OPTIRAILS: A rail traffic management system to optimise European traffic

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Abstract

International trains, in particular freight trains, spend too much time waiting for resources or for administrative tasks (customs clearance, for instance); this is particularly true in case of perturbations and train delays. To improve international rail traffic performance and reliability, train traffic should be managed comprehensively, from origin to destination.

The OPTIRAILS projects (financed by EC under the 4th and 5th EU/Framework programs, and by the project partners themselves, and supported by the UIC) aim to develop European-wide supervisory management, to control international traffic in coordination with existing national traffic management. This new corridor-oriented European supervisory layer will:
- collect and distribute information on international trains and on the network status,
- help train rescheduling or rerouting, in case of perturbation,
- sustain negotiation between infrastructure managers (and eventually train operators) in order to optimise corridor-wide traffic management.

The paper presents the OPTIRAILS rail traffic management concept. It then focuses on the different strategic options and the expected improvements for the international rail traffic.
1 Introduction

International trains, in particular freight trains, spend too much time waiting for resources or for administrative tasks (customs clearance, for instance). To improve international rail traffic performance and reliability, train traffic should be managed comprehensively, from origin to destination.

The main aim of the OPTIRAILS project (OPTImisation of traffic through the European RAIL traffic management Systems) is to specify a prospective rail traffic management system, within the ERTMS (European Rail Traffic Management System) framework, which will be applicable to international railway corridors, mainly intending to improve real-time train dispatching and route planning, as well as information for both the customers and the operating staff.

2 OPTIRAILS projects

The existing ERTMS project (ETCS, GSM-R, etc.) focuses mainly on security and technology issues. The "traffic management" layer is missing at the present time for making the ERTMS project a complete European rail traffic management system. Within this perspective there was need to identify functional and technical facilities for a pan-European rail traffic management system.

The OPTIRAILS projects (financed by the EU under the 4th and 5th EU/Framework programs, and by the project partners themselves, and supported by the UIC) were intended to design European-wide supervisory management, to control international traffic in coordination with existing national traffic management.

Two successive European projects aimed at this purpose.

2.1 OPTIRAILS I

The OPTIRAILS I (OPTImisation of traffic through the European RAIL traffic management Systems) research project has been assigned to the OPTIRAILS I Consortium by EC-DG VII under the 4th RTD programme. The OPTIRAILS I Consortium partners were: SYSTRA (F), AEATR (GB), ITALFERR (I), TRADEMCO (GR), TIFSA (E), HB (D), SNCF (F), FS (I), RENFE (E), ITEP-EPFL (CH), CSEE (F), INRETS (F), SOFREAVIA (F), SCANRAIL (DK)

This project particularly focuses on the definition of traffic management tools based on the existing and foreseeable ERTMS design. Co-operation with other European R&D projects sponsored by the EU such as: LIBERAIL, EUFRANET, MORANE, EUROPE-TRIS, EUROPE-TRIP has been undertaken so as to establish a collaborative European framework. Co-operation with projects sponsored by UIC such as the EIRENE project has also been established.

The principal results of the project are:
A review of the existing status of ERTMS, ETCS, GSM-R projects in Europe mainly as regards the particular experience already gained in France, Germany, Italy, Spain, and on some other countries [1-4].

An in-depth analysis of methods and tools available in the field of the rail traffic dispatching, a comparison with the air and road transport management systems, and a survey of potential implementation cases in Europe [5-7].

Functional requirements of traffic management and a pre-feasibility study of the project [8].

A project design of traffic management tools leading to their Functional Requirement Specifications (FRS) completed with a cost-benefit analysis of the project [9-12].

A dissemination of the project results, and recommendations through circulation of documents and organisation of seminars.

2.2 OPTIRAILS II

The OPTIRAILS II research project is the continuation of the OPTIRAILS I. It has been assigned to the OPTIRAILS II Consortium by EU-DG VII under the 5th RTD programme. The OPTIRAILS II Consortium partners are: SYSTRA (F), TRADEXCO (GR), TIFSA (E), SNCF (F), FS (I), RENFE (E), EPFL (CH), CSEE-Transport (F), NEI (N), VTT (FI), TRANSURB (B), SWEDERAIL (SW), STERIA (F), HALCROW (GB), ATKINS (DK), SBB (CH).

The OPTIRAILS II project main aim is to go further into the specification of the system. In particular, the following issues are addressed:

- Completion and consolidation of the Functional Requirement Specifications for the core traffic management system.
- Completion and consolidation of the Functional Requirement Specifications for the sub-systems and interfaces.
- Drafting of System Requirement Specifications for the core traffic management system.
- Drafting of System Requirement Specifications for sub-systems and interfaces.
- Dissemination of relevant information related to non-confidential results and project issues.
- Working out of a functional demonstrator illustrating the OPTIRAILS concepts.

3 OPTIRAILS concepts

3.1 Underlying principles

The need of a complete European rail traffic management system is obvious when considering the poor performance of current international rail traffic. The development of such a system is however a real challenge, taking into account the numerous and huge technical and political constraints.
OPTIRAILS is a real-time management system. Its aim is not timetable or operation planning, but the almost-real-time management of every day incidents during the running of the international trains.

In fact, most railway networks have already developed their own traffic management systems and are able to manage traffic operation in their own part of the international corridors. The difficulty occurs with international trains and the lack of information between Infrastructure Managers. On the one hand, IMs do not know in advance how the international trains are running in the upstream networks (are they on time, late or in advance) and when to expect them to arrive at the border. On the other hand, once a train is running in one network, the IM processes it in the better way for his own traffic operation, without taking into account the needs or constraints in the downstream network.

Another difficulty arises with the OPTIRAILS system acceptability. Actually, railway networks are in the best position to deal with problems occurring in their own network. Not only they have information on all the local and international trains as well as on the network, but they also have every day experience of the network operation. Furthermore, they will accept with difficulty orders or advice from an international higher system. On the other hand, it would be unacceptable to replace a local system, whose development had always been very expensive. Therefore, whenever a perturbation rises in one network, OPTIRAILS will deal with problems induced in subsequent networks, while letting the national systems resolving internal problems. OPTIRAILS will cope with short- to medium-term decisions (taken between the train departure from its origin and its arrival at destination). Besides, the OPTIRAILS system must not interfere with the national systems, only picking up the necessary information by means of an interface, adapted to each local system.

The different management systems today are not at the same development level in the different countries and their capabilities vary. These systems also change according to the technological development and the needs of the different IMs. A high level management system like OPTIRAILS must be able to evolve along with the development of the national systems.

In order to improve railway service quality for international trains, the OPTIRAILS system must be available as soon as possible. The beginning of the implementation is considered within 5 years.

3.2 General concepts

Taking into consideration the constraints above, the new corridor-oriented European supervisory layer must be a high-level traffic management system, which is concerned by international trains, from their origin to their destination. It is a traffic management system, which does not impact the safety. It does not interfere with the existing national or regional dispatching centres. It is evolutionary according to

- collect and distribute information on international trains and on the network status,
- help train rescheduling or rerouting, in case of perturbation,
- sustain negotiation between infrastructure managers (and possibly train operators) in order to optimise corridor-wide traffic management.

The basic information that OPTIRAILS has to collect is the timetables and the train locations. It is possible to deduce train delays from these pieces of information, but to complete its knowledge OPTIRAILS should also be able to collect the causes of delay. Train composition and corridor status are also important to better understand and predict the running of the trains. When trains are late, it is crucial to plan actions, in order to prevent delays increase and/or propagation. For decision making, good predictions of arrival time at the border or in important locations are essential. As OPTIRAILS only deals with international trains on the corridor, it has not the full information needed to provide reliable forecasts. The different IMs, with information on all the trains and complete knowledge of their network, are in a better position to provide trustworthy predictions. Running time predictions, on the other hand, are also important data to be collected and managed in the OPTIRAILS system.

Figure 1: OPTIRAILS general structure.

Four different strategic options have been considered to implement a supervisory management centre, going from the most elementary to the most complex and comprehensive solution:
- Option 1: Data monitoring to provide offline reporting.
- Option 2: Online centralised information collection and supply.
- Option 3/4: Negotiated train-path assembly.
- Option 5/6: Problem detection / problem solution.

The options are structured so that each option is included in the later one, and therefore the functionality of one option is contained in the later ones. Each option brings new functionality as compared to the previous one, and may also need refinement of the data of the preceding option. For example, options up to 3/4 only deal with international trains' data. However, problem detection and resolution provided in option 5/6 require information for all the corridor trains, international and domestic. Data acquisition functions implemented in options 3/4 should thus be enhanced to implement option 5/6.

The next sections will describe more precisely the different OPTIRAILS options.

Figure 2: OPTIRAILS options.

3.3 Option 1: Collecting data and monitoring for performances

OPTIRAILS Option 1 is the lowest and the simplest level of OPTIRAILS, which only delivers off-line reports.

3.3.1 Concept
OPTIRAILS, at option 1, collects all the basic information, which is also necessary for the upper options. This information includes all information directly concerning the running of international trains: long term planned timetable, updated timetable till train departure, real running of the trains, with delays and their causes, and IMs forecasts during train journey. It also includes information on the real train composition and on the corridor status.

This information is then analysed off-line, in order to produce periodic reports.
3.3.2 Foreseen advantages
The analysis of the collected data allows detecting the parts of the corridor where problems occur the most frequently and the causes of perturbation: capacity bottleneck, lack of resources (engines, drivers, crew, etc.), timetable problems (clients unable to provide goods in time, ...).

On the basis of these results, it would be possible to give advice to improve future quality of service.

3.4 Option 2: Centralised information

At option 2, OPTIRAILS can provide users with real-time information on the running of the trains.

3.4.1 Concept
The aim of this option is to improve the effectiveness and efficiency of international trains running on the corridor through information sharing. In particular, it will provide users with up to date information concerning the real-time running of the international trains along the corridor and the status of the corridor.

Information about timetables is collected before train departure. Information on the running of the trains and, in case of delays, on the forecasts made by the IMs (Infrastructure Managers) is collected in real-time; the causes of train delays are collected whenever possible, so as the status of the corridor (capacity restriction, possession, incidents, etc.).

At any moment, OPTIRAILS users may ask for information on the traffic operation (train locations, delays, forecasts, train composition, etc.). If OPTIRAILS does not have the required information, it will attempt to obtain it from the corresponding IM.

The main improvement compared to option 1 is that the information is collected and dispatched in real-time. OPTIRAILS users may ask at any moment for information concerning their trains, while OPTIRAILS always ensure data confidentiality.

3.4.2 Foreseen advantages
Due to centralised information, OPTIRAILS users are informed earlier and in a more accurate way about the real operation along the corridor. This information allows them to take better decisions in order to improve the operation on their own network. Accurate forecasts of arrival time at the border also let reduce waiting time for international trains by preparing on time the necessary resources. Further on, this makes it possible to better use resources by making them available only where and when they are needed.

Accurate and continuous information cannot only contribute to limit delays, but also to inform the final client (passengers, train operator companies, ...) of the expected arrival time, improving the service quality.
3.5 Option 3/4: Path assembly and solutions from negotiations

The main function of OPTIRAILS Option 3/4, when a problem occurs, is to help find a negotiated solution between the IMs involved along the corridor.

3.5.1 Concept
If the planned path of a train becomes unavailable or is not suitable anymore, for example if resources are not available, it is necessary to find a new path for the train. A consensus between OPTIRAILS partners on a new path must be found. It is essential to agree on an optimum path from a corridor point of view. However, the corridor optimum path is not always the best solution for each individual IM, hence the need of negotiation and trade offs.

In option 3/4, OPTIRAILS plays the role of a facilitator during the negotiation. It has neither the full information and nor the necessary tools to calculate and propose a solution. Its role is to collect the new paths proposed by the different IMs, to assemble them together into a corridor-wide path and to verify its feasibility and its suitability. If the new path is not feasible (because, for instance, buffer times at borders are not sufficient, or not suitable, or the new arrival time at destination is later than the contracted delivery time), OPTIRAILS plays the role of a facilitator during a negotiation between partners to try to find a more appropriate new path.

3.5.2 Foreseen advantages
With information on planned path along the corridor and on the real-time running of international trains, OPTIRAILS can check, at every moment, if the planned path is still suitable or feasible. In fact, when a train is late, OPTIRAILS can verify, on the basis of the forecasts sent by IMs, if the buffer times at borders or in important points (stations) are sufficient to allow the running of the train. If it is not the case, OPTIRAILS can points at the problem very early and warns consequently its users.

When the delay is too large or if the problem needs the search of new path for some trains, OPTIRAILS can start the path assembly process, that is the search of a new path and, if necessary, a negotiation process. An early path assembly allows to find a good solution and to minimise the delay resulting from border crossings [13]. The earlier the problem is detected, the more time is available to find a solution and the better the solution would be.

Such a path assembly process permits to limit the delay and to communicate a more reliable expected arrival time to the clients, so that they may better plan the use of their resources or prepare mitigation measures if necessary.
3.6 Option 5/6: Problem detection and resolution

This option is the most complete and the most sophisticated one. In this option, OPTIRAILS is able by itself to detect operational problems and to propose a solution.

3.6.1 Concept

Information on only international trains is not sufficient to enable problem detection and resolution. To make it possible, it is necessary to have a full picture of the network, i.e. to have data on both international and domestic trains. To realise this option, the data acquisition functions must be enhanced to collect data for all the trains. They need so to collect and deal with a much larger amount of real-time data.

New functions have to be implemented, giving to OPTIRAILS the capacity to predict potential problems in routing and to identify solutions in terms of high-level potential paths. Those proposals will be sent to the involved IMs. They have to consider the detail requirements and to implement the advice from OPTIRAILS.

Those new functions require a corridor model in which the capacity model is one of the most important points. The purpose of the corridor capacity model is to predict the likely available capacity along the corridor for the analysed train. The initial assumption is that where there is enough spare capacity, there is a high likelihood for IM to find a path. If spare capacity is scarce, there is a high probability that the train will be delayed.

3.6.2 Forseen advantages

In this option, OPTIRAILS has a complete vision of the corridor with all the trains running on it. Problems are automatically detected and the causes of potential delays for international trains can be detected earlier. As a consequence, it is possible to find solutions that limit delay increase.

The automatic search of solution is based on priority rules between trains that have been agreed upon by all OPTIRAILS partners.

It is also possible to go further in train path analysis for the international trains along the corridor. In fact, OPTIRAILS proposes a high-level, potential path. This high-level solution gives IMs a trail they can follow to define the detailed train path, so that they can focus on the search of the best possible path.

Automation of problem detection and resolution will help to reduce reaction time. This will not only permit to find better new paths for international trains when necessary, but also to enhance the capacity of the corridor thanks to a better anticipation of the real need of resources.

4 Demonstrator

A demonstrator has been developed to check the validity of the OPTIRAILS concepts, to illustrate the technical options, to show the feasibility of the concept and to prepare the acceptance of the OPTIRAILS system by its future users.
The geographical area taken into account in the demonstrator was part of a North-South corridor, from Karlsruhe in Germany to Milan in Italy, via the Gotthard tunnel in Switzerland. The presentation of the demonstrator has been conducted partly on-line, in order to prove the technical feasibility. On the other hand, different operation scenarios have been processed, pointing out the benefits of OPTIRAILS, both for option 2 (Centralised information) and for option 3/4 (path assembly system). Those scenarios have in particular highlighted the importance of early problem detection, which allows for example to find a good new path for a delayed train and to limit delay increase, and improves the use of resources thanks to a better allocation (one better conforming to the real operation on the corridor).

5 Conclusion and further developments

The OPTIRAILS project aims to develop a European-wide supervisory management system, to control international traffic in coordination with existing national traffic management.

This new corridor-oriented European supervisory layer will concentrate and disseminate all information regarding the “life” of trains along international corridors, with permanent checks of factors entailing risks for the quality of service. Such an information management would be of a great help for all actors of the transport chain, from the consignor (especially if the wagons to be used are coming from abroad) to the consignee.

OPTIRAILS is expected to reduce the consequences of incidents through:
- a better real-time path allocation (more time for decision making results on a better quality of the solution found);
- a reduction of the number of trains impacted by the initial incidents;
- a better use of resources thanks to anticipation in the study of operational modifications to the plan;
- better and earlier information of other actors, especially the final customers (in case of delay, the negative opinion of the final customers is attenuated if, properly advised, they are able to reorganise their production accordingly).

The follow-up of OPTIRAILS will be the development of the EUROOPTIRAILS project. Main issues for this project will be the implementation of a real time traffic management prototype connected to five existing centres (Germany, Austria, France, Switzerland and Italy), the running of the prototype for several months, the assessment of the results in order to check the added value of the OPTIRAILS concepts, and the definition of possible institutional frame scenario structures in order to prepare the implementation of OPTIRAILS on European corridors.

References