Integrated Communication System for Intelligent Train Applications

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Deliverable №: 26

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Author(s): Erich Renner, Paolo Umiliacchi, AF Leaders
Classification: IST
Contract Start Date: 01/12/00 Duration: 39 months
Project Co-ordinator: Mr. Erich Renner – SIEMENS AG
Partners:

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Title: Integrated Communication System for Intelligent Train Applications

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Due date: 30/04/04
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Short Description

This document provides a comprehensive summary of all project objectives, activities and achievements. It includes a view of the results obtained, the methodologies and approaches employed, changes in the state-of-the-art since the project start. The report addresses the objectives of the project as well as the degree to which these objectives have been reached.

Chapters related to individual Activity Fields have been edited by the AF leaders: G. Corradi (on behalf of Mr. G. Fadin) FAR, A. Heindel SIEMENS, R. Nies BOMBARDIER, F. Wilde BOMBARDIER, R. Schmidt SIEMENS. General parts and overall editing by Mr. E. Renner (coordinator) and Mr. P. Umiliacchi (Evaluation Manager).

History

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<tr>
<td>V1</td>
<td>04 Feb 04</td>
<td>first draft</td>
<td>Initial draft version</td>
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<tr>
<td>V2</td>
<td>30 Apr 04</td>
<td>first issue</td>
<td>Complete version</td>
</tr>
<tr>
<td>V3</td>
<td>18 May 04</td>
<td>final issue</td>
<td>Reviewed version</td>
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</tbody>
</table>

Partners owning: SIEMENS (1)
Partners contributed: SIEMENS (1), FAR, BOMBARDIER
Made available to: All participants
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1. Executive Summary

The TrainCom project aimed at defining a standard Communication Infrastructure, which is able to seamless connect train equipment and ground facilities, so as to support a wide range of applications.

The project included five Activity Fields:
1. Standardisation and Conformance (STD)
2. Train-ground Communication Infrastructure (TCI)
3. On-board Dynamic Passenger Information System (DPIS)
4. Remote Monitoring and Maintenance (ROMAIN)
5. Locomotives Interoperability (LOCO)

Activities were carried out according to the Technical Annex, as resulting from the approved Contract Amendment. It included a 3 month time extension.

The main results achieved are here summarised:

<table>
<thead>
<tr>
<th>Activity Field</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF1</td>
<td>Specification of a TCN Conformance Test, according to standard IEC 61375-1 – It contributed to the draft of the proposed standard IEC 61375-2</td>
</tr>
<tr>
<td></td>
<td>TCN Conformance testbed, to perform the tests demanded by the Conformance Test specification on TCN devices</td>
</tr>
<tr>
<td></td>
<td>TCN Coach Tester to perform the tests demanded by the Conformance Test specification on complete vehicles</td>
</tr>
<tr>
<td>AF2</td>
<td>Specification of the Train-Ground Communication Infrastructure</td>
</tr>
<tr>
<td></td>
<td>TrainCom Communication Infrastructure – system to establish a train to ground radio communication; it includes different devices: ROGATE, ROGS, RONS</td>
</tr>
<tr>
<td>AF3</td>
<td>Specification of the Dynamic Passenger Information System (DPIS)</td>
</tr>
<tr>
<td></td>
<td>Prototypes of the Dynamic Passenger Information System (DPIS)</td>
</tr>
<tr>
<td>AF4</td>
<td>Specification of the Remote Monitoring and Maintenance System</td>
</tr>
<tr>
<td></td>
<td>Prototype of the ROMAIN system</td>
</tr>
<tr>
<td>AF5</td>
<td>Specification of Remote Traction Control for Locomotive Interoperability</td>
</tr>
<tr>
<td></td>
<td>Vehicle simulator for test of remote control interoperability</td>
</tr>
</tbody>
</table>

AF1 was in charge of standardisation activities and established a good cooperation with several standardisation bodies and railway organisations:
- IEC for the Train Communication Network (TCN) Conformance Test,
- CENELEC for the Communication Infrastructure,
- CENELEC for the Dynamic Passenger Information System,
- UIC for Locomotive Interoperability and TCN Conformance Test.
- AEIF for linkage of TrainCom to Technical Specification for Interoperability of high-speed trains and conventional trains.

Two prototypes were developed and verified:
- the TCN conformance test bed, based on LabView®, to test specific devices;
- the coach tester, to perform tests on a complete vehicle.

AF2 developed the project core result, the TrainCom Communication Infrastructure (TCI). The architecture includes the Railway Open Gateway (ROGATE) aboard and the Railway Ground Station (ROGS) and Railway Name Server (RONS) on the ground. Several prototypes were tested to check their interoperability.

The specification of a European database and definition of a structure to store all data useful for the communication infrastructure and common to all possible applications were part of the work as well. Final validation occurred in combination with AF3 and AF4.

The final result is to offer to any application the possibility to use a standard Communication Infrastructure to establish a reliable link with any other application, wherever it is located (in a ground system or in a device aboard a train running anywhere in Europe).

The implementations are available for the demonstrators of the project EuRoMain and other possible future projects.

AF3 deals with the dynamic information system for passengers (DPIS), which will handle trip information and seat reservation data, according to a common database structure; automatic upload of information to trains will reduce time, manpower and errors, improving the quality of service; it can favour inter-modal operations as well.

At the heart of the system is a specific data model, where all relevant information can be accommodated according to their role, priority and updating needs.

Prototypes were validated through demonstrations on real trains.

In AF4, a prototype integrating the basic modules of the ROMAIN system over the TrainCom Communication Infrastructure was tested according to the specified architecture, which includes three databases: real time monitoring, diagnostic data collection and control configuration. The verification occurred in a laboratory; a public event was organised.

The results achieved have been forwarded to the EuRoMain project (IST-2001-34019), for further investigation and developments.

AF5 scope was to show how a locomotive or a driving trailer can remotely control another locomotive, through the standard TCN train bus (IEC 61375-1), using standard procedures as defined in UIC 556-647 (EU Remote Control). The solution was tested and demonstrated using a number of locomotives and steering coaches from different operators, manufacturers and countries.

Results were very positive and can bring to a standard solution for remote control in Europe.

Careful project management, supported by suitable procedures and tools, was successful in establishing a good cooperation between all participants, overcoming problems and having activities progress toward final results.
Extensive diffusion actions included a comprehensive Web site, a printed brochure, papers and presentations at conferences or internally organised public events, and a final CD-ROM, to present project results and the main deliverables.

The overall results were complete and successful, in accord with the Technical Annex, and perspectives for further developments and exploitation are very good.
2. Introduction

2.1. Scope

TrainCom scope was to set up a general purpose telematic link between train and ground, integrating available standard technologies like GSM, TCN and Internet protocols, offering a basic platform for new intelligent applications, which will increase the interoperability, quality of service and overall competitiveness of railways.

2.2. Organisation of work

TrainCom work was organised on the basis of a well established phase sequence:
1. assessment of User requirements
2. specification
3. development
4. verification
5. demonstration
6. exploitation

Each phase had an important role and embedded quality assessment activities. In accord with project objectives, special emphasis was given to the demonstration phase, that is the phase when it is easiest to "touch" the results and understand their benefits.

To better organise the project and to assure proper technical co-ordination during project life, the time-oriented phase structure is combined with a vertical, objective-oriented structure, which consists of a number of activity fields. The overall organisation, which was successfully applied to a previous project (ROSIN), was well suited to such a complex and articulated project and allowed to assure homogeneous and continuous progress of the identified activity fields, under the responsibility of an activity field leader, from the starting phase up to conclusion of the anticipated activities.
Due to technical and organisational reasons, the project was divided into 5 fields of activity:

6. Standardisation and Conformance (STD)
7. Train-ground Communication Infrastructure (TCI - based on ROGATE: Railway Open GATEway)
8. On-board Dynamic Passenger Information System (DPIS)
9. Remote Monitoring and Maintenance (ROMAIN)
10. Locomotives Interoperability (LOCO)

The following block diagram illustrates the relationship between the activity fields:

The following table summarises the situation of the activity field leaders, who assured a continuous and homogeneous progress of the work during project life.

<table>
<thead>
<tr>
<th>Activity field</th>
<th>Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Standardisation and Conformance</td>
<td>G. Fadin FAR</td>
</tr>
<tr>
<td>2. Communication infrastructure</td>
<td>A. Heindel SIEMENS</td>
</tr>
<tr>
<td>3. On-board dynamic information services</td>
<td>R. Nies BOMBARDIER</td>
</tr>
<tr>
<td>4. Remote monitoring and maintenance</td>
<td>F. Wilde BOMBARDIER</td>
</tr>
<tr>
<td>5. Locomotives interoperability</td>
<td>R. Schmidt SIEMENS</td>
</tr>
</tbody>
</table>
The superimposed work-package scheme can coexist without conflicts, completing the project organisation.

<table>
<thead>
<tr>
<th>WP no.</th>
<th>Work-package title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User needs and requirements</td>
</tr>
<tr>
<td>2</td>
<td>TCN Conformance testing and interoperability issues</td>
</tr>
<tr>
<td>3</td>
<td>Architecture of the communication infrastructure</td>
</tr>
<tr>
<td>4</td>
<td>Applications specification and standardisation issues</td>
</tr>
<tr>
<td>5</td>
<td>Conformance test bed</td>
</tr>
<tr>
<td>6</td>
<td>Development of the communication infrastructure</td>
</tr>
<tr>
<td>7</td>
<td>Dynamic Passenger Information Services</td>
</tr>
<tr>
<td>8</td>
<td>Maintenance system</td>
</tr>
<tr>
<td>9</td>
<td>Locomotive Remote Control and Interoperability</td>
</tr>
<tr>
<td>10</td>
<td>Verification of communication infrastructure and applications</td>
</tr>
<tr>
<td>11</td>
<td>Verification of locomotive applications</td>
</tr>
<tr>
<td>12</td>
<td>Verification of the conformance test bed</td>
</tr>
<tr>
<td>13</td>
<td>Demonstration of new on board services</td>
</tr>
<tr>
<td>14</td>
<td>Demonstration of locomotive interoperability</td>
</tr>
<tr>
<td>15</td>
<td>Dissemination and exploitation</td>
</tr>
<tr>
<td>16</td>
<td>Quality assessment and evaluation of results</td>
</tr>
<tr>
<td>17</td>
<td>Project management and external actions</td>
</tr>
</tbody>
</table>

The resulting structure is depicted in the following scheme:
WP1, dealing with User Requirements, started on the commencement date and defined the basis for all the work. WP15, which included activities related to Diffusion Actions and Exploitation of results, was active not only at the end of the project, but partially during project life, when specific actions were required.

The activity field related to “Remote monitoring and maintenance” was limited to development and first verification of basic elements of the architecture. After this, a decision was taken (in WP15) to start a proposal for further work, which finally resulted in a new project: EuRoMain.

Due to the strict interrelation between technological development and validation activities, it was not possible to completely distinguish between the research and demonstration parts. Anyway, the most relevant demonstration activities were assigned two separate work-packages: WP13 and WP14.

WP16 and WP17 (not shown) were two vertical work-packages, which were active during project life.

WP16 dealt with evaluation activities and quality assessment, including step by step evaluation of results.

WP17 included project management, to assure proper co-ordination of activities, and external actions, providing co-operation with relevant associations and concertation with other projects.

The project timing was refined during the project life and extended thanks to an additional three months period, which was part of a contract amendment:
2.3. List of participants

The TrainCom consortium included 14 participants and 2 Observer participants:

<table>
<thead>
<tr>
<th>No.</th>
<th>Participant name</th>
<th>Short name</th>
<th>Country</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SIEMENS Aktiengesellschaft</td>
<td>SIEMENS</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>Bombardier Transportation GmbH</td>
<td>BT DE</td>
<td>D</td>
<td>P</td>
</tr>
<tr>
<td>3</td>
<td>Bombardier Transportation Italy S.p.A.</td>
<td>BT IT</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>ANSALDOBREDA S.p.A.</td>
<td>ASB</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>5</td>
<td>ATOS ORIGIN S.p.A.</td>
<td>ATOS</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>Construcciones y Auxiliar De Ferrocarriles S.A.</td>
<td>CAF</td>
<td>E</td>
<td>P</td>
</tr>
<tr>
<td>7</td>
<td>F.A.R. SYSTEMS S.p.A.</td>
<td>FAR</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>8</td>
<td>FIREMA Trasporti S.p.A.</td>
<td>FIREMA</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>9</td>
<td>SC Siologic s.r.l.</td>
<td>SILOGIC</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Deutsche Bahn Reise&amp;Touristik AG</td>
<td>DB</td>
<td>D</td>
<td>P</td>
</tr>
<tr>
<td>11</td>
<td>TRENITALIA S.p.A.</td>
<td>FS-TRI</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>12</td>
<td>Österreichische Bundesbahnen</td>
<td>OEBB</td>
<td>A</td>
<td>P</td>
</tr>
<tr>
<td>13</td>
<td>Red Nacional de Ferrocarriles Españoles</td>
<td>RENFE</td>
<td>E</td>
<td>P</td>
</tr>
<tr>
<td>14</td>
<td>Alstom Transport S.A.</td>
<td>ALSTOM</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>O.1</td>
<td>Société Nationale de Chemin de fer Français</td>
<td>SNCF</td>
<td>F</td>
<td>O</td>
</tr>
<tr>
<td>O.2</td>
<td>Schweizerische BundesBahnen</td>
<td>SBB</td>
<td>CH</td>
<td>O</td>
</tr>
</tbody>
</table>

The consortium was well representative of European railway industries and operators, covering most of the European countries, including also non-EU countries like Romania. It was well dimensioned to cope with the envisaged effort and to develop solutions capable of reaching a wide consensus.

The consortium included all typologies of needed actors in the addressed application fields (the participant numbers are given in brackets):

1. System integrators, big industries manufacturing complete trains (1, 2, 3, 4, 6, 8, 14)
2. Sub-system manufacturers, SME's manufacturing components or equipment for train subsystems (7, 9)
3. ICT providers and research centres, having a specific know-how (5, subcontractors)
4. Railway operators, who manage and run trains (10, 11, 12, 13, O.1, O.2)

A total number of 7 Countries were involved, including Romania and Switzerland:
Map of TrainCom participants geographical distribution in Europe
Observer participants’ names have a grey background.
3. AF1 – Standardisation and Conformance

3.1. Overview

The overall objective of the project was to develop complete test specification and test bed concepts for the Train Communication Network (TCN). Moreover the AF1 was in charge of endorsing the outcomes of TrainCom coming from other AF to any relevant Standardisation Body. The coverage of such tasks spanned the following subjects:

- Standardisation and Conformance
- Train-ground Communication Infrastructure
- On-board Dynamic Passenger Information System (DPIS)
- Locomotives Interoperability

The TrainCom project established as a high priority the endorsement and offering of its outcome to Standardization bodies, concentrating efforts on the following bodies:

- IEC for the Train Communication Network (TCN) Conformance Test
- CENELEC for the Communication Infrastructure
- CENELEC for the Dynamic Passenger Information System
- UIC for Locomotive Interoperability and TCN Conformance Test
- AEIF for linkage of TrainCom to Technical Specification for Interoperability of high-speed trains and conventional trains

Offering and proposing contributions to the specific committees has been decided on the following basis:

- IEC (TC9). This standardisation body promoted the development of the TCN standard (IEC 61375-1), through its Technical Committee 9. A request for a Conformance Test specification for TCN (future IEC 61375-2) was directly addressed by TrainCom, as an open problem.

- TrainCom members recognised the advantage of offering results of their research to CENELEC (TC9X). As a European standardisation body, TC9X/SC9XB was chosen as the appropriate body in the definition of standards related to interoperability issues and rolling stock. The Communication Infrastructure (Deliverable 7) and the Dynamic Passenger Information System (Deliverable 9) have been proposed as contributions.

- The offer has been endorsed by the UIC (especially C5 committee - Subgroup vehicles and the Locomotive Expert Group), directly involved in the development of railway specifications. UIC was deeply involved in all phases of the specification of TCN (UIC 556) and related applications, like diagnostics (UIC 557) and remote traction control (UIC 647). It also participated in the ROSIN project as sponsoring partner (ROSIN is quoted in the UIC 1998 Annual Report) and contributed to the definition of the TrainCom objectives. All the elements coming from the Locomotive
Interoperability have been offered to such private body, that sets most of the governing rules among the European railway operators.

- AEIF, linkage was maintained with this association, which issued Technical Specification for Interoperability of high-speed trains and is in charge to issue similar specifications for conventional trains, according to EC Directives.

In the first year of the project, emphasis was on architecture choices and selection of the methodology for the application development process. In the second year of the project the emphasis was on the implementation of the applications and the modelling of strategies for different services and operating scenarios. In this development process we gained considerable experience with regard to what can and can't be done with the currently available tools and platforms. In the third year the implementation was finalized with the verification and demonstration phases, closing the TrainCom activities in February 2004. Continuous linkage with the standardisation bodies has been maintained during the whole life of the project, resulting in several events where the TrainCom contribution has been evaluated and discussed. Deliverable 6 and Deliverable 12, formed the reference guide of the AF1 work along the whole project. The former described the approach and the architecture, the latter specified in deep detail all the Conformance Test Procedures. Proceeding in the work the IEC PT group recognised the validity of the TrainCom work and used almost all of Deliverable 12, incorporating its concepts and procedures into the IEC61375-2. It is worthwhile mentioning the submission of the IEC 61375-2 paper to the National Committees in charge of commenting this norm, where the feedback obtained was used by the AF1 to steer corrections, adjustments, clarifications and improvements to Deliverable 12 and Deliverable 6. The AF1 efforts has been crowned by the IEC plenary meetings in Quebec Canada on September 2002, and Copenhagen Denmark October 2003, where the Deliverable 12 submitted to the IEC committee became the IEC CD 61375-2.

In parallel and in the overall time frame applications were chosen in such a way that they provided ample opportunity for investigation and assessment of tools and platforms for implementation. The results of these investigations and experiences are presented in the next sections.

### 3.2. Project objectives

Primary objective for the TCN conformance specification is a suitable conformance specification, which is required both at IEC and UIC level. The resulting document was proposed as the basis for the future standard IEC 61375-2.

To demonstrate the feasibility of the specification, a TCN Conformance test bed was defined in terms of the hardware and software architecture. Moreover a confidence test bed for the TCN standard was developed and tested, with the aim to check the consistency and coverage of the specification.

This test bed will be useful to preliminary check TCN equipment, before integrating them in a network. Most of the possible compatibility problems can then be identified at an early stage, at lower costs. The test bed will also be a useful tool for certification bodies (or Notified Bodies, according to the existing and proposed "Directives on interoperability" of high-speed and conventional railways), which will be able to perform the tests quicker and in an
absolutely impartial way. The same tool will be able to perform different tests, so as to reduce the total required time and cost. To validate it, a number of cross tests were performed, using at least 3 implementations (TCN devices). Interoperability issues are not limited to communication interfaces: TrainCom, while proposing new specifications (see WP 4), was also considering existing specifications, to propose them as possible European standards. TrainCom supported the work needed to define TSI’s and the standards, which will be needed to implement them. This was a part of the work done in TrainCom for interoperability (in the limits of the TrainCom scope), in co-operation with UIC, AEIF and other institutions. This work will also represent a significant contribution to the recent CENELEC initiative, aiming to define a global approach for "Standardisation of vehicle control system interfaces for compatibility", to support the implementation of the proposed "Directive on the interoperability of the trans-European conventional rail system" (COM (1999) 617 dated 19.11.1999). The objective is to develop functional standards applicable in Europe to passenger trains and freight trains, where different train network technologies are currently used.

3.3. Approach followed to achieve project objectives.

The following development process was defined and followed in the project:

- WP1 - Collecting the user requirements for Standardization and Conformance.
- WP2 - TCN Conformance testing and interoperability issues
- WP5 - Conformance test bed
- WP12 - Verification of the conformance test bed

A demonstration was not planned for this Activity Field.

3.3.1. WP1 - Collecting the user requirements for Standardization and Conformance

The aim of this phase was to collect the requirements of the system which will be really needed by the certified laboratory, TCN device manufacturers and operators. Several groups of user requirements were identified:

- Completion of TCN standardisation with TCN Conformance Test. The TCN conformance test should be able to give the level of confidence to allow the interoperability of different TCN implementation.
- Preparing the prerequisite to UIC556 Conformance The specification and the test bed should be able to act as prerequisite for the UIC556 test bed, this involves mainly the WTB Wire Train Bus Node or the Class 5 devices.
- TCN Conformance Test bed The conformance test bed should be able to cover at least 80% of the WTB and MVB clauses performing the test as automatically as possible. The current standard and state of the art testing methodologies and tools should be chosen to simplify the implementation by other interested parts.
• Types of Testing
  The conformance test bed should be able to use the black box approach stimulating the
  Device Under Test using only the exposed interfaces. White box tests should be avoided.

• Test Suites
  The conformance test bed should be able to use the specific set of test suites covering the
  Class0 up to Class4 and WTB Node (Class5), all with the black box approach. All the
  results should be reported in brief and with extended reports.

• Comparison of results
  The conformance test should allow comparison between same type of products from
  different manufacturer.

The results of this phase are described in the deliverable 2, “Analysis of User Requirements”
(TC1-D-ADT-005-03).

3.3.2.   WP2 - TCN Conformance testing and interoperability issues.

In conformance testing, we are asked to answer the question "how can we specify procedures
to check if an implementation or application conforms to our standard or specification?".

Conformance testing is usually defined as a testing procedure to see if an implementation
faithfully meets the requirements of a standard or specification and to define the extent of
such capability to fulfill the requirements. The IEC61375-1 Guidelines for Conformance
Testing specify the testing requirements and define the test architecture, but leave to a
practical implementation the conformance test procedures and test bed.

In WP02 we assumed that conformance tests should be used by implementers early in the
development process, to improve the quality of their implementations, and by industry
associations or users, wishing to manage a testing and certification program. The work has
been carried out to provide to the users of conforming products some assurance or confidence
that the product behaves as expected, performs functions in a known manner, or has an
interface or format that is known. Moreover, our focus was to set a neutral mechanism to
judge a product against the criteria of a standard or specification. The conformance test
specification developed in WP2 is a step toward Interoperability, even if it cannot assure
Interoperability but it is a base (a prerequisite) for Interoperability. Interoperability asks for
conformance but it is an implementation capability that shall be proven further and beyond
conformity. The WP02 result aims to prove beyond any doubt that an implementation is
correct, consistent, and complete with respect to its specification. The falsification testing has
been included, to give a better degree of confidence that the implementation is correct.
Falsification testing subjects an implementation to various combinations of legal and illegal
inputs, and compares the resulting outputs to a set of corresponding expected outcomes. If
errors are found, one can correctly deduce that the implementation does not conform to the
specification. Falsification testing can surely demonstrate non-conformance. The approach
used several levels. Level 1 as basic core of the specifications that must be implemented by
all products. Level 2 includes all of level 1 and also additional functionality. Level 3 is a
custom test including the previous two and specific options of the Implementation Under
Test. Mandatory and optional features have been structured using PICS in a way that the term
"optional" is used to indicate that if an implementation is going to provide the specified
functionality, then the specification must be followed.
The Conformance is organized into two major components: (1) testing program and (2) test tools. The testing program starts from existing implementations and generates repeatable results. The current available implementations from FAR, SIEMENS and BOMBARDIER have been used as reference implementations. The reason is that such implementations are able to withstand to the UIC556 Conformance Test. The conformance test bed is detailed enough so that testing of a given implementation can be repeated with no change in test results. The procedures contain information on what must be done operationally when failures occur. The testing program is as impartial and objective as possible, to remove subjectivity of both the procedures and the testing tools. Finally, the testing policy and procedures identify and define the actions of the organisation(s) responsible for conducting the tests.

All the activities were strictly linked to the IEC requirements and judgment, that required a big effort of coordination. On March 6th 2001 an IEC Meeting in Erlangen (Germany) took place, and officially confirmed a co-operation with IEC-TC9 PT 61375-2 (PT stands for Project Team). On 20th March 2001, in Paris, a PT convenor and project leaders meeting took place accepting the offering of TrainCom. Deliverables D6 and D12 accepted as a contribution to the PT were submitted as first draft (CD) before the end of July 2001. Middle of October 2001, in Florence, the TC9 plenary meeting commented the results. The feedback received from the TC9 plenary meeting was used to hit the most important points felt by the members of this group. Particularly the test of TCN specifications at coach level was a point risen by the TC9 and required an ad-hoc approach. It was asked to cover:

1) physical layer test
2) test cases for stimulating the application layer (similar to 556 test cases)
3) test procedures for MVB
4) gateway (WTB and MVB, but possibly other busses)

Moreover, the experts of TC9 suggested that, for international coaches, the characteristics of real wires have to be checked (cross-talk, impedance, attenuation). All such requests were processed inside the WP02.

In the meantime, reporting was done to the UIC. UIC 5R created the UIC556 Steering Group to maintain the document (leaflet UIC 556) and set up test sites, to certify UIC gateways. Three test sites are certified, Siemens, Adtranz (in the course of the project lifetime acquired by Bombardier) and FS (now Trenitalia). Considering that TCN conformance is a prerequisite of UIC 556 conformance, it was considered useful that the upcoming D6 and D12 had to be consistent with UIC 556 Annex 8.
In June 2002 the CD (Committee draft) was issued to the IEC Central Office containing the result of D06 and D12. The figure below shows the approach followed.

Submission to Standardisation Body: IEC

The June 2002 IEC CD 9/685 contained the whole D12, and the relevant parts of D6. The figure below shows the front cover of the IEC document.
The CD 9/685 of IEC distributed to National Committees received feedback and the PT group gave to the AF1 group the complete report. D6 and D12 were newly analysed and adjusted as needed. The Figure below shows the indicators of improvements.

**Analysis of Comments from National Committees**

![Pie Chart](image)

- **Good result**: only 24% of the clauses submitted to the IEC need adjustments.
- **The 66% need only editorial or minimal adjustment.**
- **General comments**, about test organisation, are around 9%, they can be combined with the Editorial.
- **Deliverable 12** was the most significant contribution to the IEC PT61375-2 Expert committee.

*Figure 3 – Quantitative analysis of National Committees*

The activity of WP02 continued along the course of the whole TrainCom lifetime, because D6 and D12 represented the linkage to the IEC and UIC.
After the first draft, other partial issues of D6 and D12 were submitted to the IEC, incorporating more and more elements. The WTB test was enlarged, the Coach tester included, the Repeater test updated. This huge amount of work was discussed in the IEC plenary meeting in Quebec (Canada), which generated the following outcomes.

**TC9 Resolution**

**Resolution 42.7**

SUBJECT : PT 61375-2 TCN – Conformance testing

- Further to the decisions taken on the observations received on the first CD TC9 decides to proceed with a second CD.
- TC9 requests the project team convenor to make this second CD available by March 2003.
- TC9 agrees to circulate a monolingual CDV as soon as available taking account the French commitment to provide the French version during the 5 months of the procedure.

*Figure 4 – Resolution of the TC9*
3.3.3.  **TrainCom cooperation with CENELEC on Interoperability issues**

A new standardisation work, as prepared by SGB1 CENELEC Survey group, pursuant to the resolution 17/05 of the 17th meeting of CENELEC/TC9X/SC9XB, activated the proposal for a standardization work to:

1. define the needs for information required to be transferred between rail vehicles for interoperability;
2. define the needs for functional interfaces and their performance for the transfer of this information between vehicles, including conformance testing;
3. define the scope and priorities of the resulting standards, ensuring that the work is divided into manageable parts;
4. take account of existing experience (TCN) and possible future technology;
5. co-ordinate its work with TC9X PAGI (Permanent Advisory Group for Interoperability).

The Survey Group SGB1 has reached a consensus basis to develop standards for data exchange involving railway vehicle consists, between themselves or with fixed installations, necessary for interoperability as defined in the proposed Directive on the interoperability of the trans-European conventional railway system, and as will be specified by AEIF, the Body in charge of drafting Technical Specifications for interoperability (TSI).

The scope of the work is then limited to international passenger trains and freight trains in TEN, excluding the signalling and control-command systems. This does not explicitly exclude High Speed Trains (HST), but excludes formally trams, metros and urban or suburban trains. Four standards have been defined.

3.3.3.1.  **STD1: Data dictionary and rules for functional standardisation.**

This standard will define:

1. The methods to be used for functional standardisation
2. The reference architecture defining the essential functional interfaces.
3. The concept of a central data dictionary/repository to be applied to freight and passenger traffic functions. In this context, data are to be limited to basic information elements, which are necessary to define standard messages required for interoperability, and displayed on the interfaces of the communicating entities. Entering data dictionary will provide full definition of a data element, along with its essential attributes at conceptual level.

Data dictionary shall be designed to provide a structural framework that enables continued growth and enhancement of the scope of defined data. Here the XML description of deliverable D9 has been discussed.

3.3.3.2.  **STD2: Functions in Freight traffic**

This standard intends to define the way the different functions (or parts of them), needed for interoperability reasons, operate on a freight train. The scope of this standard covers the functions which are addressed in the Technical Specifications for Interoperability (TSI), deriving from Directive on the interoperability of the trans-European conventional railway
These standard functional definitions shall be platform and communication protocol independent, and supported by conformance tests.

3.3.3.3. **STD3: Functions in Passenger traffic**

This standard intends to define the way the different functions (or parts of them), needed for interoperability reasons, operate on a passenger train. The scope of this standard covers the functions which are addressed in the Technical Specifications for Interoperability (TSI), deriving from Directive on the interoperability of the trans-European conventional railway system. These standard functional definitions shall be platform and communication protocol independent, and supported by conformance tests.

3.3.3.4. **STD4: Train to Ground Communications**

This standard intends primarily to define the links between moving trains and the Wide Area data Networks which are used for information exchanges between fixed installations:
- medium
- protocol (including the dynamic name space)

for data transmission between:
- fixed installations and
- trains, down to the consist level

3.3.3.5. **Traincom Contributions to CENELEC**

We established a continuous connection for the whole duration of the project with such group feeding the group with deliverable D7 and deliverable D9. TrainCom co-operated closely with participants in this project, in particular regarding train to ground communications and the use of Internet technologies and standards.

Endorsing such documents, AF1 provided a comparison between the Transmodel and TrainCom model, resulting that the latter is better tailored to railway needs.

**Submission to Standardisation Body: CENELEC**

![Diagram 5 – Submission to Cenelec](image)
3.3.4. WP5 - Conformance testbed

The Specification for TCN Conformance Testing (WP2) steered the implementation phase. The deliverable D6 described the architecture in terms of basic elements. The architecture used the black-box approach where the Implementation Under Test should be tested without exposing internal details nor interfaces. Black Box Testing is testing without knowledge of the internal workings of the item being tested. This is particularly important for communication equipment, where may be not practical neither feasible asking to a manufacturer to expose the internal details. TCN Communication equipment sometimes are boards, on which any component can be inspected, and even the communication software stack can be walked-through. However most times such equipment are embedded into other equipment and a communication test only on the communication board cannot be done.

Aiming to demonstrate the conformance test, we decided to adopt as much as possible existing solutions in terms of hardware and software for the prototype of a test bed. The complete architecture and its design used Labview®, the well recognized environment for test suite generation.

![Architecture of the Test Bed (WTB and MVB)](image-url)

*Figure 6 – Architecture of the Test Bed (WTB and MVB)*
The software part execution of the test sequences and suites based on LabView environment has been divided into:

1. Web interface for PICS preparation
2. PICS preparation as XML documents to ease the exchange of information amongst laboratories
3. Report Generation
4. Test Case Sequencing
5. Test Modules activated by the sequencer
6. Instrument Drivers
7. Specific Drivers.

Figure 7 – Software Architecture
The preparation of the PICS is made easier, even remotely, by usage of WEB interfaces that guide step by step in the compilation of the relevant forms.

Figure 8 – The PICS initial page
3.3.5. The MVB repeater test

The MVB repeater is, amongst other devices, classified as class 0. It needs a specific test very close to the physical effects of the wired line. The Figure shows the architecture implemented for the test.

*Figure 9 – The repeater architecture*

*Figure 10 - The repeater Software Test Bench*
3.3.6. The Coach Tester

When a vehicle is designed, there are different functions that have to be developed. Each function is physically implemented in devices that can be programmed with a special SW able to perform that function. A single device may implement more functions or an ensemble of different devices implement all the functions necessary for the vehicle operation. The need arises for an ultimate test environment, checking the conformance of the final assembled vehicle, and this is the scope of the coach tester. It may be used:

- during a homologation procedure of a new vehicle. The physical layer (connectors and cables) on board, in the real environment, can introduce some modifications that force some characteristics out of range. But functionality aspects are also involved, as the behaviour can change when a lot of devices, previously tested separately, are connected together by means of real wires in a real environment;

- during the acceptance test of a vehicle coming from another railway company.

The following figure shows the implemented interface.

![The Coach Tester Panel](image)
3.3.7. **WP12 - Verification of the conformance test bed**

In this phase the integrated system was verified. Test cases were specified and performed. The test cases and the test results were documented in the deliverable D17 and D16.

The verification phase considered the conformance test bed and three MVB devices (from Siemens, FAR and the repeater from CAF), the coach tester from AnsaldoBreda and the vehicles from Trenitalia.

The verification of AF1 has been held as a public event, divided in two steps, the laboratory verification and the final verification.

The MVB verification has been reported using the XML and HTML format as the state of the art in test reporting.

The test report for the repeater in MVB with global analysis and test results has been prepared.

The verification of the TrainCom Coach tester prototype and Real Vehicle Preliminary Verification has been done. A Public Event was held in Mestre in November 2003, where real coaches have been verified for the physical functions (cabling, connectors and terminations) and for WTB Node functions compliant with the UIC556. Test reports with all test result data and some figures to improve the comprehension of Physical and Functional tests were produced.

The verification of D12, occurred as a public event in Rovereto in February 2004, concluded the verification phase.
3.3.7.1. Public Event in Mestre

In Mestre (Italy) in November 2003 in a public event the result of the coach tester (ATOS-Ansaldo), the WTB Analyser (FAR), the WTB simulator (Bombardier Italy), and the vehicles (Trenitalia) have been presented.

![Image of a train](image)

*Figure 12 – The vehicle tested in Mestre*
3.3.7.2. Public Event in Rovereto

In Rovereto (Italy) in February 2004, in the public event the complete Test Bed given as specification to the IEC has been presented and reported. The session included, Physical, Link Layer, Real Time Protocols, and Network Management Tests.

![Figure 13 – The Test Suite Diagram](image1)

![Figure 14 – The TCN Test Bed](image2)
Figure 15 – The TCN Stimuli Generator (TDC 360)

Figure 16 – The Wave shaper (TWS 360)
3.4. Project results and achievements

One central idea in the project was to use modern technologies from Internet, like XML, and state of the art in testing environment, like LabView®, with the aim to propose an efficient Conformance Test. Therefore XML was used as the standard way to exchange data between laboratories for conformance certification.

The main and most important result is the acceptance of TrainCom results by the IEC and the incorporation of this huge work into the IEC 61375-2 TCN Conformance Test. This had the effect of reducing forecasts from an initial estimation of seven years to achieve the conformance to less than three years. The development platform is complete, authoritative and repeatable, allowing the IEC to precisely assess the standard.

The importance of TrainCom AF1 result is emphasized by the adoption of a strict connection with the experts and the tangibility of its results in terms of tests. More than 85% of the clauses included in the IEC61375-1 have been tested, with precise reporting allowing the comparison amongst different devices aiming to communicate each other. The adoption of the XML format to represent either the submission of documents (PICS) to set up the conformance and its report allows a great benefit. The repository where all reports are stored may be shared, and the list of accepted devices may be accessed for a direct comparison, making easier to carry on the interoperability tests. The degree of testing is deep enough,
including the benefit of giving, even if not in the original scope of the work, an insight about the failure of a non-conforming device.

The Coach tester was successful in showing the effectiveness of tests at vehicle level. This can reduce problems during commissioning.

All members of AF1 have been rewarded as best contributors by the IEC and all relevant elements coming from TrainCom work can be found in the IEC61375-2 document.

### 3.5. Deliverables and other outputs

In this chapter only the deliverables which were exclusively produced in this Activity Field were considered.

#### 3.5.1. D06 – Specification of the Conformance Test Bed structure

This document (TC1-D-FAR-013-07)

The document contains:

- an introduction into the activity field
- a general baseline for the conformance and test-bed definition, specifying the areas of testing
- the approach to Conformance Test with the Standard specification
- the scope of the TCN Conformance Requirements Specification and all the criteria to define the type, the competence, the limitations, etc. of the tests.

#### 3.5.2. D12 - Specification for TCN Conformance Testing - General Part and Test Suites

This document (TC1-D-FAR-029-05)

The document contains:

- the Identification of Quality Indicators for Tests Selection, that specifies the type of categories that are in the TCN Standard and how they are treated and interpreted
- all the test methods, test criteria and test suites to be used for the conformance testing of MVB devices (Physical test, Device Status test, Process Data test and Message Data test)
- a description of the test methods, test criteria and test suites to be used for the conformance testing of an MVB Repeater
- all the test methods, test criteria and test suites to be used for the conformance testing of WTB devices
- the Conformance requirements of a WTB-equipped vehicle
- two types of PICS pro-forma and the PICS table for MVB and WTB devices
3.5.3. **D13 – Technical description of the prototype of the Test Bed for TCN Conformance Testing**

This document (TC1-D-FAR-041-03)

The document contains:

- the Implementation of a the Test Suite for a MVB device (Test configuration, Hardware and Software requirements, preliminary action)
- the means to read and understand the results of the Conformance Test
- the Implementation of the Test Suite for the repeater in MVB
- the implementation of the Coach tester with the test coverage

3.5.4. **D16 - TCN Conformance Test Bed verification procedure and User Manual**

This document (TC1-D-FAR-064-04)

The document contains:

- the description of the MVB devices submitted to Conformance Test (Siemens, FAR1, FAR2), type of tests executed and corresponding results
- the preliminary LabVIEW action which leads how to execute the Conformance Test in all its parts, as Set-up, Test selection and Test step selection
- the verification of the TCN TrainCom Repeater, with Standard requirements, the coverage and the block diagram of the test suite
- the verification of the TCN TrainCom Coach tester prototype, developed in accordance with its specification, in two environments: laboratory and railway workshop or depot

3.5.5. **D17 - Test bed verification report**

This document (TC1-D-FAR-065-04)

The document contains:

- the MVB device testing report of the three devices submitted to test (Siemens, FAR1, FAR2) in HTML format (as appendix in XML format)
- the test report for the MVB repeater with Global analysis and test results
- the verification of the TCN TrainCom Coach tester prototype (Real Vehicle Preliminary Verification test report and Real Vehicle Public Verification test report) with conclusions and considerations
3.5.6. **Table of Deliverables**

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<tr>
<th>Documentation type</th>
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<tbody>
<tr>
<td>Deliverable document D06</td>
<td>Specification of the Conformance Test Bed structure TC1-D-FAR-013-07</td>
</tr>
<tr>
<td>Deliverable document D12</td>
<td>Specification for TCN Conformance Testing - General Part and Test Suites TC1-D-FAR-029-05</td>
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<tr>
<td>Deliverable document D13</td>
<td>Technical description of the prototype of the Test Bed for TCN Conformance Testing TC1-D-FAR-041-03</td>
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<td>TCN Conformance Test Bed verification procedure and User Manual TC1-D-FAR-064-04</td>
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<td>Deliverable document D17</td>
<td>Test bed verification report TC1-D-FAR-065-04</td>
</tr>
</tbody>
</table>

3.6. **Contributions and perspectives**

**ANSALDOBREDA** participated in the specification, implementation and verification phases of the coach tester, focusing on the instrumentation (the tester). The activity has been used for the preparation of the Vehicle Test.

**ATOS** participated in the specification, implementation and verification phases of the coach tester, focusing on the whole contribution. ATOS has been very active in the overall development, that included Deliverable production, management of the contacts with UIC and the public event in Mestre.

**BOMBARDIER TRANSPORTATION** participated giving the contribution for the WTB UIC556 and IEC61375-2 matching points and caveats. The work contributed substantially in the specification of the WTB conformance test. The adherence to the UIC 556 is now proved beyond any doubt, and the IEC61375-2 is a real prerequisite for such test.

**CAF** participated in the specification, implementation and verification phases of the MVB repeater working on all its aspects. The results are considered globally of great value to complete the class 0 testing. Their work has been incorporated totally in the IEC61375-2 for the repeater test. The complete test environment was based on Labview ® and the reporting of the verification has been of great value.
SIEMENS participated in the specification, implementation and verification phases of the whole AF1. They contributed to the review of all documents, putting great effort in the specification phase about the MVB devices and the procedure to set the conformance for class 1 devices. The contribution in divulging the AF1 results to AEIF and UIC has been very important. Siemens submitted the class 2 device for the final verification, passing successfully the complete conformance test.

TRENITALIA participated in the specification, implementation and verification phases of the whole AF1. Contributed to the public event in Mestre, doing the measurements and managing the logistic activities. Their contribution for the post-analysis of logged results was very important, giving the confidence that all tests specified in the papers can be carried out in the real vehicles.

ACKNOWLEDGEMENT
We have a debt of gratitude with many participants that in various ways contributed to the success of this work. A significant gratitude is given to Dr. Hubert Kirrmann, the father of TCN, for the discussion on the MVB testing. Particularly thanks to the IEC PT experts that in several technical meeting gave the fundamental insight on the refinement of testing; Gernot Hans, Diego Quagreda, Marco Zaramella, Valerio Soffiatti, Paolo Umiliacchi, Christian Girard, Pierre Zuber, Erich Renner, Alan Launey, Michele Bernocchi, Xabier Arizkorreta, Jyrki Keurulainen.
4. AF2 – TrainCom Communication Infrastructure

4.1. Overview

Intelligent trains are mobile digital networks interconnecting on-board equipment, but they are not isolated systems. Suitable simple and cost-effective communication with ground systems is required, not only for the purpose of train control system, which is handled by expensive safety-related special devices (e.g. ERTMS), but also to support a number of new applications and services. TrainCom will develop a communication system, integrating available and new technologies:

- the on-board network (TCN), including the Vehicle Bus (MVB) and the Train Bus (WTB)
- the radio link (based on GSM, or GSM-R, when available) between train and ground
- the higher level protocols and languages of Internet (TCP-IP, HTTP, XML, JAVA and others), for message routing, formatting and delivery
- the needed on-board interface (ROGATE) between TCN and the Internet world
- the ground infrastructure (Communication Servers, Name Servers, Application Servers), to support the needed communication and application services

![Diagram of TrainCom communication infrastructure]

Based on the new technology of ROGATE (Railway Open GATEway), the complete system is highly innovative and incorporates state of the art concepts and technologies. A feasibility check (development of a conceptual model and partial demonstration) was carried out in the ROSIN project, but the complete architecture and many of its modules were still to be fully specified and validated. For example, a dynamic European name space for trains (based on
Internet URL's: Universal Resource Locator) had to be defined, implemented and tested. Innovative architectures, like those under specification in the Open Services Gateway Initiative (OSGI) were taken into consideration. Applications also need to be investigated: TrainCom considered two important applications ("passenger information" and "support to maintenance"), as described below, but other applications are envisaged for the future (for example, applications for freight trains). In some cases, systems based on proprietary solutions have been developed in the past to solve specific problems, but no global and standard approach was pursued.

4.2. Project objectives

A specification for a train-ground communication system, which can support telematics services, offering ubiquitous access to on-board devices, will overcome border line problems and equipment heterogeneity: it will be tested in at least three different States, using different equipment and subsystems, linked by two on-board networking solutions (TCN and FIP); the system will try to meet user requirements in terms of response time, additional costs and functionality; effectiveness and openness will be demonstrated, so as to convince manufacturers and operators to incorporate it in new products as a standard feature. An acceptance of 50% of the operators involved in the project could be a successful result.

4.3. Approach followed to achieve project objectives

The following development process was defined and followed in the project:

- WP1 - Collecting the user requirements for the communication infrastructure
- WP3 – Specification of the architecture of the communication infrastructure
- WP6 – Development of the communication infrastructure

4.3.1. WP1 - Collecting the user requirements

The aim of this phase was to collect the requirements for the services of the communication infrastructure, which will be really needed by the railway operators and manufacturers.

The user requirements summary gave information about communication needs in different types of trains, the use and completeness of existing specifications and what is expected on this subject.

The results of this phase are described in the deliverable D2, “Analysis of User Requirements” (TC1-D-ADT-005-03).
4.3.2. **WP3 – Architecture of the communication infrastructure**

Starting from the feasibility study carried out in the ROSIN project, which achieved good results, a more general architecture for the TrainCom communication system was developed, in accord with requirements coming from WP1.

The on-board structure includes a ROGATE (Railway Open Gateway) device, linking the train network with ground systems through a GSM radio link and using Internet protocols. The impact of the upcoming GSM-R system are analysed, as well as of other technological evolutions (e.g. GPRS, UMTS).

The ground infrastructure includes the ground station (ROGS – Railway Open Ground Station), the name server (RONS – Railway Open Name Server) and some application servers, in different European countries, linked together via TCP-IP protocol (Internet). The mechanisms for IP-addressing (name space), GSM numbering and train identification matching are defined.

Based on XML, a flexible formal language for electronic data interchange, a grammar can be defined that meets railway requirements.

Another similar architecture, which has been implemented over the FIP network in a newly developed product (FIPWEB), is investigated, for possibility to use this architecture with the same gateway external interface.

The architecture was specified with sufficient detail, to allow a complete implementation. The work package WP6 defines the scope of implementation for the TrainCom demonstrator.

The architecture was proposed as a possible standard specification, in co-operation with CENELEC and AEIF.

Provision for suitable security levels, according to different User’s profiles, will become part of the security policy for the system.

Fig. 2 presents the logical architecture of the solution that was implemented as a prototype within WP06.
The results of this phase are described in the deliverable D7, “Architecture of the TrainCom communication system” (TC1-D-SIE-020-05).
4.3.3. WP6 - Development of the communication infrastructure

In this work package the main components for the TrainCom communication infrastructure were developed.

The following steps were performed by the participants of the work package.

- Specification and description of the implementation of the main components of the communication infrastructure defined in the Deliverable No.7.
- Specification of the interfaces between devices and description of the interfaces between ROGS-RONS and between ROGS/RONS and ROGATE.
- Specification of the European database and definition of a structure to store all data useful for the communication infrastructure and common to all possible applications.
- Implementation of the components by different manufacturers (ATOS/FAR, Alstom, Siemens) and with different hardware/software platforms (Linux, Windows, QNX)
- Tests in laboratory which included the procedures of the interoperability tests to be carried out in the laboratory and the obtained results.
- Specification of two use cases were included to show how the communication infrastructure is able to fulfil the requirements coming from the applications (DPIS, ROMAIN).
- Some detailed aspects like TCP/IP protocol, HTTP, Dynamic Insertion Network Object and proposal for security mechanisms were analyzed.

Fig. 3 shows the prototypes which the TrainCom project has implemented.

<table>
<thead>
<tr>
<th>Component</th>
<th>Manufacturer</th>
<th>Siemens (GER)</th>
<th>Alstom (FR)</th>
<th>ATOS/FAR (IT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RONS</td>
<td></td>
<td><img src="image1.png" alt="Prototype" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROGS</td>
<td></td>
<td><img src="image2.png" alt="Prototype" /></td>
<td><img src="image3.png" alt="Prototype" /></td>
<td></td>
</tr>
<tr>
<td>ROGATE</td>
<td></td>
<td><img src="image4.png" alt="Prototype" /></td>
<td><img src="image5.png" alt="Prototype" /></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3 – Prototype platforms
Fig. 4 shows the test configuration to verify the implementation of the communication infrastructure. Complete cross tests were performed between the different platforms.

The results of this phase are described in the deliverable D15, “Prototype of the TrainCom Communication System” (TC1-D-CAF-019-07).

4.4. Project results and achievements

The communication infrastructure was used in the TrainCom demonstrators of activity fields 3 (DPIS) and 4 (RoMain). The German implementation supported the ICE3 DPIS demonstration (AF3), the Italian implementation supported the DPIS demonstration of Trenitalia (AF3) and the demonstration of RoMain (AF4). The prototype implementations are available for the demonstrators of the project EuRoMain and other possible future projects.

4.5. Deliverables and other outputs

In this chapter only the deliverables which were exclusively produced in this Activity Field were considered.

4.5.1. D07 – Architecture of the TrainCom communication system

This document describes the architecture for a train-ground communication system, integrating Internet, GSM, TCN and other technologies.
It defines data types and database structures to support the envisaged applications like dynamic passenger information and remote maintenance.

This document describes each module of the defined architecture.

The architecture was specified with sufficient detail, to allow a complete implementation. In the following work package, WP6, the scope of implementation for the TrainCom demonstrator was defined.

Security policy, according to requirements and integration in already existing intranets of railway operators and manufacturers was defined.

This specification was proposed as a possible standard specification and submitted to CENELEC WG B14 and AEIF (in cooperation with AF1).

### 4.5.2. D15 - Prototype of the TrainCom Communication System

This document describes the prototype of the TrainCom communication system to be used in the demonstration envisaged in WP10. It also specifies the tests to be carried out for a first verification of functionality, compatibility and basic performance, together with the results of these tests.

Starting from the “Architecture of the TrainCom communication system” document prepared within WP3, where a general architecture is specified, it is decided here which parts and modules to implement and the way they are implemented in order to support the applications of the project.

### 4.5.3. Table of Deliverables

<table>
<thead>
<tr>
<th>Documentation type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliverable document D07</td>
<td>Architecture of the TrainCom communication system TC1-D-SIE-020-05</td>
</tr>
<tr>
<td>Deliverable document D15</td>
<td>Prototype of the TrainCom Communication System TC1-D-CAF-019-07</td>
</tr>
</tbody>
</table>

### 4.6. Perspectives for the future

The TrainCom communication solution will become the standard platform (interfaces, protocols and formats) on top of which a number of applications can be built, which need a reliable and interoperable link between train and ground.
It will exploit the benefits of integration between communication and information technologies in the field of railway transport, supporting real applications, which could not be possible otherwise.

Some points were found out in the last phase of the project, which could be only partially be addressed. Most of them came from discussions with other Activity Fields (mainly AF3 and AF4) and with the EuRoMain project, where more detailed requirements for the railway maintenance system were identified.

A main point is the interface between the communication infrastructure and applications, the so called “middleware”. It is required to allow applications to access the communication infrastructure transparently, as a black box system, in a standard way.

Another point is the automatic handling of multiple channels: when several communication channels can be available, even if some of them only for short periods of time (e.g. GSM and a Wi-Fi hotspots), this mechanism can allow the infrastructure to automatically choose the best channel between all those currently available, without affecting the applications (which can only see, at most, a different performance level).

Several issues were considered also at application level (see 5.6.2).

Such points can be more deeply investigated and completely solved in future research projects.
5. AF3 – Dynamic Passenger Information System

5.1. Overview

5.1.1. AF3 task and final result

Within the TrainCom project it was the task of Activity Field (AF) 3 to develop one of the two foreseen different applications based on a new train-to-ground communication system. The communication system itself was developed by AF2 and is based on Internet technology going to become a standard platform for on-board applications (especially with a logical connection to ground systems) overcoming the existing interoperability problems between the railway operators and the equipment manufacturers.

The application developed in AF3 was shown in a demonstration of a dynamic passenger information system (DPIS) in trains under full service.

For interoperability reasons the DPIS overall demonstration actually included two demonstrations (with two different demonstrator installations and demonstrator trains, respectively). As intended by the TrainCom Technical Annex, this split led to two demonstration sites, one in Germany and another in Italy, with separate public events for the demonstrations.

A separate implementation and verification was performed in Romania as well, with good results.

Each of the developed DPIS systems was split into two parts. The former was installed on-board and the latter on ground. A common data model was developed with the intention to be commonly used by different operators, to overcome border line problems and the heterogeneity of equipment. Both parts use the same common data model. For both sites, a final demonstration proved the achieved new functionality under real operation.

5.1.2. AF3 workflow

After gathering the requirements of the common data model for this application, the data structure for the Dynamic Passenger Information System was specified. The resulting new data model was based on a relational data base using a standard data base engine from the market.

A first working example based on the common data model was implemented and introduced to the TrainCom participants. Equalization with the TRANSMODEL reference model has been investigated, but it was stated that this reference model was created for mass transit applications, with focus to road transport services. Therefore the adaptation of data concepts and data structures out of this reference had to be limited to those which were useful in the railway applications.

Dynamic aspects have been investigated and described, both from the operational and from the technical point of view.

DPIS prototype systems for the train and ground installations have been developed and tested at first at laboratory level, using simulated data generation at ground and simulated...
visualisation applications. The prototypes are based on the train-to-ground communication system developed in AF2. The software of the prototypes use modern technologies from the Internet such as HTTP, XML data modelling and JAVA programming. At a second laboratory step, the prototypes have been validated using the communication system (including the ROGATE/ROGS components).

After verification of the prototypes in real train environments, two public events for the demonstration of the DPIS applications were held, one in Germany (focus: dynamic trip information) and the other in Italy (focus: dynamic seat reservation). Both demonstration events have been very successful.

5.2. AF3-related project objectives

A dynamic information system for passengers will handle trip information and seat reservation data, according to a common database structure; automatic upload of information to trains will reduce time, manpower and errors, improving the quality of service; it can favour inter-modal operations as well; operation in two different States (Germany, Italy) was demonstrated, as well as system interconnection; the goal is also to achieve a 30% reduction in operational costs, compared to present manual procedures; railway operators stated that, if successful, the system will be integrated in their trains, both for newly manufactured vehicles and in refurbishing existing coaches.

5.3. Approach followed to achieve the project objectives

The following development process was defined and followed in the project:

- WP1 - Collection of the user requirements for DPIS applications
- WP4 (Task 4.1) - Data specification and definition of a common data model for DPIS
- WP7 - Implementation of the prototype systems including simulation
- WP10 - Verification of the system including ROGATE/ROGS
- WP13 - Demonstration of the system in a real train environment (demonstrators)

5.3.1. WP1 - Collect the requirements for a DPIS application

The aim of this phase was to collect the requirements for a future DPIS system. New application issues had to be envisaged, which are really needed by the railway operators and manufacturers.

The basic questionnaire resulted in a broad list of requirements which had to be prioritized to those functions which are in accordance with the specified description of work and also with both the user needs high score and the priority for the later demonstration. According to this approach, the following functions were defined so as to be realized in a demonstrator application:

- On-board display of dynamic passenger information including
- Expected delay/arrival time at next stop (own train)
- Actual preview of next stops
- Actual overview of connecting trains at the next stop (with outlining deviations from schedule)
- Actual arrival platform (own train)
- Actual departure platform (connecting train)
- Actual exit side
- Actual seat reservation status
- Positioning using GPS

Notes with respect to later project phases:

1. The feature "Actual exit side" was defined and implemented, but is actually not supported by available data from the operators.
2. The feature "Actual seat reservation status" was shown only during the Italian demonstration, because the German reservation philosophy does not handle seat reservations after the trip has started.
3. The feature "Positioning using GPS" was implemented and demonstrated only in the Italian site.

The results of this phase are described in deliverable 2, "Analysis of User Requirements", chapter 5.3 (TC1-D-ADT-005-03).

5.3.2. **WP4 - Specify the DPIS data model and the application system**

Based on the data definitions and the basic structure of the data model defined during this work package, the user has a great variety of ways to use it. The data model for the DPIS application is flexible enough to handle both a transfer of so-called delta data (only "dynamically" changed data have to be transferred and updated) and, on the other hand, of complete "image" data (in the case an operator wants to use layouts completely pre-computed by himself in the ground station).

In the demonstrations the first approach (transfer of delta data) was chosen, because:

- it is the more flexible one in usage, e.g. in case of changes of the meanings of data,
- it costs less time and smaller bandwidth for updating data from ground to train and therefore lower data communication costs,
- it is mostly independent from technology changes in the technologies of the front-end devices, e.g. change from LED matrix display (monochrome) to a TFT colour display with higher resolution.

During WP4 also the data flow from application (ground) to application (train) and vice versa was defined and the main logical components of the DPIS application were specified.

Figure 1 shows the architecture of the DPIS common data model, where the probability that specific data has to be updated in a train decreases from left to right in this picture. To fulfil the functionality as required during WP1, it is sufficient to transfer only those data of the
green table named "Estimated stops" (containing the pure dynamic data) which has actually to be updated. All the other data have been transferred in advance to the data base on board.

---

<table>
<thead>
<tr>
<th>Traffic Data</th>
<th>Train Composition Data</th>
<th>Layout Data</th>
<th>Control Data</th>
<th>Schedule Data</th>
<th>Infrastructure Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train Positions</td>
<td>Physical Trains</td>
<td>Masks</td>
<td>Events</td>
<td>PerIODS</td>
<td>Stations</td>
</tr>
<tr>
<td>Estimated Stops</td>
<td>TrainComLinks</td>
<td>SQL Queries</td>
<td>Purposes</td>
<td>Traffic Days</td>
<td>Vehicles</td>
</tr>
<tr>
<td></td>
<td>Consists</td>
<td>Announcements</td>
<td>Actions</td>
<td>Services</td>
<td>Devices</td>
</tr>
<tr>
<td>Reservation Data</td>
<td>Media Data</td>
<td></td>
<td>Control Data</td>
<td>Courses</td>
<td></td>
</tr>
<tr>
<td>Logical Vehicles</td>
<td>Strings</td>
<td></td>
<td></td>
<td>Train Runs</td>
<td></td>
</tr>
<tr>
<td>Seat Reservations</td>
<td>Symbols</td>
<td></td>
<td></td>
<td>Planned Stops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sound Clips</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: DPIS data architecture (overview)
Figure 2: General approach as an application-to-application solution

The general approach includes client/server structures at ground and on-board (figure 2). The smaller circle-shaped symbol of the data base on-board reflects the fact that on-board a train only a part of the complete data image is needed. "DACP" stands for the high-level application protocol which has been defined in accordance with the specifications in Deliverable 7 (following the XML-based data structure "RWML = Railway Markup Language").

Modern technologies from the Internet, like HTTP and XML, are used in the system. HTTP, belonging to a lower layer than the mentioned DACP, is the standard Internet protocol for data exchange, while the presentation of data and its structure uses XML (see example below for seat reservation data).

```xml
<xs:element name="Reservations">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="Row" minOccurs="1" maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="Calendar_Day" type="xs:dateTime"/>
            <xs:element name="Course" type="xs:int"/>
            <xs:element name="Logical_Vehicle_No" type="xs:int"/>
            <xs:element name="Seat_No" type="xs:short"/>
            <xs:element name="Res_From" type="xs:int"/>
            <xs:element name="Res_To" type="xs:int"/>
            <xs:element name="Res_Last" type="xs:int" nillable="true"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```
Another example shows the flexibility of the data model approach (figure 3). Referring to figure 1 and, within it, to data group "Layout Data" with the table "Masks", figure 3 gives an impression about how to use the data model. Highlighted in this example is the Logical vehicle No. (see green square). The data model consists of tables and data to modify parameters like colour, character font, size of a text or symbol field, position of a field on a complex mask layout, etc. This avoids software modules to be changed by the manufacturer or a third party, because the operator (who is normally the "owner" of the data) is now able to do this with a minimum effort by his own and whenever such changes in a layout are needed.

It is the special quality of the data model, that even these changes in the "Look & Feel" of visualization devices are now possible by remote call initiated at ground (preferably when the vehicles are stopped on the platform or in the depot).

The results of this phase are described in deliverable 9, “Specification of the Dynamic Passenger Information System (DPIS)”, (TC1-D-BTG-021-07).

---

**Figure 3:** Context between mask content and mask structure (both can be updated)
5.3.3. **WP7 - Implementation and development of the prototypes**

In this work package the functions and controllers were implemented by the participants BT DE and FAR on their different hardware platforms using the same common data model.

Figure 4 shows the block diagram of the DPIS prototype, German site. Three controllers (hardware: desktops and laptops) are connected together by an Ethernet switch. The right controller simulates in this phase both the ground and the train DPIS application. The other two ones act as DPIS Data base Controllers (ground/train).

Pictures of the prototypes at the two sites are shown in Figure 5 and 6.

![Figure 4: Block diagram of the DPIS prototype, German site (BT DE laboratory)](image)
Figure 5: DPIS prototype, German site (BT DE laboratory)

Figure 6: DPIS prototype, Italian site (FAR laboratory)
In the deliverable 18, “Prototype Description of the Dynamic Passenger Information System (DPIS)” (TC1-D-BTG-071-02) the implementation and integration phases are described.

5.3.4. **WP10 - Verification**

The verification is described using the example of the German site.

The validation prior to the verification was done in two steps:

1. Validation of the DPIS prototypes (ground part and train part directly connected together).
   - For the German site the DPIS prototype hardware is based on standard components off the shelf (COTS products like desktop/laptop computers, Ethernet switches etc.). Test site: Bombardier laboratory in Hennigsdorf/Germany.
   - For the Italian site there were special hardware developments included, which are actual in use with the local railway operator. Test site: Laboratory of FAR Systems in Verona/Italy.

2. Validation of the DPIS prototypes including the integration tests with the communication system (ROGATE/ROGS coming from AF2).
   - For the German site these tests have been done at the SIEMENS laboratory in Erlangen/Germany.
   - For the Italian site the tests have been done in cooperation with ATOS in Milan.

For the verification, real coach/train equipment were used. For the German part, a verification session was performed in Munich/Germany, where a real ICE3 train was available for one day. The equipment was installed on the train in the conductor's compartment (figure 7).

The figure shows that the integration of the additional hardware was done by using only one interface (see red line) to the already existing on-board equipment: the video output line to the video modulator for the seat displays (in the rear side of the 1st class seats). This was needed to reduce a probable loss of dependability of the overall system train by integrating a new system only for demonstration purposes.

---

**Figure 7: DPIS Verification in the German Demonstrator Train (ICE3 type)**
The test cases and the test results have been documented in the deliverable 21, “Verification of the Dynamic Passenger Information System (DPIS)” (TC1-D-BTG-073-01). The document describes both verifications, for the German and the Italian sites.

5.3.5. **WP13 Demonstration and Presentation**

For the German site the demonstration was on 10/02/2004. The demonstrator train of type ICE3 ran from Munich to Cologne, including a high-speed passage between Frankfurt/Main and Cologne at 300 km/h. Figure 8 shows a detailed picture of one of the masks shown on the video displays in the rear of the seats. To receive such information, passengers normally have to choose a reserved video channel at their seat panel (for the demonstration, all displays were switched to channel 8).

In the shown situation, our own train had a delay of 15 minutes. The table informs the passenger that the connecting train Thalis 9444 to Paris will wait for connection with a new departure time at 14:32. Track remains unchanged (but could also be changed).

![Figure 8: Actual (dynamically refreshed) connecting situation at Cologne station](image-url)
SILOGIC performed the Romanian demonstration as public event within SILOGIC facilities, on February 11, 2004. The demonstration used one DPIS prototype (INTERNET seats reservation, travel information, on-board display) destined to the passenger cars. A Corba Client /Server Interface and a server has been developed for the DPIS applications. At the top of the communication architecture is placed a client-server application with the main functions the travel places reservation and the passengers information. On the basis of these entities the application ran as specified by the D9.

For the Italian site the demonstration was on 24/02/2004. A coach with the installed equipment was on service between Verona and Rovereto (Italy). The focus of this
demonstration was on the GPS position data and on the dynamic transfer of seat reservation data. The seat reservation displays were refreshed using the defined TrainCom communication infrastructure (from AF2) during the trip between the two stations.

Figure 10: Dynamically updated seat reservation display, Italian demonstrator

5.4. Project results and achievements

The DPIS application may be regarded as a first implementation of an European interoperable system for the exchange and cross-usage of dynamic PIS data through different communication relations, such as

- ground to train (ground updates data in the on-board data base, e.g. changed arrival platform)
- train to ground (train reports updated data to ground, e.g. own delay)
- train to train (only indirectly using the path: train to ground, ground to train)
- ground to ground, including operator to operator, if the two ground systems belong to different operators (e.g. reporting of delays for connecting trains)
- train inside (e.g. for changes of data without direct report to ground)
- ground inside (e.g. for changes of data without direct replication to trains)

One central idea in the project was to use modern technologies from the Internet (HTTP, GSM, XML) with the aim to find a way for the standardization of the data exchange for DPIS applications. It has to be noted that this standardization does not mean that all information has to be presented in the same way. Only the data model and the way of communication follows
common rules. Therefore XML is used as the standard way to exchange data between DPIS applications.

**Project results**
The specified standard way for the transmission of DPIS data from the ground station to trains was successfully used during the demonstrations. The received data were stored in a database in the ground station and in the train, respectively (depending on the data transfer direction). Functions for accessing data by means of a web browser were provided. The TrainCom communication infrastructure was used in the laboratory prototypes as well as in the demonstrations.

The comparison of the achieved results with the original objectives shows that most of the objectives were accomplished, like the specification of the architecture, the development and validation of a laboratory prototype. With the demonstrations a possible way for the development of new products and improved on-board services was pointed out. The results achieved in the specification phase for the common DPIS data base have been submitted as an input to a European standardization body (CENELEC TC9X WG B14).

**Perspectives for the future**
The results of Activity Field 3 will influence intentions of railway operators and manufacturers about how they can develop, offer or use a DPIS system in the future.

The usage of XML together with a commonly agreed and standardized data model will lead to:

- better interoperability for data exchange, especially between different operators within Europe
- cost reduction, in case of changes in the data structures, mask layouts, operator-specific symbols, etc.
- lower dependency of the railway operators from specific software solutions from the manufacturers

In any case the CENELEC standardization activities should be well supported to obtain a standard in a limited period of time.

The demonstration in Germany was the only event in TrainCom where a train in normal operation, with passengers, was involved. This allowed to collect some live feedback from passengers, during the demonstration journey. Generally speaking, the opinion of passengers was good, even if the dynamic part of information could not be appreciated, as the train was running on schedule. Anyway, the simulated delays and deviations from plan could give an idea of the potential usefulness and innovation of the system. Some more requirements for the future were expressed as well:

1) passengers would like to see only information related to their own journey; a passenger going to Nurberg is not interested in connections in Mannheim; this can be possible in the future, combining information from the seat reservation system with DPIS;

2) passengers would like to select which information to look at; in the prototype applications, several pages are shown one after the other, automatically, more interaction could be useful in the future (.g. via touch screen display);
3) passengers could have the information directly on their mobile phones or PDA’s, via bluetooth or WiFi; this can even allow to spare equipment on board.

5.5. Deliverables and other outputs

In this chapter only the following deliverables are considered:

- Deliverables exclusively produced within the Activity Field 3 (in general also including contributions from different project participants)
- Deliverables from shared activity or common to more than one AF, but where BTG acted as the lead participant

5.5.1. D02 - Analysis of User Requirements

[All AF's, shared production, leader: BTG]
This document (TC1-D-BTG-005-03) had the goal to report the analysis of the user needs and requirements related to the scope of TrainCom. Based on the input of railway operators and suppliers (the "users"), it evaluates and summarizes the impact of the user requirements for the communication system and the overlaid applications like DPIS and ROMAIN. The essential contents of the document are:

- Methodological introduction
- Project overview:
  Participants, main goals, key issues, technical structure (introductions to the 5 AF’s), expected achievements, organisational structure
- Detailed requirements for each AF, containing:
  Introduction, prioritised requirements (tables and diagrams), conclusions and goals
- General conclusion

5.5.2. D09 - Specification of the DPIS

This document (TC1-D-BTG-021-07) is a detailed specification of the DPIS data and the structure of the related data model. It defines the data types and their XML representation. It introduces the basic concept and describes the transfer from the pure XML data convention to the needs of a standard relational data base. The document contains:

- Summarised input:
  ROSIN, user requirements (from Del. 2), UIC 176, others
- DPIS data specification with general concept and relational model
- Data base environment
- A working example (from the data tables to the display of data in practice)
- Comparison with TRANSMODEL
Analysis of dynamic aspects (operational/technical)

5.5.3. **D18 - Prototype Description of the DPIS**

This document (TC1-D-BTG-071-02) describes the DPIS prototypes and how they are used for testing and operation. Where needed, the description distinguishes between the Italian and the German site.

The document contains:
- Introduction
- Description of the prototype (Italian/German site)
- Use cases (general)
- User Manual (Italian/German site)

5.5.4. **D21 - Verification of the DPIS**

This document (TC1-D-BTG-073-01) describes the verification of the DPIS application after integration with equipment and functionality related to the communication infrastructure, developed within Work Package 6 (TrainCom Activity Field 2). The verification work is done with respect to the specification as well as to fulfil the requirements for the planned demonstration. Therefore pre-tests have been included, which were performed in the real train environment.

The document deals with both the Italian and the German part of the DPIS implementation. Laboratory prototypes were set up both in German and Italian sites (located at Bombardier - Hennigsdorf/Germany and FAR Systems - Verona/Italy).

The document contains:
- Introduction to the verification work: overview, scope, restrictions
- Pre-tests for the verification of the prototypes and the applications (Italian/German)
- Pre-tests of the envisaged communication system, including a detailed report on the quality of GSM under high-speed conditions
- Site-related detailed verification (Italian/German)

5.5.5. **D23 – Report regarding the DPIS demonstration**

The document contains, for each of the demonstrations:
- a description of the structure of equipment (System architecture, System arrangement, Coach equipment, Passenger Information System, Communication Infrastructure)
- a description of the demonstration journey

5.5.6. **Table of Deliverables**

In the following table only the last actual version of each document is listed (see last two digits of the document internal code).
5.6. Problems and changes

5.6.1. Change of the demonstrator equipment

As the TrainCom project was elected to be the successor of the former ROSIN project it was obvious during the proposal and project definition phases that the ROSIN coaches should be the basis for the demonstrator in TrainCom. But, as not unusual during a longer project period of time, the owner of those coaches, the railway operator and TrainCom participant DB, was not able to keep these coaches available during the complete project time for the reason of a newly started big coach refurbishment program, which the coaches belonged to.

So, a certain deviation from the Technical Annex was unavoidable, when - after long and controversial discussion amongst the affected participants - the decision was made, NOT to take the ROSIN coaches for the DPIS demonstrator, but to choose an ICE3 train instead.

As envisaged in the Technical Annex, two demonstrators were developed, one owned by the Italian operator Trenitalia (TRI), the other by the German operator Deutsche Bahn (DBR). The demonstrators consisted of two specially equipped sleeping coaches (Italy) and an ICE3 High-Speed Train (Germany), respectively.

The interoperability aspects were not affected, because even for the seat reservation the way of data transfer follows international conventions amongst the different operators. The data generation at the local source and also the representation of the seat reservation data in the train followed the specifications of deliverable 9. The same was for the DPIS data. So, in general, it was possible to check different aspects of the system in the two demonstrators.

Anyway, as the demonstrations had to be carried out in two sites with different train equipment, but using exactly the same data model as specified in deliverable 9, the interoperability check was fulfilled (with respect to train equipment in use even if doubled).
Of course, also the effort was enlarged by additional tests and higher verification effort which resulted in the known project extension of three months.

5.6.2. Communication Middleware - a missing link

During the implementation phase a group of participants (BT DE, BT IT, CAF, DB, TRI, ÖBB) recognized that the envisaged functionality of the ROGATE and ROGS was not enough for the sophisticated handling of all the railway-specific procedures which will occur especially in larger and well-equipped high-quality trains, but also for new maintenance aspects. Some of the aspects to be solved are listed here:

- central data management of physical inauguration (physically named coaches [e.g. UIC-based coach name "802435"] are powered, but not yet in scheduled operation)
- central data management of logical inauguration (logically named coaches [e.g. passenger-relevant coach No. "5"] are coupled to a train serving a scheduled course)
- redundant data bases on the train (master/slave function). There might be several data bases in case of different applications, which have to be handled in a pre-described way
- redundant application controllers (in general: intelligent subsystems) in case of doubled or multiplied equipment in a large train or in a standard train with locomotive (e.g. more than one DPIS controller - who is master/slave within this distributed application?) The same applies to distributed applications having their own dynamically assigned IP address.
- redundant communication channels, e.g. more than one ROGATE/GSM antenna after coupling two trainsets together (who is the communication master?)
- in-train organization of the IP-based network with respect to the existing (and remaining) TCN. Definition of migration strategies.
- different physical communication channels available during the trip (e.g. by GSM-R, GPRS, UMTS, local WLAN access point)

It was commonly agreed, that the additional functionality is necessary to fulfil all the operational requirements of existing modern trainsets as well as loose-coupled standard trains. On the other hand it was clear, that this would lead to an effort which clearly exceeds the Annex 1 of TrainCom contract. So, some additional internal documents were prepared to address the new aspects from different point of views for future work:

- TC1-T-TRI-017-04 Dynamic Insertion Network Object (partly included in Del. 15)
- TC1-T-BTG-064-02 DPIS Application Communication Protocol
- TC1-T-BTG-070-01 DPIS Requirements for the Communication Middleware
- TC1-T-SIE-067-01 Description of the Middleware

Finally, the work on the so-called middleware functions has been forwarded to new or forthcoming projects, such as ModTrain or InteGRail.
5.7. Benefits and possible deployment

For BT DE the developed database and the architecture behind open new areas of applications. So it seems to make sense to choose a similar database construction (update/change/replicate mechanisms) for other applications like:

- Train Diagnosis Systems
- Digital Announcement Systems
- Closed Circuit Television (video-based survey of the interior of coaches, e.g. to detect vandalism)

Moreover, all activities within TrainCom that have the goal to introduce an IP-based network on trains will offer new opportunities for the manufacturers to overcome the restrictions of the existing bus system solutions (e.g. TCN). Furthermore, the migration to the "IP Train" will result in cost reductions for software solutions, because the IP allows the usage of browsers being available on every PC. A train with high-performance buses, on the other hand, will offer opportunities for new functionality and hardware devices, to be developed and offered to the operators or the end users (passengers, service personnel).
6. AF4 – Remote Diagnostics and Maintenance

6.1. Overview

Activity Field 4 (ROMAIN) has developed the basic elements of an innovative maintenance platform based on the developed standard TrainCom communication infrastructure. The system implements the basic concept of the Intelligent Workshop, where real-time data coming from running trains are collected according to standard formats and integrated in the complete maintenance and diagnostic workflow. Status and event data are stored in a diagnostic database, where navigation mechanisms will allow easy access for maintenance operators.

The system will significantly contribute to improve vehicle interoperability from the maintenance point of view. It will make collected data available to users, according to their skill, duties and level of intervention. Three types of users are envisaged: equipment manufacturer, vehicle integrator, maintenance and railway operator.

The Remote Monitoring and Maintenance system was specified. Standard formats and methods for the access to the data like status and events were defined in the specification phase.

A basic prototype has been developed and validated at laboratory level. It is based on the train-ground communication link developed in TrainCom and also on modern technologies from the Internet like HTTP and XML. The prototype was successfully implemented, verified and demonstrated at a public event.

The ROMAIN system allows complete real-time monitoring of the train. Therefore the maintenance process can start while the train is still running. The needed operations in the maintenance workshop can be planned and so the stopping time can be reduced and the availability will increase.

Moreover, this application is the first step to a European logistic support and fleet management system.

6.2. Project objectives

A complete architecture for remote monitoring and maintenance support of railway equipment will be defined and basic elements will be developed and validated; the results will steer exploitation intentions of railway operators and manufacturers, possibly starting the development of a complete product, which in the future can be embedded into all new devices and systems aboard trains, allowing for a new, European wide maintenance organisation; an acceptance level higher than 50% could be considered as a positive result.

6.3. Approach followed to achieve project objectives

The following development process was defined and followed in the project:

- WP1 - Collecting the user requirements for a Remote Monitoring and Maintenance system.
• WP4 - Definition of the architecture of the ROMAIN system and specification of the interfaces and modules.
• WP8 - Implementation of the basic elements of the system.
• WP10 - Verification of the system.
A demonstration was not planned for this Activity Field.

6.3.1. **WP1 - Collecting the user requirements for a ROMAIN system**

The aim of this phase was to collect the requirements of the system which will be really needed by the railway operators and manufacturers.

Four main groups of user requirements were defined for the ROMAIN system:

• Real time monitoring of the system.
  The system should be able to read and show the subsystems status and all diagnostic events of a train or an item on demand and blocking faults should be notified to the ground system.

• Configuration control.
  The system should be able to display a physical and functional breakdown of all items of the system with items’ Part Numbers.

• Data collection and statistics.
  The system should be able to store the diagnostic events of a vehicle or an item in a ground site database. Access functions to the stored data should be provided to filter and show the failures of a vehicle or an item. Statistical analysis of the data should be provided.

• Documentation.
  The system should be able to display electrical diagrams, maintenance procedures and preventive maintenance programs. The system allows searching documents by item part number, by keywords and should show a documentation index according to the functional breakdown.

The results of this phase are described in the deliverable 2, “Analysis of User Requirements” (TC1-D-ADT-005-03).

6.3.2. **WP4 - Define the architecture of the ROMAIN system.**

In this phase the architecture was defined and the main components of the system were specified.

The ground site of the system (figure 1) consists of one server for each main functionality of the system with a database and some specific modules inside. All the servers have a connection to a presentation layer which implements the access to the data in the databases and the conversion of the data for the web client (standard browser).
The on-board system (Figure 2) consists of a RoGate for the communication to the ground site and some diagnostic units. The on-board devices are connected via bus systems (MVB, FIP, Ethernet). The diagnostic units are existing vehicle devices which collect data from the vehicle or the item and generate and store events and status on-board.

Figure 1: ROMAIN Ground architecture

Figure 2: ROMAIN On-board architecture
Modern technologies from the Internet, like HTTP and XML are used in the system. The data exchange between the different structures is made by XML. The output of each module is in XML.

The main software modules were defined to fulfill the main functional requirements requested by the users. For instance the function GetEvents for the Real time Monitoring is shown.

The function GetEvents enables the user to retrieve all diagnostic events recorded into the on-board diagnostic unit. The existence of a filter allows reducing the amount of requested data, which gets important if bandwidth is restricted.

XMLFile ResultFile = GetEvents (XMLFile RequestFile)

<File example):

<?xml version="1.0" encoding="UTF-8"?>
<RML
xmlns="http://www.traincom.com/RML/2001/2.0"
xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
xsi:schemaLocation="http://www.traincom.com/RML/2001/2.0 rml2A.xsd"
version="2.0.000"
>

<Ask name="GetEvents">
    <Filter>
        <FltEntry fltsub="dicId" fltop="Equal" fltval="38318278_mpu"/>
        <LogOp> "AND" </LogOp>
        <FltEntry fltsub="EventId" fltop="Greater" fltval="10"/>
        <LogOp> "AND" </LogOp>
        <FltEntry fltsub="EventId" fltop="LessOrEqual" fltval="100"/>
    </Filter>

</Ask>

</RML>

<ResultFile> : XML file containing the answer for each event requested:

<Files example>:

<?xml version="1.0" encoding="UTF-8"?>
<RML
xmlns="http://www.traincom.com/RML/2001/2.0"
xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
xsi:schemaLocation="http://www.traincom.com/RML/2001/2.0 rml2A.xsd"
version="2.0.000"
>

<TrainData>
    <Evts dicId="38318277_mpu">
        <Evt id="000017">
            <Date>2001-01-11T00:00:08.501</Date>
            <Code>301</Code>
        </Evt>
    </Evts>
</TrainData>

</RML>
The results of this phase are described in the deliverable 10, “Specification of the Railway Open Maintenance Application” (TC1-D-ATR-010-07).

6.3.3. WP8 - Implementation of the basic elements of the system

In this work package the basic elements of the system were implemented by the participants and integrated into a basic ROMAIN system.

Implementation of the ground modules

Each partner (ATOS, CAF) uses its own server with the database structure and the application layers described above, both for the implementation and the test of the modules.

Implementation of the on-board modules

ASB uses its own software tools and its own on-board CODE system to develop a diagnostic on-board database and a device able to transfer the diagnostic records through process data on the MVB. This device will use a specified port to send data to the ROGATE and another specified port to accept command and parameters from the ROGATE.
Integration of the system

The integration of the whole ROMAIN modules over the TrainCom Network infrastructure was tested according to the architecture shown in Figure 3, where the yellow DB modules can be seen both as running over a unique machine or over three machines. The documentation module has not been implemented, because of the limited effort for the Activity Field. The TrainCom Network infrastructure used in the integration phase is that one developed by ATOS (ROGs) and FAR (ROGATE).

The Simulated Device is an MVB device simulating CODE functionalities and implemented by ASB. ASB itself have provided a PC with a VisualBasic tool allowing stimulating Diagnostic Events in the simulated CODE through its terminal RS232 port.

The ROMAIN Software Architecture on ground site has been developed under Windows system using the so called Windows DNA structure\(^1\) that consists of the use of the new

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\(^1\) Windows DNA = Windows Distributed internet Application
functionalities of MSQL 2000 Server to handle direct XML (Xpath) calls through a virtual Web page pointing directly to a MSQL Database.

With regards to external XML HTTP calls, this architecture mimics the behavior of a WEB service using an Application Server and WSDL calls.

Figure 4: ROMAIN Implemented software architecture

In the deliverable 19, “Basic prototype of on-board and ground ROMAIN System: Implementation, Integration and Verification Specifications” (TC1-D-ATO-043-03) the implementation and integration phase was described.

6.3.4. **WP10 - Verification of the basic system**

In this phase the integrated system was verified. Test cases were specified and performed. The test cases and the test results were documented in the deliverable 22, “Document about the verification of the ROMAIN system, includes Test Specifications and Test Reports” (TC1-D-CAF-052-02).

6.3.5. **Presentation of the basic system**

During the public event in Milan on the 16. September 2003 the basic ROMAIN system was presented. The presentation based on the integrated system in Figure 3.

The WEB-MMI for the Real Time Monitoring is shown in Figure 5 and Figure 6. In Figure 5 the vehicle/item status over the train and in Figure 6 the diagnostic events presents in the CODE data base are displayed.
Figure 5: Train status page

Figure 6: Train faults collection page
6.4. Project results and achievements

One central idea in the project was to use modern technologies from the Internet (HTTP, GSM, XML) with the aim to find a way for the standardization of the maintenance application. Therefore XML is used as the standard way to exchange data between the maintenance applications.

Project results
The specified standard way for the transmission of maintenance data from the train to ground station was successfully used in the prototype. The real-time monitoring of the system was demonstrated by transmitting logistical and diagnostic data (faults, alarms, critical values) wireless from a simulated train to ground. The received data were stored in a database in the ground station. Functions for the access to the data from a web browser were provided. The TrainCom communication infrastructure was used in the laboratory prototype.

The comparison of the achieved results to the original objectives shows that most of the objectives were accomplished, like the specification of the architecture, the development and validation of a laboratory prototype. With the prototype, a possible way for the development of a product was pointed out. The achieved results could only be the first step for a new European wide maintenance organisation.

Perspectives for the future
The results of the Activity Field will influence intentions of railway operators and manufacturers how they can develop a maintenance system in the future.

The use of XML suggests the creation of a new Railway standard to tag the diagnostic data inside an XML schema and to create meaningful general display pages.

The results were input and starting point for the European project EuRoMain.

Remote, real-time monitoring of equipment directly on-board trains will allow starting the maintenance process while the train is still running, alerting people, allowing precise diagnosis and planning the needed operations, greatly reducing train stopping time and optimising vehicle usage. The system represents the first step toward a trans-European fleet maintenance infrastructure, able to support rail vehicles even when they are running outside the State where they are registered, allowing mutual recognition of maintenance and repairs and so contributing to the objectives of the proposed Directive on Interoperability of the conventional railway system and of the Directive on Interoperability of high speed trains as well.

6.5. Deliverables and other outputs

In this chapter only the deliverables which were exclusively produced in this Activity Field were considered.
6.5.1. **D10 - Specification of the Railway Open Maintenance application**

This document (TC1-D-ATR-010-07) is the general specification of ROMAIN (Railway Open Maintenance) application. It defines the functions of the application, the technologies used, and the general software architecture.

The document contains:
- an introductory description of the ROMAIN application,
- a description of the architecture of the application,
- specification of constraints and guidelines (languages, technologies and tools) for the development of the software modules and
- specification of software modules.

6.5.2. **D19 - Basic prototype of on-board and ground ROMAIN System.**

This document (TC1-D-ATO-043-03) describes the most relevant topics of the ROMAIN hardware and software architecture implemented and running with regard to TrainCom applications. It will include both the ground segments (Real Time Monitor Module, Diagnostic Data Collection Module, Configuration Control Module, Documentation Module), and the on-board element (CODE).

Aim of this document is to define the implementation and verification phases of the ROMAIN application. All the modules which have been implemented are described.

6.5.3. **D22 - Basic Verification of the ROMAIN System**

This document (TC1-D-CAF-052-02) describes the tests to be performed to verify ROMAIN basic elements, checking interoperability between on-board segments (CODE) and ground segments (Real Time Monitor Module, Diagnostic Data Collection Module, Configuration Control Module, Documentation Module) and the results of this verification phase of the ROMAIN application.

The verification of the ROMAIN system consists of the integration of the ground modules (Real Time Monitoring, Diagnostic Data Collection and Configuration Control) and the onboard network (TCN) by means of a radio link provided by the TrainCom Communication Infrastructure. The interoperability between on-board segments and ground segments is checked, as well as the functionality of each of the modules implemented.

It includes also the results of these tests, which were performed in the public event for the verification of the ROMAIN system, that took place in ATOS Origin facilities in Milan on 16th September 2003.

6.5.4. **Table of Deliverables**

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6.6. Perspectives

From TrainCom results in AF4, a new project was started in IST, EuRoMain (IST-2001-34019), which specifically deals with railway maintenance. It expands the scope of AF4, addressing the topic from a more general and comprehensive point of view.

A common basis will be the TrainCom Communication Infrastructure, which will allow to achieve data communication between equipment aboard and ground systems. EuRoMain results will give a final solution to the research work started by TrainCom.

![Figure 7 - Prototype of the ROMAIN system in the lab](image-url)
7. AF5 – Locomotives Interoperability

7.1. Overview

Intelligent Locomotives can be remotely controlled according to standard specifications, achieving various levels of interoperability, which is a basic requirement for border crossing rail traffic. The focus of TrainCom activity field locomotives interoperability was on locomotive compatibility at the command and control level, via the Train Bus and according to existing specifications for remote traction control.

The application has been validated in two test sites, using vehicles from different manufacturers. The goal was to show how a locomotive or a driving trailer can remotely control another locomotive, through the standard TCN train bus (IEC 61375-1), using standard procedures as defined in UIC 556-647 (EU Remote Control). This was possible in the past only by means of proprietary solutions, often using specific cables with more than one hundred wires, each dedicated to a well-defined function. Therefore two locomotives could control each other only if they were equipped with the same product and they, and all intermediate coaches, were cabled with the required dedicated wires. So, a need for a common standard solution arose and was addressed preliminarily by the ROSIN project (FP4) and now by TrainCom (FP5).

7.2. Project objectives

A specification for interoperability of locomotives, through remote traction control, will be validated in at least two test sites (Austria, Italy), using vehicles from four different manufacturers; the application will try to meet railways expectations in terms of reduction of stop time, lower probability of delays and vehicle usage efficiency; the solution will demonstrate at least 90% of functionality envisaged in UIC leaflet 647; if successful, the solution will be adopted by train operators on new locomotives.

7.3. Approach followed to achieve project objectives

The following development process was defined and followed in the project:

- WP1 - Collecting the user requirements for Locomotives interoperability
- WP4 – Specification of an application that allows remote traction control of locomotives
- WP9 – Implementation of Prototypes for Remote Traction Control application
- WP11 - Verification of the Remote Traction Control application
- WP14 - Demonstration of the Remote Traction Control application
7.3.1. **WP1 - Collecting the user requirements**

The aim of this phase was to collect the requirements for remote control which will be really needed by the railway operators and manufacturers. The user requirements summary gave information about remote control usage in different types of trains, the use and completeness of existing specifications and what is expected on this subject. The results of this phase are described in the deliverable D2, “Analysis of User Requirements” (TC1-D-ADT-005-03).

7.3.2. **WP4 – Specification of remote control application**

In this phase the remote traction control application was specified, considering also previous solutions and implementations. The user and normative requirements for such applications are treated, as well as the evaluation of the previous issues of the UIC Leaflet 647, which deals with remote traction control using TCN network and UIC Leaflet 556 definitions. The experience gathered from already existing solutions for remote traction control on the basis of UIC Leaflet 556 were summarized, like remote control applications from OEBB, Trenitalia or from the ROSIN project. The specification for a remote control application is described by means of a functional model and descriptions of the needed general and functional requirements. The aim of the specification was to contribute to the specification work for a final version of UIC leaflet 647.

In order to properly define all signals involved in Interoperability, they can be arranged in functional modules, the macrofunctions, as in the following picture:
The results of this phase are described in the deliverable D8, “Specification of the Locomotives Interoperability application” (TC1-D-SIE-018-05).

7.3.3. **WP9 - Implementation of the Remote Traction Control Application**

In this work package the main components and procedures for remote traction control applications on vehicles from OEBB and Trenitalia were treated. The applications were used as basis for the verification and demonstration phases.

A proposal for a standard test procedure was developed in order to achieve the “Minimum Acceptance Test” for interoperability purpose.

The OEBB implementation includes a loco, equipped by an Austrian company, and a steering coach, equipped by a German company, in a push-pull configuration.

The second development, implemented in Italy, uses two locomotives and a retrofit driving trailer, which operate in pairs.

The results of this phase are described in the deliverable D11, “Prototype of the Remote Traction Control Application” (TC1-D-TRI-024-04).

A development of a prototype was carried out in Romania by Silologic as well. It can only partially implement the concept, as in Romania there are no TCN equipped locomotives at the moment.

7.3.4. **WP11 - Verification of locomotive applications**

The Locomotives Interoperability was validated in two test sites in Austria and in Italy using vehicles from different manufacturers.

1) Italy (Verona), on 29 July 2003, with loco E464 from Bombardier Italy and loco E412 from AnsaldoBreda
2) Wien (Austria), on 25 September 2003, with loco 1142 from Elin and driving trailer 80-33 from Siemens
3) Italy (Mestre), on 29 November 2003, with loco E402A from AnsaldoBreda and driving trailer Z1 from Firema

In Italy all the relevant data regarding traction control signals (according to UIC 556 and UIC 647) were checked. In Austria the demonstration focus was on specifications according UIC Leaflet 556, checking its soundness and completeness.

All events followed a common test procedure, which was articulated basically in three main steps:

a) the locomotive is tested against a vehicle simulator, which is able to exchange control data according to standard procedures, as though it was a second locomotive hosting a reference implementation. Target of this step is the validation of the software implemented on the loco under test from both the functional and UIC conformance points of view
b) the second locomotive or driving trailer is then tested in the same way; at this point, if tests are successful, both vehicles are supposed to speak exactly the same language
c) finally, the two vehicles participating in the test are coupled together, via TCN, and allowed to speak directly each other, with one of them controlling the other one; it is now possible to run the train from the leading vehicle, controlling remotely the locomotive on the opposite site

The results of this phase are described in the deliverable 14, “Remote Traction Control Application - Verification Report” (TC1-D-TRI-035-04).

Prototypes of devices suitable for locomotive remote control have been developed in Romania by SILOGIC. The prototypes have been tested and achieved homologation by AFER (Romanian Railway Authority). See also TC1-I-SIL-058-01.

7.3.5. **WP14 – Demonstration of locomotive interoperability**

The Locomotives Interoperability was demonstrated in two test sites in Austria and in Italy using vehicles from different manufacturers.

- Austria (Wien), on 25 September 2003, with loco 1142 from Elin and driving trailer 80-33 from Siemens
- Italy (Mestre), on 29 November 2003, with loco E402A from AnsaldoBreda and driving trailer Z1 from Firema

These demonstration events, which include a short test journey on normal tracks, were public demonstrations and were attended by a number of people external to the project, both railways and industries, including participants from Czech Republic and India.

The results of this phase are described in the deliverable 20, “Report presenting the results of the Locomotive Interoperability demonstration and workshop proceedings” (TC1-D-SIE-061-03).

Even if not properly a demonstration, a presentation of the prototype developed by SILOGIC was organised in Romania, in front of several Users (CFR, METROREX). The application, simulated, can open the way to future implementation of TCN in the loco fleet of CFR MARFA (see TC1-I-SIL-059-01).
7.4. Project results and achievements

A first benefit of the system is quite apparent: when a train arrives in a station and needs to reverse its direction, it is no more necessary to decouple the leading locomotive and couple a new one on the opposite side, but it is now enough that the drivers change their location, e.g. from the locomotive to the driving trailer on the opposite side, and the train can start again immediately (push-pull operation). This allows to spare personnel for coupling and decoupling locomotives and avoids the use of one more locomotive.

A less common situation occurs when a train gets an assisting locomotive in front of it: it is not necessary to have also an additional driver.

The fundamental benefit is the enhanced flexibility allowed by locomotive interoperability: as all vehicles are interoperable, different combinations of vehicles are possible, allowing for optimised management of the fleet of locomotives and driving trailers.

A benefit which is not so easy to catch is the capability of the TCN network and the UIC 556/647 profile to interface any kind of vehicles regardless their Human Machine interface. Existing Human Machine interfaces aboard locomotives range from full electromechanical device implementations like the OeBB's 1142 to the more sophisticated implementation showing one (driving trailer 80-33) or two (E412 and E464) intelligent displays substituting traditional instrumentation. Other differences between the vehicles involved are the use of incremental (E412, 80-33) vs. proportional (E464, 1142) input devices (direction setting, max speed set point, effort setting, etc).

While waiting for the harmonisation of circulation rules at European level, also for conventional trains, the presently available Human Machine interface solutions have to fulfil the country specific circulation rules. The performed validation demonstrated how the system can take care of harmonising all such differences, hiding them below the standard procedures and allowing for seamless operation between different kinds of vehicles.

Preliminary versions of the TrainCom solution have been used in normal operation since some years, e.g. in Austria and Italy. Now it can be easily adopted by other railway operators, in all countries, contributing to the interoperability of the European Railway system.

The "TCN device emulator", not originally planned, revealed itself as a proper device able to fulfil all the requirements at the basis of its specification. It is an essential part of the preliminary locomotive test procedure for remote control compatibility check. It's important noting that such a TrainCom result represents the first effectively working reference implementation for UIC556/UIC647 conformity tests.

7.5. Deliverables and other outputs

In this chapter only the deliverables, which were exclusively produced in the Activity Field, are considered.

7.5.1. D08 - Specification of the Locomotives Interoperability Application

This document specifies the Locomotives Interoperability application, which can be applied to locomotives and driving trailers on the basis of the UIC Leaflets 556 and 647.
The User Requirements and experiences from existing national solutions are summarized. Parts of this specification will be proposed as a possible standard specification.

7.5.2. **D11 - Prototypes of the Remote Traction Control Application**

This document describes the requirements for loco interoperability. A functional approach is used and a behavioural model is proposed.

This document specifies how the UIC 556 and 647 leaflets can be applied to real locomotives and driving trailers. A proposal is set up for a standard test procedure in order to achieve the “Minimum Acceptance Test” for interoperability purposes.

7.5.3. **D14 - Remote Traction Control Application - Verification Report**

This document reports the results of the interoperability verification sessions performed by OEBB and Trenitalia. The OEBB session involved the 1142 electric locomotive type and the 80-33 driving trailer type. The Trenitalia’s session involved two types of electric Locomotives, the E412 and the E464.

7.5.4. **D20 - Report presenting the results of the Locomotive Interoperability demonstration and workshop proceedings**

This deliverable is the report presenting the results of the Locomotive Interoperability demonstration of the TrainCom Activity Field “Locomotives Interoperability” demonstrations in Austria and Italy.

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<td>Deliverable document D20</td>
<td>Report presenting the results of the Locomotive Interoperability demonstration and workshop proceedings, TC1-D-SIE-061-03</td>
</tr>
</tbody>
</table>
7.6. Perspectives for the future

Perspective for the future include further development of UIC647 (e.g. to consider trains with distributed power, like ETR460 and ICE3) and a connection with train-ground communication to allow intelligent remote supervision.

Applications on the basis of UIC Leaflet 556 and 647 are going to be the standard implementations for remote traction control of rail vehicles in Europe. By using these specifications for new vehicles and by adoption of existing remote control systems, a general solution for remote traction control in Europe is feasible.
8. Project management and co-ordination aspects

8.1. Project management issues

As described in par. 2.1, since the very beginning the project was organised in such a way to allow for a distributed share of responsibility and control organisation.

Technical and Financial Coordination were done by the same person. Activity Field (AF) Leaders were able to ensure project life long technical coordination in each main development, through the different work-packages. Work-package Leaders were in charge of detailed technical coordination within the scope and time limits of each WP. Responsibility for deliverables was sometime separate from WP leadership, depending on WP size and nature.

Board meetings were regularly held (every 3 months, in the average), to check the project status and take strategic decisions. All participants had one representative in the Board. To avoid possible deadlocks, a Steering Committee was defined as part of a problem solving strategy. The Steering Committee could force decisions whenever the Board was not able to do that. As a matter of fact, this mechanism was never needed: the only idea that the Steering
Committee could be called to solve problems in place of the Board was enough to force all participants to find always an agreed solution.

Technical meetings were additionally organised when needed, at Activity Field or Work-package level. Only people involved in the related technical activities attended them.

A valuable management tool was represented by the project web site. The area reserved to project participants (members) included a complete document management system, which, combined with an agreed document protocol coding mechanism and with pre-defined document models, helped in managing the huge amount of documents produced in the project. The same part of the Web site provided for a member directory (including e-mails, phone numbers and other details) and lists of pending actions and upcoming events as well.

It is a final consideration that the TrainCom project, in terms of organisation (Activity Fields are similar to “subprojects”), number and complementarity’s of participants, ambitiousness and size of objectives (covering extensively an application area), anticipated the concept of “Integrated Project”, as defined in the Sixth Framework Programme. This is even truer, when considering at the same time the cluster project EuRoMain: the two projects together reached a total cost of about € 15 million and a total effort of about 1.300 pms.

8.2. Problems and solutions

Generally speaking, and considering the size of the project, the work went through its 39 months duration very well, as all anticipated objectives could be reached.

Of course, many problems arose during all such a time, the main ones dealing with delays and resource problems. First of all, the commencement date (1st December 2000) resulted not a good choice, as it was practically impossible to really start the project before mid of January 2001. Then, a number of unexpected and unpredictable events in some of the participating organisations (see next paragraph) caused some further delays, due to internal restructuring and consequent difficulties in the allocation of resources.

The consortium was able to adapt to the changes and re-allocate the work accordingly, so as to limit the delays and partially recover them.

Activities related to maintenance (AF4) had to cope with reduced resources, due to a cut in funding occurred during the negotiation phase. The scope of work had to be limited to basic developments and the decision had to be taken about a possible new project specifically dealing with maintenance. As the results achieved were good, it was decided to start a new project proposal and submit it at the first opportunity. The proposal was successful and the new project EuRoMain started on April 1st, 2002. Strict coordination was needed, to avoid that possible delays in TrainCom could have an impact on the new project. Monitoring the situation and organising some specific technical meetings, it was possible to properly manage the situation and forward TrainCom results to EuRoMain.

Cooperation with other projects was not simple to organise. TrainCom tried to take into account all related projects: ESCORT, TPEG, TRIDENT, GALILEAN, DRIVE, EUDD, REOST and LOCOPROL. However, only with two of them (ESCORT and REOST) it was possible to organise common meetings.
Specific problems were found related to the organisation of demonstrators. Even if preliminary plans were set up early, it was not easy to prepare the needed platforms for demonstrations, due to:

a) availability of rolling stock, which needs agreements on vehicle choice, timing, assistance;
b) constraints about installation of new equipment aboard;
c) logistic and practical needs, to allow a public demonstration to occur.

Some of these problems were originally underestimated and resulted in many changes and compromises, to be defined and agreed during the progress of the work.

The Consortium’s strong commitment helped finding always acceptable solutions.

8.3. Contract amendment

Since the beginning of the project (first Board meeting) it was clear that a contract amendment for the TrainCom project was needed, due to several issues, the main one being the changes in the names and/or ownership of several companies participating in the project.

Due to the needed reorganisation of the involved companies and consequent changes in the project workplan, it took more than expected to finalise the amended contractual documents, which were firstly issued, in a first version in December 2001.

In the following months, further issues were arisen, which were notified to the Project Officer. The EC informed us that, as the first contract amendment had not yet been processed, it was better to include in it also the new changes, which came out from the new situation in the project, along with the envisaged solutions.

The changes included were necessary to take into account all events occurred during project life and to establish a more realistic and correct planning.

This was important to allow the project to proceed in the best way up to its end.

Some changes dealt with new company names of project participants, as here summarized.

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<thead>
<tr>
<th>Old name</th>
<th>New name</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
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<td>DaimlerChrysler Rail Systems GmbH (ADTRANZ)</td>
<td>Bombardier Transportation GmbH (BT DE)</td>
<td>Acquisition of Adtranz by Bombardier Transportation</td>
</tr>
<tr>
<td>DaimlerChrysler Rail Systems (Italia) SpA (ADTRANZ IT)</td>
<td>Bombardier Transportation Italy S.p.A. (BT IT)</td>
<td>Acquisition of Adtranz by Bombardier Transportation</td>
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<td>Ferrovie dello stato Società di Trasporti e Servizi per Azioni (FS)</td>
<td>TRENITALIA SpA (FS-TRI)</td>
<td>New company founded to split railway activities</td>
</tr>
<tr>
<td>Ansaldo Trasporti S.p.A.</td>
<td>ANSALDOBREDA S.p.A. (ASB)</td>
<td>Split of previous company into three different new companies, one of which takes over in TrainCom</td>
</tr>
<tr>
<td>ATOS SpA</td>
<td>ATOS ORIGIN SpA (ATOS)</td>
<td>Change of name due to fusion with ORIGIN</td>
</tr>
</tbody>
</table>
A number of changes were related to changes in legal signatories, contact persons, or persons in other roles, for the project participants.

A small number of changes dealt with real modifications in the work program, which needed to be included in the contract amendment. Anyway, the number and extent of such changes was limited and did not affect the project objectives.

This is also true for the only relevant modification, that is the required modification of the DPIS demonstration. The change of the demonstration platform did not affect the envisaged project objectives and enhanced its effectiveness.

During work progress, some adjustments were required in the effort distribution between participants, as some of them could not allocate enough resources. Some tasks had therefore to be moved to other participants, in order to properly finalise the work.

Finally, as soon as it became clear that some delay could not be recovered before the end of the project, as well as that the high number of final public events required some more time for proper scheduling, a need for a project time extension became apparent and was included in the last version of the Contract Amendment. This required a change in the WP scheduling (Gantt diagram), which resulted in a better matching between actual and planned deadlines.

8.4. Dissemination

Since the beginning, project participants put a consistent effort on dissemination and diffusion issues. Dissemination activities included several actions:

a) development of a complete Web site, including a section immediately open to everybody, a section open to registered visitors and a private section reserved to project participants
b) publishing of a project presentation (brochure) and of articles in magazines or web sites
c) participation in conferences and set up of a number of public events organised by the project itself
d) preparation of a project CD-ROM, to be distributed to interested people

Services provided by CORDIS were valuable to improve the visibility of the project. More details are described in Deliverables D5, D24, D25.

8.5. Deliverables

Deliverable related to management activities are here summarised.

8.5.1. D01 - Project handbook and guidelines for deliverables development

This document is meant to provide quick guidelines to project participants, so as to be a reference during the work. It integrates information from different sources, as well as originally edited information, organising them in chapters corresponding to the main project aspects. It was used throughout project life by TrainCom participants, to ensure a common understanding and better quality of the project work. It included a protocol coding and models
for all types of documents, answers to common questions, procedures and internal rules. This
document was updated several times during the project life, when so required, reaching
version 7.

8.5.2. **D03 - Quality and evaluation plan**

This document provides a description of the methodology to be used in the TrainCom project,
so as to assure that an adequate quality of work can be achieved. It defines basic quality
procedures, assessment objectives and evaluation criteria. The document includes two main
sections: Quality Plan and Evaluation Plan.

On the basis of this document, individual Quality Plans and Evaluation Plans were developed
within each Activity Field.

8.5.3. **D04 - Project presentation**

The project presentation was developed early after commencement date, to be used as a first
introduction to project objectives and activities. Later on, it was updated and edited in the
form of a brochure. The paper brochure was printed in 1.000 copies, to be distributed during
public events, conferences and so on.

8.5.4. **D05 - Dissemination and Use plan**

This document describes plans for the dissemination of knowledge gained during the project
(to the extent possible and considering any restrictions imposed through the protection of this
knowledge) and the exploitation plans of the consortium as a whole or individual participants
or groups of participants (to the extent that this can be foreseen at the beginning of the
project).

8.5.5. **D24 – TrainCom Project CD-ROM**

A project CD-ROM has been developed, focusing on the project results. Multimedia contents
(pictures, movies) are widely used. It will be distributed to interested people.

8.5.6. **D25 - Exploitation Plan and Technological Implementation Plan**

This document describes how the dissemination and use plan (D5) was implemented in the
project and how the results will be exploited in the future.

It includes the TIP, Technological Implementation Plan, which describes in detail the results
of the project and the plans that the partners have to use those results and to encourage others
to use them. The complete TIP has been produced directly on-line (eTIP) in the CORDIS web
site and submitted electronically.

8.5.7. **D26 - Final report**

It is the present document, covering all the work, objectives, results and conclusions
### 8.5.8. Table of Deliverables

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<tr>
<th>Documentation type</th>
<th>Details</th>
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<td>Project handbook and guidelines for deliverables development</td>
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<td>Quality and evaluation plan</td>
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<td>Dissemination and Use plan</td>
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<td>TrainCom project CD-ROM</td>
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<td>Deliverable document D25</td>
<td>Exploitation Plan and Technological Implementation Plan</td>
<td>TC1-D-COO-069-04</td>
</tr>
<tr>
<td>Deliverable document D26</td>
<td>Final report</td>
<td>TC1-D-COO-074-02</td>
</tr>
</tbody>
</table>
9. Outlook

9.1.1. General
This chapter presents a short description on how the results and achievements of the project have benefited each partner and how the partners intend to use and exploit these further. More detailed information can be found in the Technological Implementation Plan (D25).

9.1.2. Outlook per participant

9.1.2.1. SIEMENS
The TrainCom project allowed SIEMENS to address the problem of the Communication Infrastructure in a wide and general way, so as to define a flexible and cost-effective solution. The results of the research work will be used in the next generation of Train Control Systems (SIBAS 3G) currently under development. First products could be put on the market as soon as one year.

Some activities will go on in the EuRoMain project, where the TrainCom Communication Infrastructure will be made available for demonstration within the expanded maintenance system, coming from AF4 activities.

9.1.2.2. BOMBARDIER TRANSPORTATION
For Bombardier Transportation Germany, see par. 5.7.

Bombardier Italy already started activities in Italy related to products coming from the results obtained in AF5 for Traction Remote Control and Locomotive Interoperability. The Virtual Multipurpose Vehicle (“Vehicle simulator”) showed to be a valuable tool, beyond expectations, and will be adopted by Trenitalia in the next months.

9.1.2.3. ANSALDOBREDA
The TrainCom project has opened the railway world to those communication technologies already used in other applications. The research was issued to analyse and resolve the critical aspects of this world connected with GSM and Internet protocol. Particularly the ROMAIN application and DPIS application were developed using the basic TrainCom communication architecture.

So an improvement in the maintenance world will be obtained and the services to passengers will improve.

Another important benefit coming from this project is represented by the results obtained in the standardisation and interoperability field. In fact a conformance test specification was prepared. A physical test bed for device and a vehicle tester for coach test were realised. The interoperability between vehicles was also tested with a vehicle simulator, at UIC level, and coupling two vehicles from different manufactures.

Activities using TrainCom project results have been planned.

1. TCN conformance test: Investigation about physical test results.
A test activity in lab with TCN gateway connected with the vehicle tester with cables having known length is planned. The cross talk test, propagation delay test and attenuation test will be executed. The obtained results will be compared with the ones coming from the TrainCom results obtained with a vehicle under test. The goal is the optimisation of TCN gateway installation on the vehicles.

2. UIC 647 implementation: Implementation and testing. The activity consists in UIC 647 implementation on E402A or E402B locomotive and its testing. The test will be executed using the TrainCom vehicle simulator and then coupling two or more vehicles.

3. ROMAIN: New Diagnostic System for maintenance. The design of a new diagnostic system for maintenance of ETR500 trains is in progress. The TrainCom experience has been useful in the architectural design.

9.1.2.4. ATOS ORIGIN

AtosOrigin has been involved mainly in three Activity Fields (AF1, AF2, AF4).

About the first one (TCN Standardisation and Conformance), ATOS developed the test systems for a WTB-equipped vehicle (TCN Coach tester), starting from the specification and going on through implementation, verification and public demonstration. The system, developed with AnsaldoBreda, is based on a PC with MVB interface, and a TCN WTB/MVB Gateway. It has been used for further test equipments at MVB level, and will be used in the future in different contexts: test of MVB interface at application and/or communication level.

About AF2 (Train-Ground Communication Infrastructure), ATOS contributed mainly in the specification, implementation and verification of the Ground Segment (ROGS) and the communication layer on board and on ground. The development has been used as a base for the communication between train and ground of existing and future systems. Dissemination on Maintenance System for ETR500 fleet in Italy; EuRoMain project; Dynamic Information System for railway application.

About AF4 (Remote monitoring and maintenance Implementation and verification of a prototype), the activity has been used as a base for the New Maintenance System (named "NSDM") for ETR500 fleet. It will be used for EuRoMain project and for the future Maintenance System for trainset fleets. Another small activity was done to support Firema in the AF5 (Interoperability and Remote Control). It will be used for further support to TCN network users.

9.1.2.5. CAF

Through our participation in TrainCom we have been able to contribute to addressing some key problems of the actual railway system in Europe, like standardisation and maintenance support. This has given our company a wider view of the direction of actual developments, and it has served also for CAF to make an effort to contribute actively to main issues like the development of a TCN conformance test bed.

Moreover, the contribution to the TCN conformance test procedure developed within TrainCom is considered to be very useful to verify if a TCN device complies with the TCN standard, since CAF is currently developing their own control and supervision system based on TCN technology. Also the contribution to the Remote Monitoring and Maintenance System, with the specification and implementation of a Configuration Control Module, will
be taken into account for standardisation of maintenance platforms, this job being further
developed within the EuRoMain project.

9.1.2.6. **FAR SYSTEMS**

The results of AF1 (Test Bed) test bed will be useful to preliminary check TCN equipment, before integrating them in a network. Most of the possible compatibility problems can then be identified at an early stage, at lower costs. The test bed will also be a useful tool for certification bodies which will be able to perform the tests quicker and in an absolutely impartial way. In this work-package we analysed the buyers potentially interested. They can be grouped into three classes. Equipment manufacturers is a company that develops TCN equipment or devices to be sold and installed on railway vehicles where equipment or devices of different manufacturers are present. Conformance and interoperability is a must that has to be assured by the manufacturer. The approach shall be the execution, at the manufacturer lab, of a pre-test to assure equipment (device) pre-compliance. Vehicle manufacturer is a company that build vehicles where TCN equipment or devices of different manufacturers are present. Conformance and interoperability is a must that has to be assured by the manufacturer at integration level. The approach shall be the execution, at the manufacturer lab (Static Test) and on-board (dynamic test), of a pre-test to assure vehicle pre-compliance. Third Party Laboratory is an independent laboratory that will receive the task to certify the conformance and/or interoperability of a TCN device, equipment and TCN equipped vehicle on request of a car builder or Railway operator. As plan for the end of the TrainCom project it is expected the following time frame to go into market:

Phase 1: refinement of a test bed with co-operation between a manufacturer companies and railway operators. (6 months).

Phase 2: enlargement with the TCN User Group for execution of pilot tests and evaluation on results.

Phase 3: Preparation of technical and commercial documentation.

Far systems board decided to use the outcome of AF3 (DPIS) to transform them into an industrial product that will be included as part of the delivery of 901 Inter-city vehicles.

9.1.2.7. **FIREMA**

Notwithstanding some internal problems, which forced the company to reduce heavily their involvement in the project, limiting it to AF5 only, FIREMA was able to finalise its tasks. This was a valuable situation for the company, which did not lose the contact with the railway research community and will be able, now that most problems have been solved, to easier continue its research activities and international cooperation.

9.1.2.8. **SILOGIC**

SILOGIC received a big benefit from participating in the project, mainly in terms of know-how and help in starting new developments.

They received the agreement of ASTR A VAGOANE CALATORI Company and CFR CALATORI to perform the integration of the DPIS Application in Arad factory.
9.1.2.9. **DB**

DB cooperated actively in all activity fields. We organised a number of internal meetings, to evaluate which results and at what extent could be considered for our applications. The validation focused especially on the dynamic passenger information system, which is very interesting. The concept will be incorporated in future products, but this is seen not immediately, but in the medium term, in at least a few years.

9.1.2.10. **TRENITALIA**

Trenitalia considers the use of on-board networks a must and the work done into TrainCom put in evidence the strong request of integration between the systems either on-board or ground based. Considering the European scenario, the integration between the mobile environment (the trains) and the fixed one need to be pushed in a strong way. The Train Operators highlight the strong request of interoperability between devices and services offered. Such considerations need to be translated into proven standards and interoperability certification.

The participation of Trenitalia SpA to the Traincom project leads to incorporate some of the results into the specifications related to new projects. Related to the interoperability requirements at vehicle level, Trenitalia in partnership with manufactures is developing a Vehicle simulator for field interoperability test, the standard involved are the IEC61375 Train Communication Network and the leaflets UIC556 and 647. Other projects, into the field of communication systems and integrated services, are the new maintenance system called NDS (New Diagnostic System) of the high speed ETR500 fleet based on GPRS and WiFi radio link and the Diagnostic System and the Passenger Information System of the "Minuetto", the new EMU/DMU for regional services. The goal of these projects is to increase reliability and availability of the fleets and accelerating the entire maintenance process and making it more precise and organized.

9.1.2.11. **OEBB**

Activities focused on the interoperability of locos and driving trailers (AF5).

1) OEBB had the possibility to play a part in the works for the specification of the remote control system of locomotives. Furthermore we had the possibility to look what is the trend of remote control and how do it the others. Also the contacts to other persons working in that field are very valuable.

2) The main results regarding interoperability have to be adopted by the UIC leaflets 556 and 647. When these standards (especially 647) will be stable, it is expected that they will be implemented in the control system of OEBB’s vehicles.

9.1.2.12. **RENFSE**

RENFSE cooperated especially on results in AF2, AF4 and AF5. However we are interested on several aspects of the project:

- Specification of a TCN Conformance Test
- Specification of the Train-Ground Communication Infrastructure
- Specification of the Remote Monitoring and Maintenance System
- Prototype of the ROMAIN system
RENFE intentions: we will probably consider these specifications when we make new technical specifications (T.S.) for new rolling stocks.

- Specification of Remote Traction Control for Locomotive Interoperability
RENFE intentions: we are interested in remote traction control by radio rather than by cable.

9.1.2.13. **ALSTOM**

ALSTOM was involved in most activities. One of the main results was the FIP ROGATE communication platform, which showed interoperability with the other developed prototypes. This demonstrated how the TrainCom solution could solve compatibility problems between different on-board train busses. A real life validation of this concept is expected within the EuRoMain project demonstration phase.
10. Conclusions

The TrainCom project was able to reach all of its anticipated objectives, within the limits defined in the Technical Annex.

It represents a pilot example of cooperation between main railway industries, railway operators and other companies, including SME’s, on a common goal: define some missing parts in the railway system, test them and validate them as possible standardisation proposals.

The wide consensus achieved within the project, the interest of the railway undertakings (two of them joined the project as observer participants: SNCF and SBB), the progressive growth of the User Group (more than 600 on-line users from all over the world), the cooperation with standardisation bodies and railway organisations (IEC, CENELEC, IEEE, AEIF, UIC, TER), the success of the public events organised by the project are some of the indicators of the importance and value of the project.

In accord with such European objectives and scenario, TrainCom contributed to the following objectives:

- open and integrate the railway equipment market;
- favour the interoperability at train, vehicle and equipment level;
- reduce the life cycle cost of railway vehicles;
- improve services for citizens;
- allow new value added services;
- make railways more competitive (increase of market share);
- enhance attractiveness of the public transport;
- improve comfort of passengers;
- prepare the next generation of railway vehicles;
- integrate existing and new technologies;
- allow train fleet management based on remote diagnostics and maintenance.

The number of results achieved, some of which not initially envisaged, shows the effectiveness of the effort and funds spent in the project.

One more positive result is represented by the seeds for further research work, which resulted in new projects and proposals (e.g. EuRoMain, but also new projects in the Sixth Framework program, as ModTrain and the proposed integrated project InteGRail).

Finally, the positive human experience witnessed by all participants, who enjoyed the cooperation and the work together, is something which goes beyond figures and technical results and will leave something more in the heart and mind of each involved person.
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