be appropriately exploited;
• To ensure the project outputs reach the relevant rail stakeholders who will implement them (via Project Technical Recommendations).

Task 7.1: Dissemination and Communication.(Months 1-36 (Sep 2012-Aug 2015))

Progress towards objectives and significant achievements

UNIFE and the other ECUC partners made a huge effort to ensure proper dissemination of results through publications (scientific papers, newsletters, articles) and participation in EU-level related events for an extensive promotion of ECUC activities.

Significant achievements

- ECUC newsletters. 2 newsletters (May 2015 and August 2015) have been published and distributed during all major EU-events.
- Publications. A high number of articles and interviews have been published on European magazines (Railway Gazette, International Innovation, The Parliament Magazine) or presented during European events such as Eurobrake 2014 and 2015 and CST European User Conference 2015.

ECUC website was launched towards the end of 2012 and has been regularly updated with the latest news (publications, events, public deliverables).

See Chapter 4.5.7., Table 8

Task 7.2: Workshop and Conferences dedicated to ECUC (Months 11-36 (July 2013-August 2015))
Progress towards objectives and significant achievements
Despite the limited size of the consortium and budget, ECUC has been extraordinarily active in promoting its activities and outcomes. In fact, the partners have been participating in a high number of EU-level events where ECUC was presented. Moreover, ECUC successfully hosted a public workshop, a Mid-term Conference in Brussels and a Final Conference in Vienna where an average of 25 participants attended.
Significant achievements
EU-level events. Participation in several EU-level events: Eurobrake 2014 (Lille), Eurobrake 2015 (Dresden), CST European User Conference 2014 (Berlin) and CST European User Conference 2015 (Darmstadt). ECUC Workshops. ECUC organised a Mid-term conference (November 2014) and a Final Conference (August 2015).

Task 7.3: Advisory group and liaison with other stakeholders (CEN, CENELEC, ERA, CER, EIM, UIC, Industry, Operators and NSA's).(Months 13-36 (Sept 2013- Aug 2015))
Progress towards objectives and significant achievements
ECUC established an Advisory Group in order to involve a wider community of stakeholders as support/advice in its activities. The purpose of the Advisory Group has been twofold. From one side, to allow stakeholders to contribute with input into the project activity and, from the other side, to help the consortium carry out targeted dissemination towards the stakeholders. The Advisory Group is composed by the ECUC partners plus two external members, ERA and RSSB.
Significant achievements
Two Advisory Group meetings have been organized in the second half of the project and the input the external members was very important to successfully complete the planned tasks. Moreover, the partners planned to engage some crucial stakeholders such as CEN/CENELEC once the Project Technical Recommendations were finalized. Even after finalization of ECUC project, RSSB has addressed ECUC consortium to set a presentation for the presentation of the main results to the GB Adhesion Research Group (ARG) run by RSSB at the end of 2015.

Task 7.4: Exploitation of results and standardisation. (Months 13-36 (Sept 2013- Aug 2015))
Progress towards objectives and significant achievements
Three patents, several simulation models, declared postprocessing routines and scientific information will be compiled in the IPR annex of the final report. Under Task 7.4, ECUC has delivered in D7.7 two distinctive proposals in Project Technical Recommendations, i.e. backed by all ECUC partners. Project Technical Recommendations (public, free open access), can be introduced to the SFR (Sector Forum Rail) and CEN/CENELEC. In this

way the PTRs will be considered as a rail sector voluntary contribution to the European Standardization work.

In discussion with ERA TDC WP representative the future way of authorization of vehicles equipped with ECB according to compatibility with axle counters could be explained and discussed and necessary steps for future standardization process could be shown.

Significant achievements

- Project Technical Recommendation on ECB new requirements;
- Project Technical Recommendation on Interoperability for the rest of the systems disturbed by ECB.

A summary of this recommendations can be seen in the section corresponding to D6.5 and D6.6

Any deviations from the project work programme/Annex I (DOW)?

Under Task 7.4, ECUC planned to deliver two distinctive proposals for UNIFE/UIC Technical Recommendations on *ECB new requirements* and *Interoperability for the rest of the systems disturbed by ECB.* These two documents, shaped in a form of voluntary standards coming from the Industry and Operators/Infrastructure Managers side, were planned to be transmitted to standardization bodies such as CEN and CENELEC for their standardization work. ECUC partners agreed to transform these two proposals in Project Technical Recommendations, i.e. backed by all ECUC partners.

The following table sets the date of the deliverables in the second period in relation to the expected dates

Deliverable	Expected date (initial Dow)	Submission	Comments
D7.7	31.08.2015	30.09.2015 (**)	Improved quality over the granted month
D7.3	31.08.2014	09.07.2015	
D7.4	31.08.2015	31.08.2015	

(**) Date according to extension of the latest Dow date agreed with the PO

Reasons for deviations, their impact on other tasks and available resources and planning.

The change from Technical Recommendations to Project Technical Recommendations (PTR) was due to the fact that UIC decided not to get involved anymore with ECUC project. Amendement 4 of DoW was dedicated to this issue. No impact in other tasks was done. A reduction of PM in UNIFE resources due to the reduction of this task force was reallocated to Frauscher as explained in Amendment 4.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.
Not applicable

Propose corrective actions.

Project Technical Recommendations (public, free open access), can be introduced to the SFR (Sector Forum Rail) and CEN/CENELEC by ECUC partners that are present there. In ECUC consortium, large operator agents (SNCF, NRIL, DB) and manufactures (KB) are present and can easily introduce the PTR in the corresponding bodies. In this way the PTRs will be considered as a rail sector voluntary contribution to the European Standardization work.

4. PROJECT MANAGEMENT

4.1 Introduction

ECUC project's management structure is described in Figure 1. At the top of the structure the **Project Officer** who is directly linked with the **Project Coordinator**. This figure provides a strong central coordination, performing the technical coordination, financial administration and internal and external communications, to ensure that ECUC operates in a truly integrated manner. Moreover, the Coordinator is assisted by the **Management Support Team** which is is composed of the **project management office members (PMO)** and the **Intellectual Property Officer (IPO)**.

In ECUC project all the partners are included in the **Steering Committee** and the **Scientific Committee.** The first one is the decision-making and arbitration body of ECUC concerned with policy and strategy. The second one forms the second level of the management structure. The scientific committee is composed of the work package leaders who are responsible for the day-to-day management of the individual work packages. Moreover, the Scientific Committee is the supervisory body for the project execution and reports and be accountable to the Steering Committee. In fact, and giving the size of ECUC project, most of members of the Scientific Committee overlap with the members of the Steering Committee and therefore internal communications is always guaranteed.

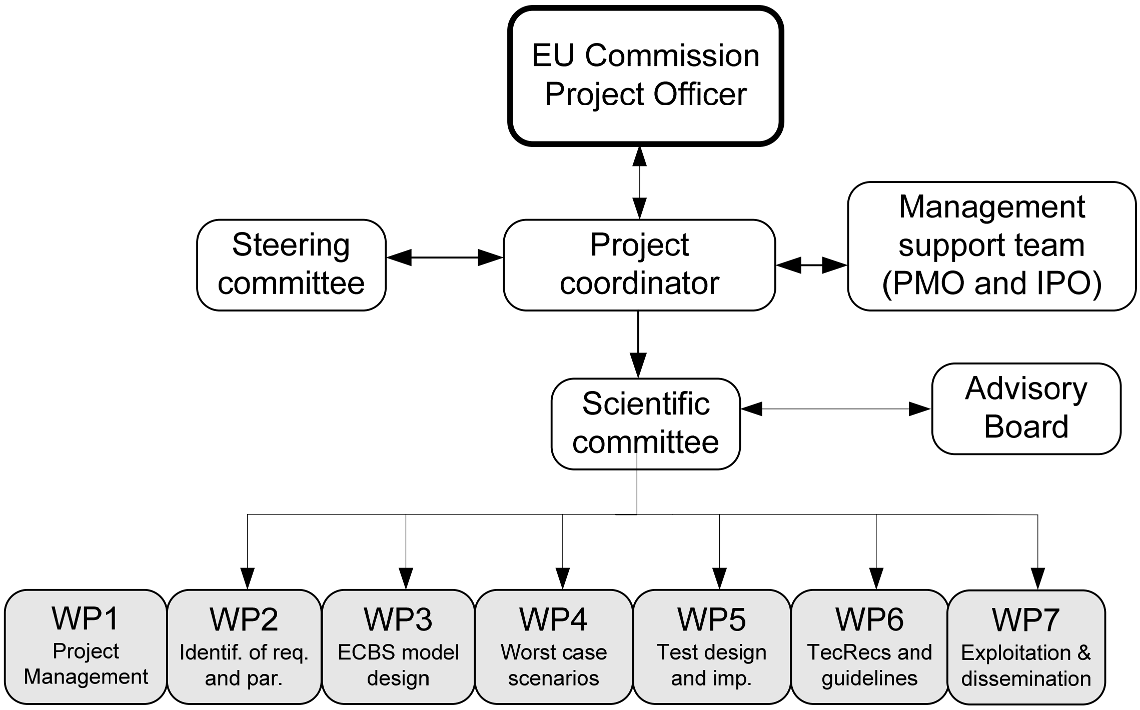


Figure 1 Management structure of ECUC

Project Management Office members (PMO)

PMO members are in charge of comparing in real time what is actually done to what is due by contract with regard to costs, time schedule and delivery. PMO members report any deviation and ask for proper decisions to be made in case of any deviation. Moreover they push the Consortium to update contractual framework toward the Commission (keep in line with the contract or amend it) and toward one another (IPR issues, budget share…) when the project deviates from what was anticipated in the proposal. Finally, PMO members also ensure the quality of work within the project through monitoring the Assessment Plan.

Intellectual Property Officer (IPO)

ECUC's IPO acts as IPR management and support of the project and supports the coordinator in dealing with legal issues. The tasks committed by IPO are to identify pre-existing know-how to be protected from each partner, support the coordinator in preparing and regularly updating the Consortium Agreement according to the project evolution and advice to partners about knowledge protection. The exploitation of results, ownership of intellectual property and rights and duties of the partners in the project are defined as a separated document and they are the result of the follow up of the IP over the progress of the project.

Meetings and Internal & External Communication Flow

A fluent communication among partners is essential to ensure the correct progress of the project. This is facilitated by the size of the consortium and by the clear identification of the people that work in the project in each partner team. The communication flow is bottom-up and top-down through communication methods such as e-mail or phone. Besides, more advanced tools like webex which allows a voice and video-conference and permits to share documents or desktop have been used. Furthermore, an email address group was created, where all the addresses of the partners are included, to facilitate the communication with the consortium.

ECUC website has a link with a private web page which contains a tool to help with the communication between consortium members. This tool which allows a better project management is the so called "sharepoint". All participants are able to upload and download information regarding their specific task according to their role and responsibilities. Besides, project documents, such as Grant Agreement, Technical Annex, Consortium Agreement, as well as deliverables and working papers are there available. Other sections are dedicated to meetings, Gantt diagram, etc. Information subjected to internal confidentiality is also held in this repository.

Summary information about the project and public reports are made available in the public website of the project as a means to effectively communicate with parties outside the consortium. Contacts with the standardization bodies and interested groups have been established by several members of the project, particularly with members of the European Rail Agency (ERA) and RSSB Adhesion Research Group (ARG). Moreover, project partners are in contact with UNISIG and UNIFE and other partners are participating in active EMC and normative working groups.

Finally, an important part of the communication protocol is the face-to-face meetings. These meetings have been necessary in order to define properly the steps to take during the project. They are listed in the present document corresponding to the second period.

4.2 Consortium management tasks and achievements

Table 7 summarizes the progress towards objectives and the mayor achievements of the consortium management tasks.

Table 7. Work Progress and Achievements of Work Package 1 (WP1)

Work package number	WP1	**Start date or starting event:**				Month m1				
Work package title	Management									
Activity type	MGT									
Participant number	1									
Participant short name	CEIT									
Person-months per participant	8									

Objectives

The coordinator has managed financial, administrative and legal / IPR issues related to ECUC in order to get an efficient progress of the project.

Task 1.1: Management (Months 1-36 (Sept 2012-Aug 2015))

Progress towards objectives and significant achievements

The quality standards were defined by the coordinator in the first month of the project and a control of its fulfilment has been assured by the coordinator and the management support team. The coordinator with the aid of the PMO has set the basis and rules that have been agreed by the partners in the following matters:

- Management structure and meetings
- Internal communication flow
- Dissemination procedure
- WPs and Tasks workflow
- IPR management procedure

Moreover, the following tasks have been carried out by the coordinator:

1. Designing and maintaining partner specific templates for collecting input to the required EC documents,

2. Managing information workflow, following deadlines up and providing support for contingency plans

3. Maintaining the dissemination and exploitation plan following the EC's requirements,

4. Lead the communication with the PO and EC.

5. Preparing, executing and post-processing of major project meetings such as Steering and Scientific Committee meetings, General Assemblies and meetings with the advisory board (tasks: agendas, invitations, location of meeting places, minutes and action lists),

6. Implementing and maintaining the project infrastructure, e.g., the internal platform for information exchange and email lists,

7. Handling of legal issues, IPR issues and maintenance of the consortium agreement.

8. Handling of the project correspondence and the day-to-day requests from partners and external bodies. Being the project representative to external agents.

.

Significant achievements

The management structure has served the objective of having the main results of the project delivered on time by specific contingency plans in spite of the deviations described below

Any deviations from the project work programme/Annex I (DOW)?

No major deviations have been reported. The final DOW has been followed in its current state. This Annex I has suffered slight modifications from the initial version in relation to WP3 extension and some final deliverables submission date but not essential changes have occurred.

WP3 timeline has been extended. The initial idea of the ECB computer model was to set the worst case conditions for interoperability once it was validated. The testruns (both in the laboratory and in track with real train) were conceived to validate the model prediction and so they did. It was requested to the EC an extension in time of WP3 corresponding to the ECB modelling precisely to cover this validation, once the measurement campaigns were ended. The main test runs of these campaigns (WP5) were concluded by November 2014 due to the difficulty to coordinate such an extensive and complicated campaign, with so many agents involved. The time consuming post-processing did not finish before March 2015. In this manner, WP3 got well into 2015 whereas WP4 (the one corresponding to set worst case conditions) was finalized in 2014. Therefore, worst cases were set by a combination of experiences and testruns and the model contributed to estimate the increase of emissions and temperature that can be achieved by these known worst cases. This final decisive step was performed in the final stages of the project at the moment to provide the project technical recommendations. In summary, the model was particularly helpful to estimate the impact of the worst cases over nominal cases but no so much to anticipate in which operational conditions they will happen: these were extracted by measurements and experiences.

Reasons for deviations, their impact on other tasks and available resources and planning. In the section above, an explanation on the interaction among WP3, WP4 and WP5 timelines is included.

In amendment number 3 a change of coordinator was described. The former coordinator Dr. Jon del Portillo changed his professional career and Dr. Daniel Valderas took the lead of the project.

Explain the reasons for failing to achieve critical objectives and/or not being on schedule and explain the impact on other tasks as well as on available resources and planning.

Critical objectives were accomplished

Propose corrective actions.

As for the change in coordinator, Dr. Valderas was involved from the very beginning of ECUC and a smooth transition avoided deviations from the normal progress of the project.

4.2.1. Problems which have occurred and how they were solved or envisaged solutions

4.2.2. Changes in the consortium

KB subcontracted in period 1 (as mentioned in the corresponding report) the services of other two companies, although not planned, because it was considered necessary to make the needed progress towards the project targets. One the one hand, the 3D transient simulation tool used (a novel approach not available within KB) drove KB to choose a subcontractor. On the other hand, the concept design was supported by an external engineering group specialized in 3D concept engineering, which was a skill not easily available within KB.

The cost for the equipment that KB required for the project exceeded the allocated budget. However, due to reduction in other sections, like, e.g consumables, the overall costs did not exceed the EC contribution.

KB budget did not include at the very beginning of the project the need of a CFS. As their EC contribution is greater than 375.000€, they include this expenses in the financial statements. The activities of Knorr-Bremse within the research project ECUC were split between two locations, Munich and Mödling. Therefore it was necessary that the external auditor had to make his audit in both locations. This reason determines that is no possible to receive a certified audit at a more favorable prize.

In amendment 4 a change about the character of the final recommendations of the project has been set. They have passed from "Technical Recommendations" to "Project Technical Recommendations" (PTR). The reason for that is that UIC has not longer being involved in the impact of the project as informed to the project officer. A procedure for the approval of the PTRs is described in the same amendment. In this way the PTRs will be considered as a rail sector voluntary contribution to the European Standardization work. In the same amendment, UNIFE shifted part of the EC contribution in relation to consumables from RTD to Dissemination (without no increase in EC contribution). For this reason 0,8 PM was released from Unife to Frauscher as the scope of T7.4 has been reduced (the project has not delivered UNIFE/UIC Technical Recommendations but Project Technical Recommendations, which requires less work from UNIFE side). Moreover, UNIFE released 0.2PM from T7.3 as Advisory Group meetings where simplified. The total 1 PM was transferred to Frauscher due to a greater than expected workload in T3.1 and T5.2.

There is an excess in equipment resources in Frauscher´s costs. In P2 a second wheel sensor (RSR 123) has been modeled. Even if the expected results were similar to the one developed in P1 (RSR 180), there was a series of unforeseen factors that lead to a much higher computational costs. In order to accelerate the simulations and deliver the results on time, a LAN license in order to perform simulations on a dedicated server and acceleration tokens to run simulations in parallel were purchased. These factors have increased the equipment resources costs.

CEIT personal costs have been updated according to the categories of researchers as reflected in the use of Resources

In amendment number 3 a change of coordinator was described. The former coordinator Dr. Jon del Portillo changed his professional career and Dr. Daniel Valderas (CEIT) took the lead of the project. Dr. Valderas was involved from the very beginning of ECUC and a smooth transition avoided deviations from the normal progress of the project.

4.2.3. Changes to the legal status of any of the beneficiaries

No changes to the legal status of any beneficiaries have been reported.

4.3 Project planning and status

All deliverables have been submitted before the end of the project. The submission dates for those corresponding to the second period are the ones listed in the following section.

4.3.1. Impact of possible deviations from the planned milestones and deliverables

Several amendments have been made along the project. They include modifications in the deadlines of some deliverables. These adjustments have been done in Amendment 2 to better adjust the workflow among WPs (as explained in that document). When extra time was needed to fully complete the submission of the deliverables with no extra EC contribution, an application to the project officer was made and the final submission date was done according to his approval. The results of the project have not been undermined by this shift on the time schedule and by September 2015 all deliverables were submitted with the expected standards (see table below).

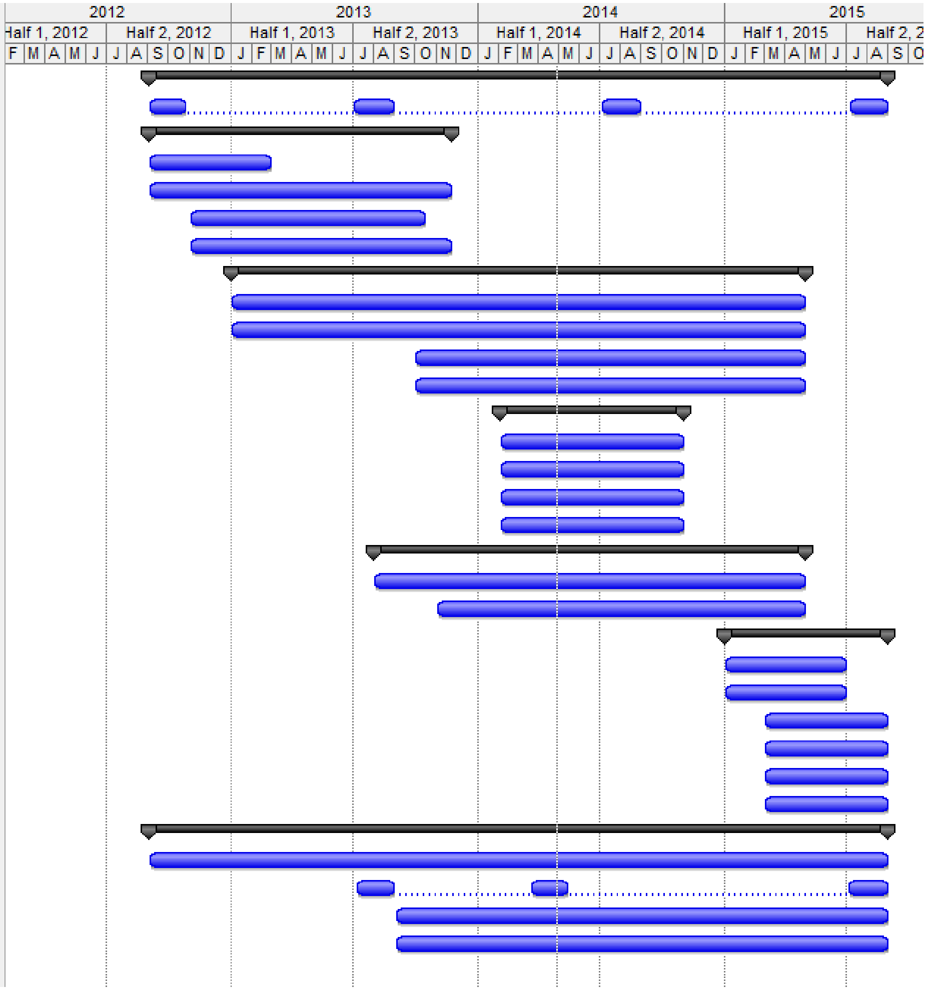
Deliverable	Expected date (initial Dow)	Submission	Comments
D3.1	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.2	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.3	30.04.2015(*)	31.05.2015(**)	Improved quality over the granted month
D3.4	30.04.2015(*)	30.04.2015	
D4.1 to D4.4	31.10.2014(*)	31.10.2014	All deliverables of WP4 were merged into only one deliverable due to soundness of content
D5.1 and D5.2	31.10.2014(*)	23.12.2014(**)	Availability track measurements
D5.3	30.04.2015	25.06.2015(**)	Second public version of the deliverable
D5.4	30.04.2015	31.08.2015(**)	Large amount of data processing
D6.1 and D6.2	30.06.2015	30.07.2015(**)	
D6.3 and D6.4	31.08.2015	31.08.2015	
D6.5 and D6.6	31.08.2015	30.09.2015 (**)	Improved quality over the granted month
D7.7	31.08.2015	30.09.2015 (**)	Improved quality over the granted month
D7.3	31.08.2014	09.07.2015	
D7.4	31.08.2015	31.08.2015	

(*) Date according to the latest version of DoW, amended from initial version

(**) Date according to extension of the latest Dow date agreed with the PO

Figure 2: updated Gantt chart. End of period 1

	Task Name	Duration	Start	Finish	Predeces
1	**WP1 Management**	**'81 days?**	**Mon 03/09/12**	**Mon 31/08/15**	
2	T1.1 Quality standards	168 days?	Mon 03/09/12	Mon 31/08/15	
3	**WP2 : Identification of the performance requirements, design pai**	**320 days?**	**Mon 03/09/12**	**Fri 22/11/13**	
4	T2.1 Systematic collection and analysis of existing information regardir	130 days?	Mon 03/09/12	Fri 01/03/13	
5	T2.2 Identification of the performance requirements of the ECB regardi	320 days?	Mon 03/09/12	Fri 22/11/13	
6	T2.3 Identification of design parameters of ECB	249 days	Thu 01/11/12	Tue 15/10/13	
7	T2.4 Identification of the relationships among the design parameters ar	277 days?	Thu 01/11/12	Fri 22/11/13	
8	**WP3 : Eddy current brake compatibility model design and implem**	**608 days?**	**Tue 01/01/13**	**Thu 30/04/15**	
9	T3.1 Electromagnetic domain model design and implementation	608 days?	Tue 01/01/13	Thu 30/04/15	
10	T3.2 Thermo-mechanical domain model design and implementation	608 days?	Tue 01/01/13	Thu 30/04/15	
11	T3.3 Integration and verification of the different domain models into the	413 days?	Tue 01/10/13	Thu 30/04/15	
12	T3.4 New generation ECB	413 days?	Tue 01/10/13	Thu 30/04/15	
13	**WP4 : Definition of representative worst case conditions**	**195 days?**	**Mon 03/02/14**	**Fri 31/10/14**	
14	T4.1 ECB operational conditions: definition of the worst case condition	195 days?	Mon 03/02/14	Fri 31/10/14	
15	T4.2 Signalling systems: definition of the worst case conditions for sig	195 days?	Mon 03/02/14	Fri 31/10/14	
16	T4.3 Rail head: definition of the worst case conditions for rail head	195 days?	Mon 03/02/14	Fri 31/10/14	
17	T4.4 Rolling stock: definition of the worst case conditions for rolling stc	195 days?	Mon 03/02/14	Fri 31/10/14	
18	**WP5 : Test site, test procedure and test setup design and impler**	**456 days?**	**Thu 01/08/13**	**Thu 30/04/15**	
19	T5.1 Laboratory tests. Definition and implementation of the test site, tes	456 days?	Thu 01/08/13	Thu 30/04/15	
20	T5.2 Track Tests. Definition and implementation of the test site, test prc	390 days?	Fri 01/11/13	Thu 30/04/15	
21	**WP6 : Technical Recommendations and design, engineering and**	**173 days?**	**Thu 01/01/15**	**Mon 31/08/15**	
22	T6.1 Development of the design, engineering and operational guideline:	129 days?	Thu 01/01/15	Tue 30/06/15	
23	T6.2 Development of the design, engineering and operational guideline:	129 days?	Thu 01/01/15	Tue 30/06/15	
24	T6.3 Development of the design, engineering and operational guideline:	131 days?	Mon 02/03/15	Mon 31/08/15	
25	T6.4 Development of the design, engineering and operational guideline:	131 days?	Mon 02/03/15	Mon 31/08/15	
26	T6.5 Development of the Technical Recommendation regarding ECB ne	131 days?	Mon 02/03/15	Mon 31/08/15	
27	T6.6 Development of Technical Recommendations for Interoperability fi	131 days?	Mon 02/03/15	Mon 31/08/15	
28	**WP7 : Exploitation and dissemination**	**'81 days?**	**Mon 03/09/12**	**Mon 31/08/15**	
29	T7.1 Dissemination and Communication	781 days?	Mon 03/09/12	Mon 31/08/15	
30	T7.2 Workshops and Final Conference dedicated to ECUC	121 days?	Fri 05/07/13	Mon 31/08/15	
31	T7.3 Advisory group and liaison with other stakeholders	521 days?	Mon 02/09/13	Mon 31/08/15	
32	T7.4 Exploitation of results and standardisation	521 days?	Mon 02/09/13	Mon 31/08/15	



4.4 List of project meetings

4.4.1. Consortium Meetings

- The 4th Steering Committee Paris (France), 19th February 2015.

  Steering Minutes

  Scientific Minutes

  Advisory Board Minutes

  Annexes: A1_A2_A3

- 5th Scientific & Steering Committee Meeting. Brussels (Belgium), 12th May 2015

  Steering Minutes

  Scientific Minutes

  Annexes: A4_A5

- 6th Scientific & Steering Committee Meeting. Teleconference. 30Th of June 2015

  Scientific Minutes

  Advisory Board Meeting

  Steering Committee Meeting

  Annexes: A6_A7_A8

4.5 Use of foreground and dissemination activities during this period

4.5.1. Development of the project website and rss

See section 4.5.7

4.5.2. Media

Some pieces of news are provided in Annex A.9:

- ECUC participated in TRA (Transport Research Arena) 2014
  http://www.ecuc-project.eu/ecuc-participated-in-tra-2014/

- ECUC project participated in CST European User Conference 2014
  http://www.ecuc-project.eu/ecuc-participated-in-cst-euc-2014/

- ECUC participate in Eurobreak 2014. 2 articles related to ECUC project were presented in the conference. Eurobrake was held between the 13th and 15th of May 2014 in Lille.
  http://www.ecuc-project.eu/ecuc-participated-in-eurobrake-2014/

- ECUC Mind Term Conference. The ECUC Mid-term conference will take place on 27th November 2014, at the Hotel Bloom (Rue Royale 250) in Brussels
  http://www.ecuc-project.eu/ecuc-mid-term-conference/

- ECUC test campaign in Germany
  http://www.ecuc-project.eu/ecuc-test-campaign-in-germany/

- ECUC in The Parliament Magazine
  http://www.ecuc-project.eu/ecuc-on-the-parliament-magazine/

- Frauscher Sensor Technology designs Rail Wheel Sensors with CST Studio Suite
  https://www.cst.com/

- Ecuc participate in CST European Users Conference 2015 Darmstadt (Germany)
  http://www.ecuc-project.eu/ecuc-participated-in-the-cst-european-users-conference-2015-in-darmstadt-28-29-april-2015/

- ECUC participates in Eurobrake 2015. 1 article related to ECUC Project was presented in the conference. Eurobrake took place between 4th and 6th of May 2015 in Dresden, Germany.
  http://www.ecuc-project.eu/ecuc-participated-in-eurobrake-2015-in-dresden-4-6-may-2015/
- ECUC CST Workshop Series 2015

- ECUC Final Conference (August 2015):
  http://www.ecuc-project.eu/ecuc-final-conference-paving-the-way-to-higher-compatibility-of-eddy-current-brake-in-europe-held-on-27-august-2015-at-marriott-hotel-in-vienna/

4.5.3. Participation in conferences

CEIT partners have participated in the following conferences:

- ECUC project participated in CST European User Conference 2015, which took place between the 28th and 29th of April in Dresden (Germany), at Science & Congress Center Darmstadtium. Daniel Valderas presented some of the results of the project up to April 2015.

- ECUC participated in Eurobrake 2015. One article was presented (Dresden)

4.5.4. Publications

The following pieces of news have been published in the Internet and are provided in Annex A.9:

The following conference papers have been published:

- *Enhancing the rolling stock standards towards a harmonized electromagnetic environment*.TRA 2014 Transport Research Arena.14-17 April 2014. Paris (France)

- *Understanding electromagnetic and thermo-mechanical interaction between Eddy current brake and infrastructure*. J. del Portillo, D. Valderas, N. Gil-Negrete, G. Lancaster, A. Alonso. Eurobrake, 13-15 May 2014, Lille, France.

- *New generation of eddy current brake.* M. Leßmann, T. Grunwald, T. Volk, G. Fregien, H. Lehmann, V. Jörgl. Eurobrake, 13-15 May 2014, Lille, France

- Electromagnetic and Thermal Modeling for Eddy Current Brakes in High Speed Trains and Interaction with Wheel Sensors.4-6 May 2015 Dresden, Germany.

4.5.5. Newsletters and Flyer

Two ECUC newsletters were released in time for two major project events, the ECUC Mid-Term Conference (November 2014, Brussels) and ECUC Final Conference (August 2015, Vienna).

4.5.6. Analysis of the web site impact

The ECUC website (http://www.ECUC-project.eu/) was set up at M3 of the project. This website has been maintained daily during the project period to report project activities, progress and achievements. The main objective of this web-site is to raise awareness of the project results with the largest pool of potential users. This web site will remain up-to-date and accessible through internet for 3 years after the end of the project, so that the results of the project keep being disseminated among our target groups.

All news related to the project are published in the web page and by means of RSS (Really Simple Syndication).

Google Analytics and Google's tools for webmasters have been employed to analyse the RSS feeds and web page use. The Google Analytics was set up to keep track of the number of visitors of the ECUC website and its trend. Figure 3**Error! Reference source not found.**

shows the number of different visitors the web page has received during the whole duration of the project. The average visitors per month (from the moment the website was established) was around 119 people per month.

The absolute number of single visitors has been 2,845. However, we have had returning visitors, so that the total amount of visits has been of 3,811, with 14,993 pages visited. This relatively large amount of returning visitors may imply that users that visited once the project web-site where interested in learning how the project was evolving and returned in a different time.

Additionally, shows where the visitors are from. We can observe that, during the analysed period, we received visits from 9 countries, mainly from Spain (506), Belgium (479), USA (465), Brazil (362) and Germany (328).

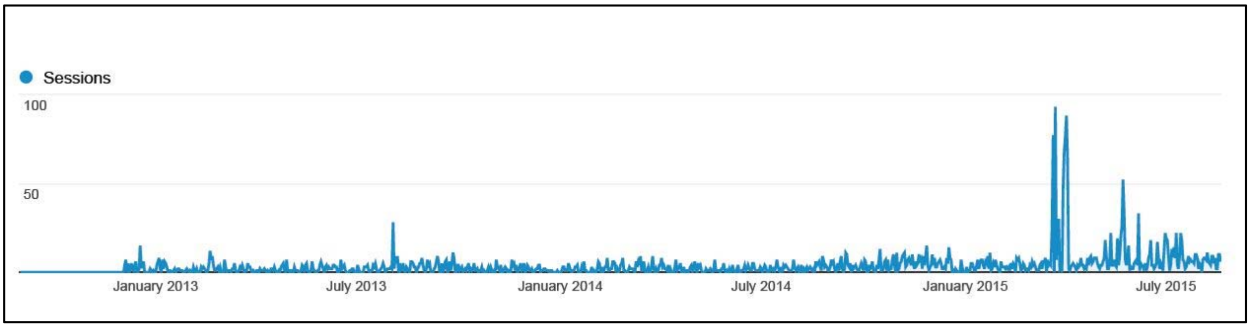


Figure 3. **Number of visitors received in the web page in the period January 2013 – August 2015**

Country	Acquisition		
	Sessions	% New Sessions	New Users
	3,811 % of Total: 100.00% (3,811)	74.65% Avg for View: 74.39% (0.35%)	2,845 % of Total: 100.35% (2,835)
1. Spain	506 (13.28%)	46.05%	233 (8.19%)
2. Belgium	479 (12.57%)	33.61%	161 (5.66%)
3. United States	465 (12.20%)	98.71%	459 (16.13%)
4. Brazil	362 (9.50%)	98.90%	358 (12.58%)
5. Germany	328 (8.61%)	71.04%	233 (8.19%)
6. (not set)	227 (5.96%)	100.00%	227 (7.98%)
7. United Kingdom	174 (4.57%)	63.22%	110 (3.87%)
8. France	161 (4.22%)	62.73%	101 (3.55%)
9. Austria	107 (2.81%)	57.94%	62 (2.18%)
10. Italy	87 (2.28%)	100.00%	87 (3.06%)

User Type	Acquisition		
	Sessions	% New Sessions	New Users
	3,811 % of Total: 100.00% (3,811)	74.65% Avg for View: 74.39% (0.35%)	2,845 % of Total: 100.35% (2,835)
1. New Visitor	2,845 (74.65%)	100.00%	2,845(100.00%)
2. Returning Visitor	966 (25.35%)	0.00%	0 (0.00%)

Figure 4. Distribution of the web page visitors throughout the World.

Likewise, a private area was established to store all confidential documents of the consortium. This private website is also useful to track the development of the project and coordinate all the tasks done within the project.

4.5.7. General Dissemination Roadmap

The following table shows the general dissemination roadmap where all the publications related to ECUC are shown:

Table 8. General Dissemination Roadmap

Month	Time	Activity	Partners
M20	Apr-2014	Ecuc participate in TRA (Paris)	CEIT
M21	May-2014	Ecuc participate in CST EUC (Berlin)	CEIT
M21	May-2014	Ecuc participate in Eurobrake Two articles were presented 2014 (Lille).	KB,CEIT
M25	Sept-2014	ECUC presented at Innotrans	UNIFE,CEIT
M27	Nov-2014	ECUC test campaign in Germany	UNIFE,DB
M27	Nov-2014	Ecuc Mind Term Conference	All
M28	Dic-2015	The Parliament Magazine	UNIFE,CEIT
M31	March-2015	Article Published in website of CST	FRAUSCHER
M32	April-2015	Oral presentation at CST European User Conference	CEIT
M33	May-2015	Ecuc participated in Eurobrake 2015. One article was presented (Dresden)	CEIT, Frauscher,KB
M34	June-2015	CST Workshop Series 2015	CEIT
M35	August-2015	ECUC article on Railway Gazette	UNIFE, CEIT
M36	August-2015	ECUC interview on International Innovation	UNIFE, CEIT, SNCF
M36	August-2015	ECUC 3rd Newsletter	All
M36	August-2015	ECUC Final Conference	All
M36	August-2015	Railway Gazette International	CEIT
M36	August-2015	General publication of ECUC final event for international press	KB, Frauscher

4.6 Deliverables and milestones tables

4.6.1. Deliverables (excluding the periodic and final reports)

This table is cumulative, that is, it should always show all deliverables from the beginning of the project. If a deliverable has been cancelled or regrouped with another one, please indicate this in the column “comments”. If a new deliverable is proposed, please indicate this in the column “comments”. If there is a deviation from the annex I, then this should be clearly explained in the comments column.

Table 9. Deliverables

Del. no.	Deliverable name	Version	WP	Lead beneficiary	Nature	Dissemination level	Delivery date	Actual/Forecast Delivery date	Status NoSubmitted/ Submitted	Comments
D1.1	Quality standards	V1	1	CEIT	R	PP	1	5/12/2012	YES	Quality standards report
D2.1	Collection of previous experiences and know-how	V3	2	DB	R	PU	3	15/05/2013	YES	Database of previous experiences of the main actors
D2.2	ECB requirements	V8	2	ALSTOM	R	PU	3	20/11/2013	YES	All the requirements that affects ECB are included
D2.3	ECB design parameters	V4	2	KB	R	PU	3	10/10/2013	YES	The main design parameters of ECB are described
D2.4	Qualitative relationship between requirements and design parameters	V4	2	KB	R	PU	4	20/11/2013	YES	Based on D2.1, D2.2 and D2.3, the effects of ECB are described qualitatively
D7.1	Dissemination and communication plan	V1	7	UNIFE	PU	PU	5	31/01/2013	YES	Provides a dissemination strategy for the ECUC project

D7.2	1st Newsletter release	V1	7	UNIFE	PU	PU	12	16/12/2013	YES	Description of the results of the 1st year of the project
D7.5	Project leaflet/flyer	V1	7	UNIFE	PU	PU	5	31/01/2013	YES	Presentation of the project
D7.6	Launch of public website	V1	7	UNIFE	PU	PU	3	30/11/2012	YES	Website with all the information of the project
D7.3	Newsletter release	V1	7	8	O	PU	24	09/07/2015	YES	Description of the results of the middle stage of the project
D4.1	Worst case conditions regarding operational conditions	V1	4	2	R	PU	26	30/10/2014	YES	Regrouped in only one deliverable for WP4
D4.2	Worst case conditions for signalling systems	V1	4	5	R	PU	26	30/10/2014	YES	Regrouped in only one deliverable for WP4
D4.3	Worst case conditions for rail head	V1	4	6	R	PU	26	30/10/2014	YES	Regrouped in only one deliverable for WP4
D4.4	Worst case conditions for rolling stock	V1	4	5	R	PU	26	30/10/2014	YES	Regrouped in only one deliverable for WP4
D5.1	Test sites, test Procedures and test setups for tests in the laboratory	V1	5	2	R	RE	26	23/12/2014	YES	Laboratory test description

D5.2	Test sites, test procedures and test setups for tests in the track	V1	5	5	R	RE	26	23/12/2014	YES	Track test description
D3.1	Electromagnetic domain model	V1	3	1	R	RE	32	31/05/2015	YES	The results of HF, LF and passive effect are described
D3.2	Thermomechanical domain model	V1	3	1	R	RE	32	31/05/2015	YES	The thermo-mechanical effect on the rail is shown
D3.3	Complete model	V1	3	1	R	RE	32	31/05/2015	YES	Comparison of the two models
D3.4	New generation ECB	V1	3	2	R	RE	32	30/04/2015	YES	Description of the new generation brake
D5.3	Test report for tests in the laboratory	V1	5	2	R	PU	32	25/06/2015	YES	Laboratory test report
D5.4	Test report for tests in the track	V1	5	5	R	PU	32	31/08/2015	YES	Track test report
D6.1	Engineering guidelines for ECB	V1	6	2	R	PU	34	30/07/2015	YES	Engineering guidelines for ECB
D6.2	Engineering guidelines for the installation of ECB in the vehicle	V1	6	3	R	PU	34	30/07/2015	YES	Engineering guidelines for the installation of ECB in the vehicle
D6.3	Engineering guidelines for signalling systems	V1	6	1	R	PU	36	31/08/2015	YES	Engineering guidelines for signalling systems

D6.4	Engineering guidelines for tracks	V1	6	6	R	PU	36	31/08/2015	YES	Engineering guidelines for tracks
D6.5	ECB new requirements	V1	6	2	R	PU	36	30/09/2015	YES	Project Technical Recommendations (1)
D6.6	Requirements for the rest of systems	V1	6	2	R	PU	36	29/09/2015	YES	Project Technical Recommendations (2)
D7.4	Newsletter release	V1	7	8	O	PU	36	31/08/2015	YES	Description of the results of the middle stage of the project
D7.7	Project Technical Recommendations	V1	7	8	PU	PU	36	30/09/2015	YES	Project Technical Recommendations in technical format

4.6.2. Milestones

Table 10. Milestones

Milestone no.	Milestone name	WPs no's.	Lead beneficiary	Deliverable date	Achieved Yes/No	Actual Forecast Achievement date	Comments
MS1	Reliability of the ECB compatibility model	WP3	1	26	YES	31/05/2015	The model was proved to be reliable after the comparison with the measurements campaigns results and that is why a postprocessing of the measurement was necessary to validate the model

MS2	Definition of the worst case conditions	WP4	5	26	YES	31/10/2014	Assessment of the prediction of worst case conditions based on data collected in WP2, WP5 and advisory group members' experience. WP3 analyzed the impact of worst cases.
MS3	Feasibility of laboratory test site, test setup and test procedure	WP5	2	30	*YES*	28/02/2015	Assessment of the EMC and thermo-mechanical test sites, test setups and test procedures in laboratory in terms of measurability of each domain's parameters, accuracy, cost and repeatability
MS4	Feasibility of track test site, test setup and test procedure	WP6	5	30	*YES*	28/02/2015	Assessment of the EMC and thermo-mechanical test sites, test setups and test procedures in track in terms of measurability of each domain's parameters, accuracy, cost and repeatability