TREND Report Summary
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Final Report Summary - TREND (Test of Rolling Stock Electromagnetic Compatibility for cross-Domain interoperability)

Executive Summary:
Rolling stock electromagnetic emissions and immunity are major concerns for train manufacturers and railway infrastructure operators, as pointed out by ERA in several reports. Unfortunately, the available harmonized EMC standards (EN50121-2, EN50121-3-1 and EN50121-3-2) do not completely address interoperability issues caused by rolling stock interferences with the most common signalling systems (GSM-R and BTM for example). Moreover, these standards do not cover representative worst-case conditions derived by transients in the rolling stock behaviour typically generated by feeding and track circuits' discontinuities.

On one hand this situation causes an important waste of time and resources for train manufacturers when integrating rolling stocks and signalling systems. And moreover in already tested trains, occasionally problems may still arise. Then, not only the responsibilities but also the technical solutions are not straightforward. The duration of the field testing employed to solve this kind of problems and to go through the certification process may vary between 3 months and 12 months. And the cost of the complete process may vary between 25k€ to 1,5M€ [ERA EMC Report 2010]. On the other hand, railway infrastructure operators suffer the railway infrastructure availability reduction caused by the rolling stock electromagnetic incompatibility with the safety critical signalling systems. The previously commented problems might cause an estimated reduction of 10% of the availability in the most crowded lines.

In this context, TREND (Test of Rolling Stock Electromagnetic Compatibility for cross-Domain Interoperability) project had the objective of addressing this situation by means of the design of a test setup that enables the harmonization of approval tests for electromagnetic compatibility (EMC) focusing not only on interferences with broadcasting services but also on railway signalling systems. TREND was also conceived to identify and design the cross acceptance test sites that reproduce representative worst case conditions for steady state and transient behaviours.

The thorough analysis of this project has comprised measurement, modelization and safety and availability analysis of the effect of the railway EMIs on the neighbouring communication and signalling systems studied. These are classified in four research areas: a spot signalling system (BTM), DC track circuit, GSM-R and broadcasting services (which include TV, radio, Freight RFID, WFI and GSM). A detailed study of the physical environment of each system has permitted a precise analysis of the EMI coupling model affecting them. Thanks to the safety and availability model of these systems, and to the more significant regulatory documents for each case, TREND has designed a test procedure that recreates representative worst-case for the rolling stock electromagnetic emissions that could affect interoperability including transient phenomena.

As a summary, TREND project has positively contributed to the objectives identified in the proposal in the aim to progress the understanding of the EMC of rolling stock with the railway environment beyond the current ‘state-of-the-art’ for the targeted signalling and communication systems.

Project Context and Objectives:
Rolling stock electromagnetic emissions and immunity are major concerns for train manufacturers and railway infrastructure operators, as pointed out by ERA in several reports. Unfortunately, the available harmonized EMC standards (EN50121-2, EN50121-3-1 and EN50121-3-2) do not completely address interoperability issues caused by rolling stock interferences with
the most common signalling systems (GSM-R and BTM for example). Moreover, these standards do not cover representative worst-case conditions derived by transients in the rolling stock behaviour typically generated by feeding and track circuits' discontinuities.

On one hand this situation causes an important waste of time and resources for train manufacturers when integrating rolling stocks and signalling systems. And moreover in already tested trains, occasionally problems may still arise. Then, not only the responsibilities but also the technical solutions are not straight forward. The duration of the field testing employed to solve this kind of problems and to go through the certification process may vary between 3 months and 12 months. And the cost of the complete process may vary between 25k€ to 1,5M€ [ERA EMC Report 2010].

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As a summary, TREND project proposal identified the objectives of this project and aimed to progress the understanding of the EMC of rolling stock with the railway environment beyond the current ‘state-of-the-art’ for the targeted signalling and communication systems.

Three points are highlighted for the technical point of view, and the first one summarizes the first phase of the project:
1 - Identification of the representative worst case conditions for the targeted signalling and communication systems that includes not only steady state but also transient behaviour. These conditions refer not only to rolling stock but also to infrastructure conditions. To achieve this, the first objective of the project proposed is: modelling of the electromagnetic interferences affecting the signalling and communication systems addressed by TREND in a complete railway environment to obtain the representative worst-case conditions for EMC approval tests.

The second part of the project and its objectives was summarized by the 2 next points. These have been the objectives pursued during the second period here reported:
2 - Definition of a controlled test environment that comprises a test setup and a test site. This test environment will provide repeatability, reliability and accuracy. Moreover, the test environment will be able to reproduce infrastructure representative worst-case conditions
3 - Design of a testing procedure that introduces stimulus to generate the representative worst case conditions and, captures and processes data in a way that the compatibility margin is evaluated to demonstrate availability and safety.

Finally, the dissemination is also a key objective of the project and 6 levels have been pointed out: Worldwide level with web page, contribution to technical journals and international congresses, contribution to the standards and active working groups on signalling and communications, dissemination to the industry, dissemination to the main stakeholders in railway and EMC topics and improvement of courses for professional advancement and also for students.

Project Results:

WP2: Identification of Railway System Electromagnetic Interferences
Objectives
Establish a common knowledge database that describes all known problems of electromagnetic compatibility.
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: Collection of EMI experiences. (Months 1-2 (Nov - Dec 2011))
Progress towards objectives
All the partners contributed to the collection of Electromagnetic Interference problems identified in railway systems, mainly in the countries represented by the TREND partners (Sweden, UK, France and Spain). The database references all the know-how acquired during recent years (Research projects, European projects, Industrial projects, reports, etc.) that has been shared and provides the detailed basis for the full range of problems to be addressed by the TREND general objectives: electromagnetic interferences for signalling and communications systems.

Significant achievements
As a result of this collection, 7 significant case studies have been presented in the Deliverable D2, in its first chapter:
- Two for Broadcasting services problems presented by Y-EMC
- Three for detector systems presented by LTU and TV
- One for GSM-R presented by IFSTTAR
- Two for spot signalling systems. The first one presented by CEIT, CAF and CEDEX and the second one by LTU and TV
It is worth noting that this collection of experiences is only a cross section of the potential problems. These case studies were the basis for the workshop organized by TREND during the EMC Europe 2012 conference, in Rome.

Task 2.2: Identification of the degrees of freedom of railway systems &
Task 2.3: Definition of qualitative relationships between variables and consequences. (Months 1-2 (Nov - Dec 2011))
Progress towards objectives
Task 2.2 and Task 2.3 have been merged into the second chapter of the Deliverable D2. From the case studies collected, all the relationships between the EMI threats and the signalling and communications systems considered as research areas of the TREND project are presented and summarized. The coupling mechanisms are then defined and analyzed theoretically and, in some cases, with preliminary testing in a laboratory to assess the potential impact.

Significant achievements
The second chapter of the Deliverable D2 presents the analyses and their conclusions. The research areas are drawn up using a table of victims and culprits; this lays down the frequency ranges and main causes for work throughout the rest of the project. This table of research areas and the consideration of the EM interactions are a significant achievement that helps to guide the consortium for the rest of the project.

WP3: Assessment of Current Harmonized EMC Approval Test
Objectives:
The main objective of this work package is to identify enhancement points of the current EMC approval tests. This general objective is divided in two more specific ones, that are complementary:
- Identify the draw backs of the current harmonized EMC approval test regarding the rolling stock
- Identification of the potential electromagnetic influences between the rolling stock and other systems (spot signalling systems, GMS-R and broadcasting) not covered by current harmonized EMC approval tests
Task 3.1 Identification of the draw backs of the current harmonized EMC approval tests: (Months 3-4 (Jan - Febr 2011))

Progress towards objectives
Considerable work has been done towards identifying the standards containing EMC approval tests for railway systems, environmental conditions and/or safety and compatibility issues. As a result 16 CENELEC European Norms have been presented and analyzed generally: EN50121-X, EN50122-X, EN50125-X, EN50159, EN50215, EN50238-X and EN50388. Then, the 4 partners dedicated to the signalling and communication research areas of TREND project and the complete rolling stock expert have detailed the analysis from their specific point of view:
- CAF group for complete Rolling Stock
- CEIT for spot signaling systems, mostly ERTMS BTM
- IFSTTAR for GSM-R
- Y-EMC for Broadcasting Services
- LTU for Track Circuits, mostly Swedish DC version

Significant achievements
The first thirteen chapters of deliverable D3 is based on the information gathered during the thorough examination and analysis of these CENELEC European Norms. The first part of this document is then a good summary of the current documents that affect and influence the electromagnetic compatibility of the communication and broadcasting systems for railway. Furthermore, additional points have been raised with relation to the specific TREND research areas within Deliverable D3. It also includes a section on safety (Induced potential and EMF) and lays down some points for future work that can be addressed during the rest of the project.

Task 3.2: Identification of electromagnetic influences not covered by the current EMC approval tests (Months 3-4 (Jan - Febr 2011))

Progress towards objectives
Besides the aforementioned standards in the previous tasks, other references like subsets and technical reports have been added to the study in order to identify the drawbacks taking into account the electromagnetic issues considered in the conclusion of Deliverable D2. A gap analysis was undertaken of all the potential electromagnetic threats identified against the current harmonized EMC approval tests.

Significant achievements
A thorough understanding of the gaps in the existing EMC standard for railways has been obtained. Firstly, this has been very useful to highlight the key points to work on during the most important parts of the project (i.e. categorising and measuring of transient emissions, considering on-board measurements, reconsidering of the frequency limits, etc.) Secondly this will help later in the project when the test environments will be designed, in WP6, WP7 and WP8.

Another significant achievement from this Task and WP was the presentation of a workshop at the EMC Europe 2012 conference, with the participation of the whole consortium; which demonstrates the quality of this research, up to now.

WP4: Design of the Railway System Model

Objectives
The main objective of this WP is to design and verify the railway system model that estimates electromagnetic interference levels affecting the functionality of the spot signalling systems, GSM-R, track circuits and broadcasting services, and their influence on safety and availability. This model is a tool that will enable in WP5 the definition of the representative worst case conditions, which is ultimately a key point to establish the technical specifications for the EMC test setup, procedure and test site.

Task 4.1: Identification of the rolling stock and infrastructure electromagnetic characteristics. (Months 5 (March 2012))
Progress towards objectives
First of all the main parts of the rolling stock and infrastructure are identified. The aim of this generic information is to provide a better understanding of the terminology to be used in the WP4’s main tasks and the deliverables. After that, the main characteristics of the rolling stock and the infrastructure affecting the signalling and communication systems and their performance are identified and presented in deliverable D4.1. These characteristics are classified as ‘internal design consideration’ and ‘external factors’.

Deliverable D4.1 is the result of this preliminary study, in which CAF and TV are the main contributors and IFSTTAR and CEIT have done the reviews. The main parameters that have to be considered when implementing the rolling stock and the infrastructure models are identified here.

Task 4.2: Definition of the infrastructure and rolling stock models. (Months 6 (April 2012))

Progress towards objectives
In task T4.2 the specifications for the appropriate infrastructure and rolling stock models are created. Two research lines were carried out in parallel. By one side, the electric modelling tool and its limitations have been selected and studied (MATLAB). By the other side, the basic requirements of the signalling and communication systems’ models have been established in order to identify the needs from the infrastructure and rolling stock side (mostly part of Task T4.3 but feedback needed for that task). With the constraints found in this analysis, and with the limitations of the consortium in terms of real data availability, the required Spanish and the Swedish infrastructures and high speed trains, have been implemented in the electrical MATLAB Simulink model tool, with interconnect-able diagram boxes and merge-able simulation procedures. CAF and LTU have performed the modelling.

Significant achievements
All the degrees of freedom concerning each part of the infrastructure and rolling stock models are identified in the deliverable D4.2. Moreover the analysis of the results is included and validated from a functional point of view. Higher frequencies than tenths of kHz have not been reached due to simulation and realistic parasitic data constraints. But for the available frequency band, the performance of the systems and their compatibility with signalling and train detection systems can be anticipated before track testing.

Task 4.3: Design, implementation and integration of the models. (Months 7-13 (May - November 2012))

Progress towards objectives
This Task T4.3 core of the WP4, studies the electromagnetic compatibility issues of the focused communication and signalling systems in this project. The victims are then:
- the BTM system
- the GSM-R system
- the DC track circuits
- the broadcasting services.

For these four issues, the objective is to develop a model that includes the major interference sources and reflects the main coupling mechanisms that lead to the action of radiated interference on sensitive systems in certain circumstances. The final model should allow us to conduct a parametric study to identify the "reasonable worst case" conditions for these four critical systems in the following work package (WP5).

In our modelling methodology, the right choices must be made in each case. CEIT has mainly worked on the BTM model and helped in the DC track circuit case, IFSTTAR’s main task has been the GSM-R system modelling, Y-EMC has been in charge of the study of the broadcasting services model availability and LTU has worked on the DC track circuits. TV and CAF have lead the 2 measurement campaigns carried out within the framework of this WP.

For each system’s modelling and analysis, a balance has been needed in order to obtain a realistic model in terms of coupling between the main EM noise sources and victim systems, and with a reasonable computation time. The software alternatives
have been considered for each study, including the workflow and the different optional solutions offered by the CST 3D electromagnetic simulation tool, in terms of solver solutions. CST Europe has been particularly interested in the project and has helped with an extra effort to cover our needs and doubts.

For the core of the task and the subsequent deliverable D4.3 the applied modelling methodology is presented for each subsystem.

Firstly, the main railway components affecting the model are described. The solver and meshing types and the definition of the elements that are included in the model are studied in order to progressively build a realistic model with reasonable computation time. As part of the workflow the specific difficulties in the modelling of these four subsystems are also highlighted and the potential solutions to these difficulties are proposed, if any are available for the chosen simulation tool.

Secondly, the models have been implemented replicating the realistic problems studied up to this point. The Model’s quality has been assessed in terms of validation (efforts crossed with the Task 4.4) to verify if such models can be employed to study the impact of specific conditions and then to look for the worst case conditions. In each case, the final model, the dimensions of the components, the configurations considered, the disturbances taken into account and the specific methodology employed to validate, are presented in detail.

Significant achievements

Deliverables D4.3 and D4.4 gather most of the work and conclusions obtained in this core work package, aligned with the key objectives of the TREND project. For these documents, IFSTTAR has collected the contributions of themselves, CEIT, LTU and Y-EMC.

These deliverables, which combine the efforts from Tasks T4.3 and T4.4 present the general methodology, which is employed in TREND, to model the electromagnetic interferences and the communication and signalling systems that are affected by them, in an easily adjustable 3D electromagnetic software tool. The results highlight the significant differences between the four “victim” subsystems (the BTM system, the GSM-R system, the DC track circuits and the broadcasting services) and the specific requirements which need to be taken account of, to design a model that permits the analysis of the disturbances which can affect them. In particular, the railway components affecting the simulation model are not necessarily identical and the model size evolves according to the main coupling under consideration, the frequencies of interest and the position of the sensitive elements. As a consequence, different software tools from the proposed CST packages have been employed: the software CST Microwave Studio was used for the BTM, GSM-R and broadcasting services victim systems while CST Cable Studio was employed for the track circuit modelling.

The different solvers used in the four models have been described in detail in both deliverables and the phenomena or elements that are difficult to model are also highlighted. The simplifications which were applied in order to limit computation time are described and justified. The definitions and the locations of the ‘antennas’ and ‘probes’ allowing analysis of the EMI which can reach the sensitive systems were also specified.

Concerning the implementation and validation of the model for each system, the comparisons between the numerical and experimental results (obtained with T4.4 efforts) were relatively satisfying. The agreement could probably be improved by increasing the accuracy of the models, in particular for the broadcasting services study. However, we have to keep in mind that improving the accuracy of the model can significantly increase the computation time. Nevertheless, for the four models, it was observed that the trends of the real behaviour of the culprit-victim relationship are reflected by the model and the main impacting factors on the interferences are well reproduced. Consequently, instead of the agreement not being perfect between the experimental and numerical results, the models will allow us to delimit the range of the parameters that influence the determination of the reasonable worst case conditions that are going to be studied and introduced in the deliverables of WP5.

For the four subsystems, we have then obtained adequate models on which the work of WP5 will be based to study the interferences and their impact on their performances, and then determine the conditions that could be considered reasonable worst case conditions. These models offer a high level of flexibility in terms of configuration (circuit components, positions, antennas behavior, pantograph, roof and lower structure, etc) and can be used to simulate any scenario instead of measuring it, what is much easier, faster and cheaper.

Specifically, some headlines of the simulations and the measurements that have validated them are:
- Fast transient pulses have been shown to be representative of the pantograph arc for the lower frequencies considered
- Handling of the train borne circuit breaker and pantograph generated EMI for a static vehicle can be used to reproduce the dynamic interferences to the communication and signalling systems
- The simulations demonstrated the high immunity to the DC Swedish track circuits to the realistic electromagnetic influences.

Several publications have been written from the results obtained in this WP and are are listed under WP9.

Task 4.4 Adjustment and verification of the model through electromagnetic influences measurement: (Months 12-14 (Octob - Decmb 2012))

Progress towards objectives
As previously described in the explanation of Task T4.3 this Task T4.4 is totally linked and coordinated with the design and implementation of the models in their electrical and electromagnetic aspects. The experimental results used for the adjustment and validation have been taken as references in order to assess the quality of the numerical results extracted from the models.

During the first period of the project, two measurement campaigns, significantly different, were performed. One in Toledo in Spain with the OARIS high speed train where the BTM issues (CEIT), the GSM-R issues (IFSTTAR) and the rolling stock emissions (CAF) affecting the broadcasting services were studied. The second one in Niemisel, in Sweden, where these previous cases have been repeated with the Swedish conditions: different supply voltage, frequency, track configuration and with a different type of rolling stock. Also, the DC track circuits' issues (LTU) were also addressed during this testing and the expertise of the Trafikverket maintenance personnel is gratefully acknowledged.

In parallel with the organization, accomplishment, gathering and sharing of all the data obtained in both measurement campaigns, the followed methodology to compare the experimental and numerical results has also been analyzed and proposed with the efforts of this Task T4.4.

Significant achievements
- As also mentioned in the significant achievements of Task T4.3 both, the results from the model and the measurements are satisfactorily comparable.
- It has been demonstrated that the organization of independent test campaigns has been an asset for the positive achievement of the TREND objectives.
- Specific measurement procedures have been designed and tested for each kind of problem in order to catch the culprit and the effect on the victim system in the most appropriate way. This is also a first step forward for the future task to perform in the second part of the project.
- From the post processing of the data point of view, a novel 3-level methodology has emerged for the railway transient electromagnetic interferences affecting the signalling and communication systems:
  - Time validation, point by point
  - Frequency validation with Gabor algorithm, adapted by IFSTTAR
  - IEEE Feature Selective Validation (advised by UPC, member of the Advisory Group)

WP5: Identification on Reasonable EMC worst case Conditions

Objectives:
The main objective of this WP is to define the conditions and the limits to the rolling stock emissions. The limits should not be set on the basis of worst known situation but on a thorough understanding of all the possible situations and the implications on safety and availability of the different communication systems involved. The worst known situation may potentially ignore even worse situations or impose limits which leads to component over sizing. The conditions to set the emission limits have to be a representative EMC worst case. This WP outputs are requirements for the EMC design site, procedure and test setup, which will be developed in next WPs.

Task 5.1: Definition of immunity limits of broadcasting services. (Months 11-12 (September-October 2012))
Progress towards objectives
For the broadcasting services, the immunity limits have been defined from previous work, mostly part of the contributions of Y-EMC. There is included in the report a table of immunity limits for the various frequency ranges used within broadcasting services.

Significant achievements
One of the chapters of deliverable D5.1 is composed by the results of this analysis done by Y-EMC and review by IFSTTAR and subsequently, the whole document, by CEIT. It is suggested that the emissions limits imposed by the existing EMC standards are insufficient for the full protection of the broadcasting services, and that the failure to distinguish between transient and continuous emissions constitutes a potential problem.

Task 5.2: Definition of the immunity limits for railway signalling systems (spot signalling systems, GSM-R and track circuits). (Months 11-12 (September-October 2012))

Progress towards objectives
For the rest of signalling systems, instead of only looking for the immunity limits, the availability and safety (if any for each case) requirements are presented and analyzed by IFSTTAR, CEIT and LTU. For some of the systems, these requirements are directly obtained from the immunity limits defined by norms, functional needs or Quality of Service (QoS) aspects. But for others, the requirements are analyzed and the parameters affecting the system are highlighted. With that and each model configuration, the first set of parameters affecting the worst case scenarios is proposed, and will be completed with the rest of the tasks of this WP.

Significant achievements
The content of the efforts of this task are included in 3 chapters of the Deliverable D5.1. LTU proposes a DC level as a limit for the DC track circuits operation. Whereas, CEIT and IFSTTAR have analyzed their assigned signalling system in terms of the influence of the transient signals into the Bit Error Rate (BER) admissible for the availability of the BTM and the GSM-R signals.

Task 5.3: Definition of the representative worst case infrastructure conditions (Months 16-18 (Feb-Apr 2013))
Task 5.4: Definition of the representative worst case rolling stock conditions (Months 16-18 (Feb-Apr 2013))
Task 5.5: Identification of conditions and limits of rolling stock emissions (Months 16-18 (Feb-Apr 2013))

Progress towards objectives
These 3 tasks have been unified in terms of work organization and of work load for a common aim. As seen in WP4, the 3D electromagnetic model is the core of the study of the influence of the EMI on the communication and signalling signals. Then, these 4 systems have been studied in this WP5 from the realistic functional post processing point of view. This has helped to define the rest of the parameters that affect their availability. With them, the complete set of variables and configuration that could determine the reasonable worst case conditions is then stated for each system.

Significant achievements
The deliverable D5.3.4_5 collects the work done for the Tasks T5.3 T5.4 and T5.5 with the contributions of CEIT, IFSTTAR, Y-EMC and LTU and a common revision completed by CAF. There, the conclusions determine the way to determine the reasonable worst case conditions for each case. And this is the starring point of the second part of the project.

WP6: Test Setup Design and Verification

Objectives
The main objective of this work package is to define the test setup for the EMC approval tests and to verify it. The test setup is the group of instruments that capture the disturbances generated by the rolling stock and may affect the communication systems. Therefore, four set of instruments are foreseen to cover the four research areas: spot signalling systems (STM, BTM and LTM), GSM-R, track circuits and broadcasting services (freight RFID, GSM, WIFI, TV and radio broadcasting services).
- Task 6.1: Definition of the test setup requirements. (Months 18-20 (Apr-Jun 2013))
- Task 6.2: Design of the test setups (spot signalling systems, GSM-R, broadcasting services and track circuits). (Months 20-26 (Jul-December 2013))
- Task 6.4: Verification of the test setup through EMI measurements. (Months 22-29 (Sept 2013- Apr 2014))

Progress towards objectives and significant achievements
In period 2 of the project, the work flow of the project has been redesigned and 4 working groups have been created. Each of them focused on one of the four signalling and communications systems under study in TRENDS:
- CEIT, CEDEX and CAF for spot signalling systems BTM
- IFSTTAR for GSM-R
- LTU and TV for DC Swedish Track Circuits
- Y-EMC for Broadcasting services

As a result, each working group has dedicated its effort on the analysis, design and verification of the whole task “Test setup, test site and test procedure” for their system, following the flow of the tasks T6.1 T6.2 T6.3 and T6.4. But, in which concerns the explanations given in that document, the explanations given, in that report, for the three work packages (WP6, WP7 and WP8) have been provided separately, as it was proposed in the DoW.

For this WP6, the progress and the significant achievements of the 4 working groups on the test setup specific subject are here explained:

A) BTM WG
CEIT, CEDEX and CAF have participated in the BTM working group, in both sides of the study: Balise immunity and Rolling Stock emissions. At the end of Period 1 of the project, the document that rules the BTM design in all its concepts was updated to its third major version. In it, another subset was directly pointing to the BTM tests definition, entitled “Subset116: Eurobalise On-Board Equipment, Susceptibility Test Specification”.

But this subset was only a draft, it is not yet published and some of the critical points are still to be completed or even to be defined. In those conditions, the work performed by the BTM working group had a direct purpose and the results are of great interest for this Subset116, by means of the UNISIG-UNIFE BTM group that has received our output for their considerations.

For the test setup subject, the work of this project has been based on describing and developing the tools and their connections which are necessary to perform the electromagnetic immunity tests for the on-board equipment and the emission tests for the Rolling Stock, as should be finally defined in the Subset116.

The main tools necessary for measurement campaigns on real trains have been defined: special antennas (Magnetic Field Probe, MFP), data acquisition tools (PXI rack with acquisition board, Acquisition SW programmed in LabVIEW) and instrumentation for the laboratory for the calibration and adjustment of the MFP installed. There have been some measurement campaigns performed by CEIT on real trains (CAF) with that test setup. Afterwards the signals acquired in the real field have been generated at CEDEX lab to disturb the communications with the BTM.

By the other side, several tools suitable both for the laboratory tests and for capture of disturbances generated by the rolling stock have been also developed by CEDEX for the laboratory work: implementation of MFP antenna, WLA antenna, acquisition of tools for antenna construction, SW development for the data acquisition in PXI rack. In the case of the Balise immunity, the main set-up for the test was already defined in the draft of the Subset-116, but the specific implementation has been done for the CEDEX lab. This CEDEX Eurobalise laboratory has been then prepared to perform the tests described in that subset. The laboratory already had some of the proposed tools (LTOM, LTMS and RSG), but some of them has to be updated to be able to generate the new signals as well as to be able to implement the new test procedures (as will be presented in WP7). The new tools have been calibrated and verified, using the methods recommended in the draft of Subset-116 and also by means of
checking against commercial antennas already calibrated (LAM). The conversion factor of the new antennas has been obtained. In this way, the new antennas (MFP, WLA) are ready to be used both for lab testing and for real field measurement campaigns.

Finally, the verification for both side of the BTM test setups have been validated by means of testing in real high speed trains and following with real BTM in the appropriate laboratory.

B) GSM-R WG

IFSTTAR, as main actor of the GSM-R working group, has specified the test set-up requirements to permit an efficient comparison between the interference received by the GSM-R antenna and the GSM-R useful signals received by this antenna. As a result, a test set-up was designed to permit to analyse the main factors of the interferences which can be linked with the final quality of the GSM-R communications. A software solution was developed to analyse the measurement performed on the GSM-R antenna and directly extract the characteristics of the interferences which can be compared with the GSM-R communications. The “good” class or the “bad” class is associated with a BER lower than 1.13%. That leads to a classification of each signal depending on 2 descriptors that depends on the measurement of the received signal and its post-processing (as will be explained in the test procedure work package explanations, WP7)

The test set-up, including software interfaces and programs, was tested, optimized and validated in presence of different interference scenarios collected during the measurement campaigns of the TREND project and former measurement files from IFSTTAR.

C) DC Track circuits WG

LTU and TV are the partners involved in the work flow of the DC track circuits test. From the study done in the first period of the project, different configuration for the 3 worst case scenarios detected in these previous WPs have been proposed. Thanks to the two measurement campaigns in the track and the well-known worst case of the lightning, two setups have been performed in a lab for testing and validation. Some equipment has been bought to build an exact reproduction of the track circuit section in it.

These test setups consist of the needed equipment in its suitable configuration. The validation has been performed through two measurement campaign in the track and lab experiments during this second period.

The 3 worst cases were tested but as a main result for the test setup point of view, it was possible to reproduce in the lab a whole track circuit section and emulate the stroke of a lightning on it.

Also, during the tests, the high robustness of the DC track circuits was checked and verified against the reasonable EMIs that could be find around this system.

D) Broadcasting Services WG

The Broadcasting services working group start its activities from the conclusions of the first period of the project concerning the reasonable worst case conditions and the immunity limits of these communication systems. Research has been carried out by Y-EMC into defining an internal test environment for the measurement of the pantograph arc from a moving train. The test setup requires an equivalent radiation mechanism to a moving train to be defined. This is done by using a spinning wheel and arc rig in a reverberation chamber.

This spinning wheel pantograph arc test rig was designed to be able to be used inside a reverberation chamber. This follows a similar radiation process to a pantograph arc from a moving train. The arc gap is changeable and various parameters of the test rig are changeable. The spark rate is set at 100Hz using a 555 timer to control the arc generation coil.

The pantograph arcing rig has been used to measure the total radiated power of the arc and the surrounding connected metallic structure. This rig is therefore used to look at how changes in the test rig effect the radiated power and the statistics within the reverberation chamber. The pantograph arcing rig performs best in the chamber with an arc gap of 5mm, a resolution bandwidth of 300kHz and a wheel speed of 28km/h. The higher wheel speeds results a more statistically uniform environment, perhaps due to the wheel acting as a stirrer. Changing of the parameters resulted in achieving the best field statistics in the chamber. The results show that interference to GSM is possible at lower separation distances.

The results from the arcing wheel have been compared with the results obtained measuring a static arc by the IFSTTAR team.
for the GSM-R working group. It is found that for small gap length (<4mm), low speed (<6km/h) and high resolution bandwidth (more than 1.5MHz) the lab data even exceed the values measured during the measurement campaign. Consequently, with the proper configuration of the parameters, a fully designed test setup has been developed, validated and can be used to replicate the arcing of a moving train.

Moreover, it is thought that the main radiation from the system comes from the surrounding metallic structure rather than the arc itself, in both this scale model and in the real pantograph. This difference in radiating shape, effectively working as the antenna may account for the differences with measured results. The measurement method using the RC could be used in the future to design pantographs that did not radiate strongly in the GSM-R band.

WP7: Design and Verification of Cross-Acceptance Test Procedures

Objectives

The main objective of this work package is to define the cross acceptance test procedure for the EMC approval tests and to verify it.

The test procedure is the group of processes that include the manipulation of the test setup, operation of the rolling stock and the equipments of the test site to reproduce the representative worst case conditions (steady and transient states) and the captured data analysis in the four research areas: spot signalling systems (STM, BTM and LTM), GSM-R, track circuits and broadcasting services (freight RFID, GSM, WIFI, TV and radio broadcasting services). Therefore, four set of procedures are foreseen to cover these four research areas.

- Task 7.1: Definition of the test procedure requirements. (Months 18-20 (Apr-Jun 2013))
- Task 7.2: Design of the test procedures (spot signalling systems, GSM-R, broadcasting services and track circuits) (Months 20-26 (Jul-December 2013))
- Task 7.3: Implementation of the test procedures (spot signalling systems, GSM-R, broadcasting services and track circuits) . (Months 22-28 (Sept 2013- Mar 2014))
- Task 7.4: Verification of the test procedure through EMI measurements .(Months 22-29 (Sept 2013- Apr 2014))

Progress towards objectives

In period 2 of the project, the work flow of the project has been redesigned and 4 working groups have been created. Each of them focused on one of the four signalling and communications systems under study in TREND:

- CEIT, CEDEX and CAF for spot signalling systems BTM
- IFSTTAR for GSM-R
- LTU and TV for DC Swedish Track Circuits
- Y-EMC for Broadcasting services

As a result, each working group has dedicated its effort on the analysis, design and verification of the whole task “Test setup, test site and test procedure” for their system (T7.1 T7.2 T7.3 and T7.4). But, in which concerns the explanations given in that document, the explanations given for the three work packages (WP6, WP7 and WP8) have been provided separately, as it was proposed in the DoW.

For this WP7, the progress and the significant achievements of the 4 working groups on the test procedure specific subject are here explained:

A) BTM WG

As already presented in WP6 explanations, CEIT, CEDEX and CAF have participated in the BTM working group, in both sides of the study: Balise immunity and Rolling Stock emissions. At the end of Period 1 of the project, the document that rules the BTM design in all its concepts was updated to its third major version. In it, another subset was directly pointing to the BTM tests
definition, entitled “Subset116: Eurobalise On-Board Equipment, Susceptibility Test Specification”.

But this subset was only a draft, it is not yet published and some of the critical points are still to be completed or even to be defined. In those conditions, the work performed by the BTM working group had a direct purpose and the results are of great interest for this Subset116, by means of the UNISIG-UNIFE BTM group that has received our output for their considerations. For the test procedure subject, the work of this project has been based on a deep review to the test procedures proposed by the draft of the Subset116, in order to have a proper interpretation and clearer technical instructions for testing. First, it is necessary to have a laboratory ready for the antenna-BTM certification tests, able to perform the radiation patterns of tele-powering and up-link emission, and to execute transmission tests, as CEDEX has. With the worst cases resulting from these analyses, the tests with real antenna-BTM equipment could be performed for BTM immunity subject. The aim of the tests is to check the BTM immunity to electromagnetic interferences that might affect to the up-link signal detection. The interference signals are injected in the air-gap by means of a special antenna, while a balise passage is being simulated for the worst conditions (high speeds, worst height/lateral displacement, worst Debris conditions).

A new development has been defined to be able to generate the realistic resulting noise signals: the ones already defined by the draft of the subset 116 and adding some medium-high probable real signals captured on-track. For that, a novel automation, synchronization and analysis SW has been then necessary for the test procedure. The noises have been obtained through the rolling stock emissions tests, which procedure includes proper data acquisition conscious and analysis of the post-processing of the signals in order to detect their real power. In that case, the Gabor Algorithm with time-frequency simultaneous analysis has been the one selected. It’s worth mentioning that the real disturbances have been obtained with two different procedures: high speed operation in a high speed track line and with a sequenced hand manipulation of the pantograph and the circuit breaker with a static train. In both cases, a trigger has to fixed the limit to save the noises. Concerning the laboratory, two types of test procedures have been defined to check the antenna-BTM immunity. In one case, the interfering signal is generated while a balise passage is being simulated, and in the other case, the interfering signal is generated without any balise passage simulation. It was possible to create the 29 test signals of Subset-116 and the 34 novel test signals with the characteristics of the CEIT proposal. With these two test procedures and the complete set of disturbances, it is possible to check how the different noises impact in the antenna-BTM detection and behaviour.

For this WP also, the verification for both side of the BTM test procedure have been validated by means of testing in real high speed trains and following with real BTM (anonymous) in the appropriate laboratory.

B) GSM-R WG

As already introduced in the explanation of the test setup work package, WP6, IFSTTAR has analyzed and evaluated the impact of the different factors defining the test conditions on the interferences collected. The quality of the GSM-R communication were studied in laboratory (on a dedicated test bench) in order to determine the parameters to fix in the test procedure.

With the results of this first approach, a procedure was obtained in order to link the BER of the disturbance signal to 2 descriptors that could classify it more easily. To make it simple, the descriptor used is defined as a monitoring of the evolution of the ratio between the received GSM-R power level and the power of the noise level induced by transient signals on the GSM-R channel when they occur. Then, the time resolution of the descriptor is adapted to be comparable with the transmission duration of one GSM-R bit (3.7μs). The aim is to be able to evaluate the impact on each GSM-R bit at each occurrence of a transient.

The test procedure was also tested, optimized and validated in presence of different interference scenarios collected during the measurement campaigns.

C) DC Track circuits WG

From the test procedure point of view for the work performed by the DC track circuit working group, LTU and TV has completed in that WP the test setup already explained in WP6.

The design of the test procedures consists of the group of processes to manipulate the 3 test setup. With that procedure, the reasonable disturbances and actions concluded in the WPs from period 1 are received by the DC track circuits in order to assess their robustness. As already said in the previous WP, the high robustness of the DC track circuits was checked during
these tests. Moreover, this sequence of steps, for each of the cases, can also be applied to check the robustness of other devices. WP6, WP7 and WP8 are coordinated for each technology, and consequently, the test procedure has been also validated in two track measurement campaigns and lab experiments during this second period.

D) Broadcasting Services WG
From the test procedure point of view, the test requirements for these communication systems have been set up to cover the procedure and methodology used to take a measurement in the chamber. This covers the way to make a measurement in the chamber. The procedure is then linked to the procedure taken in an external environment. The definition of the test procedure involves looking at what it is that is wanted to be measured and how best to measure it. The definition of Y-EMC also includes work on transferring the test procedure out of the laboratory. The results taken using the test procedure were compared with those expected in the chamber and those measured outside the chamber by IFSTTAR, for validation of the proposed test procedure. As a result, the test procedure for the measurement of arcing in a reverberation chamber has been defined.

WP8: Design and Verification of Testing Site

Objectives
The main objective of this work package is to define the cross acceptance test site for the EMC approval tests and to verify it. The test site is the facility and group of instruments that manipulated as indicated in WP7 can reproduce the representative worst case conditions (steady and transient states) regarding the infrastructure. Therefore, the test site will cover the four research areas: spot signalling systems (STM, BTM and LTM), GSM-R, track circuits and broadcasting services (freight RFID, GSM, WIFI, TV and radio broadcasting services).

- Task 8.1: Definition of the test site requirements. (Months 18-20 (Apr-Jun 2013))
- Task 8.2: Design of the test site (spot signalling systems, GSM-R, broadcasting services and track circuits) (Months 20-26 (Jul-December 2013))
- Task 8.3: Implementation of the test site (spot signalling systems, GSM-R, broadcasting services and track circuits) .(Months 22-28 (Sept 2013- Mar 2014))
- Task 8.4: Verification of the test site through EMI measurements .(Months 22-29 (Sept 2013- Apr 2014))

Progress towards objectives and significant achievements
In period 2 of the project, the work flow of the project has been redesigned and 4 working groups have been created. Each of them focused on one of the four signalling and communications systems under study in TREND:
- CEIT, CEDEX and CAF for spot signalling systems BTM
- IFSTTAR for GSM-R
- LTU and TV for DC Swedish Track Circuits
- Y-EMC for Broadcasting services

As a result, each working group has dedicated its effort on the analysis, design and verification of the whole task “Test setup, test site and test procedure” for their system organized in T8.1 T8.2 T8.3 and T8.4. But, in which concerns the explanations given in that document, the explanations given for the three work packages (WP6, WP7 and WP8) have been provided separately, as it was proposed in the DoW.

For this WP8, the progress and the significant achievements of the 4 working groups on the test procedure specific subject are here explained:

A) BTM WG
As already presented in WP6 explanations, CEIT, CEDEX and CAF have participated in the BTM working group, in both sides of the study: Balise immunity and Rolling Stock emissions. At the end of Period 1 of the project, the document that rules the BTM design in all its concepts was updated to its third major version. In it, another subset was directly pointing to the BTM tests definition, entitled “Subset116: Eurobalise On-Board Equipment, Susceptibility Test Specification”.

But this subset was only a draft, it is not yet published and some of the critical points are still to be completed or even to be defined. In those conditions, the work performed by the BTM working group had a direct purpose and the results are of great interest for this Subset116, by means of the UNISIG-UNIFE BTM group that has received our output for their considerations. For the test site subject, the work of this project has clearly been focused on a certified laboratory for the BTM immunity tests and a real train for the rolling stock emissions. The former test requires a lot of very specific equipment already used by the certified laboratories that propose the Subset85 testing. And the former should be done, undoubtedly with a real train (in a high speed line or even in a static position in a depot, as already presented in the WP7 explanations).

For the Balise immunity tests, the test site (CEDEX laboratory) has been prepared for testing the test procedures for the BTM immunity tests. The laboratory already had some of the proposed tools, but some of them had to be updated to be able to generate the new signals as well as to be able to implement the new test procedures. Some tools to equip the test site have been build (MFP and WLA) and some new tools had to be built on purpose. New commercial equipment were acquired: current probes for the WLA antenna, Coaxial Cable, 3dB 100/30W Attenuator, Low Pass filters, LAM (Loop Antenna Mid Band, the antenna used to calibrate the MFP and with similar characteristics).

As a result of this project, CEDEX has prepared the Laboratory to perform these tests, verifying tools and procedures showed in Subset-116. Some doubts and points to specify have been highlighted. The preparation of the lab to test according to Subset-116 reached important goals:
- Executing in the lab the mandatory tests defined in the first draft of the Subset-116, which allows the verification of the antenna-BTM immunity to electromagnetic interferences. This norm is mandatory according to the last version of the Eurobalise FFFS (Subset-036, v3.0.0 base line 3).
- With the signals provided by CEIT in TREND project, CEDEX has reproduced in a lab environment the same signals that have been measured in a real train in a real circulation with a test antenna (MFP: Magnetic Field Probe). This point is very important to compare and evaluate the test signals of Subset-116 and the real field signals.
- Proposition of test parameters to reproduce homogeneous rolling stock emissions in any kind of train that has to be equipped with BTM systems.

A) GSM-R WG
The analysis of the different interferences collected by IFSTTAR during the measurement campaigns and the use of the CST model permitted to analyse how the test site and the conditions of measurements impact the GSM-R interferences are received by the working antennas. The study performed permitted to define the main requirement to respect concerning the test site and conditions to measure the GSM-R interferences in acceptable and reasonable worst cases conditions, on-board the trains.

The measurement test chain was implemented and adapted to permit to modify the test conditions (positions and type of antenna) during the measurement campaigns. And different test site conditions (positions and type of antenna) were applied in order to test their impact and to validate the observations extracted from the CST model.

B) DC Track circuits WG
From the test site point of view for DC track circuits, LTU objective in this work package was to define the locations of the tests and to verify their suitability.

The location for the rail tests for the measurement campaigns was outside, in the North of Sweden, in winter, so it was tested in an extremely cold environment; which is one of the main parameters detected in the analysis of the work packages from Period 1. It was also taken into account how different can be the climate conditions in North Sweden regarding the season. The real implementation of the test site were two stations in the North of Sweden (Gamlestad and Niemisel) and in a lab of the Luleå University. And here also, the high robustness of the DC track circuits against the EMIs was checked.
Concerning the design of the ‘test site’, Y-EMC has focused its effort on the reverberation chamber environment, but also including the application to the environment external to the laboratory. The test setup and test procedure proposed has been validated with real measurements on real trains (mostly from the GSM-R working group) and the reverberation chamber has been confirmed as a suitable environment in which to perform this kind of measurement. This goes in the direction of saving cost and money to the tests on-board to enhance the cross-acceptance between the rolling stock and its signaling and communication systems. Moreover, the recreation of worst case conditions is managed by changing the parameters of the test setup to vary gap length, wheel speed etc. The results obtained from this test site are comparable with expectations. The verification of the results when compared to results taken outside the chamber has been undertaken. This also includes some work into the new draft versions of EN50121 to determine the relation between the measurements and the new standards.

As a global conclusion for the broadcasting services working group, the results taken and presented using the work done in WP6 and 7 and 8 would open a short discussion of the changes to the most recent set of draft EN50121-X standards.

WP9: Dissemination and Exploitation

Objectives
The main objective of this work package is to disseminate the results of the research in the different segments of the society; railway industry level, scientific level, academic level, standardization bodies level, railwaystake holder level and word wide level. Figure in B3.2 summarizes and represents the foreseen dissemination activities in the project.


Progress towards objectives and significant achievements
The web site created for the project is found at [www.trend-eu.org](http://www.trend-eu.org). Here can be found the contact, the updates of the news and the main activities done by all the partners of the project. 6 labels structured the information:
- A presentation of the partners with links to our own web pages
- The contact data of the coordinator
- The news which are relevant to the project, like dissemination in generic industrial forum, technical presentation given for commercial software companies or meetings announcements and summaries. 13 news have been reported for the whole project.
- The results are presented and separated in Conference papers, Journal Articles, Magazines participation and the public deliverables. The total amount of entries for each of these categories are 1 journal article, 10 conference papers, 1 industrial magazine and 10 deliverables.
- A Private label, where the partners have access to the management tool and documents useful for the work.

Task 9.2: Contribution to technical journals and international congresses. (Months 13-30 (Nov-April 2014))

Progress towards objectives and significant achievements
1 Journal and 10 conference papers have been positively evaluated during the whole project. All the data from them is presented in section Error! Reference source not found. of this document, where the authors, the title and the publication name and date is written.
Task 9.3: Dissemination to the industry. (Months 22-30 (August 2013- April 2014))

Progress towards objectives and significant achievements
As a precursor, Y-EMC coordinated a workshop at EMC EUROPE 2012, to present the first set of deliverables of the project and to discuss the project objectives and raise awareness of the project. All the partners have participated in that activity with a good coordination among all.

In the second period of the project, CEIT organized and completed an online workshop about electromagnetic simulation for railway systems in collaboration with CST for professional users and related companies. This online workshop had a great success in attendance and impact.

Moreover, other dissemination activities have been reported. Y-EMC has displayed a poster at the Railtex Exhibition, 30/04 – 02/05/13 reporting on TREND results so far. Y-EMC also made a seminar presentation including the video of continuous arcing produced by a deliberately iced catenary conductor. Y-EMC poster seen and discussed at Railtex 2013 (Largest UK rail industry show)

IFSTTAR and CEIT have presented the main step forwards in electromagnetic simulation for GSM-R and BTM systems in other national and international meetings for CST professional users and related companies.

Task 9.4: Dissemination to the main stakeholders in EMC and railways. (Months 13-30 (Nov 2012- April 2014))

Progress towards objectives and significant achievements
Multiple activities are reported in that task from several partners of the project. For example, as previously said, Y-EMC coordinated a workshop at EMC EUROPE 2012, to discuss the project objectives and raise awareness of the project. In parallel to this workshop, 4 papers and posters were presented in that EMC forum (1 from Y-EMC, 1 from LTU and 2 from IFSTTAR).

Other national and international meetings have also received inputs from the partners of TREND. CEIT presented the main objectives and ideas of TREND in the 4th annual Signalling and Tran Control forum, in Vienne on 20/03/2013 and in the Transport Research Arena TRA2014 and Y-EMC displayed a poster reporting on TREND results so far at a seminar held in the Queen Elizabeth II Conference Centre in Central London, on 27/03/13.

And in the second part of the project, one of the most important points was to disseminate the conclusions and the step forwards for standards and other regulatory documents. That is explained in the next point of this report.

Task 9.5: Contribution to standards. (Months 29-30 (March 2014- Apr. 2014))

Progress towards objectives and significant achievements
First, contacts have been started with ERA and with track circuit’s WG as people from these entities are part of the Advisory Board Group of the project. Some recommendations and tips have been received for an appropriate dissemination of the results.

Then, mostly in the second period, all the working groups have faced their appropriate standard, subsets and all kind of regulatory documents. The deliverable D9.2 entitled “Revision of the current EMC interoperability standards” is especially dedicated to that subject.

As a result, The broadcasting services and the GSM-R working groups have analyzed and proposed some step forwards for some of the documents of the 50121 series.

For DC track circuits, the Swedish regulatory organism and their specific documents have benefited with the work done by TREND.

And finally CAF and CEIT have collaborated with the BTM issues open points. Cooperation has been done with the UNISIG-UNIFE BTM working group, by means of direct participation of CAF, in order to help determining the rolling stock emissions test setup, test procedure and test site. A deep analysis has been also done by CEDEX to the subset 116 BTM immunity section, which also would be considered by this working group.
Task 9.6: Courses for professional advancement and for students. (Months 24-30 (Octob. 2013- Apr 2014))

Progress towards objectives and significant achievements

During the first period of the project a course has been organized by TREND for Spanish professional and students, in Spain. The main advances in WP2, WP3 and WP4 have been presented in cooperation with UPC, member of the Advisory Board of TREND.

http://www.iirspain.com/Producto/?cod=49E4293BD34C

During the second period of the project CEIT has disseminated the acquired know-how on railway electromagnetic compatibility in a Master Science course at the University of Navarra and in the Luleå University courses related with EMC issues as ‘Waves and antennas’ have been also taught.

Potential Impact:

Socio Economic and wider societal Impact

The impact of TREND project embraces the safety, the availability and the economical concepts, which are here linked. From a European point of view, it helps in some step forwards.

The interoperability and the cross-acceptance issues presented by the answered call and laying the foundation of TREND project are of major importance into the European Union. The improvement of the standardized EMC approval tests guarantees the safety of the railway systems. This influences enormously the availability of the trains and their integrated systems which has a significant impact on the competitiveness of the companies and on the users’ vision of the railway transport system. Specifically for the markets using the communication and signalling systems studied by TREND, both, passenger and freight market could progressively increase the rail transport volume as this kind of project keep on working on advances for signalling and communication systems. But also, the companies will save time and money on the costly measurement campaigns and punctual problems in specific places of the deployed railways.

As initially proposed in the Part B of the DOW document, and updated in the course of the project, the impact of the project offers opportunities on various levels:

Users – Passenger and Freight market.

The users of the railway transport are [EUROSTAT 2008]:
- In 2008, 405 billion passenger-kilometres were registered in the European Union (excluding Bulgaria), a 4.2% growth compared to 2007.
- The total performance of rail freight transport in the EU-27 was 447 billion tonnekilometres in 2008.
- These enormous figures have taken place in the 216.018 of kilometres-length of the lines in the European Union.

The previous data exhibit the impact of the TREND project in terms of the improvements foreseen on the railway availability for users and railway companies. Up to 2008 (last year reported by the Eurostat report at the moment of the writing of the project proposal and which trends have been confirmed by the data in the 2010 Eurostat analysis), both the passenger and the freight market have had a positive growth, and so, this tendency would be accentuated with the higher availability achieved by the fully interoperable on-board systems and trains; Highlighting the words “Punctuality” and “simple logistic”.

Furthermore, in 2008, some 2848 people were victims (seriously injured or killed) of railway accidents in the EU-27. Of the total number, 17.4 % were either train passengers or railway employees. Approximately two thirds (68.6 %) of the lives lost in rail accidents were from incidents involving rolling stock in motion, with almost all the others (26.6 %) from incidents at level-crossings. That figure could be decreased with the improvement brought by the TREND project in terms of safety for certain critical zones where the signalling is the only protection.

Transport service enterprises and their employees

The last recount done by Eurostat [EUROSTAT 2008], FIF (La Fédération des Industries Ferroviaires) [FIF] and UK Railway Companies [UK RAIL], establishes that there are 453 enterprises in the railway transport service in the EU-27. So, the trains’
higher availability and the foreseeable increase in the railway transports, for all kind of users, would have a clear impact on the service enterprises of the European Union. This is directly scalable to the employment of these principle railway industries: 891,852 people at the end of 2008. This figure would be increased if the railway transport and the investment on that solution for the mass and freight transport have an increase in its use.

Railway enterprises and other stakeholders
The number of enterprises involved in the railway industry is much higher than the figure reported in the last point. Companies such as train manufacturers, railway systems’ integrators, equipment developers, R&D centres and other technology providers are also affected by the impact of the TREND project. For them, this project will have a secondary economical benefit from 2 point of view. First, the foreseen preservation of the growth of the railway transport for passengers and freight goods will maintain the growth of the railway industry and its associated companies and will benefit the creation of employment. And second, the rolling stock system modelling, the test site, the test setup and the test procedure foreseen by TREND, will minimize the expensive measurement campaigns during the design of any communication equipment for railway applications. Obviously, the equipment assigned for on-board communications has to be validated for its use, as the other parts of the complete train. Up to now, this validation needs on board measurements, and even with them, the availability and the safety is not assured, since the worst case conditions may not have been tested. With the test laboratory to be proposed by TREND, some measurement campaigns could be diminished. That would mean a big save in time and money for the designs for the railway industry. That would have an impact not only for these railway enterprises but also for the users, as the technology would have a quicker adoption in the trains.

At IFSTTAR, for example, TREND project funded two young persons under contract: one ingenieur during one year and one post-doctorant during 7 months. Thanks to the experience they had in TREND, they both directly obtained permanent contracts in their domain of competences.

Standardization bodies
The successful completions of the objectives of TREND will help the European Union with some steps forward in the way to have a fully operable and unified network, as the EMC standards would have more accurate limits and procedures for their approval tests. The operational and technical integration of the different national railway systems in the European Union and accession countries will be simplified by the renewed EMC standards. The harmonization for the whole European Union will be improved, or at least the way to do it will be known. These standardization bodies are the first receivers of the results from TREND in all the dissemination levels, but the scientific one, more dedicated to specific investigations advances, will also be benefited.

From the generic broadcasting services point of view, increase in knowledge of railway standards and pantograph arcing results in a more fully understood electromagnetic environment. The Electromagnetic compatibility of ERTMS constituents was and is still an open issue under discussion at European level. This project allowed validating the laboratories (CEDEX) and the on-board measurements and post-processing with technical equipment adequate for EMC testing in the Railway Signalling field in line with Subset-106 of the TSI.

Public administrations
Railway transport is a key area of development from the economical, from the sustainable and from the environmental point of view. Undoubtedly, the steps forwards for the improvement of the availability and the safety thanks to the TREND project would help in this deployment. But, primarily, the interoperability and the cross-operation between different rail networks that is improved and helped by the goals of this project proposal is crucial in avoiding some of the obstacles found in the use of large European lines and systems and equipments from different suppliers.

Main Dissemination Activities

a) General Dissemination Roadmap

Table 9 presents a brief summary of the dissemination activities performed by the partners of the consortium within the
duration of the project.

General Dissemination Roadmap

M1 Nov-2011 Towards an environment without electromagnetic interference in railway signalling CEIT
M2 Dec-2011 Towards a safer European rail network www.basqueresearch.com CEIT
M2 Dec-2011 Trend Project will help to improve the safety in the railroads and to reduce the costs of certification to the industry (www.estrategia.net) CEIT
M2 Dec-2011 The main objective of Trend Project, is to improve the safety in the railroads and to reduce the costs of certification to the industry. (www.planavanza.es) CEIT
M3 January 2012 The future railway environment without electromagnetic interferences in the signaling. (www.conventroic.es) CEIT

M11 Sept-2012 Trend Project was presented within the workshops of EMC Europa 2012 Conference, last 17th of September. http://www.emceurope2012.it/ ALL
M18 April-2013 Ifstar presented TREND project in the second edition of Microwave & RF. Paris 4th of April 2013 IFSTTAR
M20 June 2013 Trend project was presented on the XIII National ITS Congress. San Sebastian (Spain) 18th-20th June 2013 CEIT
M23 Sept 2013 V. Deniau, H. Fridhi, M. Heddebaut, J. Rioult, I. Adin, J. Rodríguez. Analysis and modelling of the EM interferences produced above a train associated to the contact between the catenary and the pantograph. EMC-Europe 2013. Brugge (Belgium) 2-6, September 2013 IFSTTAR, CEIT, CAF I+D CEIT
M26 Dec-2013 Next 5th of December CEIT and CST will offer a course on “Train Signalling System Interference Estimation by CST MWS” CEIT
M30 Apr-2014 J. del Portillo, I. Adin J. Mendizabal D. Valderas I. Ortego G. Solas. Enhancing the rolling stock standards towards a
TREND project has generated an interesting foreground from the technical point of view, as just presented in the “dissemination roadmap” subsection, above and below in the next section “use and dissemination of foreground”. This has been the basis for the contributions of all the working groups to the deliverables D6.1 D7.1 and D8.1 where the test setup, the test site and the test procedure have been defined for enhancing the interoperability of the BTM, GSM-R, DC track circuits and broadcasting services for railways.

Thus, this couldn’t be considered as exploitable results resulting in direct benefits for the partners that have worked in that project. As will be explained in the use and dissemination of foreground section, the most of the impact of the results will benefit in the standards, subsets and other regulatory documents related with the signalling and communication systems studied. This could even fit for other applications where the same technologies of communication and signalling are used. However, industrial companies have shown their interest in the progresses shown.

First, CAF, as a partner will use the foreground in the ongoing Engineering projects improving the efficiency of the EMC validation and reducing the risk of having safety issues or impact on the availability due to interference between the rolling stock signalling and communication systems. For the same signalling system, BTM, CEDEX is also going to be able to apply the know-how and the laboratory definition to complete their own facilities and offer this service to potential clients.

Second, the results obtained concerning the method of classification of the EM environment according to their impact on the quality of GSM-R communications was also presented to SNCF by IFSTTAR, in order to make them evolve their test solutions in relation with the advancement of the project. In parallel, the results of the project permitted to determine the requirement to perform efficient emissions measurements concerning the transient disturbances which can affect the GSM-R communications. This is permitted to highlight the sections which have to evolve or to be completed in the EN 50121 standards to permit to introduce the control of the emissions which could affect the GSM-R.

From the DC track circuits and broadcasting services point of view, the outcome from this project has opened an new angle for the infrastructure manager to look in to different approach when it is EMI and where the source are. The understanding of the creation and propagation of the transients in the system is of great interest to infrastructure manager as TV, also partner of the project. Novel and more efficient tests could by now be applied to DC track circuits in order to assure the safety and security of the whole railway signalling systems.

List of Websites:

http://www.trend-eu.org/