European ITS Framework Architecture

-

Physical Architecture

Annex 1 – Descriptions of “example Systems”

Annex 1 of D3.2 - Issue 1

August 2000

This public report has been produced by the KAREN (Keystone Architecture Required for European Networks) project, as part of the 4th Framework Programme - Telematics Application Programme – road sector.

KAREN partners contributing to this report are:

SIEMENS TRAFFIC CONTROLS LIMITED
UNIVERSITY OF LEEDS
ALCATEL AUSTRIA
ALCATEL SPACE INDUSTRIES
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Document control sheet

Activity name: KAREN

Work area: Framework Architecture Development - WP3

Document title: Physical Architecture

Document number: D3.2 – Annex 1

Electronic reference:

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Dissemination level[1]: Public usage

Version history:

Version number	**Date**	**Editor**	**Summary of changes**
Issue 1	August 2000	R.A.P. Bossom	Final Public Issue

Approval:

	Name	**Date**
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Circulation:

Recipient	**Date of submission**
CEC	August 2000

[1] This is either: Restricted (to the programme, to the activity partners) or for Public usage

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Executive Summary

This Document is the first Annex (Annex 1) to the Main Document part of the European ITS Physical Architecture Deliverable Document (D3.2). It provides a description of each of the "example Systems" that have been used to show how the Functional Architecture can be used to create "real" Systems or Architectures. These "example Systems" illustrate examples of products that could be produced to fulfil some of the European ITS User Needs, or Architectures that could be used for further ITS development at National or local level. This approach has been adopted because there are many ways in which a Physical Architecture can be produced from a Functional Architecture.

The description of each "example System" includes details of the parts of the Functional Architecture (Functions, Data Flows and Data Stores) that it includes, as well as providing information on what the System or Architecture can provide. The final part of each description includes a section on "Key Issues". These are "Issues" that have been addressed and resolved to enable each "System" to be successfully deployed and implemented. They are also shown together in a single Chapter in the Main Document.

1. Introduction

1.1 Outline

This Document is part of the set of deliverables produced by the KAREN Project to describe the European ITS Framework Architecture. It is the first Annex to the European ITS Physical Architecture Main Deliverable Document (D3.2). It provides a description of each of the "example Systems" that have been developed as part of the Architecture. These are intended to show examples of the physical Systems and Architectures that can be developed using components from the European ITS Functional Architecture. Details of the rational behind this approach and the methodology that has been used will be found in Chapters 2 and 3 of the Main Document.

1.2 Where the document fits in the Architecture Documentation

The document is one of a set of two Annexes to the main European ITS Framework Physical Communications Architecture Deliverable Document (D 3.2). The other Annex in the set is:

D3.2, Annex 2 - Physical Architecture - Function and Data Store Overviews and Templates

1.3 Overview of the Document Structure

This document is divided into several Chapters. Each of these provides a description of an "example System" created from the European ITS Functional Architecture. These "example Systems" are intended to cover a variety of ways in which the Functional Architecture can be developed into actual Systems and Architectures. These "Systems" are able to deliver one or more of the services required by the User Needs. Each "System" is described in such a way that procurement specifications can be written for its components.

1.4 List of Abbreviations

ACI	Automobile Club d'Italia (Italian automobile club)
ADAS	Advanced Driving Assistance System
AISCAT	Associazione Italiana Società Concessionarie Autostrade e Trafori (Italian National association of Motorway Operators)
ANAS	Ente Nazionale per le Strade (Italian road national administration)
ATP	Actual Trip Preference - used in several Systems
COMETA	European Project that has defined the In-vehicle Architecture for Freight Vehicles

DATEX	DAta EXchange - the name given to a specification and activities aimed at providing and maintaining a standard for the exchange of data. For more information please go to the DATEX Web Site at: http://www.datex.org.
DFD	Data Flow Diagram - see Chapter 2 of European ITS Functional Architecture Deliverable Document for a detailed definition.
DGPS	Differential GPS
DSRC	Dedicated Short Range Communications
EDI	Electronic Data Interchange
EU	European Union
FFM	Freight and Fleet Management
GPS	Global Positioning System - the satellite network that is run by the US Department of Defense, that enables an object's position to be determined within an accuracy of down to +/- 30 metres.
GSM	Global System for Mobile - a World-wide based standard for mobile telephone communications.
GTP	General Trip Preference - used in several Systems
HGV	Heavy Goods Vehicle
ILOC	Intersection LOCation - a referencing standard
ITS	Intelligent Transport Systems
IVD	In-Vehicle Device - used on the travel guidance System
KAREN	Keystone Architecture Required for European Networks
LLOC	Link LOCation - a referencing standard
MFO	Multi-Functional Outstation - used in the Urban Traffic Control and Public Transport Priority System
MLOC	Movement LOCation - a referencing standard
OBU	On-Board Unit
P+R	Park and Ride
PC	Personal Computer
PT	Public Transport
PTM	Public Transport Management

RDS-TMC	Radio Data System - Traffic Message Channel. Note that these abbreviations are also used on their own, and take their individual meanings.
TA	Traveller Assistant - used on the travel guidance System
TARG	Traveller Assistance and Route Guidance - name for “example System”
TCC	Traffic Control Centre
TIC	Traffic Information Centre
TICS	Transport Information and Control Systems
TITOS	Torino ITS 2000 Open Showcase
TSC	Traveller Support Centre
VPS	Vehicle Positioning System - used in the Automatic Road Tolling System

2. Integrated Traffic Management Systems

2.1 Introduction

This Chapter describes four “example Systems” in the Physical Architecture that provide some integration of Traffic Management activity with other activities. These other activities include such things as Public Transport Management and Parking Management.

2.2 P1 - Integrated Urban Traffic and Public Transport Management System

2.2.1 Overview

This System offers comprehensive traffic and travel real-time data at different levels of detail and complexity. Moreover it provides available communication channels to deliver services to the travellers and interfaces to outstanding ITS application protocols.

It is based on an open environment, called TITOS (Torino ITS 2000 Open Showcase), which will be tested at the 7th ITS World Congress in Turin, Italy. TITOS will include state-of-the-art ITS components and infrastructures forming a “real-life” open platform implementing the most recent results in the field of system architecture, communication standards, service specifications and data exchange open specifications. By simply plugging-in the TITOS platform, participants will show their services or products through three different levels of interactions:

- Participants will have free access to real data from the Turin city, national and international traffic data, tourist and congress information. Examples of information provided by the 5T system (the system for the traffic and travel control and information in Torino) include vehicle flows and speeds, travel times, queues, pollution predictions and measurements, public transport travel times and timetables and car park availability.

- Subject to special agreements with 5T, it will be possible for interested service providers to benefit from processing engines that are made available by 5T and are capable of providing processed data on demand, to be used as a basis for value added services. Processing engines include information on incidents, congestion and anomalies detected on specified routes (both private vehicles and public transport network), the quickest route to reach a destination and collective re-routing information calculated according to the global dynamic control strategies.

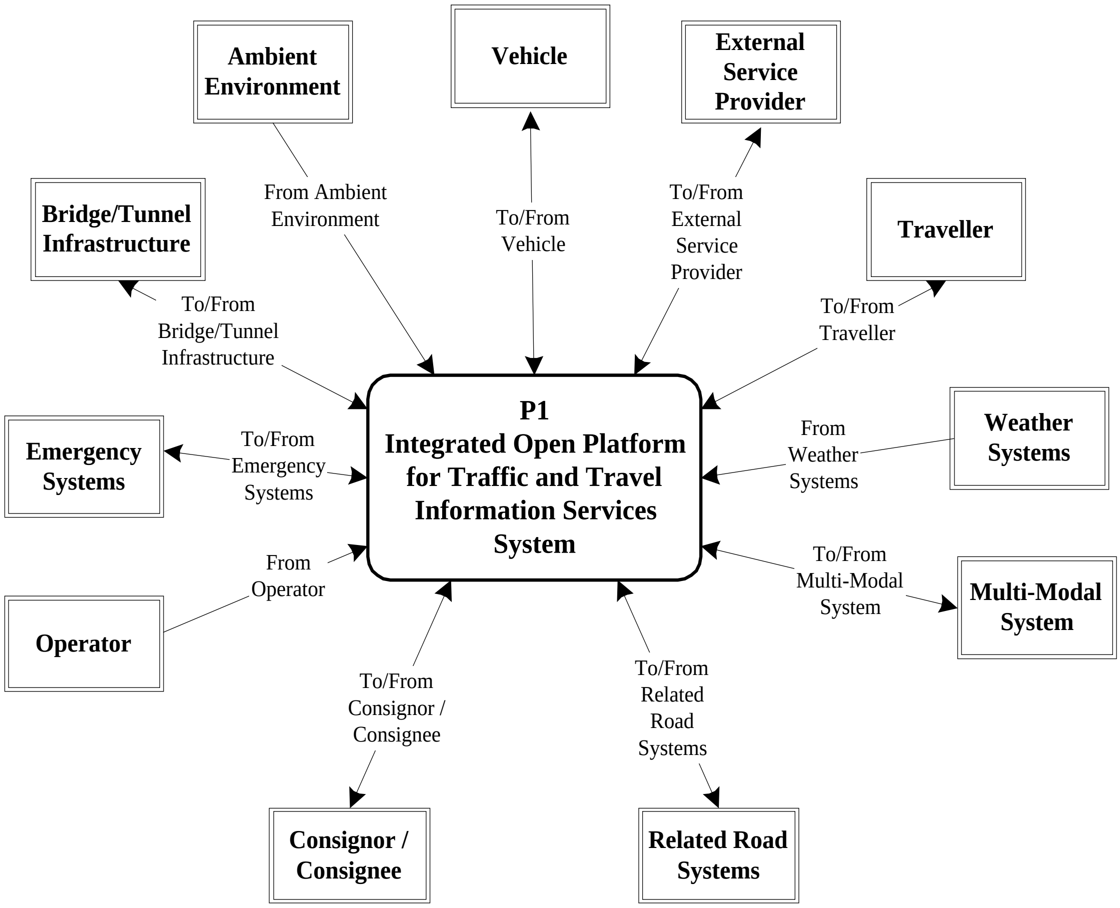
- Finally, there will be free access to different communication channels to deliver services to final users. The communication media available as a minimum will be RDS-TMC, DAB/DMB, GSM, Televideo/Teletext and Internet.

The System aims at describing a complete ITS application where TITOS represents the core component, as the principal issue of this example is to show the inter-operability of the various actors involved in a “plug and play” working environment. Obviously, other components (e.g. traffic and travel information sub-systems) and infrastructures are needed to provide a basic operative system. These components complete the ITS application we are going to describe.

2.2.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram, which is shown in the following Figure. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting the unused Terminators.

Figure 1 Integrated Urban Traffic and Public Transport Management System Context Diagram



From a comparison with Figure 1, a total of eight Terminators in the general list are not required by this System.

Some of the listed terminators are to be considered “potential” terminators. In fact, the analysed system is an “open platform”, meaning that it is open to the connection with any new actor or systems. With this point of view, many additional terminators might be included in the scheme during the different stages of the system life cycle.. As at this stage it not so obvious anticipate what the data flow to/from potential terminator will be, it was decided to analyse in detail the terminators who to-date have already shown their real interest in TITOS, while the potential terminators are listed but not described in their data flows.

Notwithstanding this, the physical architecture example continues to be valid in explaining why this system is being projected and built and will be operative by the end of the 2000 year. The potential terminators and the excluded, plus details of the actors excluded from “generic” terminators are shown in the following table.

Table 1 P1 Integrated Open Platform for Traffic and Travel Information Services System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Potential.
Bridge/Tunnel Infrastructure	Potential.
Consignor/Consignee	Potential.
Driver	Not included as it is included in the Traveller class of terminators.
Emergency Systems	Potential.
External Service Provider	The following actors in this terminator are required by this System: Bookable Service Provider, General Information Provider, Multi-modal Travel Information Provider. Not required but potential actors are: Geographic Information Provider, Planned Event Organiser, Vehicle Renting Agency and Broadcaster, Freight Storage Renting Agency.
Financial Clearinghouse	Not included. Out of scope.
Freight Equipment	Potential
Law Enforcement Agency	Not included. Out of scope.
Location Data Source	Not included as it is considered part of the platform clients.
Maintenance Organisation	Not included. Out of scope.
Multi-Modal System	The following actors in this terminator are required by this System: Multi-Modal Management System. Not required but potential actors are: Multi-Modal Crossing, Other Mode Freight System.
Operator	The following actors in this terminator are required by this System: Traveller Information Operator.

Terminator Name	Reasons for deletion or modification
Road Pavement	Not included. Out of scope.
Traffic	Not included as it represents the input of the Related Road Systems terminator class.
Transport Planner	Not included. Out of scope.
Weather Systems	Potential.

2.2.3 Sub-systems

This System consists of five main Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the following Figure together with their relationships with each other and the Terminators.

P 1.1 Interface Platform Sub-system: - this Sub-system provides all of the centralised functionality for interoperability among systems. It includes every needed interface to enable systems to exchange and share data using European standardised or emerging solutions (e.g. DATEX-Net, Intelligent Physical Agent technologies, Internet). Furthermore, this sub-system provides the needed transmission chains to receive and transmit basic data, elaborated data and services to the traveller through the desired transmission channels (e.g. be RDS-TMC, DAB/DMB, GSM, Televideo/Teletext, Internet) by providing the gateway to the shared communication infrastructure.

P 1.2 National and International Data Provider Sub-system: - this Sub-system provides traffic basic and elaborated data at the national and international level of detail. These data are obtained from the real-time monitoring made by external road systems. It actually represents the Italian national traffic information gathering centre.

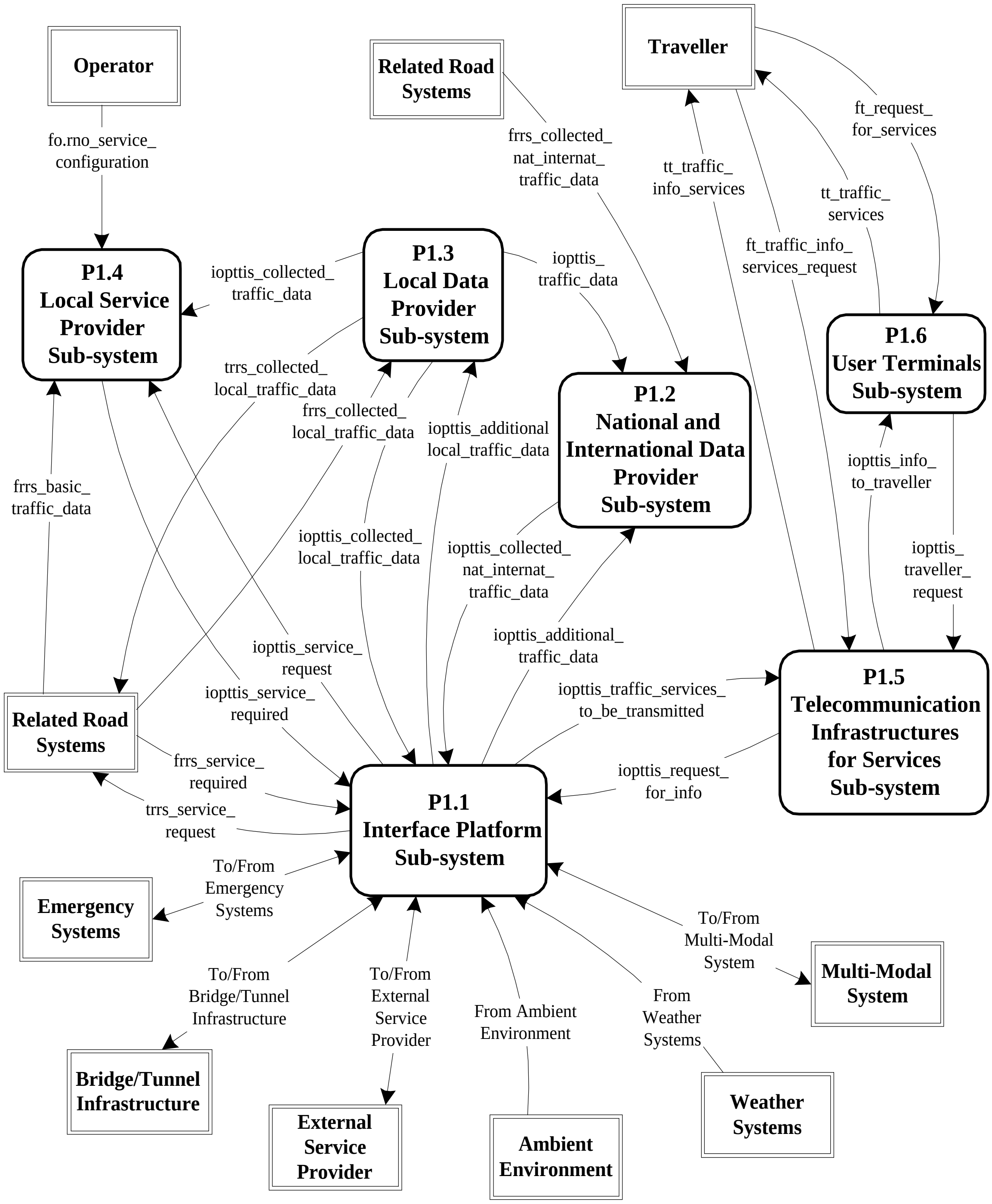
P 1.3 Local Data Provider Sub-system: - this Sub-system provides basic and elaborated traffic data needed at an urban level of detail. These data are obtained through the real-time monitoring of the traffic system in the city. In practise it represents the part of the 5T system performing the role of data provider.

P 1.4 Local Service Provider Sub-system: - this Sub-system provides services based primarily on the basic and elaborated data shared by the P1.3 (i.e. the previous Sub-system) and optionally on additional local data. It includes processing engines capable of providing processed data on demand, to be used by external service providers as a basis for value added services.

P 1.5 Telecommunication Infrastructures for Services Sub-system: - this Sub-system provides all the infrastructures needed to transmit data through different transmission channels (e.g. DAB/DMB, FM/RDS, GSM, Televideo/Teletext, Internet). The telecommunication infrastructure is owned and run by different operators who agreed to make it available and shared, through the open platform, to service providers.

P 1.6 User Terminals Sub-system: - this Sub-system includes the equipment needed to inform the traveller, static and dynamic, who is the final user of the whole System. The terminals are located at the airport and in the city with a uniform coverage of the urban area. User terminals are state-of-the-art technology equipment owned by 5T and possibly offering the possibility to host applications of external service providers.

Figure 2 P1 Integrated Open System for Traffic and Travel Information Services - Sub-Systems



2.2.4 Sub-Systems and Functions

The six Sub-systems identified in the previous section can themselves be split-up into Modules and Functions. Three of the Sub-systems (P1.1, P1.3 and P1.6) split up into Modules and this is described in the next section. The remaining three Sub-systems split up directly into Functions as shown by the table in a later section.

2.2.5 Modules

2.2.5.1 Introduction

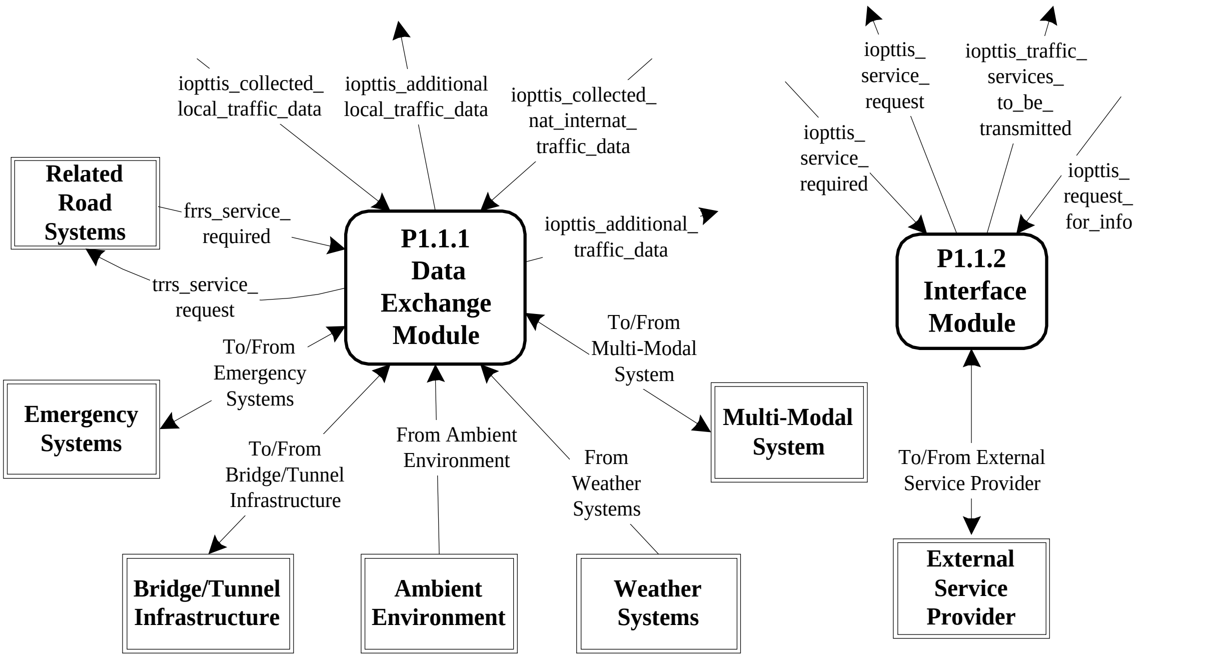
As noted above, three of the Sub-systems in this System are divided into Modules. These Modules enable parts of the Sub-systems to be provided separately and/or to be sited in differing locations. The Modules in the individual Sub-systems are described below and shown in the following Figures together with their relationships with each other and the Terminators.

2.2.5.2 Modules in P1.1 Interface Platform Sub-system

The Interface Platform Sub-system consists of two modules. These cover the exchange and sharing of data among systems, giving the possibility of sharing different transmission channels to reach the final user. Their descriptions are as follows.

P1.1.1 Data Exchange Module: - this Module enables traffic data to be shared and exchanged using different European standardised and/or emerging solutions (e.g. DATEX-Net, Intelligent Physical Agent technologies, Internet). It consists of a set of nodes which can be accessed also by external systems (e.g. Related Road System, Multi-Modal System).

Figure 3 P1 Integrated Open Platform for Traffic and Travel Information Services System - Interface Platform Sub-system Modules



P1.1.2 Interface Module: - this Module provides the needed interfaces with the different shared transmission channels. Multimedia servers handle the way that information can be provided to the various media channels, so that the DAB/DMB server will use the MOT protocol to send web pages and data to DAB transmitters, the POP internet server will use the FTP protocol to send data using the Internet, the WML server will manage WML sites to be browsed via GSM using the WAP, the GSM-SMS server will properly address SMS data to network operators, the Televideo/Teletext server will properly address data to Televideo/Teletext transmitters.

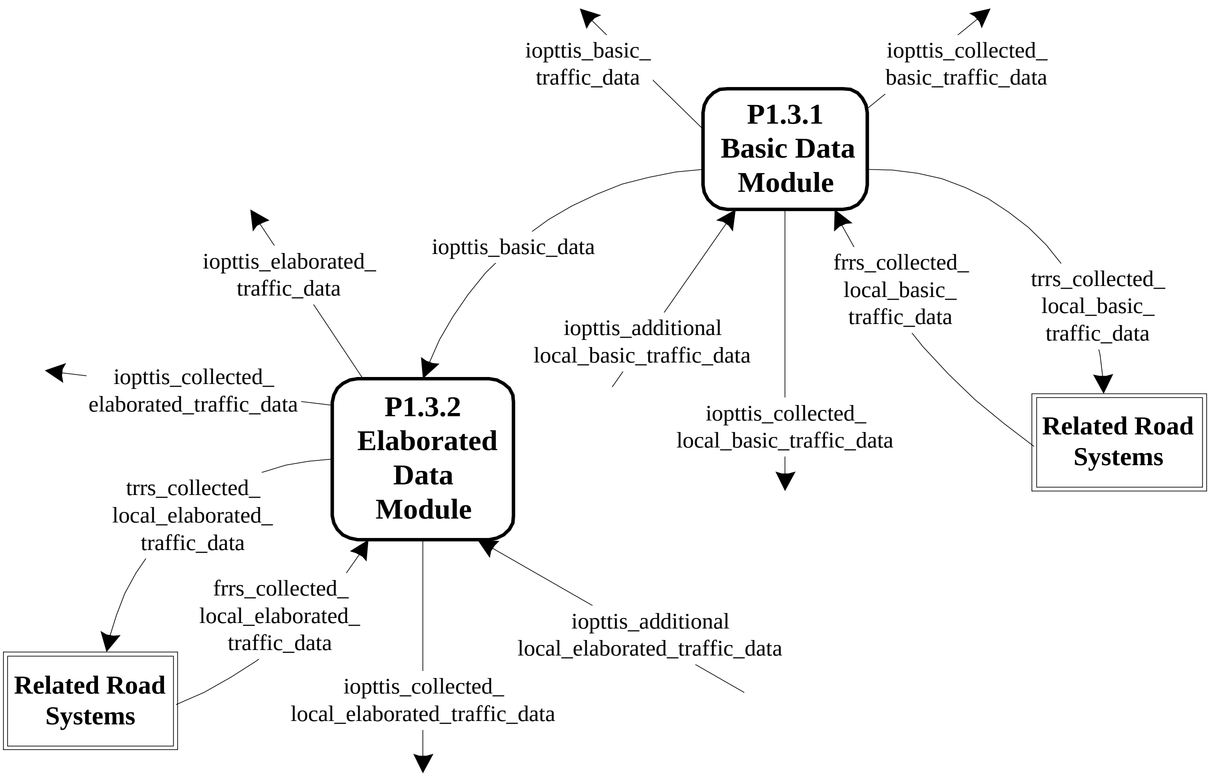
Specific functions for this Sub-system are not present in the Functional Architecture. Consequently, functions mapped on its modules represent only the necessity of the modules for the complete implementation of the functionality.

2.2.5.3 Modules in P1.3 Local Data Provider Sub-system

The Local Data Provider Sub-system consists of two modules. These cover different kind of data. On the one hand there are the basic data (e.g. vehicle flows, turning percentages, vehicle densities) which are observed on the base of real-time measurement on the field. On the other hand there are the elaborated data which have been derived from the previous basic data and worked out on the base of specific assumptions (e.g. traffic control strategies, vehicle densities). Their descriptions are as follows.

P1.3.1 Basic Data Module: - this Module provides all traffic data which are observed on the base of real-time measurement on the field.

Figure 4 P1 Integrated Open Platform for Traffic and Travel Information Services System - Local Data Provider Sub-system Modules

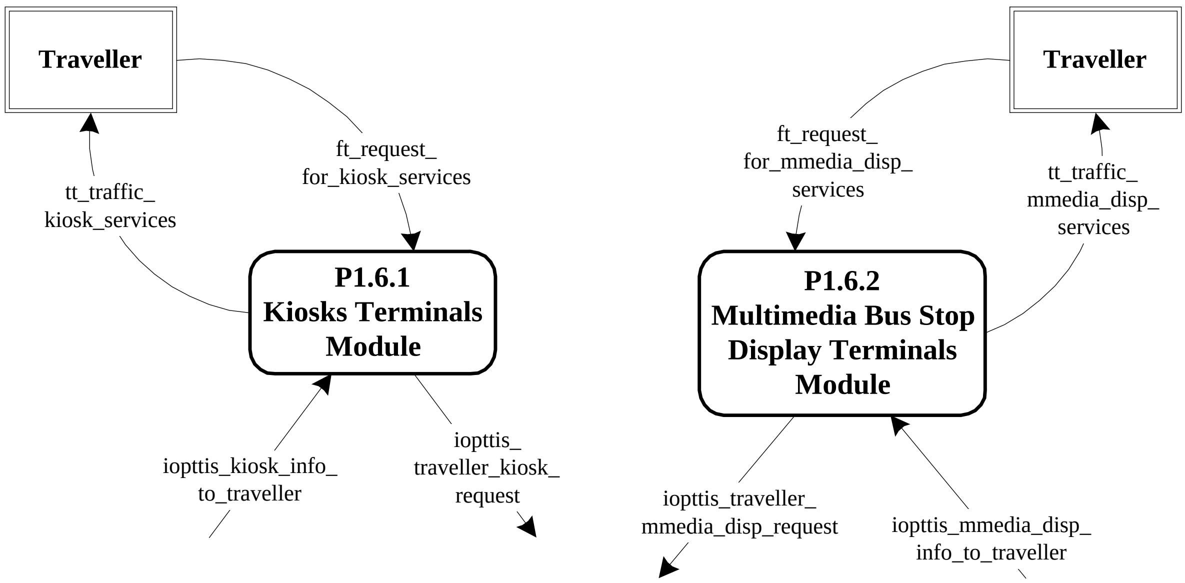


P1.3.2 Elaborated Data Module: - this Module provides all traffic information properly derived from basic data.

2.2.5.4 Modules in P1.6 User Terminals Sub-system

The User Terminals Sub-system consists of at least two modules. These represent how the travel information services can reach the final user, that is how the traveller may get useful information from the System. Their descriptions are as follows.

Figure 5 P1 Integrated Open Platform for Traffic and Travel Information Services System - User Terminals Sub-system Modules



P1.6.1 Kiosks Terminals Module: - this Module provides the interactive mobile (i.e. able to receive data via DAB) "telematics stations" with local browsing facilities to provide information to the users. They are placed at the station, at the airport, at service areas, at some hotels and conference premises. Some of them are equipped with Smart Cards readers.

P1.6.2 Multimedia Bus Stop Display Terminals Module: - this Module provides new generation terminal equipment with DAB receiver. It displays received travel information on a large screen.

2.2.5.5 Modules and Functions

The Modules identified in the two previous sections can be split up into Functions. These are identified in the table shown on the following pages. Also included are the Functions in the six Sub-systems (P1.1 - P1.6) described in section 5.2.3. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 2 P1 - Integrated Open Platform for Traffic and Travel Information Services System - Sub-systems, Modules and Functions

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P1.1	Interface Platform	Central	P1.1.1*	Data Exchange	F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 6.1.3.9, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 6.2	Plan Trip	6.1.0.4, 6.1.0.5, 6.1.1.1, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.1.2.3, 6.1.3.1, 6.1.3.4, 6.1.3.8, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.4.0.1, 6.4.0.2, 6.4.1.3
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.2, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.2, 6.4.2.4
			P1.1.2*	Interface	F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 6.1.3.10, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 6.2	Plan Trip	6.1.0.4, 6.1.0.5, 6.1.1.1, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.1.2.3, 6.1.3.1, 6.1.3.4, 6.1.3.8, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.4.0.1, 6.4.0.2, 6.4.1.3

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.2, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.2, 6.4.2.4
P 1.2	National and International Data Provider	Central			F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.2, 7.1.1.4, 7.1.1.5
P 1.2	National and International Data Provider (continued)	Central			F 3.1.2.1	Collect Inter-urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.3, 7.1.1.5
					F 3.4.1	Monitor Weather Conditions	7.1.1.6
P 1.3	Local Data Provider	Central	P 1.3.1	Basic Data	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.2, 7.1.1.4, 7.1.1.5
					F 3.1.1.2	Monitor Urban Car Park Occupation	2.1.1.3, 7.1.1.5, 7.1.11.1
					F 3.4.2	Monitor Atmospheric Pollution	7.1.1.8
					F 4.1.1	Estimate Vehicle Indicators	2.1.0.1, 2.1.4.2, 10.1.2.1
			P 1.3.2	Elaborated Data	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.2, 7.1.1.4, 7.1.1.5

Sub-system			Module		Function		
No.	Name	Location	No.	Name	No.	Name	User Needs
P 1.3	Local Data Provider (continued)	Central	P 1.3.2	Elaborated Data (continued)	F 4.1.2	Predict Vehicle Indicators	2.1.1.1, 2.1.1.3
P 1.4	Local Service Provider	Central			F 6.1	Define Traveller's GTP	6.1.0.5, 6.1.2.8, 6.2.3.7, 6.4.1.4
					F 6.2.3	Propose Trip Alternatives	6.1.1.1, 6.1.1.2, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.2.2.6, 6.4.1.3, 6.4.1.4
					F 6.2.5	Plan Road Trip(s)	6.2.1.3, 6.4.0.1, 6.4.1.1, 6.4.1.3, 6.4.1.4
					F 6.2.7	Produce Itinerary and Trip File	6.1.2.7, 6.2.2.4, 6.4.0.1, 6.4.1.3
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.1, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.0.6, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.1, 6.4.1.2, 6.4.2.1, 6.4.2.4
P 1.5	Telecommunication Infrastructures for Services	Roadside			F 6.2.3	Propose Trip Alternatives	6.1.1.1, 6.1.1.2, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.2.2.6, 6.4.1.3, 6.4.1.4
					F 6.2.5	Plan Road Trip(s)	6.2.1.3, 6.4.0.1, 6.4.1.1, 6.4.1.3, 6.4.1.4

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 1.5	Telecommunication Infrastructures for Services (continued)	Roadside			F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.1, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.0.6, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.1, 6.4.1.2, 6.4.2.1., 6.4.2.4
P 1.6	User Terminals	Roadside	P 1.6.1*	Kiosks Terminals	F 6.2.3	Propose Trip Alternatives	6.1.1.1, 6.1.1.2, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.2.2.6, 6.4.1.3, 6.4.1.4
					F 6.2.5	Plan Road Trip(s)	6.2.1.3, 6.4.0.1, 6.4.1.1, 6.4.1.3, 6.4.1.4
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.1, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.0.6, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.1, 6.4.1.2, 6.4.2.1, 6.4.2.4
			P 1.6.2*	Multimedia Bus Stop Display Terminals	F 6.2.3	Propose Trip Alternatives	6.1.1.1, 6.1.1.2, 6.1.1.3, 6.1.1.4, 6.1.2.2, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.2.2.6, 6.4.1.3, 6.4.1.4
					F 6.2.5	Plan Road Trip(s)	6.2.1.3, 6.4.0.1, 6.4.1.1, 6.4.1.3, 6.4.1.4
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.1, 6.1.2.3, 6.2.0.4, 6.2.0.5, 6.2.0.6, 6.2.1.1, 6.2.1.2, 6.2.2.1, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.1.1, 6.4.1.2, 6.4.2.1, 6.4.2.4

2.2.6 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

frrs_collected_nat_internat_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the data which have been collected by the Related Road Systems and shared through the National and International Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
frrs_collected_nat_internat_traffic_events
+ frrs_collected_nat_internat_road_network_status
The data flow consists of the following Functional Data Flows (the first three do not come from Related Road Systems):
ftrfc-urban_traffic_flow_data
ftrfc-inter-urban_traffic_flow_data
fws-weather_data
frrs-inter-urban_data_updates
frrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent functions (3.1.2.4 and 3.2.4) were not considered relevant for the example.

frrs_basic_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the data which have been collected by the Related Road Systems and provided to the Local Service Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring, control strategies, vehicle densities, congestion, O/D estimations, …). The data flow consists of the following Functional Data Flows (even though they do not come from Related Road Systems):
mt.ptja_road_network_perturbations
mt.ptja_incident_information

frrs_collected_local_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the data which have been collected by the Related Road Systems and shared through the Local Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
frrs_collected_local_basic_traffic_data
+ frrs_collected_local_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
frrs-urban_data_updates
frrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent function (3.1.1.4 and 3.2.4) were not considered relevant for the example.

frrs_collected_local_basic_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the basic data which have been collected by the Related Road Systems and shared through the Local Data Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
frrs-urban_data_updates
frrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent function (3.1.1.4 and 3.2.4) were not considered relevant for the example.

frrs_collected_local_elaborated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the elaborated data which have been collected by the Related Road Systems and shared through the Local Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows (e.g. control strategies, vehicle densities, congestion, O/D estimations,…).
frrs_collected_local_elaborated_traffic_data_traffic_events
+ frrs_collected_local_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
frrs-urban_data_updates
frrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.2.4) were not considered relevant for the example.

trrs_service_required
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data flow consists of the following constituent Physical Data Flows:
frrs_service_required_trip_planning
+ frrs_service_required_private_traffic_congestions
+ frrs_service_required_trip_support
+ frrs_service_required_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
trrs-urban_data_updates
trrs-incident_data
The last functional data flow does not belong to the mapped functions as the correspondent function (3.2.4) was not considered relevant for the example.

frrs_service_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the request for needed traffic and/or travel information. The data flow consists of the following constituent Physical Data Flows:
frrs_service_request_trip_planning
+ frrs_service_request_private_traffic_congestions
+ frrs_service_request_trip_support
+ frrs_service_request_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
frrs-urban_data_updates
frrs-incident_data
The last functional data flow does not belong to the mapped functions as the correspondent function (3.2.4) was not considered relevant for the example.

trrs_collected_local_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local traffic data which are shared by the Local Data Provider Sub-system towards the Related Road Systems. The data flow consists of the following constituent Physical Data Flows:
trrs_collected_local_basic_traffic_data
+ trrs_collected_local_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
trrs_real_time_info
trrs_pred_pt_data
trrs-urban_data_updates
trrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.2.4) were not considered relevant for the example.

trrs_collected_local_basic_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local basic traffic data which are shared by the Local Data Provider Sub-system towards the Related Road Systems (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…). The data flow consists of the following Functional Data Flows:
trrs_real_time_info
trrs-urban_data_updates
trrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.2.4) were not considered relevant for the example.

trrs_collected_local_elaborated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local elaborated traffic data which are shared by the Local Data Provider Sub-system towards the Related Road Systems (e.g. control strategies, vehicle densities, congestion, O/D estimations,…). The data flow consists of the following constituent Physical Data Flows:
trrs_collected_local_elaborated_traffic_data_traffic_events
+ trrs_collected_local_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
trrs_pred_pt_data
trrs-urban_data_updates
trrs-incident_data
The last two functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.2.4) were not considered relevant for the example.

fo.tio_service_configuration
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the configuration parameters needed by the Local Service Provider Sub-system. It represents the human interaction with the system. The corresponding functional data flow is missing.

iopttis_collected_local_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local traffic data which are shared by the Local Data Provider Sub-system through the Interface Platform Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_collected_local_basic_traffic_data
+ iopttis_collected_local_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
mt_collected_urban_traffic_data

iopttis_collected_local_basic_traffic_data

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local basic traffic data which are shared by the Local Data Provider Sub-system through the Interface Platform Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
mt_collected_urban_traffic_data

iopttis_collected_local_elaborated_traffic_data

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local elaborated traffic data which are shared by the Local Data Provider Sub-system through the Interface Platform Sub-system (e.g. control strategies, vehicle densities, congestion, O/D estimations,…). The data flow consists of the following constituent Physical Data Flows:
iopttis_collected_local_elaborated_traffic_data_traffic_events
+ iopttis_collected_local_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
mt_collected_urban_traffic_data

iopttis_traffic_data

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local traffic data which are provided by the Local Data Provider Sub-system to the National and International Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_basic_traffic_data
iopttis_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
mt_urban_to_inter-urban_traffic_data_transfers
The functional data flow does not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.1.2.4) were not considered relevant for the example.

iopttis_basic_traffic_data

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local basic traffic data which are provided by the Local Data Provider Sub-system to the National and International Data Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
mt_urban_to_inter-urban_traffic_data_transfers
The functional data flow does not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.1.2.4) were not considered relevant for the example.

iopttis_elaborated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local elaborated traffic data which are provided by the Local Data Provider Sub-system to the National and International Data Provider Sub-system (e.g. control strategies, vehicle densities, congestion, O/D estimations,…). The data flow consists of the following constituent Physical Data Flows:
frrs_collected_local_elaborated_traffic_data_traffic_events
+ frrs_collected_local_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
mt_urban_to_inter-urban_traffic_data_transfers
The functional data flow does not belong to the mapped functions as the correspondent functions (3.1.1.4 and 3.1.2.4) were not considered relevant for the example.

iopttis_collected_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local traffic data needed by the Local Service Provider Sub-system. They are provided by the Local Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_collected_basic_traffic_data
+ iopttis_collected_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
mt.ptja_carpark_occupancy
mt.ptja_pt_journey_time_prediction
mt.ptja_urban_network_perturbations
mt.ptja_urban_network_conditions
mt.ptja_urban_traffic_predictions
The last three functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.3 and 3.1.1.4) were not considered relevant for the example.

iopttis_collected_basic_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local basic traffic data needed by the Local Service Provider Sub-system. They are provided by the Local Data Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
mt.ptja_carpark_occupancy
mt.ptja_urban_network_perturbations
mt.ptja_urban_network_conditions
The last three functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.3 and 3.1.1.4) were not considered relevant for the example.

iopttis_collected_elaborated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the local elaborated traffic data needed by the Local Service Provider Sub-system. They are provided by the Local Data Provider Sub-system (e.g. control strategies, vehicle densities, congestion, O/D estimations,…). The data flow consists of the following constituent Physical Data Flows:
iopttis_collected_elaborated_traffic_data_traffic_events
+ iopttis_collected_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
mt.ptja_pt_journey_time_prediction
mt.ptja_urban_traffic_predictions
The last three functional data flows do not belong to the mapped functions as the correspondent functions (3.1.1.3 and 3.1.1.4) were not considered relevant for the example.

iopttis_service_required
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data flow consists of the following constituent Physical Data Flows:
iopttis_service_required_trip_planning
+ iopttis_service_required_private_traffic_congestions
+ iopttis_service_required_trip_support
+ iopttis_service_required_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
tt-trip_alternatives
tt-itinerary_initial
tt-road_trip_alternatives
tt_itinerary_changes
td_route_guidance_info
trrs-urban_data_updates
trrs-incident_data

iopttis_service_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the request for needed traffic and/or travel information. The data flow consists of the following constituent Physical Data Flows:
iopttis_service_request_trip_planning
+ iopttis_service_request_private_traffic_congestions
+ iopttis_service_request_trip_support
+ iopttis_service_request_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
ft-general_trip_preferences
ft-road_trip_preferences
ft-change_approval
ft-trip_selection
ft-seconday_criteria
frrs-urban_data_updates
frrs-incident_data

iopttis_additional_local_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the additional local traffic data provided by the Interface Platform Sub-system to the Local Data Provider Sub-system. They are provided by the Local Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_additional_local_basic_traffic_data
+ iopttis_additional_local_elaborated_traffic_data
The data flow consists of the following Functional Data Flows:
ftrfc-urban_traffic_flow_data
ftrfc-carpark_vehicle_data
frrs-urban_data_updates
frrs-incident_data
fae-atmospheric_pollution_inputs
fesp_environment_data

iopttis_additional_local_basic_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the additional local basic traffic data provided by the Interface Platform Sub-system to the Local Data Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
ftrfc-urban_traffic_flow_data
ftrfc-carpark_vehicle_data
frrs-urban_data_updates
frrs-incident_data
fae-atmospheric_pollution_inputs
fesp_environment_data

iopttis_additional_local_elaborated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the additional local elaborated traffic data provided by the Interface Platform Sub-system to the Local Data Provider Sub-system (e.g. control strategies, vehicle densities, congestion, O/D estimations,…). The data flow consists of the following constituent Physical Data Flows:
iopttis_additional_local_elaborated_traffic_data_traffic_events
+ iopttis_additional_local_elaborated_traffic_data_road_network_status
The data flow consists of the following Functional Data Flows:
ftrfc-urban_traffic_flow_data
ftrfc-carpark_vehicle_data
frrs-urban_data_updates
frrs-incident_data
fae-atmospheric_pollution_inputs
fesp_environment_data

iopttis_collected_nat_internat_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the national and international traffic data which is shared by the National and International Data Provider Sub-system through the Interface Platform Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_collected_nat_internat_traffic_events
+ iopttis_collected_nat_internat_road_network_status
The data flow consists of the following Functional Data Flows:
mt_collected_inter-urban_traffic_data

iopttis_additional_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the additional national and international traffic data provided by the Interface Platform Sub-system to the National and International Data Provider Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_additional_traffic_events
+ iopttis_additional_road_network_status
The data flow consists of the following Functional Data Flows:
ftrfc-inter-urban_traffic_flow_data
frrs-inter-urban_data_updates
frrs-incident_data
fae-weather_inputs
fws-weather_data

iopttis_traffic_services_to_be_transmitted
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traffic and/or travel information for the required service. The data flow consists of the following constituent Physical Data Flows:
iopttis_traffic_services_to_be_transmitted_trip_planning
+ iopttis_traffic_services_to_be_transmitted_private_traffic_congestions
+ iopttis_traffic_services_to_be_transmitted_trip_support
+ iopttis_traffic_services_to_be_transmitted_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
mt.ptja_road_network_perturbations
mt.ptja_incident_information
mt.ptja_car_park_occupancy
mt.ptja_road_network_characteristics
mt.ptja_weather_information
flds_location
mpto.ptja_available_pt_services
mpto.pt_journey_time_prediction
mt.ptja_walking_and_cycling_info
mt.ptja_pollution

iopttis_request_for_info
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the request for needed traffic and/or travel information. The data flow consists of the following constituent Physical Data Flows:
iopttis_request_for_info_trip_planning
+ iopttis_request_for_info_private_traffic_congestions
+ iopttis_request_for_info_trip_support
+ iopttis_request_for_info_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
ft-pepf_account_input
ft-pepf_payment_info

iopttis_info_to_traveller
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traffic and/or travel information for the required service. The data is transmitted to the User Terminals Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_kiosk_info_to_traveller
+ iopttis_mmedia_disp_info_to_traveller
The data flow consists of the following Functional Data Flows:
mt.ptja_road_network_perturbations
mt.ptja_incident_information
mt.ptja_car_park_occupancy
mt.ptja_road_network_characteristics
mt.ptja_weather_information
flds_location
mpto.ptja_available_pt_services
mpto.pt_journey_time_prediction
mt.ptja_walking_and_cycling_info
mt.ptja_pollution

iopttis_kiosk_info_to_traveller

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traffic and/or travel information for the required service. The data is transmitted to the Kiosks Terminals Module. The data flow consists of the following constituent Physical Data Flows:

iopttis_kiosk_info_to_traveller_trip_planning
+ iopttis_kiosk_info_to_traveller_private_traffic_congestions
+ iopttis_kiosk_info_to_traveller_trip_support
+ iopttis_kiosk_info_to_traveller_public_transport_disruptions

The data flow consists of the following Functional Data Flows:

mt.ptja_road_network_perturbations
mt.ptja_incident_information
mt.ptja_car_park_occupancy
mt.ptja_road_network_characteristics
mt.ptja_weather_information
flds_location
mpto.ptja_available_pt_services
mpto.pt_journey_time_prediction
mt.ptja_walking_and_cycling_info
mt.ptja_pollution

iopttis_mmedia_disp_info_to_traveller

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data are transmitted to the Multimedia Bus Stop Display Terminals Module. The data flow consists of the following constituent Physical Data Flows:

iopttis_mmedia_disp_info_to_traveller_trip_planning
+ iopttis_mmedia_disp_info_to_traveller_traffic_congestions
+ iopttis_mmedia_disp_info_to_traveller_trip_support
+ iopttis_mmedia_disp_info_to_traveller_public_transport_disruptions

The data flow consists of the following Functional Data Flows:

mt.ptja_road_network_perturbations
mt.ptja_incident_information
mt.ptja_car_park_occupancy
mt.ptja_road_network_characteristics
mt.ptja_weather_information
flds_location
mpto.ptja_available_pt_services
mpto.pt_journey_time_prediction
mt.ptja_walking_and_cycling_info
mt.ptja_pollution

iopttis_traveller_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the User Terminals Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_traveller_kiosk_request
+ iopttis_traveller_mmedia_disp_request

iopttis_traveller_kiosk_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the Kiosks Terminals Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_traveller_kiosk_request_trip_planning
+ iopttis_traveller_kiosk_request_private_traffic_congestions
+ iopttis_traveller_kiosk_request_info_trip_support
+ iopttis_traveller_kiosk_request_public_transport_disruptions

iopttis_traveller_mmedia_disp_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the Multimedia Bus Stop Display Terminals Sub-system. The data flow consists of the following constituent Physical Data Flows:
iopttis_traveller_mmedia_disp_request_trip_planning
+ iopttis_traveller_mmedia_disp_request_private_traffic_congestions
+ iopttis_traveller_mmedia_disp_request_trip_support
+ iopttis_traveller_mmedia_disp_request_public_transport_disruptions

tt_traffic_services
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data are provided by the User Terminals Sub-system to the Traveller, the main terminator of the System. The data flow consists of the following constituent Physical Data Flows:
tt_traffic_kiosk_services
+ tt_traffic_mmedia_disp_services
The data flow consists of the following Functional Data Flows:
tt-itinerary_changes
tt-trip_alternatives
tt-road_trip_alternatives
tt-itinerary_initial

tt_traffic_kiosk_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data is provided by the Kiosks Terminals Module to the Traveller, the main terminator of the System. The data flow consists of the following constituent Physical Data Flows:

tt_traffic_kiosk_services_trip_planning
+ tt_traffic_kiosk_services_private_traffic_congestions
+ tt_traffic_kiosk_services_trip_support
+ tt_traffic_kiosk_services_public_transport_disruptions

The data flow consists of the following Functional Data Flows:

tt-itinerary_changes
tt-trip_alternatives
tt-road_trip_alternatives
tt-itinerary_initial

tt_traffic_mmedia_disp_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data is provided by the Multimedia Bus Stop Display Terminals Module to the Traveller, the main terminator of the System. The data flow consists of the following constituent Physical Data Flows:

tt_traffic_mmedia_disp_services_trip_planning
+ tt_traffic_mmedia_disp_services_private_traffic_congestions
+ tt_traffic_mmedia_disp_services_trip_support
+ tt_traffic_mmedia_disp_services_public_transport_disruptions

The data flow consists of the following Functional Data Flows:

tt-itinerary_changes
tt-trip_alternatives
tt-road_trip_alternatives
tt-itinerary_initial

ft_request_for_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the User Terminals Sub-system. The data flow consists of the following constituent Physical Data Flows:

ft_request_for_kiosk_services
+ ft_request_for_mmedia_disp_services

The data flow consists of the following Functional Data Flows:

ft-trip_selection
ft-secondary_criteria
ft-road_trip_preferences
ft-change_approval

ft_request_for_kiosk_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the Kiosks Terminals Module. The data flow consists of the following constituent Physical Data Flows:
ft_request_for_kiosk_services_trip_planning
+ ft_request_for_kiosk_services_private_traffic_congestions
+ ft_request_for_kiosk_services_trip_support
+ ft_request_for_kiosk_services_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
ft-trip_selection
ft-secondary_criteria
ft-road_trip_preferences
ft-change_approval

ft_request_for_mmedia_disp_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information through the Multimedia Bus Stop Display Terminals Module. The data flow consists of the following constituent Physical Data Flows:
ft_request_for_mmedia_disp_services_trip_planning
+ ft_request_for_mmedia_disp_services_private_traffic_congestions
+ ft_request_for_mmedia_disp_services_trip_support
+ ft_request_for_mmedia_disp_services_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
ft-trip_selection
ft-secondary_criteria
ft-road_trip_preferences
ft-change_approval

tt_traffic_info_services

This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the needed traffic and/or travel information for the required service. The data are provided through the Telecommunication Infrastructures Sub-system to the Traveller, the main terminator of the System. The data flow consists of the following constituent Physical Data Flows:
tt_traffic_info_services_trip_planning
+ tt_traffic_info_services_private_traffic_congestions
+ tt_traffic_info_services_trip_support
+ tt_traffic_info_services_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
tt-itinerary_changes
tt-trip_alternatives
tt-road_trip_alternatives
tt-itinerary_initial

ft_traffic_info_services_request
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traveller request for needed traffic and/or travel information made through the Telecommunication Infrastructures Sub-system. The data flow consists of the following constituent Physical Data Flows:
ft_traffic_info_services_request_trip_planning
+ ft_traffic_info_services_request_private_traffic_congestions
+ ft_traffic_info_services_request_trip_support
+ ft_traffic_info_services_request_public_transport_disruptions
The data flow consists of the following Functional Data Flows:
ft-trip_selection
ft-secondary_criteria
ft-road_trip_preferences
ft-change_approval

iopttis_basic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains basic traffic data which are exchanged in the Local Data Provider Sub-system (e.g. flows, travel times, turning percentages, queues, fleets monitoring,…).
The data flow consists of the following Functional Data Flows:
mpto_real_time_veh_data
mpto_historical_veh_data

2.2.7 Key Issues

The key issue is to guarantee the integration and interoperability of ITS technologies and products.

The challenge consists of ensuring a neutral demonstration environment for ITS operators of Europe and high performance facilities for operators of other parts of the world.

State-of-the-art ITS component and infrastructure will be included in the platform forming a "real-life" platform implementing the most recent European results in the field of system architecture, communication standards, service specifications and data exchange open specifications.

Among others the main problems to be solved, in order to actually implement the example described are:

1. <u>Choice of a suitable location referencing to be used in the urban domain.</u> Currently there are not standards available for referring data as detailed as those available for the urban area (e.g. travel time, traffic flow and density for each link, vehicle turning percentages at intersections, traffic light timings, etc.). The only location referencing currently used and recommended, for example in the DATEX protocol, is the one used for the RDS-TMC. It is unsuitable for urban environment because it describes points in the network only and does not describe links/arcs nor vehicle movements in the network. In addition to these limitations, it implies the creation and maintenance of an external coded database of locations. An emerging standard solution seems to be the

ILOC (Intersection LOCation) location referencing which includes the whole description of locations and can be completed with LLOC (Link LOCation) and MLOC (Movement LOCation) for the description of links and movement of the graph. Currently the state of development and verification of this method is limited and refinement and consolidation work is still needed before being fully operational.

2. Protocol to be used for data exchange. The selection of an harmonised communication interface to share and exchange data and services is now naturally oriented to the DATEX solution, although it may not suffice all the requirements generated by urban environment based applications and services (e.g. DATEX does not include yet messages for data such as the turning percentages, travel time and vehicle position for public transport, etc.), alternative suitable communication interfaces should be looked at for specific class of data. Mobile agent technology provides, for example, a promising solution but consolidated standards are not available and specific transport related application layers may be needed.

3. Organisational structure for sharing data and infrastructure. The feasibility of an actual “real life” environment, where data and infrastructures are shared, requires suitable technical solutions but also a solid organisational structure, which is usually more critical to set-up. Separation of responsibility must be clear to involved actors and guaranteed quality and reliability of shared data and services must me given. The model provided by the “DATEX interchange agreement” can be sufficient for the pure data exchange relationship, it should be used as basis for a more comprehensive needs.

2.3 P2 – RDS-TMC Italian System

2.3.1 Overview

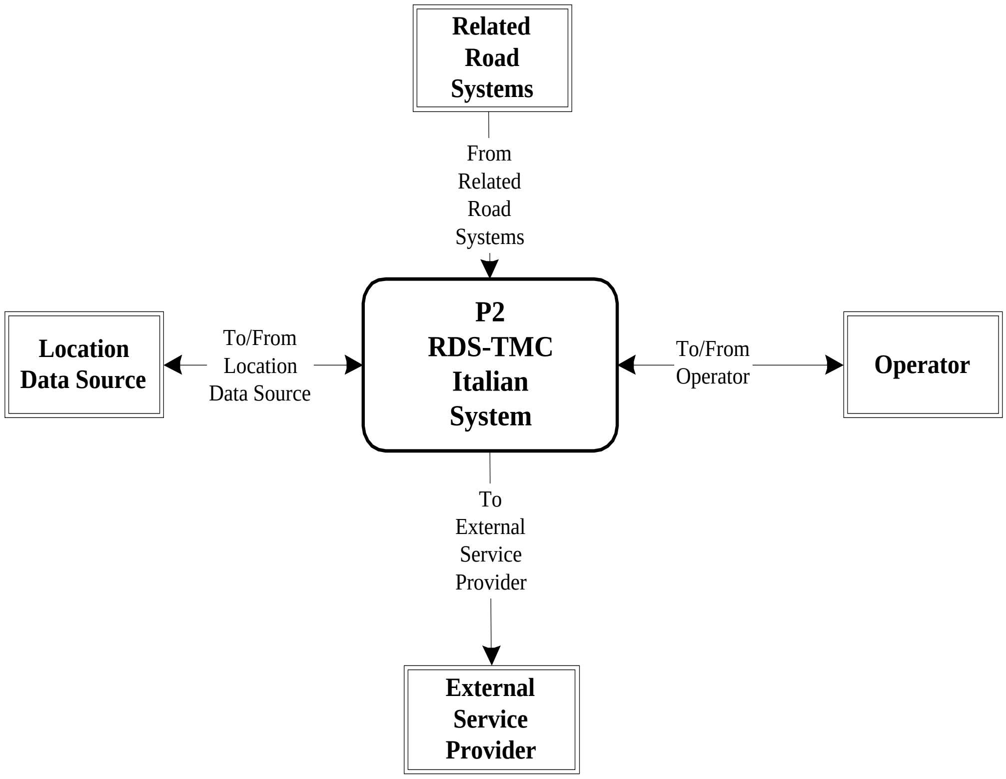
The example is based on the RDS-TMC (Radio Data System – Traffic Message Channel) Italian service. It broadcasts comprehensive localised traffic and travel real-time data at the national level (highways and motorways). The RDS-TMC Italian service allows delivery of high quality, timely and relevant information during radio normal services and in the language chosen by the user.

The described System represents the RDS-TMC traffic information centre, on the base of which the RDS-TMC service can exist. Here, data and traffic events are collected, validated and properly coded to be passed to the RDS-TMC service provider and then to the public broadcaster. Moreover, the described System is capable of providing the collected and validated traffic information to any external service provider requiring it i.e. for value added applications.

2.3.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram, which is shown in the following Figure. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting the unused Terminators.

Figure 6 P2 RDS-TMC Italian System - Context Diagram



As will be seen from a comparison with Figure 1, a total of fifteen Terminators in the general list are not required by this System. They and the reasons for their exclusion, plus details of the actors excluded from "generic" terminators are shown in the following table.

Table 3 P2 RDS-TMC Italian System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Not included. Out of scope.
Bridge/Tunnel Infrastructure	Not directly connected to the System. It could be.
Consignor/Consignee	Not included. Out of scope.
Driver	Not directly connected to the System. The Driver receives the information form external RDS-TMC service providers.
Emergency Systems	Not included. Out of scope.
External Service Provider	Only the following actors in this terminator are required by this System: Broadcaster.
Financial Clearinghouse	Not included. Out of scope.

Terminator Name	Reasons for deletion or modification
Freight Equipment	Not included. Out of scope.
Law Enforcement Agency	Not included. Out of scope.
Maintenance Organisation	Not directly connected to the System.
Multi-Modal System	Not included. Out of scope.
Operator	Only the following actors in this terminator are required by this System: Road Network Operator.
Road Pavement	Not directly connected to the system.
Traffic	Not directly connected to the system. It is provided by external Related Road Systems.
Transport Planner	Not included. Out of scope.
Traveller	Not directly connected to the System. The Traveller receives the information form external RDS-TMC service providers.
Vehicle	Not included. Out of scope at the moment.
Weather Systems	Not included. Out of scope.

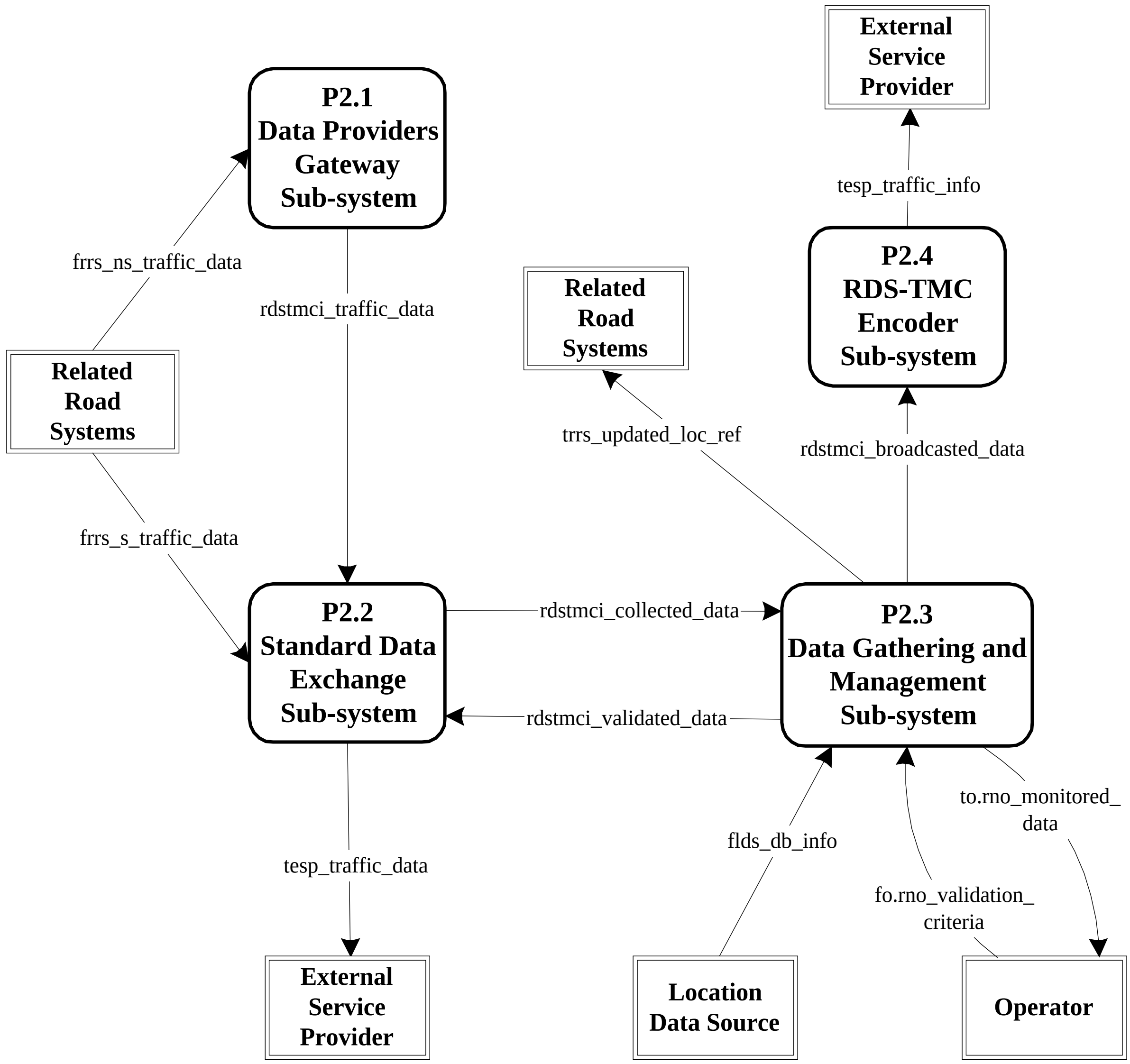
2.3.3 Sub-systems

This System consists of four main Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the following Figure together with their relationships with each other and the Terminators.

P 2.1 Data Providers Gateway Sub-system: - this Sub-system collects traffic data provided by external Related Road Systems. In this case, the external traffic data providers do not use standard communication formats. The Sub-system allows to automatically elaborate the data which can have been transmitted using different channels (telematics, telephone, telex, fax,…) as well as proprietary formats and rules. In this way the System integrates and interfaces with other “different” Related Road Systems increasing the amount of received traffic data. This improves the quality of the provided service.

P 2.2 Standard Data Exchange Sub-system: - this Sub-system collects traffic data provided by external Related Road Systems. In this case, the external data providers use the standard European communication protocol for the exchange of traffic information among TIC’s (Traffic Information Centres), that is established through the DATEX-Net specifications. The received data are now available on the base of the standard interface actuated by the Sub-system.

Figure 7 P2 RDS-TMC Italian System - Sub-systems Diagram



<u>P 2.3 Data Gathering and Management Sub-system</u>: - this Sub-system provides the monitoring and validation actions needed for the traffic information which has been collected through the previous P2.2 and P2.1 Sub-systems. In this Sub-system the Operator can observe and analyse the road network status and decide the suitable validation criteria to provide reliable traffic information towards the outside World. This criteria are mainly based on priorities and received feedback. The validated traffic information is then available and can be monitored in real time also using graphical user interfaces. The graphic user interface is supported by the geographic information provided by the Location Source terminator (TMC location referencing and maps). This Sub-system is also responsible for the maintenance of the RDS-TMC database and the transmission of the updated database info to the Related Road Systems using the RDS-TMC as reference location system.

P 2.4 RDS-TMC Encoder Sub-system: - this Sub-system provides the traffic data conversion needed to be properly passed to the service provider and then to the broadcaster. Here the DATEX is translated into the Alert format. After being validated, it is provided through UECP transmission protocol in order to reach the local FM-RDS transmitter constituting the broadcaster communication network.

2.3.4 Sub-Systems and Functions

The four Sub-systems identified in the previous section can themselves be split up into Modules and Functions. One of the Sub-systems (P2.3) splits up into Modules and it is described in the next section. The remaining three Sub-systems split up directly into Functions which are shown in the table of Functions in a later section.

2.3.5 Modules

2.3.5.1 Introduction

The P2.3 Sub-system is divided into Modules. These Modules are described below and shown in the following Figure together with their relationships with each other and the Terminators.

2.3.5.2 Modules in P2.3 Data Gathering and Management Sub-system

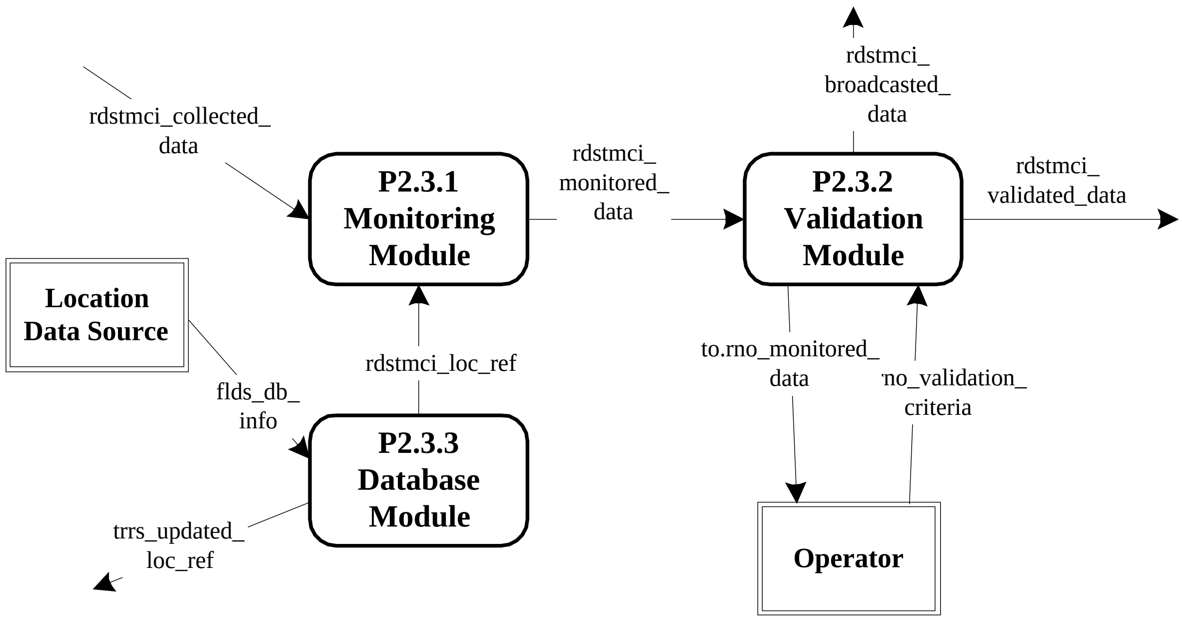
The Data Gathering and Management Sub-system consists of three Modules. These cover the collection, monitoring and validation of traffic data (e.g. accidents, congestion) provided by external Related Road Systems. Their descriptions are as follows.

P2.3.1 Monitoring Module: - this Module shows the collected traffic information to the Road Network Operator. The Database Module (P.2.3.3 below) provides the needed data (location referencing, coded events and maps) to monitor this information through a graphic user interface. On the base of what is displayed and visible an the screen, the Operator can cover the events validation task, as well as System surveillance and maintenance.

P2.3.2 Validation Module: - this Module enables the Operator to define the validation criteria for data collection and sharing. In fact, it is important to merge redundant data in addition to solving conflicting traffic information on the base of accorded priorities and received feedback.

P.2.3.3 Database Module: - this Module represents the database for events, locations, RDS-TMC location referencing and maps. Part of these data are provided by an external Location Data Source. The Database Module is necessary to show the traffic information to the Operator. In fact, the Graphic User Interface is needed at the Monitoring Module (P2.3.1 above) for the correct evaluation and analysis of the collected data. This module is also responsible for the maintenance of the RDS-TMC database so that the updated database is periodically transmitted to the Related Road Systems using the RDS-TMC as reference location system.

Figure 8 P2 RDS-TMC Italian System - Data Gathering and Management Sub-system Modules



2.3.6 Modules and Functions

The three Modules identified in the previous section can be split up into Functions. These are identified in the table that is shown below and on the following page. Also included are the Functions in the Data Providers Gateway (P2.1), Standard Data Exchange (P2.2) and RDS-TMC Encoder (P2.4) Sub-systems - see a previous section. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 4 P2 RDS-TMC Italian System - Allocation of Functions to Sub-systems and Modules

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P2.1	Data Providers Gateway	Central			F 3.1.2.1	Collect Inter-urban Traffic Data	2.1.1.3, 7.1.1.3
P2.2	Standard Data Exchange	Central			F 3.1.2.1	Collect Inter-urban Traffic Data	2.1.1.3, 7.1.1.3
P2.3	Data Gathering and Management	Central	P2.3.1	Monitoring	F 3.1.2.1	Collect Inter-Urban Traffic Data	2.1.1.3, 7.1.1.3

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P2.3	Data Gathering and Management (continued)	Central	P2.3.1	Monitoring (continued)	F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 7.1.8.1
			P2.3.2	Validation	F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 7.1.8.1
					F 3.1.2.5.7	Provide Operator Inter-urban Traffic Management Facilities	7.1.3.2, 7.1.3.3
			P2.3.3 *	Database	F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 7.1.8.1
P2.4*	RDS-TMC Encoder	Central			F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.3, 6.2.0.4, 6.2.2.4, 6.4.0.3, 6.4.2.4

2.3.7 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term "Physical" is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

frrs_ns_traffic_data
This physical data flow is used within the RDS-TMC Italian System. It contains traffic data provided to the System by external Related Road Systems. The data flows does not use standard formats, but proprietary formats with which it is necessary to automatically interface. The data flow consists of the following functional data flows (even though it does not come from a Related Road System):
ftrfc-inter-urban_traffic_flow_data

frrs_s_traffic_data
This physical data flow is used within the RDS-TMC Italian System. It contains traffic data provided to the System by external Related Road Systems. In this case, the data flows implement standard formats on the base of the DATEX-Net specifications . So that a DATEX node is needed to correctly interface with the received information. National institutions and organisations (e.g. police, Carabinieri, ANAS, ACI, AISCAT,…) are directly connected to provide the data with the DATEX formats. The data flow consists of the following functional data flows (even though it does not come from a Related Road System):
ftrfc-inter-urban_traffic_flow_data

rdstmci_traffic_data
This physical data flow is used within the RDS-TMC Italian System. It contains interpreted traffic data received from external Related Road Systems not using standard formats to transmit their traffic information. The data flow consists of the following functional data flows:
mt_collected_inter-urban_traffic_data

rdstmci_collected_data
This physical data flow is used within the RDS-TMC Italian System. It contains traffic data received from external Related Road Systems. The data flow involves the traffic information which was received both in standard and not standard formats and is now available in the DATEX format. The data flow consists of the following functional data flows:
mt_collected_inter-urban_traffic_data

rdstmci_validated_data
This physical data flow is used within the RDS-TMC Italian System. It contains collected traffic data (in DATEX format) after being validated. In fact, validation criteria are needed to solve redundancy or conflicts of the received traffic information. These criteria are established by the Operator and are based on priorities levels and provided feedback. A corresponding functional data flow is missing.

tesp_traffic_data
This physical data flow is used within the RDS-TMC Italian System. It contains collected and validated traffic data. In this way the System is capable of providing to the outside World its traffic information for any kind of required external value added service. A traveller information provider who gives traffic information when the Traveller calls is an example of a real available value added service. To do that, it is necessary that External Service Providers interface i.e. connecting following the DATEX-Net specifications. A corresponding functional data flow is missing.

flds_db_info
This physical data flow is used within the RDS-TMC Italian System. It contains part of the database information needed to provide the Operator a graphic user interface. The data flow consists of maps and TMC location referencing data. A corresponding functional data flow is missing.

trrs_updated_loc_ref
This physical data flow is used within the RDS-TMC Italian System. It contains the updated information needed by the Related Road System using the RDS-TMC as location reference system. The data flow consists of the following functional data flows:
trrs-inter-urban_data_updates

to.rno_monitored_data
This physical data flow is used within the RDS-TMC Italian System. It consists of the collected available traffic data. This data flow lets the Operator analyse the received data and decide the validation criteria needed to solve redundancy and conflicts. A corresponding functional data flow is missing. The data flow consists of the following functional data flows:
to.rno-inter-urban_responses

fo.rno_validation_criteria
This physical data flow is used within the RDS-TMC Italian System. It consists of the validation criteria defined by the Operator. This data flow lets the Operator solve redundancy and conflicts. A corresponding functional data flow is missing. The data flow consists of the following functional data flows:
fo.rno-inter-urban_commands

rdstmci_broadcasted_data
This physical data flow is used within the RDS-TMC Italian System. It contains collected validated traffic data to be broadcasted to the Traveller. This data have to be encoded to be provided to the service provider and then to the radio broadcaster. The data flow consists of the following functional data flows:
mt.ptja_road_network_perturbations
mt.ptja_incident_information

tesp_traffic_info
This physical data flow is used within the RDS-TMC Italian System. It contains collected validated traffic data to be broadcasted to the Traveller. This data have been encoded to be provided to the service provider and then to the radio broadcaster. The data flow consists of the following functional data flows (even though it has not the External Service Provider as terminator):
ptja.padas_travel_info

rdstmci_monitored_data
This physical data flow is used within the RDS-TMC Italian System. It consists of the collected available traffic data. This data flow lets the Operator analyse the received data and decide the validation criteria needed to solve redundancy and conflicts. The data flow consists of the following functional data flows:
mt_collected_inter-urban_traffic_data

rdstmci_loc_ref
This physical data flow is used within the RDS-TMC Italian System. It contains the database information needed to provide the Operator a graphic user interface. It consists of maps and TMC location referencing data in addition to other required data like the events database. A corresponding functional data flow is missing.

2.3.8 Key Issues

The Key Issues for this System are:

1. The Italian RDS-TMC service requires that the given traffic information is reliable and provided as quickly as possible. The efficacy and efficiency of this service is obtained through the direct connection to the information centres belonging to institutions/organisations like Road Police, Carabinieri and highway responsible companies. On the one hand, this gives the sureness and legitimacy of the given information. On the other, it reduces the delay between when the event happens and when the information is provided. This second characteristic is improved by the reception of other traffic data on different communication ways (telematics, telephone, telex, fax,…) and proprietary formats.

2. The System is capable of providing its validated information to other External Service Providers who are going to use the reliable traffic information within value added services.

3. Organisational issues are critical because of the number of actors involved, responsibility involved, ownership of data. The criticality is mainly related to the potential impact of information transmitted on the business of single actors. Consequently, on top of technical solutions, interchange agreements have to be established between the actors involved to make the service actually feasible.

4. Data exchange solution must take into account that the service requires two-way exchange of data with correspondent Traffic Information Services operating in neighbouring countries. In particular messages and geographical location references used must be language independent.

5. Specific solutions must be adopted to allow travellers receivers to select among three level of information details: National, Regional and Local. In the Italian implementation the same messages (i.e. including all level of information) are broadcasted over the whole country, selection capability is demanded to the receivers.

6. Specific encryption solutions may be required to have a basic level of service freely available to public and a one or more levels of services reserved to subscribers.

7. Solutions for updating and changing, when needed, the reference map and location codes must be found to make the service actually feasible. The RDS bandwidth cannot allow the transmission of these data, the Italian solution make use of CD-ROM periodically issued under the responsibility of a unique authority.

2.4 P3 – Urban Traffic Control and Public Transport Priority System

2.4.1 Overview

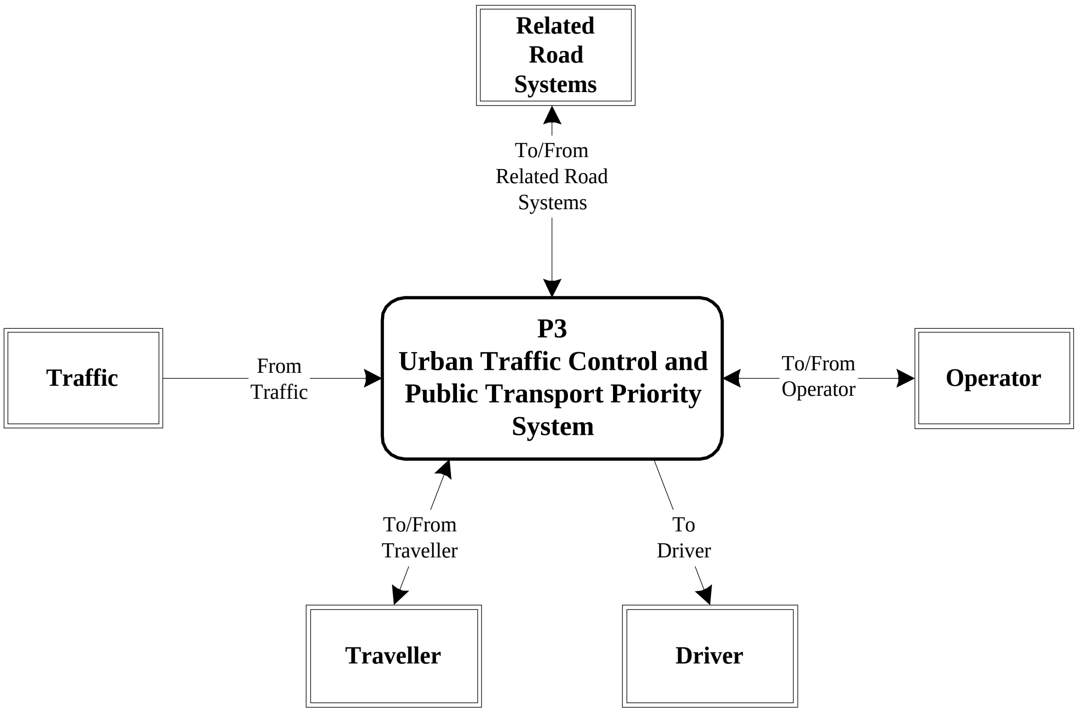
The example is based on the SPOT/UTOPIA (Urban Traffic Optimisation by Integrated Automation) system.

This System is specifically chosen to represent the architectural solutions adopted by a decentralised system. It aims at improving urban travel conditions by the application of fully automated hierarchic control principles which optimise dynamically the stages of traffic lights sets in urban areas. Optimisation is based on real time data continuously measured plus historical data and knowledge of special events.

In addition to describing how the System controls highly complex urban road networks, it will be considered how its open architecture grants the integration with other different external systems. From this point of view, in this example it is shown the interaction with the AVM (Automated Vehicle Monitoring) system, which has the task of monitoring and forecasting the movement of the urban public transport fleet. The provision of this information is necessary for the System to give priority to public transport vehicles.

Finally, it is put the attention on the so called Multifunctional Outstation (MFO). Not only does its presence assure the actuation of the urban traffic control, but it also acts as data pusher of the information provided by external systems interfacing with the System here considered.

Figure 9 P3 Urban Traffic Control and Public Transport Priority System - Context Diagram



2.4.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram, which is shown in the Figure above. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting the unused Terminators.

As will be seen from a comparison with Figure 1, a total of fourteen Terminators in the general list are not required by this System. They and the reasons for their exclusion, plus details of the actors excluded from "generic" terminators are shown in the following table.

Table 5 P3 Urban Traffic Control and Public Transport Priority System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Not directly connected to the System, even though this kind of information could be included indirectly in the reference control strategy provided by a Town Supervisor System (which has been included in the Related Road System terminator).
Bridge/Tunnel Infrastructure	Not included. Out of scope.
Consignor/Consignee	Not included.
Driver	All the actors in this terminator are required by this System, but they may not be referred to specifically by name. Instead the term "Driver" is used to indicate all actors in this Terminator.
Emergency Systems	Not included at the moment. They could be included in the sense that the System could give the maximum priority to the emergency vehicles at the controlled intersection.
External Service Provider	Not included until now.
Financial Clearinghouse	Not included as only required by Systems involving financial transactions.
Freight Equipment	Not included.
Law Enforcement Agency	No provision for law enforcement included
Location Data Source	This information is inside the System, so that it is not a terminator.
Maintenance Organisation	Not directly connected to the System.
Multi-modal System	Not included.
Operator	Only the following actors in this terminator are required by this System: Road Network Operator.
Road Pavement	Not included.

Terminator Name	Reasons for deletion or modification
Transport Planner	Not directly included as it might be connected to a Town Supervisor System (which has been included in the Related Road System terminator).
Traveller	Only the following actors in this terminator are required by this System: Public Transport Passenger, Pedestrian and Cyclist.
Vehicle	All the actors in this terminator are required by this System, but they may not be referred to specifically by name. Instead the term “Vehicle” is used to indicate all actors in this Terminator.
Weather Systems	Not included. Out of scope.

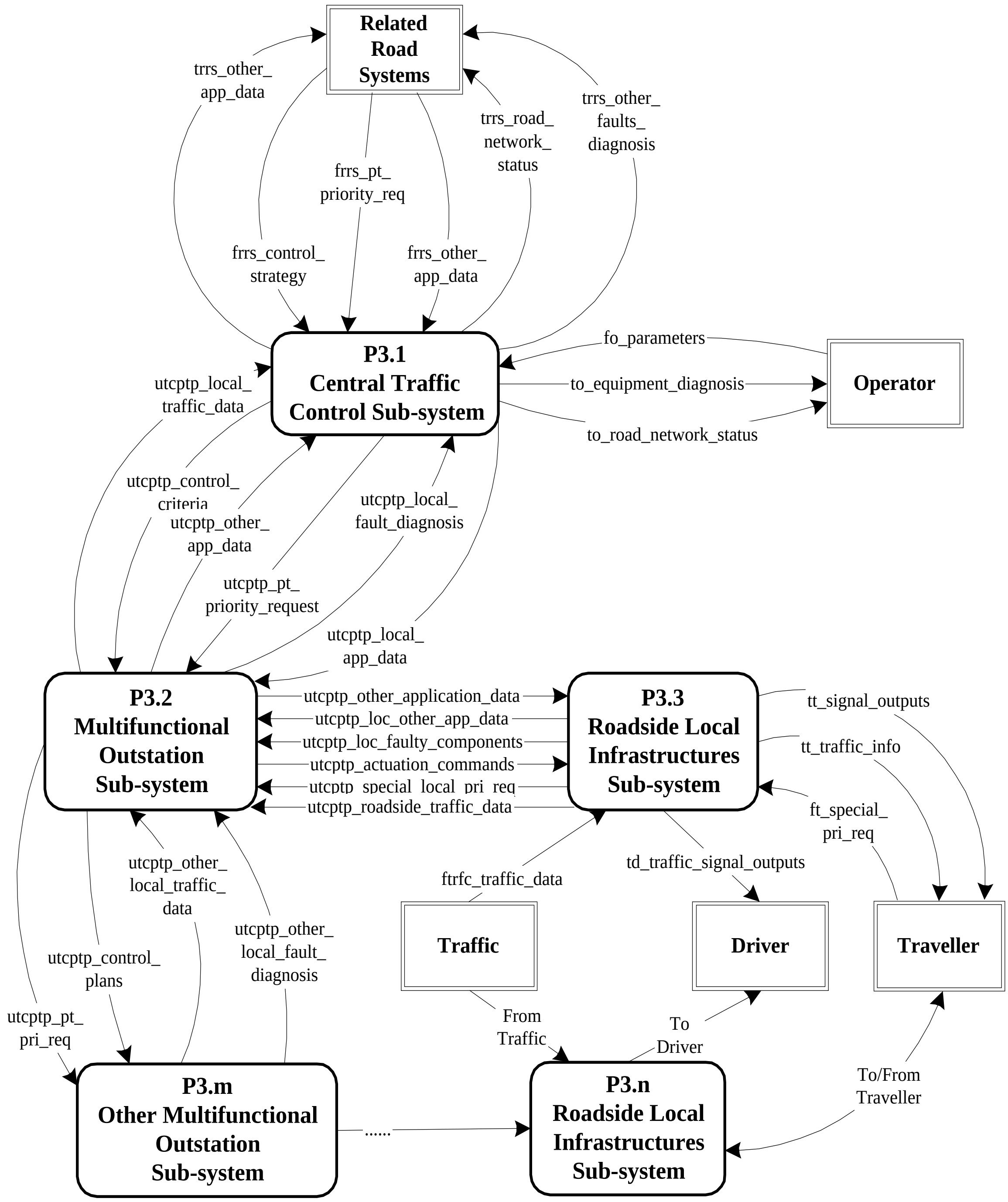
2.4.3 Sub-systems

This System consists of three main Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the following Figure together with their relationships with each other and the Terminators.

P 3.1 Central Traffic Control Sub-system: - this Sub-system provides all of the centralised functionality for traffic control at the so called “area” level, limited for this System to the provision of a reference working point and the optimum control criteria. This Sub-system interfaces with the Town Supervisor in order to receive control strategy from a higher control level, but also to provide macroscopic variables of the urban road network (e.g. travel times, flows, densities, congestion detection) and other information (e.g. the current faulty equipment). Other data are exchanged with interfacing systems for other applications (e.g. towards a Route Guidance, a VMS or the AVM system directly or through the Town Supervisor). The Sub-system collects and analyses the local traffic information (provided by the local MFO) so to detect accidents/congestion and monitor the road network status at the area level. On the base of this collected and suggested traffic information, it can take the decision of the most appropriate control criteria to be transmitted to the local controllers in the form of parameters and reference co-ordinated signal cycles (updated each about five minutes). Finally, it interacts directly with the external terminator AVM to give priority to the public transport vehicles. This action is done by the control system on the base of the provided forecasted arrivals at the controlled intersections, which are received at the area level and immediately provided to the P3.2 Sub-system to the local level.

P 3.2 Multifunctional Outstation Sub-system: - this Sub-system provides all of the peripheral functionality for traffic control at the intersection level. The MFO are autonomous systems capable of optimising the local traffic control and able to reach the optimal area control by means of a strong interaction with other MFO. The local optimised control is worked out on the base of the collection of measured and estimated traffic data made by the Sub-system itself and other near local controller, the control criteria received from the area level (see P3.1 above), and the roadside public transport vehicle priority requests. The result of this local optimised control consists in continuously updated traffic light cycles at the controlled intersection. In addition to this, the P3.2 Sub-system acts as an urban area communication network node able to exchange information belonging to other systems interfacing with the System itself. So that, for example, it is responsible for displaying information coming from the AVM at the bus stop and kiosks distributed in the city, or transmitting messages from the VMS centre to the VMS panels and so on.

Figure 10 P3 Urban Traffic Control and Public Transport Priority System - Sub-systems Diagram



P3.3 Roadside Local Infrastructures Sub-system: - this Sub-system provides all of the roadside functionality for traffic management. This includes sensors (e.g. loop detectors, special priority requests sensors), traffic light controllers and other application devices (e.g. Bus-stop displays, VMS panels, Car Park panels, Beacons). All the equipment receives actuation inputs and data from MFO Sub-system (P3.2 above), and exchange also other kind of information like faulty conditions.

In addition to these three sub-systems, the P3.m and P3.n additional Sub-systems were added to the system diagram in order to better describe the MFO Sub-system. The P3.m represents an MFO Sub-system with the same input/output data flows of P3.2, though those concerning the direct communication with the Central Traffic Control Sub-system (P3.1 above) are not drawn as not all the MFOs are directly connected to the Central Traffic Control Sub-system (P3.1 above). In fact, it is important to underline that all the MFOs form a low level communication network where local controllers strongly interact to each other. Consequently, it is not necessary for each of them to communicate with the Central Traffic Control Sub-system (P3.1 above), as the suggested control strategy of the area level is managed and distributed directly and indirectly at the lower local level of the intersections. At the local level the optimal control is based on the control strategies suggested by the P3.1 Sub-system, but it is decided at this local level with a strong interaction among controllers of the distributed network of MFO to build a decentralised control system.

Another important aspect in the choice of drawing P3.m and P3.n (which is equal to the P3.3) in the system diagram is that each MFO communicates and controls its own roadside infrastructure and can exchange different information with the other MFO located nearby.

As P3.m and P3.n have the same structure as P3.2 and P3.3 respectively. They will not be considered in the following descriptions and decomposition of Modules into Functions and their associated User Needs.

2.4.4 Sub-Systems and Functions

All the three of the Sub-systems that have been identified in the previous section can be split up into Modules. Therefore no direct relationship exists between Sub-systems and Functions.

2.4.5 Modules

2.4.5.1 Introduction

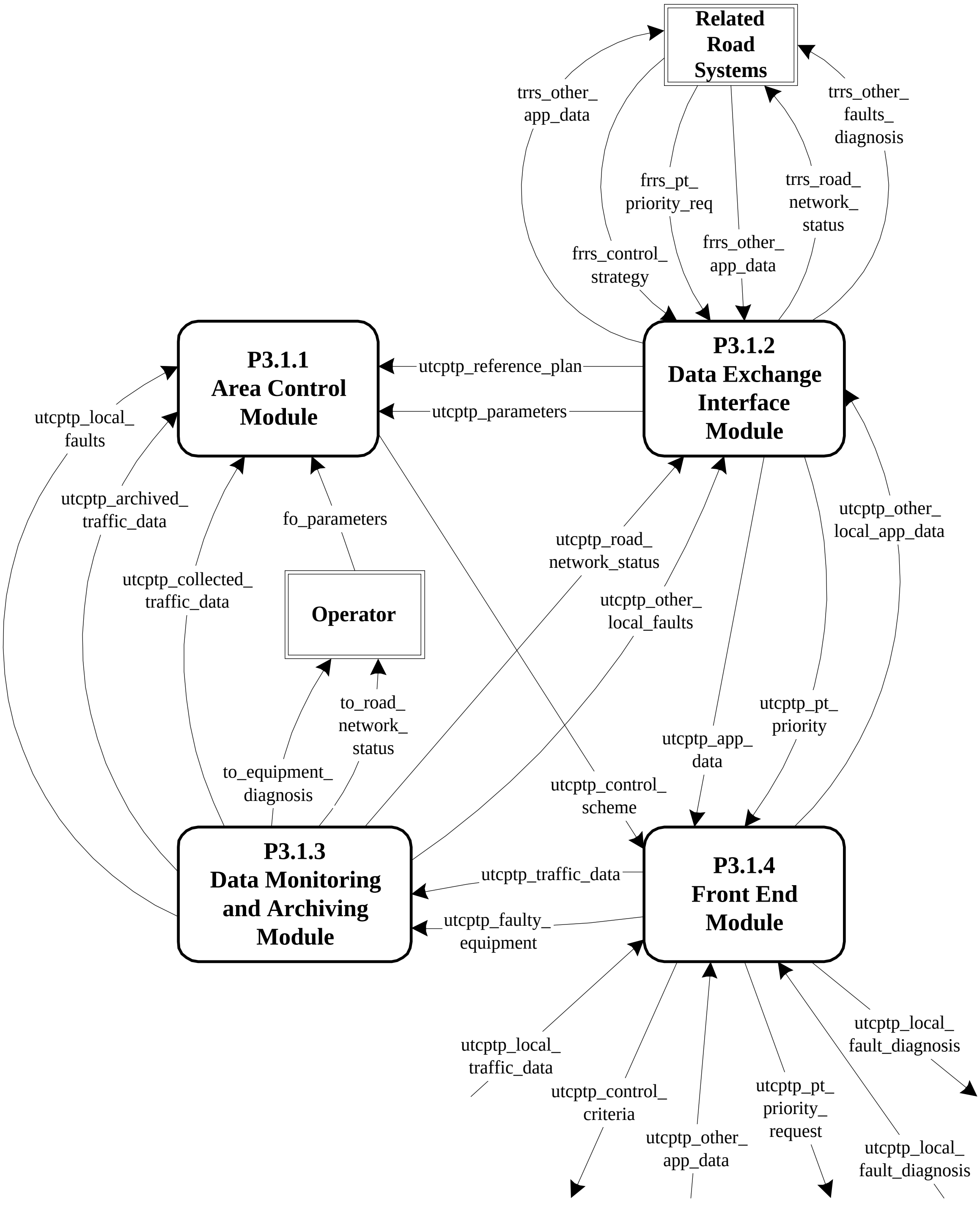
The three Sub-systems are divided into Modules. The Modules in the individual Sub-systems are described below and shown in the following Figures together with their relationships with each other and the Terminators.

2.4.5.2 Modules in P3.1 Central Traffic Control Sub-system

The Central Traffic Control Sub-system consists of four Modules. These cover the collection, monitoring and daily archiving of traffic data (e.g. flows, congestion, densities) and diagnostic information, suggesting the control strategy at the area level by transmitting control parameters to the MFO level. In addition to that, it is allowed the exchange of priority requests and other data between the MFO and related road systems. Their descriptions are provided on the following pages and the way in which they are connected in shown in the Figure below.

P3.1.1 Area Control Module: - this Module defines the optimum control criteria (e.g. reference plan, weights) needed to influence the local control action. These criteria are worked out on the base of various inputs: the reference control strategy (e.g. from the Town Supervisor), the nominal traffic data, the observed traffic variables (flows, turning percentages, incident/congestion detection) and diagnostic information.

Figure 11 P3 Urban Traffic Control and Public Transport Priority System - Central Traffic Control Sub-system Modules



P3.1.2 Data Exchange Interface Module: - this Module enables the exchange of information with the outside World. This Module is able to interpret data coming from other related road systems. These data have to be converted in a suitable format to be correctly interpreted by the System which uses proprietary formats and proprietary location referencing. The exchanged information consists in control strategies, priority requests, faults diagnosis, network status and other application data.

P3.1.3 Data Monitoring and Archiving Module: - this Module collects, archives and monitors traffic data coming from the MFO Sub-system. In fact, a specific software package running here performs the on-line monitoring of congestion levels and incident warnings. It integrates the data collected from the local units in order to deduce possible scenarios of incident or congestion situations taking into account comparisons among estimated, historical and ideal traffic parameters. On the base of a model of the incident/congestion diagnosis, this Module provides input to the Area Control Module (P3.1.1 above) to improve the management of such events. This information is completed by the faulty local diagnosis. In addition to providing these data to the Area Control Module (P.3.1.1 above), they are also available to the Operator and any related external interfaced road system.

P3.1.4 Front End Module: - this Module decides the optimum routing of data exchanged with the MFO Sub-system. The exchanged information consists in control strategies, priority requests, faults diagnosis, network status and other application data.

2.4.5.3 Modules in P3.2 Multifunctional Outstation Sub-system

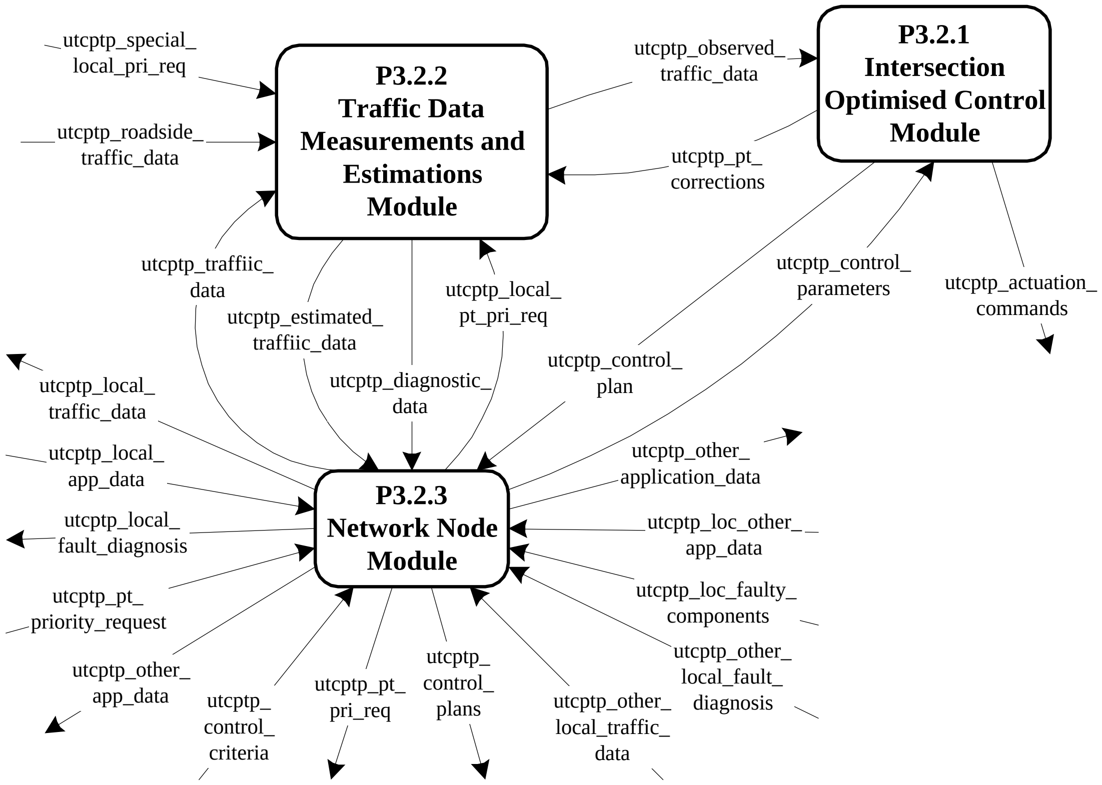
The Multifunctional Outstation Sub-system consists of three Modules. These cover the collection and estimation of intersection traffic data, the definition of the optimum local control action and the transmission of the traffic data and control plan to the near MFO Sub-systems. This happens to build an intersection level decentralised control with the strong interaction among the various MFO controllers. As well as this, the MFO is responsible of properly re-routing application and traffic data to the MFOs belonging to the low level communication network. The descriptions of the Modules are as follows.

P3.2.1 Intersection Optimised Control Module: - this Module provides the traffic light stages necessary to assure the optimum traffic control at the intersection level. The local controller has to quickly react to the perturbations at the intersection (e.g. accidents, queues, special and absolute priority requests) updating every three seconds its “rolling” optimising horizon (two minutes). So that not only has it to consider the observed status of the intersection on the base of local measurements and estimation, but it has also to evaluate what happens to the traffic leaving the intersection and what the downstream local controllers are going to do (“strong interaction”). But this is not enough, if not completed by what happens upstream to estimate the traffic arriving in the next two minutes (“look- ahead”). In conclusion, it is important to elaborate the observed traffic data and control plan belonging to the intersection itself and to the nearest intersections. An interesting optional functionality is that this Module can also evaluate and transmit the arrival time corrections for public transport vehicles.

P3.2.2 Traffic Data Measurements and Estimations Module: - this Module enables the measurements and estimations of the intersection status. This is done on the base of traffic data coming from sensors and near MFO, priority requests for public transport vehicles and special priority requests coming from the roadside infrastructures. The traffic data involves diagnostic analysis too.

P3.2.3 Network Node Module: - this Module decides the optimum routing of data exchanged with the MFO Sub-systems belonging to the intersection level network. The exchanged information consists in control strategies, priority requests, faults diagnosis, network status and other application data.

Figure 12 P3 Urban Traffic Control and Public Transport Priority System - Multifunctional Outstation Sub-system Modules



2.4.5.4 Modules in P3.3 Roadside Local Infrastructures Sub-system

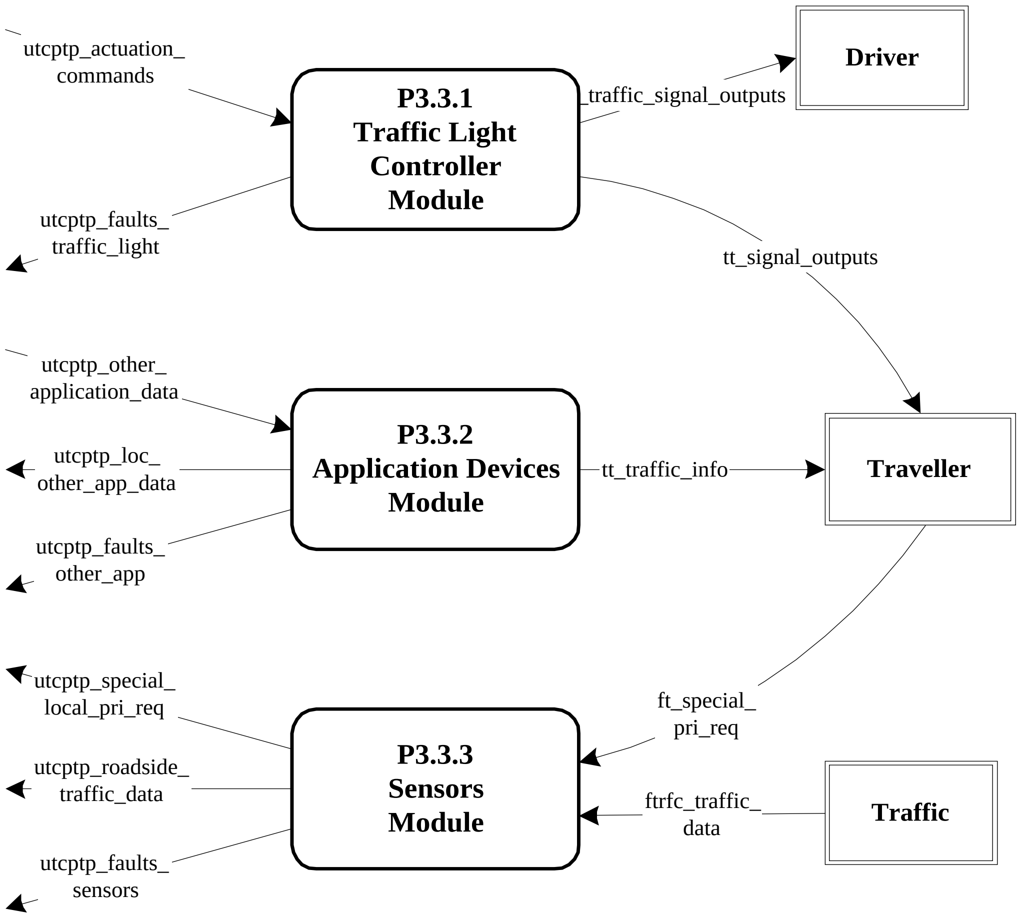
The Roadside Local Infrastructures Sub-system consists of three Modules. These cover the traffic commands and data exchange with the outside World. As well as providing instructions to control and co-ordinate Travellers and vehicles movement, this Sub-system convoys the sensor measurements and other information towards the MFO Sub-system. The descriptions are as follows.

P3.3.1 Traffic Light Controller Module: - this Module provides the output traffic light signals needed to actuate the optimum control at the intersection level giving absolute priorities to selected public transport vehicles. Moreover this module checks the actuation commands coming from the local controller. In fact, it is important to avoid conflicting conditions and to make observe the timing limits based on safety criteria and rules established by the local municipality. Finally, another important functionality is providing diagnostic data to the MFO Sub-system.

P3.3.2 Application Devices Module: - this Module represents how other application data can be directly exchanged with Travellers and Drivers. Various devices belong to this Module. The bus-stop displays inform on the public transport forecasted arrivals. The VMS panels provide traffic information such as road-works, congestion… The Car Park panels provide the forecasted available free rooms. The roadside Beacons suggest the best direction to reach a particular destination collecting at the same time the travel times along the road networks. A general important functionality is providing device diagnostic data to the MFO Sub-system.

P3.3.3 Sensors Module: - this Module provides roadside requests and data information needed for the elaboration of the optimum intersection control. As well as providing measurements of roadside sensors (e.g. loop detectors), it convoys special priority requests (e.g. firemen, pedestrian requests) and sensors diagnosis to the MFO.

Figure 13 P3 Urban Traffic Control and Public Transport Priority System - Roadside Local Infrastructures Sub-system Modules



2.4.6 Modules and Functions

The Modules identified in the previous section can be split up into Functions. These are identified in the tables that are shown below and on the following pages. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 6 P3 Urban Traffic Control and Public Transport Priority System - Allocation of Functions to Sub-systems and Modules

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P3.1	Central Traffic Control	Central	P3.1.1	Area Control	F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.8, 7.1.5.1, 7.1.5.7, 7.1.9.1, 7.1.9.2
					F 3.1.1.5.7	Provide Operator Urban Traffic Control Facilities	7.1.3.5
			P3.1.2*	Data Exchange Interface	F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 7.1.2.2, 7.1.6.1
					F 4.4.2	Require Vehicle Priority	10.1.6.1
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.3, 6.2.0.4, 6.2.1.3, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.0.3, 6.4.1.2, 6.4.2.4
			P3.1.3	Data Monitoring and Archiving	F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 7.1.2.2, 7.1.2.4
					F 3.1.1.5.7	Provide Operator Urban Traffic Control Facilities	7.1.3.1, 7.1.3.2, 7.1.3.3

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P3.1	Central Traffic Control (continued)	Central	P3.1.3	Data Monitoring and Archiving (continued)	F 3.2	Manage Incidents	7.2.0.1, 7.2.0.2, 7.2.0.3, 7.2.0.6, 7.2.0.7, 7.2.0.8, 7.2.0.9, 7.2.2.3, 7.2.4.1, 7.2.4.2, 7.2.5.2
			P3.1.4*	Front End	F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.8, 7.1.5.1, 7.1.5.7, 7.1.9.1, 7.1.9.2
					F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 7.1.2.2, 7.1.6.1
					F 4.4.2	Require Vehicle Priority	10.1.6.1
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.3, 6.2.0.4, 6.2.1.3, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.0.3, 6.4.1.2, 6.4.2.4
P3.2	Multifunctional Outstation	Roadside	P3.2.1	Intersection Optimised Control	F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.5
					F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.5
					F 3.1.1.5.5	Provide Urban Output Actuation	7.1.3.4

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P3.2	Multifunctional Outstation (continued)	Roadside	P3.2.1	Intersection Optimised Control (continued)	F 3.2	Manage Incidents	7.2.0.1, 7.2.0.2, 7.2.0.3, 7.2.0.6, 7.2.0.7, 7.2.0.8, 7.2.0.9, 7.2.2.3, 7.2.4.1, 7.2.4.2, 7.2.5.2
			P3.2.2	Traffic Data Measurements and Estimation	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.4
					F 4.4.2	Require Vehicle Priority	10.1.6.1
					F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.8, 7.1.5.1, 7.1.5.7, 7.1.9.1, 7.1.9.2
					F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 7.1.2.2, 7.1.6.1
					F 4.4.2	Require Vehicle Priority	10.1.6.1
					F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.3, 6.2.0.4, 6.2.1.3, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.0.3, 6.4.1.2, 6.4.2.4

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P3.3	Roadside Local Infrastructures	Roadside	P 3.3.1	Traffic Light Controller	F 3.1.1.5.5	Provide Urban Output Actuation	7.1.3.4
			P 3.3.2	Application Devices	F 6.3	Support Trip	6.1.03, 6.1.1.4, 6.1.2.3, 6.2.0.4, 6.2.1.3, 6.2.2.2, 6.2.2.4, 6.2.2.5, 6.4.0.1, 6.4.0.3, 6.4.1.2, 6.4.2.4
			P 3.3.3	Sensor	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.4

2.4.7 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

trrs_other_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which have been collected at the intersection level. These data are now available to the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
trrs-urban_data_updates

frrs_control_strategy
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the reference control strategy received from the interfaced Town Supervisor system, which represents an higher control level in the control hierarchy. The data flow consists of the following functional data flows:
frrs-urban_data_updates
mt_traffic_inputs_from_demand_management
The last functional data flow does not come from Related Road Systems.

frrs_pt_priority_req
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the required absolute priority request for selected public transport vehicles on the base of the forecasted arrival time at the controlled road intersections. This information is available from the related interfaced AVM system. The data flow consists of the following functional data flows:
frrs-urban_data_updates
mpto.mt_vehicle_priority_request

frrs_other_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which are needed at the intersection level. These data are available from the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
frrs-urban_data_updates
ptja.padas_travel_info
ptja.padas_route_guidance
td_route_guidance_info
tt_itinerary_changes
mt.ptja_carpark_occupancy
The last functional data flows do not come from Related Road Systems.

trrs_road_network_status
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the traffic data needed to monitor the entire road network. These data consist of macroscopic variables like travel times, flows, densities. The data flow consists of the following functional data flows:
trrs-urban_data_updates
mt_traffic_outputs_for_demand_management
trrs_incident_data

trrs_other_faults_diagnosis
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire network of application devices. This information is collected at the intersection level and required by the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
trrs-urban_data_updates
trrs_incident_data

fo_parameters
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the parameters needed to tune the optimised traffic control at the area level. The data flow consists of the following functional data flows:
fo.rno-urban_commands
fo.rno-incident_inputs

to_equipment_diagnosis
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire traffic light controller network. This information is collected at the intersection level and monitored by the Operator at the area level. The data flow consists of the following functional data flows:
to.rno-urban_responses
to.rno-incident_outputs

to_road_network_status
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the road network status at the area level. These data consist of macroscopic variables like travel times, flows, densities… and are continuously monitored by the Operator at the area level. The data flow consists of the following functional data flows:
to.rno-urban_responses
to.rno-incident_outputs

utcptp_local_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the road network status at the intersection level. The data consist of estimated variables like turning percentages, flows, densities… on the base of sensors measurements made on the field. They are collected from the various MFO which constitute the low level communication network. The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data
mt_urban_traffic_data_for_incident_detection

utctptp_control_criteria
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It consists of the co-ordination parameters (e.g. reference plan, weights) needed to influence the local control strategies. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_other_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which have been collected at the intersection level. These data are now available to the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data

utcptp_pt_priority_request
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the required absolute priority request for selected public transport vehicles on the base of the forecasted arrival time at the controlled road intersections. This information is available from the related interfaced AVM system. The data flow consists of the following functional data flows:
mpto.mt_vehicle_priority_request

utcptp_local_fault_diagnosis
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire network of traffic controllers and other application devices. This information is collected at the intersection level. It is required both by System itself at the area level and by the related systems interfacing with it (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_local_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which are needed at the intersection level. These data are available from the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
ptja.padas_travel_info
ptja.padas_route_guidance
td_route_guidance_info
tt_itinerary_changes
mt.ptja_carpark_occupancy
The previous functional data flows do not necessarily belong to the mapped functions.

utcptp_other_application_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which are needed at the intersection level. These data are available from the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
ptja.padas_travel_info
ptja.padas_route_guidance
td_route_guidance_info
tt_itinerary_changes
mt.ptja_carpark_occupancy
The previous functional data flows do not necessarily belong to the mapped functions.

utcptp_loc_other_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which have been collected at the intersection level. These data are now available to the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data

utcptp_loc_faulty_components
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of traffic controllers and other application devices located at the intersection level. This information is required both by System itself at the area level and by the related systems interfacing with it (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following constituent Physical Data Flows:
utcptp_faults_sensors
utcptp_faults_other_app
utcptp_faults_traffic_light
The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_actuation_commands
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the commands for the traffic light controller needed for the optimised control at the local intersection level. The data flow consists of the following functional data flows:
td.mt_outputs
tt.mt_outputs

utcptp_special_local_pri_req
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the special priority requests at the intersection level. These requests are provided through special sensors like public transport sensors, buttons for pedestrian calls, presence sensors in general. This information involves planning specific actions, like the insertion of optional stages in the traffic light cycle. The data flow consists of the following functional data flows:
fv.ptv_local_priority-request

utcptp_roadside_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the measurements made on the field by the roadside sensors (e.g. loop detectors). The data flow consists of the following functional data flows:
mt_collected_urban_traffic_data
mt_urban_traffic_data_for_incident_detection

utcptp_pt_pri_req
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the required absolute priority request for selected public transport vehicles on the base of the forecasted arrival time at the controlled road intersections. This information is available from the related interfaced AVM system and it is routed by the single MFO towards the peripherals MFO which are not directly connected to the Central Traffic control. The data flow consists of the following functional data flows:
mpto.mt_vehicle_priority_request

utcptp_control_plans
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It consists of the co-ordination parameters (e.g. reference plan, weights) needed to influence the local control strategies. They are routed by the single MFO towards the peripherals MFO which are not directly connected to the Central Traffic Control. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_other_local_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains two kinds of data. On the one hand, it consists of the co-ordination parameters (e.g. reference plan, weights) needed to influence the local control strategies. On the other hand, it needs the estimated traffic variables of the MFO located nearby. These data are routed towards the single MFO from the peripherals MFO which are not directly connected to the Central Traffic Control. In fact, not only has each local traffic controller to consider what the downstream are going to do, but it also has to understand what happens upstream to know the traffic conditions of the next two minutes (optimising horizon time). In this data flow there is also a particular kind of information, that is the correction of the public transport arrival times at the intersection. This information is provided by the involved local controller which is able to make the right correction on the base of its estimations. The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data
mt_urban_traffic_data_for_incident_detection

utcptp_other_local_fault_diagnosis
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire network of traffic controllers and other application devices. This information is collected at the intersection level. It is required both by System itself at the area level and by the related systems interfacing with it (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). Here it is provided by the peripherals MFOs towards the single MFO which is directly connected to the Central Traffic Control. The data flow consists of the following functional data flows:
mt_urban_equipment_status

td_traffic_signal_outputs
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It represents the traffic light cycle needed to control the vehicles movement in order to actuate the local optimised control action at the intersection level. The data flow consists of the following functional data flows:
td.mt_outputs

tt_traffic_signal_outputs
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It represents the traffic light cycle needed the co-ordinate the generic traveller movement at the intersection level. The data flow consists of the following functional data flows:
tt.mt_outputs

tt_traffic_info
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It represents the information provided to the generic traveller through the use of different devices like arrival times at bus-stop displays, traffic messages at VMS panel, available car park slots at car park panels, suggested directions through Route Guidance beacons. The data flow consists of the following functional data flows:
tt.mt_outputs

ft_special_pri_req
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the special priority requests at the intersection level. These requests are provided through special sensors like public transport sensors, buttons for pedestrian calls, presence sensors in general. This information involves planning specific actions, like the insertion of optional stages in the traffic light cycle. The data flow consists of the following functional data flows:
ft-urban_data

ftrfc_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the measurements made on the field by the roadside sensors (e.g. loop detectors). The data flow consists of the following functional data flows:
ftrfc-traffic_data_input

utcptp_local_faults
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of equipment and sensors of the entire road network at the area level. The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_archived_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains all needed traffic information which has been archived at the area level. The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data

utcptp_collected_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains all needed traffic information which has been collected at the area level. It includes road network status in terms of estimated congestion levels, flows, densities, turning percentages,…at the area level. The data flow consists of the following functional data flows:
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_data_for_incident_detection

utcptp_control_scheme
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It consists of the co-ordination parameters (e.g. reference plan, weights) needed to influence the local control strategies. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_parameters
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the parameters needed to tune the optimised traffic control at the area level. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_reference_plan
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the reference control strategy received from the interfaced Town Supervisor system, which represents an higher control level in the control hierarchy. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_road_network_status
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the traffic data needed to monitor the entire road network. These data consist of macroscopic variables like travel times, flows, densities. The data flow consists of the following functional data flows:
trrs-urban_data_updates
mt_traffic_outputs_for_demand_management
trrs_incident_data

utcptp_other_local_faults
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire network of application devices. This information is collected at the intersection level and required by the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
trrs-urban_data_updates
trrs_incident_data

utcptp_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which are needed at the intersection level. These data are available from the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
frrs-urban_data_updates
ptja.padas_travel_info
ptja.padas_route_guidance
td_route_guidance_info
tt_itinerary_changes
mt.ptja_carpark_occupancy

utcptp_pt_ptiority
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the required absolute priority request for selected public transport vehicles on the base of the forecasted arrival time at the controlled road intersections. This information is available from the related interfaced AVM system. The data flow consists of the following functional data flows:
frrs-urban_data_updates
mpto.mt_vehicle_priority_request

utcptp_other_local_app_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains specific application data which have been collected at the intersection level. These data are now available to the related systems interfacing with this System (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
trrs-urban_data_updates

utcptp_traffic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the road network status at the intersection level. The data consist of estimated variables like turning percentages, flows, densities… on the base of sensors measurements made on the field. They are collected from the various MFO which constitute the low level communication network. The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data
mt_urban_traffic_data_for_incident_detection

utcptp_faulty_equipment
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the entire network of traffic controllers and other application devices. This information is collected at the intersection level. It is required both by System itself at the area level and by the related systems interfacing with it (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_pt_corrections
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains a particular kind of information, that is the correction of the public transport arrival times at the intersection. This information is worked out by the local controller which is able to make the right correction on the base of its estimations. Then, it is provided to the MFOs requiring this correction to better plan their control action to give priority to the selected public transport vehicles. The data flow consists of the following functional data flows:
mt_urban_traffic_management_requests

utcptp_observed_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the best estimation of traffic status (horizontal queues for each “link”) at the intersection on the base of the intersection model and the available traffic data. The elaborated data are represented by roadside sensors measurement (e.g. loop detectors), traffic variable and control plan of the intersections located nearby (for the strong interaction and look ahead principles actuated by the local controllers), but also PT priority requests and special priority requests. The data flow consists of the following functional data flows:
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data
mpto.mt_vehicle_priority_request

utcptp_estimated_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traffic status at the intersection on the base of the intersection model and the available traffic data. This information is provided to the intersections located nearby on the base of the strong interaction and look ahead principles actuated by the local controllers. The data flow consists of the following functional data flows:
mt_urban_traffic_management_requests
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data

utcptp_local_pt_pri_req
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains the required absolute priority request for selected public transport vehicles on the base of the forecasted arrival time at the controlled road intersections. This information is available from the related interfaced AVM system and is provided by the Central Traffic Control. The data flow consists of the following functional data flows:
mpto.mt_vehicle_priority_request

utcptp_diagnostic_data
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of traffic controllers and other application devices at the intersection level. It is required both by System itself at the area level and by the related systems interfacing with it (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_traffic_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the traffic status at the intersections located nearby. This information is needed on the base of the strong interaction and look ahead principles actuated by the local controllers. The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
mt_predicted_urban_network_data
mt_urban_traffic_predicted_data
mt_urban_traffic_data_for_incident_detection

utcptp_control_plan
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains the plan worked out by the local traffic controller. It has to be provided to the local controllers located nearby on the base of the strong interaction and look ahead principles actuated by the local control action. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_control_parameters
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It consists of the co-ordination parameters (e.g. reference plan, weights) needed to influence the local control strategies. They are provided by the Central Traffic Control. The data flow consists of the following functional data flows:
mt_traffic_inputs_from_demand_management

utcptp_faults_sensors
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of the sensors (e.g. loop detectors) at the intersection level. This is important for the estimation of local traffic variables, but also for the diagnostic purposes needed at higher level of analysis and monitoring. The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_faults_other_app
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of other application devices at the intersection level. It is required for diagnostic purposes by the related systems interfacing with the Systems (e.g. the AVM system, the VMS system, the Car Park system, the Route Guidance system, the Pollution Monitoring system). The data flow consists of the following functional data flows:
mt_urban_equipment_status

utcptp_faults_traffic_light
This physical data flow is used within the Urban Traffic Control and Public Transport Priority System. It contains information about the diagnostic status of traffic controllers. This is important for the diagnostic purposes needed at higher level of analysis and monitoring.
The data flow consists of the following functional data flows:
mt_urban_equipment_status

2.4.8 Key Issues

A total of four Key Issues have been identified for this System. They are as follows:

1. The System has an open architecture. This gives the opportunity of exchanging data and information with other systems on the base of an agreed format. The openness to potential integration is extremely important for the given example. In fact the described System aims at providing a response to two fundamental requirements of wide-area traffic control. On the one hand it provides significant improvements in private vehicle mobility in all traffic conditions. On the other, it gives priority to selected public transport vehicles at traffic light controlled intersections. Consequently, the integration for co-operation with an AVM (Automatic Vehicle Monitoring) system is needed or alternatively obtained with special roadside detectors. In this example the AVM provides the selected public transport vehicles forecasted arrivals at the controlled intersections, and these data represent an input for the local control system to give the required priority. In addition to interfacing directly with AVM, it is also important to notice that this System can integrate with related road systems, like a Town Supervisor or other traffic control systems, emergency systems, in order to actuate a urban road network control strategy which considers also other influence factors like maximum priorities, pollution emission levels, city-wide demand management schemes, etc.

2. The System is designed to improve urban level conditions by the application of fully automated control algorithms. Its physical architecture is hierarchical and decentralised, the optimal reference control strategy is determined at the higher level on the basis of

area traffic predictions, traffic light control is finally optimised and actuated at the local level amending the reference control strategy according to the actual traffic conditions occurring at the intersections. This type of architecture requires a communication network among intersections and the connection of some nodes (e.g. one third) of this network to the control centre. The control approach is known as “goal co-ordination” and is typical of the hierarchical control systems: the upper level is in charge of determining the criteria to be adopted in the control law, while the lower level is in charge of fitting these criteria in a fast reaction feedback loop on the estimated state of the local system.

3. The communication network at the intersection level has the MFO as nodes. The MFO are the multifunctional outstations with the following peculiar functionality and benefits. First of all they have the capability of “observing” the intersection status and actuate the needed local optimum control actions. At the same time, they enable the exchange of application data and information between the local infrastructures (e.g. VMS panel, bus-stop displays, beacons, car park panels) and the related systems at the central level. As benefit, this shared communication network solution offers considerable savings on operating costs if compared to an alternative solution connecting directly each single MFO to the operations centres.

4. The open architecture is assured at the Central Traffic Control level. In fact, here the Data Exchange Interface module is responsible for the properly translation of input information into the internal proprietary formats and location referencing to be elaborated and/or routed to the local MFO’s. The data are received and distributed over the communication protocol TCP/IP.

2.5 P4 – Telematics Technologies for Transport and Traffic in Torino System

2.5.1 Overview

This example is based on the Torino (Turin) 5T system, a large-scale transport telematics system aimed to integrate a number of main Sub-systems to provide co-ordinated traffic and transport management and control over a wide area of the Torino conurbation. 5T (Telematics Technologies for Transport and Traffic in Torino) is also the name of the Consortium composed of members from the private and public sectors that was formed to construct the system.

The 5T physical architecture is structured according to an open, modular architectural model based on complementary, interconnected Sub-systems.

The data exchanged between all the 5T subsystems refer to a common location reference and data dictionary. Within the 5T architecture several proprietary systems can thus coexist and co-operate using their own language, database and protocols inside their own domain. The conversion of information from the exchange facility to the format of the proprietary subsystems is achieved by translator interfaces. These solutions also ensure that responsibilities are retained for how the information is actually used by the system operators.

In addition to this, the Sub-systems co-operate as part of a hierarchical-distributed structure under the co-ordination of a so-called Town Supervisor, but they are also capable of performing their functions independently, each on its specific operating area. This entirely modular architecture, in which systems maintain a degree of functional independence, facilitates management of the whole system and also ensures continued operation when one part of the system is not active.

Each of the 5T applications is designed to be able to work well autonomously, with capability for better performance when operating with other applications in an integrated environment. A total of ten main Sub-systems have been combined in accordance with the following three integration principles:

- *Co-operative monitoring.* An efficient and consistent analysis of the state of network cannot be efficiently assessed by a single application; it needs an overall assessment of data from various sources.

- *Co-operative equilibrium.* According to this principle, the point of optimal mobility distribution, that takes into account both users' mobility needs (network demand) and the state of the transport network (network supply) must be the sole reference point for the whole integrated system. The reference values for the 5T network are calculated by a purpose-built suite of software models known as the Town Supervisor system.

- *Co-operative control.* The reference values calculated on the basis of the co-operative equilibrium principle must be used by applications to elaborate joint control actions that reduce the difference between the equilibrium reference point and the observed traffic and transport state.

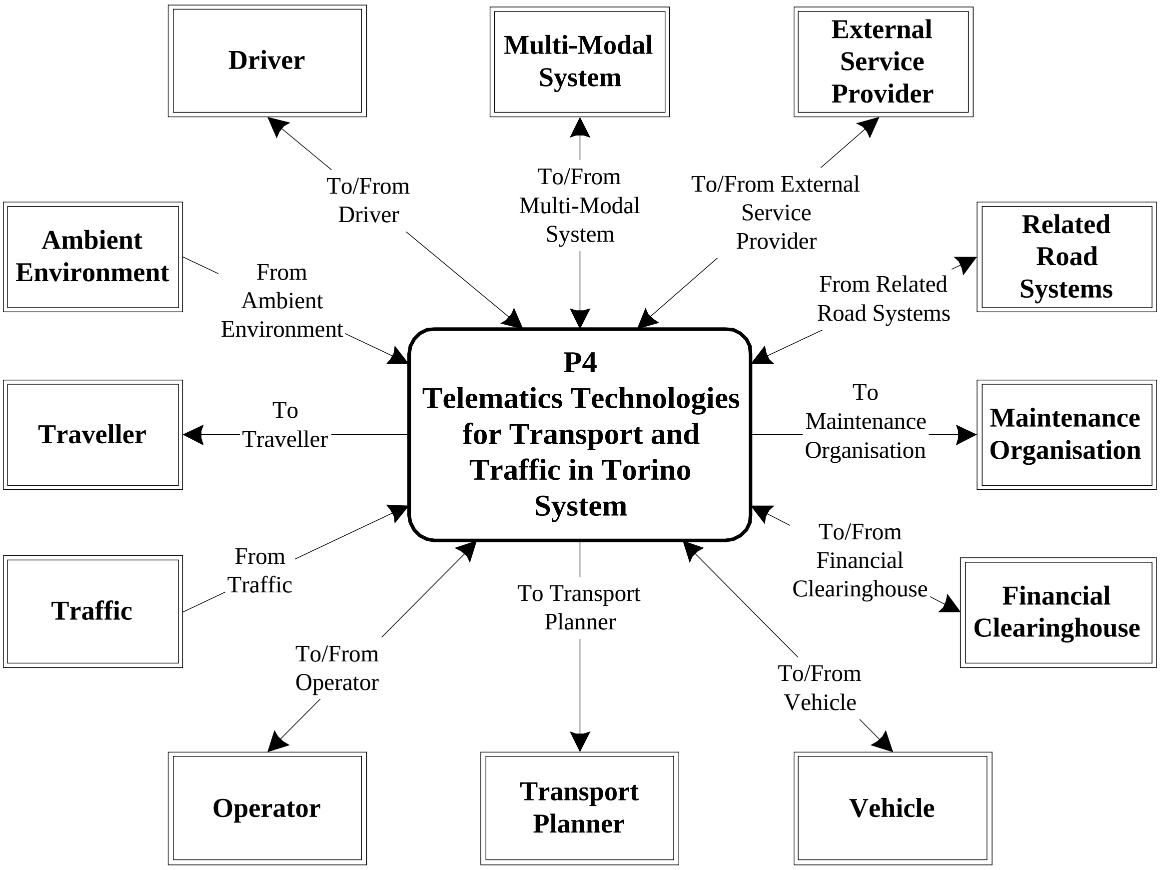
A further important element of 5T's Open System Architecture is the Multifunctional Outstation (MFO). These roadside units (already described in detail in P3 example) enable sensors and peripherals of the Sub-systems to share the same communication network. The solution offers technical benefits and significant savings on integration costs.

In this example the System will be described at the high level without considering the details of each independent Sub-system (see P3 example for a detailed description of one of these Sub-systems).

2.5.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram, which is shown in the following Figure. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting the unused Terminators.

Figure 14 P4 Telematics Technologies for Transport and Traffic in Torino System - Context Diagram



As will be seen from a comparison with Figure 1, a total of eight Terminators in the general list are not required by this System. They and the reasons for their exclusion, plus details of the actors excluded from “generic” terminators are shown in the following table.

Table 7 P4 Telematics Technologies for Transport and Traffic in Torino System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Bridge/Tunnel Infrastructure	Not included.
Consignor/Consignee	Not directly connected to the System. It could be in future.
Driver	Only the following actors in this terminator are required by this System: Private Driver, Emergency Vehicle Driver, Public Transport Driver.
Emergency Systems	Not included.

Terminator Name	Reasons for deletion or modification
Law Enforcement Agency	Not included.
Location Data Source	This information is not required as it belongs to the System.
Operator	Only the following actors in this terminator are required by this System: Public transport Operator, Road Network Operator. In fact, almost all the Sub-systems involved do not require the continuous presence of the Operator, except for maintenance work.
Road Pavement	Not directly connected to the System.
Weather Systems	Not included. Out of scope.

2.5.3 Sub-systems

This System consists of thirteen main Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the following Figure together with their relationships with each other and the Terminators.

P4.1 Town Supervisor Sub-system: - The highest level of the System architecture. It is basically a suite of software modules capable of integrating the actions of the other Sub-systems and co-ordinating their operations for the achievement of common goals. Policy decisions by the city authorities determine these common goals (e.g. improvement of the flow distribution of private traffic, improvements to the service offered by public transport and parking facilities, restricting the pollution caused by road traffic) and they are embedded in the System's algorithms. Emergencies or unusual events can be communicated to the Town Supervisor and its data base provides a powerful tool for town and transport planners. On the basis of its observation of the state of the traffic and transport network, this Sub-system calculates reference values that are used by the other Sub-systems to elaborate joint control actions.

P4.2 Urban Traffic Control Sub-system: - It has been already described in detail in the P3 example as a separated self-standing system. This Sub-system has the dual objectives of performing an optimal control of private traffic in all traffic conditions and to provide traffic light priority to selected public transport and emergency vehicles. Optimal control is sought at area, arterial and single intersection levels. As it was described in P3, this Sub-system has a hierarchical structure with distributed intelligence where the traffic control strategies for the entire network are established at the higher area level and control at the lower local level is actuated at each intersection according to actual traffic conditions and to requests for priority. Contrary to systems that operate on a 'priority-by-request' basis, the control manages to adapt gradually the traffic light stages, in order to favour priority vehicles without introducing variations that would penalise private traffic.

P4.3 Collective Route Guidance Sub-system: - This Sub-system provides guidance and general information to private vehicle users in the urban and suburban areas of Torino by means of Variable Message Signs (VMS). The subsystem aims to provide dynamic guidance through various alternative urban routes for private traffic flows with various destinations. It provides specific traffic information and guidance on the locations and occupancy conditions of parking areas. The Sub-system is able to translate the instructions and information received from the P4.1 Sub-system into clear and pertinent messages for display on the set of panels installed at various locations of the city. It can also react to indications of serious anomalies on the road network received from other Sub-systems or from human operators. The actual panels have an innovative design that aims to achieve maximum driver compliance. They are controlled at the local level by MFOs.

P4.4 Public Transport Management Sub-system: - This Sub-system has the basic tasks of controlling and monitoring the transport system's capacity as a function of demand and ensuring its regular and timely performance. It is based on a two-way connection between a central operating centre and vehicles on the network. Both data and voice communications are exchanged. The entire fleet of about 1500 vehicles is currently controlled by the Automatic Vehicle Monitoring (AVM) system. Selected vehicles can be given priority at the intersections controlled by the P4.2 Sub-system. Moreover, this Sub-system collects data on public transport travel times and supply and demand information and makes it available to the P4.1 (Town Supervisor) and the P4.7 (Informative Media Control) Sub-systems. The system's data collection capabilities have been enhanced by the experimental installation of an automatic passenger counting system on about 150 vehicles. A user information system has also been developed and integrated with the AVM to provide information to users at stops and aboard vehicles.

P4.5 Parking Control Sub-system: - This Sub-system monitors the use of car parks in the Torino area, calculates occupancy forecasts and, through close integration with the P4.7 Subsystem, provides an advance booking service. Current and forecast occupancies of each car park are sent to the P4.1 Sub-system.

P4.6 Individual Route Guidance Sub-system: - This Sub-system receives reference turning percentages per destination at the nodes of the network from P4.1. In this way it is able to implement a multi-routing strategy that is consistent with the traffic control actions taken by the other Sub-systems. The current test site covers about one tenth of the System network and five intersections have been equipped with Beacon to communicate with equipped vehicles.

P4.7 Informative Media Control Sub-system: - This Sub-system is composed of a centre equipped with a set of data bases that are able to manage the storage and diffusion of user information and to offer specific trip-planning functions. The Sub-system is responsible for the diffusion of private and public transport user information over the following media:

- The TELEVIDEO service offered by the state-owned TV broadcaster RAI, for which the Media Control centre prepares news bulletins about traffic conditions according to a specialised procedure.
- The INTERNET service.
- The User Information Terminals, for which static information is prepared periodically using CD-ROM production procedures while dynamic information is updated by means of dedicated communication lines with a PC front-end.

Moreover the centre is connected to the P4.5 Sub-system in order to implement the parking space booking function.

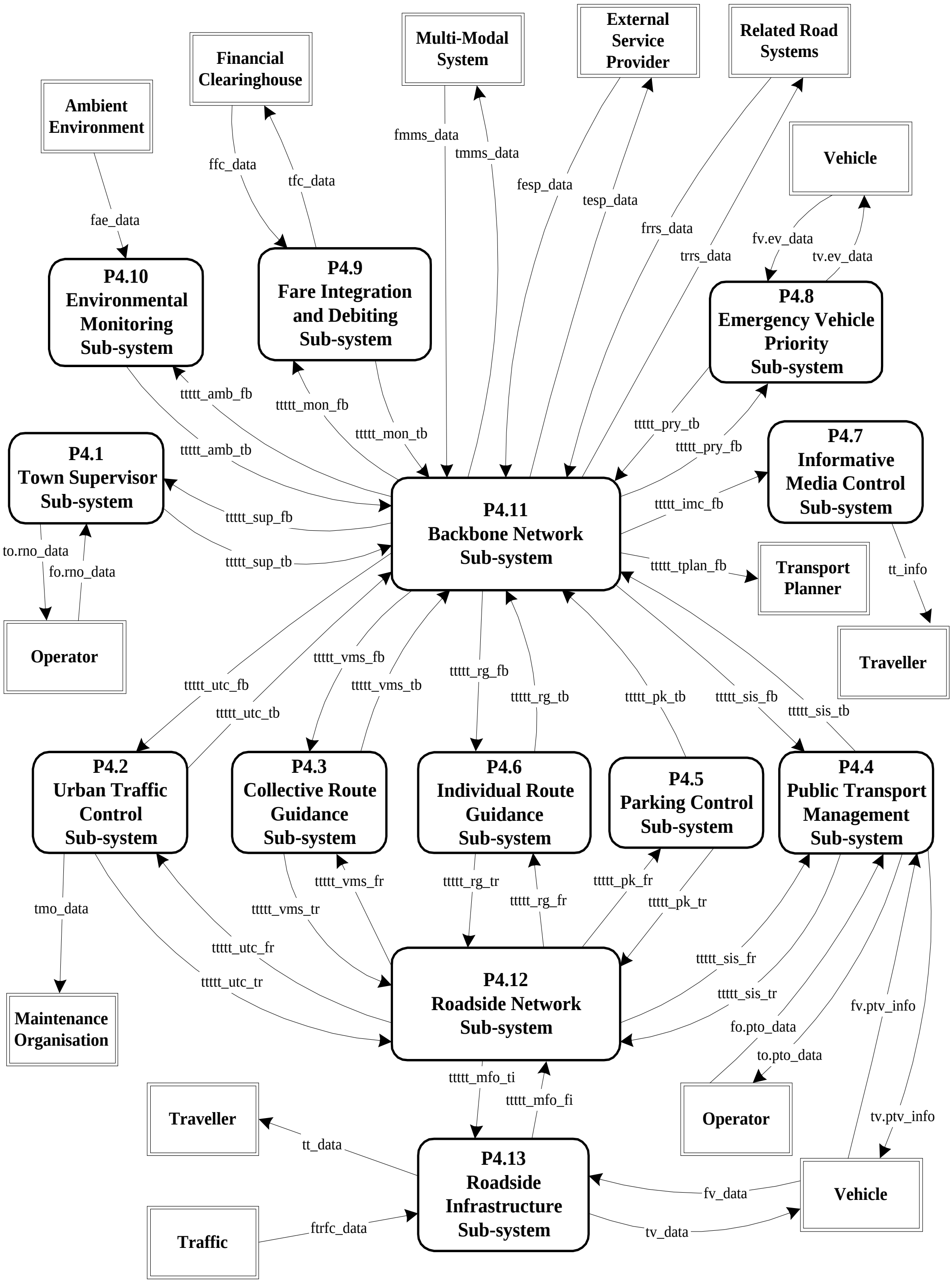
P4.8 Emergency Vehicle Priority Sub-system: - This Sub-system has the main objective of improving the management performance of the fleet of ambulances currently in service. It permits vehicles involved in an emergency mission to request privileged use of the urban road network. The system is designed to improve emergency call management and reduce the time spent by emergency vehicles in navigating through the urban network. Integration with the P4.2 Sub-system should ensure that the emergency vehicle finds a clear path on its route and receives green lights at intersections.

P4.9 Fare Integration and Debiting Sub-system: - This Sub-system aims at integrating public transport and parking payment facilities. The peculiarity of this Sub-system is that it has not been wholly engineered yet, consequently that it is not active now. As a result, it is not clear if the Traveller will interact directly with this Sub-system (in a centralised electronic payment management) or indirectly through the involved Sub-systems (in peripheral electronic payment management). This is the reason for its incomplete description. Anyway, it was tried to give a partial description of what it could be in the near future. It is to be integrated with the current payment system, maintaining the existing structures for ticket vending and parking area authorisation. The Sub-system should manage electronic payment and identification on behalf of a central institution and thus minimise the amount of necessary cash transactions. Its integration with existing credit card schemes is also foreseen. In a subsequent development phase, the system will also facilitate the issuing of entrance tickets to exhibitions, museums and public meeting facilities. The user will be issued with a single card for identification and payment.

P4.10 Environmental Monitoring Sub-system: - This Sub-system acquires meteorological and environmental data from peripheral detection stations and processes it (with the ARMONIA environmental monitoring software). It receives traffic-related data and vehicle emission estimates from the P4.2 Sub-system and uses a special software suite to calculate forecasts of air pollution for the short and medium terms. The forecasts are sent to the P4.1 Sub-system for use in its calculations of reference strategies. A total of 12 detection stations have been installed at various locations of the city.

P4.11 Backbone Network Sub-system: - This Sub-system represents the high level network thanks to which the Sub-Systems from P4.1 to P4.10 can exchange information and data. It physically of four LANs (Local Area Networks) which have been connected by high-speed data links (i.e. 2 Mbps). The data, exchanged over the whole network (over the WAN and the LANs), is defined by a data dictionary. This and a single reference description of the urban network ensures dialogue between the Sub-systems using the TCP/IP protocol. Consequently, within the System architecture several proprietary systems can thus coexist and co-operate using their own language, database and protocols. About this, the conversion of information from the exchange facility to the format of the proprietary subsystems is achieved by translator interfaces embedded in the Sub-systems themselves.

Figure 15 Telematics Technologies for Transport and Traffic in Torino Sub-systems



P4.12 Roadside Network Sub-system: - This Sub-system provides all of the peripheral functionality for the interaction at the intersection level. This Sub-system consists of a network of Multi Functional Outstations (MFO, more detail can be found in detail in the P3 example). They are autonomous systems capable of optimising the local traffic control and able to reach the optimal area control by means of a strong interaction with each other. The result of this local optimised control consists in continuously updated traffic light cycles at the controlled intersection. In addition to this, this Sub-system acts as an urban area communication network able to exchange information belonging to the other Sub-system. So that, for example, it is responsible for provision of diagnostic data, displaying AVM information at the bus stop and kiosks distributed in the city, transmitting VMS messages and car parks' availability to the urban panels, suggesting the best direction to the single driver through the beacon controllers, evaluating environment condition in the different urban locations and so on.

P4.13 Roadside Infrastructure Sub-system: - This Sub-system provides all of the roadside functionality for traffic control, data collection and info dissemination. This includes sensors (e.g. loop detectors, special priority requests sensors), traffic light controllers and other application devices (e.g. Bus-stop displays, VMS panels, Car Park panels, Beacon Controllers, Emission Sensors). All the equipment receives actuation inputs and data from P4.12 Sub-system, exchanging also other kind of information like faulty conditions.

2.5.4 Sub-Systems and Functions

The thirteen Sub-systems identified in the previous section can themselves be split up into Functions. These Functions are taken from those in the European ITS Functional Architecture - see reference in Chapter 10 of this Document. Their number, names and the User Needs that they serve are shown in the table on the following pages. The Overview description of each Function will be found in Annex 2 of the Main Document.

Table 8 P4 - Telematics Technologies for Transport and Traffic in Torino System - Allocation of Functions to Sub-systems and Modules

Sub-system			Function		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P4.1	Town Supervisor	Central	F 3.1.1	Provide Urban Traffic Management	2.1.0.1, 2.1.1.3, 7.1.1.2, 7.1.1.5, 7.1.2.2, 7.1.2.4, 7.1.3.3, 7.1.3.5, 7.1.3.6, 7.1.5.7, 7.1.6.1, 7.1.11.2
			F 3.2	Manage Incidents	7.2.0.1, 7.2.0.2, 7.2.0.3, 7.2.0.9, 7.2.2.3, 7.2.3.1, 7.2.4.1, 7.2.4.2
			F 3.3	Manage Demand	2.1.2.4, 2.1.2.5, 2.1.3.1, 2.1.4.2, 7.3.0.2, 7.3.0.3, 7.3.0.4, 7.3.0.5, 7.3.1.1, 7.3.2.1
P4.2	Urban Traffic Control	Central	F 3.1.1.1	Collect Urban Traffic data	2.1.1.3, 7.1.1.1, 7.1.1.2, 7.1.1.4
			F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 7.1.2.2, 7.1.2.4

Sub-system			Function		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P4.2	Urban Traffic Control (continued)	Central	F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.2.3, 7.1.2.1, 7.1.2.3, 7.1.2.7
			F 3.1.1.5.1	Provide Urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.5, 7.1.5.7, 7.1.9.1, 7.1.9.2, 7.1.9.3, 7.1.9.4
			F 3.2	Manage incidents	7.2.0.1, 7.2.0.2, 7.2.0.3, 7.2.0.6, 7.2.0.7, 7.2.0.8, 7.2.0.9, 7.2.2.3, 7.2.3.1, 7.2.4.1, 7.2.4.2
P4.3	Collective Route Guidance	Central	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1
			F 3.1.1.5.5	Provide Urban Output Actuation	7.1.3.4
			F 3.3	Manage Demand	2.1.2.5, 2.1.3.1, 7.3.0.4, 7.3.1.1
			F 6.3	Support Trip	6.1.0.3, 6.1.1.4, 6.1.2.3, 6.2.1.1, 6.2.2.5, 6.4.1.2
P4.4	Public Transport Management	Central	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.2
			F 4.1	Monitor PT Fleet	2.1.0.1, 2.1.1.3, 2.1.4.2, 5.1.0.1, 5.1.0.2, 5.1.0.4, 5.1.0.5, 10.1.2.1, 10.1.5.1, 10.5.0.2, 10.5.0.3
			F 4.2	Plan PT Services	2.1.0.1, 2.1.0.2, 10.1.0.1, 10.1.0.3
			F 4.3	Provide PT Management	2.2.0.1, 2.2.2.1, 2.2.2.3
			F 4.4	Control PT Fleet	2.1.0.2, 2.1.3.1, 5.3.1.1, 7.1.0.2, 10.1.0.1, 10.1.3.1, 10.1.3.2, 10.1.6.1, 10.4.1.1
P4.5	Parking Control	Central	F 3.1.1.2	Monitor Urban Car Park Occupation	7.1.11.1
			F 3.1.1.5.3	Provide Urban Car Park State	7.1.4.4
P4.6	Individual Route Guidance	Central	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.2

Sub-system			**Function**		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P4.6	Individual Route Guidance (continuted)	Central	F 6.3	Support Trip	6.1.0.3, 6.4.0.1, 6.4.0.3, 6.4.1.2, 6.4.2.4
P4.7	Informative Media Control	Central	F 6.2	Plan Trip	6.1.0.4, 6.1.1.1, 6.1.1.3, 6.1.3.1, 6.1.3.4, 6.1.3.6, 6.1.3.8, 6.2.1.1, 6.2.1.3, 6.4.0.1, 6.4.0.2, 6.4.1.3, 6.4.1.4
P4.8	Rescue Management	Central	F 8.1	Manage Freight and Fleet Ground Operations	9.5.1.6, 9.5.2.2, 9.5.2.10, 9.5.2.12, 9.5.2.14, 9.5.2.16, 9.5.3.3, 9.5.3.21
P4.9	Fare Integration and Debiting	Central	F 1.2	Manage User's Account	4.1.0.2, 4.1.0.3, 4.1.3.2, 4.1.3.3, 4.1.4.1
			F 1.3	Perform Electronic Payment Transaction	4.1.0.2, 4.1.0.3, 4.1.0.4, 4.1.1.1, 4.1.3.2, 4.1.3.3, 4.1.4.1
P4.10	Environmental Monitoring	Central	F 3.4	Provide Environmental Information	7.1.0.4, 7.1.1.7, 7.1.2.6
P4.11*	Backbone Network	Distribute d			
P4.12*	Backbone Network	Roadside			
P4.13*	Roadside Infrastructure	Roadside			

2.5.5 Physical Data Flows

As will have been seen in the Figures, the Sub-systems in this System are linked together using Physical Data Flows. The term "Physical" is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows, sometime wholly sometime partially implemented. The descriptions of the Physical Data Flows used in this System are shown below.

to.rno_data

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time traffic data provided by the Town Supervisor Sub-system (P4.1). These data are available to the System Operator. The data flow consists of the following functional data flows:
to.rno-urban_responses
to.rno-incident_outputs
to.rno-demand_management_outputs

fo.rno_data

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the parameters provided to the Town Supervisor Sub-system (P4.1) by the Network Operator. The data flow consists of the following functional data flows:
fo.rno-urban_commands
fo.rno-incident_inputs
fo.rno-demand_management_inputs

ttttt_sup_fb

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of real time information and data on the traffic situation, pollution, etc. from the various Sub-systems to globally represent the state of the network. The data flow consists of the following functional data flows:
mt_urban_inputs_from_demand_management
mt_urban_environmental_inputs
frrs-urban_data_updates
mt_traffic_data_for_incident_detection
mt_traffic_outputs_for_demand_management
mt_demand_management_environmental_data

ttttt_sup_tb

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of the parameters for the various Sub-systems based on the current global control strategy. The data flow consists of the following functional data flows:
mt_urban_outputs_for_demand_management
tt-urban_traffic_commands
trrs-urban_data_updates
mt_traffic_inputs_from_demand_management
ttp-urban_traffic_prediction_responses

tmo_data

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of the diagnostic information concerning the entire System network which is needed by the involved maintenance organisations. The data flow consists of the following functional data flow:
mt_urban_traffic_maintenance_data

ttttt_utc_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of the control strategies suggested by the Town Supervisor Sub-system (P4.1), as well as the priority requests made by the Public Transport and Rescue Management Sub-systems (P4.4 and P4.8). The data flow consists of the following functional data flows:
mt_urban_traffic_maintenance_data
mpto.mt_incident_data
frrs-incident_data

ttttt_utc_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of real time traffic data needed to monitor the entire road network (travel times, flows, densities). The data flow consists of the following functional data flows:
mt_urban_traffic_data_for_incident_detection
mt_urban_current_traffic_data_for_demand
mt_urban_traffic_flow_management_data
mt_urban_traffic_predicted_data
mt_predicted_urban_network_data
mt_urban_traffic_data_for_demand
mt.mpto_incident_notification
trrs-incident_data
tesp.b-incident_data
tesp.ttip-incident_data

ttttt_utc_fr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time information about the road network at the intersection level (macroscopic variables like turning percentages, flows, densities,…), as well as diagnostic information. The data flow consists of the following functional data flows:
ftrfc-urban_traffic_flow_data
mt_collected_urban_traffic_data
mt_traffic_data_for_incident_detection

ttttt_utc_tr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of the co-ordination parameters (e.g. reference plan, cost functions, weights) needed to influence the local control strategies, as well as priority requests. The data flow consists of the following functional data flows:
mt.ptja_urban_traffic_predictions
mpto.mt_vehicle_priority_request

ttttt_vms_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the instructions and information provided by the Town Supervisor (P4.1), like indications of serious anomalies on the network received from other Sub-systems or human operators. The data flow consists of the following functional data flow:

mt_traffic_outputs_for_demand_management

ttttt_vms_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of real time traffic information estimated at VMS panels locations, available to other Sub-systems (i.e. speed and flow). The data flow consists of the following functional data flows:
mt_urban_current_traffic_data_for_demand
mt_traffic_inputs_for_demand_management

ttttt_vms_fr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time information about the road network at the intersection level (macroscopic variables like turning percentages, flows, densities,…), as well as diagnostic information. The data flow consists of the following functional data flow:
ftrfc-urban_traffic_flow_data

ttttt_vms_tr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of clear and pertinent messages for display on the set of panels installed at various locations of the city belonging to the Roadside Infrastructure Sub-system (P4.13). The data flow consists of the following functional data flows:
tt-urban_traffic_commands
tt_itinerary_changes
ptja.padas_travel_info

fo.pto_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information and parameters provided by the Public Transport Operator. The data flow consists of the following functional data flow:
fo.pto_optimisation_criteria

to.pto_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains public transport network data provided by the Public Transport Management Sub-system (P4.4). The data flow consists of the following functional data flow:
to_pt_vehicle_info

tv.ptv_info
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains pertinent command and information needed by the vehicle in order to guarantee the planned public transport service. The data flow consists of the following functional data flow:
tv.ptv_commands

fv.ptv_info

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the data coming from the vehicle concerning its current position, possible anomalies, faults on board, emergency calls, and other useful information about the state of the network. The data flow consists of the following functional data flow:
fv.ptv_ctrl_feedbk

ttttt_sis_fb

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time information about the state of the road network (e.g. congestions, road works,…). The data flow consists of the following functional data flows:
mt.mpto_incident_info
fmms_plannings

ttttt_sis_tb

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of all the information and requests towards other Sub-systems (e.g. priority requests, arrival and travel times to the Urban Traffic Control Sub-system (P4.2) and to the Informative Media Control Sub-systems (P4.7)), diagnostic information on equipment belonging to other Sub-systems (e.g. traffic lights). The data flow consists of the following functional data flows:
mpto.mt_pt_data
tmms_pt_planning
mpto.ptja_available_pt_services

ttttt_sis_fr

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time information about the public transport network at the intersection level (travel times, localisation,…), as well as diagnostic information. The data flow consists of the following functional data flow:
ftrfc-urban_traffic_flow_data

ttttt_sis_tr

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of pertinent messages (e.g. arrival times) to be provided to the traveller at the bus-stop displays. The data flow consists of the following functional data flow:
tt.ptp_service_variations

ttttt_pk_tb

This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the current and forecast occupancies of each car park and this information is available to the other Sub-systems. The data flow consists of the following functional data flows:
mt_carpark_occupancies

mt_carpark_urban_inputs
mt_carpark_occupancy_for_demand_management

ttttt_pk_fr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains diagnostic information on the roadside Car Park panels. The data flow consists of the following functional data flow:
ftrfc-carpark_vehicle_data

ttttt_pk_tr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the current and forecast occupancies of each car park. The data flow consists of the following functional data flows:
mt.ptja_carpark_occupancy
mt_car_park_occupancy_commands

ttttt_rg_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the reference traffic assignments for the network from the Town Supervisor (P4.1). The data flow consists of the following functional data flows:
ptja_trip_data
mt.ptja_incident_information
mt.ptja_road_network_perturbations

ttttt_rg_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the travel times of the vehicles which exchange data and information with the Individual Route Guidance Sub-system (P4.6). The data flow consists of the following functional data flows:
mt_urban_traffic_flow_management_data
mt_collected_urban_traffic_data
ptja_trip_results

ttttt_rg_fr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time travel times information, as well as diagnostic information on the roadside Beacon Controllers. The data flow consists of the following functional data flows:
padas.mt_urban_floating_cars
padas.ptja_floating_cars
ft-change_approval

ttttt_rg_tr
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the turning percentages per destination to be broadcast at the roadside Beacon Controllers (belonging to the Roadside Infrastructure Sub-system (P4.13)). The data flow consists of the following functional data flows:

tt_itinerary_changes
ptja.padas_travel_info
ptja.padas_route_guidance
td_route_guidance_info

ttttt_tplan_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the traffic information and historical analysis required by the Transport Planner. The data flow consists of the following functional data flow:
mt_urban_outputs_for_demand_management

tt_info
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information required by the Traveller using different transmission channels. The data flow consists of the following functional data flow:
tt-trip_planning_information

ttttt_imc_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of specific data required to provide trip planning and other information to the Traveller. The data flow consists of the following functional data flows:
mt.ptja_road_network_perturbations
mt.ptja_road_network_characteristics
mt_ptja_carpark_occupancy
mt_ptja_incident_information

fv.ev_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains all the information needed (localisation, emergency calls, …) to improve the management performance of the involved fleets. The data flow consists of the following functional data flow (from the function the terminators maps):
mffo_onboard-status

tv.ev_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information needed to support the trip and minimise the travel times. The data flow consists of the following functional data flow (to the function the terminators maps):
mffo_ground-route_plans_and_schedules

ttttt_pry_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains information about the state of the road network (e.g. congestion, road works,…). The functional data flow is missing.

ttttt_pry_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It consists of all the information and requests towards other Sub-systems

(e.g. priority requests, arrival and travel times to the Urban Traffic Control Sub-system (P4.2)). The functional data flow is missing.

frrs_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic information (accidents, congestions, queues, …) provided by other Related Road Systems(e.g. motorways,…). The data flow consists of the following functional data flow:
frrs-urban_data_updates
frrs-incident_data

trrs_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic information on the urban road network, provided by the System itself. The data flow consists of the following functional data flows:
trrs-urban_data_updates
trrs-incident_data

fesp_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time information on traffic (e.g. CCISS, responsible for collecting traffic data in Italy, see P2 example). The data flow consists of the following functional data flows:

tesp_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time traffic information for External Service Providers. The data flow consists of the following functional data flow:
tesp.b-incident_data
tesp.ttip-incident_data

fmms_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic information concerning modes of transport different from road, like air and rail. The data flow consists of the following functional data flow:
fmms_plannings

tmms_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time traffic information for external Multi Modal Systems. The data flow consists of the following functional data flow:
tmms_pt_planning

ffc_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information required (e.g. state of the smart card, money availability,...) by the user. The data flow consists of the following functional data flow:

ffc-pepf_loading_input

tfc_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the users information and the service required. The data flow consists of the following functional data flow:
tfc-pepf_loading_output

ttttt_mon_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the users information (in order to be identified) and the data concerning the service required (in order to manage electronic payment). The data flow consists of the following functional data flows:
ft-pepf_account_input
ft-pepf_payment_info

ttttt_mon_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information required (e.g. state of the smart card, money availability,...) by the user. The data flow consists of the following functional data flows:
tt-pepf_payment_data
tt-pepf_payment_output

fae_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains meteorological and environmental data. The data flow consists of the following functional data flow:
fae-mt_inputs

ttttt_amb_fb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic-related data and vehicle emission estimates (received from the Urban Traffic Control Sub-system P4.2). The data flow consists of the following functional data flow:
frrs-environmental_data_updates

ttttt_amb_tb
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the forecasts of air pollution for the short and medium terms, which are used by the Town Supervisor Sub-system (P4.1) for the calculation of reference strategies. The data flow consists of the following functional data flows:
mt_environmental_traffic_inputs
mt_environmental_incident_inputs
trrs-environmental_data_updates

tt_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the information/commands provided to the traveller at the roadside location through different sort of equipment (traffic-lights, bus-stop displays, VMS, car park messages). The data flow consists of the following functional data flows:
tt-urban_traffic_commands
tt_itinerary_changes
tt.ptp_service_variations

fv_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains real time travel time information. The functional data flow is missing.

tv_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic information, like the turning percentages per destination broadcasted at the roadside Beacons. The functional data flow is missing.

ftrfc_data
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains the measurements made on the field by the roadside sensors (e.g. loop detectors). The data flow consists of the following functional data flow:
ftrfc-urban_traffic_flow_data
ftrfc-carpark_vehicle_data

ttttt_mfo_ti
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains actuation commands, and other application commands. The data flow consists of the following functional data flows:
tt-urban_traffic_commands
tt_itinerary_changes
tt.ptp_service_variations

ttttt_mfo_fi
This physical data flow is used within the Telematics Technologies for Transport and Traffic in Torino System. It contains traffic measurements (queues, turning percentages,…), diagnostic information, special priority requests and other application data. The data flow consists of the following functional data flows:
ftrfc-urban_traffic_flow_data
ftrfc-carpark_vehicle_data

2.5.6 Key Issues

A total of three Key Issues have been identified for this System. They are as follows:

1. The System is integrated. In fact, it represents a co-operative environment where operators and systems can all be part of a global ITS (Intelligent Transport System) and benefit from tangible added value, if compared with non-integrated solutions. On the other hand integration must not generate additional problems during the system life-time. These targets respond to the following requirements:
   - Build on existing systems
   - Allow data sharing by adding network capabilities
   - Favour the implementation of new high-level function for overall co-ordination
2. The System can host additional Sub-systems adopting the same rules without requiring any modification to the others. In fact, the integrated Sub-systems keep their own choices for data modelling, but agree on a common “language” for exchanging data with other systems. Consequently a minimum set of standards are defined (i.e. data dictionary, location reference and message format) and the impact is minimised on Sub-systems by providing proper interfaces to exchange data with the others.
3. The System is characterised by shared communication networks at all levels (between Sub-systems, from Sub-systems to roadside MFO, between MFO). At the road level, sensors, beacons and information displays share the same communication network minimising the duplication of hard-wiring. This solution allows considerable savings in both installation and operation costs, by installing multifunctional outstations on strategic locations on the transport network and connecting as many devices as possible to each of these outstations. Each outstation then provides the management of a shared communication link to the control centre or to other outstations. Thus outstations act as nodes of a shared communication network where messages/data are transmitted between devices and control centres regardless the application which they belong to.

3. Electronic Fee Collection Systems

3.1 Introduction

This Chapter describes two “example Systems” in the Physical Architecture that provide facilities for electronic payment. The first System provides facilities that enable travellers to pay electronically for the transport modes that they use as well as other services. The second System enables the electronic payment of tolls for road use without the need for the vehicle to stop.

3.2 P10 - Electronic Cash Transaction System

3.2.1 Overview

The System provides the facilities for handling the basic electronic cash transactions associated with the use of Automatic Fee Collection for the payment of transport telematic services. The system describes the process of using an electronic travel pass to pay for a number of different services. In order to keep the description of this system as simple as possible the links to the other Areas, the use of whose services may entail a charge, have been omitted from the diagrams: in addition the possible consequences of failing to pay for a service have also not been developed. In both cases the textual description of the relevant modules indicates where the links would be made.

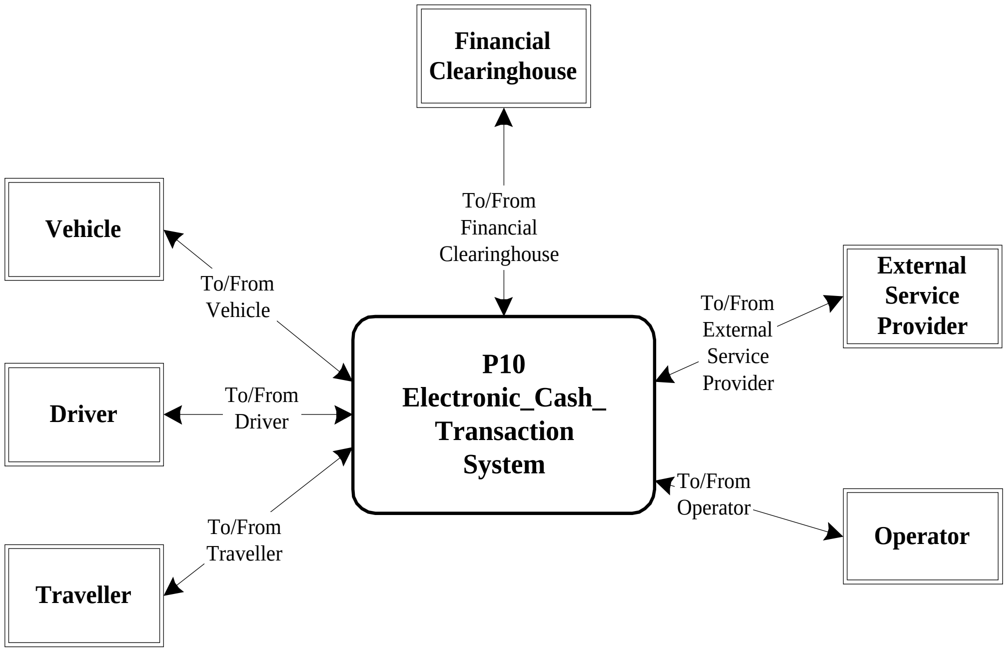
The system is based on the Conceptual Model described in DD ENV ISO 14904 “Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators”, which supports:

- different payment modes
- a wide variety of transport and transport related services
- co-ordination between the collectors of money, charging points etc:
- security and privacy

3.2.2 System Context

The system context describes the framework in which the System exists. That for this System has been derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document. The Diagram for this System (P 10) is illustrated in the Figure on the next page.

Figure 16 P10 - Electronic Cash Transaction System - Context Diagram



The above Context Diagram shows that the Terminators of the System are the three users of the System, Drivers, Travellers and Vehicles, the two providers of services, Operators and External Service Providers, and the supporting activities provided by the Financial Clearinghouse. The following Table shows the reasons for not using the other Terminators.

Table 9 P10 Electronic Cash Transaction System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	There is no pollution monitoring in this system
Bridge/Tunnel Infrastructure	There is no transport infrastructure in this system
Consignor/Consignee	The finance associated with Freight cargo is not part of this system
Emergency Systems	It is assumed that emergency services are provided free of charge
Freight Equipment	The finance associated with Freight cargo is not part of this system
Law Enforcement Agency	It is not expected that a Law Enforcement Agency will be invoked automatically during the general use of electronic cash for most applications.
Location Data Source	Not directly required as part of a financial transaction

Terminator Name	Reasons for deletion or modification
Maintenance Organisation	Not directly required as part of a financial transaction
Multi-modal System	Not directly required as part of a financial transaction
Operator	Only the following actors in this terminator are needed by this System: Parking Operator, Public Transport Operator, Road Network Operator, Toll Operator and Traveller Information Operator.
Related Road System	Not directly required as part of a financial transaction
Road Pavement	No road pavement monitoring in this system
Traffic	Not directly required as part of a financial transaction
Transport Planner	Not part of a financial transaction system
Weather Systems	No weather monitoring in this system

3.2.3 Sub-systems

The “example System” consists of four main Sub-systems that have been chosen to conform, as far as possible, to the Conceptual Model described in DD ENV ISO 14904 “Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators” -see Section 6.2.4. They are described below, and the Figure on the next page shows their relationship between each other and the Terminators. Note that, for simplicity, only one copy of each Sub-system is shown. However, in practice each may have a number of instantiations with the corresponding multiple instantiations of the data flows - see Section 3.2.4.

<u>P10.1 Collection Agent Sub-System</u>: - This Sub-system shall enable the Traveller to purchase an “electronic travel pass” (establish a contract) for one or more services, or to transfer money into it in order to pay for the service(s). The sub-system can be located anywhere that is convenient for a Traveller.

If the System is to be used to pay for on-trip information etc. then it may be necessary to provide a link to the Provide Traveller Journey Assistance area in order to set up the correct contract.

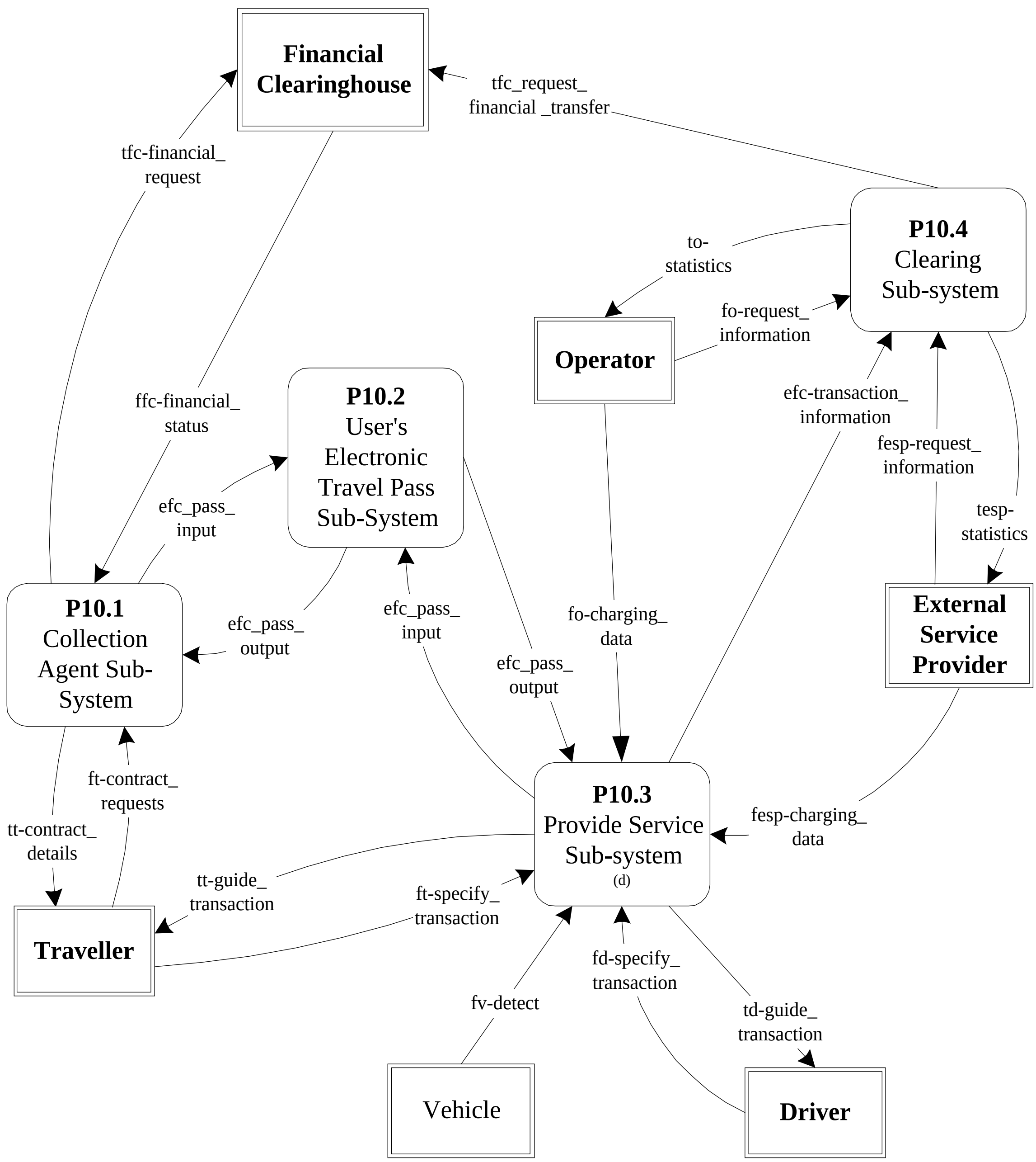
<u>P10.2 User’s Electronic Travel Pass Sub-System</u>: - This Sub-system shall store details of the services that may be used (the contracts) and the current value of the money available. This sub-system is carried by the traveller to pay for services. The sub-system contains no functions, only data stores that can be modified by both P10.1, the Collection Agent sub-system, and P10.3, the Provide Service sub-system.

P10.3 Provide Service Sub-System: - This Sub-system shall confirm that the Traveller or Driver is permitted to use the service that is requested, and shall debit the corresponding charge from his or her "electronic travel pass". The sub-system shall be able to handle exceptions (i.e. when the contract is not valid for the service, or there is insufficient money stored on the electronic travel pass).

In order to pay for certain services, or to vary the charge according to traffic conditions, it may be necessary to provide links to one or more of the Manage Traffic, Manage Public Transport Operations, Provide Advanced Driver Assistance Systems, Provide Traveller Journey Assistance or Manage Freight and Fleet Operations areas.

In the case that the exception handler identifies a alleged infringement of the law it may be necessary to provide a link to the Provide Support for Law Enforcement area.

Figure 17 P10 Electronic Cash Transaction System - Sub-system Diagram

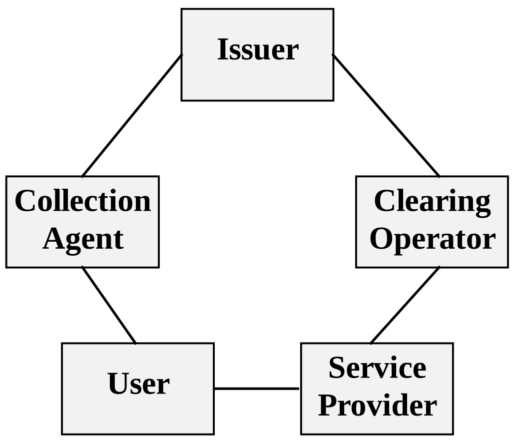


P10.4 Clearing Sub-System: - This Sub-system shall collect the data on the usage of the "electronic travel passes", calculate the money due to each Operator or External Service Provider and initiate the transfer of that money from the Financial Clearinghouse. The sub-system shall also provide statistics of usage to the Operator and External Service Provider.

3.2.4 System Dynamic, or How it Works

DD ENV ISO 14904 "Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators" separates the two main processes concerned with handling the money and paying for the services according to the Conceptual Model. This is shown in the Figure below.

Figure 18 Conceptual Model for Electronic Payment



The Collection Agent is responsible for selling, reloading and delivering the "electronic travel pass" to the User, and for collecting the payment from the user. The User then uses the pass to obtain the services offered by a Service Provider, who also makes a debit from the pass on each occasion. Each Service Provider passes the data on all transactions to a Clearing Operator who aggregates them, apportions the money between the Service Providers, and arranges for that money to be passed them. The Issuer, in this System it is the Financial Clearinghouse, is responsible for the entire payment system and for ensuring that the money with which the User paid for the pass ultimately goes to the correct Service Provider(s).

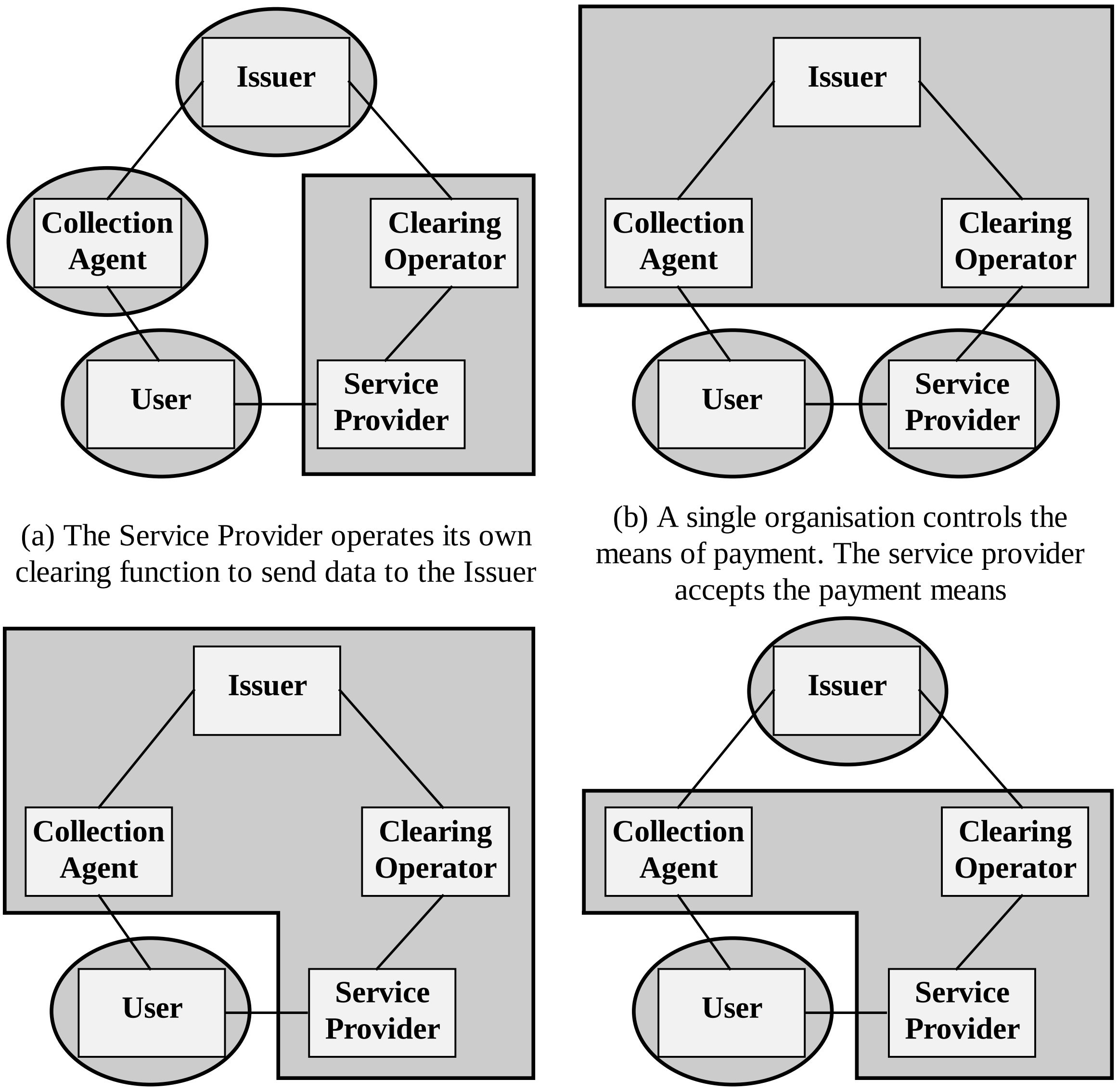
Although the above figure only shows one of each party, in practice there may be multiple instantiations, with corresponding multiple instantiations of the data flows, as follows:

- Users - it must be possible for the system to function with a large number of distinct Users;
- Collection Agent - there should be many Collection Agents in order that Users can easily obtain, or reload, their "electronic travel passes";
- Service Providers - there may be a number of different Service Providers, each probably offering a different service, but accepting the same "electronic travel pass";
- Clearing Operator - it is possible to have competing Clearing Operators within the same payment system;

- Issuers - it is possible to have competing Issuers, and for two distinct payment systems to inter-operate via their respective Clearing Operators.

These five entities can be combined in a variety of ways in order to reflect the contractual and technical arrangements between the organisations involved in a given payment system. The Figure on the next page shows some possible examples.

Figure 19 Possible Organisations for Electronic Payment



(a) The Service Provider operates its own clearing function to send data to the Issuer

(b) A single organisation controls the means of payment. The service provider accepts the payment means

(c) A single service single service provider closed payment system

(d) A multi-service payment means, e.g. a city card

3.2.5 Sub-Systems and Functions

One of the four Sub-systems (P10.3) identified in the previous section has been split up into Modules. These are described in the next section. The remaining Sub-systems (P10.1, P10.2 and P10.4) have been split up directly into Functions and Data Stores. These are shown in the tables of Functions and Data Stores in a later section.

3.2.6 Modules

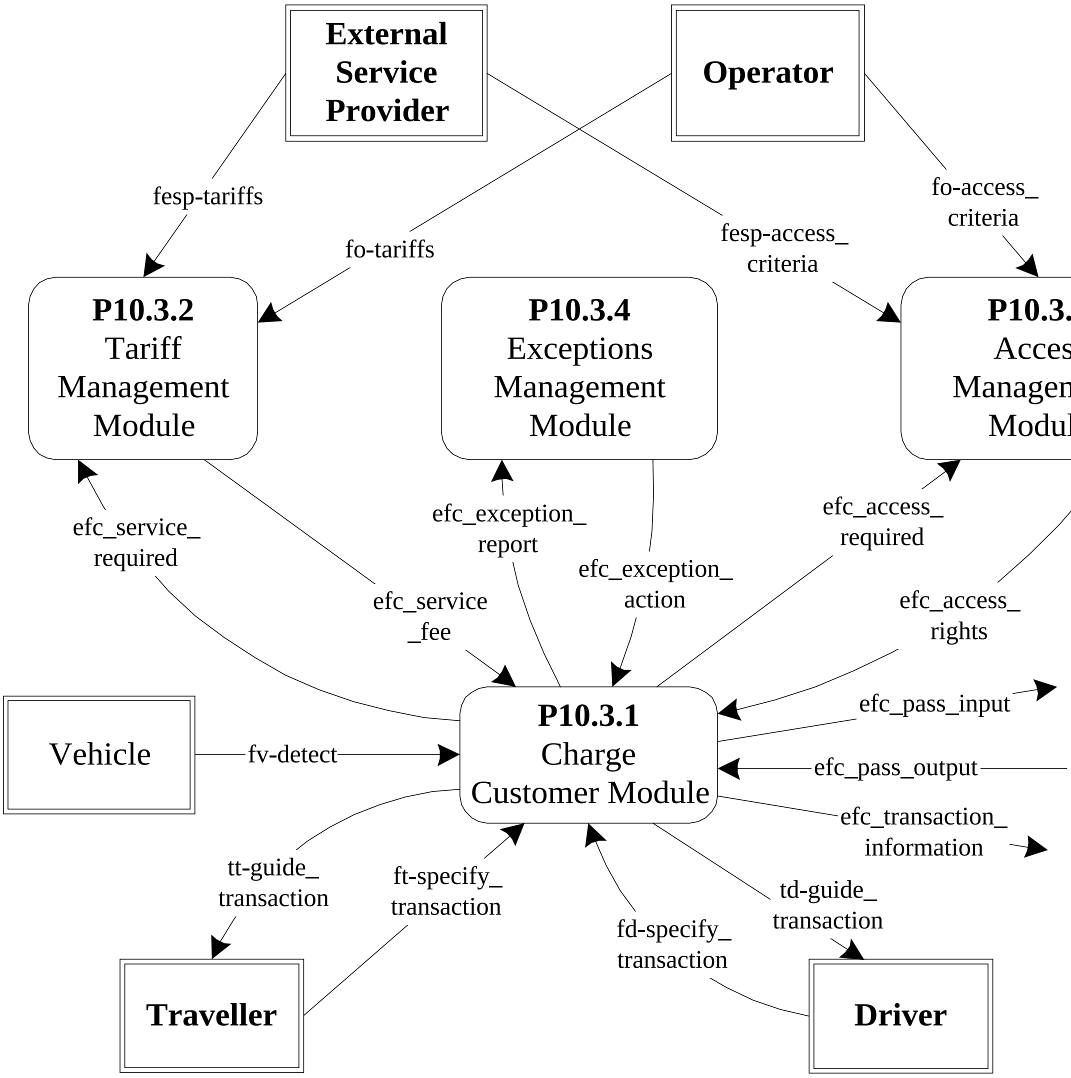
3.2.6.1 Introduction

As noted previously, one of the Sub-systems (P10.3) in this “example System” can be split up into Modules. These are described in the following section.

3.2.6.2 Modules in Sub-system P10.3 Provide Service

The Provide Service Sub-system has been divided into four Modules in order to clarify what happens. Some of the functionality (Modules) may be optional. A diagram of the Sub-system is shown in the Figure below.

Figure 20 P10 Electronic Cash Transaction System - Provide Service Sub-system Diagram



P10.3.1 Charge Customer Module - This Module shall identify the user and the service that he or she wishes to purchase. The Module shall check that the user has the necessary right to access that service, and then debit the user’s account on the “electronic travel pass” with the cost of the service.

P10.3.2 Tariff Management Module - This Module shall maintain a database of tariffs as supplied by the External Service Providers and the Operators. It shall also provide the Charge Customer Module with the correct tariff when required.

P10.3.3 Access Management Module - This Module shall maintain a database of access criteria as supplied by the External Service Providers and the Operators. It shall also provide the Charge Customer Module with the user's access rights when required.

P10.3.4 Exceptions Management Module - This module shall inform the Charge Customer Module what should happen in the event that there was insufficient credit in the "electronic travel pass" account, or that there was a request for a service for which there no contract existed.

In order to keep this "example System" simple, the possible resultant actions that may arise from an exception have not been developed.

3.2.7 Modules, Functions and Data Stores

The four Modules identified in the previous section can be split up into Data Stores and Functions. These are identified in the tables that are shown below and on the following pages. The tables also include the Data Stores and Functions in the Sub-systems without Modules that are described in an earlier section. Descriptions of the Data Stores can be found in Annex 3 of the Functional Architecture Deliverable Document - see reference in Chapter 10. The Overview description of each Function is provided in Appendix 1 of this document.

Table 10 P10 Electronic Cash Transaction System - Sub-systems, Modules and Data Stores Table

Sub-system			Module		Data Store	
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**
P10.2	User's Electronic Travel Pass	Traveller			D 1.1	EP Contracts Store
					D 1.2	User's Accounts Store
P10.3	Provide Service	Kiosk, or Central, or Roadside	P10.3.2	Tariff Management	D 1.5	Tariffs Store
			P10.3.3	Access Management	D 1.7	Access Rights Store
P10.4	Clearing	Central			D 1.3	Service Information Store
					D 1.4	Transactions Store

Table 11 P10 Electronic Cash Transaction System - Sub-systems, Modules and Functions Table

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P10.1	Collection Agent	Kiosk			F 1.1.1	Create EP Contract	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.0.4, 4.1.2.1, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 6.1.2.8
					F 1.2.1	Load User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1, 6.1.2.8
P10.2	User's Electronic Travel Pas	Traveller			No Functions, Data Stores only - see separate table.		
P10.3	Provide Service	Kiosk, or Central, or Roadside	P10.3.1	Charge Customer	F 1.2.2	Debit User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.3.1	Detect User	4.1.1.1, 4.1.1.2, 4.1.1.3
					F 1.3.2	Identify User	4.1.0.2, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.3.1, 4.1.3.4
					F 1.3.3	Check User's Contract	4.1.0.1, 4.1.0.2, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.2.2, 4.1.3.1, 4.1.3.4
					F 1.3.4	Inform and Guide User	4.1.0.2, 4.1.1.1, 4.1.2.2, 4.1.3.3, 6.1.2.8
					F 1.3.7	Recover Fee	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.1.1, 4.1.1.2, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P10.3	Provide Service (continued)	Kiosk, or Central, or Roadside	P10.3.2	Tariff Management	F 1.3.5	Compute Service Fee	4.1.0.1, 4.1.0.2, 4.1.0.4, 4.1.1.1, 4.1.2.2, 4.1.3.3, 4.1.3.4
					F 1.6.1	Manage Tariffs	7.3.2.1, 7.3.2.2, 7.3.2.3, 7.3.2.4
			P10.3.3	Access Management	F 1.5.1	Check User’s Rights	4.1.0.2, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.4.1
					F 1.6.2	Manage Access Rights	4.1.0.2, 7.3.2.1
			P10.3.4	Exceptions Management	F 1.5.2	Detect Payment Violations	4.1.0.1, 4.1.0.2, 4.1.1.3, 4.1.2.2, 4.1.3.3, 4.1.3.4, 4.1.4.1
P10.4	Clearing	Central			F 1.1.2	Establish Contract Statistics	4.1.0.2, 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.4.1	Distribute Fees Revenue	4.1.0.1, 4.1.2.1, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.4.2	Credit Operator’s Account	4.1.2.1, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F1.4.3	Inform Operators on Transactions	4.1.0.2

3.2.8 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term "Physical" is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document (D 3.1).

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

efc_transaction_information
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Charge Customer module to the Clearing Sub-system to provide the data on each transaction. The data flow consists of the following functional data flows:
pepf_transaction_information
+ pepf_contract

efc_access_rights
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Access Management module to the Charge Customer module to indicate the access rights of the user to the service requested. The data flow consists of the following functional data flow:
pepf_user_access_rights

efc_access_required
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Charge Customer module to the Access Management module to describe the type of access required. The data flow consists of the following functional data flows:
pepf_user_ID
+ pepf_service_ID
+ pepf_vehicle_data

efc_exception_action
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Exception Management module to the Charge Customer module to indicate what should happen in the event that there was insufficient credit in the account on the pass (or a service for which no contract had been requested). The data flow consists of the following functional data flow:
pepf_access_refused

efc_exception_report
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Charge Customer module to the Exceptions Management module whenever the Debit Users Account function finds that there are insufficient funds stored on the Electronic Travel Pass, or when the traveller tries to use a service for which he or she has no contract. The data flow consists of the following functional data flows:
pepf_overdraft_notification
+ pepf_agreement
+ pepf_illegal_action_notification

efc_service_fee
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent from the Tariff Management modules to the Charge Customer module to indicate the fee that should be charged for a service. The data flow consists of the following functional data flow:
pepf_service_fee

efc_service_required
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by the Charge Customer module to the Tariff Management module to describe the service that the traveller wishes to purchase. The data flow consists of the following functional data flows:
pepf_selected_service_data
+ pepf_contract
+ pepf_vehicle_data

efc_pass_output
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent to both the Collection Agent sub-system, and the Provide Service sub-system from the User's Electronic Travel Pass, though not at the same time. The Collection Agent sub-system can read the current contract details stored on the pass. The Provide Service sub-system (Charge Customer module) can check the services that may be used, and the status of the account after a debit. The data flow consists of the following functional data flows:
pepf_contract
pepf_account_status

efc_pass_input
This physical data flow is used within the Electronic Cash Transaction System. It contains data that is sent by both the Collection Agent sub-system, and the Provide Service sub-system to the User's Electronic Travel Pass, though not at the same time. The Collection Agent sub-system stores details of the services that may be used (contracts) and adds credit to the account on the pass. The Provide Service sub-system (Charge Customer module) debits the fee from the account on the pass. The data flow consists of the following functional data flows:
pepf_contract
pepf_load_account_order
pepf_debit_account_order

3.2.9 Key Issues

1. The Electronic Cash Transaction System (P10) is based on the Conceptual Model of DD ENV ISO 14904 "Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators". This, or a similar model, will have to be agreed throughout a given geographical area in order to satisfy User Need 4.1.2.2.

2. The User's ElecTroniC Travel Pass (P10.2), together with its interface, is fundamental to the correct operation of this System:
- It must be capable of mass production;
- It must be robust;
- The method, and rate, of data transfer will dictate how it may be used, e.g. in circuit or contact-less;

3. For seamless travel throughout the EU:
- The User's ElecTroniC Travel Pass (P10.2) will have to function in the same way at all locations;
- There will have to be very many, easily accessible, Collection Agent Sub-systems (10.1);
- The fv-detect data flow must be understood by all Charge Customer Modules (P10.3.1);
- It will probably be necessary to have many co-operating Clearing Sub-systems (10.4);
- The Traveller and Driver interface with the Charge Customer Modules (P10.3.1) must be understood by all travellers and drivers (see also User Need 6.1.2.8)

3.3 P11 - Automatic Road Tolling System

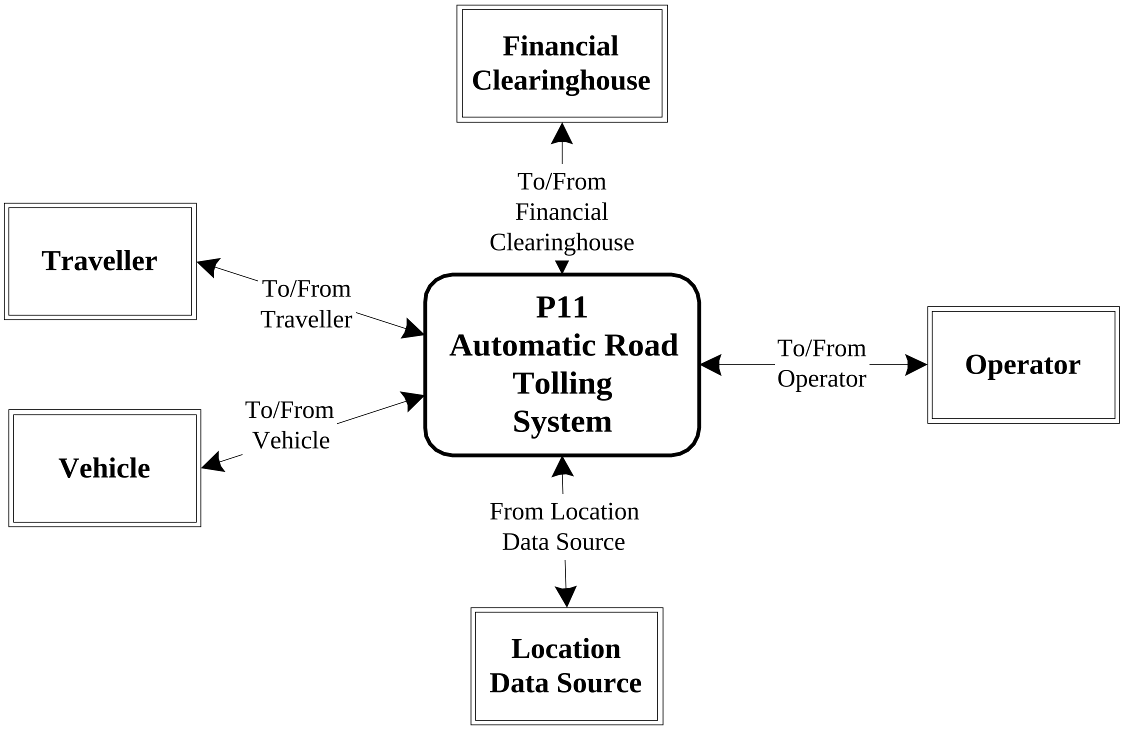
3.3.1 Overview

The system provides the facilities needed for charging for the use of a road without the driver having to stop. A pre-trip driver may set up either a pre-payment or a post-payment account, or may use electronic funds for automatic on-board payment. The system may be based on either road-side tolling points, or an in-vehicle positioning capability. If the Sub-Systems are operated by difference agencies then the System can be made anonymous, since no one organisation has the full information to re-create a trip for an individual person.

3.3.2 System Context

The system context describes the framework in which the System exists. That for this System has been derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document. The Diagram for this System (P 11) is illustrated in the Figure below.

Figure 21 P11 Automatic Road Tolling System - Context Diagram



The above Context Diagram shows that the Terminators of the System are the Traveller (pre-trip Driver), the Vehicle and one or more Operators, together with the supporting activities provided by the Financial Clearinghouse and the Location Data Source. The reasons why the other Terminators are not involved are given in Table below.

Table 12 P11 Automatic Road Tolling System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	There is no pollution monitoring in this system
Bridge/Tunnel Infrastructure	There is no transport infrastructure in this system
Consignor/Consignee	The finance associated with Freight cargo is not part of this system
Driver	This is a 'free flow traffic' system and so the driver does not have to interact with the system whilst travelling. See also Traveller.
Emergency Systems	It is assumed that emergency services are provided free of charge
External Service Provider	None of these provide road tolling
Freight Equipment	The finance associated with Freight cargo is not part of this system

Terminator Name	Reasons for deletion or modification
Law Enforcement Agency	It is not expected that a Law Enforcement Agency will be invoked automatically in this application. Failure to pay will be covered by normal debt collection mechanisms.
Maintenance Organisation	Not directly required as part of an automatic road tolling system
Multi-Modal System	Not directly required as part of an automatic road tolling system
Operator	Only the following actors in this terminator are required by this System: Road Network Operator and/or Toll Operator.
Related Road System	Not directly required as part of an automatic road tolling system
Road Pavement	No road pavement monitoring in this system
Traffic	Not directly required as part of an automatic road tolling system
Transport Planner	Not directly required as part of an automatic road tolling system
Traveller	The only actor in this terminator required by this System is the (pre-trip) Driver
Weather Systems	No weather monitoring in this system

3.3.3 Sub-systems

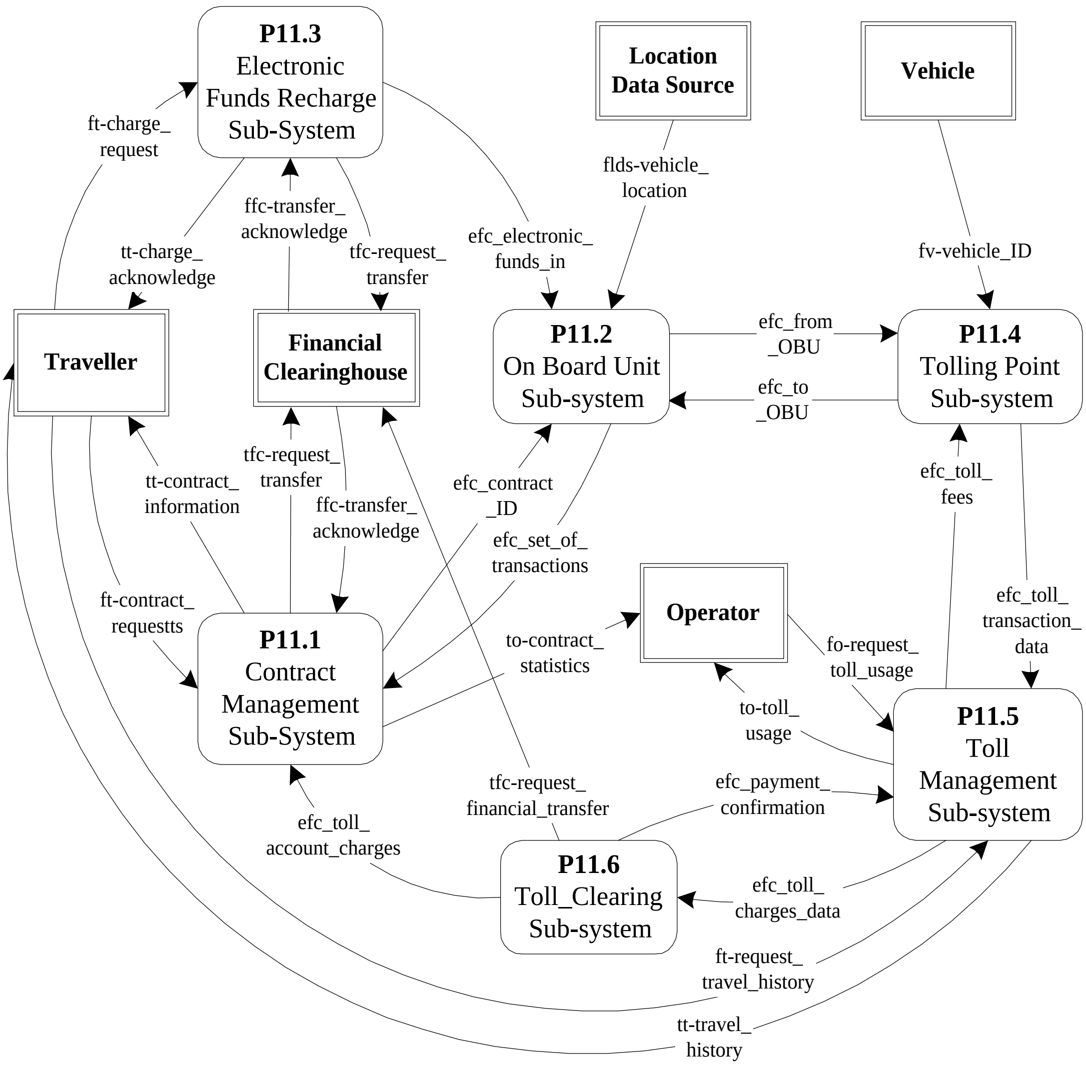
The system consists of six Sub-systems which are described below. They are also shown in the Figure on the next page, which shows their relationship between each other and the Terminators. It is an application of the Conceptual Model of DD ENV ISO 14904 “Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators” - see Section 3.2.4. Note that, for simplicity, only one copy of each sub-system is shown. However in practice each may have a number of instantiations with the corresponding multiple instantiations of the data flows - see Section 3.3.4.

P11.1 Contract Management Sub-system: - This Sub-system shall enable the Traveller to set up a contract to use a road tolling system using pre-payment, post-payment or on-board payment facilities, and to send a contract number to the On Board Unit Sub-System. The sub-system shall also receive the charges that should be made to each account from the Toll Clearing Sub-System, debit the accounts accordingly, and provide each Traveller with a financial statement. If a Vehicle Positioning System is used that accumulates the charges within the vehicle, this system shall receive the total charge.

P11.2 On Board Unit Sub-System: - This Sub-system shall store the contract number of the Traveller and transmit it to each Tolling Point Sub-System. If the Traveller has chosen on-board payment, the sub-system shall also store the electronic funds and debit them by the amount transmitted from the Tolling Point Sub-System, informing the Tolling Point Sub-system of any overdraft.

In the case of tolling using a Vehicle Positioning System (VPS), this sub-system shall contain the list of tariffs to be charged. It shall also calculate the charge to be made, and then either make a debit from the on-board electronic funds, or accumulate a total for later transmission to the Contract Management Sub-system.

Figure 22 P11 Automatic Road Tolling System - Sub-system Diagram



P11.3 Electronic Funds Recharge Sub-System: - This Sub-system shall enable the Traveller to recharge the electronic funds in the On-Board Unit Sub-System, when using the on-board payment facilities.

P11.4 Tolling Point Sub-System: - This Sub-system shall receive the contract number from an on-board unit and identify the class of vehicle, and the type of contract. If the Traveller is using on-board payment then the sub-system shall transmit the charge to the on-board unit. Otherwise the sub-system shall send the contract number, together with the charge, to the Toll Management Sub-System If no on-board unit is identified the sub-system shall send an 'image' of the vehicle to the Toll Management Sub-System, together with the charge.

If the Operator wished to vary the charges according to the traffic conditions, this Sub-system could be linked to the Manage Traffic area.

P11.5 Toll Management Sub-System: - This Sub-system shall maintain a data store of each On Board Unit Sub-System contract number and the Tolling Point Sub-Systems that it has passed, and supply this information, on request, to the corresponding Traveller. The sub-system shall pass on the total charges for each contract number to the Toll Clearing Sub-System to recover the money, also any 'images' of non-equipped vehicles. The sub-system shall provide the Operator with statistics of usage, and manage the toll tariffs for transmission to each Tolling Point Sub-System.

P11.6 Toll Clearing Sub-System: - This Sub-system shall distribute fees to the operators and send the charges to be made on each user to the Contract Management Sub-system. Whilst the sub-system shall receive the 'images' of the non-equipped vehicles, the subsequent debt collocation is not developed.

3.3.4 System Dynamic, or How it Works

This system provides the Traveller with a choice of payment methods, namely:

- On-board payment
- Pre-payment account
- Post-payment account
- Vehicle Positioning System (VPS) charging

though the first two revert to post-payment when there are not enough funds available in the account or the on-board unit.

Privacy is maintained through the use of a contract number held inside an On Board Unit Sub-System, and the separation of the tasks of contract management and road toll operation via a clearing system. The Contract Management Sub-System knows the identify of each Traveller and the charges he, or she, has built up, but does not know the details of the trips. The Toll Management sub-system knows the route taken by each contract number, but does not know the identity of the corresponding traveller unless he, or she, makes a request for a copy of the details held.

Payment can be made using one of a number of techniques:

1. The Traveller's contract number is transmitted to the Tolling Point Sub-system when required, and the driver receives an invoice at a later date.

2. The On Board Unit Sub-System can also be charged with electronic money which is debited automatically each time that a Tolling Point Sub-System is passed. If this becomes overdrawn then (1) is used.

3. The VPS creates a charge according to the current location of the vehicle and the algorithm that it has been given. Whilst it does not require Tolling Point Sub-Systems whenever a charge is to be made, there do need to be a few in existence in order to be able to provide the On Board Unit with the current version of the charging algorithm.

When using on-board pre-payment, the issue as to what should be done when there are no funds available is not developed.

4. Alternatively all the VPS charges can be accumulated for later transmission to the Contract Management Sub-system and post-payment.

The Toll Clearing Sub-System consolidates the data from a number of toll operators, arranging for the correct money to be passed to each one, and sending combined charges for each contract number to the corresponding Contract Management Sub-System (there may be more than one). The Toll Clearing Sub-System also receives the 'images' of the non-equipped vehicles, though their subsequent processing is not developed further.

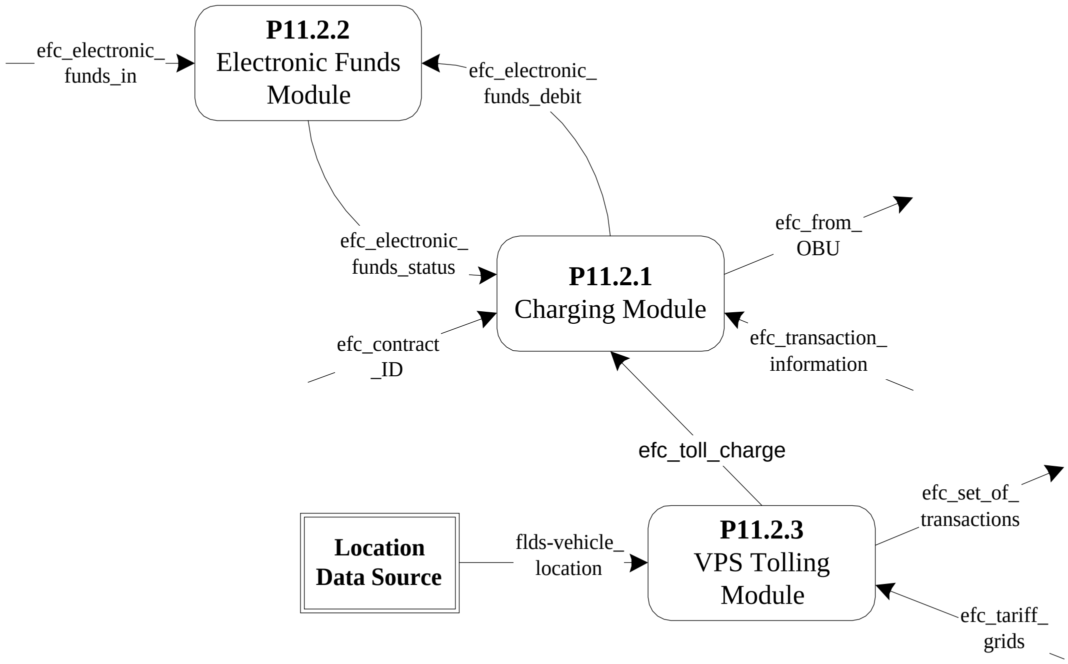
As described in Section 6.2.4, it is possible for there to be multiple instantiations of each sub-system, with the corresponding multiple instantiations of the data flows, as follows:

- On Board Unit - it must be possible for the system to function with a large number of distinct On Board Units;
- Electronic Funds Recharge - there should be many of these sub-systems in order that Users can easily reload their On Board Units;
- Tolling Point - there will be many Tolling Points;
- Toll Management - it is possible for sets of Tolling Points to be owned, and/or managed, by different Toll operators;
- Toll Clearing - it is possible to have competing Toll Clearing operators within the same payment system;
- Contract Management - it is possible to have competing Contract Managers, and for two distinct payment systems to inter-operate via their respective Toll Clearing operators.

3.3.5 Sub-Systems and Functions

One of the four Sub-systems (P11.2) identified in the previous section has been split up into Modules. These are described in the next two sections. The remaining Sub-systems (P11.1, P11.3, P11.4, P11.5 and P11.6) have been split up directly into Functions and Data Stores. These are shown in the tables of Functions and Data Stores in a later section.

Figure 23 P11 Automatic Road Tolling System - On-board Unit Sub-system



3.3.6 Modules

3.3.6.1 Introduction

As noted previously, one of the Sub-systems (P11.2) in this System can be split up into Modules. These Modules are described in the following Section.

3.3.6.2 Modules in Sub-system P11.2 On Board Unit

The On-Board Unit Sub-system has been divided into three Modules in order to clarify the different modes of payment that may be used. A diagram of the Sub-system is shown in the Figure above.

P11.2.1 Charging Module - This Module shall receive the charge to be paid from either the Tolling Point Sub-system or the VPS Tolling Module. If the Traveller has chosen on-board payment then this Module shall debit the Electronic Funds Module, informing the Tolling Point Sub-system of any overdraft (when VPS is not being used).

P11.2.2 Electronic Funds Module - This Module shall store the funds available to pay for the toll charges. It shall be credited by the Electronic Funds Recharge Sub-system, and debited by the Charging Module.

P11.2.3 VPS Tolling Module - This Module shall store the current charging algorithm, calculate the current charge when applicable, and then either pass it on to the Charging Module, or accumulate the total for onward transmission to the Contract Management Sub-system at a later time.

3.3.7 Modules, Functions and Data Stores

The three Modules identified in the previous section can be split up into Data Stores and Functions. These are identified in the tables that are shown below and on the following pages. Also included in the tables are the Data Stores and Functions in the Sub-systems without Modules that are described in an earlier section. Descriptions of the Data Stores can be found in Annex 3 of the Functional Architecture Deliverable Document - see reference in Chapter 10. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 13 P11 Automatic Road Tolling System - Sub-systems, Modules and Data Stores Table

Sub-system			Module		Data Store	
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**
P11.1	Contract Management	Central			D 1.1	EP Contracts Store
					D 1.2	User's Accounts Store
P11.2	On Board Unit	Vehicle	P11.2.1	Charging	D 1.1	EP Contracts Store
			P11.2.2	Electronic Funds	D 1.2	User's Accounts Store
			P11.2.3	VPS Tolling	D 1.4	Transactions Store
					D 1.5	Tariffs Store
P11.4	Tolling Point Sub-System	Roadside			D 1.5	Tariffs Store
P11.5	Toll Management	Central			D 1.4	Transactions Store
P11.6	Toll Clearing	Central			D 1.3	Service Information Store
					D 1.6	Fraud Store

Table 14 P11 Automatic Road Tolling System - Sub-systems, Modules and Functions Table

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P11.1	Contract Management	Central			F 1.1.1	Create EP Contract	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.0.4, 4.1.2.1, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 6.1.2.8
					F 1.1.2	Establish Contract Statistics	4.1.0.2, 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.2.1	Load User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1, 6.1.2.8
					F 1.2.2	Debit User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.2.3	Inform Users on Transactions	4.1.0.2, 4.1.0.3, 4.1.3.3, 4.1.3.4, 6.1.2.8
P11.2	On Board Unit	Vehicle	P11.2.1	Charging	F 1.2.2	Debit User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.3.2, 4.1.3.3, 4.1.3.4
			P11.2.3	VPS Tolling	F 1.3.4	Inform and Guide User	4.1.0.2, 4.1.1.1, 4.1.3.3
					F 1.3.5	Compute Service Fee	4.1.0.1, 4.1.0.2, 4.1.0.4, 4.1.1.1, 4.1.3.3, 4.1.3.4
					F 1.3.7	Recover Fee	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.1.1, 4.1.1.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1
P11.3	Electronic Funds Recharge	Kiosk			F 1.2.1	Load User's Account	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1, 6.1.2.8
P11.4	Tolling Point	Roadside			F 1.3.1	Detect User	4.1.1.1, 4.1.1.2, 4.1.1.3
					F 1.3.2	Identify User	4.1.0.2, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.3.1, 4.1.3.4

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P11.4	Tolling Point (continued)	Roadside			F 1.3.3	Check Users' Contract	4.1.0.1, 4.1.0.2, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.3.1, 4.1.3.4
					F 1.3.4	Inform and Guide User	4.1.0.2, 4.1.1.1, 4.1.3.3
					F 1.3.5	Compute Service Fee	4.1.0.1, 4.1.0.2, 4.1.0.4, 4.1.1.1, 4.1.3.3, 4.1.3.4
					F 1.3.7	Recover Fee	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.1.1, 4.1.1.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1
P11.5	Toll Management	Central			F 1.2.3	Inform Users on Transactions	4.1.0.2, 4.1.0.3, 4.1.3.3, 4.1.3.4, 6.1.2.8
					F 1.3.7	Recover Fee	4.1.0.1, 4.1.0.2, 4.1.0.3, 4.1.1.1, 4.1.1.2, 4.1.3.2, 4.1.3.3, 4.1.3.4, 4.1.4.1
					F 1.4.3	Inform Operators on Transactions	4.1.0.2
					F 1.6.1	Manage Tariffs	7.3.2.1, 7.3.2.2
P11.6	Toll Clearing	Central			F 1.4.1	Distribute Fees Revenue	4.1.0.1, 4.1.2.1, 4.1.2.2, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.4.2	Credit Operator's Account	4.1.2.1, 4.1.3.2, 4.1.3.3, 4.1.3.4
					F 1.5.2	Detect Payment Violations	4.1.0.1, 4.1.0.2, 4.1.1.3, 4.1.2.2, 4.1.3.3, 4.1.3.4, 4.1.4.1

3.3.8 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document (D 3.1).

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

efc_toll_account_charges
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Toll Clearing Sub-System to the Contract Management Sub-System to provide details of the charges for those vehicles that did not use on-board payment. The data flow consists of the following functional data flow:
pepf_transaction_information

efc_payment_confirmation
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Toll Clearing Sub-System to the Toll Management Sub-System to confirm the payment of the fee due. The data flow consists of the following functional data flow:
pepf_transaction_order

efc_toll_charges_data
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Toll Management Sub-System to the Toll Clearing Sub-System to provide details of the fees due, and details of those transactions with the On-Board-Unit which have failed. The data flow consists of the following functional data flows:
pepf_transaction_information
+ pepf_illegal_action_notification
+ pepf_overdraft_notification

efc_toll_transaction_data
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Tolling Point Sub-System to the Toll Management Sub-System to provide details of each transaction, a request for payment if the vehicle did not use on-board payment, details of that payment if it did (for later transfer of money), and a report of any failures to identify the OBU, or an overdraft situation with the electronic funds. It also contains information that can be used to calculate occupancy rate and travel times. The data flow consists of the following functional data flows:
pepf_transaction_information
+ pepf_overdraft_notification
+ pepf_service_fee
+ pepf_contract
+ pepf_pass_record
+ pepf_illegal_action_notification

efc_toll_fees
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Toll Management Sub-System to the Tolling Point Sub-System to provide the charges to be used. The data flow consists of the following functional data flow:
pepf_tariff_grids

efc_transaction_information
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Tolling Point Sub-System to the Charging Module to provide the charge that should be debited from the on-board electronic funds. The data flow consists of the following functional data flow:
pepf_transaction_information

efc_tariff_grids
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Tolling Point Sub-System to the VPS Tolling Module to provide the charging algorithm for use by the VPS. The data flow consists of the following functional data flow:
pepf_tariff_grids

efc_to_OBU
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Tolling Point Sub-System to the On Board Unit Sub-System to provide the charge that should be debited from the on-board electronic funds. It can also provide the entire charging algorithm for use by the VPS system. The data flow consists of the following functional data flows:
efc_transaction_information
efc_tariff_grids

efc_from_OBU
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the On Board Unit Sub-System to the Tolling Point Sub-System to provide the contract number, and to validate an on-board payment, when activated. The data flow consists of the following functional data flows:
pepf_contract
+ pepf_overdraft_notification

efc_set_of_transactions
This physical data flow is used within the Automatic Road Tolling System. It is sent by the VPS Tolling Module to the Tolling Point Sub-System to provide an accumulated set of charges for post-payment. The data flow consists of the following functional data flow:
pepf_transaction_information

efc_electronic_funds_in
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Electronic Token Recharge Sub-System to the Electronic Funds Module to provide funds for on-board payment. The data flow consists of the following functional data flow:
pepf_load_account_order

efc_contract_ID
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the Contract Management Sub-System to the Charging Module so that the vehicle can be identified by the contract number only. The data flow consists of the following functional data flow:
pepf_contract

efc_electronic_funds_debit
This physical data flow is used within the Automatic Road Tolling System. It is sent by the Charging Module to the Electronic Funds Module to indicate the amount to be debited. The data flow consists of the following functional data flow:
pepf_debit_account_order

efc_electronic_funds_status
This physical data flow is used within the Automatic Road Tolling System. It is sent by the Electronic Funds Module to the Charging Module to indicate the status of the funds after each transaction. The data flow consists of the following functional data flow:
pepf_account_status

efc_toll_charge
This physical data flow is used within the Automatic Road Tolling System. It contains data that is sent by the VPS Tolling Module to the Charging Module to indicate the amount to be charged. The data flow consists of the following functional data flow:
pepf_transaction_information

3.3.9 Key Issues

1. For seamless travel throughout the EU:
   - The On Board Unit Sub-System (P11.2) will have to function in the same way at all locations;
   - There may be many Contract Management Sub-systems (P11.1);
   - There may be many Toll Management Sub-systems (P11.5);
   - It will probably be necessary to have many co-operating Toll Clearing Sub-systems (P11.5);
   - The efc_from_OBU and efc_to_OBU data flows must be understood by all On Board Unit Sub-Systems (P11.2);
   - The handling of vehicles whose On Board Unit Sub-System is defective, or not present, has not been developed in this System. A consistent approach will need to be taken that is likely to have an affect on the fv_vehicle_ID data flow.

2. If a Vehicle Positioning System (VPS) style of tolling is to be used:
   - All vehicles will have to be fitted with an appropriate on-board unit;
   - There must be a mechanism for updating the charging algorithms within each on-board unit;
   - Enforcement for VPS is still under investigation, and has not been developed in this System. The technique that is finally chosen will have to operate in a consistent manner throughout the EU.

4. Safety and Emergency Systems

4.1 Introduction

This Chapter describes an "example System" that provides the early response in critical situations, named as Incident Management System, and Systems for covering the transport of hazardous goods to secure the monitoring and to minimise the risk and the reaction time in the case of an accident.

4.2 P 22 – Hazardous Goods Management System

4.2.1 Overview

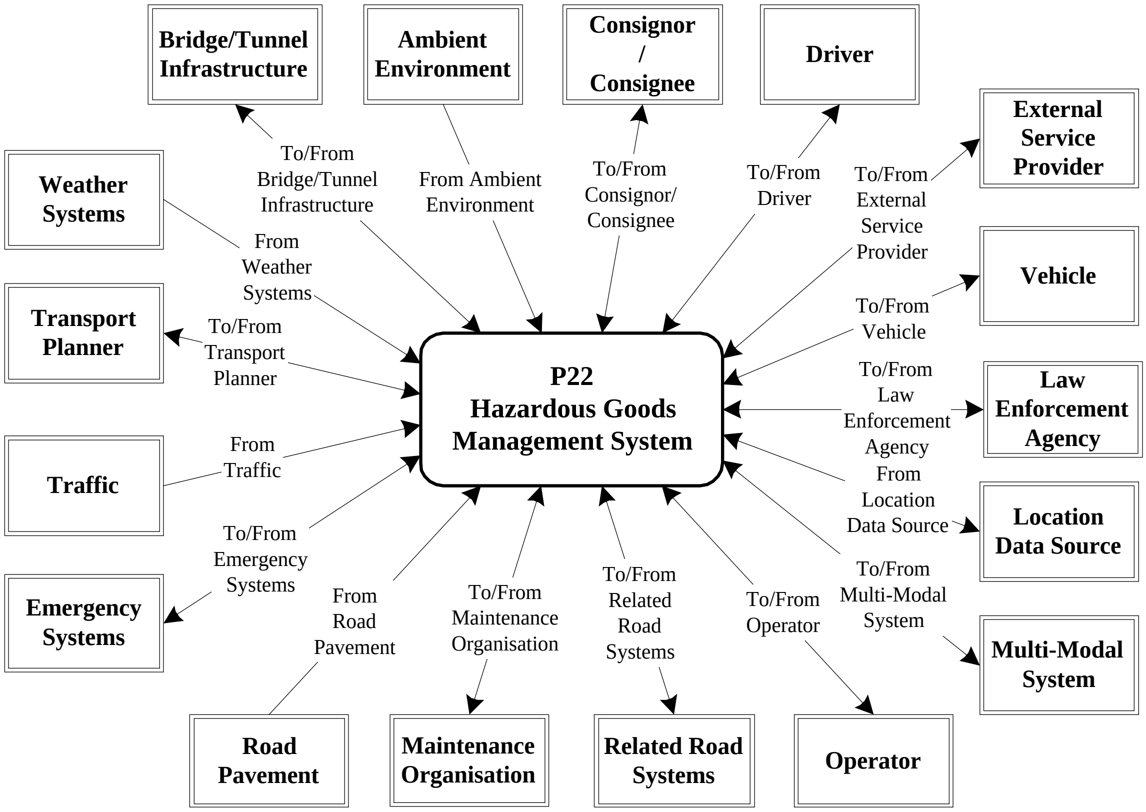
The System provides options to monitor the route of hazardous goods along their way and to reduce the interference time to a minimum.

4.2.2 System Context

The System Context describes the framework within which the System exists. It is illustrated using a System Context Diagram, which is shown in the Figure on the following page. In the Diagram are shown the links that this particular System has with the outside World. The outside World is represented by terminators.

The diagram for this System is derived from the full European ITS Framework Architecture Context Diagram shown by Figure 1 in Chapter 6 of the Main Document. The derivation process involves the deletion of the terminators that are not used by this System. The descriptions of those terminators that are used by this System will be found in Table 3, which is also part of Chapter 6 of the Main Document.

Figure 24 P 22 Hazardous Goods Management System - Context Diagram



As will be seen from a comparison with Figure 1, several terminators from the general list are not required by this System. The reasons for their exclusion are shown in the table below and on the following page.

Table 15 P 22 Hazardous Goods Management System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Financial Clearinghouse	No financial transactions will be performed by this system.
Freight Equipment	Not used in this system
Traveller	No traveller information will be performed by this system.

4.2.3 Sub-systems

The System consists of two main Sub-Systems. The first is located in the vehicle, the other is named as Control Centre. They are described below and shown in the following Figure together with their relationships with each other and the Terminators.

P 22.1 In-Vehicle Sensors and On-board Processor - this Sub-System is monitoring the hazardous good to avoid critical situation caused by improper storage. It also receives information from the road-side systems or via broadcast. In case of an emergency either a manual (released by the driver) or an automatically released emergency signal will be generated.

P 22.2 Control Centre - this Sub-System has the role of a supervising institution, to control the way of the vehicle and to react in the case of an incident.

4.2.4 Sub-Systems and Functions

The two Sub-Systems described above can be split up in several Functions as shown in the table below. Some of the Functions are taken from the In-Vehicle Equipment Functional Area and others from the Freight and Fleet Management Area. They have been included in these Sub-systems because of their importance to hazardous goods management.

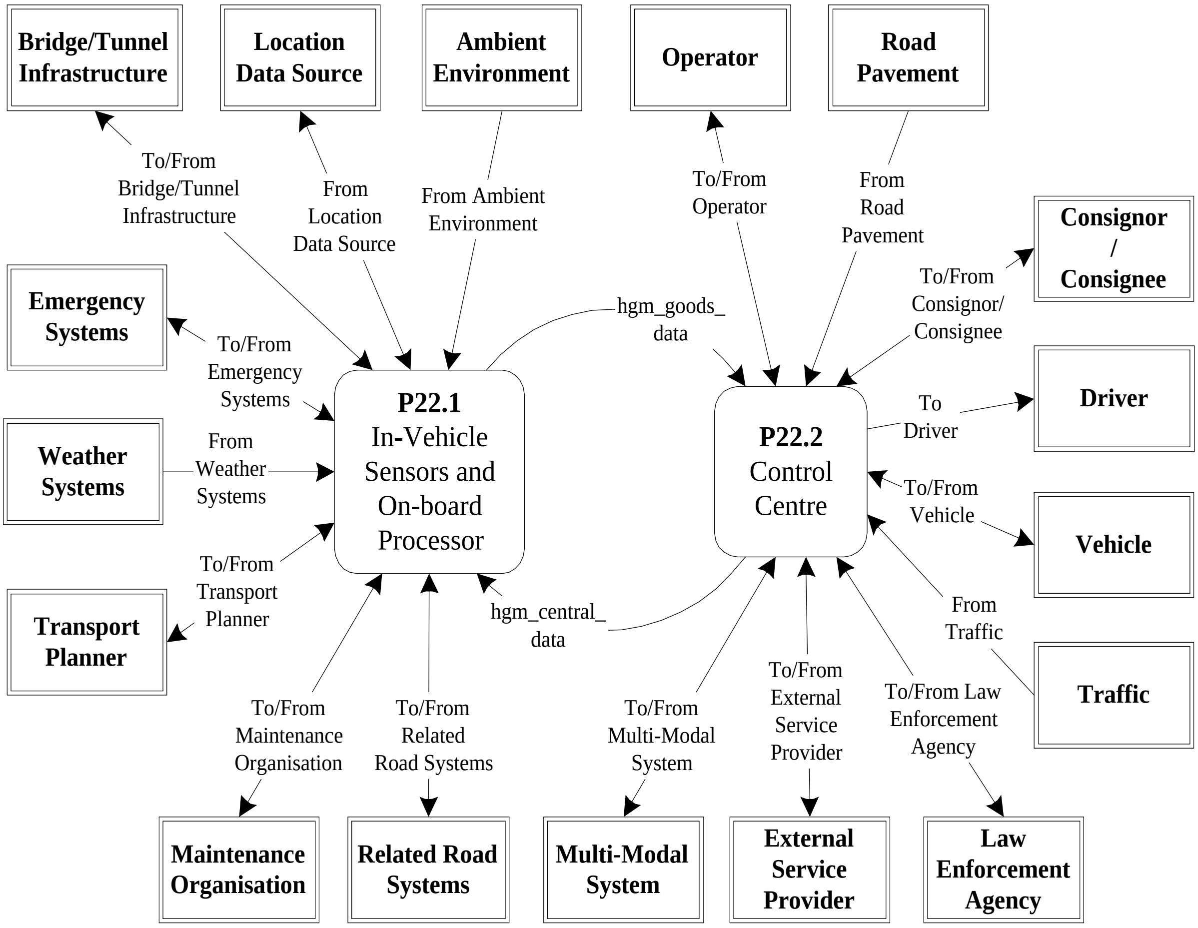
Table 16 P 22 Hazardous Goods Management System - Sub-systems and Functions

Sub-system			**Function**		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P 22.1	In-Vehicle Sensors and On-board Processor	Vehicle	F 5.5.2	Enhance Driver Alertness	8.5.0.3
			F 5.5.3	Monitor Vehicle Status	
			F 5.5.4	Record Operational Data	
			F 5.5.7	Provide Mayday Call	8.5.1; 8.5.11
			F 5.7.3	Provide Vehicle Position Determination	8.5.1; 8.5.11
P 22.2	Control Centre	Central	F 8.1.2.2	Handle Hazardous Goods Transport Declaration	9.5.1.3, 9.5.1.4
			F 8.1.3	Control Freight/Cargo Operations	9.5.1.6
			F 2.1.5	Provide Access and Maintain Data for Emergency	7.2.1.2, 7.2.0.5, 7.2.0.7

4.2.5 Modules

As will be seen from the descriptions above, neither of the two Sub-systems in this System contains any Modules.

Figure 25 P 22 Hazardous Goods Management System - Sub-system Diagram



4.2.6 Physical Data Flows

As will have been seen from the above Figure, the Sub-systems in this System are linked together using Physical Data Flows. The term "Physical" is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

hgm_goods_data
This physical data flow is used within the Hazardous Goods Management System. It contains data that has been collected or produced by the In-Vehicle sensors and on-board processor Sub-system and is for use in another Sub-system, the Control Centre Subsystem.

hgm_central_data
This physical data flow is used within the Hazardous Goods Management System. It contains data that has been collected or produced by the Control Centre Subsystem and is for use in another Sub-system, the In-Vehicle sensors and on-board processor Subsystem, to avoid incidents and dangerous situations along the route of the vehicle.

4.2.7 Key Issues

Two Key Issues have been identified for this System. They are as follows.

1. The definition of a consistent classification of hazardous goods is required to guarantee that the correct information is available in case of an emergency.

2. The response time of the system must be nearly real-time to reduce the interference time of emergency services to a minimum.

5. Traffic Management Systems

5.1 Introduction

This Chapter describes “example Systems” that provide various forms of road traffic management facilities. Two forms of System are described. The first provides basic Urban Traffic Management, whilst the second provides both Urban and Inter-urban Traffic Management.

5.2 P 30 - Urban Traffic Management System

5.2.1 Overview

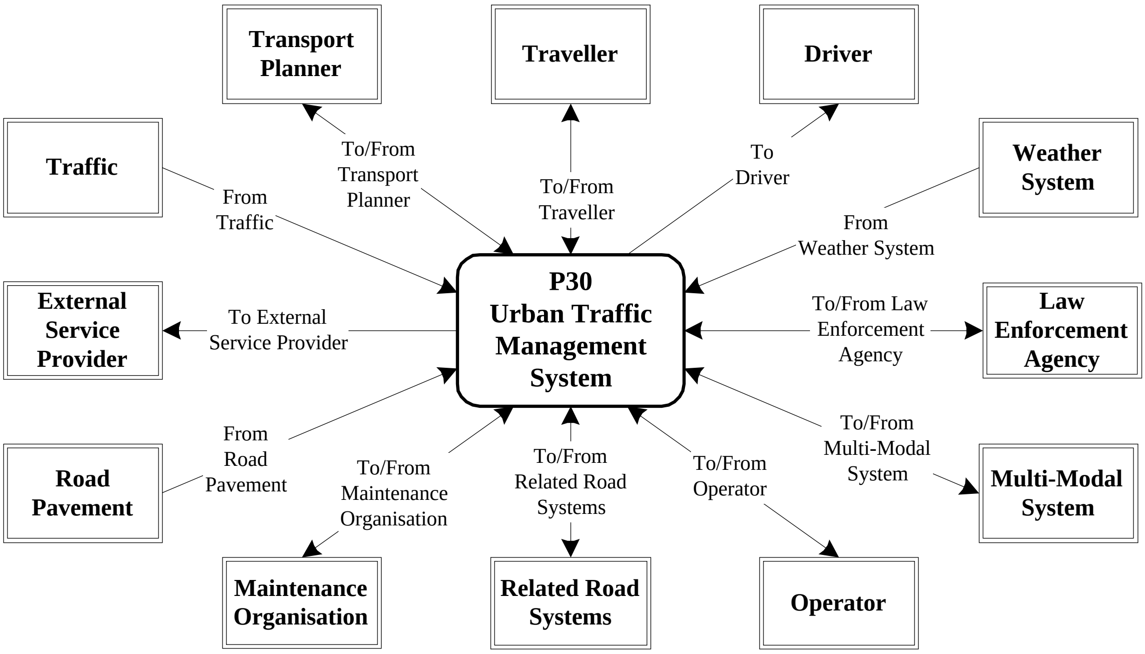
This System provides facilities that enable the management of road traffic that is using an urban road network. In addition to the actual traffic management facilities, the System includes additional facilities for the maintenance of the physical road network and the equipment used by the System for the management of traffic. Emergency Vehicle priority is provided using equipment on-board the Vehicle that links to local System equipment at the roadside. Links from this System to other Systems are also provided to enable co-ordination of traffic management across organisational boundaries.

This System has been included to show urban traffic management in its simplest form. For example, the urban road network includes no bridges or tunnels, and there are no control of inter-urban road networks. Also there are no facilities for Incident or Demand Management, nor any Environmental Monitoring. However there are three additional facilities not yet found in widespread use among traffic management systems currently implemented in many towns and cities across Europe. The first is lane management, which will enable such things as tidal flow control on multi-lane roads, the second is vehicle speed control, and the third is the links to the Multi-Modal Systems. The second facility has been the subject of recent testing in Europe and will enable vehicle speeds to be regulated without the need for physical devices such as speed ramps. The third facility will enable the movement of vehicles on other modes of transport such as railways and canals to be co-ordinated with road traffic movements.

5.2.2 System Context

The System Context describes the framework within which the System exists. It is illustrated using a System Context Diagram, which is shown by the Figure on the following page. The Diagram shows the links that the Urban Traffic Management System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting Terminators that are unused by the System.

Figure 26 P30 Urban Traffic Management System - Context Diagram



As will be seen from a comparison with Figure 1, a total of seven terminators in the general list are not required by this System. They and the reasons for their exclusion, plus details of the actors excluded from "generic" terminators are shown in the following table.

Table 17 P 30 Urban Traffic Management System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Not required - no Environmental Monitoring in this System.
Bridge/Tunnel Infrastructure	The urban road network being managed by this System does not contain any bridges or tunnels.
Consignor/Consignee	Only required by Systems involving Freight and Fleet Management.
Driver	All the actors in this terminator are required by this System, but they are not be referred to specifically by name. Instead the term "Driver" is used to indicate all actors in this Terminator.
External Service Provider	Only those actors that receive information from the System (Broadcaster and Traffic and Travel Information Provide) are required.
Financial Clearinghouse	Only required by Systems involving financial transactions.

Terminator Name	Reasons for deletion or modification
Freight Equipment	Not used in this System
Multi-Modal System	Only the following actors in this terminator are required by this System: Mutli-Modal Crossing and Multi-Modal Management System.
Operator	Only the Road Network Operator actors is required from this terminator.
Road Related System	The System can exchange data with adjacent urban traffic management Systems, or with inter-urban traffic management Systems.
Traveller	Only the following actors in this terminator are required by this System: Pedestrian and Cyclist.
Vehicle	Links to this terminator are not required by this System.

5.2.3 Sub-systems

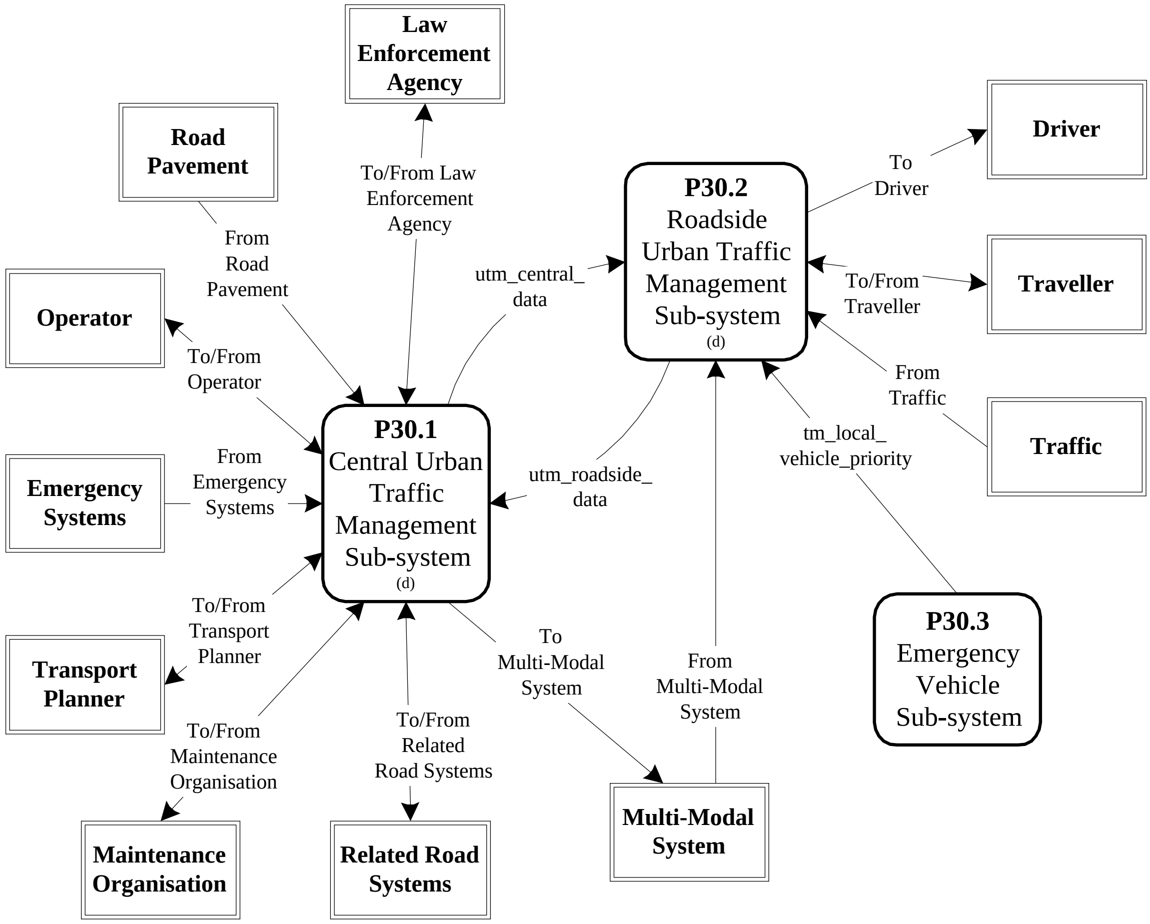
This System consists of three Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the Figure on the following page. This Figure also includes their relationships with each other and with the terminators.

P 30.1 Centralised Urban Traffic Management Sub-system: - this Sub-system provides all of the centralised functionality for urban traffic management. This includes the selection and implementation of the most appropriate management strategy in some or all of the road network. It will be possible for different strategies to be implemented in different parts of the road network. The Sub-system also includes facilities for the storage and collation of traffic and road use data for use by itself and other Systems.

P 30.2 Roadside Urban Traffic Management Sub-system: - this Sub-system provides all of the roadside functionality for urban traffic management. This includes the collection of traffic data for use by the central Sub-system (see P30.1 above), response to local priority requests from Emergency Vehicles, and the output of instructions to road users and pedestrians. These instructions are provided by the central Sub-system through the traffic management strategy that is currently being implemented.

P 30.3 Emergency Vehicle Sub-system: - this Sub-system is responsible for generating local priority requests from Emergency Vehicles. These requests are used to create priority for the Vehicles as they approach the control Module in the Roadside Urban Traffic Management Sub-system (P30.2) - see above. This Vehicle based Sub-system will only be used when a priority route cannot (or has not) been selected by the Emergency System and provided to the Centralised Urban Traffic Management Sub-system (P30.1) - see above.

Figure 27 P 30 Urban Traffic Management System - Sub-systems



5.2.4 How does it work - Urban Traffic Management Methodologies

5.2.4.1 Introduction

The main feature of any urban traffic management methodology is to improve the efficiency of use of the urban road network. This can be looked at it two ways. Firstly the general use of the road network by all types of vehicle can be improved. This is usually done by reducing the amount of "delay" that vehicles experience through co-ordination of the way that the traffic lights work at junctions. Secondly, further particular improvement can be given to some vehicles such as those belonging to the Emergency Services. Usually this means giving priority at traffic lights to these vehicles. Priority can also be given to those vehicles carrying the most people, e.g. Public Transport Vehicles. This is covered by Chapter 2 which describes examples Integrated Transport Systems.

5.2.4.2 Optimising the use of the urban road network

As noted above the general use of the urban road network can be improved by reducing the amount of "delay" experienced by all vehicles. In this case a "delay" can be caused by anything from the vehicle having to slow down because it arrives at the end of a slow moving queue to a complete stop. Reducing the "delay" is usually achieved by monitoring traffic flow and optimising the operation of traffic lights. The optimisation will aim to give the least delay to the most vehicles and can be achieved by adjusting the start and duration of “green times” that vehicles experience.

There are two ways in which the optimisation process can be carried out. Firstly it can be done locally at each traffic light. In this case adjacent traffic lights will have to communicate with each other so that their operation can be co-ordinated and traffic data can be collected for upstream flows. This requires functionality in the traffic light controller itself and is usually known as “distributed control”. This method is used by the traffic management functionality included in the first four “example Systems” (P 1 - P 4) included in Chapter 2.

The second way in which optimisation of traffic flow can be achieved is by applying the traffic light co-ordination centrally. This means that all the traffic data must be provided to the central location from which the control data originates. The traffic signal controllers do not need to have much functionality beyond that need for their own operation, and do not need to communicate with one another. This way of optimisation is the one that is used by the “example System” in this Chapter.

5.2.4.3 Providing Emergency Vehicle priority

There are also two ways in which priority can be given to Emergency Vehicles. The first is locally through the use of equipment on the vehicle itself. This equipment enables the local traffic light controllers to know that the vehicle is approaching and that it requires priority for green. The second way of providing priority is through a request to the central part of the System. This request will originate from the Emergency Systems Terminator and will usually specify that priority be given along a particular route. The central part of the system integrates this request into its general traffic management optimisation so that the Emergency Vehicle(s) arrive at traffic lights that have been showing green long enough for any other traffic to have moved out of the way. Once the Vehicle(s) have passed through each traffic light, the central part of the System can restore the disrupted traffic flow to normal by making suitable adjustments to its optimisation processes.

Both types of Emergency Vehicle priority are supported by this “example System”. For the local priority request, the functionality in the Vehicle is provided by Sub-system P 30.3 and it communicates directly with functionality at the Roadside in Sub-system P 30.2.

5.2.5 Sub-Systems and Functions

Two of the three Sub-systems (P 30.1 and P 30.2) identified in the previous section have been split up into Modules. These are described in the next two sections. The remaining Sub-system (P 30.3) has been split up directly into a single Function which is shown in the table of Functions in a later section.

5.2.6 Modules

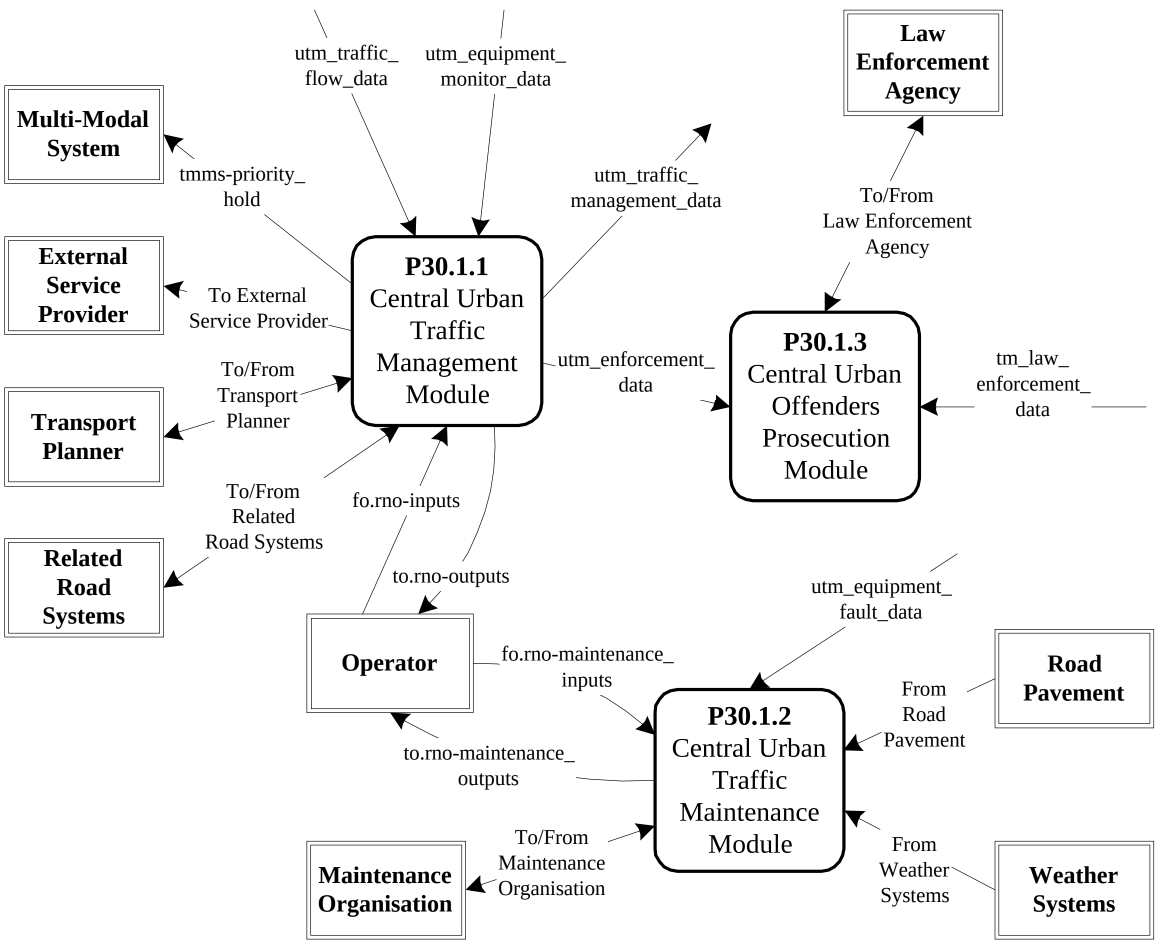
5.2.6.1 Introduction

As noted above, two of the Sub-systems in this System are divided into Modules. These Modules enable parts of the Sub-systems to be provided separately and/or to be sited in different parts of the Sub-system locations. The Modules in the individual Sub-systems are described in the following sections and shown in the following Figures together. Again the Figures also show their relationships with each other and the Terminators.

5.2.6.2 Modules in P 30.1 Central Urban Traffic Management Sub-system

The Central Urban Traffic Management Sub-system consists of three Modules. These cover the central storage of data about traffic, the creation of traffic management instructions that are to be sent to the roadside Sub-system, the management of maintenance and the prosecution of offenders. Their descriptions are as follows and they are shown in the following Figure. This Figure shows their relationships with each other and the Terminators.

Figure 28 P 30 Urban Traffic Management System - Central Sub-system Modules



P 30.1.1 Central Urban Traffic Management Module: - this Module provides a number of facilities that enable traffic in the urban road network to be managed. The two most important of these facilities are the storage of data collected at the roadside and the creation and output of traffic management strategies in the form of instructions to travellers and drivers that will be output at the roadside. Other facilities include the interface for the Road Network Operators and the generation of traffic management strategies by the Transport Planner.

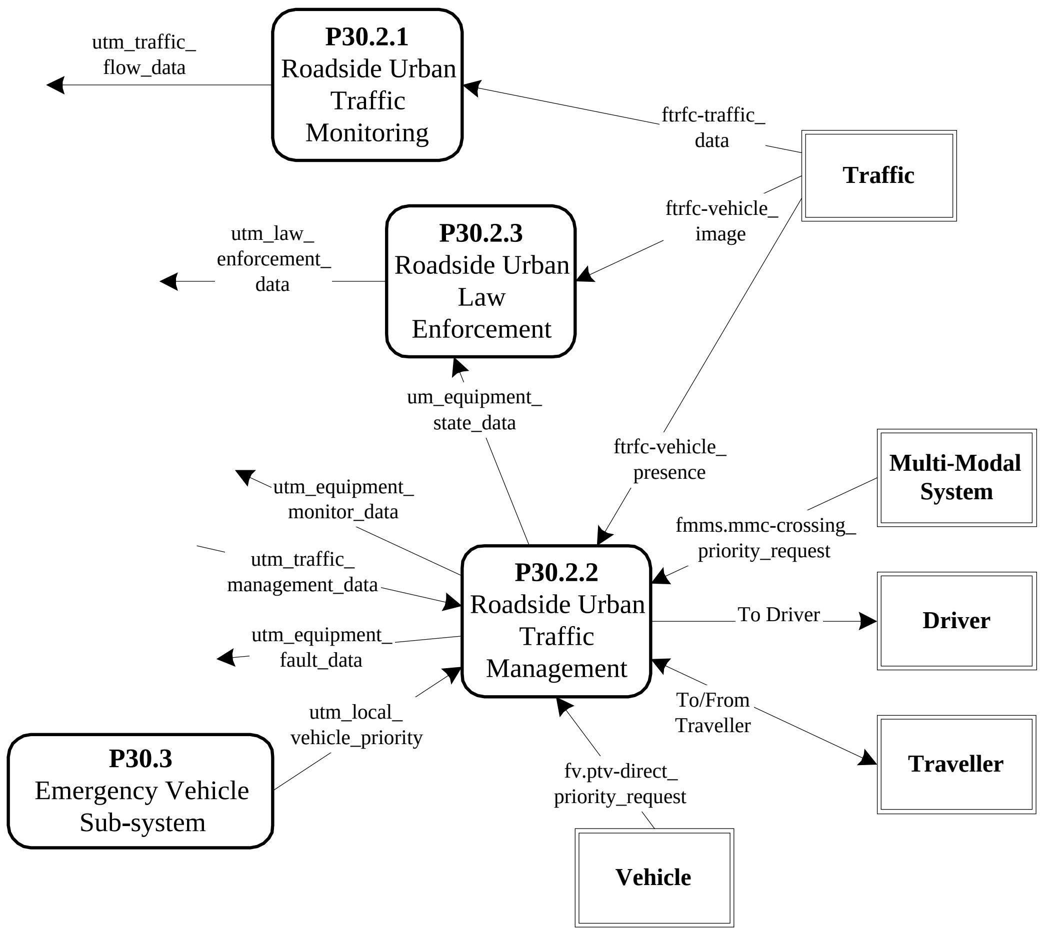
P 30.1.2 Central Urban Traffic Maintenance Module: - this Module monitors the road network, looking for the need to carry-out maintenance activities. This need may arise because of the use that road traffic has made of the network, the detection of faults in equipment, or weather conditions. Once the need for maintenance activity has been established, details are sent to the Maintenance Organisation for action.

P 30.1.3 Central Urban Offenders Prosecution Module: - this Module receives data from the Roadside Sub-system about violations of the rules that vehicles using the road network must follow. Data about each violation is sent to the Law Enforcement Agency for eventual prosecution of the offender.

5.2.6.3 Modules in P 30.2 Roadside Urban Traffic Management Sub-system

The Roadside Urban Traffic Management Sub-system (P 30.2) also consists of three Modules. These cover the collection of data about traffic, roadside actuators that provide instructions to Travellers and the control of vehicle movements. Their descriptions are as follows and they are illustrated in the following Figure. Note that the Emergency Vehicle Sub-system has been included in this Figure for clarity and ease of understanding.

Figure 29 P30 Urban Traffic Management System - Roadside Sub-system Modules



P 30.2.1 Roadside Urban Traffic Data Collection Module: - this Module enables data to be collected at the roadside about traffic movements within the road network. This data may also include that showing the use that vehicles have made of car parks.

P 30.2.2 Roadside Urban Traffic Management Actuation Module: - this Module enables instructions to be output to Travellers and/or Drivers using the road network. These instructions are provided by the Central Traffic Management Sub-system. They may be visual or audible commands that the Traveller and/or Driver must action, or advice for them to follow. In this instance the Travellers will be pedestrians, who are walking through the road network as part of their journeys.

P 30.2.3 Roadside Urban Law Enforcement Module: - this Module monitors that activities of road vehicles to ensure that they do not break any of the laws relating to vehicle movements. When a violation of the law is detected, data about the vehicle is collected and sent to the Prosecution Module in the Central Sub-system.

5.2.7 Modules, Data Stores and Functions

The six Modules identified in the two previous sections can be split up into Data Stores and Functions. These are identified in the tables that are shown below and on the following pages. Also included are the Functions in the Emergency Vehicle Sub-system (P 30.3) - see previous section. Details of the Data Stores can be found in Annex 3 of the Functional Architecture Deliverable Document - see reference in Chapter 10. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 18 P30 Urban Traffic Management System - Modules and Data Stores

Sub-system			Module		Data Store	
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**
P 30.1	Centralised Urban Traffic Management	Central	P30.1.1	Central Urban Traffic Management	D 3.1	Urban Traffic Data Store
					D 3.7	Urban Road Static Data Store
			P30.1.2	Central Urban Traffic Maintenance	D 3.6	Maintenance Data Store
			P30.1.3	Central Urban Offenders Prosecution	D 1.6	Fraud Store
					D 7.1	Rules Store

Table 19 P30 Urban Traffic Management System - Modules and Functions

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 30.1	Centralised Urban Traffic Management	Central	P30.1.1	Central Urban Traffic Management	F 3.1.1.3	Provide Urban Traffic Forecasts and Strategies	2.1.2.1, 2.1.2.3, 7.1.2.2, 7.1.2.4, 7.1.6.1, 7.1.7.4, 7.1.8.1, 7.1.11.2
					F 3.1.1.4	Manage Urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.1.5.1	Provide Urban Traffic Control	2.1.2.2, 2.1.3.1, 7.1.4.5, 7.1.4.8, 7.1.4.9, 7.1.5.1, 7.1.5.5, 7.1.5.6, 7.1.5.7, 7.1.5.8, 7.1.9.1, 7.1.9.2, 7.1.9.3, 7.1.9.4, 7.1.12.1, 7.1.12.2
					F 3.1.1.5.2	Provide Planned Urban Traffic Control Facilities	7.1.3.6, 7.1.3.7
					F 3.1.1.5.7 F 3.1.1.5.9	Provide Operator Urban Traffic Control Facilities Manage Urban Static Traffic Data	7.1.3.1, 7.1.3.2, 7.1.3.3, 7.1.3.5

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 30.1	Centralised Urban Traffic Management (continued)	Central	P30.1.2	Central Urban Traffic Maintenance	F 3.5.1	Evaluate Short Term Maintenance Needs	2.2.0.1, 2.2.0.3, 2.2.0.5, 2.2.3.1, 2.2.4.1
					F 3.5.2	Evaluate Long Term Maintenance Needs	2.2.0.6, 2.2.3.1, 2.2.4.1
					F 3.5.3	Evaluate Equipment Maintenance Needs	2.2.2.1, 2.2.2.2
					F 3.5.4	Evaluate De-icing Need	2.2.1.1
					F 3.5.5	Provide Operator Maintenance Operations Interface	
					F 3.5.6	Manage Maintenance Data Store	2.2.0.6, 2.2.2.3
			P30.1.3	Central Urban Offenders Prosecution	F 7.1.1	Perform Measure	3.1.0.1, 3.1.0.2, 3.1.0.3, 3.1.0.4, 3.1.1.3, 3.1.1.4
					F 7.1.2	Check Compliance	3.1.0.1, 3.1.0.2, 3.0.1.3
					F 7.3.1	Sort Fraud Notifications	3.1.1.1, 3.1.1.2
					F 7.3.2	Establish Prosecution File	3.1.1.1, 3.1.1.2, 3.1.0.5
					F 7.4	Store Fraud	3.1.0.2, 3.1.0.3, 3.1.0.5

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 30.1	Centralised Urban Traffic Management (continued)	Central	P30.1.3	Central Urban Offenders Prosecution (continued)	F 7.5.1	Manage Rules	3.1.0.1, 3.1.0.5
P 30.2	Roadside Urban Traffic Management	Roadside	P30.2.1	Roadside Urban Traffic Monitoring	F 3.1.1.1	Collect Urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.2, 7.1.1.4, 7.1.1.5
					F 3.1.1.2	Monitor Urban Car Park Occupation	2.1.1.3, 7.1.1.5, 7.1.11.1
			P30.2.2	Roadside Urban Traffic Management	F 3.1.1.5.3	Provide Urban Car Park States	7.1.4.4
					F 3.1.1.5.5	Provide Urban Output Actuation	7.1.3.4
					F 3.1.1.5.4	Provide Urban Traffic Speed Management	7.1.7.1, 7.1.7.2, 7.1.7.3, 7.1.7.5, 7.1.7.6
					F 3.1.1.5.6	Provide Urban Traffic Lane Management	7.1.4.3, 7.1.5.2, 7.1.5.3, 7.1.5.4, 7.1.10.1
			P30.2.3	Roadside Urban Law Enforcement	F 3.1.1.5.8	Detect Urban Traffic Violations	
P 30.3	Emergency Vehicle	Vehicle			F 2.1.3	Manage Emergency Vehicle	5.2.0.1, 5.2.0.4, 5.2.0.5, 7.2.1.1

5.2.8 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

utm_local_vehicle_priority
This physical data flow is used within the Urban Traffic Management System. It contains a request for local vehicle priority that is sent from the emergency vehicle Module to the roadside traffic management Module. The data flow consists of the following constituent Functional Data Flow:
psef.mt_emergency_local_priority_request

utm_traffic_management_data
This physical data flow is used within the Urban Traffic Management System. It contains traffic management data that is being sent to the roadside Module for implementation. The data flow consists of the following constituent Functional Data Flows:
mt_operator_urban_lane_override
+ mt_operator_urban_speed_override
+ mt_urban_lane_management
+ mt_urban_speed_setting
+ mt_urban_traffic_control_requests

utm_equipment_state_data
This physical data flow is used within the Urban Traffic Management System. It contains data about the current roadside equipment state that can be used by the law enforcement Module to detect any violations. The data flow consists of the following constituent Functional Data Flows:
mt_urban_actuator_status
+ mt_urban_lane_status

utm_law_enforcement_data
This physical data flow is used within the Urban Traffic Management System. It contains data about vehicles that have violated the rules and management strategies that are currently being output by the roadside traffic management Module. They will have been detected by the roadside law enforcement Module. The data flow consists of the following Functional Data Flow:
mt.psle-urban_fraud_notificaations

utm_equipment_fault_data
This physical data flow is used within the Urban Traffic Management System. It contains data about faults in roadside equipment that have been detected by the roadside traffic control module. The data flow consists of the following constituent Functional Data Flows:
mt_urban_equipment_status
+ mt_urban_reponse_fault

utm_equipment_monitor_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains data about the response of the roadside traffic management Module to traffic management strategy data. The data flow consists of the following constituent Functional Data Flow:
mt_urban_traffic_management_responses

utm_traffic_flow_data
This physical data flow is used within the Urban Traffic Management System. It contains traffic flow data that has been collected by the roadside traffic monitoring Module. The data flow consists of the following constituent Functional Data Flows:
mt_collected_urban_traffic_data
+ mt_carpark_urban_inputs
+ mt_urban_traffic_flow_management_data

utm_enforcement_data
This physical data flow is used within the Urban Traffic Management System. It contains data about the current traffic flow rules that will be used by the offenders prosecution Module to decide what action to take when a violation has been detected. The data flow consists of the following constituent Functional Data Flow:
mt.psle_urban_enforcement_guidelines

utm_central_data
This physical data flow is used within the Urban Traffic Management System. It contains data that is being sent from the Central Sub-system to the Roadside Sub-system. The data flow consists of the following constituent Physical Data Flow:
utm_traffic_management_data

utm_roadside_data
This physical data flow is used within the Urban Traffic Management System. It contains data that is being sent from the Roadside Sub-system to the Central Sub-system. The data flow consists of the following constituent Physical Data Flows:
utm_equipment_fault_data
+ utm_equipment_monitor_data
+ utm_law_enforcement_data
+ utm_traffic_flow_data

fmms.mmc-crossing_priority_request
This physical data flow is sent to the Urban Traffic Management System by the Multi-Modal Crossing actor in the Multi-Modal System terminator. It contains a request for priority to be given to traffic on another transport mode (Rail, ship, aircraft) at a multi-modal crossing. The physical data flow consists of the following Functional Data Flow
fmms.mmc-urban_crossing_request

fo.rno-inputs

This physical data flow is sent to the Urban Traffic Management System by the Road Network Operator actor in the Operator terminator. It contains inputs about the operation of the System and its affect upon the urban road network. The physical data flow consists of the following Functional Data Flow:
fo.rno-urban_commands

fo.rno-maintenance_inputs

This physical data flow is sent to the Urban Traffic Management System by the Road Network Operator actor in the Operator terminator. It contains the inputs about maintenance activities that affect the urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
fo.rno-maintenance_commands

From Law Enforcement Agency

This physical data flow is sent to the Urban Traffic Management System by the Law Enforcement Agency terminator. It contains information about the "rules" by which prosecutions can be reported for offences that have been detected within the urban road network. The physical data flow consists of the following Functional Data Flow:
flea-psle_rules

From Maintenance Organisation

This physical data flow is sent to the Urban Traffic Management System by the Maintenance Organisation terminator. It contains the results from previous outputs requesting maintenance activities that affect the urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
fmo-update_activity_status

From Related Road Systems

This physical data flow is sent to the Urban Traffic Management System by the Related Road Systems terminator. It contains data from other Systems for use by this System. The physical data flow consists of the following Functional Data Flow:
frrs-urban_data_updates

From Road Pavement

This physical data flow is sent to the Urban Traffic Management System by the Road Pavement terminator. It contains information about current and predicted conditions that affect the physical condition of the urban road network. The physical data flow consists of the following Functional Data Flows:
frp-current_conditions
+ frp-long_term_wearing_state
+ frp-short_term_wearing_state

From Transport Planner

This physical data flow is sent to the Urban Traffic Management System by the Transport Planner terminator. It contains inputs about the generation of traffic management strategies for use within the urban road network. The physical data flow consists of the following Functional Data Flow:
ftp-urban_traffic_prediction_commands

From Traveller
This physical data flow is sent to the Urban Traffic Management System by the Traveller terminator. It contains requests for action by Travellers who are using the urban road network. They will usually be pedestrians or vulnerable road users such as cyclists. The physical data flow consists of the following Functional Data Flow:
ft-urban_data

From Weather Systems
This physical data flow is sent to the Urban Traffic Management System by the Weather Systems terminator. It contains information about current and predicted weather conditions that affect the urban road network. The physical data flow consists of the following Functional Data Flows:
fws-ice_formation_conditions
+ fws-long_term_maintenance_conditions
+ fws-short_term_maintenance_conditions

ftrfc-traffic_data
This physical data flow is sent from the Traffic terminator to the Urban Traffic Management System. It contains analogue traffic data that is sent to the roadside traffic monitoring Module. The data flow consists of the following Functional Data Flow:
ftrfc-carpark_vehicle_data
+ ftrfc-urban_traffic_flow_data

ftrfc-vehicle_image
This physical data flow is sent from the Traffic terminator to the Urban Traffic Management System. It contains analogue traffic data that is some type of image (visual, infra-red, magnetic, etc.) that shows a road vehicle and is sent to the roadside law enforcement Module. The data flow consists of the following Functional Data Flow:
ftrfc-urban_traffic_identity_data

ftrfc-vehicle_presence
This physical data flow is sent from the Traffic terminator to the Urban Traffic Management System. It contains analogue traffic data that is sent to the roadside traffic management Module for use locally. The data flow consists of the following Functional Data Flow:
ftrfc-local_traffic_presence_data

fv.ptv-direct_priority_request
This physical data flow is sent to the Urban Traffic Management System by the Public Transport Vehicle actor in the Vehicle terminator. It contains a request for priority to be given to a public transport vehicle locally at a part of the urban road network that is controlled by the roadside traffic management Module. The physical data flow consists of the following Functional Data Flow
fv.ptv-local_priority_request

tmms-priority_hold
This physical data flow is sent from the Urban Traffic Management System to the Mutli-Modal System terminator. It contains a request for the traffic on a non-road based mode of transport (rail, ship, aircraft) to be stopped as it will not get priority at a multi-modal crossing. The physical data flow consists of the following Functional Data Flow:
tmms.mmc-urban_crossing_inhibit

To Driver
This physical data flow is sent by the Urban Traffic Management System to the Driver terminator. It contains instructions to Drivers of vehicles that are using the urban road network. They can be actors who are Drivers of any of the types of vehicle listed in the terminator description. The physical data flow consists of the following Functional Data Flow:
td-urban_traffic_commands

To External Service Provider
This physical data flow is sent by the Urban Traffic Management System to the External Service Provider terminator. It contains data about traffic and travel conditions within the urban road network for use by the Broadcaster and Traffic and Travel Information Providers within this terminator. The physical data flow consists of the following Functional Data Flows:
tesp.b-urban_traffic_data
+ tesp.ttip-urban_traffic_data

To Law Enforcement Agency
This physical data flow is sent to the Urban Traffic Management System by the Law Enforcement Agency terminator. It contains prosecution files for offences that have been detected within the urban road network. The physical data flow consists of the following Functional Data Flow:
tlea-psle_prosecution_file

To Maintenance Organisation
This physical data flow is sent from the Urban Traffic Management System to the Maintenance Organisation terminator. It contains the results from previous outputs requesting maintenance activities that affect the urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flows:
tmo-de-icing_tasks
+ tmo-equipment_tasks
+ tmo-long_term_activities
+ tmo-short_term_activities

To Related Road Systems
This physical data flow is sent from the Urban Traffic Management System to the Related Road Systems terminator. It contains data from this Systems for use by other Systems. The physical data flow consists of the following Functional Data Flow:
trrs-urban_data_updates

To Transport Planner
This physical data flow is sent by the Urban Traffic Management System to the Transport Planner terminator. It contains the results from previous inputs about the generation of traffic management strategies for use within the urban road network. The physical data flow consists of the following Functional Data Flow:
ttp-urban_traffic_prediction_responses

To Traveller
This physical data flow is sent to the Urban Traffic Management System by the Traveller terminator. It contains instructions to Travellers who are using the urban road network. They will usually be pedestrians or vulnerable road users such as cyclists and This output may be the result of previous request for action. The physical data flow consists of the following Functional Data Flow:
tt-urban_traffic_commands

to.rno-maintenance_outputs
This physical data flow is sent from the Urban Traffic Management System to the Road Network Operator actor in the Operator terminator. It contains the results from previous inputs about maintenance activities that affect the urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
to.rno-maintenance_responses

to.rno-outputs
This physical data flow is sent from the Urban Traffic Management System to the Road Network Operator actor in the Operator terminator. It contains the results from previous inputs about the operation of the System and its affect upon the urban road network. The physical data flow consists of the following Functional Data Flow:
to.rno-urban_responses

5.2.9 Key Issues

The Key Issues for this System are as follows.

1. The successful operation of the System depends at least in part on its ability to accurately detect the traffic conditions in the road network that it is serving, particularly in those parts that form “bottle-necks” or are crucial to the rest of the network. Deployment of this detection can be costly, both in capital for initial installation, and in revenue for on-going maintenance and operation.

2. Most Systems are judged to be operating successfully if they are seen to manage the traffic using the road network in the most efficient way. What is judged as being “efficient” will depend on the traffic policy goals of the Government Organisation(s) that regulates the use of the road network. However it will also depend on the techniques that are available to achieve efficient traffic management. There are several of these techniques all have varying degrees of success in different road network configurations. It is therefore important that any System is capable of implementing the most appropriate technique in each part of the road network.

3. Most traffic management techniques rely on the detection of traffic conditions to trigger or modify their implementation. However in many cases, particularly when congestion is rising, the detection is often too late for the implementation of any traffic management technique to achieve any worth-while benefits. It is therefore necessary for cheap and reliable congestion prediction techniques to be developed that can lead to the advanced implementation, thereby achieving better results in terms of more efficient operation of the road network.

4. The total cost of operation of the System will depend in part on the cost of the infrastructure used to communicate data between the central traffic management and roadside Sub-systems. The type of infrastructure used, and the ability for it to be shared with other users will be crucial to the size of these costs.

Note: an example of the System Specification for this “example System” is provided in Annex 2 of the European ITS Physical Architecture Main Document.

5.3 P31 - Inter-urban Traffic Management System

5.3.1 Overview

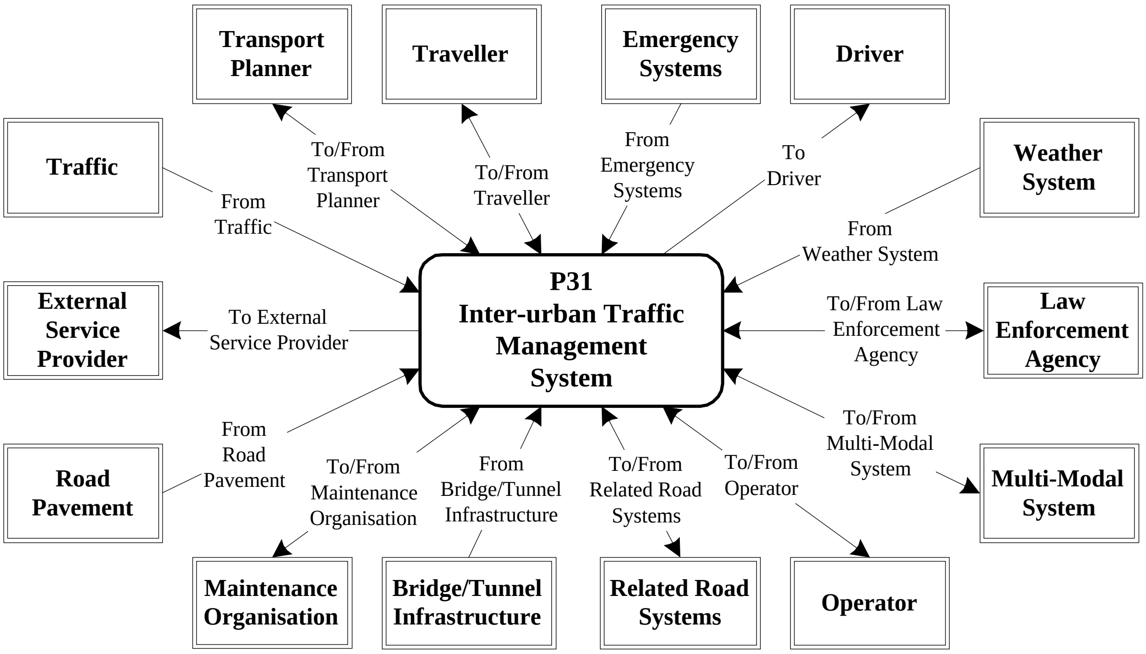
This System provides facilities that enable the management of road traffic that is using an inter-urban road network. In addition to the actual traffic management facilities, the System includes additional facilities for the maintenance of the physical road network and the equipment used by the System for the management of traffic. Links from this System to other Systems are also provided to enable co-ordination of traffic management across organisational boundaries.

Like the previous System for urban networks (P30), this System has been included to show inter-urban traffic management in its simplest form. For example, there are no facilities for Incident or Demand Management, nor any Environmental Monitoring. However bridges and tunnels are included and there are two additional facilities not yet found in use among inter-urban traffic management systems currently implemented across Europe. The first is vehicle speed control, and the second is the links to the Multi-Modal Systems. The first facility has been the subject of recent testing in Europe and will enable vehicle speeds to be regulated without the need for physical devices such as speed ramps. The second facility will enable the movement of vehicles on other modes of transport such as railways and canals to be co-ordinated with road traffic movements.

5.3.2 System Context

The System Context describes the framework within which the System exists. It is illustrated using a System Context Diagram, which is shown by the Figure on the following page. The Diagram shows the links that the Inter-urban Traffic Management System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting Terminators that are unused by the System.

Figure 30 P31 Urban Traffic Management System - Context Diagram



As will be seen from a comparison with Figure 1, a total of six terminators in the general list are not required by this System. They and the reasons for their exclusion, plus details of the actors excluded from "generic" terminators are shown in the following table.

Table 20 P 31 Urban Traffic Management System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Not required - no Environmental Monitoring in this System.
Consignor/Consignee	Not required by this System.
Driver	All the actors in this terminator are required by this System, but they are not be referred to specifically by name. Instead the term "Driver" is used to indicate all actors in this Terminator.
External Service Provider	Only those actors that receive information from the System (Broadcaster and Traffic and Travel Information Provide) are required.
Financial Clearinghouse	Only required by Systems involving financial transactions.
Freight Equipment	Not required by this System.
Location Data Source	Only required by Systems providing route guidance, or other services that need vehicle or traveller location.

Terminator Name	Reasons for deletion or modification
Multi-modal System	Only the following actors in this terminator are required by this System: Mutli-modal Crossing and Multi-modal Management System.
Operator	Only the Road Network Operator actors is required from this terminator.
Traveller	Only the following actors in this terminator are required by this System: Pedestrian and Cyclist.
Vehicle	This terminator is not required by this System.

5.3.3 Sub-systems

This System consists of three Sub-systems. They have been chosen to suit both the intended location and contents of the System components. They are described below and shown in the Figure on the following page. This Figure also includes their relationships with each other and with the terminators.

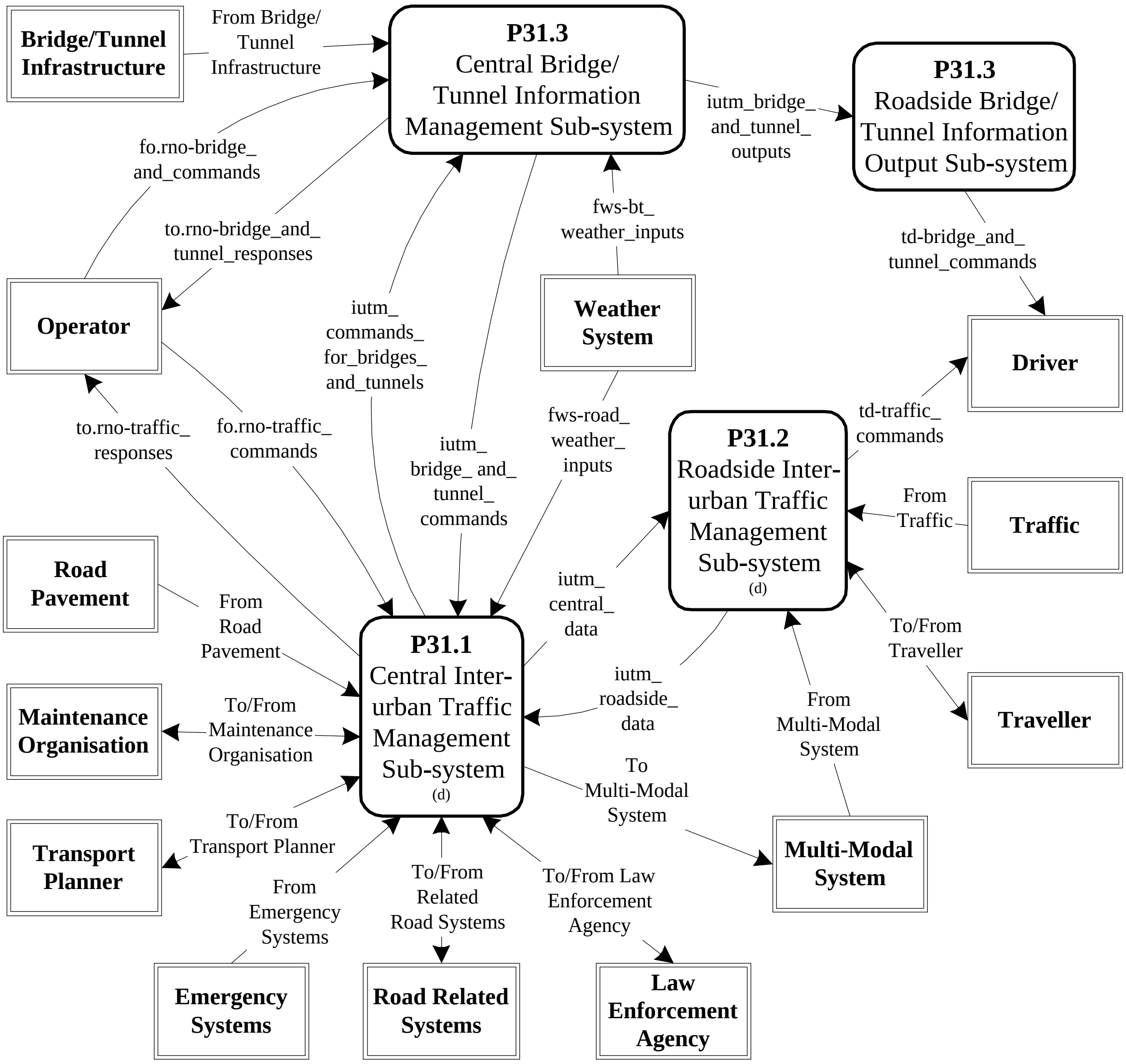
P 31.1 Centralised Inter-urban Traffic Management Sub-system: - this Sub-system provides all of the centralised functionality for inter-urban traffic management. This includes the selection and implementation of the most appropriate management strategy in some or all of the road network. It will be possible for different strategies to be implemented in different parts of the road network. The Sub-system also includes facilities for the storage and collation of traffic and road use data for use by itself and other Systems. Functionality to manage the flow of traffic through bridges and tunnels is also included in the Sub-system.

P 31.2 Roadside Inter-urban Traffic Management Sub-system: - this Sub-system provides all of the roadside functionality for inter-urban traffic management. This includes the collection of traffic data for use by the central Sub-system (see P31.1 above) and the output of instructions to road users and pedestrians. These instructions are provided by the central Sub-system through the traffic management strategy that is currently being implemented.

P 31.3 Central Bridge/Tunnel Information Management Sub-system: - this Sub-system is responsible for acting on data that it receives about conditions in Bridges and Tunnels. The information is provided by external entities that monitor the conditions on bridges and in tunnels. From the data, information and instructions to drivers are produced and sent out via the infrastructure belonging to the Bridge and/or Tunnel. Requests can also be sent to the Central Inter-urban Traffic Management Sub-system - see P31.1 above. Information and instruction for output in Bridges and Tunnels can also be generated as a result of strategy data received from the Central Inter-urban Traffic Management Sub-system. All information and instructions must be confirmed by the Operator before being output.

P 31.4 Roadside Bridge/Tunnel Information Output Sub-system: - this Sub-system turns data that it receives into information that is output to drivers and pedestrians on bridges, or drivers in tunnels. The data is provided by the Central Bridge/Tunnel Information Management Sub-system - see above, and is output using visual and audio devices.

Figure 31 P31 Inter-urban Traffic Management System - Systems Diagram



5.3.4 How does it work - Inter-Urban Traffic Management Methodologies

5.3.4.1 Introduction

The main feature of any inter-urban traffic management methodology is to improve the efficiency of use of the inter-urban road network. This can be looked at it two ways. Firstly the general use of the road network by all types of vehicle can be improved by providing road condition information and instructions to drivers. If the road network includes bridges and tunnels then additional specific information will be provided about their local traffic conditions. Secondly, further particular improvement can be given to some vehicles such as those belonging to the Emergency Services. Priority can also be given to those vehicles carrying the most people, e.g. Public Transport Vehicles. This is covered by Chapter 2 which describes examples Integrated Transport Systems.

5.3.4.2 Improving the use of the inter-urban road network

The use of the inter-urban road network can be improved by providing road condition information and/or instructions to drivers. The data from which the road condition information is produced is provided by vehicle detection within the inter-urban road network managed by the System. Traffic congestion prediction and incident identification algorithms may be used to analyse the raw traffic data and produce predictions from which the information can be generated. Information rather than raw data can also be provided by Systems managing adjacent inter-urban and urban road networks The driver information is usually in the form of advanced warnings about problems that will affect traffic flow. These can be things such as incidents, bad weather, or just the effects of high traffic volumes. Sometimes the information can include advice about alternative routes, and these may be aimed at particular types of vehicle. Alternative route advice is produced using algorithms that look at the effects of diverting traffic away from its expected route.

The instructions that are sent to drivers usually take the form of speed or lane use restrictions, and may be either advisory or mandatory. Sometimes separate indications being provided for each type of vehicle. when mandatory, the instructions may be backed up by enforcement, usually using video image capture and analysis techniques.

5.3.4.3 Information for Bridges

The purpose of the information for bridges is to provide advice about weather conditions that may affect all types of traffic and (possibly) pedestrians. Examples are high winds and fog, but in other cases the information may be about the bridge closing usually to allow the passage of ships and other vessels. In the case of high winds, the information may be mandatory in that particular types of vehicle may be prohibited from using the bridge. The data upon which the information is based will be provided by other systems such as those for bridge management, or those belonging to a Weather Service.

5.3.4.4 Information for Tunnels

The purpose of the information for tunnels is to provide advice about traffic conditions actually within the tunnel. Examples are incidents, particularly fire, and poor atmospheric conditions, e.g. high pollution broken tunnel ventilation. Either of these may give rise to lane restrictions or complete closure. Restrictions on vehicles tend to be permanent and apply to cyclists and pedestrians. Again the information that is output will be based upon data from other systems, although in this case it will only be those responsible for tunnel management.

5.3.4.5 Information Output

The drivers will receive the information or instructions by some type of sign display. This may be a simple device that shows a speed or lane use indication, or one of the many forms of text sign display that can show 50-100 characters. If they apply to a particular lane (or lanes) then they will be mounted over the traffic flow. Otherwise they will be mounted where they can be seen by all drivers, either on gantries, or on cantilever mountings by the side of the carriageway. In all cases the relationship of the display location to entry and exit slip roads will be such that drivers are able to make best use of the information being provided.

The signs will be driven from the central Sub-system. Those that are particular to bridges and/or tunnels may be driven from their own Sub-system, or they may be driven by the same Sub-system as the signs for the rest of the network. This makes Sub-system P 31.4 optional in any implementation.

5.3.4.6 Providing Emergency Vehicle priority

Emergency Vehicle priority can only be provided by restricting the use of lanes. This can be used to enable Emergency Vehicles to have sole use of particular lanes enabling them to by-pass other traffic. The priority request will be to the central part of the System from the Emergency Services terminator, and may specify that priority is given along a particular route, or part of the road network.

5.3.5 Sub-Systems and Functions

The four Sub-systems identified in the previous section can themselves be split up into Modules and Functions. Two of the three Sub-systems (P 31.1 and P 31.2) identified in the previous section have been split up into Modules. These are described in the next two sections. The other two Sub-systems (P 31.3 and P 31.4) have been split up directly into Functions and these are shown in the table of Functions in a later section.

Note that although the location of both Sub-systems P 31.1 and P 31.3 is “Central” this does not mean that they have to be in the same physical location, e.g. room, or building. Each of the Sub-systems can be in a separate location if this is the best solution for a particular deployment. The factors affecting this decision could be physical (length of road network, location of bridges/tunnels), or organisational (different organisations being responsible for the road network and bridges/tunnels).

5.3.6 Modules

5.3.6.1 Introduction

As noted above, two of the Sub-systems in this System are divided into Modules. These Modules enable parts of the Sub-systems to be provided separately and/or to be sited in different parts of the Sub-system locations. The Modules in the individual Sub-systems are described in the following sections and shown in the following Figures together. Again the Figures also show their relationships with each other and the Terminators.

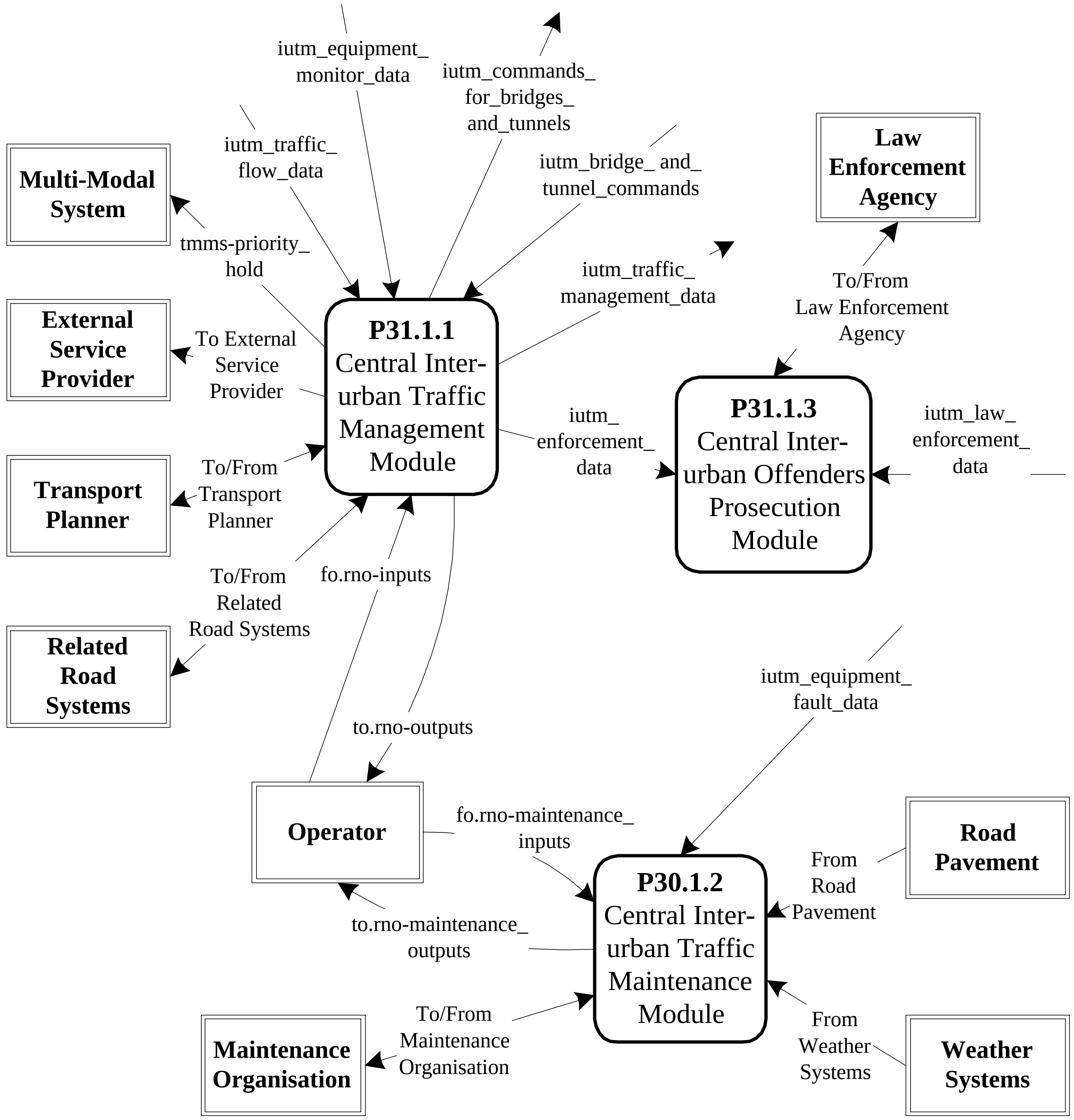
5.3.6.2 Modules in P 31.1 Central Inter-urban Traffic Management Sub-system

The Central Inter-urban Traffic Management Sub-system (P 31.1) consists of three Modules. These cover the central storage of data about traffic, the creation of traffic management instructions that are to be sent to the roadside Sub-system, the management of maintenance and the prosecution of offenders. Their descriptions are as follows and they are shown in the following Figure. This Figure on the next page shows their relationships with each other and the Terminators.

P 31.1.1 Central Inter-urban Traffic Management Module: - this Module provides a number of facilities that enable traffic in the inter-urban road network to be managed. The two most important of these facilities are the storage of data collected at the roadside and the creation and output of traffic management strategies in the form of instructions to travellers and drivers that will be output at the roadside. Other facilities include the interface for the Road Network Operators and the generation of traffic management strategies by the Transport Planner.

P 31.1.2 Central Inter-urban Traffic Maintenance Module: - this Module monitors the road network, looking for the need to carry-out maintenance activities. This need may arise because of the use that traffic has made of the inter-urban road network, the detection of faults in equipment, or weather conditions. Once the need for maintenance activity has been established, details are sent to the Maintenance Organisation for action.

Figure 32 P31 Inter-urban Traffic Management System - Central Sub-system Modules



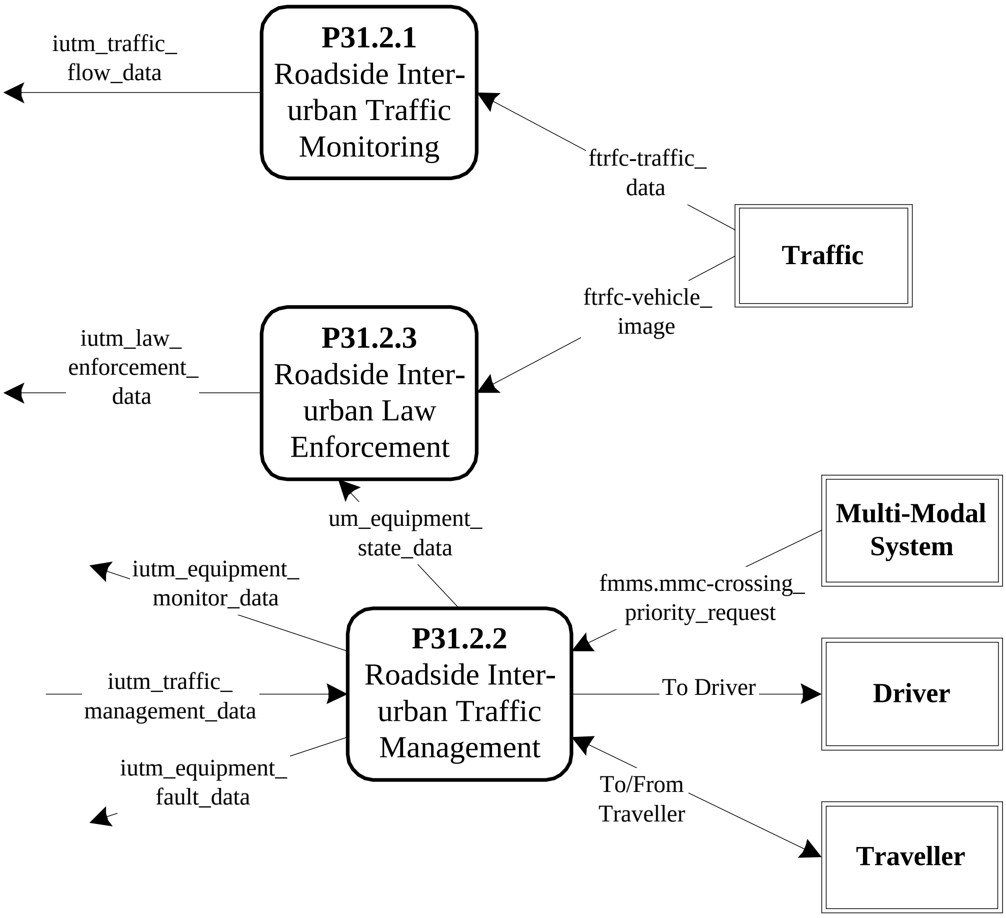
P 31.1.3 Central Inter-urban Offenders Prosecution Module: - this Module receives data from the Roadside Sub-system about violations of the rules that vehicles using the inter-urban road network must follow. Data about each violation is sent to the Law Enforcement Agency for eventual prosecution of the offender.

5.3.6.3 Modules in P 31.2 Roadside Inter-urban Traffic Management Sub-system

The Roadside Inter-urban Traffic Management Sub-system (P 31.2) also consists of three Modules. These cover the collection of data about traffic, roadside actuators that provide instructions to Travellers and the control of vehicle movements. Their descriptions are as follows and they are illustrated in the Figure on the following page.

P 31.2.1 Roadside Inter-urban Traffic Data Collection Module: - this Module enables data about traffic movements within the inter-urban road network to be collected at the roadside. This data may include details of the use that vehicles have made of service areas.

Figure 33 P31 Inter-urban Traffic Management System - Roadside Sub-system Modules



P 31.2.2 Roadside Inter-urban Traffic Management Actuation Module: - this Module enables instructions to be output to Travellers and/or Drivers using the inter-urban road network. These instructions are provided by the Central Traffic Management Sub-system

(P31.1). They may be visual or audible commands that the Traveller and/or Driver must action, or advice for them to follow. In this instance the Travellers will be pedestrians, who are walking through the road network as part of their journeys.

P 31.2.3 Roadside Inter-urban Law Enforcement Module: - this Module monitors the activities of road vehicles to ensure that they do not break any of the laws relating to vehicle movements. These "laws" will both general ones (driving on the correct side of the carriageway) and those that particularly apply to vehicle movements within the inter-urban road network. When a violation of the law is detected, data about the vehicle is collected and sent to the Prosecution Module in the Central Sub-system.

5.3.7 Modules, Data Stores and Functions

The six Modules identified in the two previous sections can be split up into Data Stores and Functions. These are identified in the tables that are shown below and on the following pages. Also included are the Functions in the two Bridge/Tunnel Sub-systems (P 31.3 and P 31.4) - see a previous section. Details of the Data Stores can be found in Annex 3 of the Functional Architecture Deliverable Document - see reference in Chapter 10 of this Document. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 21 P31 Inter-urban Traffic Management System - Modules and Data Stores

Sub-system			Module		Data Store	
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**
P 31.1	Centralised Inter-urban Traffic Management	Central	P31.1.1	Central Inter-urban Traffic Management	D 3.2	Inter-urban Traffic Data Store
					D 3.8	Inter-urban Road Static Data Store
			P31.1.2	Central Inter-urban Traffic Maintenance	D 3.6	Maintenance Data Store
			P31.1.3	Central Inter-urban Offenders Prosecution	D 1.6	Fraud Store
					D 7.1	Rules Store

Table 22 P31 Inter-urban Traffic Management System - Modules and Functions

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 31.1	Central Inter-urban Traffic Management	Central	P31.1.1	Central Inter-urban Traffic Management	F 3.1.2.3	Provide Inter-urban Traffic Forecasts and Strategies	2.1.2.1, 2.1.2.3, 7.1.2.2, 7.1.2.4, 7.1.6.1, 7.1.7.4, 7.1.8.1
					F 3.1.2.4	Manage Inter-urban Traffic Data	2.1.1.3, 2.1.2.3, 2.1.4.1, 2.1.4.2, 7.1.2.1, 7.1.2.3, 7.1.2.7, 7.1.8.1
					F 3.1.2.5.1	Provide Inter-urban Traffic Management	2.1.2.2, 2.1.3.1, 7.1.4.1, 7.1.4.2, 7.1.4.5, 7.1.4.8, 7.1.4.9, 7.1.5.1, 7.1.5.5, 7.1.5.6, 7.1.5.7, 7.1.5.8
					F 3.1.2.5.2	Provide Planned Inter-urban Traffic Management Facilities	7.1.3.6, 7.1.3.7
					F 3.1.2.5.7	Provide Operator Inter-urban Traffic Management Facilities	7.1.3.1, 7.1.3.2, 7.1.3.3, 7.1.3.5
					F 3.1.2.5.9	Manage Inter-urban Static Traffic Data	
			P31.1.2	Central Inter-urban Traffic Maintenance	F 3.5.1	Evaluate Short Term Maintenance Needs	2.2.0.1, 2.2.0.3, 2.2.0.5, 2.2.3.1, 2.2.4.1
					F 3.5.2	Evaluate Long Term Maintenance Needs	2.2.0.6, 2.2.3.1, 2.2.4.1

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 31.1	Central Inter-urban Traffic Management (continued)	Central	P31.1.2	Central Inter-urban Traffic Maintenance (continued)	F 3.5.3	Evaluate Equipment Maintenance Needs	2.2.2.1, 2.2.2.2
					F 3.5.4	Evaluate De-icing Need	2.2.1.1
					F 3.5.5	Provide Operator Maintenance Operations Interface	
					F 3.5.6	Manage Maintenance Data Store	2.2.0.6, 2.2.2.3
			P31.1.3	Central Inter-urban Offenders Prosecution	F 7.1.1	Perform Measure	3.1.0.1, 3.1.0.2, 3.1.0.3, 3.1.0.4, 3.1.1.3, 3.1.1.4
					F 7.1.2	Check Compliance	3.1.0.1, 3.1.0.2, 3.0.1.3
					F 7.3.1	Sort Fraud Notifications	3.1.1.1, 3.1.1.2
					F 7.3.2	Establish Prosecution File	3.1.1.1, 3.1.1.2, 3.1.0.5
					F 7.4	Store Fraud	3.1.0.2, 3.1.0.3, 3.1.0.5
					F 7.5.1	Manage Rules	3.1.0.1, 3.1.0.5
P 31.2	Roadside Inter-urban Traffic Management	Roadside	P31.2.1	Roadside Inter-urban Traffic Monitoring	F 3.1.2.1	Collect Inter-urban Traffic Data	2.1.1.3, 7.1.1.1, 7.1.1.3, 7.1.1.5
					F 3.1.2.2	Monitor Service Area Vehicle Occupation	2.1.1.3

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 31.2	Roadside Inter-urban Traffic Management (continued)	Roadside	P31.2.2	Roadside Inter-urban Traffic Management	F 3.1.2.5.3	Generate Service Area Vehicle Occupancy States	7.1.4.4
					F 3.1.2.5.4	Provide Inter-urban Traffic Speed Management	7.1.7.1, 7.1.7.2, 7.1.7.3, 7.1.7.5, 7.1.7.6
					F 3.1.2.5.5	Provide Inter-urban Output Actuation	7.1.3.4
					F 3.1.2.5.6	Provide Inter-urban Lane Management	7.1.4.3, 7.1.5.2, 7.1.5.3, 7.1.10.1
			P31.2.3	Roadside Inter-urban Law Enforcement	F 3.1.2.5.8	Detect Inter-urban Traffic Violations	
P 31.3	Central Bridge/ Tunnel Information Management	Central			F 3.1.3.1	Assess Bridge Status	7.1.4.6
					F 3.1.3.2	Assess Tunnel Status	7.1.4.7
					F 3.1.3.3	Provide Bridge and Tunnel Operator Interface	7.1.4.6, 7.1.4.7
					F 3.1.3.4	Output Bridge Information	7.1.4.6
					F 3.1.3.5	Output Tunnel Information	7.1.4.7
P 31.4	Roadside Bridge/ Tunnel Information Output	Roadside			F 3.1.3.4	Output Bridge Information	7.1.4.6
					F 3.1.3.5	Output Tunnel Information	7.1.4.7

5.3.8 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term "Physical" is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

iutm_bridge_and_tunnel_commands
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about instructions that have been sent to Drivers and Travellers using bridges and tunnels on the inter-urban road network. The data flow consists of the following constituent Functional Data Flows:
mt_bridge_inter-urban_inputs
+ mt_tunnel_inter-urban_inputs

iutm_bridge_and_tunnel_outputs

This physical data flow is used within the Inter-Urban Traffic Management System. It contains instructions and information to be sent to Drivers and Travellers using bridges and tunnels on the inter-urban road network. The data flow consists of the following constituent Functional Data Flows:
mt_bridge_information_outputs
+ mt_tunnel_information_outputs

iutm_commands_for_bridges_and_tunnels
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about traffic management strategies that have been implemented in the inter-urban road network. The data flow consists of the following constituent Functional Data Flows:
mt_inter-urban_bridge_inputs
+ mt_inter-urban_tunnel_inputs

iutm_traffic_management_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains traffic management data that is being sent to the roadside Module for implementation. The data flow consists of the following constituent Functional Data Flows:
mt_operator_inter-urban_lane_override
+ mt_operator_inter-urban_speed_override
+ mt_inter-urban_lane_management
+ mt_inter-urban_speed_setting
+ mt_inter-urban_traffic_control_requests

iutm_equipment_state_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about the current roadside equipment state that can be used by the law enforcement Module to detect any violations. The data flow consists of the following constituent Functional Data Flows:
mt_inter-urban_actuator_status
+ mt_inter-urban_lane_status

iutm_law_enforcement_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about vehicles that have violated the rules and management strategies that are currently being output by the roadside traffic management Module. They will have been detected by the roadside law enforcement Module. The data flow consists of the following Functional Data Flow:
mt.psle-inter-urban_fraud_notificaations

iutm_equipment_fault_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about faults in roadside equipment that have been detected by the roadside traffic control module. The data flow consists of the following constituent Functional Data Flows:
mt_inter-urban_equipment_status
+ mt_inter-urban_reponse_fault

iutm_equipment_monitor_data
This physical data flow is used within the Integrated Urban Traffic and Public Transport Management System. It contains data about the response of the roadside traffic management Module to traffic management strategy data. The data flow consists of the following constituent Functional Data Flow:
mt_inter-urban_traffic_management_responses

iutm_traffic_flow_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains traffic flow data that has been collected by the roadside traffic monitoring Module. The data flow consists of the following constituent Functional Data Flows:
mt_collected_inter-urban_traffic_data
+ mt_carpark_inter-urban_inputs
+ mt_inter-urban_traffic_flow_management_data

iutm_enforcement_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data about the current traffic flow rules that will be used by the offenders prosecution Module to decide what action to take when a violation has been detected. The data flow consists of the following constituent Functional Data Flow:
mt.psle_inter-urban_enforcement_guidelines

iutm_central_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data that is being sent from the Central Sub-system to the Roadside Sub-system. The data flow consists of the following constituent Physical Data Flow:
iutm_traffic_management_data

iutm_roadside_data
This physical data flow is used within the Inter-Urban Traffic Management System. It contains data that is being sent from the Roadside Sub-system to the Central Sub-system. The data flow consists of the following constituent Physical Data Flows:
iutm_equipment_fault_data
+ iutm_equipment_monitor_data
+ iutm_law_enforcement_data
+ iutm_traffic_flow_data

fmms.mmc-crossing_priority_request
This physical data flow is sent to the Inter-Urban Traffic Management System by the Multi-Modal Crossing actor in the Multi-Modal System terminator. It contains a request for priority to be given to traffic on another transport mode (Rail, ship, aircraft) at a multi-modal crossing. The physical data flow consists of the following Functional Data Flow
fmms.mmc-inter-urban_crossing_request

fo.rno-traffic_commands
This physical data flow is sent to the Inter-Urban Traffic Management System by the Road Network Operator actor in the Operator terminator. It contains inputs about the affect the System is having upon the inter-urban road network, and about maintenance activities. The physical data flow consists of the following Functional Data Flows:

fo.rno-inputs

+ fo.rno-inter-urban_maintenance_inputs

fo.rno-inputs
This physical data flow is sent to the Inter-Urban Traffic Management System by the Road Network Operator actor in the Operator terminator. It contains inputs about the operation of the System and its affect upon the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
fo.rno-inter-urban_commands

fo.rno-maintenance_inputs
This physical data flow is sent to the Inter-Urban Traffic Management System by the Road Network Operator actor in the Operator terminator. It contains the inputs about maintenance activities that affect the inter-urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
fo.rno-maintenance_commands

fws-bt_weather_inputs
This physical data flow is sent to the Inter-Urban Traffic Management System by the Weather Systems terminator. It contains information about current and predicted weather conditions that affect bridges and tunnels that are part of the urban road network managed by the System. The physical data flow consists of the following Functional Data Flow:
fws-weather_for_bridges

fws-road_weather_inputs
This physical data flow is sent to the Inter-Urban Traffic Management System by the Weather Systems terminator. It contains information about current and predicted weather conditions that affect the urban road network managed by the System. The physical data flow consists of the following Functional Data Flows:
fws-ice_formation_conditions
+ fws-long_term_maintenance_conditions
+ fws-short_term_maintenance_conditions

From Bridge/Tunnel Infrastructure
This physical data flow is sent to the Inter-Urban Traffic Management System by the Bridge/Tunnel Infrastructure terminator. It contains information about current conditions on bridges and inside tunnels that are part of the road network managed by the System. The physical data flow consists of the following Functional Data Flows:
ftbi-bridge_and_tunnel_inputs
+ ftbi-current_status

From Law Enforcement Agency
This physical data flow is sent to the Inter-Urban Traffic Management System by the Law Enforcement Agency terminator. It contains information about the "rules" by which prosecutions can be reported for offences that have been detected within the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
flea-psle_rules

From Maintenance Organisation
This physical data flow is sent to the Inter-Urban Traffic Management System by the Maintenance Organisation terminator. It contains the results from previous outputs requesting maintenance activities that affect the inter-urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
fmo-update_activity_status

From Related Road Systems
This physical data flow is sent to the Inter-Urban Traffic Management System by the Related Road Systems terminator. It contains data from other Systems for use by this System. The physical data flow consists of the following Functional Data Flow:
frrs-inter-urban_data_updates

From Road Pavement
This physical data flow is sent to the Inter-Urban Traffic Management System by the Road Pavement terminator. It contains information about current and predicted conditions that affect the physical condition of the inter-urban road network. The physical data flow consists of the following Functional Data Flows:
frp-current_conditions
+ frp-long_term_wearing_state
+ frp-short_term_wearing_state

From Transport Planner
This physical data flow is sent to the Inter-Urban Traffic Management System by the Transport Planner terminator. It contains inputs about the generation of traffic management strategies for use within the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
ftp-inter-rban_traffic_prediction_commands

From Weather Systems
This physical data flow is sent to the Inter-Urban Traffic Management System by the Weather Systems terminator. It contains information about current and predicted weather conditions that affect the inter-urban road network, including any bridges and/or tunnels that it contains. The physical data flow consists of the following Physical Data Flows:
fws-bt_weather_inputs
+ fws-road_weather_inputs

ftrfc-traffic_data
This physical data flow is sent from the Traffic terminator to the Inter-Urban Traffic Management System. It contains analogue traffic data that is sent to the roadside traffic monitoring Module. The data flow consists of the following Functional Data Flow:
ftrfc-service_area_vehicle_data
+ ftrfc-inter-urban_traffic_flow_data

ftrfc-vehicle_image
This physical data flow is sent from the Traffic terminator to the Inter-Urban Traffic Management System. It contains analogue traffic data that is some type of image (visual, infra-red, magnetic, etc.) that shows a road vehicle and is sent to the roadside law enforcement Module. The data flow consists of the following Functional Data Flow:
ftrfc-inter-urban_traffic_identity_data

tmms-priority_hold
This physical data flow is sent from the Inter-Urban Traffic Management System to the Mutli-Modal System terminator. It contains a request for the traffic on a non-road based mode of transport (rail, ship, aircraft) to be stopped as it will not get priority at a multi-modal crossing. The physical data flow consists of the following Functional Data Flow:
tmms.mmc-inter-urban_crossing_inhibit

td-bridge_and_tunnel_commands
This physical data flow is sent by the Inter-Urban Traffic Management System to the Driver terminator. It contains instructions to Drivers of vehicles that are using bridges and tunnels that are part of the inter-urban road network. They can be actors who are Drivers of any of the types of vehicle listed in the terminator description. The physical data flow consists of the following Functional Data Flows:
td-bridge_status
+ td-tunnel_status

td-traffic_commands
This physical data flow is sent by the Inter-Urban Traffic Management System to the Driver terminator. It contains instructions to Drivers of vehicles that are using the inter-urban road network. They can be actors who are Drivers of any of the types of vehicle listed in the terminator description. The physical data flow consists of the following Functional Data Flow:
td-inter-urban_traffic_commands

To External Service Provider
This physical data flow is sent by the Inter-Urban Traffic Management System to the External Service Provider terminator. It contains data about traffic and travel conditions within the inter-urban road network for use by the Broadcaster and Traffic and Travel Information Providers within this terminator. The physical data flow consists of the following Functional Data Flows:
tesp.b-inter-urban_traffic_data
+ tesp.ttip-inter-urban_traffic_data

To Law Enforcement Agency
This physical data flow is sent to the Inter-Urban Traffic Management System by the Law Enforcement Agency terminator. It contains prosecution files for offences that have been detected within the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
tlea-psle_prosecution_file

To Maintenance Organisation
This physical data flow is sent from the Inter-Urban Traffic Management System to the Maintenance Organisation terminator. It contains the results from previous outputs requesting maintenance activities that affect the inter-urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flows:
tmo-de-icing_tasks
+ tmo-equipment_tasks
+ tmo-long_term_activities
+ tmo-short_term_activities

To Related Road Systems
This physical data flow is sent from the Inter-Urban Traffic Management System to the Related Road Systems terminator. It contains data from this Systems for use by other Systems. The physical data flow consists of the following Functional Data Flow:
trrs-inter-urban_data_updates

To Transport Planner
This physical data flow is sent by the Inter-Urban Traffic Management System to the Transport Planner terminator. It contains the results from previous inputs about the generation of traffic management strategies for use within the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
ttp-inter-urban_traffic_prediction_responses

To Traveller
This physical data flow is sent to the Inter-Urban Traffic Management System by the Traveller terminator. It contains instructions to Travellers who are using the inter-urban road network. They will usually be pedestrians or vulnerable road users such as cyclists and This output may be the result of previous request for action. The physical data flow consists of the following Functional Data Flow:
tt-inter-urban_traffic_commands

to.rno-traffic_responses
This physical data flow is sent from the Inter-Urban Traffic Management System to the Road Network Operator actor in the Operator terminator. It contains the results from previous inputs about System operation and maintenance. The physical data flow consists of the following Functional Data Flows:
to.rno-maintenance_outputs
+ to.rno-outputs

to.rno-maintenance_outputs
This physical data flow is sent from the Inter-Urban Traffic Management System to the Road Network Operator actor in the Operator terminator. It contains the results from previous inputs about maintenance activities that affect the inter-urban road network, or equipment used in its management. The physical data flow consists of the following Functional Data Flow:
to.rno-maintenance_responses

to.rno-outputs
This physical data flow is sent from the Inter-Urban Traffic Management System to the Road Network Operator actor in the Operator terminator. It contains the results from previous inputs about the operation of the System and its affect upon the inter-urban road network. The physical data flow consists of the following Functional Data Flow:
to.rno-inter-urban_responses

5.3.9 Key Issues

The Key Issues for this System are as follows.

1. The successful operation of the System depends at least in part on its ability to accurately detect the traffic conditions in the inter-road network that it is serving. Given the large geographic area sometimes served by inter-urban road networks, deployment of this detection can be costly, both in capital for initial installation, and in revenue for on-going maintenance and operation.

2. Most Systems are judged to be operating successfully if they are seen to manage the traffic using the road network in the most efficient way. For inter-urban networks, this generally means keeping the traffic flowing in such a way that the maximum flow rate is obtained with minimum disruption. One of the major problems appears to be the prediction of flow breakdown (congestion) due to both traffic volumes and incidents. Work is needed to refine and enhance these techniques to give better advanced warning of congestion without increasing the concentration of detection. There is also a need to look more closely at ways of determining diversionary routes with enough warning to enable drivers to take action.

3. The total cost of operation of the System will depend in part on the cost of the infrastructure used to communicate data between the central traffic management and roadside Sub-systems. The type of infrastructure used, and the ability for it to be shared with other users will be crucial to the size of these costs.

6. Vehicle (not FFM or PTM) Systems

6.1 Introduction

This chapter describes the "example System" in the Physical Architecture that provides Advanced Driving Assistance in the vehicle.

6.2 P50 - Advanced Driving Assistance System (ADAS)

6.2.1 Overview

This System provides all kinds of facilities for Advanced Driving Assistance. It is based on similar Systems that exist or are under development in different countries and particularly as part of the European Commission 4th Telematics Application Programme (4FP).

In this System both the standard components (like engine, brakes, dash-board, sensors etc.) and the ADAS equipment (like radar, cameras, automatic controls, telematic equipment etc.) are considered as part of the vehicle.

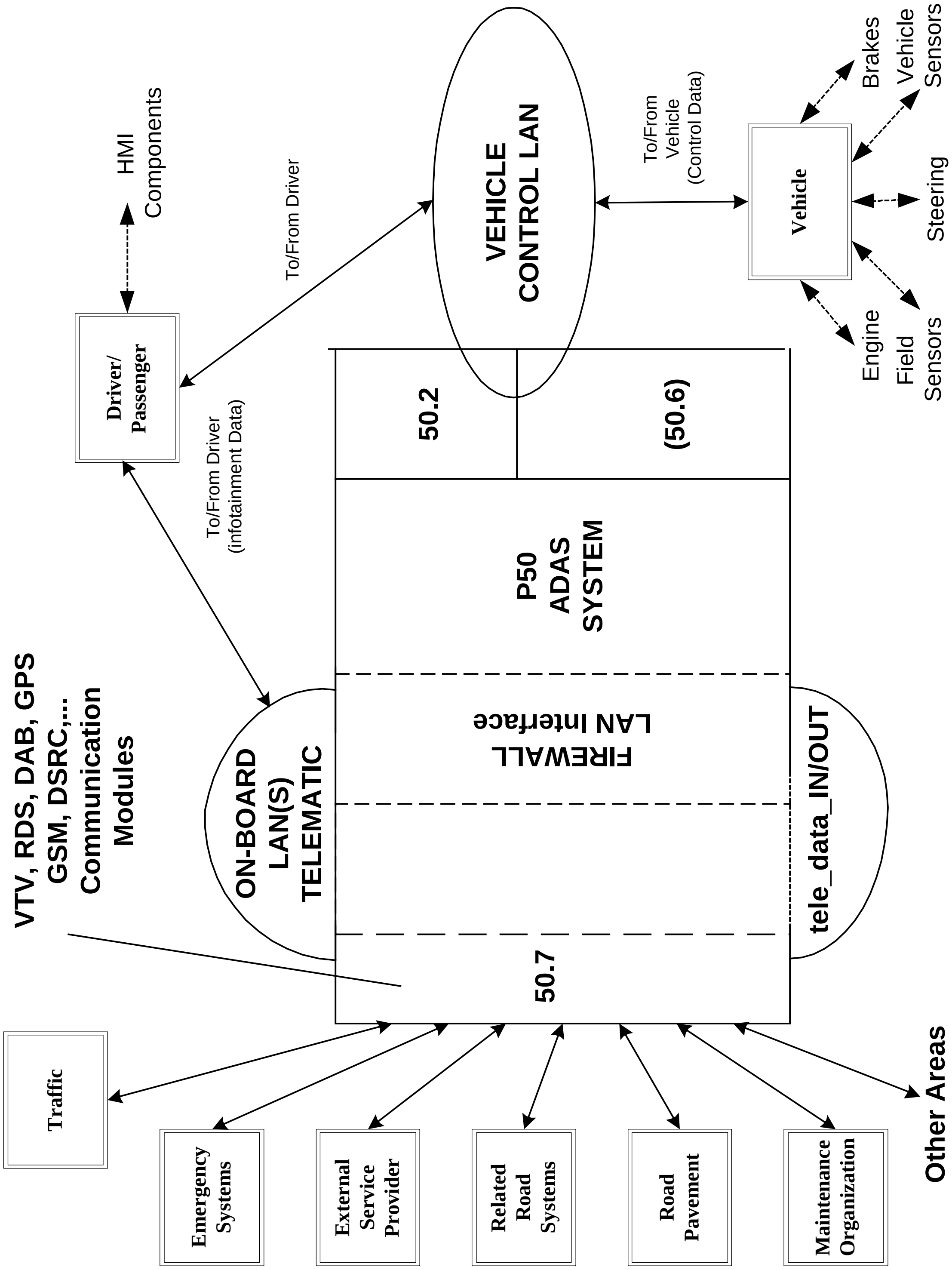
The Driver-Vehicle Interaction sub-system includes interactions both with the standard cockpit equipment and the ADAS related equipment. Together with the driver also the passengers are (implicitly) considered.

There are two on-board networks for the interconnection of the different functionality. The first network is related to the telematic functions (i.e. it is a kind of multimedia bus) and its main aim is to circulate, to all the on-board modules, the information coming from (or going to) outside the vehicle (via the communication media like RDS, GSM, DAB, DSRC etc.). This bus has provisions to check the integrity of the data and to avoid misuse. The second network is a kind of vehicle control bus that, depending on the required function, guarantees a suitable level of dependability. In real applications it can be split in two or more lines to assure safety critical operations. This is illustrated by the diagram in the Figure on the next page.

There is a one-to-one correspondence between High Level Functions and Low Level Functions in the Functional Architecture and Sub-systems and Modules in the Physical Architecture. The concept is that the High Level Functions (and the corresponding Sub-systems in the Physical architecture) are the basic building blocks for all the ADAS (existing and future). Combining two, or more, of these blocks all the Applications can be implemented.

For example putting together P50.3 (Longitudinal Collision Avoidance) and P50.6 (Driver-Vehicle Interaction) the functionality Longitudinal Collision Warning is made. Adding to the previous two the block P50.2 (Automated Vehicle Operation) the functionality Longitudinal Collision Avoidance is implemented.

Figure 34 P50 Advanced Driving Assistance System Concept Diagram



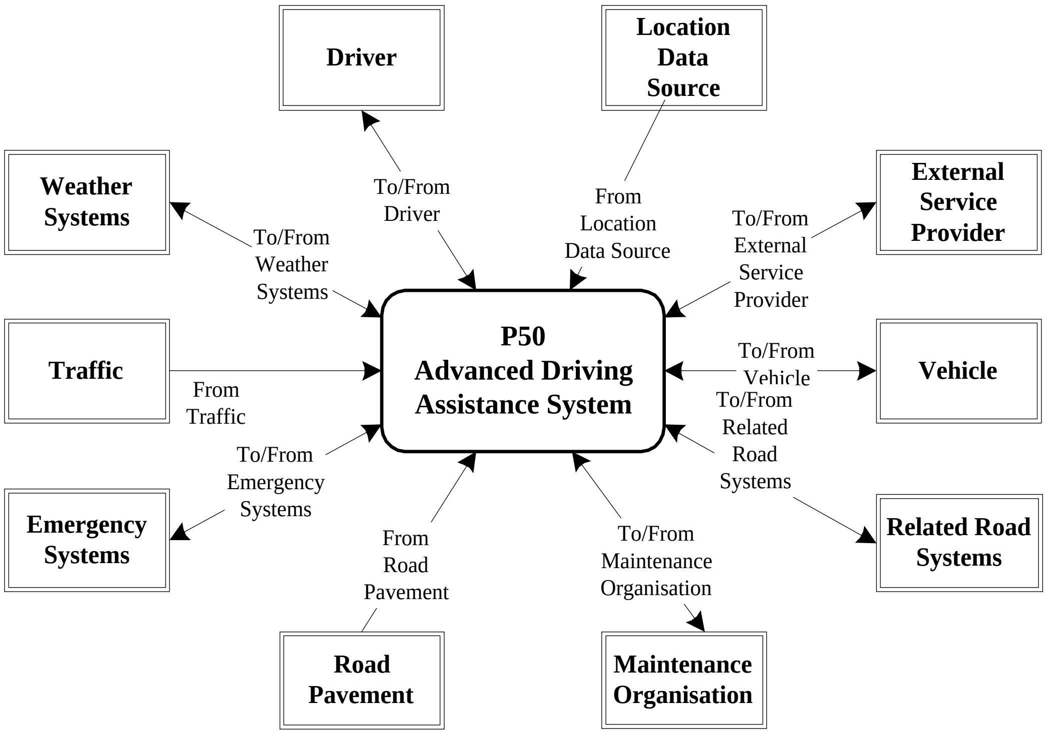
Proceeding further we can add P50.4 (Lateral Collision Avoidance) and we have the Collision Avoidance (both emergency breaking and obstacle avoidance by steering) functionality.

Combining the available blocks it is possible to design the Implementation Units of all the known ADAS functionality up to the Automatic Vehicle Guidance and/or all the Telematic Services.

6.2.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram which is shown in the following Figure. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram shown in Chapter 6 of the Main Document, by deleting the unused Terminators.

Figure 35 P50 Advanced Driving Assistance System Context Diagram



A list of all the terminators in the Framework Architecture Context Diagram and the reasons for the omission of some of them is provided by the Table on the following page. As will be seen from the Figure above, very few terminators are in fact missing. Those that are relate to finance, other modes of transport, the presence of vehicles (Traffic), other Systems, System operators, bridge and tunnel infrastructures, law enforcement and the environment, or are specific to freight operations.

Table 23 P 50 Advanced Driving Assistance System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	No Pollution Monitoring in this System
Bridge/Tunnel Infrastructure	No direct connection to Bridge/Tunnel Infrastructure in this system
Consignor/Consignee	No direct connection in this system

Terminator Name	Reasons for deletion or modification
Driver	Only the following actors in this terminator are required by this System: Private Driver (and implicitly Private Passengers). Emergency Vehicle Driver, Freight Vehicle Driver, Hazardous Freight Vehicle can be considered.
Emergency Systems	No direct connection in this system except in the future possibly for direct calls.
External Service Provider	Only the following actors in this terminator are required by this System: Bookable Service Provider, General Information Provider, Geographic Information Provider, Multi-modal Travel Information Provider, Planned Event Organiser, Vehicle Renting Agency and Broadcaster.
Financial Clearinghouse	No direct connection in this system. The connection is made through other Systems.
Freight Equipment	No direct connection in this system
Law Enforcement Agency	No direct connection in this system. Connection through other Systems.
Location Data Source	Used to enable the vehicle to determine its location.
Maintenance Organisation	Used as a source of data about the infrastructure.
Multi-modal System	No direct connection in this system. Through other Systems connection is possible with: Multi-modal Crossing, Multi-modal Management System.
Operator	No direct connection in this system. Through other Systems connection is possible with: Parking Operator, Emergency Operator, Road Network Operator, Toll Operator and Traveller Information Operator.
Related Road System	No direct connection in this system except for possible direct exchange of data in the future.
Road Pavement	Used as a source of data to help with vehicle control.
Traffic	No direct connection in this system as it is a source of analogue data showing the presence of a vehicle.
Transport Planner	No connection in this system.
Traveller	No direct connection in this system

Terminator Name	Reasons for deletion or modification
Vehicle	Only the following actor in this terminator is required by this System: Private Vehicle. Emergency Vehicle, Freight Vehicle. A Hazardous Goods Vehicle can be partially considered.
Weather Systems	Used to receive data about visibility conditions around the vehicle.

6.2.3 Sub-systems

This System consists of eight main Sub-systems. They have been chosen to suit the contents of the system components. All of them are located in the vehicle and are described on the following pages. They are shown in the following Figure together with their relationship each other and the Terminators.

P 50.1 Visibility Enhancement Sub-system: In adverse visibility conditions this Sub-system shall provide a direct, enhanced by instrumental means, vision of the interesting area to the driver.

P 50.2 Automated Vehicle Operation Sub-system: This Sub-system shall provide all kind of vehicle automatic controls and procedures to allow a full automated vehicle operation.

P 50.3 Longitudinal Collision Avoidance Sub-system: This Sub-system shall provide all kind of facility to detect impending collisions on the longitudinal (principal axis of motion of the vehicle) direction and provides data for warnings and/or automatic controls the longitudinal vehicle dynamics to avoid the collision.

P 50.4 Lateral Collision Avoidance Sub-system: This Sub-system shall provide all kind of facility to detect impending collisions on the transversal directions (with respect to the principal axis of motion of the vehicle) and provides data for warnings to the driver and automatic vehicle lateral control to avoid the collision.

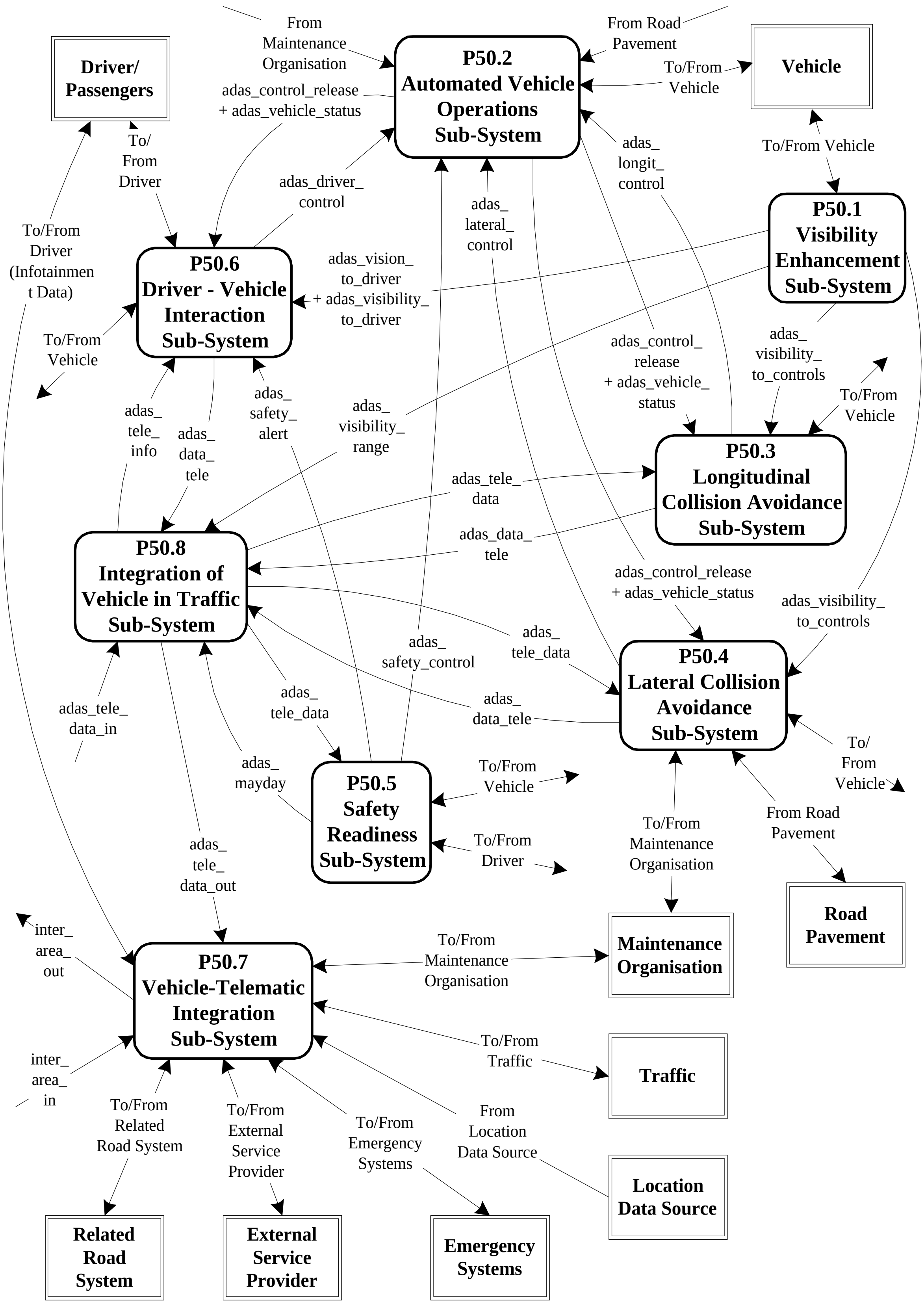
P 50.5 Safety Readiness Sub-system: This Sub-system shall provide all the facility to avoid accidents due to impaired drivers. It detects driver impairment, warns the surrounding traffic and provides data for automatic vehicle control to a safe stop.

P 50.6 Driver - Vehicle Interaction Sub-system: This Sub-system shall provide all kind of Driver-Vehicle interaction facilities both for current functionality and for ADAS. It includes all kind of visual, acoustic and haptic information together with the capability to manage all the inputs from the driver (manual, acoustic etc.). It includes also the management of virtual reality driving supports.

P 50.7 Vehicle - Telematics Integration Sub-system: This Sub-system shall provide the on-board availability and use of all kind of telematic supports for a better use of the vehicle in the ITS world.

P 50.8 Integration of Vehicle in Traffic Sub-system: This Sub-system shall provide the integration of the vehicle, equipped with telematic systems, in the whole traffic systems providing all the services for the efficient exploitation of Transport Telematics.

Figure 36 P50 Advanced Driving Assistance System - System Diagram



6.2.4 Sub-Systems and Functions

All of the eight Sub-systems in this "example System" are split up into Modules. These are described in the following Section.

6.2.5 Modules

6.2.5.1 Introduction

The eight Sub-systems in this System are divided into Modules. The Modules in each of the Sub-systems are described in the following sectins.

6.2.5.2 Modules in P50.1 Vision Enhancement Sub-system

The Vision Enhancement Sub-system consists of five Modules. These provide enhancement of the view that the driver needs to see in order to navigate the vehicle through the road network. Their identities are as follows and their relationship is shown in the Figure below.

P50.1.1 Visibility Range Monitoring

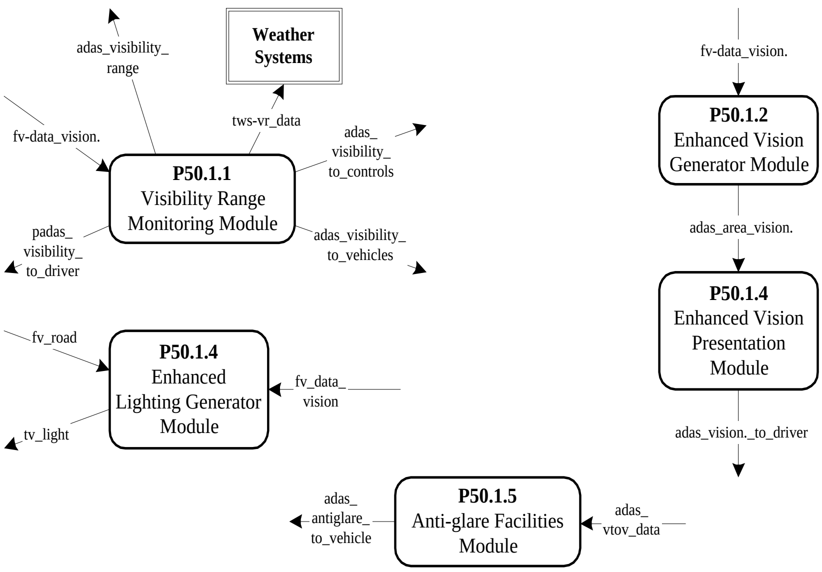
P50.1.2 Enhanced Vision Generator

P50.1.3 Enhanced Vision Presentation

P50.1.4 Enhanced Lighting Generator

P50.1.5 Anti-glaring (Co-operative) Facility

Figure 37 P50 Advanced Driving Assistance System - Vision Enhancement Sub-system



6.2.5.3 Modules in P50.2 Automated Vehicle Operation Sub-system

The Automated Vehicle Operation Sub-system consists of five Modules. These enable the vehicle to operate automatically but with driver intervention if required. The identity of each Module is shown by the list below. Their relationship with one another is shown in the Figure on the previous page.

P50.2.1 Longitudinal Automatic Control

P50.2.2 Lateral Automatic Control

P50.2.3 Driver - Control Interaction

P50.2.4 Infrastructure Support

P50.2.5 Pre-crash Restraint Deployment

Figure 38 P50 Advanced Driving Assistance System - Automated Vehicle Operation Sub-system

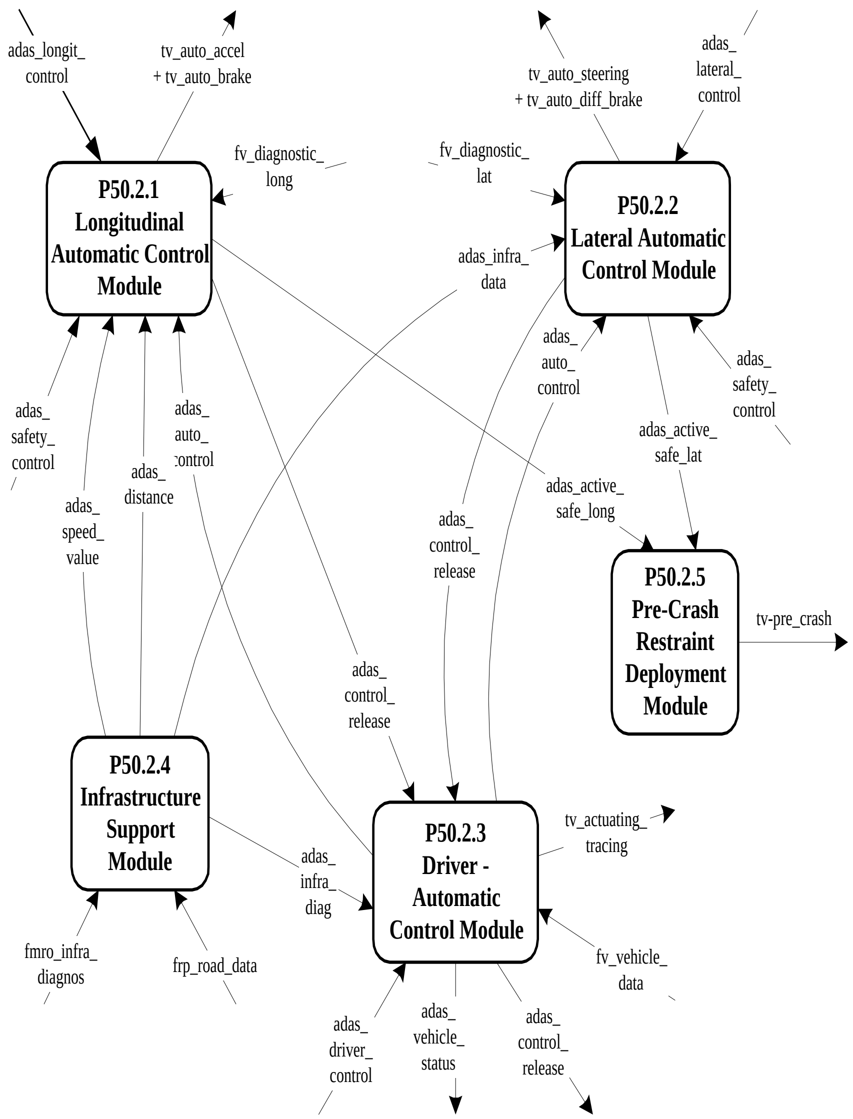
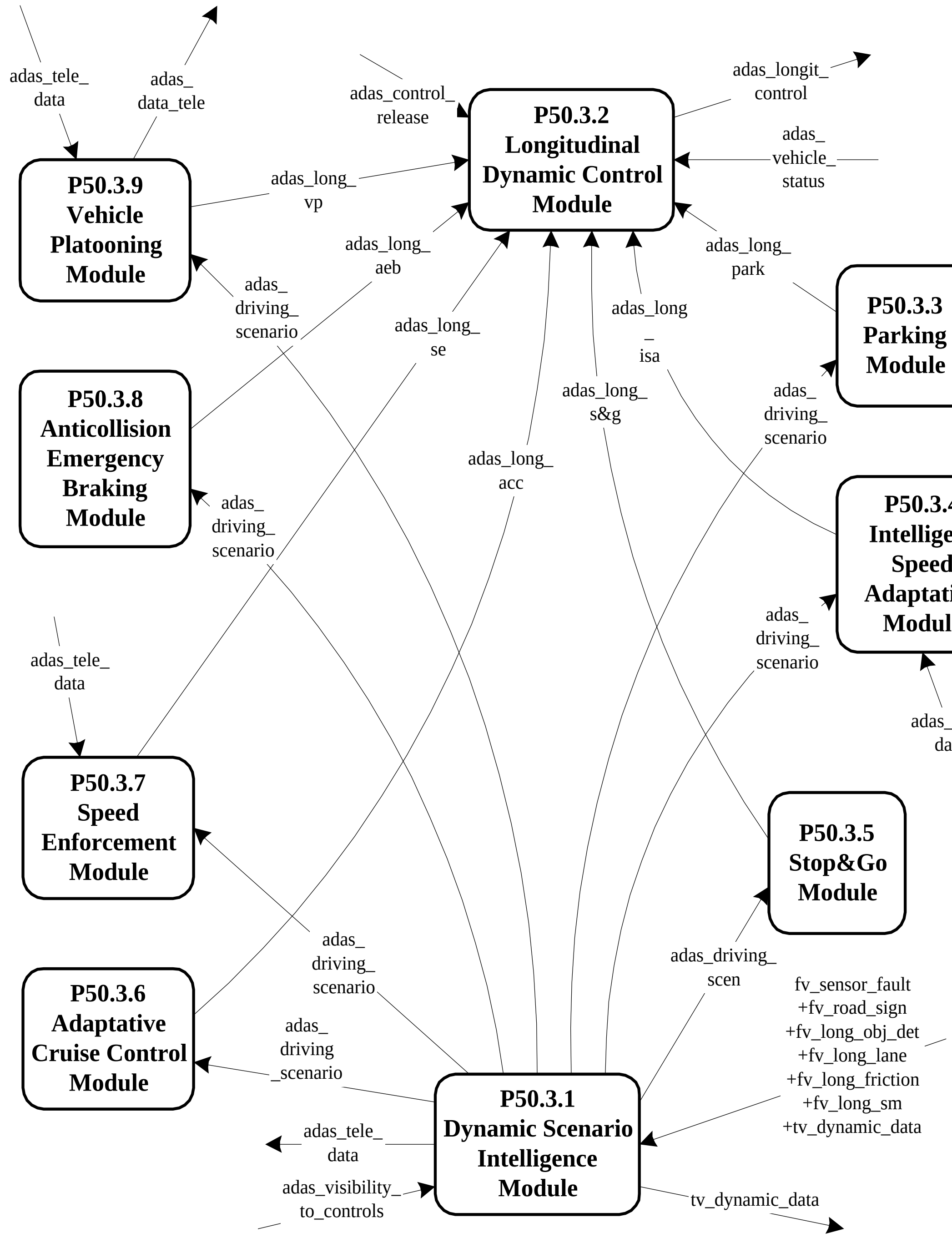


Figure 39 P50 Advanced Driving Assistance System - Longitudinal Collision Avoidance Sub-system



6.2.5.4 Modules in P50.3 Longitudinal Collision Avoidance Sub-system

The Longitudinal Collision Avoidance Sub-system consists of nine Modules. These enable the vehicle to guided so that stability and safe operation is provided in its longitudinal axis. This also includes speed control and facilities to enable the vehicle to operate as part of a multi-vehicle platoon. The identity of each Module is shown by the list below. Their relationship with one another is shown in the Figure above.

P50.3.1 Dynamic Scenario Intelligence

P50.3.2 Longitudinal Dynamic Control

P50.3.3 Parking

P50.3.4 Intelligent Speed Adaptation

P50.3.5 Stop & Go

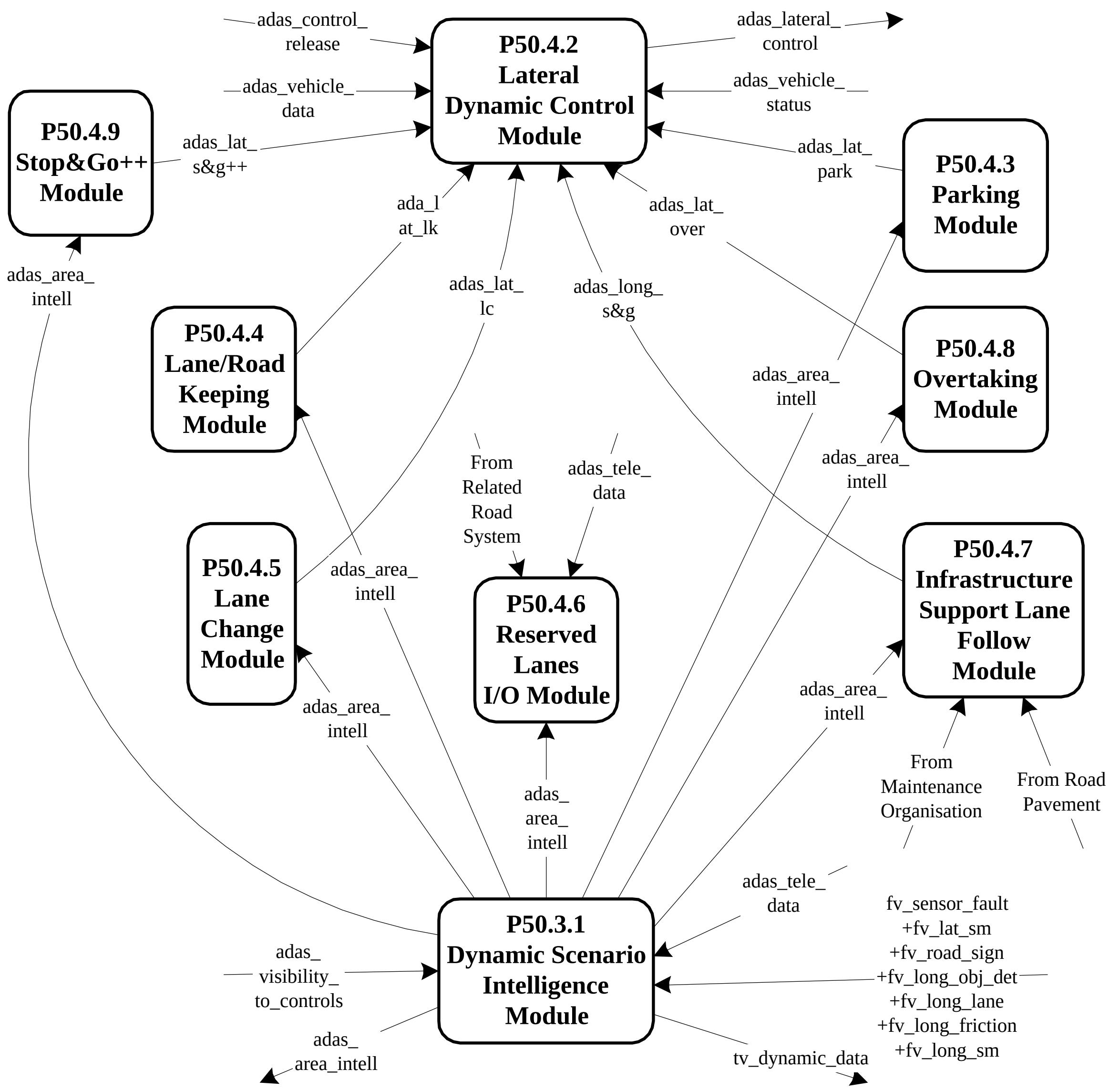
P50.3.6 Adaptive Cruise Control

P50.3.7 Speed Enforcement

P50.3.8 Anti-collision Emergency Braking

P50.3.9 Vehicle Platooning

Figure 40 P50 Advanced Driving Assistance System - Lateral Collision Avoidance Sub-system



6.2.5.5 Modules in P50.4 Lateral Collision Avoidance Sub-system

The Lateral Collision Avoidance Sub-system consists of nine Modules. These enable the vehicle to guided so that stability and safe operation is provided in its lateral axis. This also includes facilities for keeping the vehicle in a lane on the road and for safely overtaking other vehicles. The identity of each Module is shown by the list below. Their relationship with one another is shown in the Figure on the previous page.

P50.4.1 Dynamic Area Intelligence

P50.4.2 Lateral Dynamic Control

P50.4.3 Parking

P50.4.4 Lane /Road Keeping

P50.4.5 Lane Change

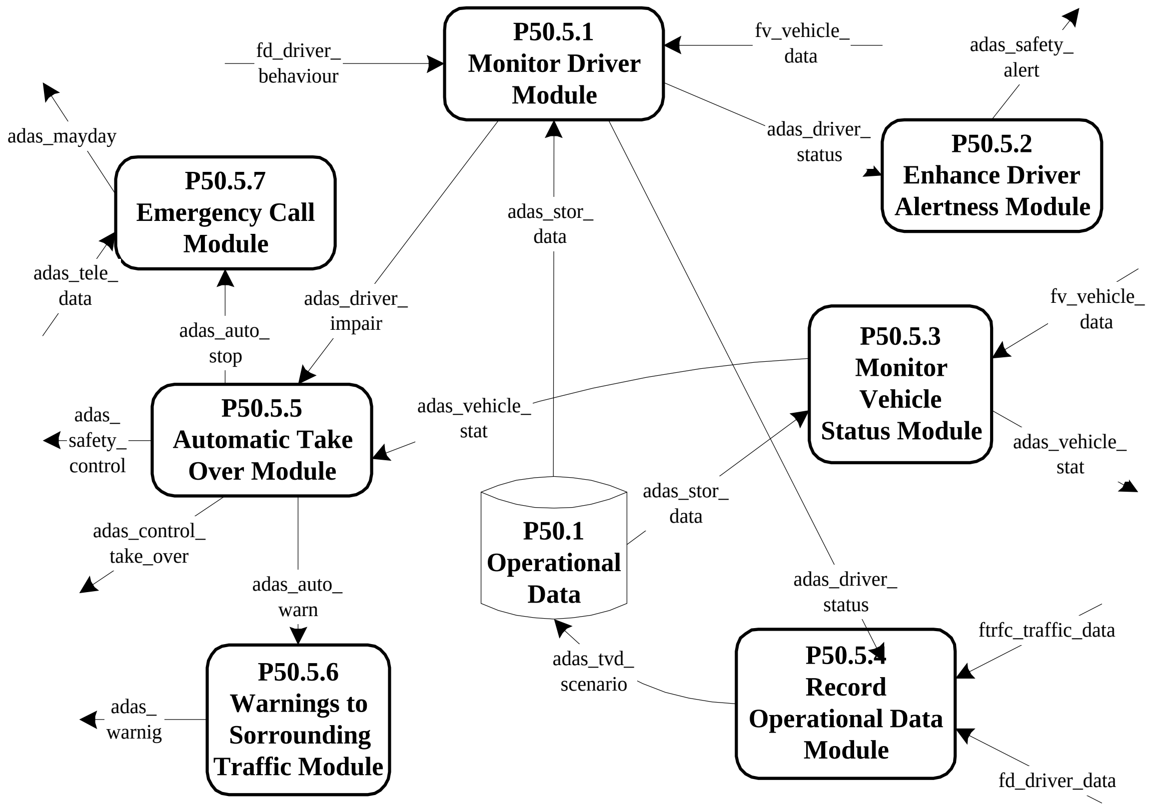
P50.4.6 Reserved Lanes I/O

P50.4.7 Infrastructure Support (for Lane Following)

P50.4.8 Overtaking

P50.4.9 Stop & Go ++

Figure 41 P50 Advanced Driving Assistance System - Safety Readiness Sub-system



6.2.5.6 Modules in P50.5 Safety Readiness Sub-system

The Safety Readiness Sub-system consists of seven Modules. These monitor the status of the vehicle and its driver. If problems are found and the driver is unable to respond, facilities are provided to enable the vehicle to park itself safely at the side of the road. The identity of each Module is shown by the list below. Their relationship with one another is shown in the Figure on the previous page.

P50.5.1 Driver Status Monitoring

P50.5.2 Enhance Driver Alertness

P50.5.3 Monitor Vehicle Status

P50.5.4 Operational Data Recording

P50.5.5 Automatic Take-over

P50.5.6 Warnings to Surrounding Traffic

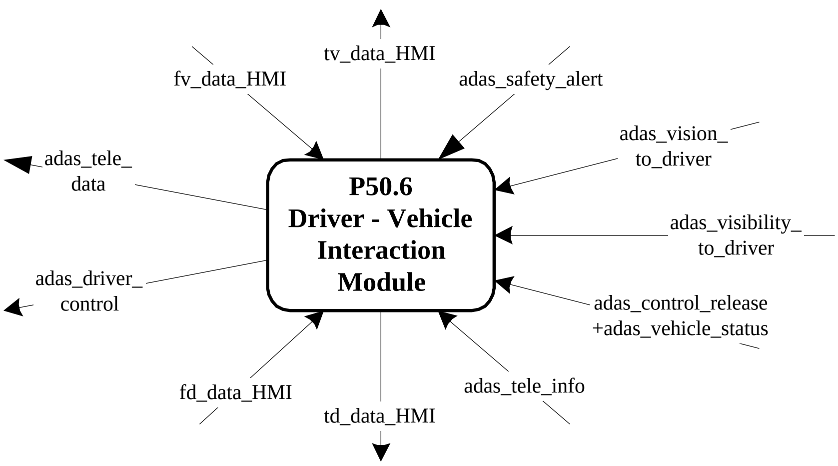
P50.5.7 Emergency Call

6.2.5.7 Modules in P50.6 Driver - Vehicle Interaction Sub-system

The Driver - Vehicle Interaction Sub-system consists of one Module. It enables the Driver and the Vehicle to inter-act with one another so that the Driver has access to the other facilities that the System is providing in the Vehicle The Module identity is shown below. The inter-action of the Module with the other Sub-systems is shown in the System diagram - see a previous Figure. Detail of its input and output Physical Data Flows is shown in the Figure below.

P50.6.1 Driver-Vehicle Interaction

Figure 42 P50 Advanced Driving Assistance System - Vehicle Interaction Sub-system



6.2.5.8 Modules in P50.7 Vehicle - Telematics Integration Sub-system

The Vehicle - Telematics Integration Sub-system consists of four Modules. These enable the vehicle to communicate with the road infrastructure and also with other internal Systems not responsible for Telematics. This includes facilities that enable the vehicle to determine its position. The identity of each Module is shown by the list below. Their relationship with one another is shown in the Figure below.

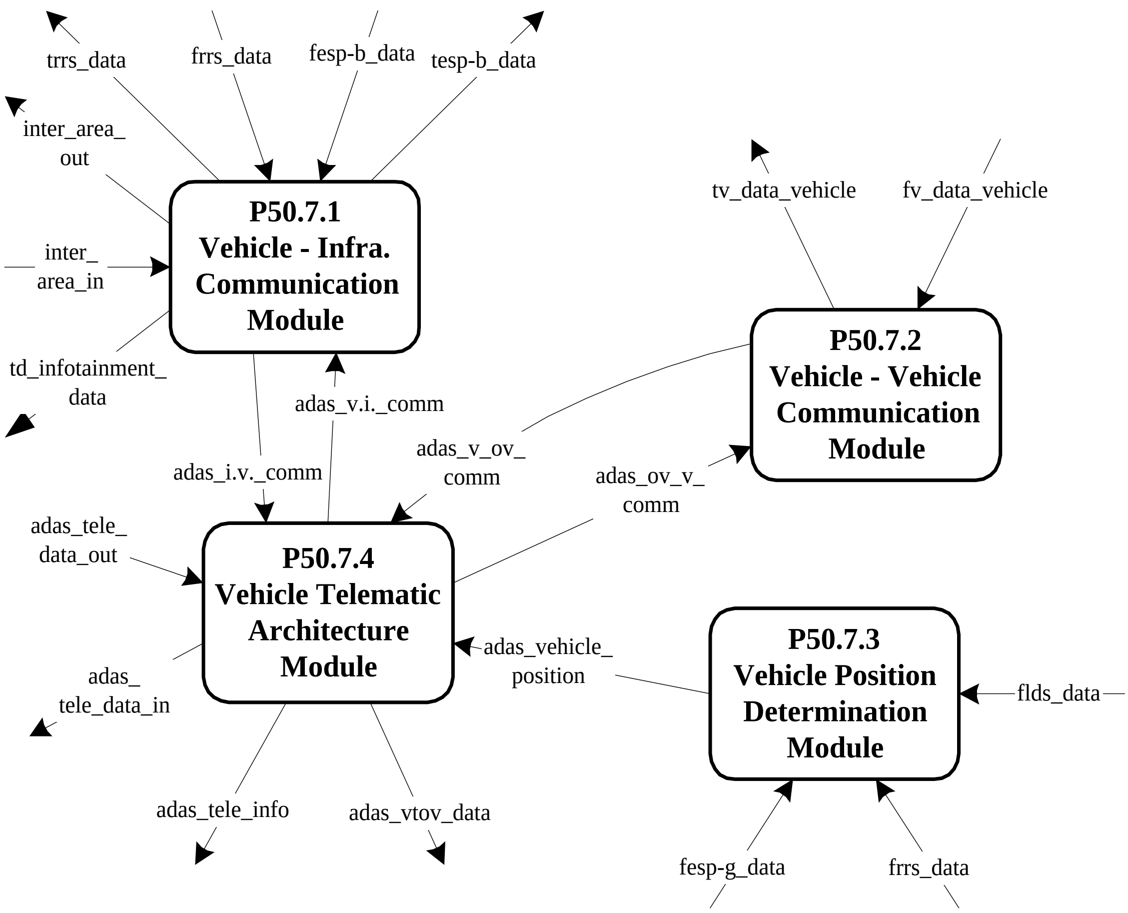
P50.7.1 Vehicle - Infrastructure Communication

P50.7.2 Vehicle - Vehicle Communication

P50.7.3 Vehicle Position Determination

P50.7.4 Vehicle Telematic Architecture

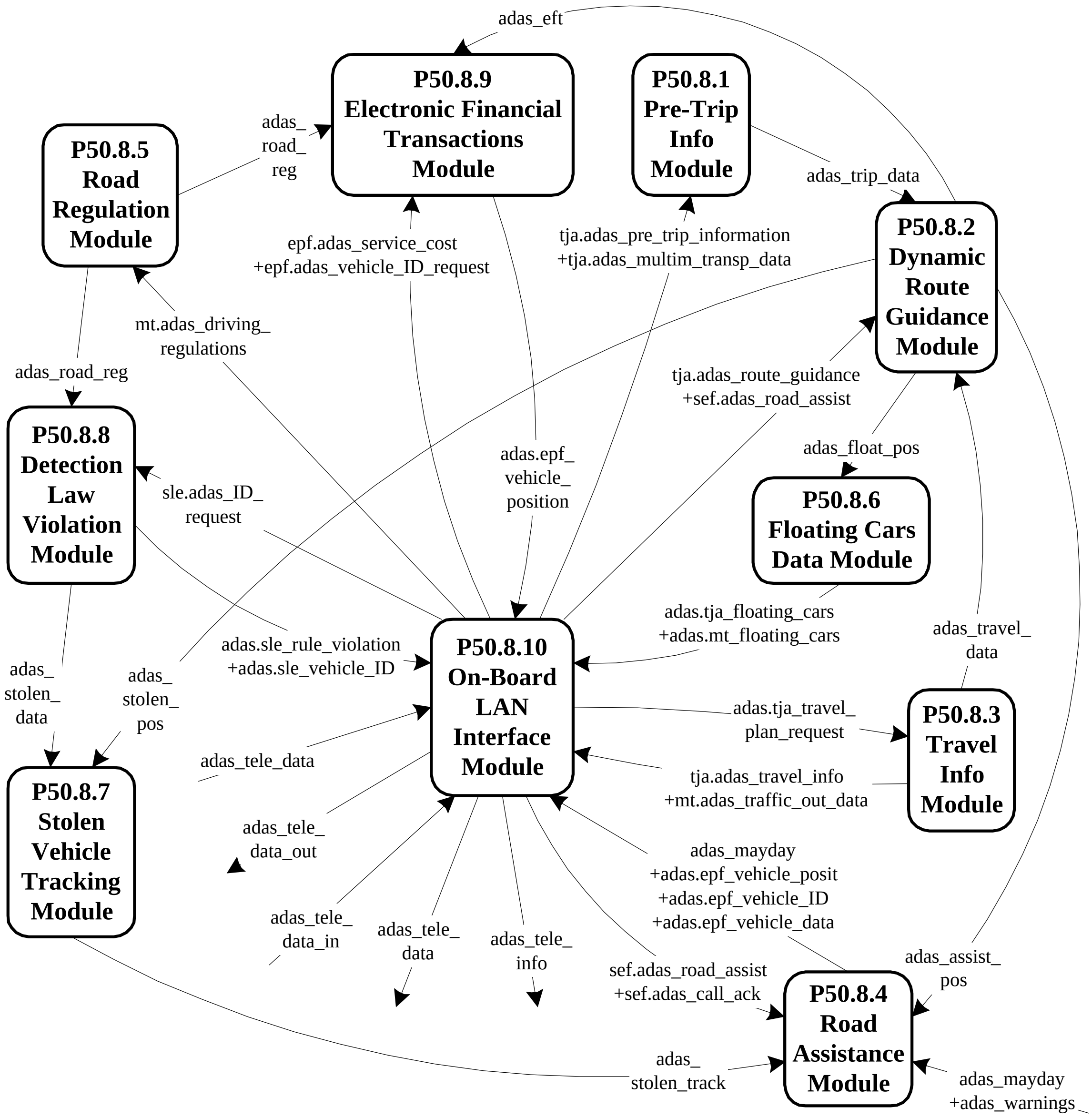
Figure 43 P50 Advanced Driving Assistance System - Vehicle - Telematics Integration Sub-system



6.2.5.9 Modules in P50.8 Integration of Vehicle in Traffic System Sub-system

The Integration of Vehicle in Traffic System Sub-system consists of ten Modules. These enable the vehicle to interface with other Telematics facilities such as route guidance, law enforcement and travel information. They also enable the vehicle to act as a “floating car” and contribute to the data upon which traffic and travel information is based. The identity of each Module is shown by the list starting at the bottom of this page. Their relationship with one another is shown in the following Figure.

Figure 44 P50 Advanced Driving Assistance System - Integration of Vehicle in Traffic System Sub-system



The list of Modules in the Integration of Vehicle in Traffic System Sub-system (P50.8) is as follows:

P50.8.1 Pre Trip Information

P50.8.2 Dynamic Route Guidance

P50.8.3 Travel Information

P50.8.4 Road Assistance

P50.8.5 Road Regulations

P50.8.6 Floating Cars Data

P50.8.7 Stolen Vehicle Tracking/Prosecution

P50.8.8 Detection of Law Violation

P50.8.9 Electronic Financial Transactions

P50.8.10 On-board LAN Interface

6.2.6 Modules and Functions

Each of the Modules corresponds directly with each of the Low Level Functions in the Functional Architecture. Therefore the Functions that are in each Sub-system are the same as those in each High Level Function in the Functional Architecture. In view of this the Function Overviews and User Needs for each Module will be found by looking for the Functions with the corresponding numbers. in Annex 2 of the Main Document.

6.2.7 Physical Data Flows

The Sub-systems and Modules in this System are linked together using Physical Data Flows. These are the same as the corresponding Functional Data Flows. The description of these will be found in Annex 2 of the Functional Architecture Deliverable Document (D 3.1).

6.2.8 Key Issues

1. The Area of Vehicle Systems has the particularity of having, by definition, all the sub-systems and modules located inside the vehicle. This is typical of this area only as, in general, systems for Intelligent Transport have a more distributed architecture and consequently a wider allocation of the sub-system, functions and modules in different places.

7. Traveller Assistance and Route Guidance Systems

7.1 Introduction

This Chapter describes an "example System" in the Physical Architecture that provides assistance to Travellers with their journeys. The aim of the System is to enable Travellers to make the most comfortable and efficient journey.

7.2 P60 Traveller Assistance and Route Guidance System

7.2.1 Overview

The Traveller Assistance and Route Guidance (TARG) System provides facilities that enable a traveller to plan journeys in advance and then execute them. The original journey plan can be updated at the time that the journey is made, to take account of changes in traffic and travel conditions. The principal interface for the traveller is the Traveller Assistant (TA). This is used for all journey planning, and can also be initialised with the traveller's personal journey preferences. The TA can also provide on-line guidance once the journey is in progress, and can also be used in the vehicle during the course of the journey. When in the vehicle, the TA communicates with an In-Vehicle Device (IVD) to enable it to be provide with access to travel information from roadside devices and the vehicle radio.

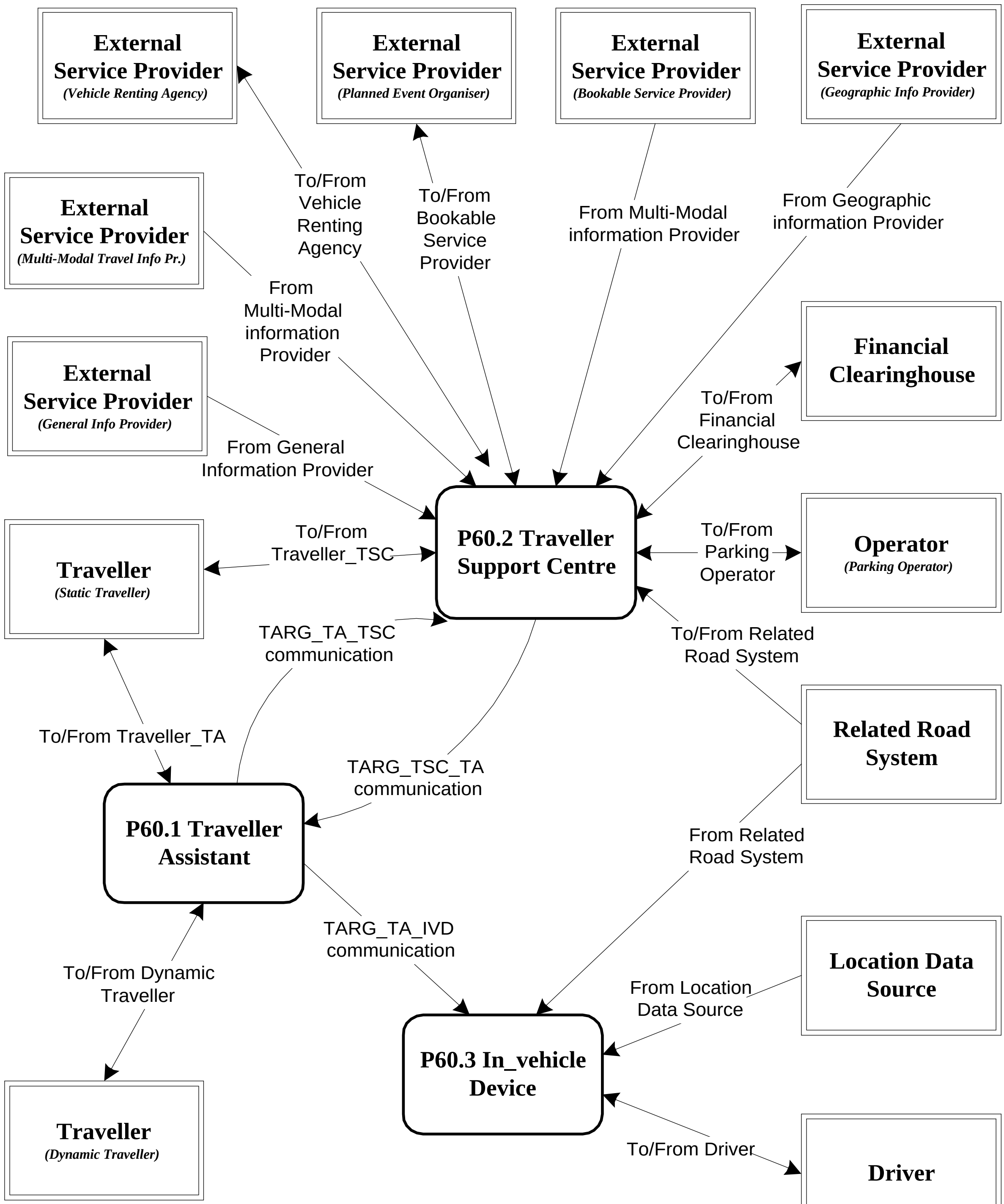
In order to carry out journey planning, the TA is able to communicate to a Traveller Support Centre (TSC). This is also part of this System and is kiosk based. It can communicate with other Systems to enable the retrieval of information that is relevant to the journey planning. The TSC will concentrate on its local geographic area, but will communicate with peer units in other areas if needed. One of the TSC facilities is that it enables the traveller to remain ignorant of the source of the information being used to plan the journey. Fee collection is included in the TSC as not all information is free.

7.2.2 System Context

The system context describes the framework in which the System exists. That for this System has been derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document. The Diagram for this System (P 60) is illustrated in the Figure on the next page.

As will be seen from the Context Diagram on the next page, the System communicates with seven terminators. These comprise, the External Service Provider (using six of its actors), the Financial Clearinghouse, the Operator, the Traveller (its two main actors are used), the Driver, Road Related Systems and the Location Data Source. The Driver is shown in Chapter 6 of the Main Document as being part of the Traveller terminator, but is also given its own definition.

Figure 45 P60 Traveller Assistance and Route Guidance System - Context Diagram



Note that in the Context Diagram for the TARG System shown above, the individual actors within the External Service Provider, Traveller and Operator terminators are shown as separate "boxes". This has been done to aid clarity in understanding of the actors from these terminators that are involved with the System. The reasons why the other terminators shown in Chapter 6 of the Main Document of this document are not involved in this System are provided in the Table on the next page.

Table 24 P60 Traveller Assistance and Route Guidance System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	Deleted. Information about ambient environment collected from Related Road System
Bridge/Tunnel Infrastructure	Deleted. Information about bridge/tunnel infrastructure collected from Related Road System
Consignor/Consignee	Deleted. Not applicable.
Driver	Only the following actors in this terminator are required by this System: Private Driver, Emergency Vehicle Driver, Freight Vehicle Driver, Hazardous Freight Vehicle Driver and Public Transport Driver.
Emergency Systems	Deleted. Not applicable.
External Service Provider	Only the following actors in this terminator are required by this System: Bookable Service Provider, General Information Provider, Geographic Information Provider, Multi-modal Travel Information Provider, Planned Event Organiser, Vehicle Renting Agency.
Financial Clearinghouse	Included for payments for bookings of various kinds.
Freight Equipment	Deleted. Not applicable.
Law Enforcement Agency	Deleted. Not applicable.
Location Data Source	Included for Route Guidance function.
Maintenance Organisation	Deleted. Not applicable
Multi-modal System	Deleted. The information about the operation of the transport systems are collected via Multi-Modal Travel Information Provider (part of External Service Provider).
Operator	Only the following actors in this terminator are required by this System: Fleet Operator, Freight Operator, Parking Operator, Public Transport Operator, Emergency Operator, Road Network Operator, Toll Operator and Traveller Information Operator.

Terminator Name	Reasons for deletion or modification
Related Road System	Included for the provision of information about road traffic and road traffic environment.
Road Pavement	Deleted. Information about the Road Pavement is channelled via Related Road System
Traffic	Deleted. Traffic information is channelled via Related Road System.
Transport Planner	Deleted. Transport planning is part of another system, although such planners can use TARG for travel planning.
Traveller	Only the following actors in this terminator are required by this System: Public Transport Passenger, Pedestrian, Cyclist, Car-pooler (summarised as *Dynamic Traveller)*, Driver and Static Traveller.
Vehicle	Deleted. Vehicle parameters (other than location) are not considered during route guidance.
Weather Systems	Deleted. Weather Systems information is channelled via Related Road System.

7.2.3 Sub-systems

The Traveller Assistance and Route Guidance (TARG) System consists of three Sub-systems. They are as follows.

P 60.1 The personal assistant: Traveller Assistant (TA) Sub-system: - This Sub-system is a memory box or an intelligent processor for the traveller with the capability to communicate with the Traveller Support Centre (see P60.2 below) for route definition and the gathering of all interesting information. The TA may exist in a number of levels of sophistication and functionality, hence the variation between a memory box and intelligent processor, but the basic functionality is user identification, easy access to the Traveller Support Centre and the support of customised travel planning.

More advanced functions will include storage of all information related to the travel including perturbations and bookings, reuse of information from former travels and route guidance.

In the description a distinction is made between the *static traveller* (taking actions to initialise the TA and to prepare the travel by means of TSC communication) and the *dynamic traveller* (actually any en-route traveller, except the IVD driver, using the TA for travel performance).

P 60.2 Traveller Support Centre (TSC) Sub-system: - This Sub-system is a kiosk-type system with the ability to have a collection of pertinent data and the facility to communicate with various other types of systems for information retrieval. One of the facilities the TSC offers is that the traveller does not need to know where the information is. The TSC knows that and collects it if that is desired (mostly for a certain fee, sometimes for free).

The TSC functions as an information intermediate, to provide the traveller access to an array of information, without the need to know where the information actually is, how to access it and how to combine it.

The TSC is bound to a certain region, may have information from outside that region, but will rely on its peers elsewhere to supply it with comparable information from other regions. The peer TSC's are depicted as terminators 'Related Road System'.

The TSC is not necessarily limited to traveller information in the restricted sense of the term. Also tourist and even commercial information can be delivered, if so desired. (This is not depicted in the diagram.)

P 60.3 The In-Vehicle Device (IVD) Sub-system: - This Sub-system is a device in the vehicle that can be coupled with the Traveller Assistant. It enables the collection of information and, for the more advanced types of devices, with external systems such as road-side equipment and radio, for the collection of the most recent information available.

The IVD is assumed to take its journey routing information from the TA; however, a fully equipped in-vehicle route guidance system may perform similar actions. When the fully equipped in-vehicle system is used, the driver has to know the destination(s) himself.

7.2.4 Sub-Systems and Functions

One of the three Sub-systems (P 60.2) identified in the previous section has been split up into Modules. These are described in the next two sections. The remaining Sub-systems (P60 1 and P 60.3) have been split up directly into a single Functions. These are shown in the table of Functions in a later section.

7.2.5 Modules

7.2.5.1 Introduction

The Traveller Assistant Sub-system (P60.1) is in fact a hand-held device and needs no further modules as seen from a system's point of view.

The In-Vehicle Device (P60.3) is Sub-system in the TARG system, but can also be regarded as a module in the entire vehicle, the sub-system being the vehicle's information collection and processing system. Note that in some form of location determination system the vehicle is used as a sensor to determine its location as a kind of dead reckoning system, in which case the IVD is functionally solidly linked to the vehicle system; however, in other implementations GPS can be used as a sensor connected to the IVD which annihilates the need for a tight coupling. There may be a link with an artificial speech generator to communicate with the driver, which can also be used by other sub-functions in the vehicle. Taking everything together, there is no necessity to describe any modules of the IVD.

The TSC (P60.2) Sub-system is different, but also here many different physical implementations are possible. The TSC, as a communication interface between information system and traveller, can be a rather simple terminal, but it can also be a an intelligent processor. The first solution is the client-server architecture, likely to be adopted in areas for public transport, where the functionality of the TSC may be fairly limited; the intelligence of the system will then be offered by a server. But at points where more advanced functionality is offered, e.g. at airports and vehicle renting organisations, the TSC may be a full computer system in itself.

7.2.5.2 Modules in P60.2 Traveller Support Centre (TSC)

In this implementation, the Traveller Support Centre (TSC) Sub-system is located in a fixed place such as a kiosk and is divided into six Modules. They are shown in the Figure on the following page and are described below.

P 60.2.1 Traveller Communication Module - This module facilitates the communication between TSC and the traveller, to put the necessary questions, to present alternatives for choices and to gain approval for modes of transport, route, bookings etc.

P 60.2.2 Traveller Assistant Communication Module - This module enables the TSC to read the information from the TA and to write the results on the TA, if approval is given by the Traveller.

P 60.2.3 Operator Communication Module - This module permits the TSC to look for vacant places in a car parking, to ask for tariffs and to book a place if possible and desired by the traveller. Currently, only one of the group of operators is included namely the car park operator, but extension to other operators can be accommodated. The Toll Operator is a point in case, but currently not included due to the absence of corresponding User Needs.

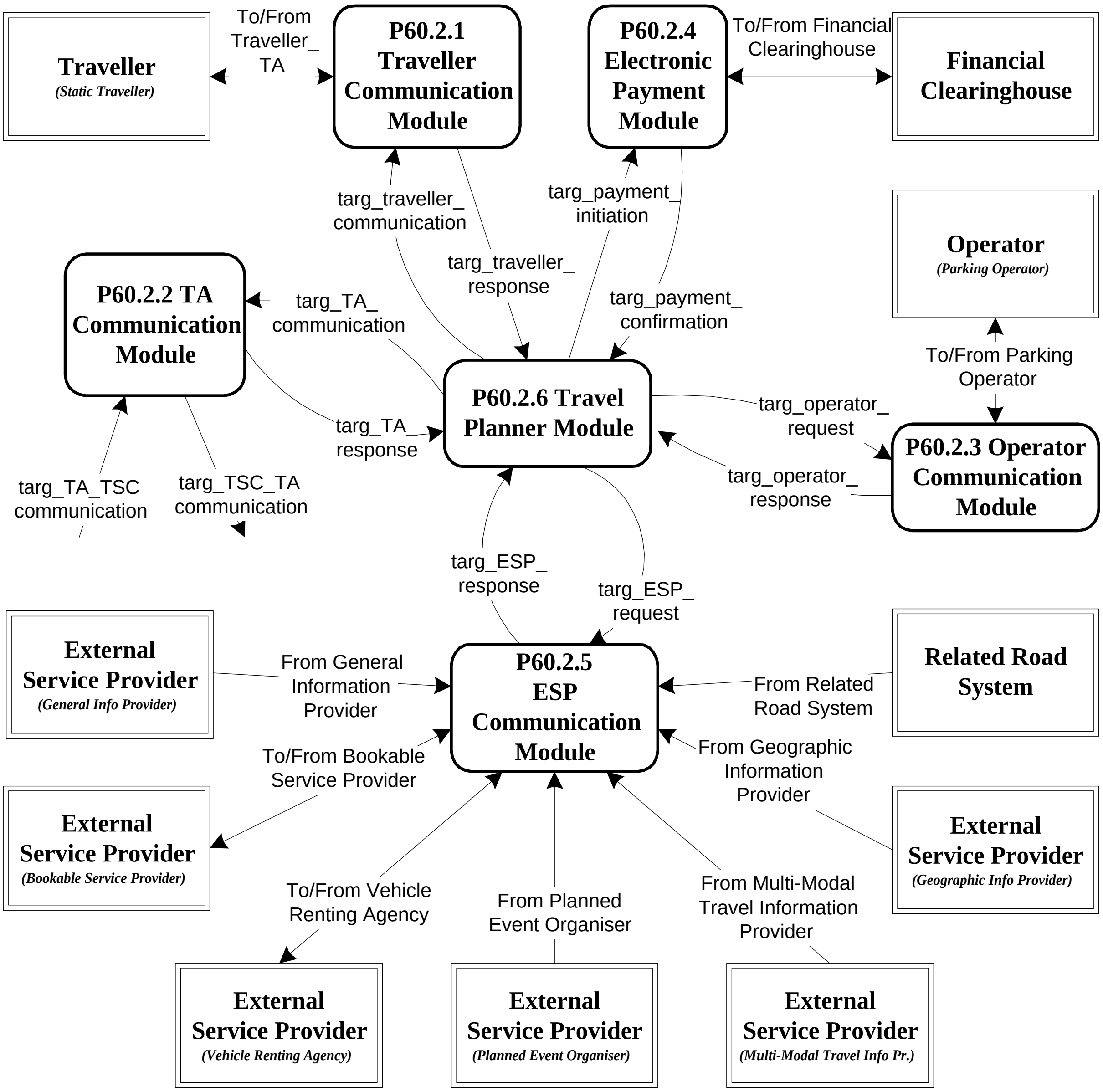
P 60.2.4 Electronic Payment Module (communication module) - This module is specified under the functionality of ‘Provide Electronic Payment Facilities’. It is replicated here for clarity; for further information refer to the corresponding sections.

P 60.2.5 Internet Communication Module - This module knows on which addresses which information can be found, is able to connect to that site and to request the needed information automatically. The module keeps its information current by regularly questioning the various sites for availability and currency. The connected sites can be collective sites (e.g. all vehicle renting agencies combined) which is the preferred situation but also individual sites can be uses, e.g. the site of a hotel.

A special connection is to the peer TSC, geographically adjacent or even further away, for collecting similar information elsewhere. The communication includes eventual bookings for events, hotels, restaurants or for other transport modes.

P 60.2.6 Travel Planner Module - This module plans the actual trip using the various sources via the communication modules available. Communication with the Traveller is needed and performed via the Traveller Communication Module.

Figure 46 P60 Traveller Assistance and Route Guidance System - Traveller Support Centre (TSC) Sub-system Diagram



7.2.6 Sub-systems, Modules and Functions

The six Modules identified in the previous sections and the Figure above can be split up into Functions. These are identified in the table that is shown on the following pages. Also included are the Functions in the two other Sub-systems (P 60.1 and P 60.3) that are described in a previous section. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 25 P60 Traveller Assistance and Route Guidance System - Sub-systems, Modules and Functions

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 60.1	Traveller Assistant (TA)	Traveller			F 6.1	Define Traveller's GTP (General Trip Preferences)	6.1.0.4, 6.1.0.5, 6.1.2.8, 6.1.3.1, 6.1.3.3, 6.1.3.8, 6.2.0.5, 6.2.3.1, 6.2.3.6, 6.2.3.7, 6.4.1.4
					F 6.4	Evaluate Trip	6.1.0.5
P 60.2	Traveller Support Centre (TSC)	Kiosk	P60.2.1	Traveller Communication	F 6.2.1	Define Traveller's ATP (Actual Trip Parameters)	6.1.0.5, 6.1.3.8, 6.2.2.3, 6.4.1.4
					F 6.2.4	Select and Define Bookings	6.1.1.4, 6.1.2.3, 6.1.3.1, 1.3.4 , 6.1.3.6, 6.2.2.1, 6.2.2.3, 6.2.2.6, 6.4.1.1
			P60.2.2	Traveller Assistant Communication	F 6.2.2	Identify Prime Criteria	6.1.0.4, 6.1.0.5
			P60.2.3	Operator Communication	F 6.2.6	Perform Bookings and Payments	6.1.3.1, 6.1.3.4, 6.1.3.6
			P60.2.4	Electronic Payment Module	F 6.2.6	Perform Bookings and Payments	6.1.3.1, 6.1.3.4, 6.1.3.6
			P60.2.5	Internet Communication	F 6.2.4	Select and Define Bookings	6.1.1.4, 6.1.2.3, 6.1.3.1, 1.3.4 , 6.1.3.6, 6.2.2.1, 6.2.2.3, 6.2.2.6, 6.4.1.1

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P 60.2	Traveller Support Centre (TSC) (continued)	Kiosk	P60.2.5	Internet Communication	F 6.2.6	Perform Bookings and Payments	6.1.3.1, 6.1.3.4, 6.1.3.6
			P60.2.6	Travel Planner	F 6.2.3	Propose Trip Alternatives	6.1.1.1/2/3/4, 6.1.2.2, 6.2.1.1, 6.2.1.3, 6.2.2.2, 6.2.2.6, 6.4.1.3/4/5
					F 6.2.5	Plan Road Trips	6.1.3.6, 6.2.1.3, 6.4.0.1, 6.4.0.2, 6.4.1.3, 6.4.1.4
					F 6.2.7	Produce Itinerary and Trip File	6.1.2.7, 6.2.2.4, 6.4.0.1, 6.4.1.3
P 60.3	In-Vehicle Device (IVD)	Vehicle			F 6.3.1	Track Traveller and Implement Trip Plan	6.4.0.3, 6.4.1.2
					F 6.3.2	Assess Perturbations	6.1.1.4, 6.1.2.1, 6.1.2.2, 6.2.0.6
					F 6.3.3	Inform Traveller	6.1.0.3, 6.1.2.3, 6.2.0.4/5/6, 6.2.2.1/2/3/4/5
					F 6.3.4	Provide Route Guidance	6.2.1.1, 6.2.1.2, 6.2.2.2, 6.4.0.1, 6.4.1.1, 6.4.1.2, 6.4.1.5, 6.4.2.4

7.2.7 Physical Data Flows

As can be deducted from the Figures, the Sub-systems and Modules are linked together using Physical Data Flows. The relationship between Physical Data Flows and Functional Data Flows is that, each group as a total, does what the other does, but that the Physical Data Flows indicate communication between physical entities, not logical ones.

targ_TA_TSC_communication
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that is from the Traveller Assistant to the TSC. In this way the TSC receives the private data of the traveller, general trip preferences and existing information about similar trips from the past. This data flow represents the following Functional Data Flow:
ft-general_trip_preferences

targ_TSC_TA_communication
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that is from the TSC to the TA. The information about the trip planned in the course of the planning sequence is stored for later use. This data flow represents the following Functional Data Flow:
ptja_trip_plan_complete

targ_TA_IVD_communication
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that delivers the route guidance information to the in-vehicle device. This data flow represents the following Functional Data Flow:
ptja_trip_data

targ_ESP_request
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that requests information from an external service provider or a peer TSC (Related Road System) for trip planning purposes. This data flow represents the following Functional Data Flows:
ptja.esp_service_data
+ ptja.esp_renting_request
+ ptja.esp_event_request
+ ptja.esp_pt_service_request
+ ptja.esp_road_traffic_info_request
+ ptja.esp_booking

ESP_targ_response
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that acquires the information from the external service providers and the peer TSC systems. This data flow represents the following Functional Data Flows:
esp.ptja_general_information
+ esp.ptja_service_data
+ esp.ptja_renting_confirmation
+ esp.ptja_event_information
+ esp.ptja_available_pt_services
+ esp.ptja_road_traffic_information
+ esp.ptja_road_network_characteristics
+ rrs.ptja_esp_information

targ_operator_request
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that requests for a possible vacancy in a parking lot, eventual tariff. This data flow consists of the following Functional Data Flow:
ptja.mt_carpark_request

targ_TA_request
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that requests for information stored on the TA and provides the result of the trip planning process. This data flow consists of the following Functional Data Flows:
ptja_GTP_request
+ ptja_full_trip_description

targ_traveller_communication
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that requests further specification of the trip from the traveller and also requests for selection of trip alternatives, bookings and payments. It also includes information to serve fleet and freight management. This data flow consists of the following Functional Data Flows:
tt-request_preferences
+ tt-trip_alternatives
+ ptja_search_parameters
+ ptja_trip_plan_before_road_planning
+ tt-booking_alternatives
+ tt-booking_mishap
+ tt-itinerary_initial
+ ptja.mffo_answer_on_pollution_situation
+ ptja.mffo_answer_on_traffic_situation
+ ptja.mffo_answer_on_weather_situation

targ_payment_initiation
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that request offers all pertinent data to the electronic payment module for any sort of payment, to be done on behalf of the traveller. This data flow consists of the following Functional Data Flow:
ptja_pepf_payment

targ_traveller_response
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that provides the answer from the traveller concerning further trip information and selection, choice of bookings, consent for payments. It also caters for the additional needs and restrictions of manage freight and fleet operations if the traveller turns out to be a driver or planner of a (hazardous goods) truck. This data flow consists of the following Functional Data Flows:
ft-factual_parameters
+ ft-secondary_criteria
+ ft-trip_selection
+ ptja_factual_parameters
+ ft-road_trip_preferences
+ ft-booking_choice_and_sequence
+ ft-booking_approval
+ ft-final_approval
+ mffo.ptja_request_on_pollution_situation
+ mffo.ptja_request_on_traffic_situation
+ mffo.ptja_request_on_weather_situation

targ_payment_confirmation
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that confirms that the payment has been done successfully (or delivers an error message in case of refusal). This data flow consists of the following Functional Data Flow:
pepf.ptja_service_price

targ_operator_response
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that confirms the booking for a vacant place in a parking and the tariff. (To be extended if desired with communications with other operators). This data flow consists of the following Functional Data Flow:
mt.ptja_carpark_occupancy

targ_TA-response
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that extracts all relevant information from the TA concerning personal data, trip preferences and previous trips. This physical data flow consists of the following Functional Data Flow:
ptja_trip_preferences

From General Information Provider
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys all information that may be of interest to the traveller, primarily information that can be found in the yellow pages, the tourist office and so forth. This physical data flow consists of the following Functional Data Flow:
fesp.gip-ptja_general_information

To Bookable Service Provider
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys all information for which a booking can be prepared or can be performed. This physical data flow consists of the following Functional Data Flow:
tesp.bsp-ptja_service_data

From Bookable Service Provider
This data flow conveys information about the price for a previously requested bookable service. This physical data flow consists of the following Functional Data Flow:
fesp.bsp-ptja_service_price

To Vehicle Renting Agency
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys all information requesting a booking for a vehicle. This physical data flow consists of the following Functional Data Flow:
tesp.vra-ptja_renting_request

From Vehicle Renting Agency
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys all information giving approval to a previous booking request for a vehicle. This physical data flow consists of the following Functional Data Flow:
fesp.vra-ptja_renting_approval

To Planned Event Organiser
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys the request for information about planned events of a certain type (or all) in a certain region. This physical data flow consists of the following Functional Data Flow:
tesp.peo-ptja_event_request

From Planned Event Organiser
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys the information about planned events of a certain type (or all) in a certain region. This physical data flow consists of the following Functional Data Flow:
fesp.peo-ptja_event_information

From Multi-Modal Travel Information Provider
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys the information about public transport facilities, to be used as alternatives to private transport. This service provider is the source of information about road traffic condition in a certain area. This physical data flow consists of the following Functional Data Flows:
fesp.mmtip-ptja_pt_service_request
+ fesp.mmtip-ptja_available_pt_services
+ fesp.mmtip-ptja_road_traffic_info_request
+ fesp.mmtip-ptja_road_traffic_information

From Geographic Information Provider
This physical data flow is used within the Traveller Assistance and Route Guidance System. It contains data that conveys the information about the road network. This physical data flow consists of the following Functional Data Flows:
fesp.g-ptja_road_network_characteristics

The definitions for each of the Functional Data Flows that are included in the above Physical Data Flows are provided in Annex 2 of the Functional Architecture Deliverable Document (D 3.1).

7.2.8 Key Issues

Three key issues have been identified as being of relevance to the Traveller Assistance and Route Guidance System. They are as follows.

1. Message formats: The communication with external sources of information will primarily be done via internet. This however necessitates message formats to be defined for questions and answers. A general format is required, for each type of internet site (e.g. hotels, event information) a more specific message will be needed and maybe each individual site will foster its own dedicated information set. This in total requires reference models and a reference architecture, to accommodate future extensions.

2. TA functionality: What is described above is the most advanced version of the TA, which also includes information from previous trips. Less advanced solutions are possible, the lowest one being to work without a TA alone. However, if trip planning is to succeed in the proposed manner, repeated and cumbersome re-entry of the same data has to be avoided, especially to prevent errors to be made by the traveller in a boring machine communication process.

3. User orientation: What is offered is a technical solution, which needs to take the human, the traveller, at the centre. What the traveller wants is pivotal, the technical solution is secondary. Unfortunately, the user needs are not very specific in this respect and cannot be used as guidance; a seamless user involvement is mandatory to make it really useable and useful.

8. Law Enforcement Systems

8.1 Introduction

This chapter describes a system that provides the detection of violation and the identification of the affected vehicle and/or driver.

8.2 P 70 - Law Violation and Vehicle Detection System

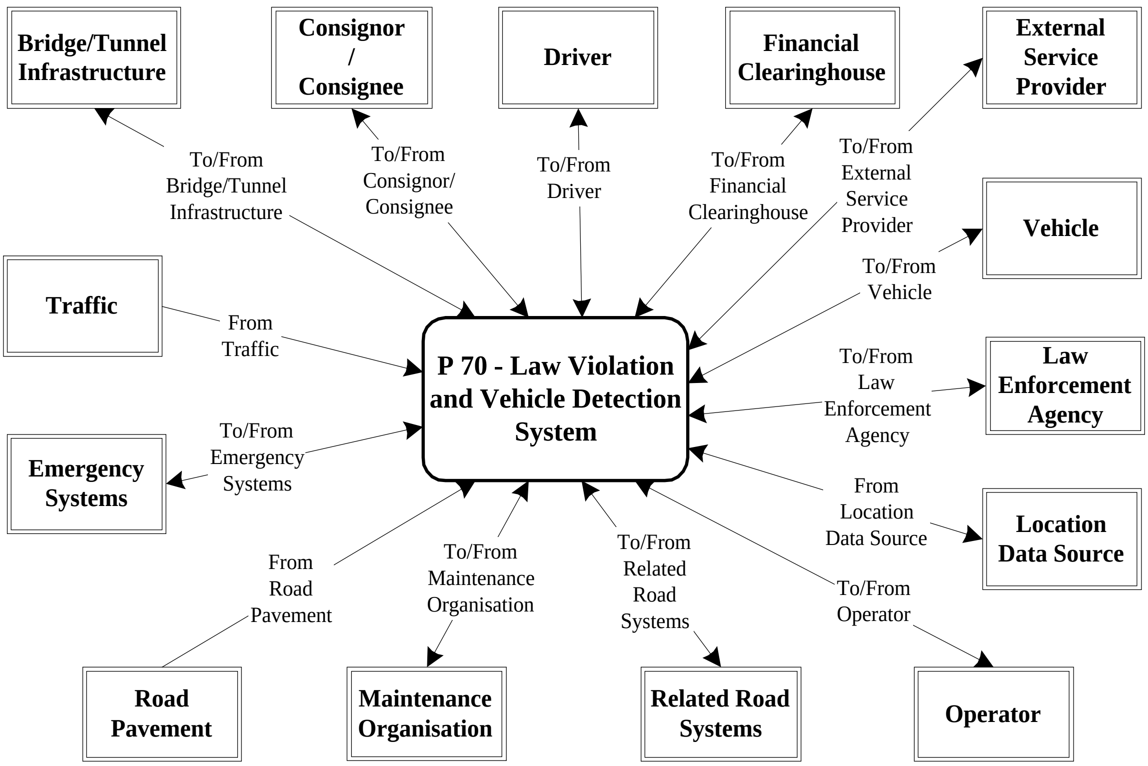
8.2.1 Overview

The system is able to detect speed violation as well as any incident within the area of Electronic Toll Collection to guarantee the identification of the vehicle and, depending on the national law, also the identity of the driver.

8.2.2 System Context

The System Context describes the framework within which the System exists. It is described using a System Context Diagram, which is shown in the following Figure. The Diagram shows the links that this particular System has with the outside World. It is derived from the full European ITS Framework Architecture Context Diagram described in Chapter 6 of the Main Document, by deleting the unused Terminators.

Figure 47 P 70 Law Violation and Vehicle Detection System - Context Diagram



As will be seen from a comparison with Figure 1, several terminators from the general list are not required by this System. The reasons for their exclusion are shown in the table below.

Table 26 P 70 Law Violation and Vehicle Detection System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	There is no monitoring in this system.
Bridge/Tunnel Infrastructure	In the case of the integration of the system in already existing infrastructure.
Consignor/Consignee	Not relevant for this system.
Driver	If the driver is identified, he is involved indirectly, without any specifications about his acting (private, emergency,...)
Emergency Systems	Information could be provided for that system.
External Service Provider	Not needed in this system, information are provided by the Law Enforcement Agency.
Location Data Source	The system is working stationary without any needs for locarion information.
Multi-modal System	There are no multi-modal links in this system.
Operator	Those mainly involved in this System are: Emergency Operator, Road Network Operator, and Toll Operator.
Road Pavement	Not involved in this system.
Traveller	Not involved in this system.
Weather Systems	Not involved in this system.

8.2.3 Sub-systems

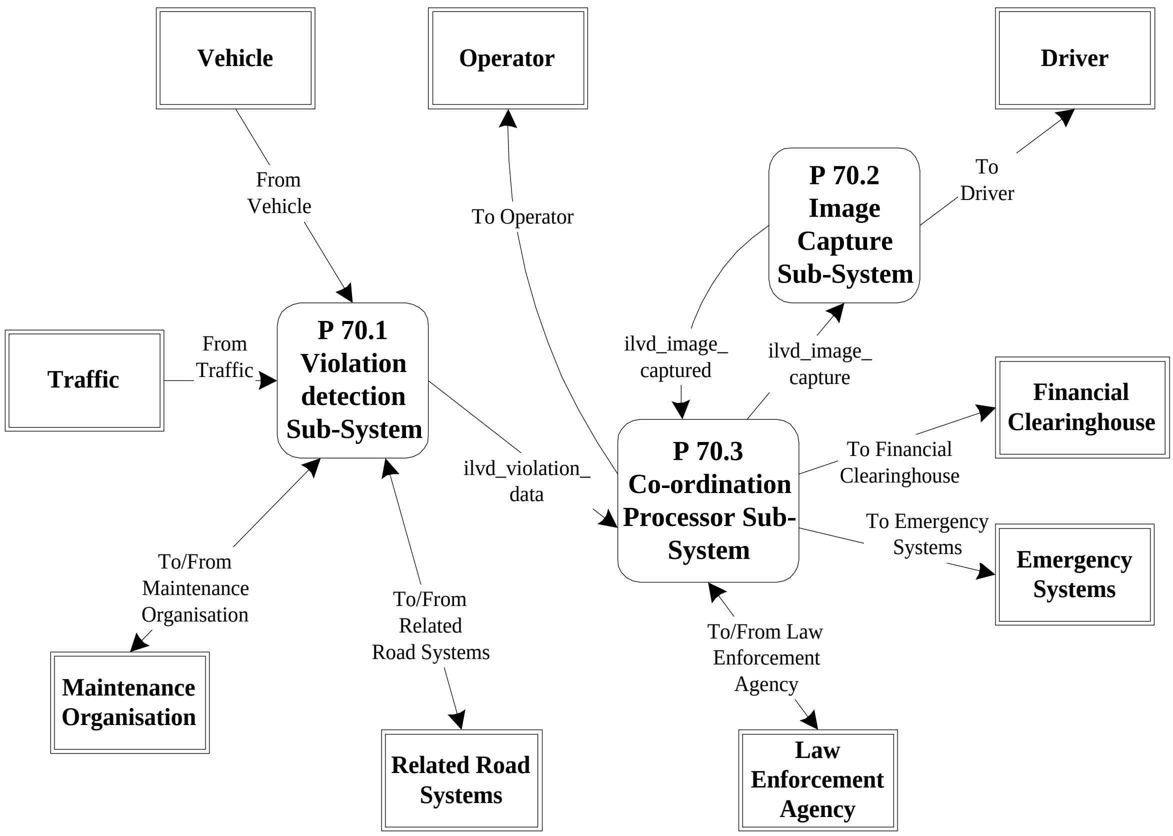
The System consists of three main Sub-Systems. These Sub-Systems are described below and shown in the Figure on the following page. This Figure also includes their relationships with each other and with the terminators..

P 70.1 Violation detection Sub-System: - This Sub-System detects the vehicle, classifies it and transmits this data to the Co-ordination Processor Sub-System. In the case of violation it transmits the relevant data caused by the vehicle additionally. The Sub-System provides the functionality to have an overview about the traffic-violation selected by different types of vehicles.

P 70.2 Image Capture Sub-System. - This Sub-System receives images of the passing vehicles and captures images of violating vehicles on the request of the Co-ordination Processor Sub-System.

P 70.3 Co-ordination Processor Sub-System: - This Sub-System receives data from the Violation Detection Sub-System and initiates the capturing of the passing vehicle by the Image Capturing Sub-System. Every communication with the world outside of the system and with all related Terminators will be handled by this Sub-System.

Figure 48 P 70 Law Violation and Vehicle Detection System - System Diagram



8.2.4 Sub-Systems and Functions

The three Sub-Systems described in the section and shown in the Figure above can be divided into Functions. This division is shown in the following table. More details of each Function in the form of their Overview descriptions will be found in the Annex to this Document.

Table 27 P70 Law Violation and Vehicle Detection System - Sub-systems and Functions

Sub-system			Function		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P 70.1	Violation Detection	Roadside	F 7.1.1	Perform Measure	3.1.0.1, 3.1.0.2, 3.1.0.3, 3.1.0.4, 3.1.1.3, 3.1.1.4
			F 7.1.2	Check Compliance	3.1.0.1, 3.1.0.2, 3.0.1.3

Sub-system			**Function**		
No.	**Name**	**Location**	**No.**	**Name**	**User Needs**
P 70.2	Image Capture	Roadside	F 7.2.1	Analyse Image	3.1.0.1, 3.1.0.2, 3.1.0.3, 3.1.1.1, 3.1.1.2
P 70.3	Co-ordination Processor	Roadside	F 7.2.2	Determine Violator ID	3.1.0.1, 3.1.0.2, 3.1.0.3, 3.1.1.1, 3.1.1.2
			F 7.3.2	Establish Prosecution File	3.1.1.1, 3.1.1.2, 3.1.0.5

8.2.5 Modules

As will be seen from the previous section, no Modules are needed by any of the Sub-systems in this System.

8.2.6 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

ilvd_violation_data
This physical data flow is used within the Law Violation and Vehicle Detection System. It contains data about a violation and is used to initiate the procedure of detection and identification of a vehicle.

ilvd_image_capture
This physical data flow is used within the Law Violation and Vehicle Detection System. It is generated within the co-ordination Module to start the image capturing procedure when data about a violation has been received.

ilvd_image_captured
This physical data flow is used within the Law Violation and Vehicle Detection System. It contains the image(s) obtained in response to a previous request.

8.2.7 Key Issues

The key issues for this System are as follows:

1. The system has to follow the legal restrictions covering laws on detection, image capturing of the driver and other relevant issues. The co-operation with all kinds of executive power (Law Enforcement Agency, Police, ..) is absolutely necessary while planing and implementing the system.

2. Due to the fact that this systems is containing high-sensitive data it is necessary to ensure high security standards and very low fault tolerance.

9. Freight and Fleet Management Systems

9.1 Introduction

This Chapter describes a Freight and Fleet Management System as an “example System” for the Physical Architecture.

9.2 P81 - Distributed Freight Management System

9.2.1 Overview

This System provides a Freight Management System for a large haulage company. The System is physically distributed, consisting of a Fleet Management Sub-system (plans the operations of trucks, trailers and drivers) and several Freight Management Services Sub-Systems (dealing with business transactions and negotiating with Consignor/Consignee Principals).

It has been created to illustrate how the recommendation of certain standards at the European level could:

1. in the short term improve the efficiency of existing Freight Management systems

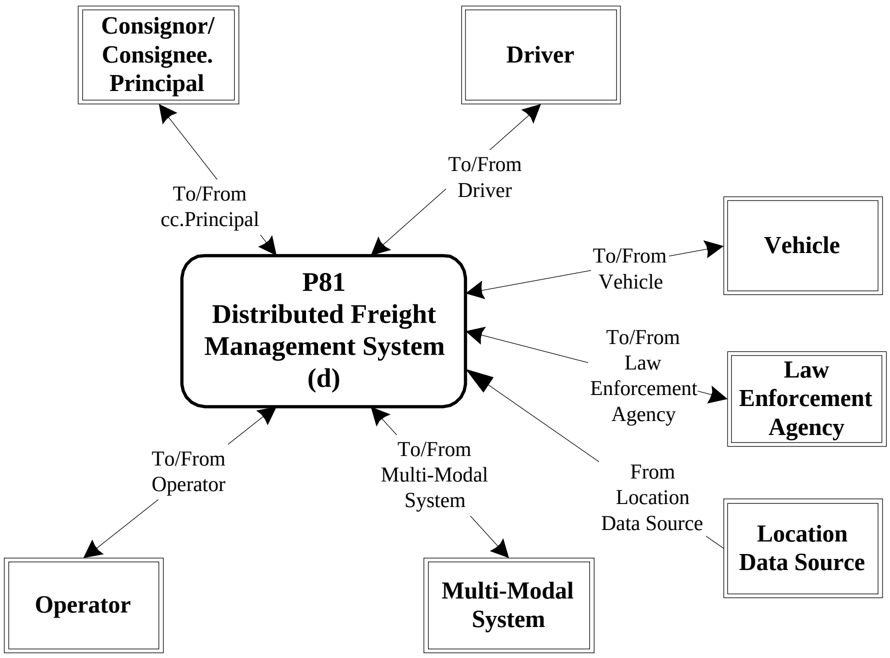
2. in the medium term, harmonise the transport of Freight across Europe in a wider sense, after study of the results of European ITS and by evolving European transport policy to further use ITS

9.2.2 System Context

The System Context describes the framework within which the System exists. It is illustrated using a System Context Diagram, which is shown in the Figure on the following page. In the Diagram are shown the links that this particular System has with the outside World. The outside World is represented by terminators.

The diagram for this System is derived from the full European ITS Framework Architecture Context Diagram shown by Figure 1 in Chapter 6 of the Main Document. The derivation process involves the deletion of the terminators that are not used by this System. The descriptions of those terminators that are used by this System will be found in Table 3, which is also part of Chapter 6 of the Main Document.

Figure 49 P81 Distributed Freight Management System - Context Diagram



As will be seen from a comparison with Figure 1, several terminators from the general list are not required by this System. The reasons for their exclusion are shown in the table below and on the following page.

Table 28 P81 Distributed Freight Management System - Terminator Deletions and Modifications

Terminator Name	Reasons for deletion or modification
Ambient Environment	No interface according to Functional Architecture
Bridge/Tunnel Infrastructure	No interface according to Functional Architecture
Emergency Systems	No interface according to Functional Architecture
External Service Provider	No interface according to Functional Architecture
Financial Clearinghouse	No interface according to Functional Architecture
Road Pavement	No interface according to Functional Architecture
Traffic	No interface according to Functional Architecture
Transport Planner	No interface according to Functional Architecture

Terminator Name	Reasons for deletion or modification
Traveller	No interface according to Functional Architecture
Weather Systems	No interface according to Functional Architecture

9.2.3 Sub-systems

The Distributed Freight Management System consists of two Sub-systems. They provide two things:

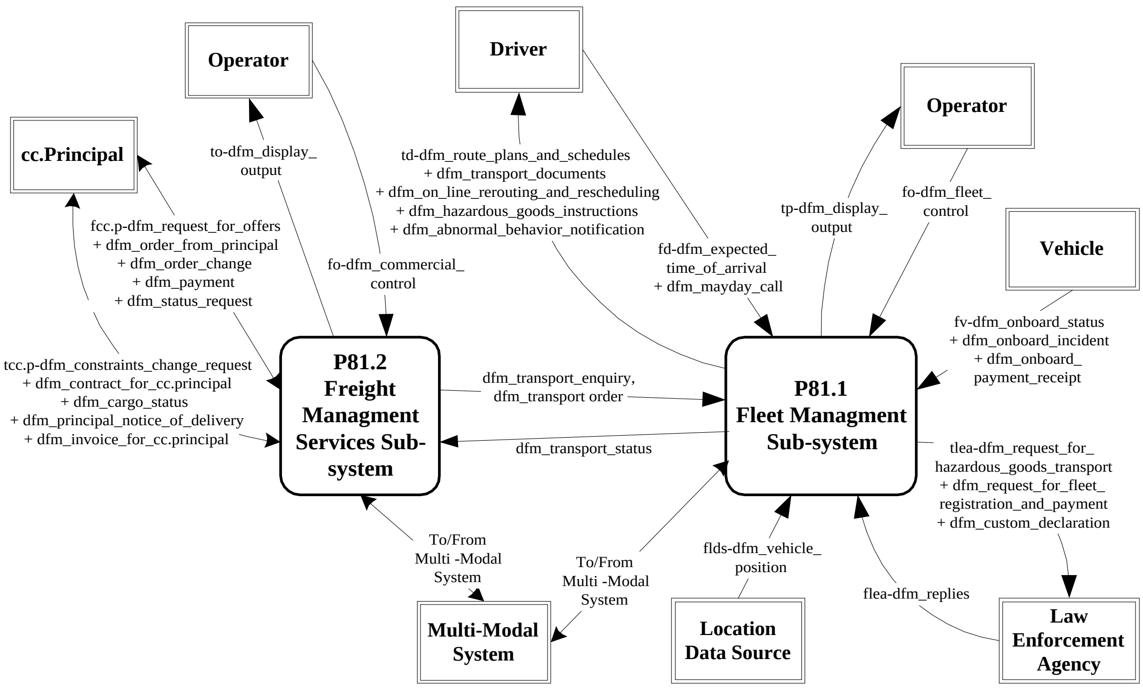
(a) a demonstration of the different functionality within the management system;

(b) an illustration of how a large haulage company would use a distributed commercial infrastructure to be physically close to its customers. In this case the customers are represented by the "Principal" actor within the Consignor/Consignee terminator.

The two Sub-systems are described below. They are also shown in the Figure on the following page, together with their relationships to each other and the terminators.

P81.1 Fleet Management Sub-system: - this Sub-system provides all of the centralised functionality for the management of a fleet (planning, maintenance of physical resources).

Figure 50 P81 Distributed Freight Management System - Sub-system Diagram



P81.2 Freight Management Services Sub-system: - this Sub-system is responsible for all the business functions (office-work) in the Distributed Freight Management System (customer relations, negotiation etc.). It forms the interface between the "Principal" actor within the

Consignor/Consignee terminator (end-user) terminator and the actual Fleet resources used to carry-out any given transaction.

9.2.4 Sub-Systems and Functions

The two Sub-systems identified in the previous section can themselves be split up into Modules and Functions. The Modules that form the P81.1 Sub-system (Fleet Management Sub-system) and P81.2 Sub-system (Freight Management Services Sub-system) are described in the Modules and Functions the next but one Section starting on the following page.

9.2.5 Modules

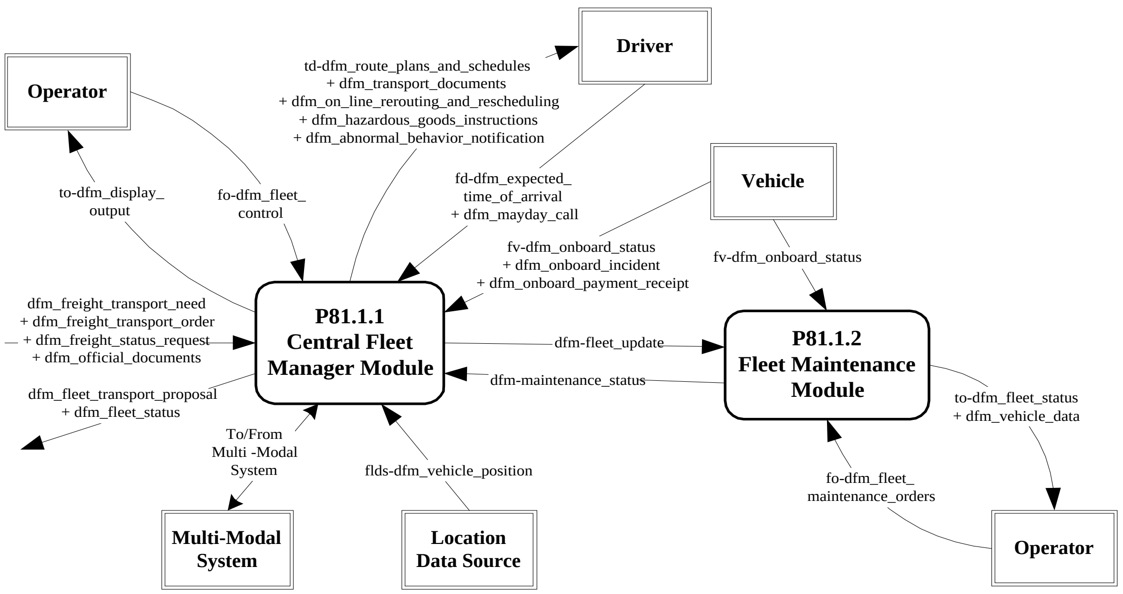
9.2.5.1 Introduction

The Modules that are included in the two individual Sub-systems are described and illustrated in the following Sub-sections.

9.2.5.2 Modules in P81.1 Fleet Management Sub-system

P81.1.1 Central Fleet Manager Module: - this Module is responsible for the centralised preparation, planning and control of fleet operations. There may be an interface with a multi-modal system if the transport order will need to use other modes of transport, such as heavy rail, sea or air.

Figure 51 P81 Distributed Freight Management System - Fleet Management Sub-system Modules



P81.1.2 Fleet Maintenance Module: - this Module is responsible for the good maintenance of the freight and fleet resources and on a more general level, the evaluation of fleet performance.

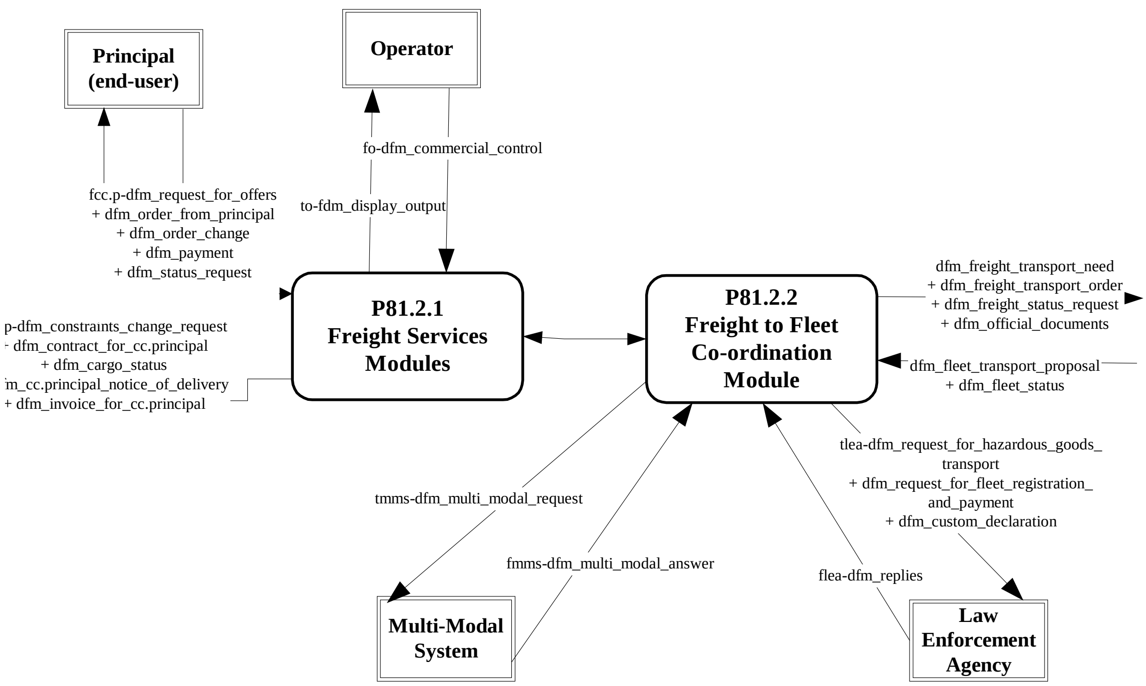
9.2.5.3 Modules in P81.2 Freight Management Services Sub-system

The Freight Management Services Sub-system consists of two types of Module. There may be several versions or copies of the first Module in any given implementation of the System. The details of the two Modules are as follows.

P81.2.1 Freight Services Modules: - this is a set of Modules that demonstrate the distributed nature of the Distributed Freight Management System. The Freight Services Modules in this example are each functionally identical and physically distributed across Europe. Each "Principal" (end-user) has a single point of contact with a Freight Service Module in order to access freight services.

P81.2.2 Freight to Fleet Co-ordination Module: - this Module co-ordinates with the Fleet Management Sub-system that manages the resources necessary to carry out the transport order. It also co-ordinates with multi-modal systems and systems belonging to other modes of transport.

Figure 52 P81 Distributed Freight Management System - Freight Management Services Sub-system Modules



9.2.6 Dynamics - How it all works

This section describes the chronological order of events involved in a Freight Management Operation. It makes use of the Modules described in the previous section.

1. The “Principal” actor within the Consignor/Consignee terminator sends a request for quotation for a freight transport service to one of the Freight Services Modules. This transport enquiry includes information on the nature of the cargo, the due delivery dates and the names and locations of the Consignor and Consignee.

2. The Freight Services Module passes the enquiry to the Freight to Fleet Co-ordination Module and specifies a date before which the it expects an answer.

3. The Freight to Fleet Co-ordination Module groups difference enquiries and sends a batch to the Fleet Management Sub-system for route planning and feasibility analysis

4. The Fleet Management Sub-system examines which drivers are available, which trucks are available and chooses a route. Inter-model planning may take place at this stage. Also, precautions need to be taken if hazardous or non-standard cargo is involved. This route planning information is returned to the Fleet Co-ordination Module with a cost estimation.

5. The Fleet Co-ordination Module passes the transport offer to the Freight Services Module where the price of the proposed transport offer is negotiated with the “Principal”.

6. The “Principal” either refuses the offer, re-negotiates or agrees with the offer, thereby establishing a transport order and associated contract.

7. The Freight Services Module informs the Freight to Fleet Co-ordination Module to action the Fleet Management Sub-system to execute the transport order.

8. The transport order is executed under control of the Central Fleet Manager Module inside the Fleet Management Sub-system. The driver and vehicle are monitored during the trip and informed of any hazards, changes to plan etc. These status reports may be sent by the Freight Management Services Sub-system to inform the “Principal” of the progress, upon request or spontaneously.

9. Once the transport order has been carried-out, the “Principal” is informed and invoiced by the Freight Services Module.

9.2.7 Modules and Functions

The four Modules identified in the section before last consist of one or more Functions. Those Functions included in each Module are identified in the table that is shown on the following pages. The Overview description of each Function is provided in Annex 2 of the Main Document.

Table 29 P81 Distributed Freight Management System - Table of Sub-systems, Modules and Functions

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P81.1	Fleet Management		P81.1.1	Central Fleet Manager	F 8.2.2.1	Plan & Prepare Fleet Operations	9.1.0.2, 9.5.1.6, 9.5.2.2, 9.5.2.3, 9.5.2.4, 9.5.2.5, 9.5.2.10, 9.5.2.13, 9.5.2.14, 9.5.3.12
					F 8.2.2.2	Control and Monitor Fleet Operations	5.3.1.3, 5.3.1.5, 9.1.0.2, 9.4.0.1, 9.4.0.2, 9.4.0.4, 9.5.0.2, 9.5.1.6, 9.5.2.10, 9.5.2.13, 9.5.3.10, 9.5.3.12, 9.5.3.13, 9.5.3.14, 9.5.3.18, 9.5.3.23
			P81.1.2	Fleet Maintenance	F 8.3	Manage vehicle/driver/cargo/equipment during trip	9.1.0.1, 9.1.0.3, 9.1.0.4, 9.2.0.1, 9.3.0.1, 9.3.0.2, 9.3.0.3, 9.4.0.1, 9.4.0.2, 9.4.0.3, 9.5.1.2, 9.5.1.4, 9.5.1.7, 9.5.1.8, 9.5.2.6, 9.5.2.12, 9.5.3.1, 9.5.3.2, 9.5.3.4, 9.5.3.5, 9.5.3.6, 9.5.3.8, 9.5.3.9, 9.5.3.11, 9.5.3.16, 9.5.3.17, 9.5.3.20
					F 8.2.3	Evaluate Fleet Operations Performance	9.5.1.10, 9.5.1.11, 9.5.2.16, 9.5.3.21

Sub-system			Module		Function		
No.	**Name**	**Location**	**No.**	**Name**	**No.**	**Name**	**User Needs**
P81.2	Freight Management Services		P81.2.1	Freight Services	F 8.1.1	Manage Freight Business Transactions	9.5.1.1, 9.5.1.3, 9.5.1.4, 9.5.2.10, 9.5.2.14
			P81.2.2	Freight to Fleet Co-ordination	F 8.1.2	Prepare Freight Operations	9.5.1.3, 9.5.1.4
					F 8.1.5	Manage Inter-modal Transport Synchronisation	9.5.4.4, 9.5.4.5, 9.5.5.1, 9.5.5.4, 9.5.5.5

9.2.8 Physical Data Flows

As will have been seen in the Figures, the Sub-systems and Modules in this System are linked together using Physical Data Flows. The term “Physical” is used to distinguish them from Functional Data Flows which are described in the Functional Architecture Deliverable Document.

Physical Data Flows may consist of other Physical Data Flows, but will always consist of one or more Functional Data Flows. The descriptions of the Physical Data Flows used in this System are shown below.

dfm_maintenance_status
This physical data flow is used within the Distributed Freight Management System. The Fleet Maintenance Module is wholly responsible for keeping the trucks and trailers on the road in good condition, maintaining documentation etc. It periodically sends the maintenance status to the Central Fleet Manager Module.

dfm_fleet_update
This physical data flow is used within the Distributed Freight Management System. It represents an order sent from the Central Fleet Manager Module to the Fleet Maintenance Module to evaluate the fleet of transport resources and determine whether it is necessary to order replacement trucks.

dfm_freight_transport_need
This physical data flow is used within the Distributed Freight Management System. It is sent to the Fleet Management Sub-system by the Freight Management Services Sub-system. It is the original request for a fleet operation using the resources available (drivers, trucks, trailers). It contains the “Principal” need ID, “Principal” name and address, origin/destination conditions, departure/arrival dates conditions, cargo/freight characteristics and electronic signature. The data flow consists of the following Functional Data Flow:
mffo_freight-transport_need

dfm_freight_status_request
This physical data flow is used within the Distributed Freight Management System. It is sent to the Fleet Management Sub-system by the Freight Management Services Sub-system. It contains the freight transaction ID.

dfm_fleet_status
This physical data flow is used within the Distributed Freight Management System. It is sent by the Fleet Management Sub-system in response to the dfm_freight_status_request. It contains the status of the fleet used to transport cargo and the status of individual transport orders. It includes the freight transaction ID, cargo status ID, current operation (pick-up, conveying, delivering), position, expected time of arrival, with or without incident and incident description. The data flow consists of the following Functional Data Flow:
mffo_fleet-status

dfm_transport_status
This physical data flow is used within the Distributed Freight Management System. It contains the status of the execution of the transport operation: including fleet transporter proposal ID, current position, estimated arrival date and any problem reports (e.g; extra documentation required, unplanned journey problems etc.)

dfm_official_documents
This physical data flow is used within the Distributed Freight Management System. It contains official documents required for the journey.

dfm_fleet_transport_proposal
This physical data flow is used within the Distributed Freight Management System. It contains a proposal for a fleet operation prepared by the Fleet Management Sub-system: including fleet transporter proposal ID, "Principal" name and address, origin/destination proposal, departure/arrival date proposal.

dfm_transport_order
This physical data flow is used within the Distributed Freight Management System. It contains the details of the transport order to be executed: fleet transporter proposal ID, "Principal" name and address, origin/destination conditions, departure/arrival dates conditions, cargo/freight characteristics. The data flow consists of the following constituent Physical Data Flow:
dfm_official_documents

dfm_transport_enquiry
This physical data flow is used within the Distributed Freight Management System. It contains the details of the transport need and also a status request. The data flow consists of the following constituent Physical Data Flows:
dfm_freight_transport_need
+ dfm_freight_status_request

9.2.9 Key Issues

The Key Issues brought to light by the Distributed Freight and Fleet Management System are as follows.

1. Freight Service Provider: It is easy to imagine that with the widespread acceptance of the Internet and the increasing ease of data communications will become more widespread. For example, a potential customer for freight services ("Principal" actor within the Consignor/Consignee terminator in the "example" System) having no experience with contacting Haulage Companies, would prefer to deal with a broker that offers freight services. Such a broker could offer different freight services via a Web Site, the site, for example, having the following characteristics:
    - a tariff table
    - a Secured Sockets Layer for secured payment of freight services
    - traffic information for the principal routes in Europe
    - a simple route planner

2. New communication protocols: The mobile phone Operators Harmonisation Group has agreed to apply third generation (3G) wireless communication systems to allow EDI, video transmission, data exchange via Universal Mobile Telephone Services. This would bring cost benefits by allowing competing products to provide communications between Fleet Management Sub-system and the Driver/Vehicle (in the Vehicle to Terminal interface and the Terminal to Central Fleet Manager interface).

3. Hazardous Goods, or more generally "Non-standard Goods": What becomes apparent when designing physical systems is the desire to make a system "realistic", or to make it adaptable to the real world where market forces predominate. This is especially true for the road transport domain where competition is high. For any operational planning system, the important things to identify at the start of process are the constraints imposed by the inherent nature of the system and the constraints imposed by the real world. In the case of this system (though the argument could equally well apply other types of route planning systems, route monitoring systems, emergency-response systems etc.) the physical manifestations of these constraints are:

   - infrastructure dimensions: road widths, bridge heights, tunnel diameters etc.
   - trailer sizes
   - cargo dimensions (though Container sizes are standardised)

   Recommendations for standard ways of describing these constraints should be developed as soon as possible. This will enable improvements to be made in the *interoperability* between Systems.

4. Container tagging: Consider a park of freight Containers; studies have shown that a company can expect a turnover of between 15 and 20% of its containers through loss or theft. A cheap electronic tag could be attached to a container to enable low-efficiency tracking of containers (e.g. with one-way communication based on a wireless infrastructure. A satellite surveillance would be costly and unreliable due to masking, since the tag must have line-of-sight communications with a satellite to send a message).

10. References

(a) European ITS Framework Architecture Functional Architecture Deliverable Document (D 3.1), Issue 1, August 2000.

(b) European ITS Framework Architecture User Needs Deliverable Document (D 2.2), August 2000.

(c) European ITS Framework Architecture Overview Deliverable Document (D 3.6) , Issue 1, August 2000.

The above Documents are available on the European Commission Web Site at: http://www.trentel.org, by following the links “Transport->Deployment Information->System Architecture->System Architecture Library. They are also available on the CD-ROM containing the European ITS Framework Architecture that has been produced for the European Commission by the KAREN Project.