FINAL REPORT

TR 1038, MORANE

MOBILE radio for RAilway Networks in Europe

SNCF - Project co-ordinator

TELEMATICS APPLICATIONS PROGRAMME
(TRANSPORT)

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Version number 1
Part I - Executive Summary
TR 1038 MORANE

MOBILE RAILWAY NETWORKS IN EUROPE

A RADIO BEARER SYSTEM TO MEET ALL THE NEEDS OF RAILWAYS USERS

The aim of MORANE is to specify, develop, test and validate prototypes of a new radio system, meeting the specifications defined by UIC and based on GSM technology, to meet the global requirements of railways including control and command. MORANE will use trial sites locations in France, Italy and Germany.

Setting the Scene

The decision was taken by the UIC in 1992 to select a new radio system for the railways based on a recognized European standards.

Several railways had to face the question of replacing old analogue radio equipment.

The new system had to be accepted by the community of railways, offer an cost-effective solution and provide a path for evolution and support of new value added services.

Phase two is addressing the requirements related to telecommunications railways aspects such as broadcast and group calls, fast call set up associated with priority and pre-emption mechanisms.

Phase one was dealing with the modification of the Public GSM system to meet the specific railways requirements related to operational railways aspects which are the addressing features (functional and location dependant addressing) and the handling of high priority calls.

Approach

A general approach to the problem has been taken, dividing it into two different phases.

The results are now being tested using three different trial sites. Each one of them includes a variety of configurations and several topological conditions. The trial site in France allows for testing at very high speeds up to 350 km/h.
Results and Achievements

It is yet too early to give the final project results. The MORANE detailed specifications, based on the UIC functional requirements set up by the European Integrated Railway radio Enhanced Network (EIRENE) project have been established. This included the definition of standards interfaces for subsystems.

The phase one features have been implemented and tested on the three trial sites.

In addition the different subsystems have been developed and tested, including the Mobile Switching Centre (MSC), the Base Station Controllers (BSC) and the Base Terminal Stations (BTS) for the network side.

The Mobile Stations include two different types:

- The cab radio with the Man Machine Interface
- The General Purpose Handheld which will be widely used as a hand portable by the railway users.

Interoperability between equipment from several suppliers has been tested.

Conclusions and Plans for the Future

The MORANE project allows to increase the technical as well as operational harmonisation between European Railways.

From the perspective of the Users, it improves the maintenance and spare parts aspects by the fact that the new system offers a single bearer system to support all railways needs.

It allows development of competitive products for the railway market.
Part II - Final Report
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1. **Setting the Scene**

European railways are major users of mobile radio systems. They use radio for a wide range of services, e.g. train-ground communication, maintenance, emergency situation, passenger information. The current systems are different throughout Europe, even within one country different frequencies and technologies are used for different applications. Most of the equipment is based on analogue technology and has exceeded their product life cycle.

Railways are facing the following questions:

- Which digital radio system should be used to replace ageing analogue radio systems currently in use?
- How to ensure the continuity of service and respecting the budgetary constraints of investment if new system will be implemented?
- How to guarantee future evolution of a new system?

In 1993 the UIC decided following a detailed technical and economical trade-off of digital technologies to base the new system on GSM (Global System for Mobile Communication). This should ensure that railways could participate on the evolution of the public standard and on the resulting economy of sales for the equipment.

The decision to choose an open standard had some drawback as not all specific requirements were covered by the GSM. Enhancements for special needs where needed which were detailed by the UIC project EIRENE.

The GSM system has to be modified to meet the following railways requirements:

- those arising from railway operational needs like special addressing facilities and post accident analysis of train communication.
- those related to telecommunications railways aspects such as broadcast and group calls, fast call set up associated with priority and pre-emption mechanisms.

In 1995 UIC decided to establish a project to set up tests of the new system.

The three railways SNCF, DB and FS set up the Consortium MORANE to conduct the trials. The overall aim of the project was to specify, develop test and validate the new GSM-R (GSM for Railways) system.

In particular the project intended:

- To provide specifications for the new functionalities, the interfaces and the system tests.
- To develop prototypes of the radio system (mobile and fixed part) and implement them
on 3 trial sites in Germany, France and Italy.

- To validate the prototypes with reference to the specifications and the user requirements.
- To investigate the performance of the existing GSM and the new GSM-R under railway specific conditions.
- To contribute on a high level to the standardisation for the future European Radio System for Railways.

In order to provide the specifications and the related prototypes major suppliers for GSM and for railway equipment where asked to join the project. It was decided to split the responsibilities with respect to the different subsystems which have been identified for the new system. Research companies have been included so that independent test definition and evaluation was ensured.

The final composition of the consortium is shown below.

<table>
<thead>
<tr>
<th>Partner</th>
<th>Key role</th>
<th>Country</th>
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<tbody>
<tr>
<td>SNCF</td>
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<td>Italy</td>
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</tbody>
</table>
2. **Approach**

2.1. **Project approach**

Some major decisions and achievements have already been reached prior to the project start:

- GSM has been chosen by the UIC as the basis for the next digital radio system for railways.
- An exhaustive capture of railways requirements has been performed within EIRENE and other former projects.
- A great amount of standardisation work within ETSI has been undertaken sponsored by the UIC concerning some telecommunications railways features: broadcast calls, group calls and fast call set up time.
- Technical concepts for developing specific railways features have already merged: they had been elaborated with the support of user representatives who take care that no deviation against requirements are made and of industries aiming at developing cost-effective solutions.

Referring to the work programme project life cycle, the MORANE project fits with the five phases model:

- The task of identifying user needs has been performed within the course of the study engaged by UIC in order to standardise the future radio system for railways,
- The EIRENE draft functional specification has been developed within UIC and was provided to MORANE for extensive review,
- prototypes were specified and built for specific railway features,
- prototypes were validated on industrial platforms as well as on real trial sites,
- presentation to users has been performed on real trial sites,

A first major achievement within the MORANE project was the elaboration of a Sub System Requirements Specification (SSRS) which contains the description of the functions to be developed and validated during the project.

This specification has served as a basis to elaborate the detailed design specifications in order to start the development activities for the MORANE phase 1 features, i.e. Functional Addressing, Location Dependent Addressing, Presentation of Functional Numbers and Confirmation of High Priority Calls.

In parallel to these design specifications, system and equipment validation documents have been elaborated to allow validation of the actual development results against the performance
expected by the users.

The basic assumption for the development work was the use of the standard GSM technology. The aim was to stay as close as possible within the standard evolution path of GSM in order to avoid specialised solutions for railways. The EIRENE project had already identified some basic telecommunication features which they have passed to ETSI for standardisation.

A further assumption for the specifications and developments for the MORANE prototypes was to base them on standard services already defined in GSM or on enhancements which could become open European Standards.

The infrastructure for trial sites was equipped first with GSM 2 standard equipment.

The work to be performed on these trial sites was:

- to evaluate the ability of the GSM system to operate in a railway environment,
- to enhance this GSM system in order to meet the railways' user needs,
- to validate and demonstrate to a large set of users the capability of the enhanced system to answer to specific private mobile radio needs.

The enhancements of the GSM system would be made on standard equipment provided by the suppliers of the consortium.

### 2.2. Validation and Evaluation

#### 2.2.1. Validation on Trial Sites

Demonstrators have been set up on three trial sites (in Germany, France and Italy), with different topographical features. GSM equipment has been gradually upgraded with hardware and software packages from different industrial origins and developed on the basis of the detailed equipment specifications in order to meet the railway specific requirements.

The MORANE trial sites are installed on line sections to offer a good accessibility to tests and to trial participants. The MORANE trial sites offer particular and complementary characteristics which allow to carry out a full validation.

- Tests at high speed can be performed. Especially, on the French trial site, a speed up to 350 km/h can be achieved.
- Comparative analysis on radio coverage in tunnels was possible on DB and FS lines, where tunnels differ in some important criteria like tunnel profiles, surface...
roughness/smoothness and lengths; the tracks selected on these lines present an high percentage of route running inside tunnels equipped using different technologies (antennas, leaky cables).

- The crossing of a significant urban railway junction (Firenze) could be well studied on FS track and allows to analyse the radio propagation and to solve problems of cellular engineering in urban areas.

- The three trial sites distributed over Europe allow interworking tests of the GSM for Railways.

2.2.1.1. France

The trial site of about 87 km long is composed of two contiguous sections located on the following lines:

- High speed line, from Marne la Vallée station to Vemars named « Barreau Est » of Paris, 32 km long,
- High speed line from Vemars to Antheuil-Portes, part of LGV Nord, 55 km long.

The maximum speed available will be 350 km/h between Vemars and Antheuil-Portes. The site is providing a wide range of geographical and topographical conditions such as : tunnels, cuttings, stations, major junctions. The site can be directly accessed by motorway, metro and airport.

2.2.1.2. Italy

The trial site of about 78 km long is composed of a section of the railway line : Bologna-Firenze- Roma.

The maximum speed available is 250 km/h.

The site is providing a wide range of geographical and topographical conditions such as : tunnels (19), cuttings, stations, major junctions. The site can be directly accessed by motorway, train and airport.

2.2.1.3. Germany

The trial site proposed for the MORANE trials is part of the high speed line Stuttgart-Mannheim. A section of about 60 km between Stuttgart and Bruchsal is the trial site of the previous German programme. It has been made available for the MORANE trials. An appended section of 44 km up to Mannheim was equipped in order to have a whole site of
about 100 km long.

The maximum speed available is 280 km/h.

The site is providing a wide range of geographical and topographical conditions such as: tunnels, cuttings, stations, major junctions. The site can be directly accessed by motorway, train and airport.

2.2.1.4. Co-ordination between the trial sites

In order to ensure a parallel evolution on all three trial sites a team has been established to co-ordinate the activities. It is composed of the following:

- MORANE Project Manager
- The Technical Group Leaders of MORANE
- The National Site Project Leaders (NSPL) of FS, DB and SNCF.

The global orientation is given by the Project Management Team and applied in the day-to-day management by the NSPLs. The NSPLs are reporting to the Project Management Team on trial site installation progress during an ad-hoc progress meeting. The testing and validation activities are defined in the meeting. The exchange of experience is a major objective for this organisation.

2.2.1.5. Users involved in the Validation

A Validation and Integration Team (VIT) is in charge to perform the tests concerning the integration and the validation of MORANE configuration items. This team is composed of MORANE railways users, the industry partners responsible of their configuration items and the research centres.

VIT is in charge:

- To validate the SSRS,
- To perform the integration tests of the MORANE system,
- To perform the validation tests of the MORANE system.
2.2.1.6. Evaluation criteria

Three main objectives have been chosen for the evaluation of the prototypes implemented on the demonstrators:

1. Testing the operation of the system
2. User Acceptance on platform and on demonstrators
3. Performance of the system

The system operation is validated against the test specifications of the developed feature. The user acceptance is against the user requirements as defined in the related EIRENE documents. Performance measurements have to be compared with the expected quality of service.

2.2.2. Other forms of Evaluation and Validation

2.2.2.1. Peer Review

Each deliverable of the list established between the DG XIII Technical Officer and the MORANE Project Manager, is evaluated by a peer review group, composed of two or three experts who are in charge to give comments and suggestions, so as to guarantee a good quality level of the deliverable and foresee eventual improvements. In order to ensure the confidentiality towards the usage of the deliverable to be reviewed confidentiality agreement has been filled and signed. The peer review is done according to the model prepared and concerns mainly the following aspects:

- Ability of the deliverable to meet the users needs,
- Conformance to the different objectives,
- Conformance to the project quality procedures,
- Quality of the technical work,
- Presentation of the existing achievements and results,
- Quality of the deliverable.

After collecting all the peer review sheets from the different peer reviewers, MORANE PMT prepares a global Peer Review Report which includes a foreword regarding the deliverable (scope, contents, abstract, summary of the work done), the peer review sheets of each reviewer and a global statement summarising the results, the actions taken as required and the final evaluation of the deliverable.

The collection of peer review reports concerning the MORANE deliverables contain globally good comments and some ideas in order to improve mainly the presentation format of the deliverable. Some extra requests of links between the deliverables is sometimes requested.
2.2.2.2. **Feedback from external sources**

The project MORANE has been presented on several conferences during the past years:

- TTCM4 Conference in Brussels, March 1997
- AIC Conference in London, May 1997
- European Rail Technology Conference, July 1997
- EUROFORUM Paris, September 1997
- World Congress Rail Research in Florence, November 1997
- ITS Conference in Berlin, December 1997
- Barcelona Telematics Application Programme seminar and exhibition in February 1998,
- UIC conference in Tokyo in April 1998,
- AIC conference on GSM-R in May 1998,

Two Seminars have been organised. One on the 14th & 15th October 1997, where the first MORANE solutions and results have been presented to a large set of users and to industry. Also EIRENE & ERTMS have presented their work status.

The second one was held at 25th & 26th November 1998 at the UIC in Paris, where the MORANE newest solutions and results have been presented via different stands and also real time demonstrations. The growing number of participants reflects also the increasing interest in the work performed by MORANE.

MORANE has contributed to the Eirene newsletter, a quarterly dissemination material issued by the UIC. MORANE partners are promoting the results and developments achieved in the project in their commercial brochures.

A MORANE web page have been established (http://recherche.sncf.fr/morane/index.htm) and links have been set up to the official UIC EIRENE web page (http://www.eirene-uic.org/eirene) where also information about the first implementations are available.

MORANE has contributed to the elaboration of a video named “trains without frontiers” describing the unified ERTMS/ETCS Train Control System using GSM-R.

A CD ROM has been produced with EIRENE. It contains the present versions of the available specifications. The CD ROM was distributed at the above mentioned UIC conference in November 1998.
2.2.2.3. **Collaboration with other projects**

MORANE is a European consortium composed by 21 partners coming from 8 different countries. Amongst the partners the main difference is the business area:

- Railways: representing the users of the new system
- Industries (large and medium size): aiming to deliver equipment
- Research centres: independent scientific institutes

All the partners contribute with their own specificity in order to achieve the aims of the project.

It has also to be considered that the MORANE project was too big to be funded only by one contract. Several contracts with the EU are therefore covering the funding of the project. Funds are coming from the 4th R&D programme (Telematics and Transport) and from the TEN-T funds. The MORANE project is part of the ERTMS (European Rail Traffic Management System) project.

This means that this project requested more efforts in management than other projects. One aspect is the splitting of the activities to be covered by the DG XIII contract amongst the different partners.

This experience, which after 39 months can be considered very positive, gives to all the partners an added value in terms, first of all of relationships, but also in terms of performed results.

In a wider context than the MORANE consortium, positive results have been achieved in the frame of the external activities (supports and events). Concertation meetings have been organised in order to exchange viewpoints and information amongst projects of the same area (rail sector). The Area Report contains several of the results obtained. More generally the TAP conferences have been occasions to show to the Telematics world some of the achievements of MORANE.
3. **Results and Achievements**

The overall aim of MORANE is to specify, develop, test and validate prototypes of a new radio system, meeting the EIRENE specifications defined by UIC and based on GSM technology, to meet the global requirements of railways including control and command.

In particular the project intended:

- To provide specifications for the new functionalities, the interfaces and prototypes.
- To develop prototypes of the radio system (mobile and fixed part) and implement them on 3 trial sites in Germany, France and Italy.
- To validate the prototypes with reference to the specifications and the user requirements.
- To investigate the performance of the existing GSM and the new GSM-R under railway specific conditions.
- To contribute on a high level to the standardisation for the future European Radio System for Railways.

3.1. **Specifications for the new functionalities**

A first achievement reached within the MORANE project is the specification of the new system, in particular the elaboration of a Sub System Requirements Specification (SSRS). The SSRS contains the description of the functions related to railway operational needs to be developed and validated during the project.

This specification has served as a basis to elaborate the detailed design specifications in order to start the development activities for the MORANE phase 1 features i.e. Functional Addressing, Location Dependent Addressing, Presentation of Functional Numbers and Confirmation of High Priority Calls.

The following solutions have been identified and specified:

- **Addressing schemes** corresponding to the use of functional numbers, such as train running number, instead of Public Land Mobile Network (PLMN) numbers.

- **Dynamic translation** from functional numbers to PLMN numbers should be performed within the GSM-Railway network. Functional addressing, is done using a combination of two GSM supplementary services called Call Forwarding Unconditional (CFU) and Unstructured Supplementary Service Data (USSD).

- **Location dependant addressing** uses Short Code and Cell Information (location area
code and Cell Identifier) for Cell-specific routing implemented at the switching level, allowing the transformation of short codes into ISDN numbers to address the appropriate controllers in charge of this area. These addressing functions rely on a common numbering plan for all the European railway networks proposed by MORANE.

- Train-to-ground protocol (i.e. transfer of information between train and fixed network equipment without user action).

- Confirmation of High Priority Calls: For operational reasons, railways should store mobile confirmation to high priority calls sent by the network. The storage takes place in a so-called acknowledgement centre. The information is routed to this equipment through the fixed network interfacing at the MSC premises. This function is realised with the support of GSM User-To-User Signalling (UUS 1) supplementary service.

- The Presentation of functional numbers ensures a visual information about the destination to the calling subscriber and about the originator to the called subscriber. The functional numbers have to be interpreted by the MMI applications of called and calling parties and the appropriate information displayed. For normal calls in the GSM-R network, trains and controllers may be called by using functional numbers instead of real MSISDN numbers. These functional numbers might be activated by the Follow-Me service. These functional numbers have to be included in a standard GSM transport mechanism that support a transparent end-to-end information transfer. This is realised by using UUS1.

The MORANE project has issued Form Fit Functional Specifications (FFFS) and the Functional Interface Specifications (FIS) for the above described railway features.

3.2. Development of prototypes

The development of prototypes has been performed on software modules and hardware modules.

The four features have been implemented on the mobile side, i.e. on the Mobile Station MS and on the network side, i.e. on the MSC and HLR equipment of the Network switching sub-system.

The full functionality has been achieved in several development steps.

- Presentation of functional numbers and confirmation of high priority calls
These features are supported by the UUS1 supplementary service. The development of the UUS1 in the direction mobile to fixed network has been completed end of August 1997. The development of the UUS1 in the direction fixed to mobile network has been completed end of January 1998.

- Functional addressing

The feature for its use inside a single GSM-R network has been completed end of August 1997. The development of the feature allowing functional addressing between two GSM-R networks has been completed in November 1998. The sub-addressing function development, as part of the functional addressing has been completed in February 1998.

- Location dependent addressing

This feature has been completed end of August 1997.

- MMI prototype

In 1997, a driver MMI simulator has been developed and implemented on a Personal Computer. This simulator was based on the driver MMI specification. The specification was elaborated in close relationship with users under the DGVII contract.

The specification was updated in 1998 in order to take into account the different states of the mobile (idle mode, connected mode). Then, the simulator has been reviewed by the MORANE railways users and is now completed and ready to be demonstrated broadly to users.

The driver MMI software and hardware have been developed and the integration with the EIRENE Mobile Station has started in February 1999.

- General purpose handheld prototype

The development of the general purpose radio handheld has been performed by SAGEM based on the platform of a public GSM mobile. The frequency adaptation and the implementation of the addressing schemes and the train-to-ground protocol have been finalised by AMC and then by SAGEM.
3.3. Validation and Acceptance of Prototypes

In parallel to the elaboration of specifications and the development of prototype equipment, the system and equipment validation documents have been elaborated to validate the actual development results against the specifications and the requirements of the users.

A system validation test handbook was issued for each version of the MORANE prototype. The demonstrators have been validated against the system validation test handbook on industrial platform by the VIT team, including MORANE railways users. After the successful acceptance each new version has been implemented on the demonstrators on trial site.

The validation was performed in three phases as following:

For the system version 1, the following MORANE phase 1 features were implemented: Functional Addressing (except follow-me interrogation), Location Dependent Addressing and Presentation of Functional Numbers (Mobile to fixed network).

- The network configuration items of the MORANE system version 1.0 are:
  - SIEMENS NSS version 5.0,
  - AMC Mobile Station version 1.0,
  - KAPSCH Mobile Station version 1.0.

For the system version 2, the following MORANE phase 1 features were implemented: Functional Addressing (except MSC - MSC communication), Location Dependent Addressing, Presentation of Functional Numbers and Confirmation of High Priority Calls.

- The network configuration items of this MORANE system version 2.0 are:
  - Siemens Transportation Acknowledgement Centre version 1.0
  - SIEMENS NSS Version 6.0,
  - AMC Mobile Station Version 2.0,
  - KAPSCH Mobile Station Version 2.0.

For the system version 3, the following MORANE phase 1 features were implemented: Functional Addressing (including MSC - MSC communication, i.e. network interworking), Location Dependent Addressing, Presentation of Functional Numbers and Confirmation of High Priority Calls.

- The network configuration items of this MORANE system version 3.0 are:
• Siemens Transportation Acknowledgement Centre version 1.0
• SIEMENS NSS Version 7.0,
• KAPSCH Mobile Station Version 2.0.

The prototype development acceptance for all features was completed.

3.4. **Performance Measurements**

The performances of the GSM-R system installed on the three trial sites have been verified for the following end-to-end parameters:

- Call set-up time,
- End-to-end transmission time,
- Byte error rate.

Then, the performances of the GSM-R system with the MORANE phase 1 features have been tested for the following parameters:

- Call set-up with functional addressing,
- Call set-up with location dependent addressing,
- Call success rate.

These performances tests had as a main objective to verify the GSM-R system compliance with the railways requirements objectives defined within the EIRENE Project.
3.4.1. Performance results on a standard GSM-R communication platform

Voice and Data services have been investigated.

- As far as call set-up times are concerned, the EIRENE objectives are met for Mobile Originated Calls on the three trial sites. They are not met for the 95 % of calls value in case of Mobile Terminated Calls.

<table>
<thead>
<tr>
<th>Number of samples</th>
<th>MOC 95%</th>
<th>MOC 100%</th>
<th>Number of samples</th>
<th>MTC 95%</th>
<th>MTC 100%</th>
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<td>1739</td>
<td>≤ 3.3s</td>
<td>≤ 5.5s</td>
<td>1782</td>
<td>≤ 5.8s</td>
<td>≤ 7.2s</td>
</tr>
</tbody>
</table>

EIRENE requirements for non-emergency Mobile Originated Calls (MOC) and Mobile Terminated Calls (MTC)

- The handover signalling time measured on SNCF and on FS trial sites gives 95 % of results lower than 425 ms. This value is in the range of the proposed EIRENE requirements.

- The end-to-end transmission delay results for voice and analogue data transmission are below the reference value stated by the GSM recommendations. The results for ISDN data transmission are above the reference value on the three trial sites. Since the reference value represents only the delay due to the GSM network, it does not include the delay between the interworking functions in the MS and the user terminal on the fixed side.

- Concerning handover break duration for data transmission, it has been observed that the handover break is always shorter in uplink (170-400 ms) than in downlink (500-700 ms). Moreover, it has been noticed that differences exist between BSS suppliers.

- For Byte Error Rates, the values obtained are between $10^{-6}$ (analogue 9.6 uplink) and $6.6 \times 10^{-4}$ (ISDN 9.6 downlink).
3.4.2. Performance results of the GSM-R system with the use of MORANE phase 1 features

- Call set-up times have been measured with the use of functional addressing and location dependent addressing. The results obtained are in the same range as those obtained for the standard GSM-R communication.

- Call Success Rates have been measured for data connections on standard GSM-R on SNCF trial site and the value is greater or equal to 98.9%. They have also been measured in the context of the use of functional addressing where the value is greater than 97% and in the context of the use of location dependent addressing where the value is greater than 90% (average values for SNCF and FS trial sites).

The main conclusions which have been drawn from the end-to-end performance measurements are:

- The speed has no significant impact on the end-to-end voice and data performances. The values for call set-up times, handover times and transmission delay do not differ significantly for speed between 80km/h and 300 km/h.

- The implementation of the railway specific features concerning the addressing schemes have no significant impact on the system performance. The enhanced GSM-R system has the same behaviour as the standard GSM system in terms of set-up times.

- The call success rate and the handover break length in terms of interruption of data communication is highly dependent on the radio network planning and the optimisation of the network.

3.4.3. EMC measurements

In order to characterise the EMC environment and the disturbances produced by the sparks created between the pantograph of the engine and the catenary, different series of tests have been carried out.

These EMC tests were carried out on several different TGV lines on board the SNCF measurement coach called Melusine as well as on the German MORANE trial site.

These EMC measurements highlight that the increase of speed and power of high speed trains leads to higher levels of the transients induced on a GSM antenna placed in the vicinity of the pantograph. The statistical analysis performed in the time domain shows a good coherence between the results recorded on the different TGV train runs.
As the waveforms are now well identified, the characteristics presented in the two reports concerning the EMC measurements can be used to define a suitable test procedure to check the influence of such disturbances on the GSM-R system.

### 3.5. Standardisation for the future European Radio System for Railways

MORANE has contributed to high level standardisation processes within ETSI for Advanced Speech Call Items and within EIRENE for the specific railway functions.

The detailed specifications elaborated for the railway specific features, i.e. the MORANE FFFIS and FIS documents, will be incorporated in the future CENELEC standard for the radio part of the European Rail Traffic Management System (ERTMS). This standard will be part of the Technical Specifications for Interoperability (TSI) for the High Speed Rail Network in Europe.

Some elements inside the specifications have been forwarded to the ETSI in order to become part of the public GSM standard. MORANE also contributed to the further enhancements of the Advanced Speech Communication Items (ASCI) in ETSI, that were defined on request of the UIC. The elaboration of design specifications for ASCI with a focus on the development and implementation for the demonstrators lead to significant enhancements on the standards.

By carrying out the prototype development and trials to validate the emerging European standard for railway radio, the project supported the European policy objective of improved technical harmonisation in the railway community.

#### 3.5.1. Use of the trial sites

The users, i.e. the railways involved in the project, had the opportunity to experience the operation of a new communication system and the evolution of new features in this system while the specification and development were ongoing. This procedure ensured a close cooperation between users and industry during the whole product development phase.

The experience gained during the set-up of the demonstrators has been shared between Railways and also industry and research in common workshops. They focussed on the radio behaviour and the performance of the GSM-R system. Common guidelines for radio network optimisation have been elaborated for the railway specific environment as well as common settings for the network implementation.

The issue of a technology implementation plan shows how European railways will use the results of the MORANE project.
3.5.2. Achievements of partners

The software and hardware developments performed in the project have been integrated in the standard software releases of the suppliers for GSM equipment. These products are available on the market and can be offered to railways and further customers, like public operators or Private Mobile Radio (PMR) users.

First contracts with railways in Europe have already been launched including all the features developed and validated in the MORANE project.

In fact, the open standard developed provide a European market for railway radio systems which has the effect of increasing supplier access to an European-wide instead of Nation-wide markets and of increasing supplier competitiveness. Moreover, the GSM-R is an interoperable system in a sense that a mobile equipment abroad the train of one railway could operate on a GSM-R network of another railway.

4. Conclusions and future plans

The GSM standard chosen for the replacement of the existing analogue systems has been enhanced with respect to the user requirements and has been validated against functional and performance requirements. The prototypes developed and tested on the three trial sites are covering the requirements.

The GSM-R system developed and validated by MORANE will become the European standard for the next generation of railway radio systems, thus allowing GSM-R radio equipment on different railway networks to be interoperable. This capability will improve the operational effectiveness for international train services and will bring particular benefits in the increasing integration of the European train network, while widening the market and increasing suppliers competitiveness, to the benefit of the railway operators. GSM-R systems will improve the effectiveness, efficiency and overall safety levels of railway network operations. In particular, they will provide the radio communications bearer for ERTMS through which even greater economic, environmental and social benefits can be gained. Railway operators will be able to offer value-added services on trains and improve passenger services.

The exploitation aspects foreseen for the different partners could be summarised as follows:

- Product development and sale for GSM-R equipment (NSS, BSS, Mobile Station, Antennas, repeaters and leaky feeders, driver and dispatcher MMIs) for SIEMENS AG, SIEMENS Transportation Systems Limited, ITALTEL, NORTEL, KAPSC, SAGEM, ALSTOM, DAPA, SIRTI
• Implementation, optimisation and validation of GSM-R networks for SNCF, DB, FS, BV, RENFE, DNRA, RACAL TELECOM

• Technical and economical support to the deployment of GSM-R networks for INRETS, ISSEP and MARCONI

A new competitive radio product to sell to railways in Europe has been developed which is also interesting for public operators. The suppliers for GSM equipment in the MORANE project expect that mainly the ASCI features as well as addressing schemes could attract potential customers in the field of Private Mobile Radio.

Some of the European railway operators have already decided to implement GSM-R as bearer service for their radio communication needs.

The following table summarizes the national implementation projects in progress:

<table>
<thead>
<tr>
<th>Railway</th>
<th>Implementation activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV Sweden</td>
<td>8,000 km of route</td>
</tr>
<tr>
<td>DB Germany</td>
<td>30,000 km of route</td>
</tr>
<tr>
<td>FS Italy</td>
<td>250 km of route</td>
</tr>
<tr>
<td>NS Holland</td>
<td>3,000 km of route</td>
</tr>
<tr>
<td>Railtrack UK</td>
<td>1,000 km of route</td>
</tr>
<tr>
<td>SBB Switzerland</td>
<td>Pilot line</td>
</tr>
</tbody>
</table>

Also, some railways outside Europe have stated their intention to implement ERTMS which will include a GSM-R system.

Thirty-two railways have already signed a Memorandum of Understanding declaring a unified aim to introduce GSM-R as quickly as possible and to co-operate for its wide application.
5. **Contact details**

Project Consortium

<table>
<thead>
<tr>
<th>Contact address for the Project:</th>
<th></th>
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<tbody>
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</tr>
</tbody>
</table>

6. **Appendixes**

   **Appendix A - MORANE deliverables**

   **Appendix B - Information dissemination materials**
APPENDIX A

DOCUMENTS DELIVERED

D1.1 Project management plan
D2.1 External liaisons report
D2.2 Validation plan
D2.3 Presentation report
D2.4 System architecture
D3.1 Test results and analysis report
D4.2 Report on the train-ground protocol
D5.3 MORANE system test handbook (MORANE system version 1.0 & 2.0)
D6.1 System acceptance reports MORANE system version 1.0 & 2.0
D7.2 Driver MMI simulator
D8.1 Performance test reports on the 3 trial sites
D8.2 Global summary of performance results
D9.1 Technology implementation plan
D10.1 Broadcast & group call detailed specification
D11.1 General purpose radio handheld development status
D12.1 Performance test specification

PROTOTYPES

D4.1 Ground-train protocol prototype
D5.1 Functional addressing scheme prototype at NSS level
D5.2 Location dependent addressing scheme prototype
D7.1 Driver MMI prototype
APPENDIX B

SASIB    Simulation software of the driver MMI
SIEMENS  GSM-R – The European Railway Communication System
NORTEL NETWORKS   GSM-R – your ticket to enhanced railway communications
KAPSCH   GSM-R Grenzenlose Kommunikation für Bahnen
UIC CD-ROM  EIRENE/ETCS – Railway signalling and Communication systems for the 21st Century
UIC Video   Trains without frontiers
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Further information on the TELEMATICS APPLICATIONS Programme:
You can obtain more information on the projects of the TELEMATICS APPLICATIONS Programme from:

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