

**F-MAN**

**F-MAN**

**IST-2000-29542**

*Rail Car Asset Management*

## **Deliverable D16: Final report**

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Partners:

**SCIRO S.p.A.**

**IVU Traffic Technologies AG**

**European Datacomm**

**National Technical University of Athens**

**SIGMA Conseil**

**Caminhos de Ferro Portugueses, E.P.**

**Prometni Institut Ljubljana D.O.O.**

**TECNOSISTEMI S.p.A. TLC ENGINEERING & SERVICES (\*)**

**TRENITALIA S.p.A. (\*\*)**

(\*) withdrawn on 30 September 2003

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## DELIVERABLE SUMMARY SHEET

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Short description:

**This document represents Deliverable D16 – *Final Report* for the F-MAN project. This report provides a comprehensive 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.**

**Taking into account the structure proposed by the EC in “*Guidelines for preparing project reports*”, the document contains:**

- **Overview on the project, its objectives and the methodology followed to reach them**
- **Presentation of all project results and achievements, included an overview of the official Deliverables**
- **Description of the Project management and coordination aspects**

**At the end of the report, some conclusions are also presented, taking into account the possible future development of the F-MAN prototype auspicated by the potential Users.**

Partners owning: **SCIRO S.p.A.**

Partners contributed: **Università degli Studi di Genova**

Made available to: **F-MAN Partners – Commission Project Officer**



## DELIVERABLE D16

### Final report

		YES	NO
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	SCIRO	✓	
	IVU	✓	
	EDC	✓	
	NTUA	✓	
	SIGMA	✓	
	CP	✓	
	PI	✓	
	EUROPEAN COMMISSION – DG Information Society	✓	
	SNCF	✓	

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<b>C</b>					
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## REVISION

### Revision A

Revision A takes into account the Reviewers' comments from the Final Review held in Genoa on 2-3 December 2004. The contents of § 4.3, § 4.4 and Chapter 8 have been modified accordingly.

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# 1 Project Overview

The European cargo railways are facing more and more productivity problems with the single wagonload regime. One reason is the poor visibility of their wagons, their main asset. In so far, a highly efficient asset management is scarcely feasible with the classical tools. The project F-MAN, started in October 2001 and completed in September 2004, is providing a solution to that problem: a telematic system provides wagons position and status information to an application software, which is giving the future fleet manager enough information to secure an economic selection of “his” wagons and an updating of that decision if the wagon is in delay.

The project developed the F-MAN System Prototype whose schematic overlook is provided in the following Figure 1.

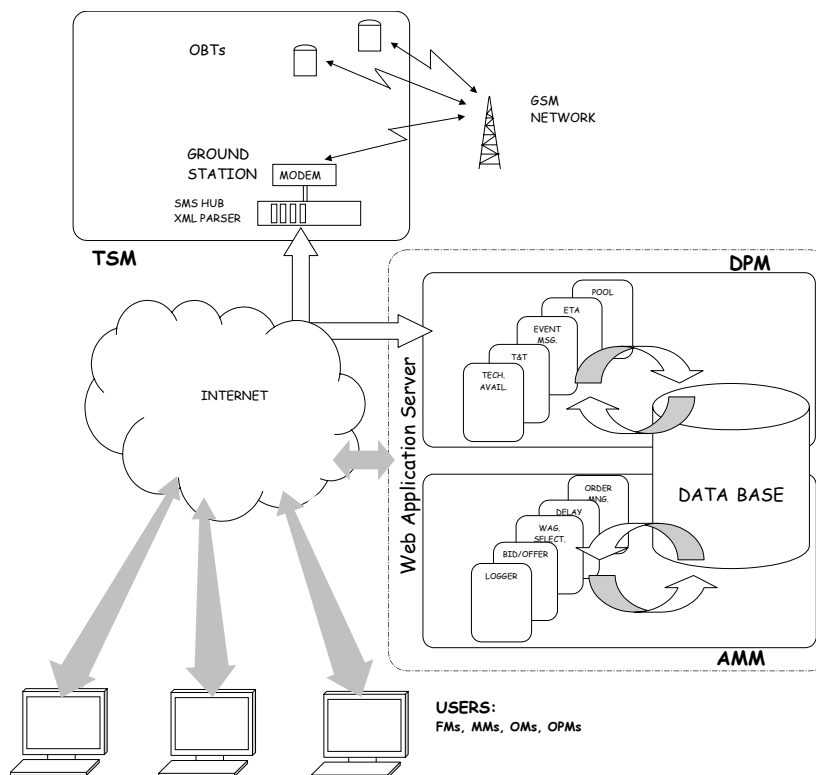


Figure 1 – F-MAN overall system architecture

As shown in Figure 1, the F-MAN system is mainly composed of three modules (TSM, DPM, AMM) which include both hardware and software elements:

1) Tracking System Module (TSM). This module is composed of On-Board-Terminals (OBTs) and the information management system, which is ground based. The OBT is mainly composed of a

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GNSS receiver combined with a GSM module, which is able to perform a sufficient European coverage, plus a set of sensors to collect information about wagon status (loaded, unloaded, running, stopped, ...). Each rail car Owner and F-MAN User is given the possibility of using a Graphical User Interface (GUI) in order to visualize his wagons on a map in real time, and also to show on the screen relevant information regarding each wagon (i.e. loaded, unloaded, stopping, running, wagon history, etc). The OBT information management ensures an Event Messaging, which is the basis for the Data processing.

2) Data Processing Module (DPM). This module concentrates all information coming from the OBTs, it performs some operations, it distributes information to the different actors of the system and it stores data for offline analysis. It is an articulated communication system based on Internet technologies. To forecast Expected Time of Arrival (ETA), OBT data (line tracking) have to be processed by means of proper algorithms. Depending on the specific wagon task of the Customer (wagon type, destination, time frame), the new function of a Fleet Manager needs a quick response time from the F-MAN Pool per wagon type. Thanks to this prompt information coming from the F-MAN system, the Fleet Manager is continuously able to reduce his empties by offering them to other Rail Cargo Operators (RCOs) via Internet. Some information concerning railcar maintenance is also collected with the final aim of improving the wagons availability.

3) Asset Management Module (AMM). This module is a set of software tools. It is developed as a Decision Support System, thus it is able to suggest the fleet manager proper management actions for the rail car planning activities. This includes the definition of some financial and commercial incentives, which are fully customisable on request.

As mentioned above, those three modules constitute the F-MAN System Prototype. The prototype has been tested and verified on site: 50 wagons were equipped with OBTs. The relevant railway dispatching offices successfully evaluated the incoming data on the basis of the functional requirements.

Moreover, a simulation evaluated the productivity gain mentioned in the Technical Annex to the contract, with persuading results. The prototype is ready and tested; and the industrialisation of the product has started running his itinerary.

## 1.1 F-MAN Partnership

As far as the partnership is concerned, research institutions, railway operators and IT-companies have participated in the F-MAN Consortium. The following bullet list shows the main contractors, whose profile and role within the project is shortly reported in Table 1:

- **Università degli Studi di Genova** – Italy (short name UGDIE)
- **Sciro S.p.A.** – Italy (short name SCIRO)
- **IVU Traffic Technologies AG** – Germany (short name IVU)
- **European Datacomm** – Belgium (short name EDC)
- **National Technical University of Athens** – Greece (short name NTUA)

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- **Sigma Conseil** – France (short name SIGMA)
- **Caminhos de Ferro Portugueses E.P.** – Portugal (short name CP)
- **Prometni Institut Ljubljana D.O.O.** – Slovenia (short name PI)

*Table 1 – Composition of the Consortium*

Partner's Short Name	Role <sup>1</sup>	Country	Organisation's (business) activity	R&D function in the project
UGDIE	CO	I	University	Assessment and evaluation, Administrative and financial co-ordination, Quality management
SCIRO	CS	I	System Engineering	Scientific co-ordination, Users needs specification, Functional requirement and analysis, Tracking & Tracing
IVU	CR	D	Software tools for transport	Fleet management tools
EDC	CR	B	Communication System and service provider	Development and integration of communication equipment
NTUA	CR	GR	University	Architecture design, Data processing, ETA algorithm
SIGMA	CR	F	Rail Consultants Company	Functional requirements and verification
CP	CR	RO	Rail Cargo Company	User needs specification, Functional requirements and verification
PI	CR	SI	Transport research centre	User needs specification, Functional requirements and verification

It is worth noting that, since the beginning of the project, the Consortium has set up a Railway Operators Group (ROG) open to any European railway operator, establishing an efficient communication channel between the project and its main appraisal groups, in order to strengthen the soundness of the application assessment. In the following Table 2 the companies joining the ROG are depicted.

<sup>1</sup>  
CO = Financial Co-ordinator  
CS = Scientific Co-ordinator  
CR = Contractor

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*Table 2 – Companies joining the Railway Operators Group*

<b>Company</b>	<b>Role/Department</b>
SNCF – French Railways	Freight Direction – Innovation Pole (ROG Manager)
CP – Portuguese Railways	R&D Department
SZ – Slovenian Railways	Cargo Department
TRENITALIA S.p.A. – Italian Railways	Cargo Division – R&D Department
DB Cargo – German Railways	R&D Department
Intercontainer-Interfrigo (ICF) s.c. (Switzerland – Private Operator)	IT Coordination
NETLOG Netzwerk-Logistik GmbH (Germany – Private Operator)	R&D Department
HPI GmbH (Germany) – Private Operator	Distribution Department
ABX Logistics GmbH (Germany) – Private Operator	Marketing Department
Trimodal Europe BV (The Netherlands) – Private Operator	Rail Department

During the periodic activities that the F-MAN Consortium carried on with the aforementioned ROG members, other relevant Railway Undertakings, in addition to the ones depicted in Table 2, decided to cooperate with the Group with the double aim of steering the research through their experience and of maintaining a link with a state-of-the-art application as F-MAN is.

Being such report public, it is worth noting that the name of the official contact persons for the companies depicted in Table 2 are not reported here for privacy reasons, while the full information is available on request to the European Commission.

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## 2 Project Objectives

This project aimed at improving the sustainability of rail freight transport and the competitiveness of Railway Cargo Operators (RCOs), including the new Rail Undertakings. The original main objective of F-MAN was to provide the RCOs with innovative tools to control their international wagon fleet, and to enhance the productivity of wagons. To reach that goal, the Consortium had to design and develop the following items:

- The On-Board Terminal to collect wagon position and status information and send it to the Operation Centre, according to pre-defined events criteria (Event Messaging);
- The Operation Centre to forecast the Expected Time of Arrival using suitable models;
- The Internet-based bid and offer module (F-MAN pool) to reduce the empty returns;
- The status-oriented maintenance module to improve the availability of wagons;
- A Decision support system based on financial and commercial criteria to assist the control of wagons fleet.

To reach all the ambitious objectives of the F-MAN project, the Consortium proposed to adopt a modular architecture that, on the one hand would have provided suitable flexibility in respect to the hardware choices, and on the other hand would have granted the maximum scalability of the system itself. As the following Chapters will describe, such early proposal became the Consortium choice and its validity was confirmed during the technical development phase of the project and the prototype verification phase.

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### 3 Approach followed to achieve project objectives

Research and development activities have been carried out thanks to a well defined and structured work plan: tasks have been allocated to eight different Work Packages, whose preliminary description and main outcomes are provided in Table 3, and whose main milestones are reported in Table 4.

*Table 3 – Work Packages list*

WP no.	Work Package title	WP Leader	Start month	End month	Deliverable no.
WP 1	Users' Needs	SCIRO	0	7	D3
WP 2	Functional Requirements and Architecture	NTUA	7	11	D4, D5
WP 3	Development	NTUA	12	19	D6, D7, D8, D9
WP 4	Integration	IVU	20	33	D10
WP 5	Testing and verification	CP	23	34	D11.1, D11.2
WP 6	Assessment and Evaluation	UGDIE	0	36	D12, D13
WP 7	Dissemination and Implementation	SCIRO	0	36	D2, D14, D15
WP 8	Project Management	SCIRO	0	36	D1, D16

*Table 4 – Milestones*

Milestone no.	Milestone description	Set at month no.
M0	Project launch	0
M1	User needs identified	7
M2	Closure of the conceptual phase	11
M3	Development completion	19
M4	Prototype completion	33
M5	Project completion	36

In the following, a short description of each Work Package is provided to give evidence of the approach followed to achieve the project objectives.

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### 3.1 Work Package no. 1 – Users’ Needs

As a basis for the functional requirements, the Users needs, whose definition was the objective of this WP1, were identified according to the following procedure:

- Analysis of the future accessible strategies for rail cargo companies. This activity was done through interactions and direct interviews and questionnaires to the railway operators involved in the partnership (CP, PI-SZ and SIGMA-SNCF) and their partners.
- Wider consultation on organisational conditions and their possible evolutions through interviews with a broader set of rail cargo operators.

Collected feedback was presented to the Railway Operators Group during a dedicated Workshop in order to fine tune the Users needs.

### 3.2 Work Package no. 2 – Functional Requirements and architecture

The objectives of this WP2 were to specify the functional requirements of a Fleet Management for rail cargo companies, and to design a proper architecture for the F-MAN system. To reach those goals, the following process was run:

- taking into specific account the investigation performed in WP1, the overall requirements, as well as the functional specification of the system were drawn out. In order to ensure the complete definition of the system, the AFNOR standard was adopted;
- based on the “main function identification” of the overall system, the F-MAN system architecture was defined, as well as the one of each single module.
- thanks to the AFNOR application, it was then possible to check, through a methodical bottom-up procedure, the thoroughness and consistency of the designed architecture.

### 3.3 Work Package no. 3 – Development

This WP3 aimed at developing the F-MAN tools (namely, hardware and software), in compliance with the specification and the definition set in WP2. The following F-MAN modules were developed:

- Tracking System Module (TSM)  
The Tracking System Module is composed of On-Board Terminal (OBT) and the ground information management system. The OBT is composed of a GNSS receiver combined with a GSM module. Such module also provides the Users with visualisation of wagons on customisable digital maps.
- Data Processing Module (DPM)  
The Data Processing Module concentrates, distributes and processes all information coming from the OBT to the other elements of the ground system. It is an articulated communication

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system based on Internet technologies. Special care was dedicated to the realisation of an ETA (Expected Time of Arrival) software, giving inputs to the Asset Management Module.

➤ The Asset Management Module (AMM)

The Asset Management Module is a set of software tools taking information from the TSM through the DPM, and uses such information in order to provide support to the User. Conceived as a Decision Support System, it suggests the Fleet Manager proper actions to comply with Customer's orders.

### 3.4 Work Package no. 4 – Integration

The objective of WP4 was to integrate the aforementioned modules to realise the F-MAN prototype, which was used in further Work Packages to evaluate the concepts and to verify the application functionalities. The integration process was linked in a sort of closed loop with the one carried out in the framework of WP5 (Testing and verification) in order to fine tune and improve, where necessary, the application to meet the functional requirements and to fulfil the acceptance criteria. The realised prototype includes OBTs mounted on board of 50 railcars owned by CP, SNCF and SZ. From the technical point of view, the main activities carried out within WP4 dealt with the development of proper internal interfaces among the SW modules and of proper communication interfaces between on-board equipment and ground equipment.

### 3.5 Work Package no. 5 – Testing and verification

WP5 objective was to ensure that the F-MAN prototype fulfilled the functional requirements defined in WP2, and that it worked properly under specified conditions, producing useful feedback to WP4 to refine the working prototype. In particular the following two sets of tests were carefully planned and developed:

- *functional tests*, with the main purpose of verifying the prototype functionalities and behaviour; they were performed both by the prototype developers and by the Users;
- *field tests*, related to the real operation of the 50 OBT equipped wagons; they were performed by the Users, supported by the prototype developers.

As far as the verification sites are concerned, international corridors connecting Portugal and Spain, France, Italy, Austria, Slovenia and other countries were run by the F-MAN wagons.

### 3.6 Work Package no. 6 – Assessment and evaluation

This WP6 dealt with the evaluation and assessment of the project outcomes. Evaluation aimed at the estimate of the added value of the project taking also into account the results of the comparison with “reference cases”. To this aim an *ad-hoc* simulation tool was developed to trace out, under

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many different scenarios, a precious indicative comparison between the efficiency of the actual standard management criteria adopted by the most relevant Train Operating Companies operating in Europe, and the efficiency of F-MAN fleet management approach. Evaluation activities were initially devoted to the preparation of a thorough Evaluation Plan, which provided information and methods to allow a fair assessment of the project results. Based on the guidelines provided by the Evaluation Plan and the results deriving from the validation activities performed on the prototype, the final assessment of the added value of the project was carried out, taking also into account the preliminary Users acceptance collected through a dedicated questionnaire filled in by ROG members. Throughout project life, the Evaluation staff also managed Peer review processes for all technical deliverables before their submission to the EC.

### **3.7 Work Package no. 7 – Dissemination and Implementation**

This Work Package was devoted to dissemination activities and to the definition of specific exploitation intention per individual end product and per involved partner. The main result of the dissemination has been to contribute to the visibility of F-MAN scientific, technological and practical results both inside the railway community and among other potential users. Objectives and relevant results of the project has been disseminated in the following ways:

- Set up and update of the project WEB site
- Participation to international conferences and publications on scientific journals
- Organisation of specific events

In addition, to ensure compliance between project development and user requirements and to bring inside the Consortium as much as possible the railway operators expertise, a specific Railway Operators Group has been set up. Such group acted as a support to provide a concrete link between the research activities and their exploitation.

### **3.8 Work Package no. 8 – Project management**

This Work Package dealt with general project management, both internally to the Consortium and toward the Commission, in order to monitor the project development and progresses, verify the milestones and the time schedule, check and release the project deliverables, control the overall performance and audit the costs. Those activities have been directly carried out by the Financial and Scientific Project Coordinators (respectively, UGDIE and SCIRO), supported by a Project Board involving the responsible partner for each Work Package. All the partners have contributed to this Work Package, supporting the Project Coordinators during the preparation of Effort and Progress Reports, Annual Review documents and for the issue of the Final Report. A Quality Plan, based on consolidated procedures, was defined at the very beginning of the project and a detailed Configuration Management carried out throughout the whole project life cycle, by means of specific SW tools developed to the purpose.

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## 4 Project results and achievements

### 4.1 The exploitable results

The project produced a relevant number of countable results which are worth being briefly reported in the following paragraph. Then, the list of accompanying project documentation is provided both for the sake of thoroughness of the presentation of all the outputs that the F-MAN Consortium produced, and the sake of project reference for further investigation of results.

#### 4.1.1 F-MAN prototype

The objective of F-MAN prototype is to provide the fleet manager of Railway Cargo Operators (RCOs) with innovative tools to control his wagon fleet, and to enhance the productivity of wagons. The F-MAN prototype consists of: a) Tracking System Module (TSM) to locate wagons wherever they are in Europe, and to retrieve wagon status information (loaded, unloaded, moving, ...); b) Data Processing Module (DPM) to progressively estimate the Expected Time of Arrival (ETA) for each wagon, and to make available all information regarding wagon history; c) Asset Management Module (AMM) to propose a proper choice of wagons to comply with clients' orders, according to customisable productivity indicators; d) Graphical User Interface (GUI) to present the fleet manager, in an intuitive and user friendly way, wagons position and operating data on geographical maps. In particular, the aim of the Tracking System Module is to retrieve information on the position and status of wagons, which is the basic input to efficiently manage the railcar fleet. TSM is based on GPS technology used in combination with a GSM communication system to transfer information from each wagon to the centralised F-MAN system. The core of the Module is the On Board Terminal (OBT), a stand-alone device provided with an autonomous long-life energy supply, which is installed on each freight railcar belonging to the fleet. Apart from positioning information, there is the capability of detecting the status of the wagon. All information coming from the OBTs is collected by the SMS Hub which, after a proper validation process, translates it in XML language and dispatches it through the Internet to the DPM and the AMM. The SMS Hub performs also the reverse translation whenever data, coming from the other F-MAN modules, need to be transmitted to the OBT (translation XML/SMS format). The Data Processing Module concentrates all information coming from the On Board Terminals the wagons are equipped with, and distributes it to the rest of the ground system, and from the latter to the different workstations located at the user premises. It is an articulated communication system based on Internet technologies. It manages rights to access the application, makes available data for maintenance planning and provides an estimate of the arrival time of the wagons. Such algorithms allow to estimate the time a wagon will arrive at its final destination. The Asset Management Module is a set of software tools taking information from the Tracking System Module through the Data Processing Module, and processes it in order to suggest to the fleet manager a proper solution to comply with clients' orders. AMM has been developed as a Decision Support System, thus it indicates those choices of wagons that may improve the rail car productivity. The aim of the Graphical User Interface is to present on the computer screen of the end user all those data regarding the position, the status, and the history of

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the wagon(s) selected by the user himself. Basically, this system is able to show on the screen a digital map of the geographic area where the selected wagon(s) are/have been/will be, depending on the query that the user formulates. All relevant F-MAN functions to operate the system and to fulfil the communication demands are available via the GUI.

#### 4.1.2 Asset Management Module

The Asset Management Module (AMM) is a set of software tools taking information from the Tracking System Module (TSM) through the Data Processing Module (DPM), and processes it in order to suggest to the fleet manager proper solutions to comply with clients' orders. AMM has been developed as a Decision Support System, thus it indicates those choices of wagons that tend to improve the rail car productivity. The module implements customisable algorithms which drive the wagons choice by means of financial and commercial rules. Thanks to the effectiveness of such rules, suggestions coming from the AMM help the fleet manager to reduce empty trips of wagons and to satisfy a larger number of clients' orders using the same fleet.

#### 4.1.3 Data Processing Module

The Data Processing Module (DPM) receives all information coming from the Tracking System Module (TSM) and distributes it by Internet technologies to the rest of the ground system and from the latter to the different workstations located in the user premises. The DPM is also devoted to performing the digital storage of all the data incoming from the other F-MAN modules, constituting so the F-MAN database. The DPM covers other three main functionalities: a) the Delay Detection, and in particular the calculation of the Expected Time of Arrival (ETA), which is based on the calculation of specific probability distribution functions; b) the management of the F-MAN pool of wagons. This functionality is devoted to pushing in new wagons in the F-MAN fleet, or to withdraw them from the fleet, or to set new agreements with other commercial operators, or to implement a politic of special privileges to some customers rather than others, and so on; c) the technical availability of wagons. This functionality of the DPM allows the continuous update of the maintenance parameters of the wagons belonging to the F-MAN fleet. The maintenance information is both time-based and mileage-based thanks to the multiple information coming from the TSM.

#### 4.1.4 Tracking System Module

The aim of the Tracking System Module (TSM) is to retrieve information on the position and status of wagons, which is the basic input to efficiently manage the railcar fleet. TSM is based on GPS technology used in combination with a GSM communication system to transfer information from each wagon to the centralised F-MAN system. The core of the Module is the On Board Terminal (OBT), a stand-alone device provided with an autonomous long-life energy supply, which is installed on each freight railcar belonging to the fleet. Apart from positioning information, there is the capability of detecting the status of the wagon (loaded, unloaded, moving, stopped, or other, depending on the sensors that the user decides to install). All information coming from the OBTs is collected by the SMS Hub which, after a proper validation process, translates it in XML language and dispatches it through the Internet to the DPM and the AMM. The SMS Hub performs also the

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reverse translation whenever data, coming from the other F-MAN modules, need to be transmitted to the OBT (translation XML/SMS format). There are also different possible ways to check the running of equipped wagons along their itinerary. For instance, it is possible to remotely load a timetable in an OBT and to obtain information on the wagon position and status in comparison with the planned trip (called Timetable Supervision Mode). The OBT is also provided with an intelligent management system (fully customisable at any time by the user) to extend the lasting of energy supply. The position and status of wagons may also be displayed on geographic maps directly on the screen of the authorised user through the Internet (see also Graphical User Interface, GUI). Other functionalities are better described in the related F-MAN documents.

#### 4.1.5 Graphical User Interface

The aim of the Graphical User Interface (GUI) is to present on the computer screen of the end user all those data regarding the position, the status, and the history of the wagon(s) selected by the user himself. Basically, this system is able to show on the screen a digital map of the geographic area where the selected wagon(s) are/have been/will be, depending on the query that the user formulates. All relevant F-MAN functions to operate the system and to fulfil the communication demands are available via the GUI. The following functions are implemented in the GUI: a) Tracking and Tracing of wagons and visualisation of wagons on electronic maps; b) Dispatching of wagons; c) Information on location and status of wagons, available wagons, etc.; d) Order processing. The GUI has been developed as an Application Service Provider, based on Internet technologies. All end users have the possibility to directly retrieve data from the system through the GUI, and to carry out by it some actions, as for instance to insert bookings.

#### 4.1.6 Expected Time of Arrival – ETA algorithms

Such algorithms allow to estimate the time a wagon will arrive at its final destination. Freight trains face delays mainly because passenger trains get priority, and an initial hold-up often leads to a build-up of delays. A realistic ETA at the destination station is essential for an effective wagon allocation/booking and constitutes one of the hardest tasks for train operators whenever they have to face international trips. ETA calculation relies on location messages from On-Board Terminals (OBTs) that are collected and processed by the Data Processing Module (DPM) in the probabilistic form of conditional cumulative distribution functions. The algorithm provides the probability the wagon will not arrive at destination station within X h where X is the time margin from the scheduled wagon arrival at destination until its next scheduled transport activity.

#### 4.1.7 Service, support & training for installation and use

Service, support & training for installation and use deal with all those activities that allow Railway Cargo Operators (RCOs) to properly use the F-MAN tools. As previously mentioned, the objective of F-MAN project is to provide the fleet manager of RCOs with the following innovative tools to control his wagon fleet, and to enhance the productivity of wagons: a) Tracking System Module (TSM) to locate wagons wherever they are in Europe, and to retrieve wagon status information (loaded, unloaded, moving, shunting, ...); b) Data Processing Module (DPM) to progressively

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estimate the Expected Time of Arrival (ETA) for each wagon, and to make available all information regarding wagon history; c) Asset Management Module (AMM) to propose the "optimal" choice of wagons to comply with clients' orders, according to customisable productivity indicators; d) Graphical User Interface (GUI) to present the fleet manager, in an intuitive and user friendly way, wagons position and operating data on geographical maps. All those elements require proper installation procedures and set-up, for both hardware and software components. Furthermore, training activities may help the fleet manager get used with the new tools in order to raise his productivity.

#### 4.1.8 SMS Hub

The SMS Hub provides a communication gateway, communicating via SMS with the telematics units on wagons (the On Board Terminals) and via SMTP (e-mail) over the Internet with the backoffice software (the Asset Management Module and the Data Processing Module). The Hub translates SMS PDU formatted OBT originated messages to XML formatted messages, following a well defined XML schema. OBT terminated messages, coming from the backoffice in XML format, are translated into the proper SMS PDU format and sent over the GSM network to the target OBT.

### 4.2 Technological Quality and Innovation

Several fundamentals constituting the core of the F-MAN project may be referred to as Innovation, and many of them bear technological quality aspects that are not negligible. This paragraph wishes providing the Reader with the most interesting elements emerging from the project that may be mentioned under both technological quality and innovation definitions.

The first innovative element is doubtlessly the idea to adopt and properly transpose some management criteria more typical of other production and industrial sectors, rather than of the railway transport field. The F-MAN "philosophy" as a whole, and in particular its concepts regarding the wagon pool management and the minimisation of the empty returns are concepts that, just a decade ago, were unthinkable in the European railway freight transport marketplace. The opening of the latter to new Railway Undertakings and the slow – but continuous – process transforming the traditional stakeholders from public entities to private Companies, who wish having their shareholders – and Customers – satisfied with their performances, may be considered the cradle of F-MAN project idea. And that is a relevant example of innovation indeed.

To continue, it is worth mentioning that, within project's innovative aspects, a significant role is played by the introduction of new maintenance concepts in the railway field. Still nowadays, maintenance philosophy is based only on two aspects: the wagon mileage maintenance and the time-based maintenance. According to them, each RU performs his calculation of the needs for maintenance for each wagon of the fleet, provided that low precision on both wagon mileage data and time-based data implies a significant loss in overall efficiency and wagon availability, causing profit loss at the end. F-MAN preventive maintenance approach not only does solve the above mentioned limitations and inefficiencies, but it results also into a further step beyond the state-of-

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the-art, introducing “status oriented and preventive maintenance” rules based on reliable and on-time data automatically retrieved from the field.

Another example of innovation introduced is represented by the Expected Time of Arrival (ETA) calculation, which is based on innovative concepts and algorithms that are able to improve and fine-tune their efficiency during the system operation (“self-learning” algorithms).

Last, but not least, it is worth mentioning the Tracing and Tracking capabilities of the F-MAN system. The innovation in this case stands both in the solution proposed to overcome, in a cost effective way, problems concerning energy consumption of on-board batteries and transmission costs (by means of the *ad hoc* “event messaging” philosophy), and the precious idea of freeing wagon localisation tasks from infrastructure-based data, thanks to the wagon capability of localise itself on the European Railway Network and to transmit this piece of information directly to the concerned Fleet Manager.

As the Reader has easily deduced from the previous statements of this paragraph, technological quality and innovation aspects are intensively interlaced among themselves. F-MAN developers are Companies that have been working at the frontier of research and technology development since decades, and their expertise was the ground basis on which each single aspect of the F-MAN Functional Analysis, System Architecture, modules and sub-modules design and implementation were put into practise. The “wide-spectrum” know-how of each Partner proved to be absolutely necessary to reach the ambitious goals of the project, and, nevertheless, it represented the added value accompanying the team-working experience in the three years of the project.

### 4.3 Community added value and contribution to EU policies

F-MAN deals with Transport Telematics, that is to say it addresses the application of telematics to transport systems. It fits and contributes to the achievement of several FP5 IST programme objectives, as they are described in the relevant Work program. More particularly, F-MAN is addressed to FP5 IST Action Line 1.6.2 – Systems for intelligent vehicles. It is worth noting that the contents reported in this paragraph and in the following one (§ 4.4) deal with all the possible **contributions** of the F-MAN project at the European Community level, stated that the proposed application should be seen as just one of the bricks needed to build a complex building.

F-MAN impacts positively on the implementation of the Information Society and Telecommunication policy. In fact, F-MAN encourages the application of information tools in a field (i.e., the rail freight transport one) known to be reluctant to the introduction of IT solutions. The project matches the need for universal services ensured with interoperability of services and network interconnection throughout the European Union. In fact, F-MAN aims at providing tools that make the management of railcar fleet possible under a European coverage, what is impossible for the moment being. The project developed state of the art equipment that ensures the effectiveness of such requirement.

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F-MAN is also an important key to the completion of a freight-related information society. For instance, it would be possible to make available the state of the shipment, or the additional costs due to over routing to the customer requiring the shipment (or to the consignee). This will be easily achieved by integrating F-MAN with already existing or brand-new software for shipment tracing, or to common EDI systems, with the development of proper interfaces and the definition of the needed data format to be exchanged.

F-MAN has positive impact on the implementation of the EU Transport policy. In fact, it contributes to the improvement of freight transport efficiency, reducing the operational costs of rail links in the Integrated transport chain. Moreover, it makes it fruitful and profitable to route goods through railway links, thus increasing the overall capacity and productivity of the European freight transport network. That is to say, F-MAN contributes to improving the circulation of goods throughout Europe.

As a consequence of the contribution to the transport policy, F-MAN may also play its relevant part in the implementation of the Transport component in the Trans-European Network (TEN). In fact, F-MAN contributes to increasing the interoperability among member states railway networks and to integrate new links in the TEN, it encourages the offer of a wider choice of delivery to destinations, and it facilitates the connections between regions on the periphery of the recently enlarged European Union and those at its centre. F-MAN may enhance the integration between transport and telematics, which already gave birth to many inventions needed for sustainable mobility, and it may furthermore stimulate their use.

The contribution to the EU Environment policy could be seen as a sort of major revenue due to the implementation of measures relevant to the EU Transport policy. F-MAN contributes to increasing the competitiveness of rail transport with respect to road. More generally, F-MAN helps to strike a better balance in the use of various transport modes, so that freight traffic could be less dominated by lorries. In fact, the development of new and effective transport systems and services (such as F-MAN) serves this overall objective by strengthening the competitive attraction of intermodality, which is definitely more environmentally friendly than mere road transport is.

F-MAN represents one step towards the development of a single market. In fact, the market share of rail transport within each member state of the Union is - still nowadays - strongly biased in favour of the former national railway companies. Part of this behaviour is surely due by the current way of tracing freight railcars through their journeys, which is feasible within the borders of their origin countries but it is rather difficult outside them. The possibility of tracing and then managing the fleets of railcars even when travelling abroad makes it more profitable to extend the rail cargo companies' market, and then to achieve the status of single market for railway transport.

The increase of cargo company productiveness may also contribute to the creation of more job opportunities, even if, in the short term, it might seem that the introduction of F-MAN may lead to an employment loss, due to the reduction of man workload needed to locate railcars, and to plan their exploitation. This consideration is supported by both empirical evidence and several economic analyses, which conclude that the diffusion of information and communication technologies positively contributes to job creation in long term even in the transport context.

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It has been definitely worth carrying out the F-MAN project at a European level. In fact, the needs of rail cargo companies that would be satisfied by F-MAN are common to any European rail freight operator, and the project results contribute positively to the implementation of several EU policies. The value of the solution proposed by F-MAN is also acknowledged by the number of external partners (ROG) declaring their interest to the project, as well as the UIC. The presence (via membership or agreement) of three railway operators (CP, SZ and SNCF) and their commercial and financial agreements with other European Railways make the European value of the project partnership even wider.

#### **4.4 Contribution to Community social objectives**

The F-MAN system can contribute in several ways to the improvement of the quality of life and health and safety, particularly from the point of view of working conditions, to the improvement of employment and the creation of new job opportunities and, finally, to the preservation and enhancement of the environment and the natural resources.

One of the principal aims of the F-MAN system is to increase the competitiveness of freight transport in the scope of the Integrated Transport Chains in comparison to road through an improved service, more efficient operation and better security. As a matter of fact, F-MAN is expected to increase the productivity and the effectiveness of rail cargo companies through the integration of different IT subsystems and the implementation of suitable management procedures; hence, F-MAN may support the rail cargo operator (i.e. the enterprise), the fleet manager and the terminal operators to perform their job more efficiently and effectively. F-MAN may help the personnel of rail cargo companies to work under better conditions. In fact, they may be properly and adequately supported by the F-MAN system to manage their fleet of railcars, to determine the location of each wagon, when needed, and to plan the composition of trains in order to meet the customers' requests, expressed in terms of demand for transport. It is also important to underline that F-MAN could considerably increase the quality of service of rail freight transport, by making the actual status of the shipping available to customers, when required. Fleet manager may suffer less stress too. As a matter of fact, at present the database storing the information about wagon locations and train composition is updated directly by the marshalling yard personnel, who are often neither very enthusiastic for this kind of job, nor very confident or caring for this task. This implies a noticeable risk of mistakes and/or inconsistencies and requires the fleet manager to update and correct the database manually (possibly inserting even more errors) after a thorough search for the "lost wagons". With the introduction of F-MAN the aforementioned updating manual operation will disappear. Moreover, F-MAN may contribute positively to transport externalities such as pollution, contributing to health throughout Europe thanks to a reduction in emissions (through an increase of the rail transport market share with respect to road as a consequence of resource optimisation, and therefore of rail attractiveness). It is known that, given a freight volume, railways are more environmental friendly than road transport; so the environment benefits significantly, whenever freight volumes are switched from road to rail. Also the European citizens may benefit from the introduction of F-MAN, and the consequent rationalisation of the freight transport management;

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actually, the reduction of transport costs and the improvements in logistic activities for a wide range of industries should have repercussions on the prices of merchandise for the final consumer. Finally, another important benefit related to costs concerns the problem of dealing with rail traffic that may be optimised through the European railway network. The rationalisation of railcar allocation to journeys and transports, together with the reduction of empty wagons runs, should result, on the long period, in an increase of railways making a better use of train slots (even on secondary lines) and, as a consequence, in the increase of the exploitation of the capacity of the lines. In summary, the application of the F-MAN system by Railway Undertaking Companies may be an important step in the development of a freight transport management characterised by a total quality implementation, an increased productivity and a noticeable reduction in costs.

The adoption of F-MAN could also show positive effects on employment in the European transport industry. The increase of productiveness in rail cargo companies will contribute to the creation of more job opportunities, as well as of new professional profiles, even if, in the short term, it might seem that the introduction of F-MAN may lead to an employment loss. This consideration is supported by both empirical evidence and several economic analyses, which conclude that the diffusion of information and communication technologies contributes positively to job creation in long term even in the transport context. Moreover, added value telematics infrastructures create for the Information Society industries opportunities for larger deployment, so the introduction of F-MAN, as a side effect, could be one element for an increased demand in European telecommunication equipment and services.

From the point of view of the environmental preservation and enhancement, F-MAN may have positive effect on ecological and safety aspects of transport. It has been already discussed how F-MAN, through the increase of rail transport attractiveness and consequently of the market share, will contribute to the reduction in CO<sub>2</sub> emissions and other air pollutants, contributing to realising an Integrated transport chain characterised by an improved and safer mobility in combination with reduced pollution.

#### **4.5 Economic development and S&T prospects**

Stated that freight transport demand is dependant on industrial growth, a better utilisation of freight cars increases the readiness of rail to provide industry with transport units. To reach such goal, current practice and philosophy, mainly based on the personal experience of the involved actors, should be supported and boosted by proper Decision Support Tools, such as the ones provided by the F-MAN system.

Moreover, National Economies need more efficient transport systems, especially regarding alternatives to road transport. Also in such a context, F-MAN system appeal results evident. Indeed, F-MAN is devoted to raise the market shares and competitiveness of a cleaner freight transport system, as the railway is, by means of increasing the productivity of wagons and, as a consequence, the quality of the service.

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Similarly, the ongoing process of liberalisation of the railway transport market will further stimulate the adoption of effective tools to enhance wagons management and control, resulting in a significant increase of TOC shareholders' profits.

The major outcome of the F-MAN three-years RTD Project is the development of a valuable functional prototype, which is now on its way to industrialisation and commercialisation. Starting from the actual release of the prototype, the main further development towards a more stable industrial release will take care of the necessary customisation of the toolset and the development of the necessary specific interfaces to link F-MAN tools to the legacy software of the TOCs. It has to be pointed out that this customisation could also include an interface toward classical data input tool for (train) position detection provided by the Infrastructure Managers. Such solution could solve transient problems due to the OBTs purchase and installation process, whenever just a subset of the wagons is OBT equipped, while the whole fleet has to be managed and controlled.

F-MAN system is a versatile set of tools that may be easily transferred to any European TOC, just by means of proper software interfaces depending on the TOC legacy management software and, mainly, on the willingness of that TOC to integrate his software with an "external" system. Looking at the next future, it seems possible, and even probable, that F-MAN System, as well as other IT tools applying Satellite Services – GPS today, but very soon GALILEO Services and the combination of them – will play a key role as major instruments at European RCOs disposal, capable of helping them earning more competitiveness in respect to other transport modes, in particular road transport.

#### **4.6 Other relevant projects and standardisation**

Since the preparation of the proposal of the F-MAN project, the Consortium dedicated relevant effort to monitor, collect and, wherever applicable, to absorb sensible know-how from the past and the current state-of-the-art in the frame of the European research in the field. Taking also advantage from the considerable expertise of many Partners in the project, and thanks to the precious help the Users provided the Consortium with, it has been possible to build a common state-of-the-art platform, starting from which relevant progress was achieved during the three years activity.

For sake of conciseness, just a couple of explicative examples are provided in the following two paragraphs, notwithstanding that most detailed information can be retrieved from the issued Deliverables.

##### **4.6.1 New Wagon Status project**

The UIC rail cargo companies were pushed by the EC to liberalize their international wagon regime (RIV). The results could be described as a wagon treatment abroad, which got rid of the "Return to Sender" regime – after unloading. Or in other words: the wagon operator has to contract in future with the wagon owner the operation mode (including the payment for empty / loaded wagons transportation) per each wagon mission. A wagon – managed with the F-MAN tool set – will

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initiate all the necessary status data, which the wagon owner and wagon operator needs. Moreover: they are able to evaluate the wagon selection based on the best choice method.

#### 4.6.2 F-MAN and the Technical Specifications for Interoperability (TSI)

F-MAN project was originated in year 2000 when the Technical Specification for Interoperability (TSI) regarding the "TELEMATIC APPLICATIONS" subsystem for Freight Services were still under definition by the dedicated Association, that is the AIEF - European Association for Railway Interoperability. Anyway, since the very beginning of the project, the F-MAN Consortium has duly taken into account the work that had already been performed by the AIEF, in order to grant that the F-MAN system under development could be included under the umbrella of the TSI specifications, with minor adaptations and/or modifications to its core design. The latter is ensured by the intrinsic nature of F-MAN application - referring both to its hardware and software components - which was developed following the concept of the "open systems", thus embracing the maximum adaptability, flexibility and interoperability with existing, and future standards and norms already present on the market. Just as an example, it may be mentioned the capability of F-MAN system to work with different OBT equipment, simply developing the proper software interface to let the two systems communicate successfully.

Nevertheless, at the beginning of this paragraph, just the inputs that the elaboration and preparation of TSI for Freight Services provided the F-MAN project with, were mentioned. On the other hand, it would also be worth mentioning that the process was bi-directional, with the due restraint and modesty that a comparison between those two so different elements obviously requires. Indeed, since the TSI Version 1.6 issued by the AIEF on February 13<sup>th</sup>, 2004, the F-MAN project was included, together with only few other projects, in the Chapter "Inputs from running projects". In the paragraph dedicated to F-MAN within the mentioned Chapter, the influence that F-MAN project exerted on the TSI preparation is made explicit. There, the AIEF states that: "It's true the tracking system of this (i.e. F-MAN) project is based on On-Board terminals, but the provision of real time data regarding rolling stock, wagon movement and the calculation of the estimated time of arrival (ETA) are points which were taken into account for the TAF TSI".<sup>1</sup>

To end with, referring to what previously stated concerning the "open system" philosophy that drove the developers to the actual F-MAN prototype, it is easy to conclude that the industrial product which will originate will include all the required features to grant full compliance with the TSI specifications.

<sup>1</sup> Quotation from page 20 out of 101 of: *Report Of Presentation of the Technical Specification for Interoperability "TELEMATIC APPLICATIONS" subsystem for Freight Services - Version 1.8 on 22.03.2004 - Updated following the decision of the CSG on 19/03/04*

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## 5 Deliverables and other outputs

Project Deliverables are briefly described in this Chapter and a comprehensive table of the Deliverables reported in Paragraph 5.18. Other outputs like participation in industrial exhibitions, articles and conference presentations are also listed in Paragraph 5.19.

### 5.1 Deliverable D1 – Overall Quality Plan

Deliverable D1 defines the general organisational and management aspects, the operating procedures, the resources and the criteria adopted for monitoring the services to be provided in connection with the F-MAN project, as part of the European Union 5<sup>th</sup> Framework Programme, assuring compliance with the Contract (and relative annexes) undertaken with the European Commission. In particular, the Overall Quality Plan defines the project management and decision making structures, specifies the roles of Project Co-ordinators (distinguishing between the Scientific Co-ordinator and the Administrative and Financial Co-ordinator), of the Project Management Board and of WP Leaders, identifying the relevant responsibilities in the operating procedures to be adopted as far as Communication flow, Quality assurance and Conflicts resolution are concerned. The Overall Quality Plan also provides the instructions to be followed and forms to be used in order to manage the quality assurance of the documents issued by the Consortium.

### 5.2 Deliverable D2 – Project Presentation

Deliverable D2 contains a short and concise description of the F-MAN project. It is structured as a four pages brochure, containing an illustrative presentation of F-MAN main objectives, expected results, Consortium, as well as the anticipated contribution of the project outcomes, not only on the railway sector but also on the EC policies and other social objectives. The first page of the brochure provides the reader with the global overview of the project and the Consortium; the main goal of F-MAN is described, the participants identified and the references to the IST Programme provided. In the second page, scope and objectives of the project are described: users are addressed and the context identified. The third page refers to technical matters: by means of textual parts and pictures, current problems concerning freight rail cars management are presented together with the approach utilised in F-MAN for their solution. At last, in the fourth page a schematic Gantt diagram is presented, describing the development phases of the project, the expected outcomes identified and the contribution provided by F-MAN to both rail competitiveness and EC policies reported. Such Deliverable has been structured taking into account the EC guidelines concerning project documentation, and has anticipated the set-up of the F-MAN web page ([www.fman.org](http://www.fman.org)), whose main page is depicted in Figure 2.

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Figure 2 – Main page of the F-MAN Web site

### 5.3 Deliverable D3 – Users’ needs for a future Fleet Management

Deliverable D3 aims at providing the Users’ needs for the F-MAN application and follows the logical steps listed hereafter:

- description of the present situation, with a look on the national and international rail operations, the applicable rules, the way of operating the trains, the data exchange and the documentation handling, and the actual fleet management;
- description on the future trends in the international railway scenario;
- description of a set of problems affecting the railway field which emerge from the snapshot on the present situation and future trends;
- identification of the different F-MAN Users, definition of the meaning of “need” for each of them, identification of their needs (Users’ needs), identification of F-MAN Users’ needs, as that sub-set of the overall needs which may be addressed by F-MAN system;
- presentation of the main elements that will compose the future F-MAN scenario and definition of a general identikit for the role of the future Fleet Manager;
- a brief overview on other EU research projects, to allow the Consortium to take advantage from the already performed research actions and results.

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## 5.4 Deliverable D4 – Description of the Functional Requirements

Deliverable D4 is dedicated to the description of the F-MAN system requirements and the functional specification of the overall system, in compliance with the AFNOR standard X50. In particular, this document deals with F-MAN external functional analysis, which includes the following phases:

- determination of the external environment where F-MAN has to work;
- determination of the principal functions;
- determination of the constraints;
- validation of functions and constraints;
- determination of the main characteristics of functions and constraints.

The users' needs described in Deliverable D3 have been analysed in order to determine system functions and constraints, considering the F-MAN system as a black box whose composition is completely unknown and, in compliance with the AFNOR standard, by disregarding solutions being able to carry them out.

## 5.5 Deliverable D5 – F-MAN architecture

Deliverable D5 defines the overall Architecture of the F-MAN system, and it is based on the functional requirements. The F-MAN architecture defines the main components of the system, as well as their role, responsibilities and interrelations in fulfilling the functional requirements specification. The main features of the three main modules of the system (Tracking System Module, Data Processing Module, Asset Management Module) have been analysed and presented. The output presented in Deliverable D5 provided the needed input for both development and integration phases.

## 5.6 Deliverable D6 – Description of the F-MAN tools

Deliverable D6 contains the description of the F-MAN tools that have been designed along the project lifetime. The focus is on the information that this Deliverable provides regarding the characteristics of the different modules and the way they are integrated among themselves. Important details are presented in:

- Asset Management Module
- Data Processing Module
- Tracking System Module (included On Board Terminal and Centralised SMS Hub)
- Modules interfaces

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## 5.7 Deliverable D7 – Asset management kernel

Deliverable D7 is dedicated to the description of the Asset Management Module, dealing with the module architecture and functions, and it provides:

- description of the framework and architecture;
- description of the database tables for the AMM;
- description of the screen design;
- description of the AMM business process and implementation on the web pages.

The type of Deliverable D7, according to the Technical Annex I to the Contract, is set as “prototype” rather than “report”. This means that the paper documentation, prepared by the Consortium and whose contents have been previously reported, has to be regarded as an accompanying report to the prototype.

## 5.8 Deliverable D8 – Tracking kernel

Deliverable D8 is dedicated to the description of the Tracking System Module, and it reports a description of the On Board Terminal and the Ground Station, providing information related to the technical specifications and the installation procedures. Information related to the event messaging procedure and to the interface between the Tracking System Module and the Data Processing Module is reported too. The type of Deliverable D8, according to the Technical Annex I to the Contract, is set as “prototype” rather than “report”. This means that the paper documentation, prepared by the Consortium and whose contents have been previously reported, has to be regarded as an accompanying report to the prototype.

## 5.9 Deliverable D9 – Data Processing kernel

Deliverable D9 is dedicated to the description of the Data Processing Module, which implements an information management system able to:

- perform the user and wagon registration (F-MAN pool formulation);
- maintain the system database;
- translate wagons raw data into information ready to be used by the relevant users;
- integrate wagons OBT data with information coming from other entities to forecast ETA;
- perform the management of SMS communication;
- determine wagons availability taking into account status oriented maintenance and planned inspections.

The type of Deliverable D9, according to the Technical Annex I to the Contract, is set as “prototype” rather than “report”. This means that the paper documentation, prepared by the

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Consortium and whose contents have been previously reported, has to be regarded as an accompanying report to the prototype.

### **5.10 Deliverable D10 – F-MAN functional prototype**

Deliverable D10 contains the complete description of the F-MAN tools that have been developed along the project lifetime, after the integration of the modules, and can be considered as the F-MAN User Manual. The goal of this document is to provide the F-MAN user with a comprehensive information about the application. It has been structured to be technical enough to let the reader understand the behaviour of the application but not too specific in order to avoid confusing the user. To this purpose, the main contents of the document are the following:

- overview of the F-MAN system architecture, its main modules and concepts
- roles of the users of the system;
- reference guides for the utilisation of the AMM and DPM
- reference guide for the utilisation of the TSM digital map interface

Four Annexes have been included in the document in order to complete the description of the F-MAN prototype and to provide further information which may be useful for a thorough understanding of the application functioning and behaviour. Once again, the type of Deliverable D10, according to the Technical Annex I to the Contract, is set as “prototype” rather than “report”. This means that the paper documentation, prepared by the Consortium and whose contents have been previously reported, has to be regarded as an accompanying report to the prototype.

### **5.11 Deliverable D11.1 – The F-MAN verification plan**

Deliverable D11.1 aims at reporting all the needed details to plan prototype verification process and relevant activities. In particular, it presents the following information:

- an overall description of the tests. In particular, the tests operators team is presented and wagons characteristics, OBT installation sites, sensor installation conditions and tests corridors are described. Moreover, a description of tests procedure, test time schedule, software operators, verification reporting activities and user dissemination opportunities are provided;
- a description of the methodological approach considered for realising the verification plan. In particular, there is an explanation of the division of each function and each constraint of the F-MAN system into proper items to be measured and the identification, for each item, of some criteria to be verified;
- a detailed analysis of the verification plan. For each of the defined F-MAN Functions and Constraints, a table is provided identifying the items and their verification criteria.

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## 5.12 Deliverable D11.2 – Verification report

Deliverable D11.2 is dedicated to reporting the results collected during the Verification phase of the F-MAN Project. As detailed in the Verification plan, the verification activities were structured in two distinct sets:

- the testing of the proper functioning of each separate module (AMM, DPM, TSM);
- the testing of the overall F-MAN system following the On Board Terminals installation, their complete initialisation and the proper set up of all the parameters that characterise their functioning.

The first phase, started in summer 2003, lasted till the end of April 2004; the second phase started in March 2004, with the first OBT installed at Miramas depot (France), and relevant on-field results collected since that date. It is worth noting that the results presented in the report refer to the set of data collected till the end of September 2004. The document contains the following topics:

- a complete description of the F-MAN verification scenarios, and in particular of the railway corridors along which the F-MAN equipped wagons ran during the tests;
- an overview of the verification process, where the procedure adopted to perform the field tests is described as well;
- a description of the setting-up of the test sites equipment is provided, where the adopted solutions to reach the primary goals of the verification task are presented too;
- the description of the results achieved during the testing and verification phases, where verification reporting tables for F-MAN Functions and Constraints are presented, as well as ETA results and communication and OBT related measures.

## 5.13 Deliverable D12 – Evaluation Plan

Aim of Deliverable D12 is to ensure understanding and acceptance of the evaluation goals, and to define evaluation activities and their end products. The document presents the following steps of the validation process in their logical succession:

- definition of users and their needs, as the basis for the identification of the main goals of the F-MAN applications;
- description of the applications to be validated within the project;
- identification of assessment objectives (general analysis of potential assessment objectives relevant to the project);
- definition of expected impacts (pre-assessment) for users/non-users affected by the applications;
- selection of assessment categories to be addressed within the project (based on actual possibilities and resources of the project);
- outline of validation methods for the selected assessment objectives and relevant study design (definition of indicators, reference case, qualitative and quantitative assessment, statistical considerations, etc.).

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### 5.14 Deliverable D13 – Evaluation results

Deliverable D13 is based on the Evaluation Plan, which identified evaluation objectives, guidelines and procedures to be considered by F-MAN partners in order to allow a fair and exhaustive assessment of project results and their impact for users and decision makers relevant to the rail freight transport context. This Deliverable aims at providing the reader with a description of the results achieved by the Evaluation team as a consequence of the assessment process implemented within the F-MAN project. Being such deliverable characterised by the security level Public, the issuers have preferred to prepare the report as a stand alone document, and for these reasons it is structured in two parts:

- in the first part a comprehensive and concise description of the research framework is provided, as well as the objectives, the technical approach and the validation methodologies relevant to the F-MAN project;
- in the second part a detailed report on the results of validation and evaluation activities, that determines the overall project assessment, is presented.

### 5.15 Deliverable D14 – Dissemination and use plan

Deliverable D14 describes the dissemination actions, the plan for dissemination of knowledge gained during the work and a preliminary overview on the exploitation of the project results, for each partner and for the F-MAN consortium as a whole, as identified in the early stage of the system development. According to the EC Guidelines for preparing Project reports, this Deliverable is structured in the following sections:

- Overview
- Description of Dissemination Plan
- Description of Use Plan

As far as the overview on the exploitation intentions are concerned, the information provided in the Deliverable has to be considered a preliminary analysis carried out by the partnership, paving the way for the issue of the final exploitation plans elaborated at the end of the project and presented in Deliverable D15.

### 5.16 Deliverable D15 – Technological Implementation plan

Deliverable D15 represents a specification for the use, dissemination and exploitation of the results of the project, and describes the participants' actual achievements in dissemination and their plans for the exploitation of their results. The TIP allows the project contractors to show how they are going to meet their obligations, enables the Commission to gather information needed to make evaluations and internal comparisons, and represents a tool for further disseminating the non-

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confidential information about the project outcomes through the services provided by the EC. In the first section of the document the publishable contents of the TIP are described. They deal with a detailed global overview on the project and its impacts at the European level, and with the description of the eight main exploitable results:

- F-MAN prototype
- Asset Management Module
- Data Processing Module
- Tracking System Module
- Graphical User Interface
- ETA algorithm
- Service, support & training for installation and use
- SMS Hub

In the second section of the document the confidential contents of the TIP are described. They deal with the exploitation plan(s) of each Partner and describe its intentions for the exploitation and dissemination of one or more of the project main results, together with a timetable of its future activities.

### **5.17 Deliverable D16 – Final report**

Deliverable D16, that is the present document, provides a comprehensive 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. Taking into account the structure proposed by the EC in “Guidelines for preparing project reports”, the document contains:

- overview on the project, its objectives and the methodology followed to reach them;
- presentation of all project results and achievements, included an overview of the official Deliverables;
- description of the Project management and coordination aspects.

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### 5.18 Deliverables list

In the following Table 5, the list of the project Deliverables is provided. Its is worth mentioning that security level *Restricted* addresses those Deliverables that are accessible to the circulation list (specified by the Consortium) and Commission Project Officer only.

Table 5 – List of F-MAN Project deliverables

Del. No.	Deliverable name	WP no.	Lead participant	Deliverable type	Security	Delivery (project month)
D1	Overall Quality Plan	WP8	SCIRO	Other	Internal	1
D2	Project Presentation	WP7	NTUA	Web-page	Public	7
D3	Users' needs for a future Fleet Management	WP1	SCIRO	Report	Public	7
D4	Description of the Functional Requirements	WP2	SCIRO	Report	Restricted	9
D5	F-MAN architecture	WP2	NTUA	Report	Restricted	11
D6	Description of the F-MAN tools	WP3	SCIRO	Report	Restricted	19
D7	Asset management kernel	WP3	IVU	Prototype	Internal	19
D8	Tracking kernel	WP3	SCIRO	Prototype	Internal	19
D9	Data Processing kernel	WP3	NTUA	Prototype	Internal	19
D10	F-MAN functional prototype	WP4	IVU	Prototype	Restricted	33
D11.1	The F-MAN verification plan	WP5	SCIRO	Plan	Restricted	25
D11.2	Verification report	WP5	CP	Report	Public	34
D12	Evaluation Plan	WP6	UGDIE	Report	Public	19
D13	Evaluation results	WP6	UGDIE	Report	Public	36
D14	Dissemination and use plan	WP7	SCIRO	Report	Restricted	9
D15	Technological Implementation plan	WP7	SCIRO	Report	Restricted	36
D16	Final report	WP8	SCIRO	Report	Public	36

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### **5.19 Articles and Conference presentations regarding the F-MAN project**

This section is dedicated to resuming the articles published by the F-MAN Partners along the course of the project, as well as the main dissemination activities carried out during Conferences, Workshops and dedicated meetings. In such a context, it is worth mentioning that detailed information about the contents of the dissemination activities depicted in the following Table 6 can be retrieved from the F-MAN WEB site ([www.fman.org](http://www.fman.org)), which represents the most effective dissemination tool utilised by the Consortium. The site was developed since the early phase of the project and continuously updated during its whole lifecycle.

*Table 6 – Dissemination activities*

<b>Event</b>	<b>Action</b>	<b>Authors</b>
WCRR 2001 - World Congress on Railway Research, November 25 <sup>th</sup> – 29 <sup>th</sup> , 2001, Köln Germany	The paper titled “ <i>A vision of future freight rail fleet management</i> ” was presented	E. Kuhla, R. Bozzo, A. Derito, R. Nurchi and V. Recagno (SCIRO)
NECTAR Workshop on “Impacts of Network Integration on Spatial Structures”, May 10 <sup>th</sup> & 11 <sup>th</sup> , 2002, Ikaria, Greece	The paper titled “ <i>Integrating operational information along the transport chain: the case of wagon asset management</i> ” was presented	A. Ballis, D. Rigopoulos and E. Koukoutsis (NTUA)
RailServ, Cluster meeting May 31 <sup>st</sup> , 2002, Copenhagen, Denmark	A presentation was given to the audience	E. Kuhla (SCIRO)
Sixth UIC Internet Club Forum, November 28 <sup>th</sup> & 29 <sup>th</sup> , 2002, Paris, France	The presentation titled “ <i>Railcar Asset Management – EU Project F-MAN</i> ” was given	E. Kuhla (SCIRO)
Gesamtverkehrsforum 2003 - Güterverkehrsforum, October 11 <sup>th</sup> & 12 <sup>th</sup> , 2003, Braunschweig, Germany	The presentation titled “ <i>IT – Lösungen für den grenzüberschreitenden Schienen-Güterverkehr</i> ” was given	E. Kuhla (SCIRO)
Railway Gazette International – November 2003 Issue	The paper titled “ <i>F-MAN will boost wagon productivity in Europe</i> ” was published	E. Kuhla (SCIRO), A. Ballis (NTUA) and M. Guigon (SNCF)
ERRI: Satellite-based Application for Railways, January 20 <sup>th</sup> & 21 <sup>st</sup> , 2004, Paris, France	The presentation titled “ <i>Asset Management of European Freight wagons</i> ” was given	E. Kuhla and G. Cosulich (SCIRO)
UIC Section Materiel Reunion, May 4 <sup>th</sup> , 2004, Paris, France	The presentation titled “ <i>F-MAN: Asset Management of European Freight wagons</i> ” was given	E. Kuhla and G. Cosulich (SCIRO)
Ninth International Conference COMPRAIL 2004, May 17 <sup>th</sup> – 19 <sup>th</sup> , 2004, Dresden, Germany	The paper titled “ <i>Fleet management in railway freight transport: the EU project F-MAN</i> ” was presented	M. Giannettoni and S. Savio (UGDIE)
ITS in Europe 2004 Congress & Exhibition, May 24 <sup>th</sup> – 26 <sup>th</sup> , 2004, Budapest, Hungary	The Consortium prepared dissemination material that was distributed and discussed during the Congress	F-MAN Consortium

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International Railway Seminar (AICCF – IRCA), May 27 <sup>th</sup> & 28 <sup>th</sup> , 2004, Ljubljana, Slovenia	During the two days seminar, panels regarding F-MAN project and results were exposed and commented	P. Kranjec (PI)
IST Results e-bulletin – June 2004	A presentation of the F-MAN application titled “ <i>A competitive boost for rail freight</i> ” has been published in the bulletin ( <a href="http://istresults.cordis.lu">http://istresults.cordis.lu</a> )	S. Savio (UGDIE) and E. Kuhla (SCIRO)
ETA Workshop, January 11 <sup>th</sup> , 2005, UIC premises, Paris, France	Topics concerning ETA procedures will be presented and discussed	E. Kuhla (SCIRO), A. Ballis (NTUA)

## 6 Project management and co-ordination aspects

Project management and co-ordination activities have been carried out by two different partners:

- UGDIE (CO) covered the administrative and financial aspects;
- SCIRO (CS) covered the scientific and technical aspects.

In such a context, “Management” dealt with monitoring the contractual obligations fulfilment and the financial situation of the project towards the budget, and with reporting to the European Commission (EC). “Co-ordination” dealt with controlling the development of the research activities and the achievement of the expected results, according to the contents of the Technical Annex to the contract.

In performing those tasks, UGDIE and SCIRO have been supported by the other partners according to the hierarchical structure depicted in the following Figure 3. Such management and co-ordination structure was based on two levels:

- The Project Co-ordinators (PCs) level;
- The Work Package Leaders (WPLs) level.

Generally speaking, the work division between the two levels was defined by the following philosophy: on the basis of the WP activities (which was responsibility of the relevant Work Package Leader) the Project Co-ordinators had to manage and co-ordinate the project on the WPLs level. The Administrative and Financial Co-ordinator had also the responsibility to provide the interface between the Consortium and the EC. Through an escalating procedure:

- The WP Leaders had to supervise and co-ordinate the activities carried out by each Task Responsible of their Work Package, as far as results and relevant timetable were concerned, reporting to the Project Co-ordinators deviations, if any, from the project plans.
- The Project Co-ordinators had to manage and co-ordinate the whole project, reporting to the EC deviations, if any, from what contractually agreed.

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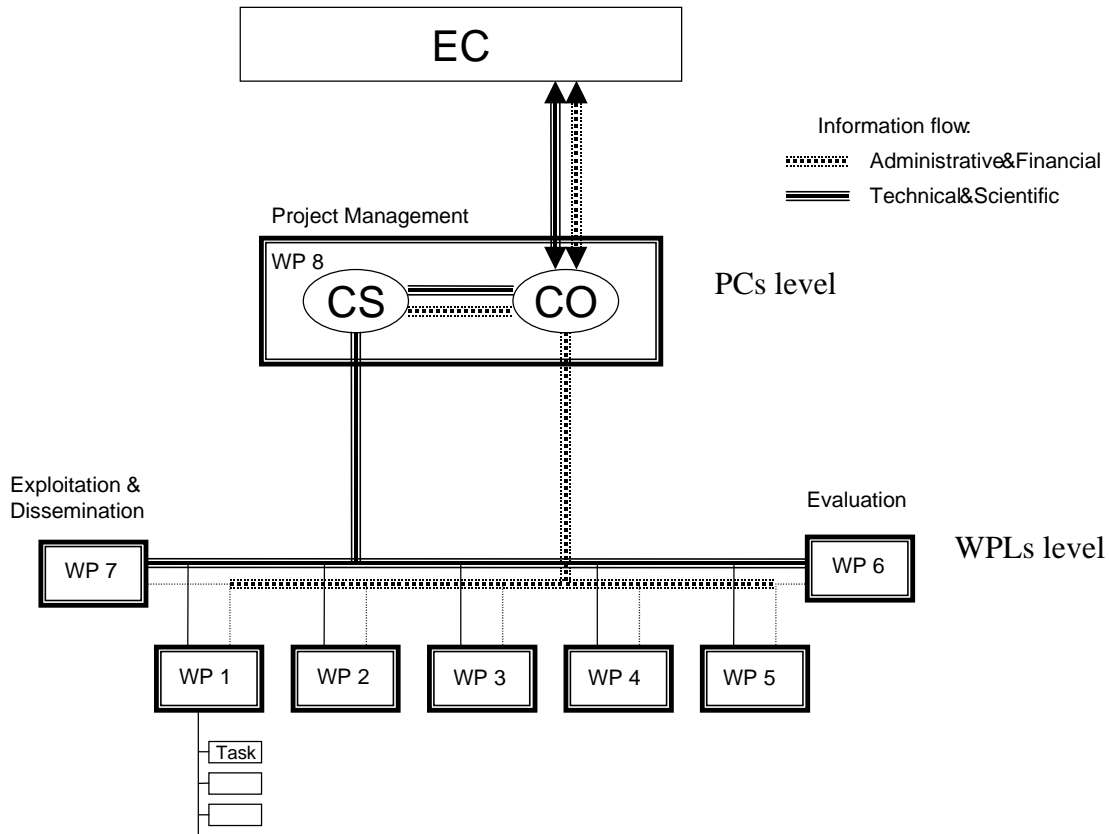


Figure 3 – Management and co-ordination structure

The basis for an effective management of the project were two coded documents, “Overall Quality Plan” and “Documentation Handling”, issued by the Project Co-ordinators at the beginning of the project. Those documents clearly described the operating procedures to be adopted, the documents to be issued and the processes to be implemented, as part of the contractual activities, throughout the life cycle of the project. Moreover, a dedicated project documents database was also developed by UGDIE in order to carry out the configuration management. Such tool revealed to be extremely important for documentation tracking and tracing purposes, taking into account that more than one hundred coded documents have been issued by the Consortium.

From the operating point of view, the most important co-ordination element was represented by the Project Management Board. This included the Work Package Leaders under the co-ordination of the Scientific Co-ordinator. Project Management Board meetings were triggered by milestone deadlines or unexpected issues, in order to:

- agree on deliverables and reports;

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- discuss possible solutions concerning problems not solved at the WP level;
- define organisational and planning items.

During the development of the activities, all the partners have strongly cooperated with the Project Co-ordinators level to reach the successful completion of the project, sometimes performing more than contractually required.

Information exchange has been fast and on-time. From one side all the partners were informed by the Project Co-ordinators about the project status, the planning and any other issues, where appropriate, in order to obtain maximum transparency and awareness. On the other side technical, administrative and financial information has been promptly communicated by each of them to the Project Co-ordinators, who have immediately distributed it to the other partners, whenever needed. Information/requests received from the EC and concerning the Consortium has been real-time forwarded by the Administrative and Financial Co-ordinator to the partnership.

For the whole duration of the project, the partners have also provided the Project Co-ordinators with their effective contribution for issuing the Quarterly Management and Progress Reports, as well as with comments and suggestions for improving the contents of the project Deliverables, according to the two rounds process foreseen in F-MAN for the Peer Review procedure.

During the lifecycle of the project the Consortium had to face heavy problems concerning the withdrawal of two Partners, namely Trenitalia S.p.A. and Tecnosistemi S.p.A. – TLC Engineering & Services, which were present within the partnership at the beginning. The problem of the withdrawal of Trenitalia arose very early and was successfully solved by the arrival of a new Partner, namely Sigma Conseil, and the presence of SNCF as leader of the ROG. Anyway some delay was collected and the Consortium judged not feasible its recovery within the scheduled project deadline. For such reason a request for a time extension of three months, with no budget increase in respect to the one defined at the beginning, was also submitted to the EC. The request was fully accepted by the EC and formalised in the 1<sup>st</sup> Amendment to the contract, where the contractual deadline for completing project activities was shifted from March 2004 to June 2004. The problem of the withdrawal of Tecnosistemi arose by the end of the second project year and was successfully solved by the Consortium through a reallocation of work and budget. Anyway some delay was collected also in this case and the Consortium judged not feasible its recovery within the scheduled project deadline. For such reason a request for a further time extension of three months, with no budget increase in respect to the one defined at the beginning, was also submitted to the EC. The request was fully accepted by the EC and formalised in the 3<sup>rd</sup> Amendment to the contract, where the contractual deadline for completing project activities was shifted from March 2004 to September 2004.

At last, although the Final Cost Statements will be officially submitted after the issue of the current report, the first draft version of that documentation has been already analysed by the Administrative and Financial Co-ordinator and, taking into account the costs claimed by the whole partnership, it is possible to assess that the project activities have been fully completed within the budget.

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## 7 Outlook

Partners applying for Intellectual Property Rights are willing to establish a joint venture to exploit the project results properly, i.e. partners will exploit the project results as a whole and share the relevant benefits in terms of commercial exploitation. The Joint Venture will propose to interested clients (i.e., Rail Cargo Companies, wagon leasing companies) the F-MAN tools developed either as a complete product set, or as a service, using the Application Service Provision model, by applying a small licence fee and a “pay per transaction” scheme. The development of the final F-MAN product will come 12-18 months after the end of the project, following an industrialisation phase that ensures that the product is viable for market purposes (i.e., improving the release available for the functional prototype to a more appealing and effective product).

Each partner will also be allowed to exploit individually its own achievements following establishment of IPR or to grant to some other partners permission to exploit them. Individual partners' exploitation intentions are described in details in a dedicated section of Deliverable D15 – Technological Implementation Plan. Being the contents of that section confidential, an undisclosed overview of the exploitation intentions of the Partners, grouped according to the main business core of the company in the field F-MAN deals with, is provided in the following. Such groups are:

1. Technology developers
2. Users
3. Academic bodies

The group of the technology developers is mainly constituted by partners such as SCIRO, IVU and EDC. Aside the role of researchers and technology developers covered within the F-MAN project, such Companies have missions which include roles of technology advisor, technology provider, technology customisation and system integration. All those roles are positively influenced by the expertise that such companies have acquired during the research activities performed in the three years of the project, and those benefits are reflected in their business activities. Their exploitation intentions, namely the industrialisation and commercialisation of the F-MAN tools, have already been presented, according to the obvious confidentiality restrictions, at the beginning of this paragraph.

Among the group of Users, it is possible to include CP, SNCF and SZ, which are the three main Railway Cargo Operators that participated at the F-MAN project. It is worth mentioning that SNCF, which also acted as the Leader of the ROG group, formally was included in the partnership only indirectly (participating through the Company SIGMA), as well as SZ (active through a contract agreement with PI). All the mentioned companies will be able to effectively benefit from the know-how gained during the project development. The employment of the industrialised release of the F-MAN tools would indeed:

- increase the competitiveness of the rail freight services offered by the company, raising the level of service and its quality towards the customer. This could be achieved by the implementation of a suitable fleet management scheme that could provide the customers with a more reliable offer;

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- increase efficiency and productivity through a better utilisation of the company assets;
- improve the capacity and features of the company's IT systems, in order to enlarge the reliability of the information flowing through the different company branches;
- reduce maintenance costs, by optimising the fleet maintenance scheme.

As far as the academic bodies are concerned, the group consists of UGDIE and NTUA. As higher education and research institutions, their exploitation plans are mainly related to teaching, dissemination and knowledge improvement activities. The know-how gained from the project, as far as information technologies for transport operation and management are concerned, will be used to improve the contents of regular and post-graduated courses. Moreover, regarding the use of the final results, such education and research institutions will be mainly oriented to perform academic follow-up (papers in scientific journal and conferences).

## 8 Conclusions

From the scientific point of view, the tests results on the prototype determined a high degree of satisfaction of the overall Partnership, both the End Users and the technology developers/academic bodies. Indeed, the quality of the results matched the expectations of the Partnership, especially in consideration of all the difficulties that such a delicate system had to cope with.

The advantages that the adoption of F-MAN system in railway cargo operations proved to be clear and evident to the End Users. They mainly reside in the possibility of increasing the productivity of the management of their wagons fleet, which is a key element towards any general optimisation process.

Notwithstanding all the positive results obtained by F-MAN system at its up-to-date prototype stage, raising the look to the future of the system to step from the actual prototype configuration to a marketable industrial product, some customisation of the system should be performed to match all customers requirements. But customisation needs are typical phases in niche applications as the one the F-MAN solution is devoted to.

Thanks to the developed prototype it was possible to demonstrate that the underlying concept for an asset management is valid and feasible. For instance, based on the order of the Order Manager, the Fleet Manager is able to raise “his” productivity by selecting the best-choice wagon proposed him by the F-MAN tools. Moreover he is able to change his former selection of a wagon based on a proactive ETA information. This and all the other processes have been verified on-the-field and the general feasibility has been reinforced by some simulations based on a considerable amount of operated wagons.

The challenge for the future is actually going on, being the Partnership already actively working in that direction.

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## 9 Acronyms and abbreviations

The following acronyms are used in this document:

AMM	Asset Management Module
DPM	Data Processing Module
ETA	Expected Time of Arrival
FM	Fleet Manager
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GS	Ground Station
GSM	Global System for Mobile Communication
IM	Infrastructure Manager
MM	Maintenance Manager
OBT	On-Board Terminal
OM	Order Manager
OPM	Operational Manager
PDU	Protocol Data Unit
RCO	Railway Cargo Operator
ROG	Railway Operators Group
RTD	Research and Technology Development
RU	Railway Undertakings
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
TOC	Train Operating Company
TSM	Tracking System Module
TT	Tracing & Tracking
UIC	Union Internationale Chemin de fer
WP	Work Package
WO	Wagon Owner
XML	eXtensible Markup Language

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