European ITS Framework Architecture

Functional Architecture

D3.1

Main Document

Version 1.1

March 2002

Document Control Sheet

Activity Name: FRAME

Work Area: Consistency Checking - WP5

Document Title: Functional Architecture – Main Document

Document Number: D3.1

Main author(s) or editor(s): Richard Bossom, Olivier Le Guellec, Angela Nigro, Peter Jesty

Dissemination Level: Public usage

Version history:

Version Number	Date	Editor	Summary of changes
Version 1	August 2000	R.A.P. Bossom	First Public Issue
Version 1.1	March 2002	R.A.P. Bossom	Revised issue with inconsistency corrections

Approval:

	Name	Date
Prepared	Olivier Le Guellec	*January 2002*
Reviewed	*Richard Bossom*	*January 2002*
Authorised	*Richard Bossom*	*March 2002*

Circulation:

Recipient	Date of submission
CEC	March 2002

Architecture Change History

Version	Date	Summary of Changes
1.0	August 2000	None, first issue.
1.1	March 2002	Changes made to remove inconsistencies in the use of Data Flows in Functional Areas 1 – 4 and 6 – 8.
		New Function (F1.1.3) added to Functional Area 1 to provide data input for Data Store 1.3.
		Text in Function Overviews for Area 1 modified to improve comprehension.
		Descriptive text in Chapter 6 (Area 1) modified to improve comprehension.

Table of Contents

Figures

Tables

Executive Summary

This document provides a description of the Functional Architecture, which forms part of the European ITS Framework Architecture. Functional Architecture defines and describes what functionality needs to be included in a System that can fulfil the requirements of the European ITS Framework Architecture User Needs. These User Needs are provided in a separate document produced by another part of the FRAME Project.

This document describes the Functional Architecture in some detail and also covers the methodology used for its development. It shows how the Architecture links to the outside World through terminators and how it has been divided into Functional Areas. The way in which these have been divided into Functions is also included, together with diagrams for all the Areas. These diagrams (called Data Flow Diagrams) show how the Functions relate to each other, to Data Stores and to the terminators through the Data Flows.

Details of the Information Architecture are provided through the description of the Data Flows and Data Stores. These and the descriptions of the Functions are contained in three separate Annexes to the document. The reasons for using these three Annexes are to simplify the study of the Architecture and to avoid producing one large document. An overview of what is in each Functional Area can be obtained from the main part of the document before the detail of the Functions, Data Flows and Data Stores is studied using each of the three Annexes.

This document forms the starting point for the description of the European ITS Framework Architecture. This description will be expanded by further documents that will provide descriptions of the other parts of the Architecture, such as the Physical Architecture and Deployment Study.

1.   Introduction

1.1.   Scope

This document is part of the set of deliverables produced by the FRAME Project to describe the European ITS Framework Architecture. This particular document (D3.1) provides a description of the Functional Architecture that has been developed by the Project Team. The background to the development of the Functional Architecture is provided in the European ITS Framework Architecture Overview document (D3.6).

1.2.   Where the document fits in the Architecture Documentation

The document is one of a set of seven documents provided by the FRAME Project to describe the complete European ITS Framework Architecture. The other documents in the set are as follows:

  D3.1   European ITS Functional Architecture - this document

  D3.2   European ITS Physical Architecture

  D3.3   European ITS Communications Architecture

  D3.4   European ITS Cost Benefits Report

  D3.5   European ITS Deployment Study Report (internal use only, but included in D4.2)

  D3.6   European ITS Framework Architecture Overview

  D3.7   European ITS Models for ITS deployment

The other Documents can be obtained from the reference shown in the last Chapter of this document.

1.3.   Definition of a Functional Architecture

A Functional Architecture defines and describes what functionality needs to be included in a System that can fulfil the requirements of the European ITS Architecture User Needs. These are provided in a separate document produced by another part of the FRAME Project.

The Functional Architecture therefore expresses the System in functional terms. It also shows how its functionality links to the outside World and in particular the users of the System and the data that is used within the System. The data description is sometimes included in a separate Information Architecture, but for the FRAME project, this has been subsumed into the Functional Architecture. The functionality in the Architecture will ultimately be included in examples of Systems that will be included in the Physical Architecture.

The Functional Architecture forms part of the European ITS Framework Architecture and therefore shares its characteristics. These characteristics are described in the Overview Document - see Deliverable D 3.6.

1.4.   Document Structure

This document is divided into four main parts. The first (this document) contains the description of the methodology, interfaces to the outside World and general Functional Architecture description. Three Annexes are provided as separate documents and contain the full Function descriptions (Annex 1), the full Data Flow descriptions (Annex 2) and the full Data Store descriptions (Annex 3).

1.5.   List of Abbreviations

DFD	Data Flow Diagram
EP	Electronic Payment
ITS	Intelligent Transport Systems
KAREN	Keystone Architecture Required for European Networks
PT	Public Transport
P+R	Park and Ride
TCC	Traffic Control Centre
TIC	Traffic Information Centre
TICS	Transport Information and Control Systems
UML	Unified Modelling Language

2. Methodology

2.1. Introduction

This chapter of the document describes the reasons for choosing the methodology that has been used to develop the Functional Architecture. It also describes how it has been applied to the development work.

2.2. Two Possible Methods

2.2.1. Introduction

Within the field of Informatics, or Software Engineering, there are now two different principal approaches being used for the design of information systems:

- Function, or Process Oriented - data flow, functional decomposition, process oriented;

- Object Oriented - objects, classes, abstraction, inheritance, encapsulation (information hiding).

In the following parts of this section the use of the two methods is reviewed.

2.2.2. Process Oriented Approach

Ease of Use

The Process Oriented approach was initially used by software engineers because it was already in use in all other fields of engineering. There is clearly a 'naturalness' about the method which makes it the obvious one to use, and easy to understand; it is unlikely that alternatives were even considered when it first began to be applied. As a consequence when engineers from a variety of disciplines have to work together on a system, and this occurs with many, if not most, Intelligent Transport Systems (ITS), the Process Oriented approach is commonly understood by them all.

Types of System

Process based methodologies have been used for all types of system and in all stages of the life-cycle for many decades. They are well understood though they cannot guarantee the production of a working and workable system.

Safety-Related Systems

It is obvious that most systems produced in the ITS domain are, or will be, safety-related to some degree. All the current Standards, Guidelines and techniques available to assure the safety of a system assume, or are based on, the use of a Process Oriented approach; indeed they are encouraged [IEC 61508, MISRA 1994].

2.2.3. Object Oriented Approach

Ease of Use

The emergence of OO is a natural consequence of the way that the subject of information technology has progressed for the last 30 years. Digital computers need discrete mathematics to model their workings, and set theory leads naturally to the concept of objects. For those who have been educated in discrete mathematics for many years the use of an OO methodology is as natural to use as a Process Oriented one is for an engineer steeped in function analysis and calculus.

The distinctive feature of OO is the 'object', which is an instantiation of a class, which combines the data, and behavioural properties of all the objects that might be in that class. By means of this encapsulation the detailed operations can be hidden, thus permitting the system designer to work at higher levels of abstraction, and closer to the application. This approach also offers other facilities such as polymorphism and inheritance, which lead to a greater possibility of re-use.

Types of System

OO methodologies were originally targeted at information systems, i.e. software (only) systems that depend only on the processing of data, and are thus intangible. They are particularly good at handling situations where similar processes needs to be performed on different types of data. The first use of an object-oriented approach was in the late 1960s to simulate the behaviour of real world objects, e.g. cars and traffic lights in a road-system simulation. Since then its use has spread, in particular to applications that are centred around the use of (distributed) databases, graphics and user interfaces.

Safety-Related Systems

As has been stated previously most systems in the ITS domain are, or will be, safety-related to some degree especially those concerned with the control of vehicles or hazardous goods. None of the current Standards, Guidelines recommend an Object Oriented approach despite the fact that the use of formal mathematical techniques is encouraged. The use of C++ is severely discouraged either directly [MISRA 1998], or by implication [IEC 61508].

2.3. Comparison between Process and Object Orientated Design

2.3.1. Life-Cycle Activities

It is important to distinguish between the architecture, design and implementation (programming) stages of a system life-cycle. Whilst there is a natural tendency to assume that the same methodology should be used throughout, it is not necessary. In addition the differences between the Process Oriented and OO approaches are not always as great as is sometimes made out. In their basic form both approaches use functions and data but in different ways, with Process Orientation concentrating on the former and OO on the latter. The decision as to which to use to create a framework architecture thus depends on which aspect is considered to be more important at this level of abstraction.

It should be noted that, whilst both approaches aim to create a working system, but this does not guarantee a workable one. Neither methodology is sufficient to produce a design for an entire system that includes organisational and institutional issues.

2.3.2. Types of System

Whilst an OO approach is definitely more natural to use than a Process Oriented one for certain applications, the popularity of OO is such that almost all new software systems are now produced using an OO technique somewhere in the life-cycle, in particular by programming with the language C++. Unfortunately there has been little objective measurement as to the effectiveness of the OO approach, with most of the evidence consisting of the subjective opinions of its protagonists [Hatton 1998]. However, this does not necessarily mean that the Process Oriented approach is better than an Object Oriented one, or vice-versa. Very good, and very bad, systems have been created with both approaches; the most important ISSUE seems to be that of familiarity with the application, and experience in the use of the methodology.

Whilst simple examples are often given showing the use of OO in control systems that include some hardware, quality attributes, e.g. reliability and maintainability, necessary for a real system are difficult to introduce, and it is still debatable as to how much of an OO approach should be used in these circumstances, in particular when the application is safety-related.

2.3.3. Structured Decomposition

Both the Process and Object Oriented approaches depend on structured decomposition in order to develop a design. Therefore they might need a Computer Assisted Software Engineering (CASE) tool to assist in the maintenance of consistency, especially when the system is large and/or complex.

2.3.4. Complexity

One of the benefits claimed of the OO approach is that it makes the design of complex systems easier; the features of abstraction, inheritance and encapsulation, in particular, being used to do so. However it has been noticed that "From supervising undergraduate group projects employing OO software engineering to develop a small system up to the working prototype stage, I have concluded that the profound confusion of almost all the teams was due, not to the stupidity of the students (nor of the lecturer), but to the lack of intellectual rigour with which the whole approach has been defined" [Mellor 1998].

In fact, of course, often the complexity has not really been removed, it has just been hidden, and the little evidence that does exist shows that it is more expensive to fix defects in programs written in an OO language, C++, than when non-OO languages, C and Pascal, are used [Hatton 1998]. OO is not conducive to real complexity reduction [Webster 1995]; Process Oriented methods do permit it, but it requires experience, and is often not applied.

2.3.5. Re-use

Whilst one of the claimed advantages of OO is the ability to re-use objects, the concept of re-use is not unique to OO. A few of us still remember collecting stacks of punched cards containing FORTRAN subroutines from a (physical) library to append to the rest of the cards that made up our program. The full benefit of re-use can only be made when no changes at all are made to the module, but this rarely happens in practice. Given the ease with which it is possible to create a new fault whilst making a change, much of the benefit of re-use is lost if changes have to be made.

2.3.6. Users of the Framework Architecture

There will be many different classes of user of the Framework Architecture, in particular:

- Senior decision makers

- Engineers from many disciplines

- Representatives of the end users

The majority of these users will not have studied software engineering, or informatics, as their primary subject. This is reflected in the methodologies that have been used in projects during Frameworks II - IV, during which the vast majority used a Process Oriented approach. The few which have taken an OO approach tend to be those specifically concerned with large databases, e.g. TITAN (née EUROBUS Transmodel), in which software engineers are known to have taken part.

2.4.   Conclusion

The key points from above are:

- Most users of the Framework Architecture will only understand the Process Oriented approach, and are likely to be more interested in the processes than the data.

- The Object Oriented approach was originally targeted at information, or software only, systems. ITS also include direct and indirect safety-related control systems for which the applicability of an OO approach is still being debated.

- Safety-related systems normally need a Process Oriented approach to satisfy current Standards and Guidelines.

- It is not necessary to use the same methodology throughout the life-cycle.

- For some informatics applications an Object Oriented approach is more natural to use than a Process Oriented one.

- The lack of real rigour of the Object Oriented approach can make it difficult to understand fully.

- The hidden complexity of the Object Oriented approach can make it difficult to get systems working correctly - this is probably not relevant to the architecture framework phase of the life-cycle.

- Both approaches need care to be taken to ensure consistency during their structured decomposition.

- Re-use is not always what it might seem to be - but this is probably not relevant to the architecture framework phase of the life-cycle.

2.5.   Recommendation for the KAREN project

As a result of the above it is recommended that for the European ITS Framework Architecture development:

a) The Process Oriented approach should be used;

b) At some level in the decomposition, to be defined, a Unified Modelling Language (UML) top-level Use Case diagram for each function should be drawn for those who wish to proceed later using an OO approach. Whilst it may not be necessary, or feasible, to do this for every Use Case a number of typical examples can be produced to demonstrate the approach.

2.6.   Process Oriented approach in the KAREN Project

2.6.1. Introduction

The Process Oriented approach has been implemented in the KAREN Project. It describes the Functional Architecture as a series of Functional Areas. Each of these contains Functions and (sometimes) Data Stores that are linked together and to the terminators with Data Flows.

2.6.2. Functional Areas

At its highest level, the Function Architecture consists of a number of Functional Areas. Each Area is given a name and a number. It contains Functions whose purpose and activities are related. The names each include a "verb" and are expressions of the area of responsibility filled by the functionality in the Area. Thus a Functional Area called "Manage Public Transport Operations" contains all the functionality for that purpose. The numbers are single digits and allocated to each Area.

Each of the Functional Areas in the European ITS Functional Architecture has a simple textual description. These will be found in Chapter 5 of this document. They are written in "shall" language for two main reasons. Firstly to make it easier to understand what functionality the Area contains. The second reason is to make it possible to verify that something conforming to the European ITS Architecture does contain all the functionality that is required.

2.6.3. Functions

The functionality in each Functional Area is divided into what are called Functions. There are two types of Function in the Areas and they are as follows.

(1) High Level Functions: these are Functions that are very complex. To make their description easier to understand, they have been broken down into lower level Functions. Some of these may again be High Level Functions, or they may be Low Level Functions as described below. The High Level Function descriptions consist of an Overview plus a list of constituent Functions. Again "shall" language is used for the text of the Overviews, as the reasons previously given for the Functional Area descriptions still apply. Because the Overviews can be used elsewhere, e.g. in the Physical Architecture, they will always start with the phrase "This High Level Function….". The High Level Functions rarely fulfil User Needs by themselves but always fulfil those covered by their constituent Low Level Functions.

(2) Low Level Functions: these are Functions whose functionality can be described without the need for sub-division into lower level Functions. They therefore represent the lowest level of functionality in each Area. Their descriptions consist of an Overview, lists of input and output Data Flows and detailed Functional

Requirements. The latter provide details of what the Functions actually do. Again "shall" language is used for the Overview and Functional Requirements, as the reasons already given in the previous section on Functional Areas still apply. Like the Overviews for the High Level Functions, those for the Low Level Functions may be used elsewhere, therefore they will always start with the phrase, "This Low Level Function…..".

Both types of Function are numbered and take the first digit of their numbers from the Functional Area in which they reside. The rest of the digits form a numbered sequence within each Area. For example, all the Functions in Area 3 are numbered 3.1, 3.2, etc. When Function 3.1 is a High Level Function and is divided into its own group of Low Level Functions, they are numbered, 3.1.1, 3.1.2, etc. The Low Level Functions that make up High Level Function 3.2 will be numbered 3.2.1, 3.2.2, etc. This process is repeated if (for example) Function 3.2.2 is in fact another High Level Function that has its own lower level Functions.

Like the Functional Areas, each Function has its own name. Again this name is an expression of what it does and will include a "verb" in the wording. Thus a Function with the name "Manage Emergency Vehicles" will contain functionality that enables the operation of emergency vehicles to be managed.

There will be no duplication of High Level Functions. This means that a particular set of Functions, e.g. those for route guidance, will provide that facility for all Functional Areas. It is possible however for Low Level Functions to be duplicated. This is intended to reduce the amount of complexity in the Functional Architecture and make the subsequent derivation of the Physical Architecture easier.

The formal descriptions for all the Functions in both types appear in Annex 1 of this document. This has separate Chapters for each Functional Area, and within these separate sub-sections for High and Low Level Functions. Where the structure of the functionality is complex, i.e. there are a large number of High Level and/or Low Level Functions, it is illustrated with one or more hierarchy diagrams. These show how many High Level Functions there are, and how each of them has been divided into Low Level Functions.

2.6.4. Data Stores

The Functional Areas or the High Level Functions may include Data Stores. They are used to hold data that is used by several High Level Functions within an Area, or the Low Level Functions within a High Level Function. They are also named and numbered. The name is used to indicate what type of data the Store contains. The number consists of two digits, the first being the Area number. The second digit is obtained by numbering from one (1) the Stores in each Functional Area.

A description of each Data Store is provided in Annex 3 of this document. This description will contain details of what data is in the Store and is not intended to imply the use of any particular physical design or storage methodology. However taken together, the Data Store descriptions will provide the Information Architecture component of the Framework Architecture.

It will be assumed that each Data Store contains the appropriate store management facilities - e.g. read/write control, journal creation, back-up, etc. These facilities will also be assumed to

cover any communications needs, particularly if the Data Store is used by Functions that the Physical Architecture places in other locations. In many cases Data Flows requesting that data is provided from the Store, or confirming that data has been written to the Store are not shown, although they are assumed to exist and used if required.

2.6.5. Data Flows

Linking the Functions to each other, to terminators and to Data Stores are the Data Flows. These enable data to be sent from one Function to another, two or from Data Stores, or to of from terminators. All of the Data Flows have names that start with letter codes that conform to the following "rules".

(1) The initial letters of the Functional Area are used when the Data Flow totally resides in that Area, e.g. "psef";

(2) When a Data Flow links Functions in one Functional Area with those in another, the initial letters of the starting and finishing Areas are used in that order, e.g. "psef.mpto";

(3) When a Data Flow links a Function to a terminator, then the initial letters are "f" followed by the terminator acronym for Flows from terminators and "t" followed by the terminator for Flows to terminators;

(4) When a terminator only links to a single Functional Area, then the Data Flow name starts with "To", "From", or "To/From", depending on whether the data is flowing in one or both directions, followed by the full terminator name.

The terminator acronyms are defined in the table at the end of Chapter 5, which describes each of the terminators. A description of each Data Flow and what it contains is provided in Annex 2 of this document.

To simplify some DFD's, only one Data Flow may be shown linking two Functions. However this Data Flow may consist of a number of different Data Flows, called constituent Data Flows. If they exist for a particular Data Flow, their identities will be found at the end of the description of that Data Flow. This is particularly useful in DFD's showing High Level Functions, where there may be Data Flows going from different Low Level Functions to corresponding Functions in other Areas, or to terminators.

2.6.6. Data Flow Diagrams (DFD's)

The Data Flow Diagrams show how the functionality for each Area is divided into High and Low Level Functions. They also show how these Functions are linked to each other and to the terminators through Data Flows. When used by several Functions, Data Stores are also shown, together with the Data Flows linking them to the Functions.

The DFD's are all numbered in a hierarchical sequence and named. The numbering scheme uses the Area number as the first digit. The second and subsequent digits are taken from the Function that they are describing - see the previous section on Functions. The DFD names are direct copies of either the Area name or the name of the Function that they show. A brief description of each of the DFD's in the Functional Areas is given in Chapter 6 of this document.

Within each DFD will be found rectangular shapes representing the Functions. The size of the rectangle will vary from one DFD to anther and has no significance of any sort. It is usually dictated by the number of Functions, Data Stores and Data Flows in each DFD. Each shape contains the number and name of the Function, using the previously defined rules. The shapes for High Level Functions are symbolised by a "(d)" underneath the name of the Function.

The DFD's may also include cylindrical shapes called Data Stores. Like the Function shapes, the size may vary from one DFD to another and again has no significance. Each shape contains the number and name of the Data Store, using the previously defined rules.

The DFD's contain lines that represent the Data Flows. Nearly all of the lines have an arrow at one end to show the direction in which the data is flowing. Occasionally lines with arrows at both ends have been used because data flows in both directions and space can be saved by using only one line in the DFD. The use of lines with arrows at both ends is almost entirely confined to those Data Flows that link the terminators to the System in the Context Diagram - see Chapter 4, or those few Data Flows linking terminators to the only Functional Area with which they have an interface.

The name of the Data Flow will be somewhere adjacent to the line, its position varying with the relative space on the DFD. Each name conforms to the rules already defined in an earlier section of this Chapter.

2.6.7. The use of "Trigger" Flows

The notion of control flow in the Functional Architecture is contained in the "Functional Requirements" section that forms part of each Function specification. This is normal as the Functional Architecture is strongly oriented towards data driven control. All the Functions in the Architecture are connected to each other with Data Flows that will be generally implemented with discreet messages. The arrival of a message at a Function will capture both the notion of a Data Flow and of a possible control event. When a Function issues a message as a result of its own processing it can also be effectively issuing a control flow simultaneously. Functions that wait for messages and begin processing on their arrival are effectively activated by a data/control flow (or flows). Control is essential to its design and explicitly appears in this way throughout the Function descriptions.

This concept of data driven control is used throughout the Functional Architecture and is highlighted by the use of "trigger" Data Flows. These are Data Flows that will do one of three things:

(1) effectively "start" a Function;

(2) enable a Function to continue because it has been waiting for the arrival of that data flow;

(3) poll a source for data.

Throughout the Data Flow definitions in Annex 2, it will be seen that each Data Flow is identified as being a "trigger flow" or not. The differentiation between the types of Data Flow is also made in the description of Function in Annex 1. Here the different types of Data Flow appear in different parts of the descriptions to make their use more obvious.

2.7. Tools and Methods

The Process Oriented approach has been implemented by the KAREN Project without the use of formal "tools". This was found to be desirable because it removed the need for members of the Team to purchase something that they might (at least for the moment) not otherwise use. Thus the Data Flow Diagrams (DFDs) have been created using a drawing package (VISIO ™) and the Function, Data Flow and Data Store descriptions have been captured using a relational database (Microsoft Access ™). All other written material has been produced using a word processor (WORD ™ for Office 95 ™).

A series of "templates" were created for use with all the above packages. They enable the architecture deliverables produced by WP 3 to have a consistent "look and feel", even though they have been produced by several different people located in various parts of Europe. A "standard" database was produced for each type of object (Function, Data Flow and Data Store) so that the details of each could be captured in a consistent way. The same databases were also used to generate the textual descriptions that are included in the Annexes to this document. An overview description of the contents of each database is given at the beginning of the second Chapter of each Annex.

3.   Relationship with the European ITS Architecture User Needs

3.1.   Introduction

The functionality in all system architectures must be related to a set of User Needs. These Needs define the services that users of the System require to see fulfilled for it to be of any use to them. The User Needs form the foundation upon which the system architecture is built.

3.2.   European ITS Framework Architecture User Needs

For European ITS Architecture, the User Needs have been defined in a separate deliverable [UN]. In this deliverable, the User Needs have been divided into Groups representing requirements that are related. Examples are Financial Transactions, Traffic Management and Freight and Fleet Operations. Within each Group, there are further divisions into Categories so that requirements for the same Services are kept together. The objective has been to make the User Needs easier to read and understand.

3.3.   Relationship between European ITS Functional Architecture and User Needs

The relationship between the European ITS Functional Architecture and the User Needs Groups is shown by Table 1 below. This has been produced to provide an overview of way in which the Functional Architecture serves the User Needs. The two left hand columns show the Architecture as a series of Functional Areas, whilst the other columns show the User Needs Group Categories that they serve.

Table 1 Relationship between European ITS Functional Areas and User Needs Group1

Functional Area	User Need Group Category	
	Number	**Title**
1. Provide Electronic Payment Facilities	4.1	Electronic Financial Transactions
	6.1	Pre-trip Information
	7.3	Demand Management
2. Provide Safety and Emergency Facilities	10.5	Public Travel Security
	5.1	Emergency Notification and Personal Security
	5.2	Emergency Vehicle Management
	7.2	Incident Management
	9.4	Commercial Vehicle On-board Safety Monitoring

| Functional Area | User Need Group Category | |
	Number	Title
3. Manage Traffic	2.1	Transportation Planning Support
	2.2	Infrastructure Maintenance Management
	5.1	Emergency Notification and Personal Security
	5.2	Emergency Vehicle Management
	6.1	Pre-trip Information
	7.1	Traffic Control
	7.2	Incident Management
	7.3	Demand Management
	8.2	Automated Vehicle Operation
4. Manage Public Transport Operations	10.1	Public Transport Management
	10.2	Demand Responsive Public Transport
	10.3	Shared Transport Management
	10.4	On-trip Public Transport Information
	10.5	Public Travel Security
	2.1	Transportation Planning Support
	2.2	Infrastructure Maintenance Management
	4.1	Electronic Financial Transactions
	5.1	Emergency Notification and Personal Security
	5.3	Hazardous Materials & Incident Notification
	7.1	Traffic Control
	7.3	Demand Management
5. Provide Advanced Driver Assistance Systems	4.1	Electronic Financial Transactions
	5.1	Emergency Notification and Personal Security
	8.1	Vision Enhancement
	8.2	Automated Vehicle Operation
	8.3	Longitudinal Collision Avoidance
	8.4	Lateral Collision Avoidance
	8.5	Safety Readiness
	8.6	Pre-crash Restraint Deployment

Functional Area	User Need Group Category	
	Number	Title
6. Provide Traveller Journey Assistance	10.1	Public Transport Management
	10.2	Demand Responsive Public Transport
	10.4	On-trip Public Transport Information
	6.1	Pre-trip Information
	6.2	On-trip Driver Information
	6.4	Route Guidance and Navigation
	7.3	Demand Management
7. Provide Support for Law Enforcement	3.1	Policing/Enforcing Traffic Regulations
8. Manage Freight and Fleet Operations	5.3	Hazardous Materials & Incident Notification
	9.1	Commercial Vehicle Pre-clearance
	9.2	Commercial Vehicle Administrative Processes
	9.3	Automated Roadside Safety Inspection
	9.4	Commercial Vehicle On-board Safety Monitoring
	9.5	Commercial Fleet Management

The Functional Areas shown in the two left-hand columns will be defined later in Chapter 5 of this document. The User Needs Group Categories and the individual User Needs that they contain are defined in the European ITS Architecture User Needs deliverable [UN].

In some cases, a User Needs Group Category is served by parts of two separate Functional Areas. This is because the Areas contain similar functionality and so may serve different User Needs. This is illustrated by Table 2 below. In this Table the two left-hand columns have been changed to be the European ITS Architecture User Needs Group Category Numbers and Titles. The remaining columns show the Functional Areas. Thus it is possible to see how the individual User Needs Groups are served by the different Functional Areas.

Table 2 Relationship between the European ITS Architecture User Needs and Functional Areas

Table 2 User Need and Group Category		Functional Area
Number	Title	
2.1	Transportation Planning Support	3. Manage Traffic
2.2	Infrastructure Maintenance Management	3. Manage Traffic

Table 2 **User Need and Group Category**		Functional Area
Number	**Title**	
3.1	Policing/Enforcing Traffic Regulations	7. Provide Support for Law Enforcement
4.1	Electronic Financial Transactions	1. Provide Electronic Payment Facilities 4. Manage Public Transport Operations 5. Provide Advanced Driver Assistance Systems
5.1	Emergency Notification and Personal Security	2. Provide Safety and Emergency Facilities 4. Manage Public Transport Operations 5. Provide Advanced Driver Assistance Systems
5.2	Emergency Vehicle Management	2. Provide Safety and Emergency Facilities
5.3	Hazardous Materials & Incident Notification	4. Manage Public Transport Operations 8. Manage Freight and Fleet Operations
6.1	Pre-trip Information	1. Provide Electronic Payment Facilities 3. Manage Traffic 6. Provide Traveller Journey Assistance
6.2	On-trip Driver Information	6. Provide Traveller Journey Assistance
6.4	Route Guidance and Navigation	6. Provide Traveller Journey Assistance
7.1	Traffic Control	3. Manage Traffic 4. Manage Public Transport Operations
7.2	Incident Management	2. Provide Safety and Emergency Facilities 3. Manage Traffic
7.3	Demand Management	1. Provide Electronic Payment Facilities 3. Manage Traffic 4. Manage Public Transport Operations 6. Provide Traveller Journey Assistance
7.4	Safety Enhancements for Vulnerable Road Users	3. Manage Traffic
8.1	Vision Enhancement	5. Provide Advanced Driver Assistance Systems
8.2	Automated Vehicle Operation	5. Provide Advanced Driver Assistance Systems

Table 2 **User Need and Group Category**		Functional Area
Number	**Title**	
8.3	Longitudinal Collision Avoidance	5. Provide Advanced Driver Assistance Systems
8.4	Lateral Collision Avoidance	5. Provide Advanced Driver Assistance Systems
8.5	Safety Readiness	5. Provide Advanced Driver Assistance Systems
8.6	Pre-crash Restraint Deployment	5. Provide Advanced Driver Assistance Systems
9.1	Commercial Vehicle Pre-clearance	8. Manage Freight and Fleet Operations
9.2	Commercial Vehicle Administrative Processes	8. Manage Freight and Fleet Operations
9.3	Automated Roadside Safety Inspection	8. Manage Freight and Fleet Operations
9.4	Commercial Vehicle On-board Safety Monitoring	2. Provide Safety and Emergency Facilities 8. Manage Freight and Fleet Operations
9.5	Commercial Fleet Management	8. Manage Freight and Fleet Operations
10.1	Public Transport Management	4. Manage Public Transport Operations 6. Provide Traveller Journey Assistance
10.2	Demand Responsive Public Transport	4. Manage Public Transport Operations 6. Provide Traveller Journey Assistance
10.3	Shared Transport Management	4. Manage Public Transport Operations
10.4	On-trip Public Transport Information	4. Manage Public Transport Operations 6. Provide Traveller Journey Assistance
10.5	Public Travel Security	2. Provide Safety and Emergency Facilities 4. Manage Public Transport Operations

4. Functional Architecture links to the outside World

4.1. Introduction

This section provides the definition and description of the terminators for the European ITS Framework Architecture. They are illustrated using the Context Diagram that shows the links between the terminators and the Architecture. Finally a table of acronyms is provided that will be used throughout the rest of this document.

4.2. Definition of Terminator

A terminator is the link between the Framework Architecture and the outside World. It provides a definition of what the Architecture expects the outside World to do, the data it is expected to provide, and the data to be provided to it by the Architecture. A terminator may be a human entity, a system, or a physical entity from which data can be obtained such as the atmosphere, or road surface. Both human entities and systems may be part of Organisations or Public Authorities that contribute in some way to the provision of ITS services. A rigorous definition is provided for each terminator, written in "shall" language. This is to make it easier to verify that the terminators do fulfil the roles that the Architecture expects. The terminators provide links to both the Functional and Physical Architectures so that the same terminator definitions will be found in the Physical Architecture document.
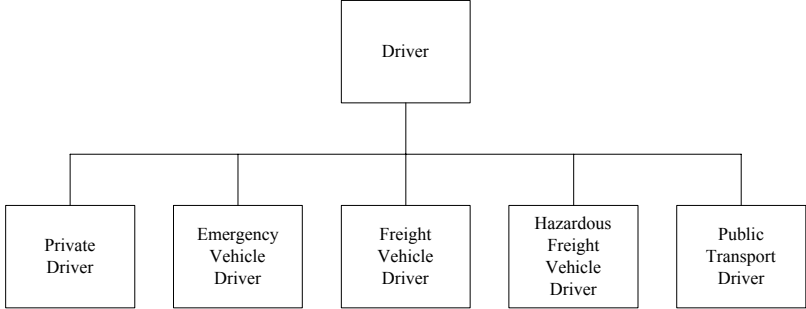
4.3. European ITS Architecture Terminator Definitions

There are twenty terminators for the European ITS Framework Architecture. They are defined in the following table, which provides their names and definitions. In every entry, the term "the System", with a capital 'S', means the implementation of the European ITS Architecture as a System.
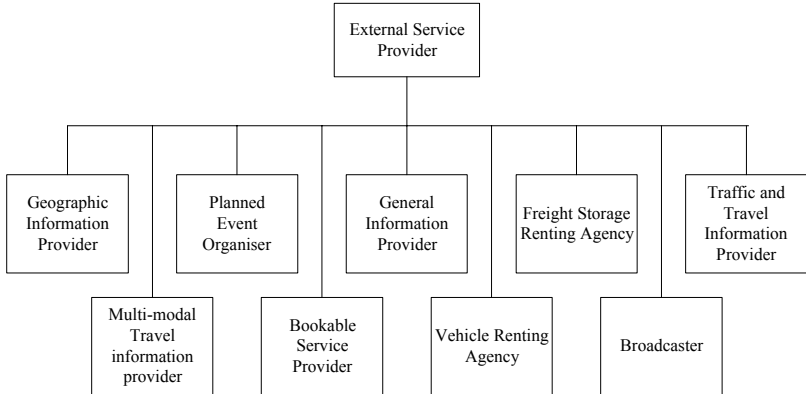
Table 3 European ITS Framework Architecture Terminator Definitions

Terminator Name	Terminator Description
Ambient Environments	This terminator shall represent the operational setting in which road-related ITS services interface and operate. It shall consist of weather effects such as snow, rain, fog, pollution effects such as dust, smoke, and man-made electromagnetic effects. This terminator is a physical entity from which data can be obtained. In this case the data shall be obtained through monitoring by appropriate functionality within the System. The data provided by this functionality shall enable Travellers to be informed about adverse conditions. The monitoring shall also enable Authorities and System Operators to choose relevant management strategies to minimise any adverse effects on the use of the road network
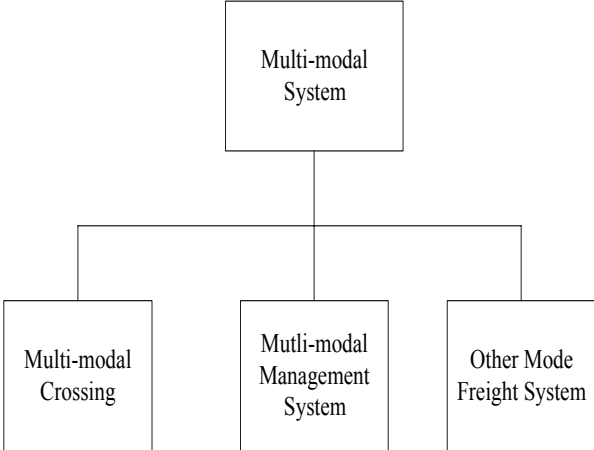
Terminator Name	Terminator Description
Bridge/Tunnel Infrastructure	This terminator shall represent the physical conditions of bridges and tunnels. It shall represent either the conditions themselves or systems that can detect these conditions. In the first case an analogue input shall be provided from the terminator, and in the second case an input containing data. In either case, the conditions shall comprise such things as the status of the bridge or tunnel infrastructure, atmospheric pollution levels on the bridge or in the tunnel, fire (tunnels only) and weather conditions (bridges only). When these are provided by analogue inputs, they must be monitored by appropriate functionality within the System to detect adverse conditions that could affect travel conditions. If data inputs are provided then they shall be capable of being interpreted by the System to determine if and when any adverse conditions prevail.
Cargo	This terminator shall represent all devices in which goods can be transported with some level of protection. These devices are not road vehicles or parts of road vehicles. However it must be possible for them to be carried by road vehicles. The prime example of a device represented by this terminator is the freight container. In this case such a container will have some on-board intelligence with which the System can communicate and exchange data about the cargo being carried.
Consignor/Consignee	This terminator shall represent human or physical entities that need freight (goods) to be transported from one place to place. When the transport is being arranged, the freight (goods) may be referred to as a "consignment". • Freight Shippers - the Sender/Recipient of goods and the owner of details regarding the goods. It shall interface with the System so that good may be prepared and accepted for transport; • Principal - an individual or more often an organisation that is the originator of a freight request. The actor may, after a period of negotiation, establish a contract for a freight service with a freight haulage company. After successful delivery of the Consignment the actor pays the company. It shall be possible for either or both of these actors to arrange for goods to be transported as a consignment, using facilities provided by the System.
Driver	This terminator shall represent the human entity that controls a licensed vehicle on the road network. Operators of Private, Freight, Public Transport and Emergency Services vehicles shall be included. The terminator shall originate Driver requests to, and receives driver information from the System. The actors generalised in the Driver terminator are shown below.
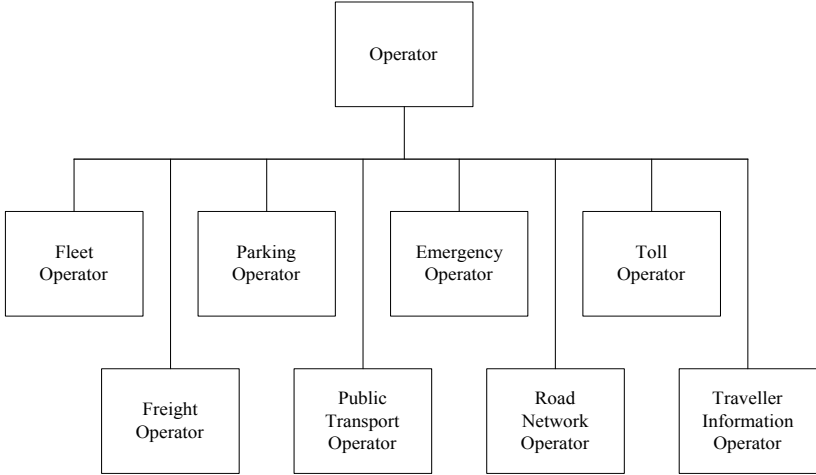
Terminator Name	Terminator Description
Driver (continued)	The actors generalised in the Driver terminator shall comprise those for vehicles such as Private Cars, Freight, Public Transport and Emergency Services. They are shown in the diagram below. Driver Private Driver — Emergency Vehicle Driver — Freight Vehicle Driver — Hazardous Freight Vehicle Driver — Public Transport Driver
Emergency Systems	This terminator shall represent systems that are designed for and used by Emergency Services as part of their operations. In this context the term "Emergency Services" shall include organisations that are responsible for services such as fire, police, ambulance and vehicle recovery. The Emergency Systems shall be able to co-ordinate the activities of individual Services. They shall dispatch and control the activities of the vehicles and personnel belonging to a particular Service when they attend incidents. The Emergency Systems shall be given information by the System about emergencies that its functionality has detected. In return the Emergency Systems shall provide reports on progress in dealing with the emergency to enable traffic and travel management strategies to be updated. The Systems shall also provide details of emergency situations affecting road transportation that are reported directly to them, such as through a Mayday call from a vehicle.
External Service Provider	This terminator shall include two types of actors who interface with the System. They shall be responsible for providing two different types of information. The first type of actor shall comprise the providers of information used by the System. It shall include information provided as a result of requests from the System. The first type of actor in this terminator shall comprise the providers of information used by the System. It shall include information provided as a result of requests from the System. The individual actors included in this type and what they provide shall comprise the following: • Bookable Service Provider - a provider of information about such services that can be booked. These shall comprise but not be limited to things such as accommodation, plus leisure and sports activities, events, etc.
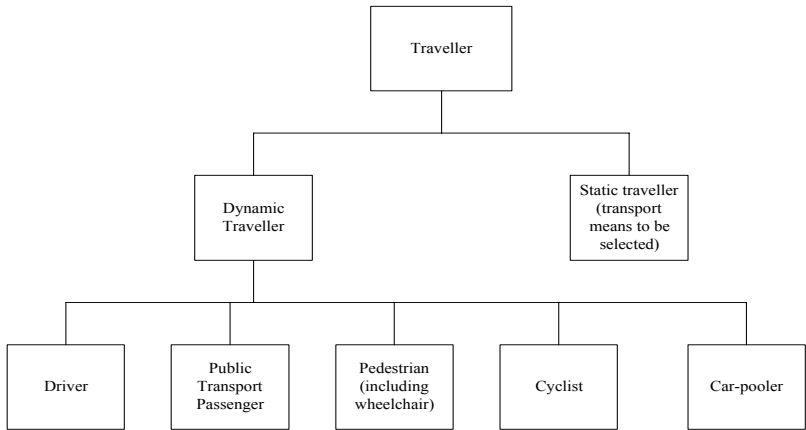
Terminator Name	Terminator Description
External Service Provider (continued)	• Freight Storage Renting Agency - an organisation from which is shall be possible to rent a freight storage area for individual cargo units. Rental shall be performed by a freight operator during the process of synchronising multi-mode transport or of providing the transport service to the consignor in case there is no storage area available at the destination. • General Information Provider - a provider of information about such services as garages, shops, banks, post offices, places of interest, tourist sites, town and city plans, etc.; • Geographic Information Provider - a provider of digitised map data that shall be for use in vehicles and where ever information or data output is to be shown against the background of a map; • Multi-modal Travel Information Provider - a provider of travel information for non-road transport modes (rail, waterborne and air), including details of multi-modal exchange facilities; • Planned Event Organiser - an organiser of external events that may have an impact on the travel conditions on the road network, such as football matches, parades, etc.; • Vehicle Renting Agency - an organisation from which it shall be possible to hire a vehicle for part of a trip. The definition of a vehicle shall comprise but not be limited to a car, coach (for parties), bicycle, taxi, aeroplane, train, or boat. The second type of actor shall comprise the providers of traffic and travel information based on data that originates from within the System. The following two actors fit into this category. • Broadcaster - a provider of traffic and travel information to travellers. It shall be possible for the broadcast mechanism to be through "live" radio (interrupting other programmes) or through other means, such as the Internet and wireless technologies. The information shall be freely available either as a public service or through sponsorship. • Traffic and Travel Information Provider - a provider of a subscription service through which travellers can obtain traffic and travel information. The style, presentation, availability and content of the information shall be the responsibility of each of the above two actors. In some cases the information may be based on data obtained from other sources.
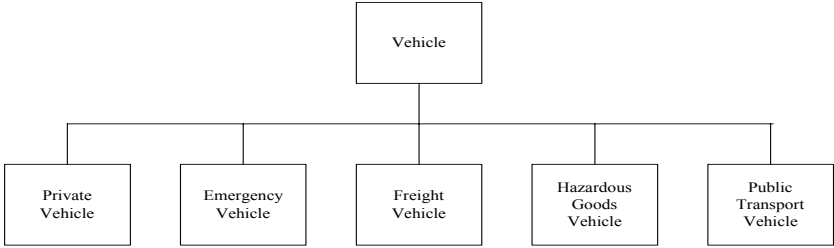
Terminator Name	Terminator Description
External Service Provider (continued)	The last two actors shall each use their own infrastructure(s) to provide the information to Travellers. Neither actor shall be able to input data directly to the System beyond requests for traffic and travel data that they will use as the basis of the information that they output. All the different actors of the two types that are included in the External Service Provider terminator and defined on the previous page are shown in the diagram below.
Financial Clearinghouse	This terminator shall represent the organisation(s) that process all electronic fund transfer requests originated from the System. These organisations shall enable the transfer of funds from the user of the System (i.e. a Traveller) to the provider of a service. Typically such transfers shall occur when a Traveller pays for services, such as tolls, or parking. These transfers shall also occur if at the same time, the Traveller pays for other services, such as accommodation.
Law Enforcement Agency	This terminator shall represent an Authority taking the necessary measures or actions to achieve compliance with laws, rules and regulations for the management of road traffic. If any violations of laws are detected by the System, the terminator shall provide sufficient data for the Authority to identify and initiate prosecution of the offenders. This data that is provided by the System shall as a minimum comprise such things as, visual image, vehicle identity, location, time, date, nature of violation.
Location Data Source	This terminator shall represent external entities that provide position information to the System. Typically this information shall be provided continuously without requests being made by any of the receiving Functions within the System. The information shall be used by these Functions in the determination of the position of vehicles and travellers within the road network managed by the System. Positional information is useful when for example, the location of a Public Transport vehicle is needed to determine the need for and timing of priority at junctions controlled by the System.

Terminator Name	Terminator Description
Maintenance Organisation	This terminator shall represent a human entities or Systems that are part of organisations able to carry out work to build and/or maintain a road network and/or can carry out maintenance on equipment that is part of the System. It shall be possible for the terminator to exchange data with the System in two ways. Firstly by providing information to the System about the time, place and duration of planned road works. The second way of exchanging data shall be when the terminator receives requests from the System for maintenance work to be performed. Maintenance activities shall include any repairs required to roadside sensors and actuators that form part of the System, and to Public Transport equipment. It shall also be possible for the status and completion of maintenance activities to be reported by the terminator to the System.
Multi-Modal System	This terminator shall represent any systems that manage the transportation of Travellers and Freight by modes that are other than those that use the road network. These modes shall comprise but not be limited to things such as heavy rail, water (canals, and other in-land waterways), ferry operations, and air services. All of them shall either have a direct interface with the road network (e.g. a crossing), or shall be available for use as part of a trip that can be planned and implemented by a Traveller, or be used for the transport of freight.

This terminator has been subdivided into the following actors.

 • Mutli-Modal Crossing - shall provide the input from a non-road based transportation system that has a physical interference with a road-crossing. This input shall enable the System to generate traffic control strategies that can grant temporary priority to the non-road traffic. Examples of actors that are included in this terminator are heavy rail systems, river bridges, etc. The System shall be able to send data requesting that the physical interfaces remain open to road traffic to enable the passage of emergency vehicles, or vehicles with hazardous goods. This may cause interruption to the other mode, e.g. a train may have to stop and wait for a road crossing to open.

 • Multi-Modal Management System - shall provide the link to other non-road information or control systems that may need to exchange information with the System. Access to these systems shall be used to enable trip planning, or to exchange information about incidents that have occurred. It shall be possible for these incidents may be in the network controlled by either the System or the Related Multi-modal System. |

Terminator Name	Terminator Description
Multi-Modal System (continued)	• Other Mode Freight System - shall provide the link to systems that are responsible for the conveyance of freight using modes of transport other than road, e.g. water, air, and rail. These systems shall exchange data with the System to enable the synchronisation between the use of the different modes in order to maximise the efficiency of freight transport, e.g. to reduce the waiting time at modal interchanges. The actors included in this terminator and described above are illustrated in the diagram shown below. Multi-modal System Multi-modal Crossing Mutli-modal Management System Other Mode Freight System
Operator	This terminator shall comprise a diverse set of human entities who can perform privileged interactions with the System, thereby contributing to the way in which it operates. It shall be possible for this contribution to include the planning, monitoring, controlling and the evaluation of the System operation. The scope of the human entities (actors) included in this terminator is shown in the diagram below. It shall be possible for some or all of them to be combined into a lesser number of entities for particular System implementations. Thus for example, it shall be possible for the Freight Operator and the Fleet Operator to be the same human entity if required by a particular implementation. The Road Network Operator actor includes both the Traffic Operator who is the user of the System and the System Operator who is its guardian. The Traffic Operator will use the System to manage traffic, whilst the System Operator will control the way in which the System manages traffic and the static data that it uses.

Terminator Name	Terminator Description
Operator (continued)	The diagram below shows the actors that are included in the Operator terminator. *(diagram: Operator hierarchy showing Operator at top, with Fleet Operator, Parking Operator, Emergency Operator, Toll Operator, and Freight Operator, Public Transport Operator, Road Network Operator, Traveller Information Operator)*
Road Pavement	This terminator shall represent road-surfacing material whose status is monitored by the System. The data that is collected shall enable the System to decide what maintenance operations are necessary to ensure that the surface causes no hazard to vehicles, pedestrians, as well as those in wheelchairs, or have imperfect sight. The different status of the road surfacing that can be measured shall include but not be limited to conditions such as ice, flood water, landslides, etc.
Road Related System	This terminator shall represent a link to other instances of Systems that have been produced using the European ITS Framework Architecture. Typically these Systems shall be located in TCC's or TIC's that either serve other geographic areas, or are part of other organisations serving the same geographic area. This terminator shall enable traffic and travel information as well as traffic flows and control strategies to be exchanged with these other Systems. It shall be possible for data to and from these other Systems to be requested by either System, or for it to be exchanged between the Systems at regular intervals.
Traffic	This terminator shall represent the movement of vehicles along a route. Traffic shall depict the vehicle population from which traffic surveillance information is collected and upon which traffic management measures are applied. It shall be possible for the movement of vehicles shown by this terminator to be manifest to the System in a number of forms. These shall include but not be limited to such things as video, laser or infra-red images, magnetic signature or any other way in which the presence of a vehicle can be determined.

Terminator Name	Terminator Description
Transport Planner	This terminator shall represent the human entities and/or systems that are responsible for planning changes to the structure of the road transportation network managed by the System. It shall be possible for them to use information gathered by the System and to provide input and guidance to enable the System to produce strategies that can be implemented to optimise transport network use. This optimisation may be required for incident management, or to influence the demands for particular modes of road transport so that particular transport policies may be implemented.
Traveller	This terminator shall represent as an actor any human entity who uses (or is about to use) a transportation service provided by the System. Such a human entity shall be called a Traveller. It shall be possible for the service provided by the System to be available to a Traveller across all road related modes of travel. These shall comprise, Public Transport, private car, cycling and walking. Travellers shall also be able to use other modes of transport through the interfaces provided by the System to other terminators.
	The Traveller shall be able to interact with the System to get travel information and to plan a trip. When doing this, the Traveller is assumed to be static and is thus the Static Traveller actor. If the Traveller embarks on a trip he/she becomes a Dynamic Traveller. Such a Traveller may be a Driver, a Public Transport passenger, a Pedestrian, a Cyclist, or a Car Pooler. It is possible for a Dynamic Traveller to switch between any of these actors depending on the mode(s) used between the origin and destination of the trip.
	The actors that are included in the Traveller Terminator are shown in the diagram below.
	Note: the Driver actor is further decomposed by Vehicle type as a separate Terminator – see previous definition.

Terminator Name	Terminator Description
Vehicle	This terminator shall represent the Vehicle in terms of parameters connected with its operation and devices or systems that can be used to change its operation through the action of the System. The parameters shall be monitored by sensors within the System and shall comprise but not be limited to the physical movement, orientation, location and condition of the Vehicle, plus the condition of the Driver. For Public Transport Vehicles the number of its passengers and their requests for fare payment and other services shall be included, whilst the condition of the cargo shall be included for Freight Vehicles. The in-vehicle devices and systems represented by this terminator shall either be those that are standard fittings or be those needed to enable specific other services to be provided. Examples of such devices shall comprise but not be limited to, engine management, automatic braking systems, power assisted steering, cruise control, climate control, entertainment, air bag deployment, central locking and vehicle transmission operation. The individual actors that have been included in this terminator are illustrated in the diagram shown below.
Weather Systems	This terminator shall represent the system or human entity that provides general area weather information and weather forecasts to the System. The information that is provided shall comprise things such as temperature, fog, rain and wind (direction and strength), whilst the forecasts shall predict changes in these conditions. It shall be possible for both types of information to be provided on a regular basis or on request from the System. The System shall also be able to send information back to the terminator. This information shall cover weather conditions that have been determined by functionality in the System.

The above table is important because it defines the functionality in each of the Terminators and also sets the System boundary. This boundary defines what is "inside" and "outside" the System. Things that the System needs to provide the ITS services required by the User Needs are "inside" the System, e.g. Vehicle detectors and other roadside device. However so far as the Vehicle is concerned, only those devices needed to implement ITS services are included "inside" the System. This means that the systems for such things as automatic cruise control, engine management, traction control, brake control, air conditioning, and air-

bag deployment that are currently fitted as standard to most Vehicles are "outside" the System.

4.4.   Context Diagram

The connections between the twenty terminators defined in the previous section and the System are shown by the Context Diagram in Figure 1 below. Each terminator is linked to the System by a terminator Data Flow. Those shown in the Context Diagram are the Top Level, or Context Terminator Data Flows. The definitions for each of the Data Flows on this diagram (including a list of their constituent Data Flows) will be found in part of Annex 2 to this Document.

Figure 1 European ITS Framework Architecture Context Diagram
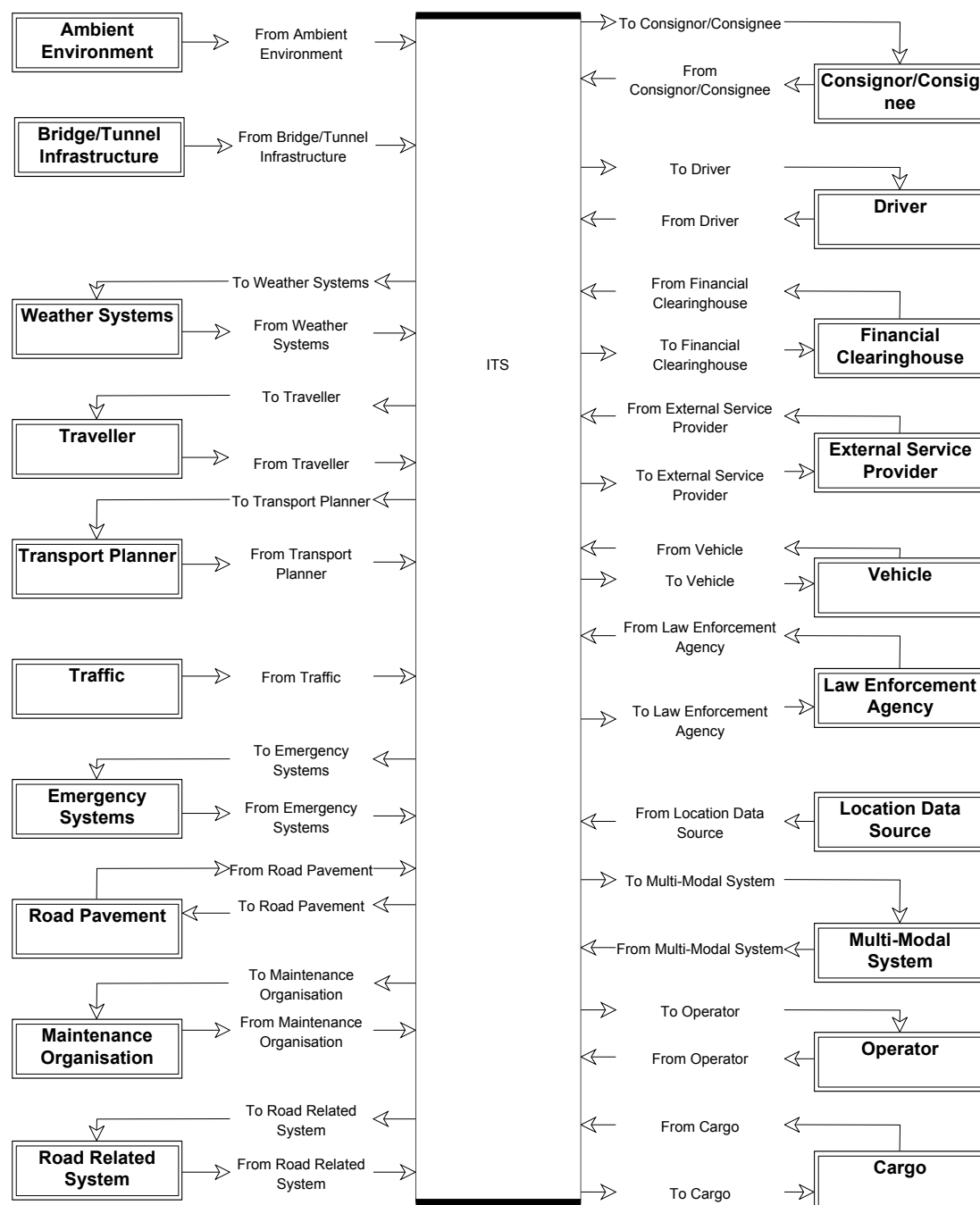
4.5.   Table of Acronyms

A set of acronyms has been created for each of the terminators and is shown by Table 4 below. They utilise the initial letter or a set of letters that represents the terminator name. The set includes acronyms for the actors identified as being part of terminators. These acronyms are in two parts, the first being the acronym for the terminator to which the actor belongs. The objective is to provide consistency in the use of names across all the Data Flows Diagrams (DFD's) and within the databases for Function, Data Flow and Data Store definitions.

Table 4 Terminator Acronyms

Terminator Name	Actor (sub-terminator) Name	Acronym
Ambient Environment		ae
Bridge/Tunnel Infrastructure		tbi
Cargo		ca
Consignor/Consignee		cc
	Freight Shipper	cc.fs
	Principal	cc.p
Driver		d
	Emergency Vehicle Driver	d.e
	Freight Vehicle Driver	d.fvd
	Hazardous Freight Vehicle Driver	d.hfvd
	Private Driver	d.pr
	Public Transport Driver	d.ptd
Emergency Systems		es
External Service Provider		esp
	Bookable Service Provider	esp.bsp
	Broadcaster	esp.b
	Freight Storage Renting Agency	esp.fsra
	General Information Provider	esp.gip
	Geographic Information Provider	esp.g
	Multi-Modal Travel Information Provider	esp.mmtip
	Planned Event Organiser	esp.peo
	Traffic and Travel Information Provider	esp.ttip
	Vehicle Renting Agency	esp.vra
Financial Clearinghouse		fc

Terminator Name	Actor (sub-terminator) Name	Acronym
Law Enforcement Agency		lea
Location Data Source		
Maintenance Organisation		mo
Multi-Modal System		mms
	Multi-Modal Crossing	mms.mmc
	Multi-Modal Management System	mms.mmms
	Other Mode Freight System	mms.omfs
Operator		o
	Emergency Operator	o.eo
	Fleet Operator	o.flo
	Freight Operator	o.fro
	Parking Operator	o.po
	Public Transport Operator	o.pto
	Road Network Operator	o.rno
	Toll Operator	o.to
	Traveller Information Operator	o.tio
Road Pavement		rp
Road Related System		rrs
Traffic		trfc
Transport Planner		tp
Traveller		t
	Car-Pooler	t.cp
	Cyclist	t.c
	Driver	d
	Dynamic Traveller	dt
	Pedestrian	t.p
	Public Transport Passenger	t.ptp
	Static Traveller	st
Vehicle		v
	Emergency Vehicle	v.ev
	Freight Vehicle	v.fv
	Hazardous Freight Vehicle	v.hfv
	Private Vehicle	v.p

Terminator Name	Actor (sub-terminator) Name	Acronym
	Public Transport Vehicle	v.ptv
Weather Systems		ws

These acronyms are used as part of Data Flow names in the rest of the European ITS Functional Architecture Main Document and in its three Annexes.

4.6.   Use of Terminators by Functional Area

Not all of the Terminators will be used by every Functional Area. This is because some Terminators are specific to the functionality in each of the Areas. The distribution of the use of the Terminators between the Areas is shown by the table below an on the following pages.

Table 5 Use of Terminators by Functional Areas

Terminator Name	Functional Area		Flow Direction
	Name	No.	
Ambient Environment	Manage Traffic	3	I
Bridge/Tunnel Infrastructure	Manage Traffic	3	I/O
Consignor/Consignee	Manage Freight and Fleet Operations	8	I/O
Driver	Manage Freight and Fleet Operations	8	I/O
	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
	Provide Advanced Driver Assistance Systems	5	I/O
	Provide Electronic Payment Facilities	1	I/O
	Provide Security and Emergency Facilities	2	I/O
	Provide Support for Law Enforcement	7	I/O
	Provide Traveller Journey Assistance	6	O
Emergency Systems	Provide Security and Emergency Facilities	2	I/O
External Service Provider	Manage Freight and Fleet Operations	8	I/O
	Manage Public Transport Operations	4	I
	Manage Traffic	3	I/O
	Provide Advanced Driver Assistance Systems	5	I/O
	Provide Electronic Payment Facilities	1	I/O
	Provide Security and Emergency Facilities	2	I/O
Financial Clearinghouse	Provide Electronic Payment Facilities	1	I/O
Freight Equipment	Manage Freight and Fleet Operations	8	I/O
Law Enforcement Agency	Manage Freight and Fleet Operations	8	I/O
	Provide Support for Law Enforcement	7	I/O
Location Data Source	Manage Freight and Fleet Operations	8	I

Terminator Name	Functional Area		Flow Direction
	Name	No.	
	Provide Advanced Driver Assistance Systems	5	I
	Provide Security and Emergency Facilities	2	I
	Provide Traveller Journey Assistance	6	I
Maintenance Organisation	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
	Provide Advanced Driver Assistance Systems	5	I
Multi-Modal System	Manage Freight and Fleet Operations	8	I/O
	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
Operator	Manage Freight and Fleet Operations	8	I/O
	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
	Provide Electronic Payment Facilities	1	I/O
	Provide Security and Emergency Facilities	2	I/O
	Provide Traveller Journey Assistance	6	I/O
Related Road System	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
	Provide Advanced Driver Assistance Systems	5	I
Road Pavement	Manage Public Transport Operations	4	I
	Manage Traffic	3	I
	Provide Advanced Driver Assistance Systems	5	I/O
Traffic	Manage Traffic	3	I
	Provide Advanced Driver Assistance Systems	5	I
Transport Planner	Manage Traffic	3	I/O
Traveller	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I/O
	Provide Electronic Payment Facilities	1	I/O
	Provide Security and Emergency Facilities	2	I/O
	Provide Traveller Journey Assistance	6	I/O
Vehicle	Manage Freight and Fleet Operations	8	I/O
	Manage Public Transport Operations	4	I/O
	Manage Traffic	3	I
	Provide Advanced Driver Assistance Systems	5	I/O
	Provide Electronic Payment Facilities	1	I
Weather Systems	Manage Traffic	3	I

Terminator Name	Functional Area		Flow Direction
	Name	**No.**	
	Provide Advanced Driver Assistance Systems	5	O

The symbol "I" means that data is sent from the Terminator to the Functional Area, whilst the "O" symbol means that the data is sent from the Functional Area to the Terminator. The "I/O" symbol means that data is sent in both directions.

Descriptions (including lists of constituent Data Flows) of the main Data Flows that link the Terminators to the System and their descriptions will be found in Annex 2 of this Document.

5. Functional Architecture Overview

5.1. Introduction

This chapter provides an overview of the functionality in the Functional Architecture. This is the top level of the functional breakdown (often called "functional decomposition") of the System shown in the middle of the Context Diagram - see Figure 1.

5.2. Functional Area Definitions

The Functional Architecture has been divided into eight Functional Areas. These contain Functions, Data Flows and Data Stores that are closely related to each other and are part of the System. The number, name and functionality included in each of the Areas is defined in the following table. Each definition is written in "shall" language to make it easier to verify that the Area does provide the functionality that the Architecture expects.

Table 6 Functional Area Definitions

Area Number	Area Name	Area Description
1.	Provide Electronic Payment Facilities	This Area shall provide functionality that enables the acceptance of payment for services provided by other Functional Areas within the Architecture. It shall have an interface with the Financial Clearinghouse terminator to enable actual payment transactions to be made. If fraudulent payment is detected, any details that are available shall be passed to functionality in the Law Enforcement Area.
2.	Provide Safety and Emergency Facilities	This Area shall provide functionality that enables the Emergency Services to respond to incidents. The Functions in this Area shall have links with the Manage Traffic Area to enable the reporting and detection of incidents, the management of their impacts and the granting of priority to Emergency Vehicles. It shall be possible for priority to be provided either locally at each controlled point on the road network, or as a "route" through the network. There shall be links to the Provide Traveller Journey Assistance Area to enable priority routes for Emergency Vehicles to be produced.

Area Number	Area Name	Area Description
3.	Manage Traffic	This Area shall provide functionality enabling the management of traffic in urban and inter-urban environments. Functionality shall be included to detect and manage the impact of incidents, produce and implement demand management strategies, monitor car park occupancies and provide road transport planning. Links shall be provided to the Provide Safety and Emergency Facilities and Manage Public Transport Areas so that their vehicles are given priority through the road network and to enable assistance to be provided in the implementation of incident and demand management strategies. The External Service Provider terminator shall be sent data about traffic conditions and strategies.
4.	Manage Public Transport Operations	This Area shall provide functionality to enable the management of Public Transport. It shall include the scheduling of services and the generation of information that can be made available to travellers. The Area shall have links with the Manage Traffic Area to provide priority for its vehicles, and to provide data on the use of services so that an assessment can be made of demand for different modes of transport. The Manage Traffic Area shall also provide requests for service changes to enable a move towards a better balance in the use of transport modes. There shall also be links to other Areas to provide information about fraud and incidents that have been detected in the Public Transport network.
5.	Provide Advanced Driver Assistance Systems	This Area shall provide functionality that enables the control of vehicles whilst they are using the road network. Interfaces shall be provided to the Provide Safety and Emergency Facilities Area to provide a speedy response to "mayday" calls from vehicles. Vehicle identities shall be provided to other Areas for payment collection and the identification of fraud. Functionality shall also be provided to enable the output of traffic and travel information provided by the Manage Traffic Area.
6.	Provide Traveller Journey Assistance	This Area provides functionality that enables the provision of information to all types of travellers about traffic conditions and about other modes of transport. Functions also provide route determination and guidance, plus travel planning. This includes access to other services such as accommodation.

Area Number	Area Name	Area Description
7.	Provide Support for Law Enforcement	This Area shall provide functionality to enable the provision of an interface to Law Enforcement agencies. This interface shall be used to provide information about frauds and violations that have been detected by functionality within other Areas. Examples of frauds and violations shall include but not be limited to invalid or missing payment, speeding, incorrect use of lanes in the road, incorrect observance of other commands sent to drivers. Over-weight vehicles shall be detected by functionality within the Area itself and the details passed to the Law Enforcement Agency.
8.	Manage Freight and Fleet Operations	This Area shall provide functionality that enables the management of Freight and Fleet Operations. This shall control the use of freight vehicles and their transportation of goods. The use of other modes of freight transport shall also be supported. An interface to the Provide Safety and Emergency Facilities Area shall also be included to enable the provision of information about hazardous goods. Route planning for this and other types of goods shall be provided through the interface to the Provide Traveller Journey Assistance Area.

All the Areas themselves breakdown into sets of Functions and Data Stores, with Data Flows between them. Details of the way in which they are described and their structure are provided in the section of this chapter.

The interface between the Functional Areas is provided through the data that flows between them. This is shown in the highest level Data Flow Diagram, called DFD0, in Figure 2 on the next page.

The Data Flows linking the Areas are defined in the last section of Annex 2. Almost every Data Flow consists of a number of constituent Data Flows that are also described in Annex 2

Figure 2 Functional Area Diagram (DFD0)

5.3.   Detailed Functional Area Descriptions

The next and subsequent chapters provide a more detailed description of each of the eight Functional Areas identified in the previous section.   For each Functional Area textual overview descriptions are provided, covering the various levels of functionality shown by the DFD's.

The definition of what is a Function, how it is divided into two types, plus the definitions of what are Data Stores and Data Flows has already been provided in Chapter 2. It is essential that this is read and understood before reading the following Chapters.

Each Chapter is designed to be read on its own, without the need to refer to any of the other Chapters.   This has been done so that selected parts of the functionality can be studied without necessarily referring to the other parts.

6.　　Area 1. Provide Electronic Payment Facilities

6.1.　Introduction

This chapter describes the functionality in Area 1　Provide Electronic Payment Facilities. The functionality in Area 1 has prime responsibility for the collection of electronic payments for services.　These payments are based on "contracts" that have previously been set up using functionality within the Area.　Fraudulent payment is also detected.

6.2.　DFD 1 - High Level Functions in Provide Electronic Payment Facilities

At the highest level the functionality for this area is divided into the following High level functions :

　　　F 1.1 Set up Contract

　　　F 1.2 Manage User's Account

　　　F 1.3 Perform Electronic Payment Transaction

　　　F 1.4 Manage Operators' Revenue

　　　F 1.5 Control Fraud

　　　F 1.6 Manage Tariffs and Access Rights

The Functions provide the means to perform electronic payment related to the different services offered by the system.　A small number of Data Flows between the Functions enable them to communicate with each other.　There are also a larger number of Data Flows that enable the Functions to exchange data with other Areas and with the terminators.　These Data Flows and the Functions are shown in the highest level DFD for Area 1 - DFD 1.　This is contained in the Figure on the next page.

The functionality in this Area is based on the notion of contracts established between the user and the service providers or operators.　It enables the definition of the service to be used and the mode of payment.　The functionality encompasses the elaboration of the contract, the management of users and operators' accounts, the performance of the financial transaction, the detection of frauds related to these operations, and the management of the tariffs and access data stores.

The six High Level Functions in DFD 1 divide into Low Level Functions.　These are described in the following sections.

Figure 3 DFD 1 Provide Electronic Payment Facilities
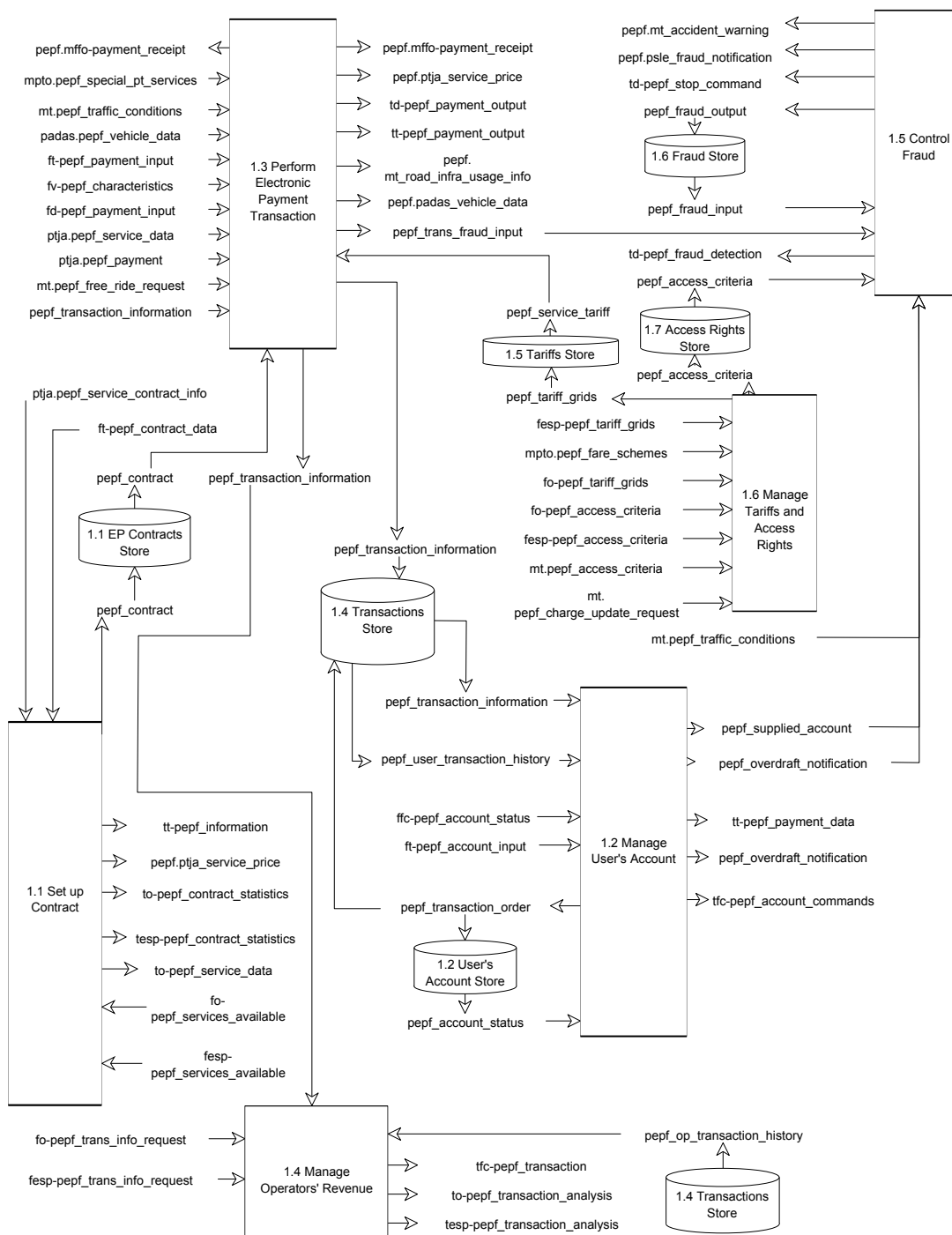
6.3.   Function 1.1 Set up Contract

This high level Function in the Provide Electronic Payment Facilities Area provides functionality to set up a contract for the collection of electronic payment. It is divided into two lower level Functions that are as follows:

F 1.1.1 Create EP Contract

F 1.1.2 Establish Contract Statistics

F 1.1.3 Manage Service Data

These three Functions enable contracts for the collection of electronic payment to be set up and provide details of the contracts. Radiating from these Functions are a few Data Flows that enable them to exchange data with the Data Store and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.1 - DFD 1.1.

Figure 4 DFD 1.1 Set up Contract
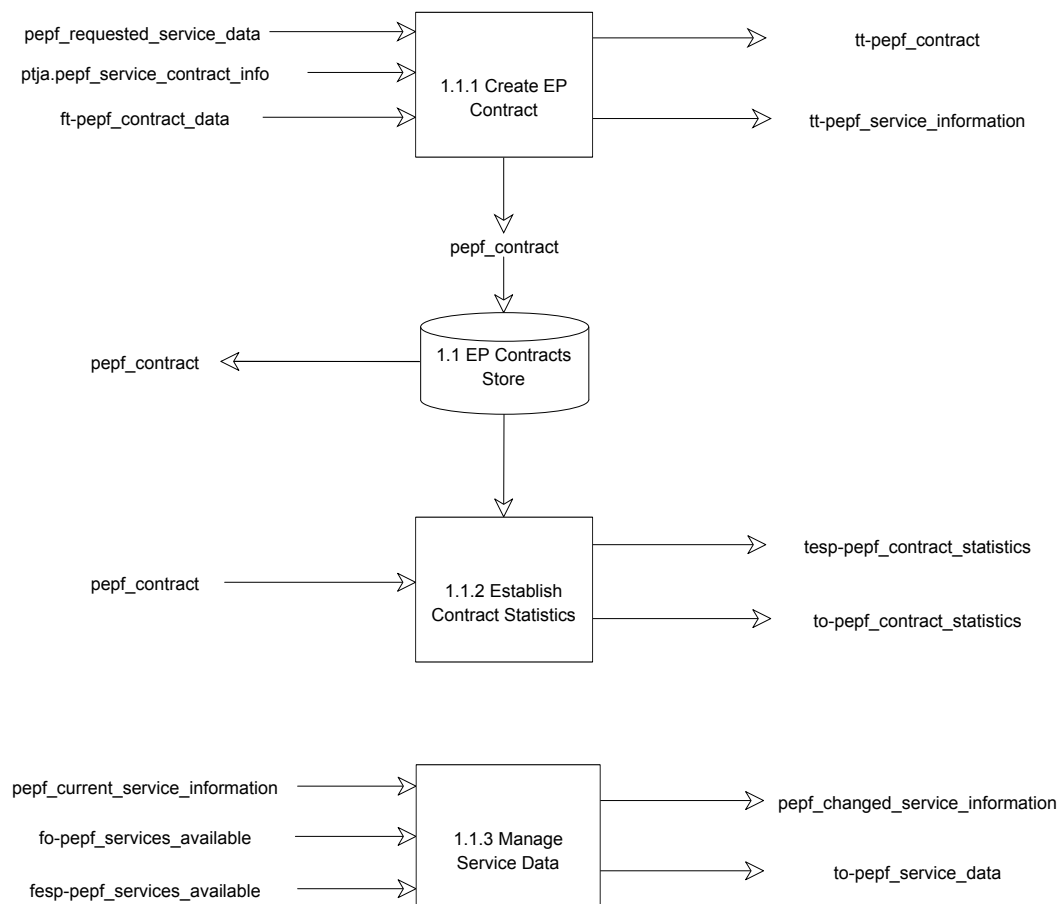
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1), the Data Flows are described in Annex 2, and the Data Stores in Annex 3. The Create EP Contract Function (F1.1.1) enables a "contract" or authorisation to be set up for the use of one or more ITS services.

The information about this authorisation is stored by the Function in the EP Contracts Store (D1.1). The Establish Contract Statistics Function (F1.1.2) provides statistical summaries of these authorisations for use by the relevant service providers. The Manage Service Data Function (F1.1.3) receives information from the Operators about the services that are

available and thus keeps the Service Information Store (D1.3) up-to-date. Both Data Stores are shared with functionality in other parts of the Area.

6.4.   Function 1.2 Manage User's Account

This high level Function in the Provide Electronic Payment Facilities Area provides functionality to users' accounts for electronic payment. It is divided into three lower level Functions that are as follows:

> F 1.2.1 Load User's Account
>
> F 1.2.2 Debit User's Account
>
> F 1.2.3 Inform Users on Transactions

The Functions manage the operation of users' accounts. They can use these accounts as a mechanism through which to pay for ITS services. Radiating from these Functions are several Data Flows, some of which enable the Functions to load and read data from Stores. The remainder enable the Functions to exchange data with other functionality in the Provide Electronic Payment Facilities Area and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.2 - DFD 1.2.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1) , the Data Flows are described in Annex 2, and the Data Stores in Annex 3.

The Load User's Account Function (F1.2.1) works under the control of the Traveller to transfer credit from a Financial Clearinghouse to the User's Account Store (D1.2). If necessary these transfers can be on a per "contract" basis, by checking the contents of the EP Contracts Store (D1.2) for the services that the Traveller is authorised to use.

The Debit User's Account Function (F1.2.2) debits the User's Account Store (F1.2) by an amount contained in the pepf_transaction_information Data Flow. If the Function finds that there are insufficient funds in the User's Account Data Store (D1.2) then an overdraft message will be sent to the Detect Payment Violations Function (F1.5.2).

All credit and debit transactions are recorded in the Transaction Data Store (D1.4) and the Traveller may get a summary of them on request to the Inform Users on Transactions Function (F1.2.3).

Figure 5 DFD 1.2 Manage User's Account
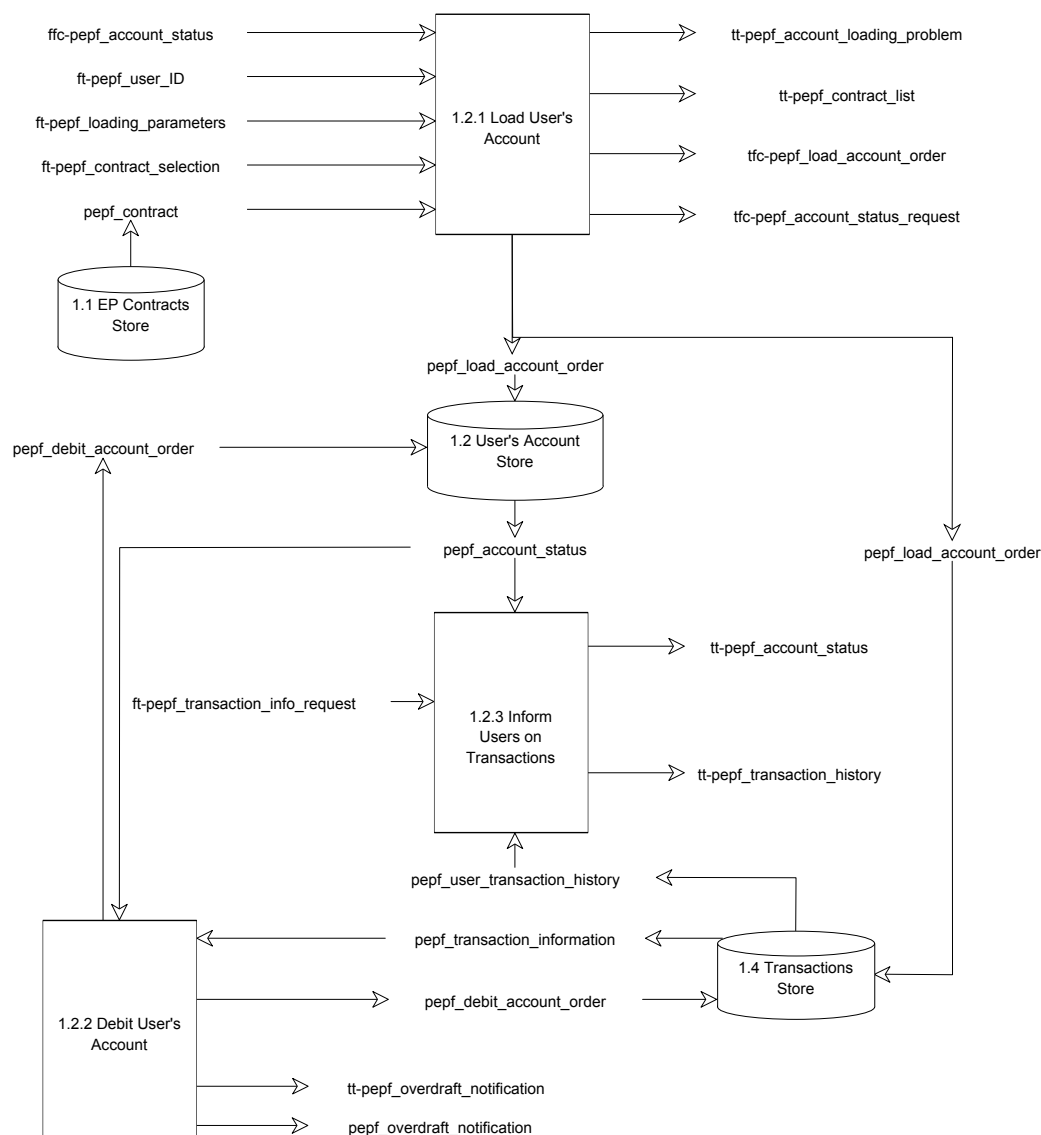
6.5. Function 1.3 Perform Electronic Payment Transaction

This high level Function in the Provide Electronic Payment Facilities Area provides functionality to perform the actual electronic payment transaction. It is divided into seven lower level Functions that are as follows:

F 1.3.1 Detect User

F 1.3.2 Identify User

F 1.3.3 Check User's Contract

F 1.3.4 Inform and Guide User

F 1.3.5 Compute Service Fee

F 1.3.6 Check Advanced Payment

F 1.3.7 Recover Fee

The Functions identify that a user has to pay and if no advanced payment has been made, collect the payment. Radiating from these Functions are a large number of Data Flows, some of which enable the Functions to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Provide Electronic Payment Facilities Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.3 - DFD 1.3.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1), the Data Flows are described in Annex 2, and the Data Stores in Annex 3.

When a Traveller wishes to use an ITS service he or she, or their vehicle, is detected by the Detect User Function (F1.3.1). When a vehicle is detected, then the Traveller becomes a Driver so far as the following transactions are concerned. In a multi-modal trip it is therefore possible for the Traveller and Driver ID to actually be the same. The Detect User Function sends a signal to the Identify User Function (F1.3.2) so that if necessary the Traveller (or the Driver in a vehicle) can be identified.

Control then passes to the Inform and Guide User Function (F1.3.4) to discover the manner in which the payment shall be made. This may be either via a dialogue with the Traveller, or from the ITS service that is about to be used. If necessary the Check User's Contract Function (F1.3.3) is used to check that the Traveller is authorised to use the service. The Compute Service Fee Function (F1.3.5) then calculates the amount of money due.

If necessary, the Check Advanced Payment Function (F1.3.6) is used to see whether the Traveller has a credit balance to pay for that service. The Recover Fee Function (F1.3.7) receives the amount due from the Inform and Guide User Function (F1.3.4) and then proceeds to recover the amount either directly from the Traveller's payment card, or by debiting the user's account - see the Debit User's Account Function (F1.2.2).

Figure 6 DFD 1.3 Perform Electronic Payment Transaction
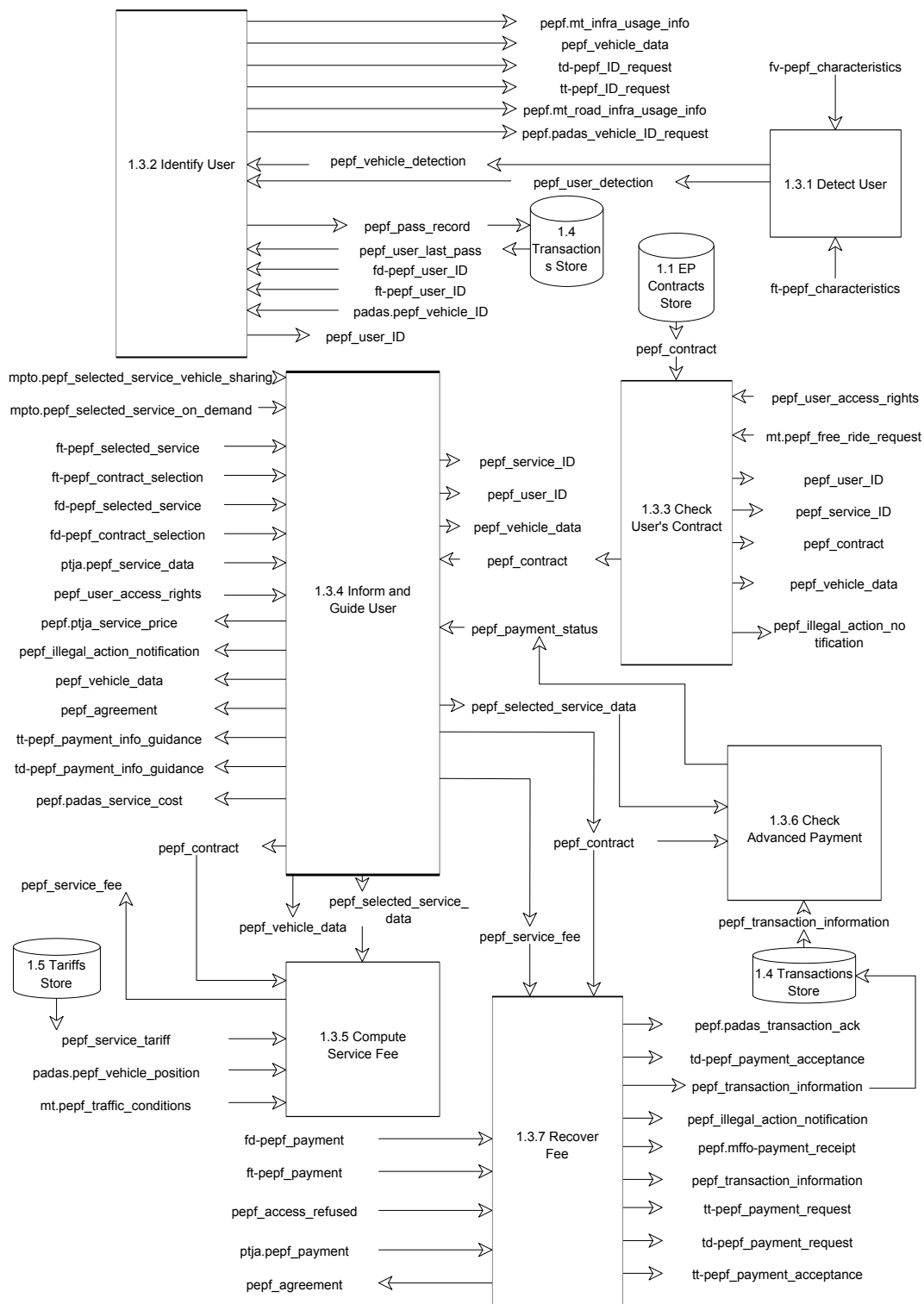
6.6.   Function 1.4 Manage Operators' Revenue

This high level Function in the Provide Electronic Payment Facilities Area and enables the payments that have been collected to be distributed to the correct providers of the services. It is divided into three lower level Functions that are as follows :

F 1.4.1 Distribute Fees Revenue

F 1.4.2 Credit Operator's Account

F 1.4.3 Inform Operators on Transactions

The Functions receive information about the payment that have been made and distributes the payments, informing the Operator of what has happened. Radiating from these Functions are a few Data Flows, one of which enables two Functions to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Provide Electronic Payment Facilities Area and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.4 - DFD 1.4.

Figure 7 DFD 1.4 Manage Operators' Revenue
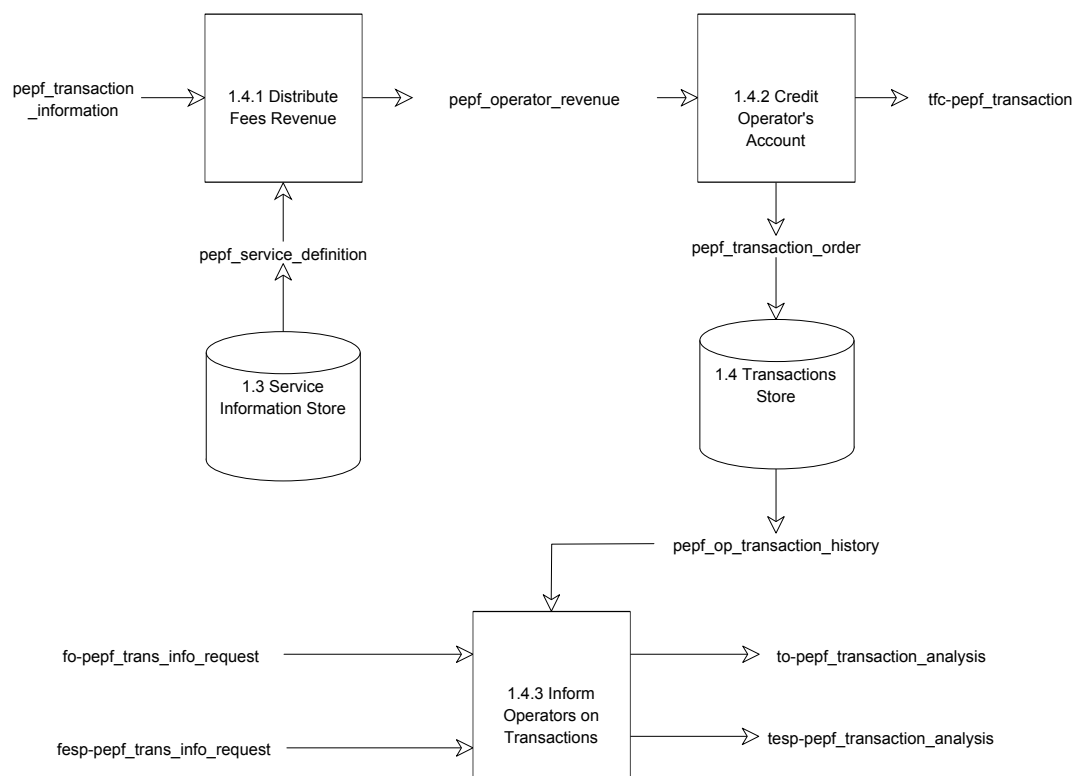
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1), the Data Flows are described in Annex 2, and the Data Stores in Annex 3.

For each transaction the Distribute Fees Revenue Function (F1.4.1) looks in the Service Information Data Store (D1.3) for the Operator(s), or Service Provider(s), to whom the fee should be credited. The "operator(s)" may be those running toll roads, bridges, or providing PT services.   The Credit Operator's Account Function (F1.4.2) then asks the Financial

Clearinghouse to make the required payment, whilst recording this fact in the Transaction Data Store (D1.4).

The Inform Operators on Transactions Function (F1.4.3) enables System Operators, or those working for Service Providers, to view all the transactions concerning the ITS services that have been provided.

6.7. Function 1.5 Control Fraud

This high level Function in the Provide Electronic Payment Facilities Area provides functionality to control fraud that may arise with the collection of electronic payments. It is divided into four lower level Functions that are as follows:

> F 1.5.1 Check User's rights
>
> F 1.5.2 Detect Payment Violations
>
> F 1.5.3 Detect Access violations
>
> F 1.5.4 Block Access

The Functions check users' access rights and detect payment violations, blocking access if a violation is detected. Three Data Flows enable three of these Functions to exchange data with each other. There are several other Data Flows that enable the Functions to exchange data with other parts of the Provide Electronic Payment Facilities Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.5 - DFD 1.5.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1) , the Data Flows are described in Annex 2, and the Data Stores in Annex 3.

The Check User's Rights Function (F1.5.1) is called by the Check User's Contract Function (F1.3.3) to check the user's "legal" rather than "contractual" right to use a service. The Detect Payment Violations Function (F1.5.2) receives information from the Check User's Contract Function (F1.3.3) and the Debit User's Account Function (F1.2.2) as to whether an attempt to access, or pay for an ITS service, was successful or not.

Unsuccessful attempts are recorded in the Fraud Data Store (D1.6), which can be checked on request by F1.5.2. Records of bad debts can be cleared when information from the Load User's Account Function (F1.2.1) indicates that sufficient funds have been credited to the account. The Detect Access Violation Function (F1.5.3) is activated by the Inform and Guide User Function (F1.3.4) when access to a service has been refused, or by the Recover Fee Function (F1.3.7) whenever a fee has not been recovered from the Traveller.

The Block Access Function (F1.5.4) receives commands from both the Detect Payment and Detect Access Violation Functions (F1.5.2 and F1.5.3) to block the access to the service in the event of a non-payment or when the Traveller possesses no authorisation.

Figure 8 DFD 1.5 Control Fraud
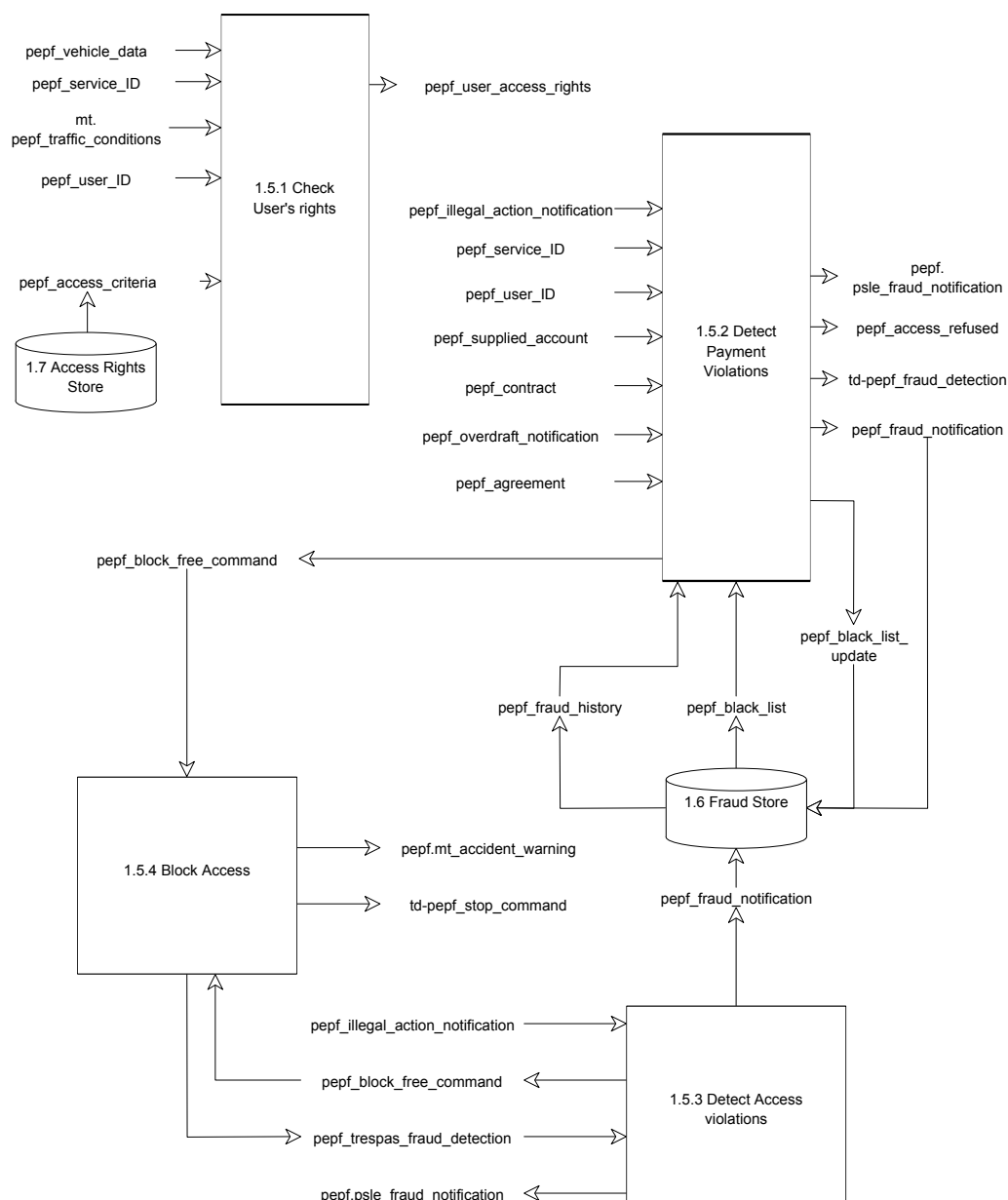
6.8. Function 1.6 Manage Tariffs and Access Rights

This high level Function in the Provide Electronic Payment Facilities Area provides functionality for the management of tariffs and access rights. It is divided into two lower level Functions that are as follows:

F 1.6.1 Manage Tariffs

F 1.6.2 Manage Access Rights

The Functions perform act independently to enable input of data into the Stores of tariffs and access rights. The few Data Flows enable the Functions to exchange data with other Areas

and with the terminators. The Functions and Data Flows are contained in the DFD for Function 1.6 - DFD 1.6.

Figure 9 DFD 1.6 Manage Tariffs and Access Rights
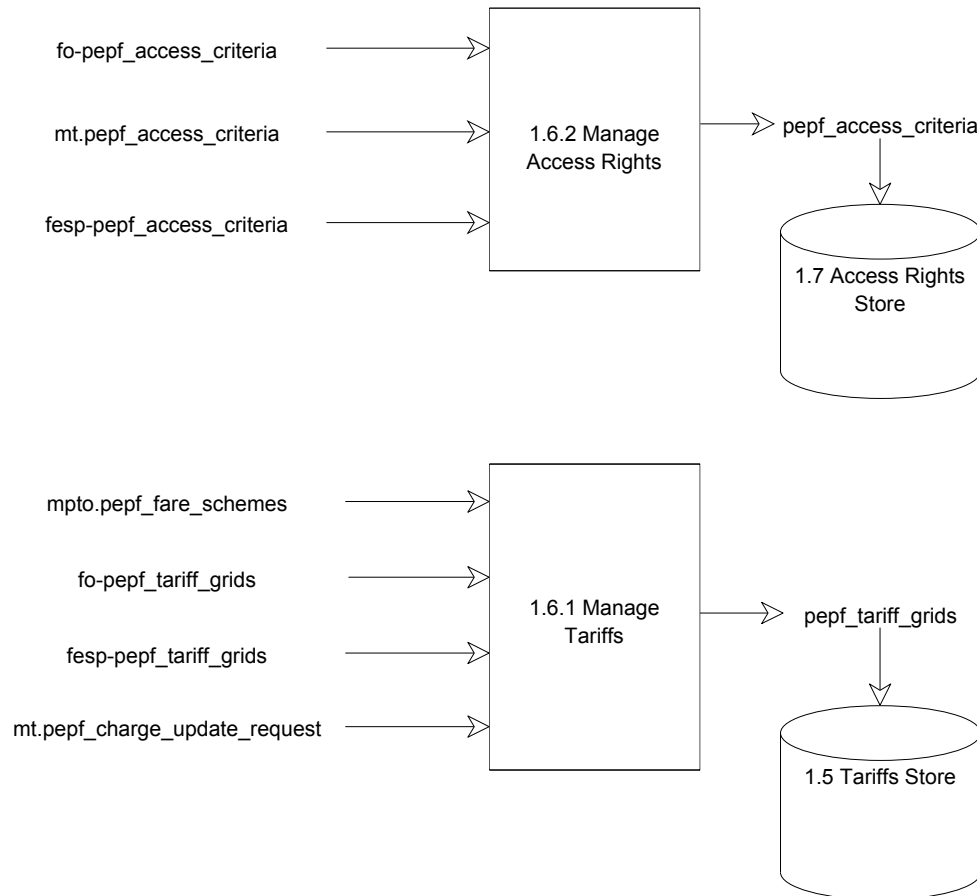
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Electronic Payment Facilities Area (1), the Data Flows are described in Annex 2, and the Data Stores in Annex 3.

The Manage Tariffs Function (F1.6.1) receives information from Operators and Service Providers about their current fees, and thus keeps the contents of the Tariffs Data Store (D1.5) up-to-date. The Manage Access Rights Function (F1.6.2) receives information from Operators and Service Providers about their rules of access, and thus keeps the contents of the Access Rights Data Store (D1.7) up-to-date.

7. Area 2. Provide Safety and Emergency Facilities

7.1. Introduction

This chapter describes the functionality in Area 2 Provide Safety and Emergency Facilities. The spheres of responsibility covered by this Area comprise the management of what response is provided when an emergency occurs, and the notification of stolen vehicles.

7.2. DFD 2 - High Level Functions in Provide Safety and Emergency Facilities

At the highest level the functionality for this area is divided into the following High level functions :

F 2.1 Manage Emergencies

F 2.2 Manage stolen vehicle notification

There are no Data Flows between these Functions. There are many Data Flows that enable the Functions to exchange data with other Areas and with the terminators. These Data Flows and the Functions are shown in the highest level DFD for Area 2 - DFD 2.

Figure 10 DFD 2 Provide Safety and Emergency Facilities
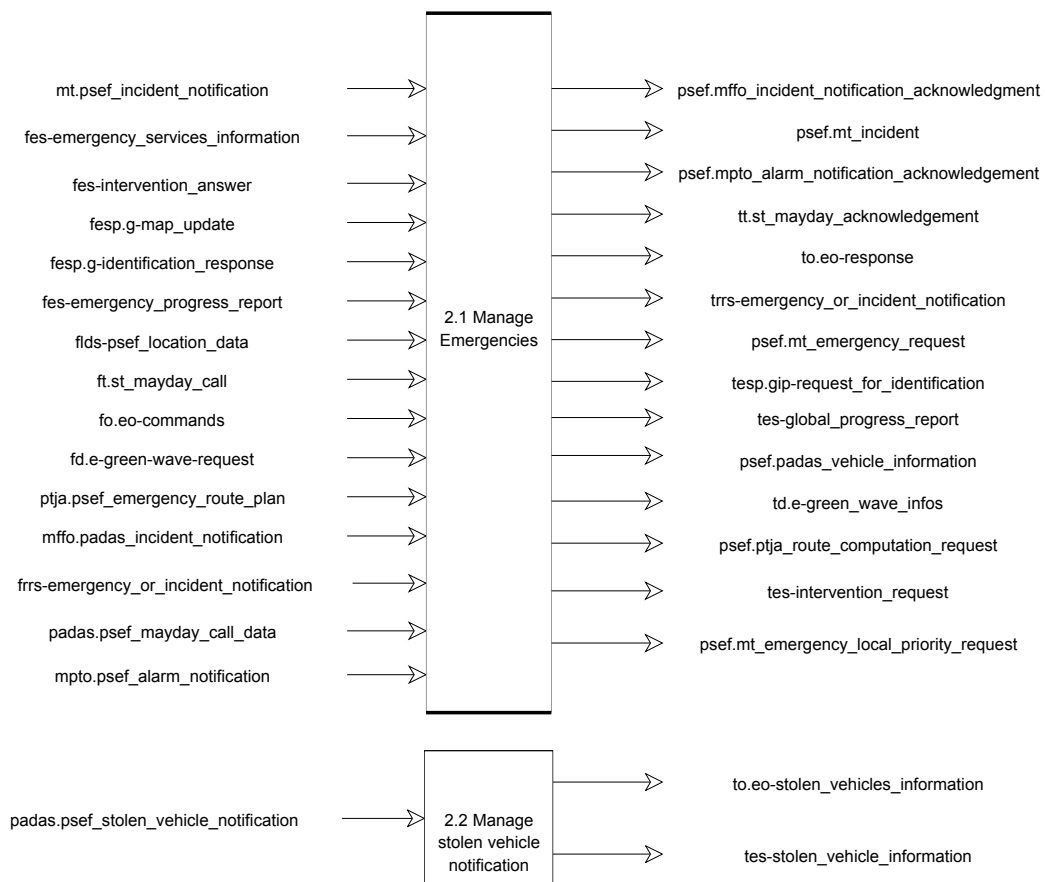
7.3.   **Function 2.1 Manage Emergencies**

This high level Function in the Provide Safety and Emergency Facilities Area provides functionality   for the management of emergencies.   It is divided into five lower level Functions that are as follows:

F 2.1.1 Acquire Mayday Call on Roadside

F 2.1.2 Manage Emergency Intervention

F 2.1.3 Manage Emergency Vehicle

F 2.1.4 Provide Emergency Control to the Operator

F 2.1.5 Provide Access and Maintain Data for Emergency

The Functions gather data about the emergencies as and when they occur, and manage the response of the Emergency Services. The data may come directly from vehicles, the roadside, functionality in other Areas, or from other Systems.

Radiating from these Functions are a large number of Data Flows. A minority of these enable the Functions to exchange data with each other. The vast majority enable the Functions to exchange data with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 2.1 - DFD 2.1.

With one exception, all the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Safety and Emergency Facilities Area (2). They each work with one or more of the other Functions in the DFD to collect and analyse data about emergencies as and when they occur. This data is then used to plan the response including the involvement of the appropriate Emergency Service(s) and their vehicles. The progress of their response to the emergency is monitored so that changes can be requested if needed. The communication with the other Areas enables Emergency vehicle priority routes to be determined and implemented. The single Data Store (D 2.1) is used to hold the common emergency data. It is described in Annex 3.

Figure 11 DFD 2.1 Manage Emergencies
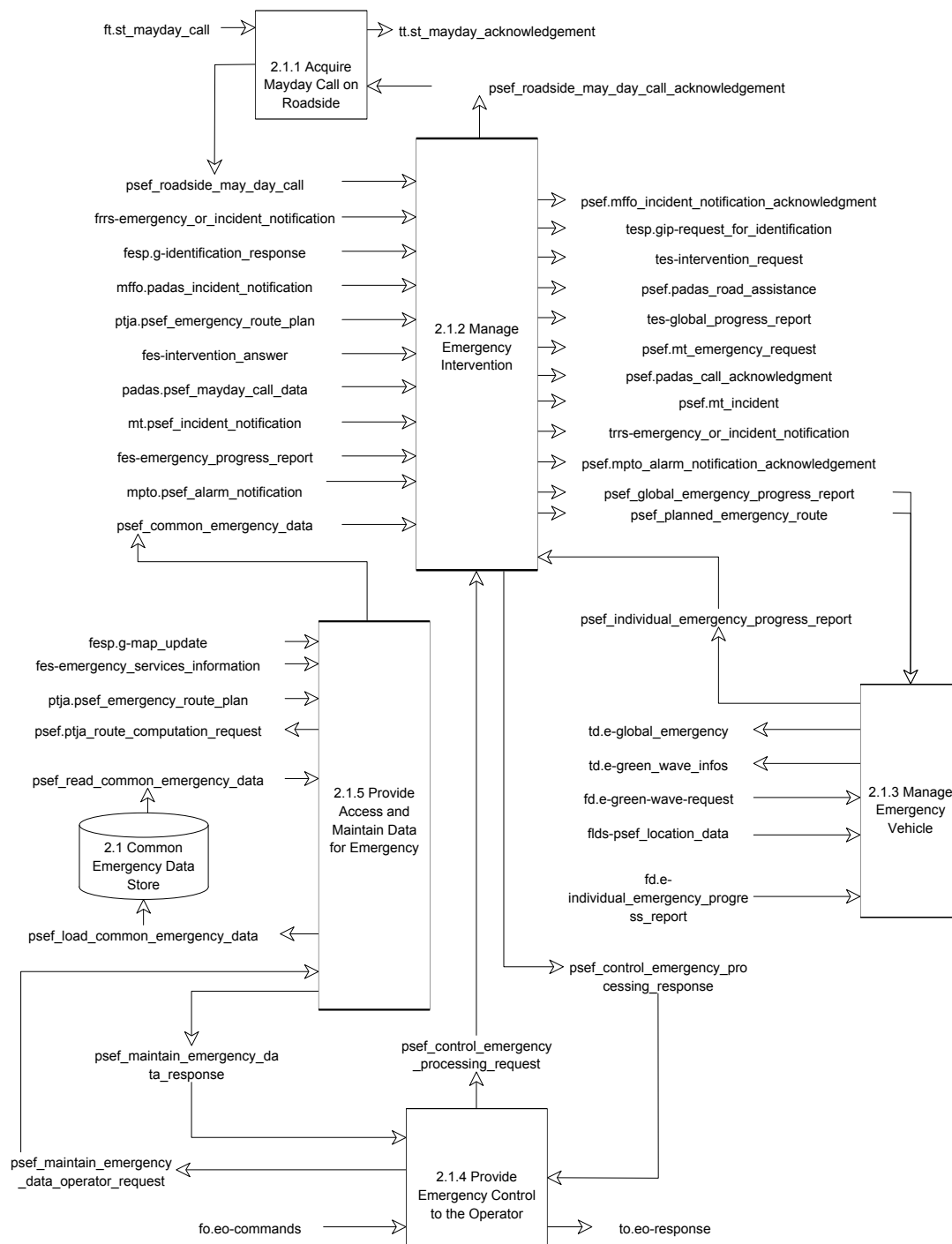
7.4. Function 2.1.2 Manage Emergency Intervention

This high level Function in the Provide Safety and Emergency Facilities Area and includes functionality for management of intervention by the appropriate Emergency Service(s) when an emergency occurs. It is divided into four lower level Functions that are as follows:

F 2.1.2.1 Identify and Classify Emergencies

      F 2.1.2.2 Manage Incident and Emergency Information

      F 2.1.2.3 Plan Emergency Intervention

      F 2.1.2.4 Process Emergency Progress Reports

The Functions listed on the previous page enable a response to be planned for each emergency as and when it occurs. Once the intervention is in progress, the status is monitored and progress reports produced.

Between each of these Functions there are several Data Flows. About half of these enable the Functions to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Provide Safety and Emergency Facilities Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 2.1.2 - DFD 2.1.2.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Safety and Emergency Facilities Area (2). They each work with one or more of the other Functions in the DFD to identify and classify the emergency and request response(s) from the appropriate Emergency Service(s). Information about the current state of the emergency and progress with the response is collected in real time by one of the Functions and stored by another of the Functions. The remaining Functions in the DFD will request the appropriate Emergency Service(s) to respond, or to change their current response. The Data Store (D 2.2) holds this data so that it can be used to determine future intervention actions and to produce reports. The Data Store is described in Annex 3.

Figure 12 DFD 2.1.2 Manage Emergency Intervention
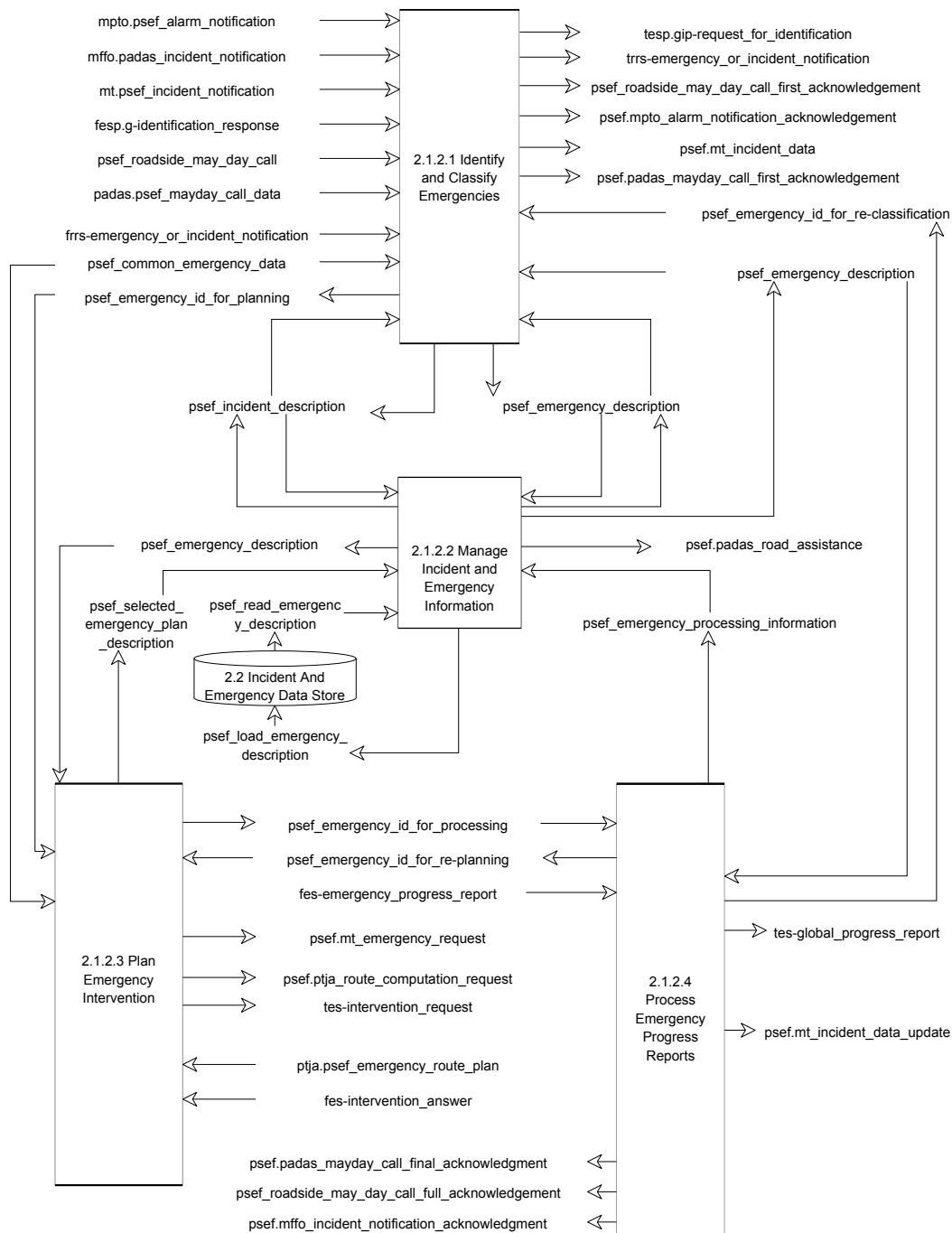
8.   Area 3. Manage Traffic

8.1.   Introduction

This chapter describes the functionality in Area 3 Manage Traffic. As its name implies, this Area is responsible for managing the flow of traffic through the road network served by the System. The functionality that the Area contains will enable the traffic flow to be managed in a way that encourages efficient use of the road space and minimises the impact of vehicles on the environment. It will strive to achieve this at all times of the day and days of the week, regardless of the volume and location of traffic within the road network. When planned or un-planned incidents occur functionality is provided to enable their impact on the road network to be minimised. Facilities to enable a dialog with the Emergency Services are also provided to manage their involvement in incidents, including the provision of priority for their vehicles through the road network. Part of the functionality in this Area will also enable the demand for use of the road network to be managed in a way that encourages Travellers to use transport modes other than the private car. Finally, the Area includes functionality to enable the management of the maintenance of the road network and the equipment that is used by the System. This maintenance also includes such things as de-icing to combat winter weather conditions.

8.2.   DFD 3 - High level Functions in Manage Traffic

At the highest level the functionality for this area is divided into the following High level functions :

> F 3.1 Provide Traffic Control
>
> F 3.2 Manage Incidents
>
> F 3.3 Manage Demand
>
> F 3.4 Provide Environmental Information
>
> F 3.5 Manage Road Maintenance

Between each of these Functions there are some Data Flows. A few of these enable the Functions to exchange data with each other. However at this level the vast majority of the Data Flows enable the Functions to exchange data with other Areas and with the terminators. These Data Flows are contained in the highest level DFD for Area 3 DFD 3.

Figure 13 DFD 2.1.2 Manage Emergency Intervention

As will be seen from the DFD, each of these High Level Functions has been divided into lower level Functions. These Functions are described in the following sections of this Chapter.

8.3. Function 3.1 Provide Traffic Control

This high level Function in the Manage Traffic Area provides functionality for the management of traffic using the road network served by the System. It has been divided into three lower level Functions that are as follows:

F 3.1.1 Provide Urban Traffic Management

F 3.1.2 Provide Inter-urban Traffic Management

F 3.1.3 Provide Traffic Management for Bridges and Tunnels

Between each of these Functions there are some Data Flows. A few of these enable the Functions to exchange data with each other. However at this level the vast majority of the Data Flows enable the Functions to exchange data with other parts of the Manage Traffic Area (see previous page), with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.1 - DFD 3.1. This is shown in the Figure on a following page.

As can be seen, the functionality has been divided into three lower level Functions covering the management of traffic in the "urban" and "inter-urban" parts of the road network, plus traffic using bridges and tunnels. In this context, the definition of "urban" and "inter-urban" road networks are as follows.

(a) "urban" - these are road networks that have lots of junctions, some controlled, some not. The type of traffic management that is provided is one that enables rights of way at some or all of the junctions to be managed. These rights of way may be for any combination of vehicles in general, particular types of vehicle (e.g. Public Transport), bicycles and/or pedestrians. In most cases the junctions will be close enough to enable their operation to be co-ordinated for the improvement of traffic flow. Other management options such as lane and speed management may also be used in the parts of the network between the junctions. The main emphasis of traffic management strategies will usually be on making the most efficient use of road network. Other facilities such as priority for Public Transport and Emergency Services' vehicles, pedestrians and cyclists, plus the management of car park use may also be included in any System implementation. When included in particular Systems. the use of enforcement facilities will be for compliance with traffic regulations including speeding.

(b) "inter-urban" - these are road networks that have few junctions. What junctions there are enable traffic to enter and leave the network and are usually "grade separated", i.e. they have flyovers and underpasses. None of the junctions are controlled in the sense that traffic within the network can be stopped from moving through the junction, as in those that are part of an "urban" road network. Management of traffic is confined to regulating vehicle speeds (higher than in the "urban" network) and lane use, through various types of signs, and restricting access of vehicles to the network - sometimes called "ramp metering". Any special facilities for Particular types of vehicle (e.g. Public Transport and Emergency Services) will be provided through lane management, or the control of access ramps. It will be unusual for facilities to be provided for pedestrians and cyclists as they are normally prohibited from using this type of road network due to the higher average speed of the other vehicles. When included in a particular System implementation, enforcement facilities will cover speed conformity and sometimes lane discipline. This type of network usually provides links from one urban area to another and in so doing may pass through urban areas. However the method of traffic management does not change for the parts of the inter-urban network that are within urban areas.

The management of "rural" road networks has not been covered by a separate set of Functions. This is because the management of traffic in this type of network can be provided by using the functionality for the "urban" road network described in (a) above. In this case there will be few if any controlled junctions and long distances between such junctions. Often the roads will be narrow, with lots of bends and limited use of multi-lane carriageways. This means that in general average speeds will be lower that those on "inter-urban" road networks, but higher than those on "urban" road networks. The degree of co-ordination between successive junctions may be slight or non-existent due to the large distances that will separate them. There will be no need for speed management other than by static signs and no opportunity for special measures for particular types of vehicle, e.g. Public Transport and Emergency Services. Thus the main management focus of System implementation for "rural" road networks will be on traffic information and diversions. The use of incident management may be quite important because the options for detection by other vehicle users will be limited.

The management of bridges and tunnels will be designed to detect abnormal conditions (e.g. weather condition on bridges, and fire or pollution in tunnels). The occurrence and impact of these conditions will be used by the other two lower level Functions to provide driver information and implement diversions. It is assumed that bridges and tunnels can be part of both "urban" and "inter-urban" road networks, so links are provided to both of these lower level Functions. The provision of ventilation, lighting and other such services within tunnels is assumed to be covered by other systems that are outside of the Framework Architecture.

The division of functionality into the three lower level Functions shown in the DFD has been used because the way in which each of these three parts of the road network is managed will be slightly different. Each of these lower level Functions is designed to work on its own, but will link with the others if they are present and co-ordination of their traffic management activities is needed. These links will enable the provision of co-ordination between urban and inter-urban traffic management strategies and the sharing of data.

Links to neighbouring urban traffic management systems and regional inter-urban traffic management centres are provided through the Data Flows to and from the Road Related Systems terminator. Although these Data Flows only link to one terminator, it is possible for the data to be sent to, or received from, a number of different Systems. Thus the single terminator can represent one or more other Road Related Systems.

As will be seen from the DFD, each of the three High Level Functions has been divided into lower level Functions. These Functions are described in the following sections of this Chapter.

Figure 14 DFD 3.1 Provide Traffic Control

8.4.   Function 3.1.1 Provide Urban Traffic Management

This high level Function in the Provide Traffic Control Function (F 3.1) and provides functionality for the management of traffic in the urban part of the road network. It is divided into five lower level Functions that are as follows:

> F 3.1.1.1 Collect Urban Traffic Data
>
> F 3.1.1.2 Monitor Urban Car Park Occupation
>
> F 3.1.1.3 Provide Urban Traffic Forecasts and Strategies
>
> F 3.1.1.4 Manage Urban Traffic Data
>
> F 3.1.1.5 Provide Urban Traffic Management Facilities

A few of the Data Flows between these Functions enable them to exchange data with each other. However at this level the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.1.1 - DFD 3.1.1.

All the functionality in this DFD exists at the same level, with one exception - F 3.1.1.5. A detailed description of each of the other Function is provided in the part of Annex 1 that is devoted to the Manage Traffic Area (3). The Provide Urban Traffic Management Facilities Function (F 3.1.1.5) is a high level Function that has been divided into lower level Functions covering different aspects of traffic management in the urban part of the road network. It has been treated in this way to make it easier to understand and to provide some flexibility in the functional configuration of individual Systems. Two of the Functions (F 3.1.1.1 and F 3.1.1.2) collect and process "raw" traffic data from the movement of vehicles. The processing carried out by these Functions includes validation of the "raw" data, so that it is capable of use by other Functions. The resulting processed data is sent by each of these two Functions to the Manage Data Function (F 3.1.1.4). This Function has three main activities to perform, which are as follows.

(1) The collation and fusion of the data received from the Data Collection Functions before loading it into the Traffic Data Store (D 3.1).

(2) The exchange of data with other systems. For similar urban traffic management systems the data is exchanged through the Related Road System terminator. The exchange of data with inter-urban traffic management systems is achieved through data flows that link with the corresponding Function (F 3.1.2.4) in the inter-urban part of the Manage Traffic Area - see DFD 3.1.2 in a later section.

(3) The provision of data for use as a basis for the traffic and travel information that is provided to Travellers. This data is taken from the Traffic Data Store and sent to the Broadcaster and Travel Information Provider actors in the External Services terminator.

A separate Function (F 3.1.1.3) is used to provide forecasts of traffic conditions and to develop traffic management strategies for future use. Both can be based on traffic data that has been collected by the Manage Data Function (F 3.1.1.4). They are provided to Functions in the high level Traffic Management Function (F 3.1.1.5) which is described in the next section.

Figure 15 DFD 3.1.1 Provide Urban Traffic Management
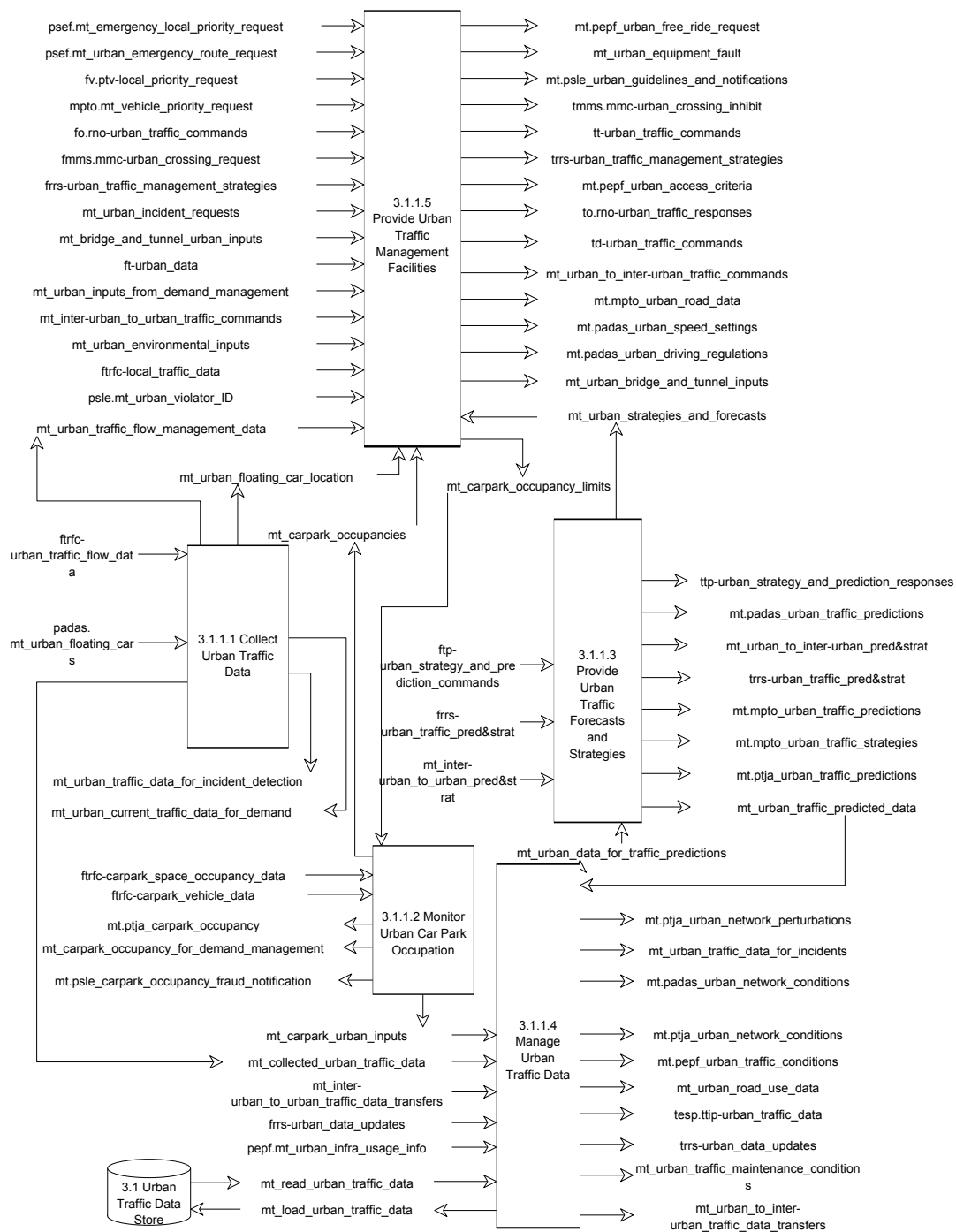
The inputs provided by the Transport Planner terminator to the development Function (3.1.1.3) can come from several sources. They can be the result of work done off-line with models of the road network and historic traffic flow data, and can also benefit from the input of policy makers and transport strategists. Provision is also made for the exchange of strategies with those developed in the inter-urban area, and with Functions in the Manage Public Transport Area.

Note also that the term "car park" used in the naming of Function 3.1.1.2 and in some of the Data Flow names can also mean Park and Ride (P+R) site. It is intended to cover any site (geographic area) that is used for parking by road vehicles. A site can therefore by a plot of land, a building, or part of the road space that has been set aside for parking, providing that the following two main criteria are met. Firstly that it must be possible to determine the number of vehicles that are "parked" at any instant in time and secondly that is must be possible to determine the length of stay of vehicles in each of the car park spaces. For any type of site to be monitored by Function 3.1.1.2, its location should be in the "urban" part of the road network. In addition its use must be managed by other Functions in this DFD or those in the Provide Urban Traffic Management Facilities Function (F 3.1.1.5) - see the next section. The occupancy state of sites in the inter-urban road network will be provided by Functions monitoring that type of road network and be sent directly to the Manage Data Function (F 3.1.1.4). The car park monitoring Function (F 3.1.1.2) has a dual role in that it also detects violations of the time limit for the occupancy of each car park space by the same vehicle. This data is sent to the Provide Support for Law Enforcement Area.

The Data Store (D 3.1) is used to hold urban traffic data that has been collected or produced by the Data Collection Functions described in the preceding paragraphs. This data is for use by other Functions in both the Manage Traffic and other Areas of the System. The contents of the Store are described in more detail in Annex 3.

8.5.   Function 3.1.1.5 Provide Urban Traffic Management Facilities

This high level Function is in the Provide Urban Traffic Management Function (F 3.1.1) and provides functionality for the management of traffic in the urban part of the road network. It is divided into nine Low Level Functions that are as follows:

> F 3.1.1.5.1 Provide Urban Traffic Management
>
> F 3.1.1.5.2 Provide Planned Urban Traffic Management Facilities
>
> F 3.1.1.5.3 Provide Urban Car Park States
>
> F 3.1.1.5.4 Provide Urban Traffic Speed Management
>
> F 3.1.1.5.5 Provide Urban Output Actuation
>
> F 3.1.1.5.6 Provide Urban Traffic Lane Management
>
> F 3.1.1.5.7 Provide Operator Urban Traffic Management Facilities
>
> F 3.1.1.5.8 Detect Urban Traffic Violations
>
> F 3.1.1.5.9 Manage Urban Static Traffic Data

About half of the Data Flows between the Functions enable them to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with terminators. The Functions and Data Flows are contained in the DFD for Function 3.1.1.5 - DFD 3.1.1.5.

Figure 16 DFD 3.1.1.5 Provide Urban Traffic Management Facilities
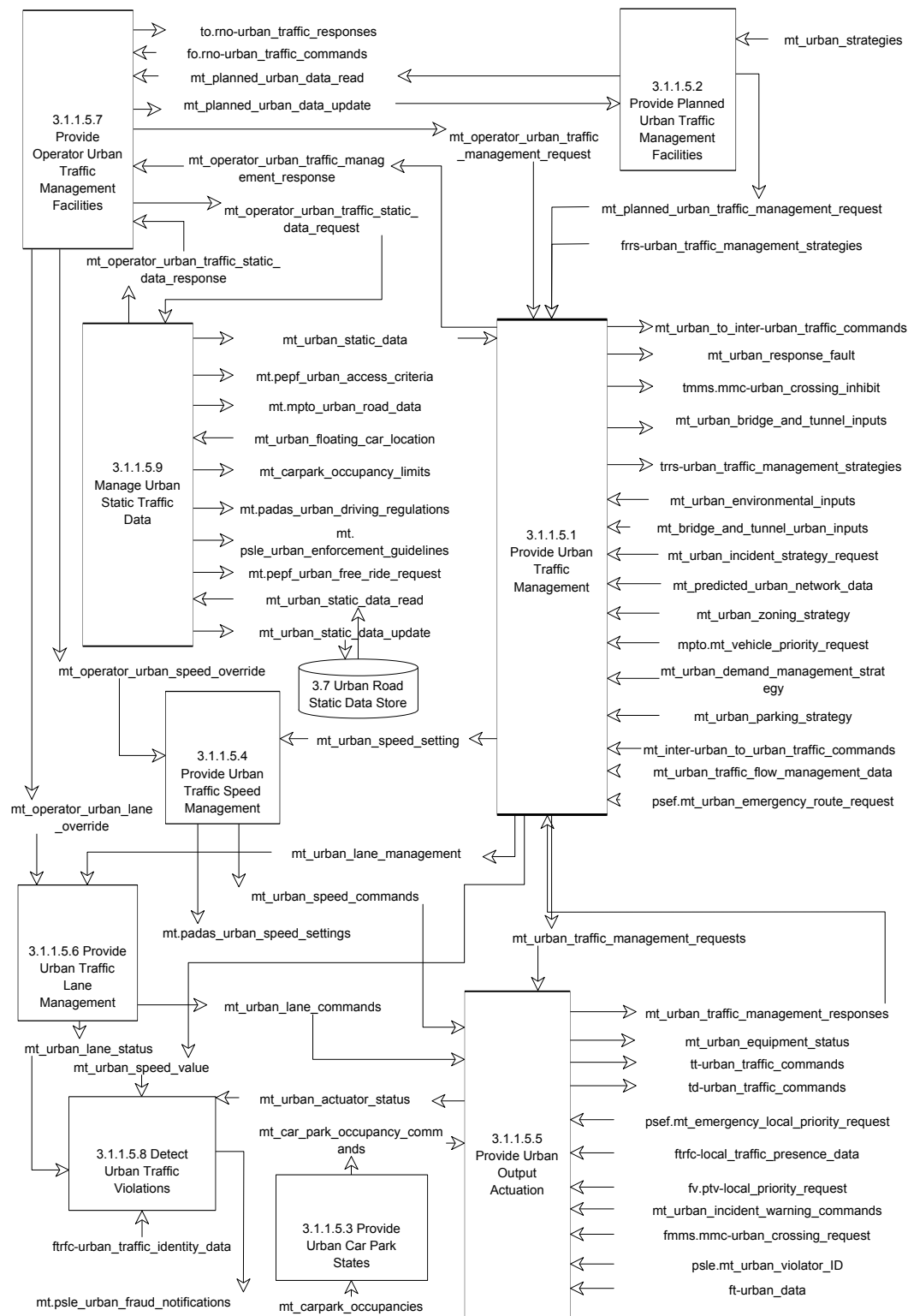
All the functionality in this DFD exists at the same level. A detailed description of each Function is provided in the part of Annex 1 that is devoted to the Manage Traffic Area (3).

They each work with one or more of the other Functions in the DFD to enable traffic to be managed in the urban road network.

The Functions in this DFD enable the traffic in the urban road network to be managed using pre-defined strategies. The traffic is "managed" by sending instructions to Drivers through the output actuation Function (F 3.1.1.5.5). These instructions may be provided through traffic management strategies, as a result of processing "live" traffic data, or by the local detection of vehicles, or as a result of strategies implemented either by an inter-urban traffic management System or by another urban traffic management System.

The way in which instructions are delivered to Drivers by the Urban Output Actuation Function (F 3.1.1.5.5) is through visual outputs of the type produced by traffic signals, or signs. The signs can be anything from a simple device that reveals a fixed message to sophisticated devices that display variable text strings. These signs can also be used to provide car park information based on detection of the numbers of vehicles entering and leaving a car park - see description of DFD 3.1.1 in the previous section. The data for output on the signs is made available to the output Function (F 3.1.1.5.5) through Function 3.1.1.5.3. One further use for the Urban Output Actuation Function (F 3.1.1.5.5) is to display the identity of those breaking speed limits and other "rules", using data from Functions in the Provide Support for Law Enforcement Area.

Some instructions output by Function 3.1.1.5.5 will apply to pedestrians and/or other types of Traveller. They will enable them to cross the road network at designated points. These instructions will also be output using traffic signals or signs. However these outputs will be enhanced by audio and other types of media that are suitable for vulnerable road users, the elderly and the disabled. Facilities are included in Function 3.1.1.5.5 to enable pedestrians to provide direct input of their need to cross the road network.

Emergency or Public Transport Vehicle priorities are provided through data flows from Functions in the Provide Safety and Emergency Facilities and Manage Public Transport Areas (Areas 2 and 4 respectively). These data flows are sent to the traffic management Function (F 3.1.1.5.1) if priority is required at a succession of junctions. This is sometimes called a "green wave", and enables the way in which the priority is given and the effect on other traffic to be managed. If only local priority is require, or there is no concern about the way it is provided and its affect on other road users, the data flows are sent directly to the output actuation Function (F 3.1.1.5.5). This Function will also accept local inputs requesting vehicle priority from either Emergency or Public Transport vehicles. These may be from the vehicles themselves, or from equipment actuated by the vehicles, e.g. by the overhead power collector on a tram.

The Urban Road Static Data Store (D 3.7) contains data defining the layout and configuration of the urban road network. It includes data about the way the parts of the network link together, their size and ability to accommodate vehicles, plus any other "regulations" governing their use. This data is used by the Functions in this DFD and is also sent to Functions in other Areas such as Provide Electronic Payment Facilities, Provide Support for Law Enforcement and Provide Advanced Driver Assistance Systems.

8.6.   Function 3.1.2 Provide Inter-urban Traffic Management

This high level Function in the Provide Traffic Control Function (F 3.1) and provides functionality for the management of traffic in the inter-urban part of the road network. It is divided into five lower level Functions that are as follows:

F 3.1.2.1 Collect Inter-urban Traffic Data

F 3.1.2.2 Monitor Service Area Vehicle Occupation

F 3.1.2.3 Provide Inter-urban Traffic Forecasts and Strategies

F 3.1.2.4 Manage Inter-urban Traffic Data

F 3.1.2.5 Provide Inter-urban Traffic Management Facilities

Between each of these Functions there are some Data Flows. A few of these enable the Functions to exchange data with each other. However at this level the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.1.2 - DFD 3.1.2.

All the functionality in this DFD exists at the same level, with one exception - F 3.1.2.5. A detailed description of each of the other Function is provided in the part of Annex 1 that is devoted to the Manage Traffic Area (3). The Provide Inter- urban Traffic Management Facilities Function (F 3.1.2.5) is a high level Function that has been divided into lower level Functions covering different aspects of traffic management in the inter-urban part of the road network. It has been treated in this way to make it easier to understand and to provide some flexibility in the functional configuration of individual Systems.

Two of the Functions (F 3.1.2.1 and F 3.1.2.2) collect and process "raw" traffic data from the movement of vehicles. The processing carried out by these Functions includes validation of the "raw" data, so that it is capable of use by other Functions. The resulting processed data is sent by each of these two Functions to the Manage Data Function (F 3.1.2.4). This Function has three main activities to perform, which are as follows.

(1) The collation and fusion of the data received from the Data Collection Functions before loading it into the Inter-urban Traffic Data Store (D 3.2).

(2) The exchange of data with other systems. For similar inter-urban traffic management systems the data is exchanged through the Related Road System terminator. The exchange of data with urban traffic management systems is achieved through   data flows that link with the corresponding Function (F 3.1.1.4) in the urban part of the Manage Traffic Area - see DFD 3.1.1 in a previous section.

(3) The provision of data for use as a basis for the traffic and travel information that is provided to Travellers. This data is taken from the Inter-urban Traffic Data Store (D 3.2) and sent to the Broadcaster and Travel Information Provider   actors in the External Services terminator.

A separate Function (F 3.1.2.3) is used to provide forecasts of traffic conditions and to develop traffic management strategies for future use. Both can be based on traffic data that

has been collected by the Manage Data Function (F 3.1.2.4). They are provided to Functions in the high level Inter-urban Traffic Management Function (F 3.1.2.5) which is described in the next section.

Figure 17 DFD 3.1.2 Provide Inter-urban Traffic Management
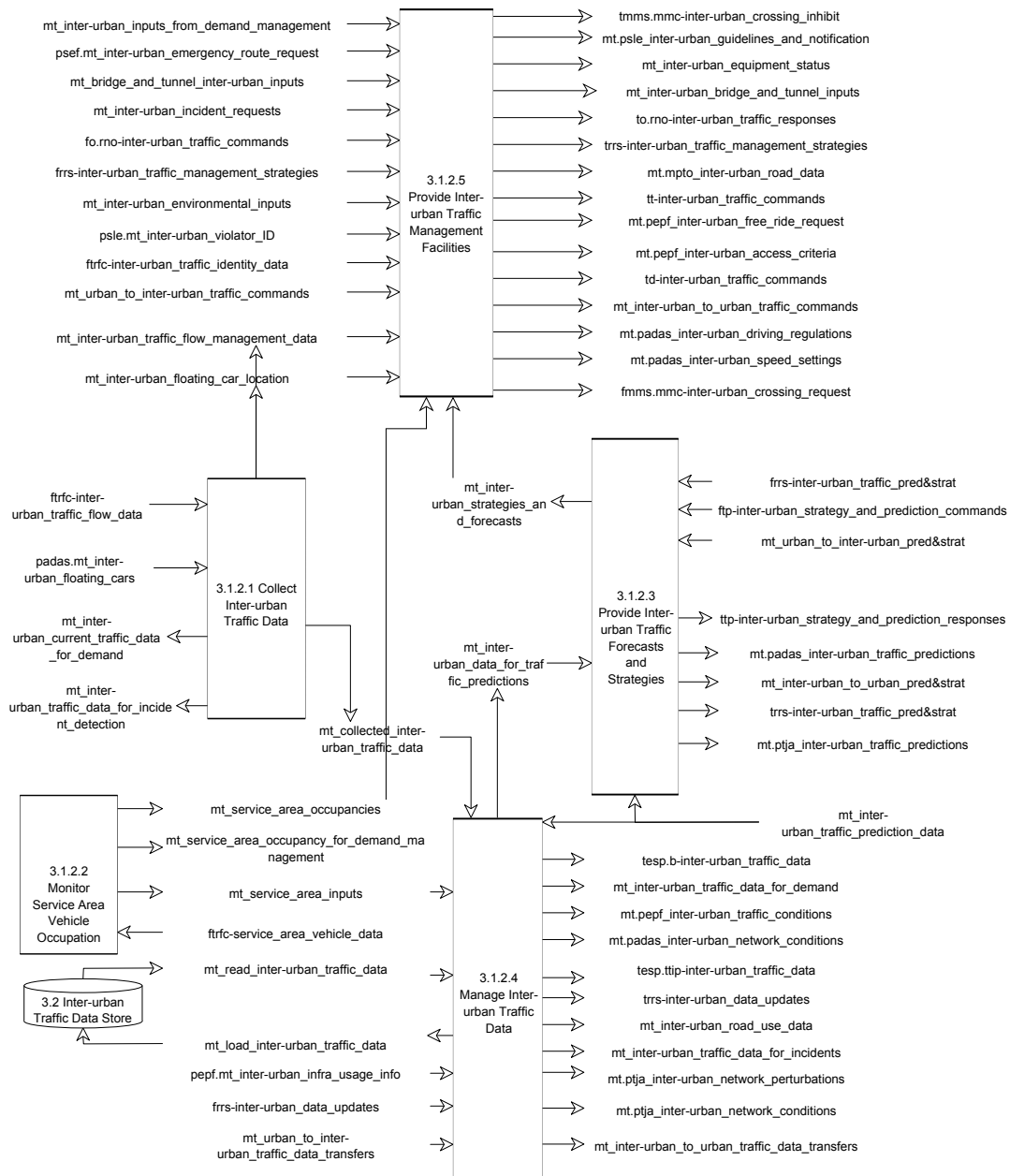
The inputs provided by the Transport Planner terminator to the development Function (3.1.2.3) can come from several sources. They can be the result of work done off-line with models of the road network and historic traffic flow data, and can also benefit from the input of policy makers and transport strategists. Provision is also made for the exchange of strategies with those developed in the urban area, and with Functions in the Manage Public Transport Area.

Note also that the term "service area" used in the naming of Function 3.1.2.2 and in some of the Data Flow names can also mean Park and Ride (P+R) site. It is intended to cover any site (geographic area) that is used for parking by road vehicles. A site can therefore by a plot of land or a building that is connected to the road network, or dedicated "Service Area" that has facilities for such things as food and resting, and therefore needs to include space for parking. The only criterion is that it must be possible to determine the number of vehicles that are "parked" at any instant in time. For any type of site to be covered by Function 3.1.2.2, its location should be in the "inter-urban" part of the road network. In addition its use must be managed by other Functions in this DFD or by those in the Provide Inter-urban Traffic Management Facilities Function (F 3.1.2.5) - see later section. Other Functions can provide information about P+R sites in the "urban" environment, but this will be based on occupancy data provided by urban functionality - see section 8.4.

The Data Store (D 3.2) is used to hold inter-urban traffic data that has been collected or produced by the Data Collection Functions described in the preceding paragraphs. This data is for use by other Functions in both the Manage Traffic and other Areas of the System. The contents of the Store are described in more detail in Annex 3.

8.7. Function 3.1.2.5 Provide Inter-urban Traffic Management Facilities

This high level Function in the Provide Urban Traffic Management Function (F 3.1.2) and provides functionality for the actual control of traffic in the inter-urban part of the road network. It is divided into eight lower level Functions that are as follows:

> F 3.1.2.5.2 Provide Planned Inter-urban Traffic Management Facilities
>
> F 3.1.2.5.4 Provide Inter-urban Traffic Speed Management
>
> F 3.1.2.5.6 Provide Inter-urban Lane Management
>
> F 3.1.2.5.7 Provide Operator Inter-urban Traffic Management Facilities
>
> F 3.1.2.5.8 Detect Inter-urban Traffic Violations
>
> F 3.1.2.5.9 Manage Inter-urban Static Traffic Data

Between each of these Functions there are some Data Flows. About half of these enable the Functions to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.1.2.5 - DFD 3.1.2.5.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or more of the other Functions in the DFD to provide traffic control in the inter-urban road network.

The Functions enable the traffic in the inter-urban road network to be managed using pre-defined strategies. The traffic is actually "managed" by the Traffic Management Function (F 3.1.2.5.1), which outputs instructions to Drivers through data flows that are sent to the Output Actuation Function (F 3.1.2.5.5). These instructions may be provided through management strategies, as a result of processing "live" traffic data, or by the local detection of vehicles, or as a result of strategies implemented either by an urban traffic management System or by another inter-urban traffic management System.

Figure 18 DFD 3.1.2.5 Provide Inter-urban Traffic Management Facilities
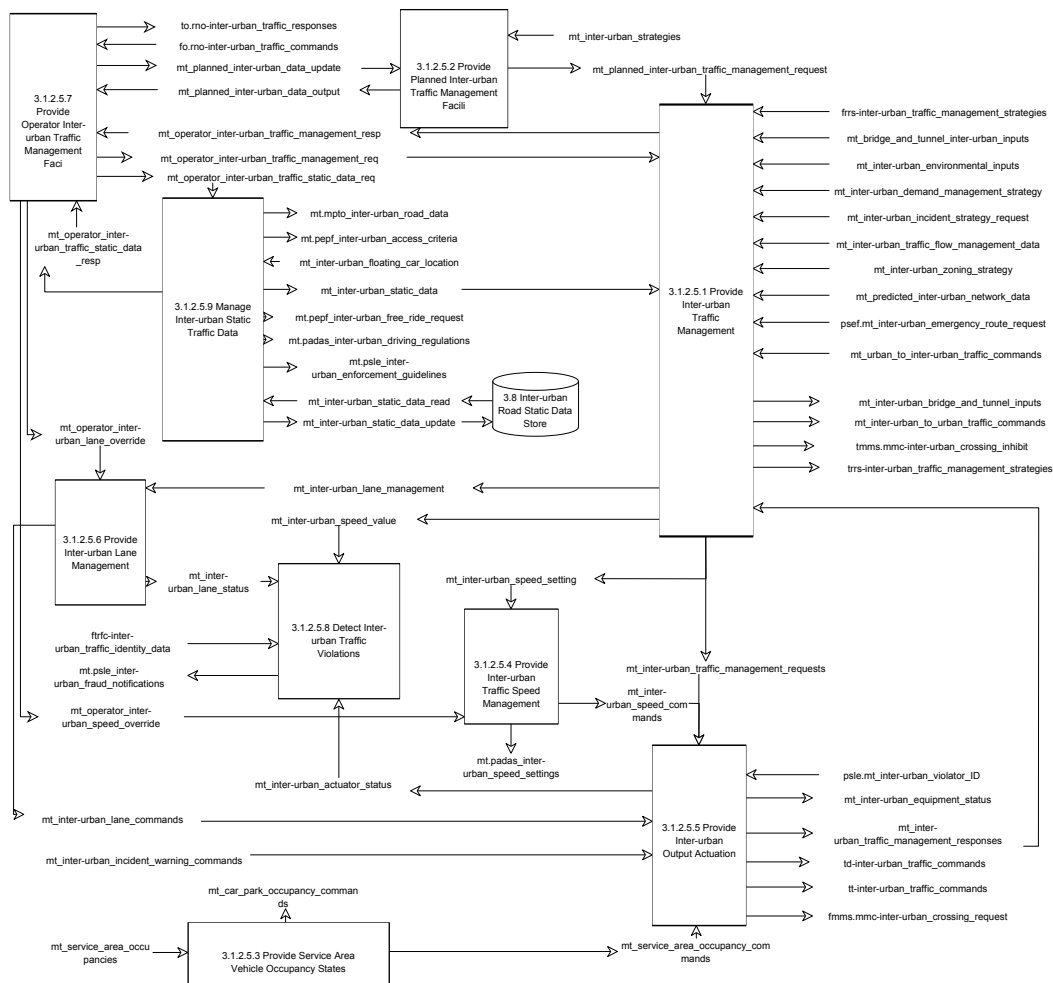
The way in which the instructions are delivered to Drivers by the Inter-urban Output Actuation Function (F 3.1.2.5.5) is through the use of some type of visual output such as that available traffic signals, or signs. The signs can be of any type, varying a simple device to reveal a fixed message, to more sophisticated devices that are able to display variable text strings and/or symbols. These signs may also be used to provide information about parking at service areas that is made available through Function 3.1.2.5.3, and the identity of those breaking speed limits and other "rules", using data from Functions in the Provide Support for Law Enforcement Area.

Priorities for Emergency or Public Transport Vehicles are provided as a result of inputs received from functionality in the Provide Safety and Emergency Facilities and Manage Public Transport Areas (Areas 2 and 4 respectively). This input is sent to the traffic management Function (F 3.1.1.5.1) for integration into the current strategies.

The Inter-urban Road Static Data Store (D 3.8) contains data that defines the layout and configuration of the inter-urban road network. Thus the data will include information about the way the various parts link together, their size and ability to accommodate vehicles, plus any other "regulations" governing their use. This data is used by the Functions, and is also sent to other Areas of the System.

8.8.   Function 3.1.3 Provide Traffic Management for Bridges and Tunnels

This high level Function in the Provide Traffic Control Function (F 3.1) and provides functionality for the management of traffic on bridges and in tunnels that are part of the road network. It is divided into three lower level Functions that are as follows:

F 3.1.3.1 Assess Bridge Status

F 3.1.3.2 Assess Tunnel Status

F 3.1.3.3 Provide Bridge and Tunnel Operator Interface

F 3.1.3.4 Output Bridge Information

F 3.1.3.5 Output Tunnel Information

Between each of these Functions there are some Data Flows. About of these enable the Functions to exchange data with each other. The remainder enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.1.3 - DFD 3.1.3.

Figure 19 DFD 3.1.3 Provide Traffic Management for Bridges/Tunnels
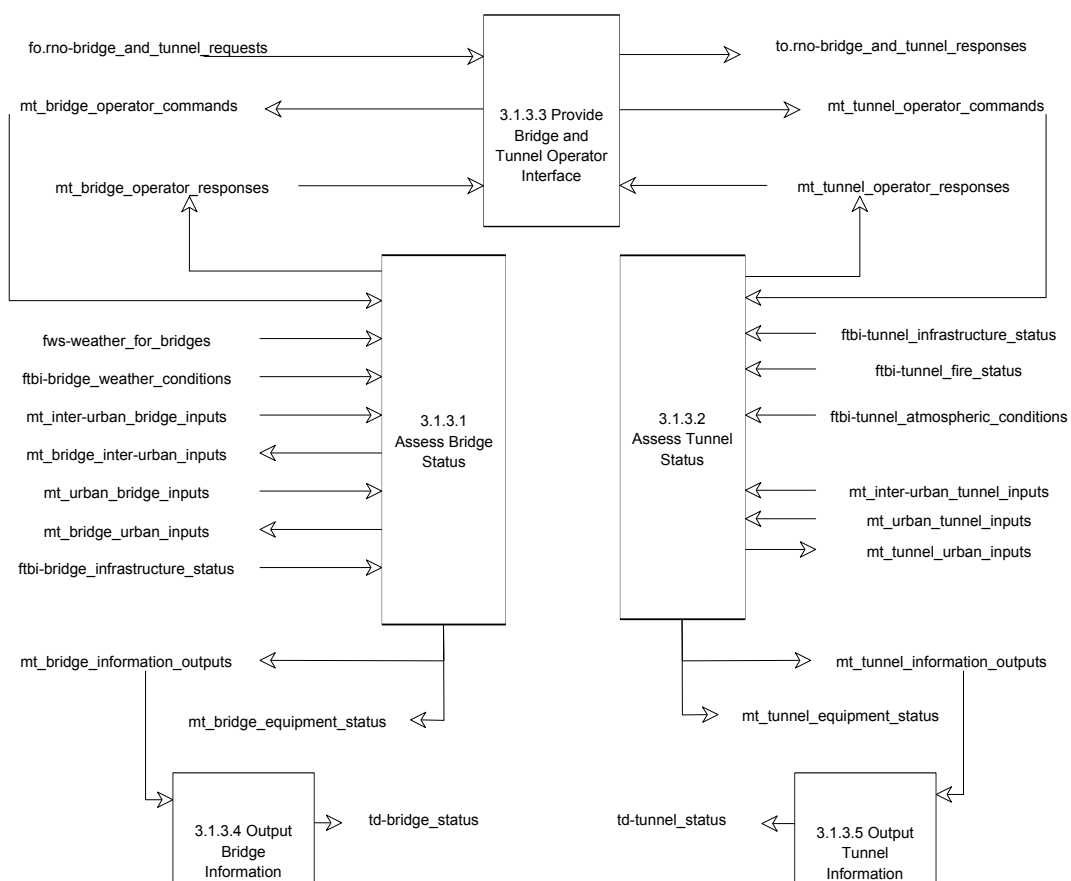
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or

more of the other Functions in the DFD to provide traffic for Bridges and Tunnels in the road network served by the System.

Two Functions (F 3.1.3.1 and F 3.1.3.2) are provided to analyse the inputs that provide data about the conditions of the Bridge and Tunnels. These inputs may come from the Bridge and Tunnel Infrastructure terminator, or in the case of Bridges from the Weather Services terminator. The result of the analysis of the inputs is sent to other parts of the Manage Traffic Area so that it can be used as one of the inputs that determine the current required traffic management strategies. When these conditions are such that Drivers need to be directly informed, such as in cases of fire or flood, then the relevant Function (F 3.1.3.4 or F 3.1.3.4) will output the information. These Functions may also be used to output information that results from input to the Analysis Functions from other parts of the Manage Traffic Area.

The Operator is provided with a dedicated Function (F 3.1.3.3). This provides the ability for the Operator to monitor the activities of the two Analysis Functions, and to override their outputs if required.

8.9. Function 3.2 Manage Incidents

This high level Function in the Manage Traffic Area provides functionality for the management of incidents. It is divided into five lower level Functions that are as follows:

F 3.2.1 Detect Incidents

F 3.2.2 Identify and Classify Incidents

F 3.2.3 Assess Incidents and Determine Responses

F 3.2.4 Manage Incident Data

F 3.2.5 Provide Incident Management Operator Interface

The Functions use the definition of an "incident" which says that it is an out of the ordinary occurrence. Therefore normal peak travel congestion does not qualify as an "incident" unless it is made worse by some other event. This may be planned, e.g. a parade, or be due to a random event such as a road traffic accident, or a major fire in a building next to part of the road network.

Between each of these Functions there are some Data Flows. A minority of these enable the Functions to exchange data with each other. However the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.2 - DFD 3.2.

Figure 20 DFD 3.2 Manage Incidents
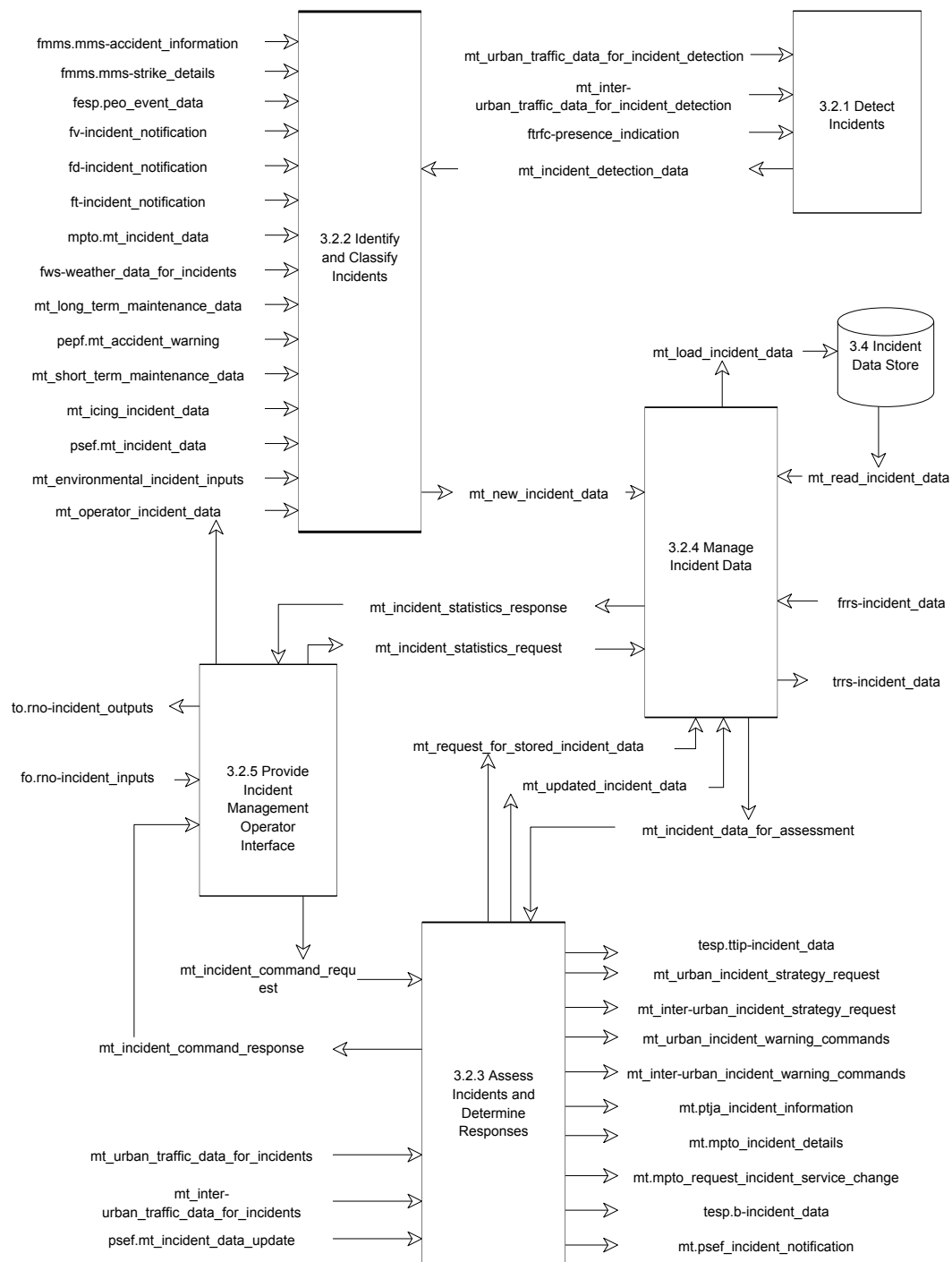
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or more of the other Functions in the DFD to provide incident management for the whole of the road network. The data about incidents is collected by the Function that identifies and classifies incidents (F 3.2.2). Sources of incident data available to this Function include other Areas in the System, e.g. Area 4, Manage Public Transport Operation, as well as its own incident detection Function (F 3.2.1).   This analyses traffic data from the traffic data

collection Functions (F 3.1.1 and F 3.2.1) and/or traffic presence data (e.g. video images) to determine that a possible incident exists. There are other sources of incident data such as the Planned Event Organiser (PEO) and the Operator. The PEO may provide information about events such as football matches, parades, carnivals and other processions. The Operator may provide information on any type of event that cannot be communicated by the PEO. Data from the Operator is received via the Function that provides the interface through which the Operator can access the System (F 3.2.5). All the incident data is classified to enable all data for each separate incident to be considered together and assessed to confirm that the incident is real.

Once an incident becomes confirmed and current, its data is passed to the assessment Function (F 3.2.3). This Function assesses what is needed to mitigate the effects of the incident upon both current and predicted traffic conditions within the road network. The result of this assessment can be either the implementation of predefined incident management strategies, or a message to the Operator that an appropriate strategy does not exist. The Operator may then create a strategy in real-time, or request that a less appropriate strategy is implemented. Strategies are implemented by sending data to Functions within the Manage Traffic and other Areas.

The Data Store (D 3.4) is used to hold incident data that has been collected by some Functions. It also holds incident management strategies that have been produced by other Functions. The incident data is exchanged with other instances of the System through the Road Related Systems terminator by the incident data management Function (F 3.2.4). This is to enable due account to be taken of incidents that occur in the road networks served by other Systems. The contents of the Store are described in Annex 3.

8.10. Function 3.3 Manage Demand

This high level Function in the Manage Traffic Area provides functionality for the management of demand. It is divided into five lower level Functions that are as follows:

> F 3.3.1 Receive Information on Travel Factors
>
> F 3.3.2 Implement Demand Management Strategy
>
> F 3.3.3 Develop Demand Management Strategy
>
> F 3.3.4 Manage Demand Data Store
>
> F 3.3.5 Provide Demand Management Operator Interface

The Functions use the term "demand" to mean the desire for travellers to use particular modes of transport. Facilities are provided by these Functions to enable this demand to be managed so that the use of one mode does not dominate the others, unless this is required by national or local transport policies. This also enables priority to be given to certain modes of transport, again only if this is a goal of national or local policies.

Between each of these Functions there are some Data Flows. A minority of these enable the Functions to exchange data with each other. However the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.3 - DFD 3.3.

Figure 21 DFD 3.3 Manage Demand
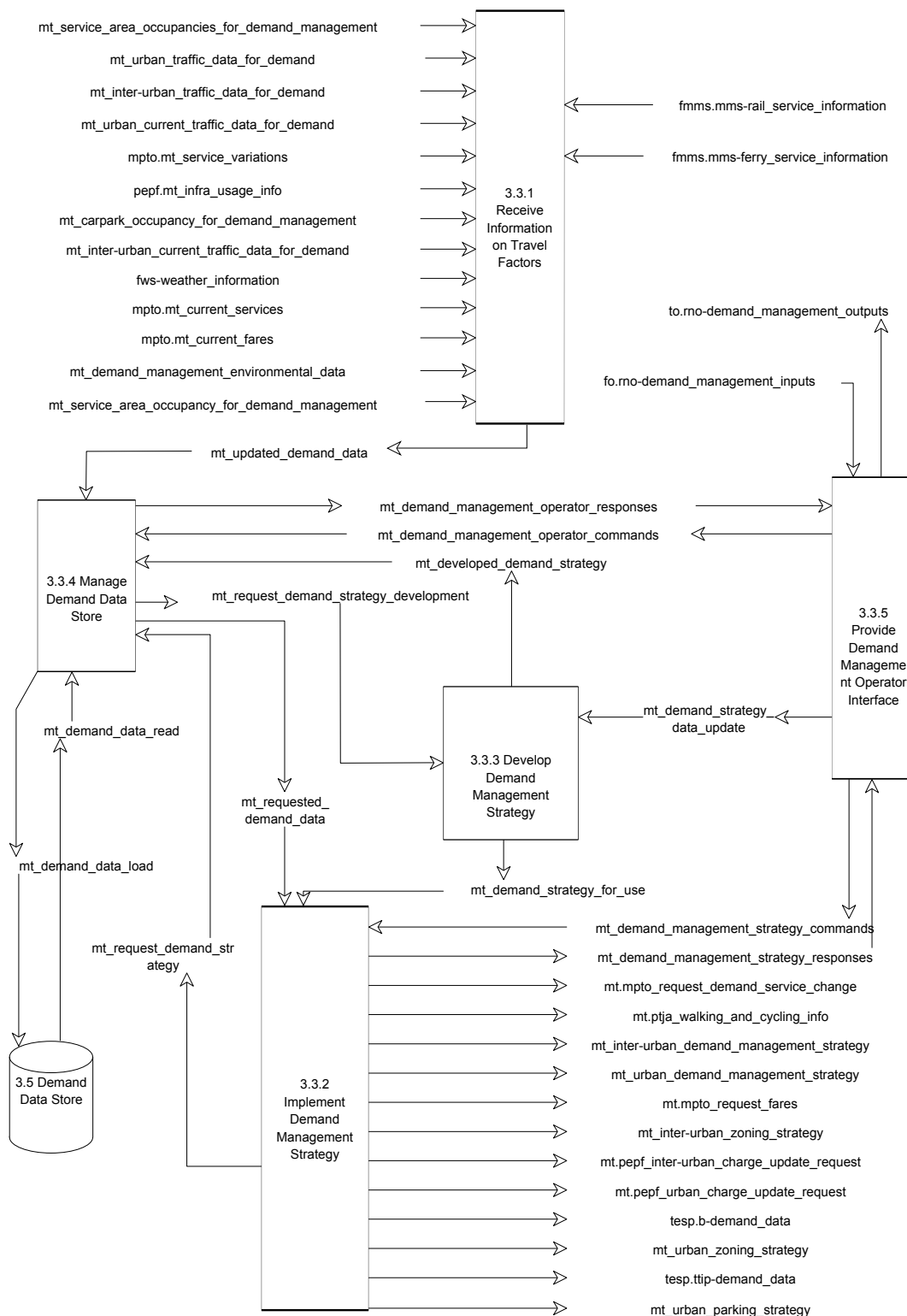
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or

more of the other Functions in the DFD to provide demand management for the whole of the road network.

Demand management is based on data about current and predicted use of transport modes in the area served by the System. This data is collected by the Receive Information Function (F 3.3.1). Data comes to this Function from a several sources. These include current traffic flow rates, plus car park and services area use from other parts of the Manage Traffic Area, details of the current services from the Manage Public Transport Area and the Multi-Modal Systems terminator, plus the use of toll areas from the Provide Electronic Payment Facilities Area.

Analysis of this data is carried out by the develop demand management strategy Function (F 3.3.3), using algorithms to model the impact of different management scenarios on the spread of demand amongst the travel modes. Another result of this analysis will be to show how travellers are making journeys (and using car parking) by time of day, day of week and by travel mode. The analysis of this data may be carried out periodically, or at the request of the Transport Planner through the Operator interface Function.

Any demand management strategies produced from the analysis will be passed to the implementation Function (F 3.3.2). This will implement the strategy, sending any required commands to Functions in the Manage Traffic and other Areas. Demand patterns resulting from special events can be analysed after the event has taken place and used to produce special strategies to be implemented when these events occur. The management of changes in demand at the time of the event occurrence will be carried out by the Manage Incidents Functions - see previous Section.

The Data Store (D 3.5) is used to hold data on the use of travel modes that has been collected by some Functions. It also holds demand management strategies that have been produced by other Functions. Both sets of data are used by the Functions themselves, with reports being available to the Operator. The Data Store is described in Annex 3.

8.11. Function 3.4 Provide Environmental Information

This high level Function in the Manage Traffic Area provides functionality for the production of information about the state of the environment in the geographic area served by the System. It is divided into six lower level Functions that are as follows:

> F 3.4.1 Monitor Weather Conditions
>
> F 3.4.2 Monitor Atmospheric Pollution
>
> F 3.4.3 Monitor Noise Pollution
>
> F 3.4.4 Predict Environmental Conditions
>
> F 3.4.5 Provide Environmental Conditions Operator Interface
>
> F 3.4.6 Manage Environmental Conditions Data

The Functions gather data about the environment from a variety of sources, concentrating mainly on the atmosphere and noise. The data is collected and made available to other Functions in the Manage Traffic Area and to other Areas, as well as in the form of reports to the Operator.

Between each of these Functions there are some Data Flows. A minority of these enable the Functions to exchange data with each other. However the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.4 - DFD 3.4.

Figure 22 DFD 3.4 Provide Environmental Information
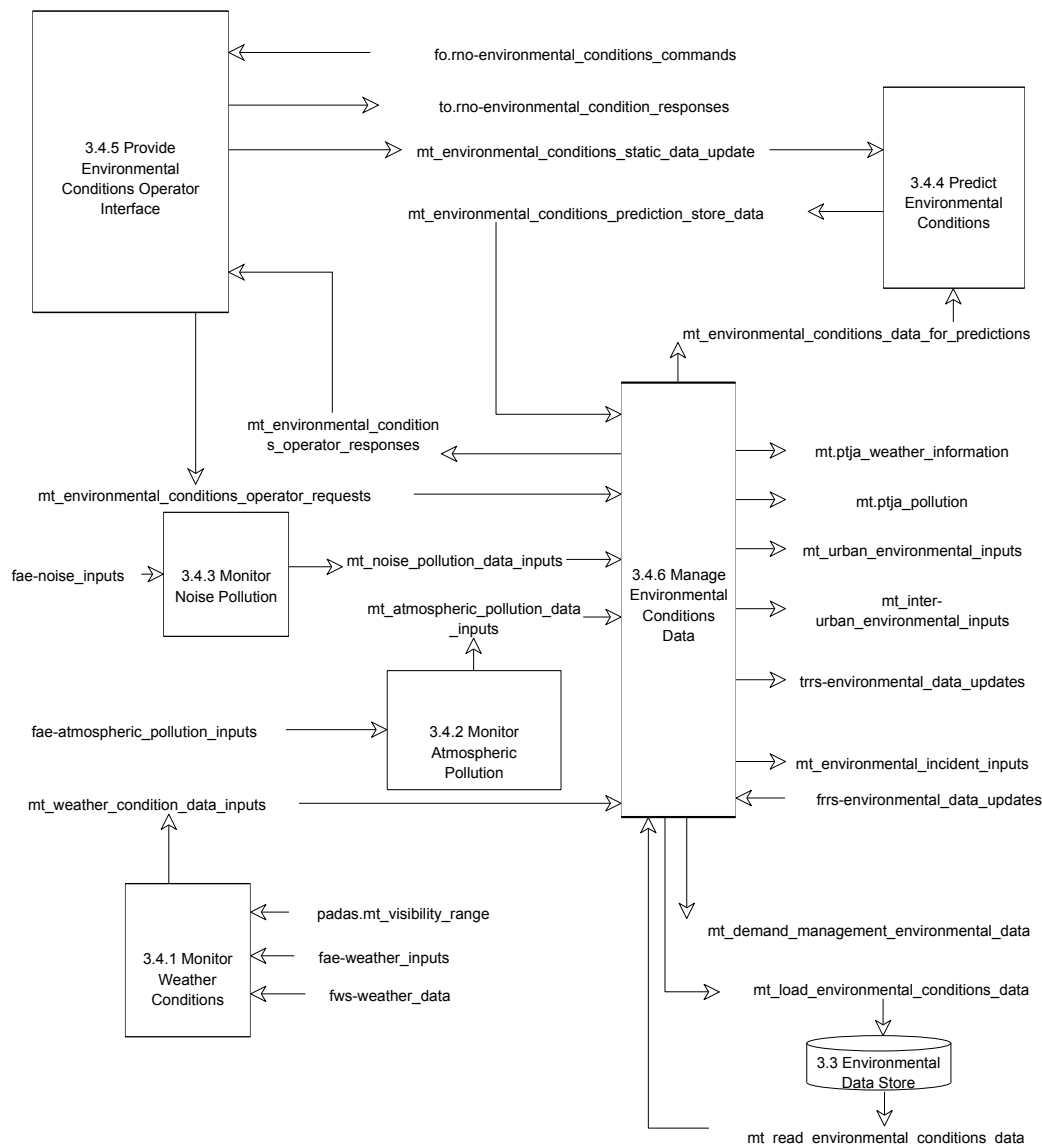
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or more of the other Functions in the DFD to collect and collate data on the environment for the whole of the geographic area served by the System. Three types of data are collected and analysed. Each is dealt with by a separate Function and cover weather conditions (F 3.4.1), pollution of the atmosphere (F 3.4.2) and noise (F 3.4.3). Data is also collected from other Systems that cover adjacent geographic areas. All of the data is stored and analysed by the environmental conditions data management Function (3.4.6). This Function can also send the

data to the prediction Function (F 3.4.4) so that pollution problems can be highlighted before they occur.

The data management Function (F 3.4.6) will analyse the data it has collected and stored looking for any abnormal pollution levels. When these are found, it will send information about the nature of the abnormal to Functions in the Manage Traffic and other Areas. Functions in the Manage Traffic Area will use the information to influence current and future traffic management strategies and to provide data about pollution based incidents to Travellers. An Operator interface Function (F 3.4.5) is provided to enable the working of the conditions management Function to be monitored. If necessary the Operator can override any decisions that the Function has made, or update the criteria used to assess whether or not pollution levels are abnormal.

The Data Store (D 3.3) is used to hold data about environmental conditions that has been collected by the management Function (F 3.4.6). This data analysed as described above, with reports being available to the Operator when requested. The contents of the Data Store are described in Annex 3.

8.12. Function 3.5 Manage Road Maintenance

This high level Function in the Manage Traffic Area provides functionality for the management of the maintenance that is required from time to time by the road network itself and any equipment that may used to provide the functionality in the System. It is divided into six lower level Functions that are as follows:

F 3.5.1 Evaluate Short Term Maintenance Needs

F 3.5.2 Evaluate Long Term Maintenance Needs

F 3.5.3 Evaluate Equipment Maintenance Needs

F 3.5.4 Evaluate De-icing Need

F 3.5.5 Provide Operator Maintenance Operations Interface

F 3.5.6 Manage Maintenance Data Store

The Functions gather data about the use being made of the road network, local road and pavement surface conditions and equipment functioning. This data is analysed and used to instruct the Maintenance Organisation to carry out maintenance and/or repair work, and to apply de-icing treatment when conditions demonstrate it is needed.

Between each of these Functions there are some Data Flows. A minority of these enable the Functions to exchange data with each other. However the vast majority enable the Functions to exchange data with other parts of the Manage Traffic Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 3.5 - DFD 3.5.

Figure 23 DFD 3.5 Manage Road Maintenance
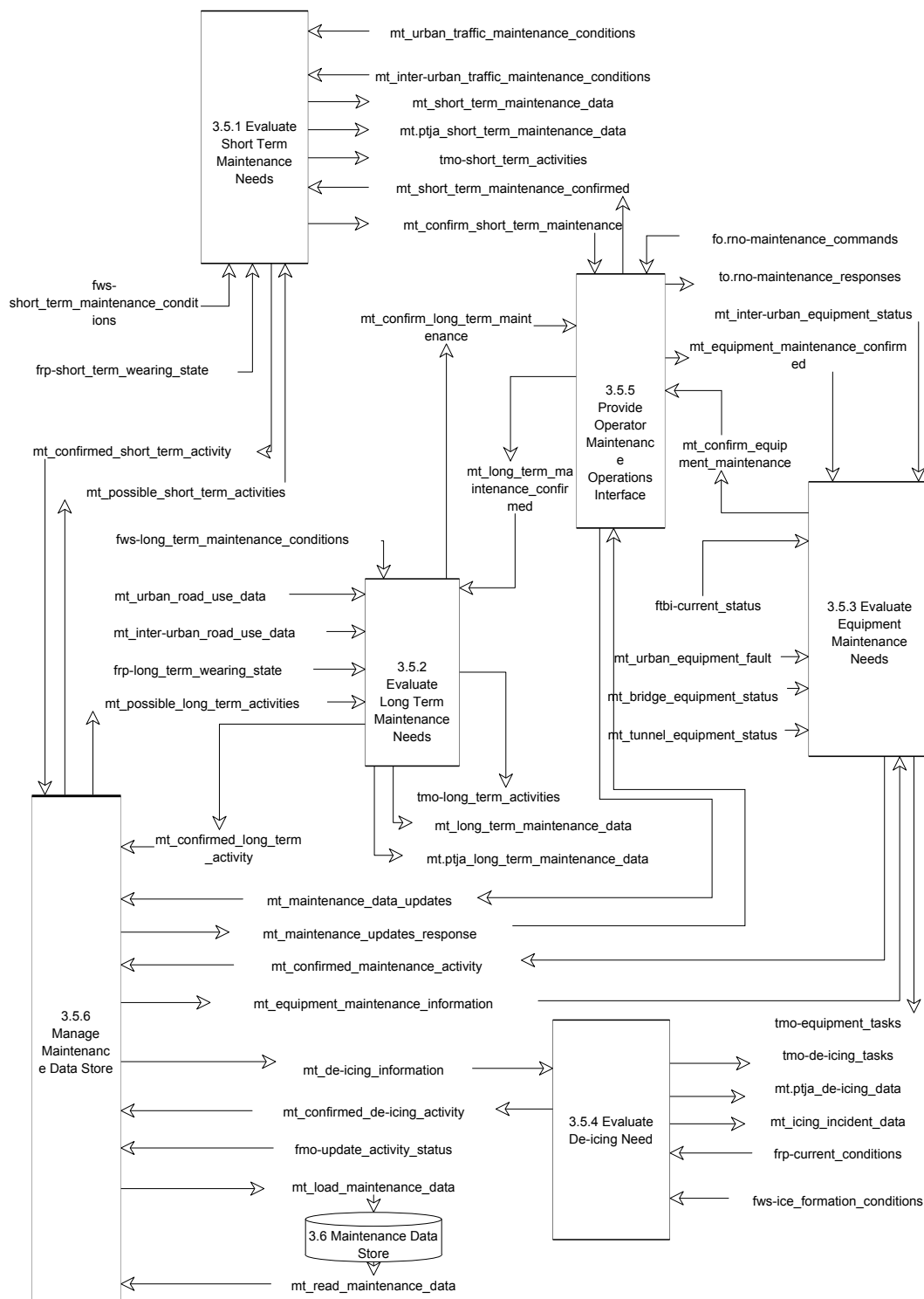
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Traffic Area (3). They each work with one or more of the other Functions in the DFD to collect and analyse data on the state of the road network served by the System, System equipment faults and the local weather conditions. Separate Functions (F 3.5.1/2, F 3.5.3 and F 3.5.4) provided for the analysis of each of these

three types of data. The state of the road network is analysed by two separate Functions, one each for short and long term maintenance (F 3.5.1 and F 3.5.2). Any resulting requests for repair activities and de-icing activity are produced by the relevant Functions and are sent to the Operator for confirmation. When this is received, the activity requests are sent to the appropriate Maintenance Organisation(s) and for logging by the data store management Function (F 3.5.6). The Functions will use the most appropriate Organisation for each activity according to the stored list - see later paragraph below. Thus the same Organisation does not have to be involved in every maintenance activity.

The Operator interface for activity confirmation is provided through the maintenance operations interface Function (F 3.5.5). This may also be used by the Operator to request extra maintenance activity and update the details of activities requested from the Maintenance Organisations.

The Data Store (D 3.6) is used to hold data about permitted maintenance and repair activities, the Maintenance Organisation(s) that can carry-out each activity, the probable impact of the activities on traffic, plus a log of the status of current and past work. This data is used by the Functions in this Area, with reports on maintenance activity being available to the Operator on request. The contents of the Data Store are described in Annex 3.

9.   Area 4. Manage Public Transport Operations

9.1.   Introduction

This chapter describes the functionality in Area 4 Manage Public Transport Operations. As its name implies, this Area is responsible for managing the operation of Public Transport services in the geographic area served by the System.

The Functions that the Area contains will provide facilities that enable Public Transport services to be planned and operated in a way that meets the needs of Travellers. The other goal of the Functions will to ensure that the services are provided in ways that make the most efficient use of the Public Transport vehicle fleet and of the inter-urban and urban road networks. The Functions will attempt to achieve this most efficient operation at all times of the day and days of the week, even when un-planned incidents occur. Part of the functionality in this Area will also manage vehicle "pooling" services and use of "demand responsive" Public Transport.

9.2.   DFD 4 - High Level Functions in Manage Public Transport Operations

At the highest level the functionality for this area is divided into the following High level functions:

> F 4.1 Monitor PT fleet
>
> F 4.2 Plan PT Service
>
> F 4.3 Provide PT Management
>
> F 4.4 Control PT Fleet

Between each of these Functions there are some Data Flows. A few of these enable the Functions to exchange data with each other. However at this level the vast majority enable the Functions to exchange data with other Areas and with the terminators. These Data Flows are contained in the highest level DFD for Area 4 DFD 4. This is shown in the next Figure.

Figure 24 DFD 4 Manage Public Transport Operations
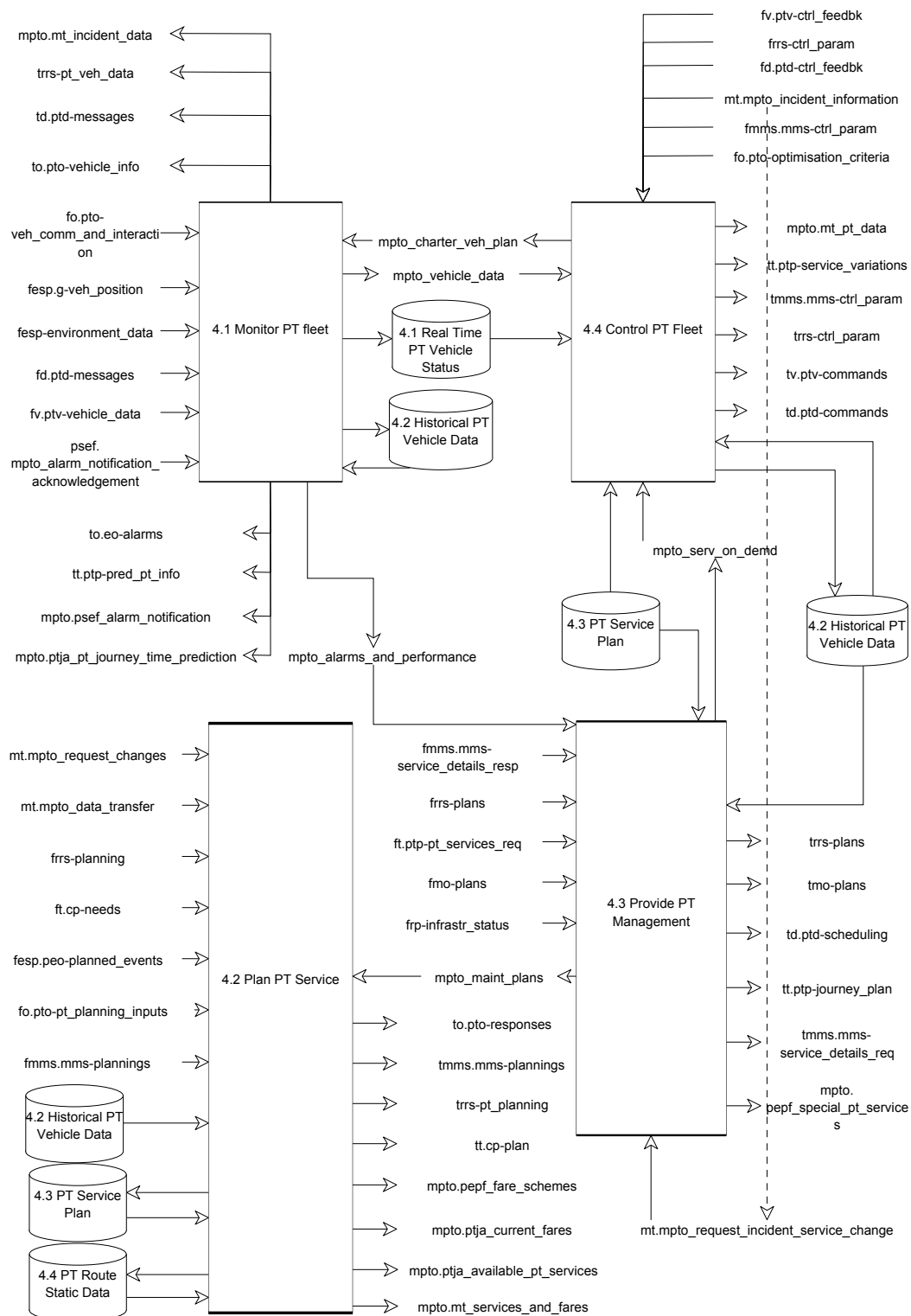
As will be seen from the DFD, each of these High Level Functions divides into lower level Functions. These are described in the following sections.

9.3.   Function 4.1 Monitor PT fleet

This high level Function in the Manage Public Transport Area provides functionality for monitoring the operation of vehicles in the Public Transport Fleet and detecting incidents on-board the vehicles. It is divided into four lower level Functions that are as follows:

> F 4.1.1 Estimate Vehicle Indicators
>
> F 4.1.2 Predict Vehicle Indicators
>
> F 4.1.3 Calculate Service Performance
>
> F 4.1.4 Confer to Vehicles

The Functions gather data about the use being made of the Public Transport vehicles and their state of operation. They also provide communications with the vehicles and with their drivers. The data provided by the vehicles is analysed and used to produce arrival and journey time predictions, and performance data. The arrival prediction data is sent to the Provide Traveller Assistance Area for use in trip planning and displayed to Travellers.

Between each of these Functions there are some Data Flows. A minority of these Data Flows enable the Functions to exchange data with each other. The remainder of the Data Flows enable the Functions to exchange data with other parts of the Manage Public Transport Operations Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 4.1 - DFD 4.1.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Public Transport Area (4). They each work with one or more of the other Functions in the DFD to collect and analyse data on the operation of the Public Transport vehicles.

The Function that communicates with the vehicles (F 4.1.4) is also used to collect data about incidents detected on-board the vehicles and to enable communication with the drivers. Data about incidents is sent to Functions in the Provide Safety and Emergency Facilities Area. Any response received from the Functions in that Area can be passed on to the driver.

The Estimate Vehicle Indicators Function (F 4.1.1) collects data from the vehicles and analyses it to work out how they are showing the vehicles to be performing. The results are stored and are used as one of the inputs by the Predict Vehicle Indicators Function (F 4.1.2). This Function also predicts vehicle arrival times at service stops on the routes and outputs them both within the vehicle and at other locations. The stored data is also used by the Calculate Service Performance Function (F 4.1.3). This calculation is done at the request of the Public Transport Operator to whom the results are provided, as well as being by other Functions in the Manage Public Transport Area.

Figure 25 DFD 4.1 Monitor PT Fleet
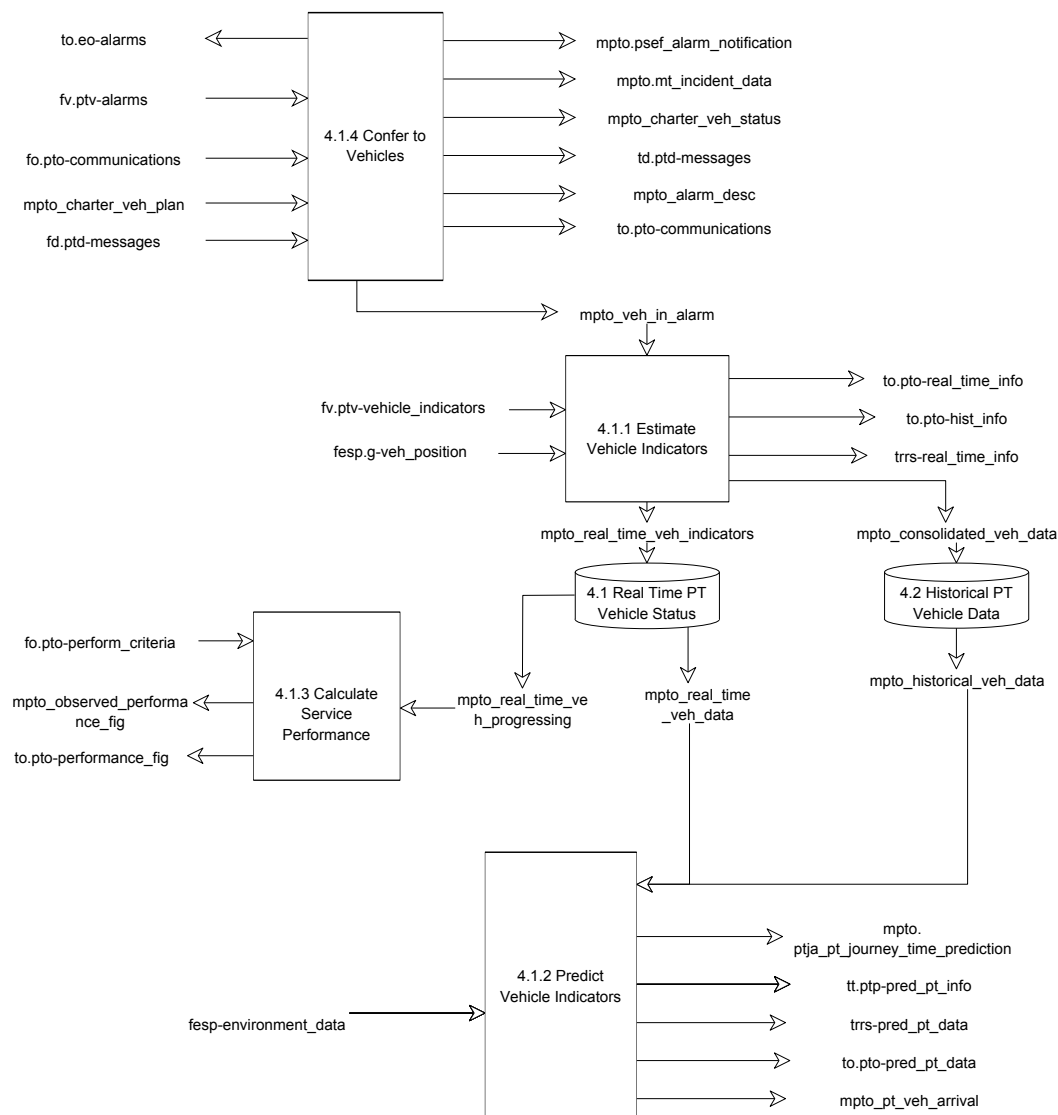
The two Data Stores (D 4.1 and D 4.2) are used to hold the current (real-time) and historic vehicle status data. This data is used predict arrival times and produce performance reports. The Data Stores are described in Annex 3.

9.4. Function 4.2 Plan PT Service

This high level Function in the Manage Public Transport Area provides functionality for the preparation of schedules and fares that apply to the services being provided by the Public Transport operation. It is divided into four lower level Functions that are as follows:

F 4.2.1 Plan & Schedule Services

F 4.2.2 Plan Vehicle Pooling Services

F 4.2.3 Manage Fare Schemes

F 4.2.4 Manage PT Route Stores and Operator Interface

The Functions prepare schedules using data such as service strategies from the Public Transport Operator, the current schedules, historical vehicle data, data about the road network, traffic predictions and data from Multi-Modal Systems. The schedules are then used to prepare fare schemes and as the basis for the deployment of car pooling services.

Between each of these Functions there are some Data Flows. A minority of these Data Flows enable the Functions to exchange data with each other. However the vast majority of them enable the Functions to exchange data with other parts of the Manage Public Transport Operations Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 4.2 - DFD 4.2.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Public Transport Area (4). They each work with one or more of the other Functions in the DFD to produce the service schedules and the fare schemes.

The Plan & Schedule Services Function (F 4.2.1) uses data about the road network, the current schedules and data from other sources to prepare new (or revised) schedules. The other data that is used includes, details of the services provided by other modes (from the Multi-Modal System), traffic predictions for the inter-urban and urban road networks, schedules from other PT Management Systems, historic data about Public Transport vehicle performance and planned events. Two other data inputs are used to trigger the determination of new (or revised) schedules. The first is input from the Public Transport Operator that will include details about the strategies and policies to be used in planning the schedules for the services, as well as details of the services themselves. The second data input source is a request for new schedules from the demand management part of the Manage Traffic Area. This input will have been prompted by a demand management strategy that has been implemented as a result of a change in the demand levels across the transport network.

Another Function (F 4.2.3) calculates the fares for the services and schedules. Again it does this on request from the Public Transport Operator, who also provides input about fare policies, charging regimes, etc. It will also provide details of the current fares to the Manage Traffic Area when requested by functionality in that Area.

The results of the determination of new schedules and fares are sent to Functions in the Provide Traveller Journey Assistance Area to be used when Travellers plan trips. The fares are also provided to Functions in the Provide Electronic Payment Facilities Area. The schedules are loaded into the services Data Store (D 4.2) for use in subsequent service and schedule determinations, and by other Functions in the Manage Traffic Area.

A separate Function (F 4.2.2) provides facilities for the planning of vehicle pooling services, when requests by a "car pooling" Traveller. This Function uses the service and schedule data that is produced by the planning and scheduling Function (F 4.2.1) that is available from the services Data Store (D 4.2).

The Public Transport Operator can obtain details of the services and schedules that have been produced using the Operator interface Function (F 4.2.4). This Function also enables the Operator to obtain details of the static data and to update it if necessary.

Figure 26 DFD 4.2 Plan PT Service
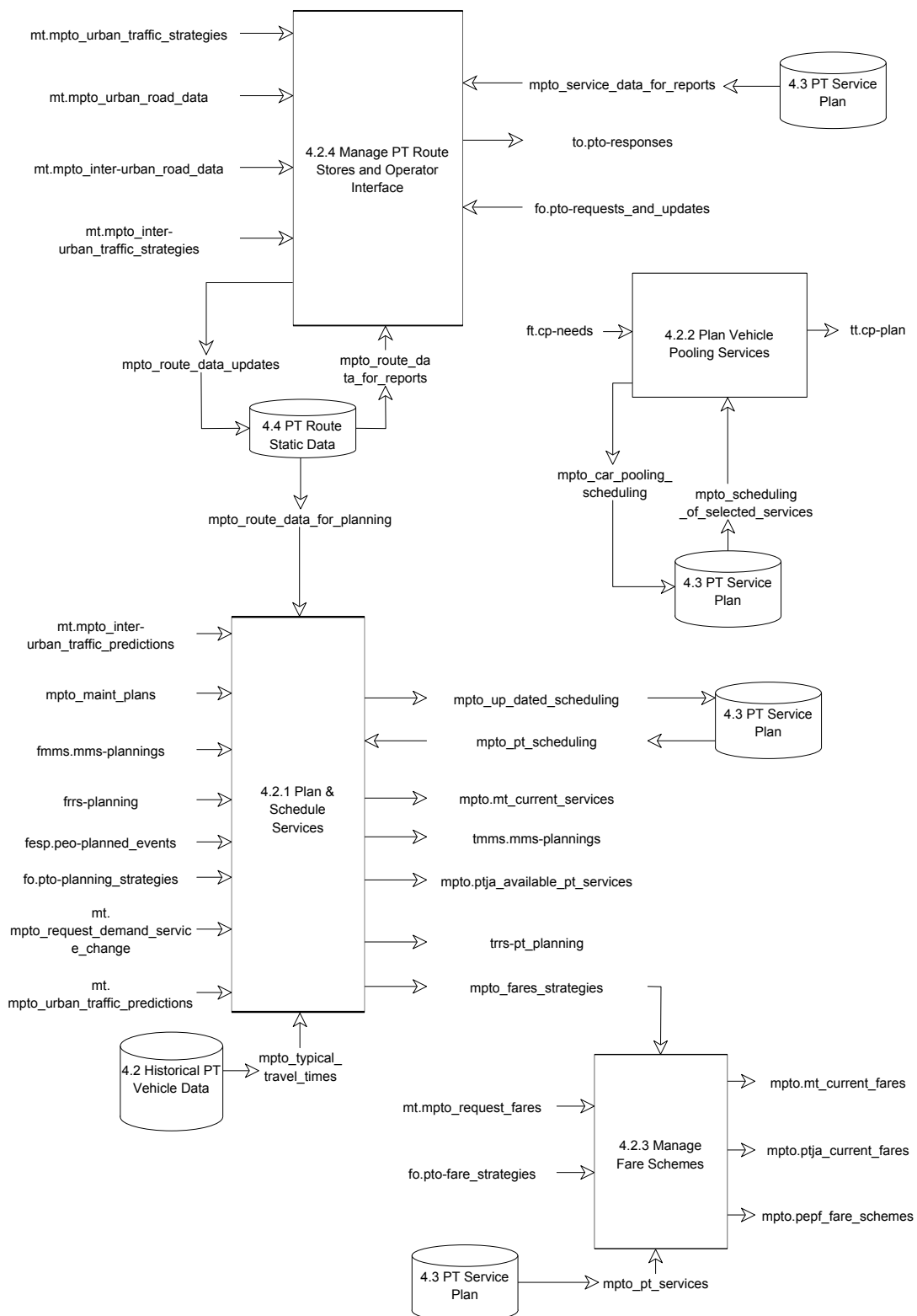
The three Data Stores (D 4.2, D 4.3 and D 4.4) hold data about the historic performance of Public Transport vehicles, the service and schedules, and static data respectively. The first Data Store (D 4.2) is provided with data by the functionality in DFD 4.1. The data in the

route Data Store (D 4.4) is provided by Functions in the Manage Traffic Area and by the Public Transport Operator - see above. The data in this Store provides information such as the layout of the road network and any roads or junctions that are unsuitable for Public Transport vehicles. The Data Stores are described in Annex 3.

9.5. Function 4.3 Provide PT Management

This high level Function in the Manage Public Transport Area provides functionality for the co-ordination of maintenance activities, demand responsive transport services, driver management and vehicle sharing. It is divided into five lower level Functions that are as follows:

F 4.3.1 Provide Service on Demand

F 4.3.2 Provide Maintenance Co-ordination

F 4.3.3 Manage PT Drivers

F 4.3.4 Manage Vehicle Sharing

F 4.3.5 Monitor Infrastructure

The Functions use information from the Stores of current (real-time) and historic vehicle data, plus schedule details to produce vehicle sharing plans, driver work schedules and vehicle maintenance plans. These Stores are provided with data by Functions responsible for monitoring the Public Transport vehicles and preparing schedules - see previous sections 6.5.3 and 6.5.4 respectively.

Between each of these Functions there are some Data Flows. A minority of these Data Flows enable the Functions to exchange data with each other. Most of the Data Flows enable the Functions to exchange data with other parts of the Manage Public Transport Operations Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 4.3 - DFD 4.3.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Public Transport Area (4). The Data Stores are described in Annex 3.

The Manage Vehicle Sharing Function (F 4.3.4) uses current PT service and schedule data from its Store (D 4.3) with current and historic vehicle data from their Stores (D 4.1 and D 4.2 respectively) to produce plans for vehicle sharing. These plans are produced to suit the journey requirements provided by Travellers and will only be implemented once they have been confirmed by the Travellers. When confirmed, the Manage PT Drivers Function (F 4.3.3) uses these shared vehicle plans and the current PT services and schedules (D 4.3) to prepare Public Transport driver working schedules.

A separate Function (F 4.3.1) provides on-demand Public Transport services. These are provided at the request of the Traveller and are based on the current PT services and schedules (D 4.3). Details of the services that this Function produces are sent to the Functions in the Provide Electronic Payment Facilities Area so that payment can be collected from the Traveller.

Figure 27 DFD 4.3 Provide PT Management
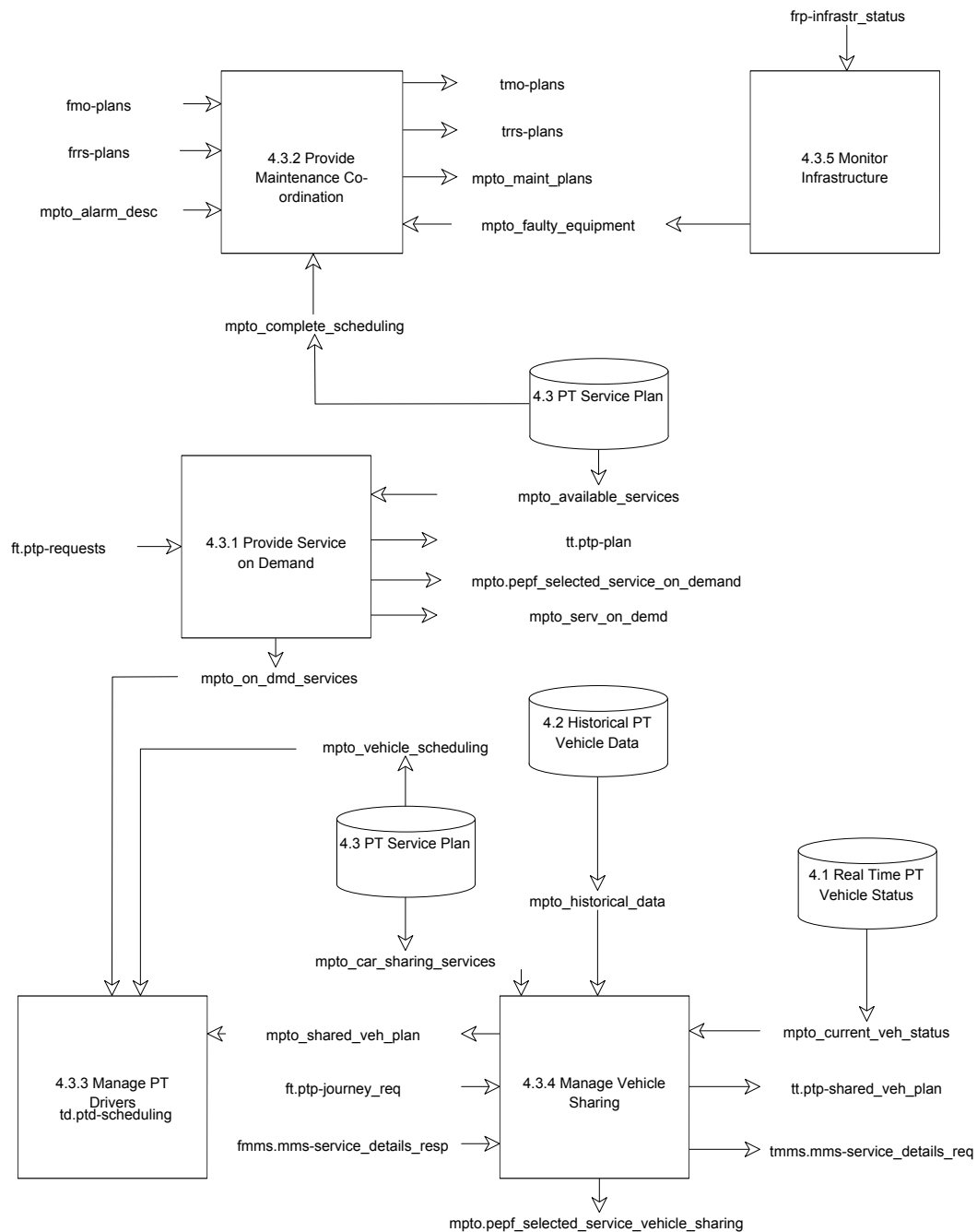
The current PT services and schedules are also used to plan vehicle maintenance. This is carried out by the Provide Maintenance Co-ordination Function (F 4.3.2). This Function uses input from the Monitor Infrastructure Function (F 4.3.5) to determine the maintenance plans, together with data about alarms that have been raised by equipment on the Public Transport vehicle and the results of an analysis of the vehicle's performance, produced by functionality in DFD 4.1. These plans are also exchanged with other relevant Public Transport Management Systems (through the Road Related Systems terminator) and are used by the service and schedule determination Function (F 4.2.1).

The three Data Stores (D 4.1, D 4.2 and D 4.3) hold data about the real time Public Transport vehicle performance, historic vehicle performance and the current PT service and schedules, respectively. The first two Data Stores (D 4.1 and D 4.2) are provided with data by the functionality in DFD 4.1. The data in the current PT service and schedules Data Store (D 4.3) is provided by Functions in DFD 4.2. The Data Stores are described in Annex 3.

9.6. Function 4.4 Control PT Fleet

This high level Function in the Manage Public Transport Area provides functionality to control the Public Transport vehicles and request priority for them at parts of the road network. It is divided into four lower level Functions that are as follows:

F 4.4.1 Optimise Control Action

F 4.4.2 Require Vehicle Priority
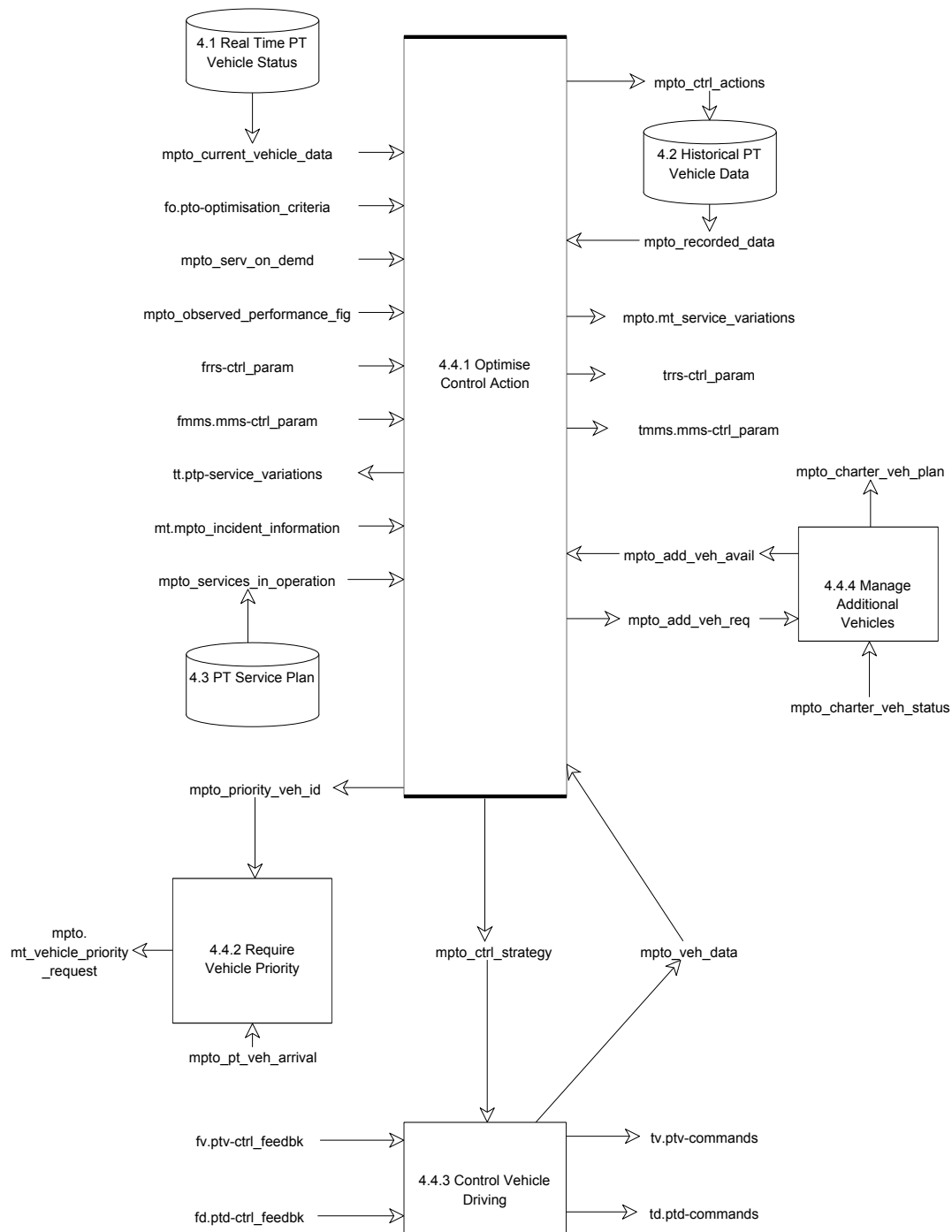
F 4.4.3 Control Vehicle Driving

F 4.4.4 Manage Additional Vehicles

The Functions use information from the Stores of current (real-time) and historic vehicle data, plus schedule details to produce their commands and priority requests. These Stores are provided with data by Functions responsible for monitoring the Public Transport vehicles and preparing schedules - see previous sections 6.5.3 and 6.5.4 respectively.

Between each of these Functions there are some Data Flows. A minority of these enable the Functions to exchange data with each other. However the vast majority enable the Functions to exchange data with other parts of the Manage Public Transport Operations Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 4.4 - DFD 4.4.

All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Manage Public Transport Area (4). The Data Store is described in Annex 3.

The Optimise Control Actions Function (F 4.4.1) uses the current PT service and schedule data from its Store (D 4.3) together with current and historic vehicle data from their Stores (D 4.1 and D 4.2) to optimise the control of Public Transport vehicles. The optimisation process also takes account of what is going on in other similar Public Transport Management Systems, the requirements of the "on demand" schedules produced by the Functions in DFD 4.3, the services provided by other transport modes (from the Multi-Modal Systems terminator) and incidents. Details of the incident are provided by the incident management part of the Manage Traffic Area. The output from the optimisation performed by this Function is used to provide commands to the vehicle and the Public Transport driver, and to request priority at controlled parts of the road network. The request for vehicle priority is only sent when the Function determines that is needed for the vehicle to maintain (or not loose further time from) its schedule. Local vehicle priority requests are provided by data input directly from the Public Transport Vehicle terminator to functionality in the Manage Traffic Area - see DFD 3.1.1.5. Any changes to current services are sent to Travellers who are Public Transport passengers.

Figure 28 DFD 4.4 Control PT Fleet

Control of the Public Transport vehicle resulting from the output of Function F 4.4.1, is provided by the Control Vehicle Driving Function (F 4.4.3). This provides control in two ways. Either directly to the vehicle, with adjustments based on feedback from the vehicle, or by sending commands to the Public Transport vehicle driver. Again feedback from the driver is used to adjust the outputs.

A separate Function (F 4.4.4) is provided to manage additional vehicles for use in charter services. This Function is driven by data from the Confer to vehicles Function (F 4.1.4) to which it returns the results of its processing.

The three Data Stores (D 4.1, D 4.2 and D 4.3) hold data about the real time Public Transport vehicle performance, historic vehicle performance and the current PT service and schedules, respectively. The first two Data Stores (D 4.1 and D 4.2) are provided with data by the functionality in DFD 4.1. The data in the current PT service and schedules Data Store (D 4.3) is provided by Functions in DFD 4.2. The Data Stores are described in Annex 3.

10. Area 5. Provide Advanced Driver Assistance Systems

10.1. Introduction

This chapter describes the functionality in Area 5 Provide Advanced Driver Assistance Systems. The functionality in Area 5 will enable vehicles to be controlled in an automatic fashion, whilst preserving the ability of the driver to take control when needed. If will also provide assistance to the driver in the control and manoeuvring of the vehicle.

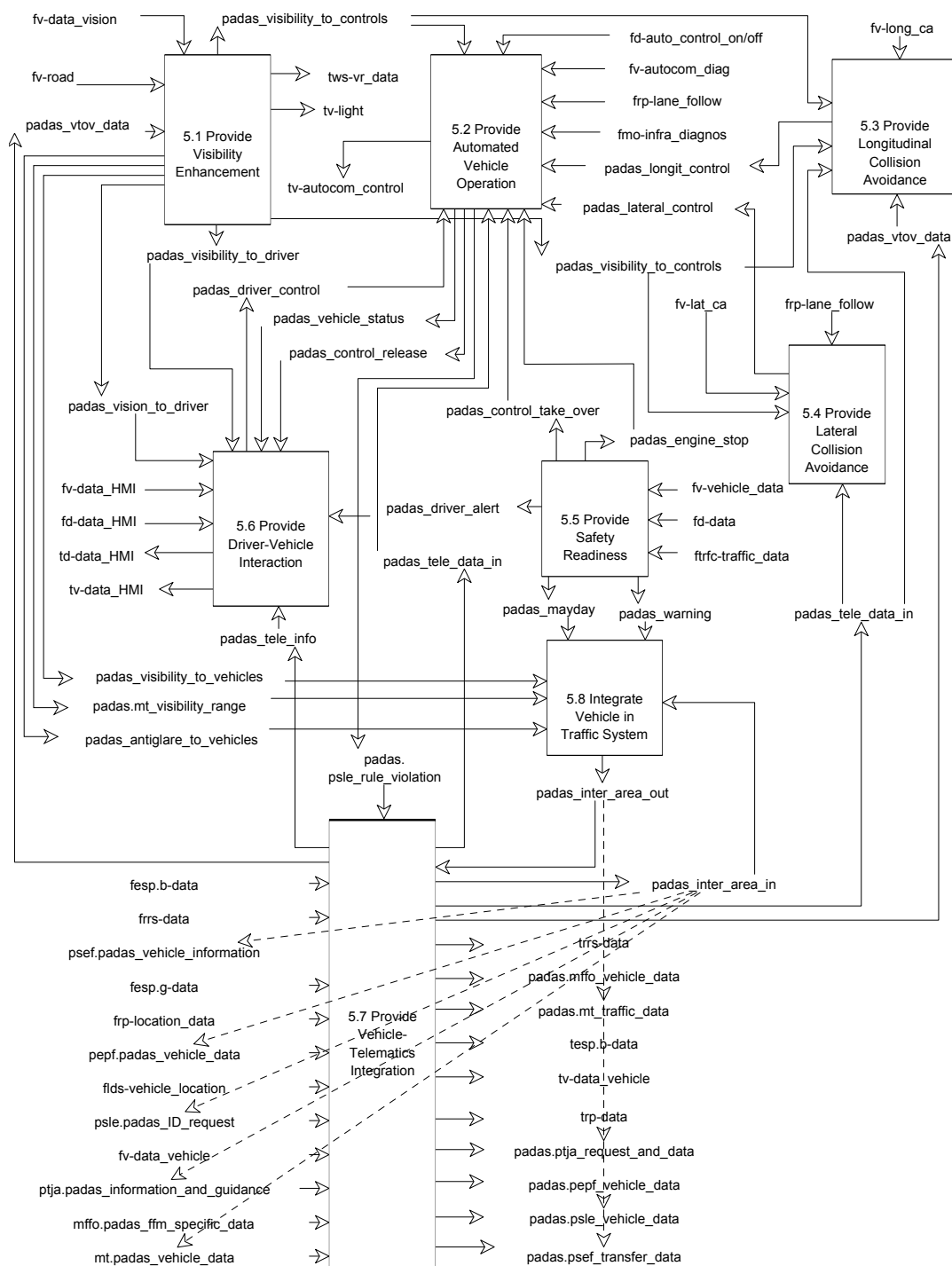## 10.2. DFD 5 - High Level Functions in Provide Advanced Driver Assistance Systems

At the highest level the functionality for this area is divided into the following High level functions :

> F 5.1 Provide Visibility Enhancement
>
> F 5.2 Provide Automated Vehicle Operation
>
> F 5.3 Provide Longitudinal Collision Avoidance
>
> F 5.4 Provide Lateral Collision Avoidance
>
> F 5.5 Provide Safety Readiness
>
> F 5.6 Provide Driver-Vehicle Interaction
>
> F 5.7 Provide Vehicle-Telematics Integration
>
> F 5.8 Integrate Vehicle in Traffic System

Between each of these Functions there are some Data Flows. A few of these enable the Functions to exchange data with each other. However at this level the vast majority enable the Functions to exchange data with other Areas and with the terminators. These Data Flows are contained in the highest level DFD for Area 5 DFD 5. This is shown in the next Figure.

The functionality in this Area has been divided into the Functions to make it easier for different facilities to be included (or not) in any implementation. However, Function 5.7, which provides the interface to other functional Areas, must be included when any of Functions 5.1, 5.2, 5.3, 5.4, 5.6 and 5.8 are required. Also none of these Functions can operate successfully without the driver to vehicle interaction Function (F 5.6). Function 5.5, which contains safety readiness facilities, can be provided on its own, or with Functions 5.2, 5.6 and/or 5.8.

As will be seen from the DFD, the seven High Level Functions divide into Low Level Functions. As already noted, the provide driver-vehicle interaction Function (F 5.6) included in DFD 5 is a simple one (Low Level) that does not need to be sub-divided for its functionality to be understood. Its description will be found in Annex 1 of this document. All of the remaining Functions (High Level) are described in the following sections of this Chapter.

Figure 29 DFD 5 Provide Advanced Driver Assistance Systems

10.3. Function 5.1 Provide Visibility Enhancement

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enhance the visibility of the road available to a driver from inside the vehicle. It is divided into four lower level Functions that are as follows:

F 5.1.1 Monitor Visibility Range

F 5.1.2 Generate Enhanced Vision of Driving Area

F 5.1.3 Provide Enhanced Lighting

F 5.1.4 Provide Anti-glaring (Co-operative) Facilities

F 5.1.5 Provide Anti-glaring (Co-operative) Facilities

These four Functions enhance a driver's vision of the road. They are all free standing and thus do not have any links with each other. Several Data Flows are provided for the exchange of data with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 5.1 - DFD 5.1.

All the functionality in this DFD exists at the same level. The four Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). Within this DFD each Function provides a different set of facilities. The first of these (provided through Function 5.1.1) is the determination and monitoring of the visibility that the driver is currently experiencing. This data is used as input to the vehicle control functionality and provides information on current visibility conditions to the Manage Traffic Area (3). The second facility (provided through Function 5.1.2) is the generation of an enhanced view of the driving area and this is sent to the Function (5.6) that is responsible for vehicle-driver interaction. The third facility (provided through Function 5.1.3) enhances the lighting that the vehicle is providing to enable the driver to see where the vehicle is going, whilst the fourth facility (Function 5.1.4) reduces the "glare" that the vehicle is giving to other road users.

Figure 30 DFD 5.1 Provide Visibility Enhancement

padas_vtov_data

5.1.5 Provide Anti-glaring (Co-operative) Facilities

padas_antiglare_to_vehicles

fv-data_vision

5.1.1 Monitor Visibility Range

padas_visibility_to_vehicles

padas_visibility_to_controls

padas_visibility_to_driver

tws-vr_data

padas.mt_visibility_range

padas_vtov_data

5.1.4 Provide Anti-glaring (Co-operative) Facilities

padas_antiglare_to_vehicles

fv-road

fv-data_vision

5.1.3 Provide Enhanced Lighting

tv-light

fv-data_vision

5.1.2 Generate Enhanced Vision of Driving Area

padas_vision_to_driver

10.4. Function 5.2 Provide Automated Vehicle Operation

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that enables the vehicle to be operated without the intervention of the driver. It is divided into five lower level Functions that are as follows:

F 5.2.1 Provide Longitudinal Dynamic Control

F 5.2.2 Provide Lateral Dynamic Control

F 5.2.3 Provide Driver-(Automatic Controls) Interactivity

F 5.2.4 Provide Infrastructure Support

F 5.2.5 Provide Pre-Crash Restraints Deployment

These five Functions provide facilities for automatic vehicle operation that can be invoked or cancelled at the request of the driver. All of the Functions are linked together by a small number of Data Flows. Other Data Flows are provided for the exchange of data with other High Level Functions, with the Provide Support for Law Enforcement Area and with the terminators. The Functions and Data Flows are contained in the DFD for Function 5.2 - DFD 5.2.

Figure 31 DFD 5.2 Provide Automated Vehicle Operation
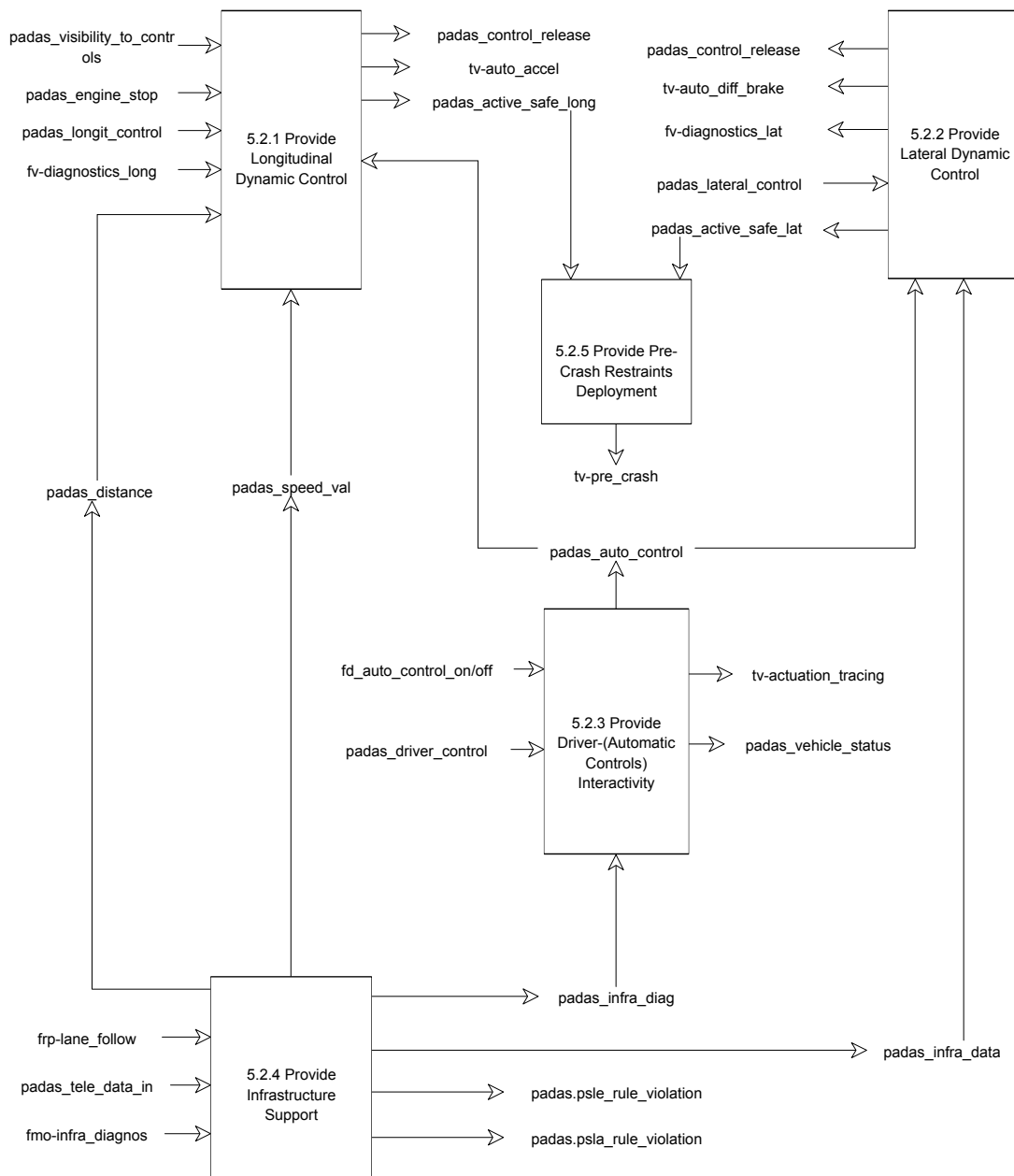
All the functionality in this DFD exists at the same level. The five Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). The first two Functions (F 5.2.1 and F 5.2.2) provide the actual interfaces through which the outputs from the longitudinal and lateral control Functions are passed to the vehicle. The third Function (F 5.2.3) provides the interface through which the driver can override the way automatic control is applied to the vehicle. Facilities for monitoring of the vehicle's interaction with the road based infrastructure are provided by the fourth Function (F 5.2.4). From this interaction the Function is able to calculate distance and speed information for use by the longitudinal and lateral control Functions and to identify rule violations arising from the vehicle's improper position and/or speed. Deployment of crash restraints is provided by the fifth Function on (F 5.2.5) receipt of input from the longitudinal and lateral control Functions.

10.5. Function 5.3 Provide Longitudinal Collision Avoidance

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enable the vehicle carry out actions connected with control of is longitudinal position relative to its surroundings. It is divided into nine lower level Functions that are as follows:

> F 5.3.1 Provide Dynamic Scenario Intelligence
>
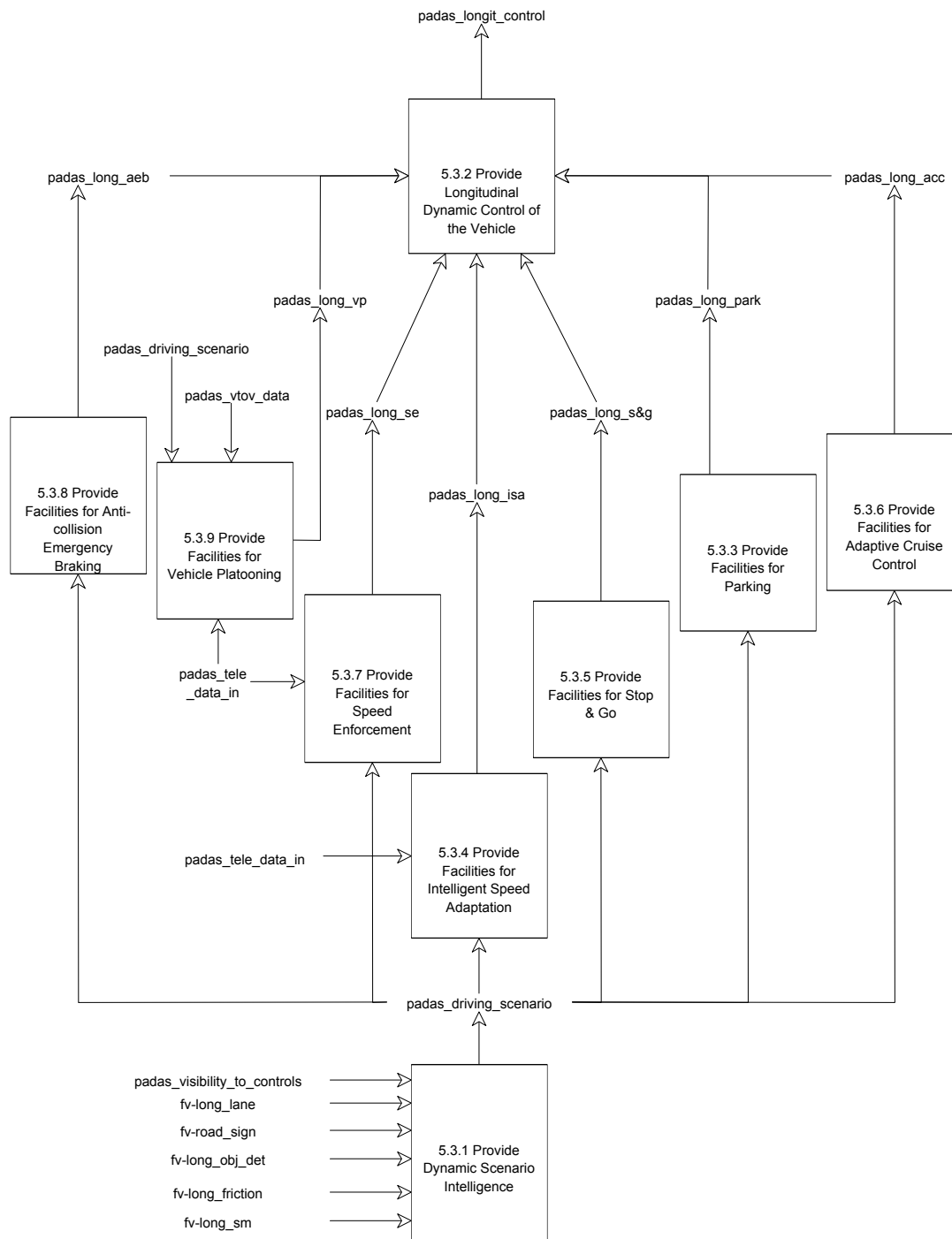> F 5.3.2 Provide Longitudinal Dynamic Control of the Vehicle
>
> F 5.3.3 Provide Facilities for Parking
>
> F 5.3.4 Provide Facilities for Intelligent Speed Adaptation
>
> F 5.3.5 Provide Facilities for Stop & Go
>
> F 5.3.6 Provide Facilities for Adaptive Cruise Control
>
> F 5.3.7 Provide Facilities for Speed Enforcement
>
> F 5.3.8 Provide Facilities for Anti-collision Emergency Braking
>
> F 5.3.9 Provide Facilities for Vehicle Platooning

These nine Functions enable the vehicle to avoid certain types of collision, carry out specific manoeuvres or the parts of manoeuvres that require longitudinal control of the vehicle, as well as providing facilities that enable it to become part of a platoon of vehicles. The first two Functions are linked with the others by single Data Flows, and also provide the connection point for Data Flows from the terminators and with other High Level Functions. Three of the remaining Functions also receive Data Flows from other High Level Functions. The Functions and Data Flows are contained in the DFD for Function 5.3 - DFD 5.3.

All the functionality in this DFD exists at the same level. The nine Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). The first two Functions (F 5.3.1 and F 5.3.2) provide the input and output interfaces respectively for the other seven Functions. The inputs into the first Function (F 5.3.1) come from the Vehicle terminator either directly or via the visibility Functions in DFD 5.1. Each of the other seven Functions (F 5.3.3 - 9) provides a different facility that is connected with the longitudinal control of the vehicle. Two of these (F 5.3.3 and F 5.3.5) are complimented by Functions providing similar facilities for lateral control - see next section (10.6). They each use their own separate inputs from the first Function (F 5.3.1) and send

their individual outputs to the second Function (F 5.3.2). This Function produces a single output, which is sent to the longitudinal control Function in DFD 5.2.

Figure 32 DFD 5.3 Provide Longitudinal Collision Avoidance

10.6. Function 5.4 Provide Lateral Collision Avoidance

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enable the vehicle carry out actions connected with control of is lateral

position relative to its surroundings. It is divided into nine lower level Functions that are as follows:

F 5.4.1 Provide Dynamic Scenario Intelligence

F 5.4.2 Provide Lateral Dynamic Control of the Vehicle

F 5.4.3 Provide Facilities for Parking

F 5.4.4 Provide Facilities for Lane/Road Keeping

F 5.4.5 Provide Facilities for Lane Change

F 5.4.6 Provide Facilities for Reserved Lanes I/O

F 5.4.7 Provide Infrastructure Support for Lane Following

F 5.4.8 Provide Facilities for Overtaking

F 5.4.9 Provide Facilities for Stop & Go ++

These nine Functions enable the vehicle to carry out specific manoeuvres or the parts of manoeuvres that require lateral control of the vehicle, including such things as lane keeping, overtaking, etc. The first two Functions are linked with the others by single Data Flows, and also provide the connection point for Data Flows from the terminators and with other High Level Functions. Two of the remaining Functions also receive Data Flows from other High Level Functions. The Functions and Data Flows are contained in the DFD for Function 5.4 - DFD 5.4.

All the functionality in this DFD exists at the same level. The nine Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). The first two Functions (F 5.4.1 and F 5.4.2) provide the input and output interfaces respectively for the other seven Functions. The inputs into the first Function (F 5.4.1) come from the Vehicle terminator either directly or via the visibility Functions in DFD 5.1. Each of the other seven Functions (F 5.4.3 - 9) provides a different facility that is connected with the lateral control of the vehicle. Two of these (F 5.4.3 and F 5.4.9) are complimented by Functions providing similar facilities for longitudinal control - see previous section (10.5). They each use their own separate input from the first Function (F 5.4.1) and send their individual outputs to the second Function (F 5.4.2). This Function produces a single output, which is sent to the lateral control Function in DFD 5.2.

Figure 33 DFD 5.4 Provide Lateral Collision Avoidance
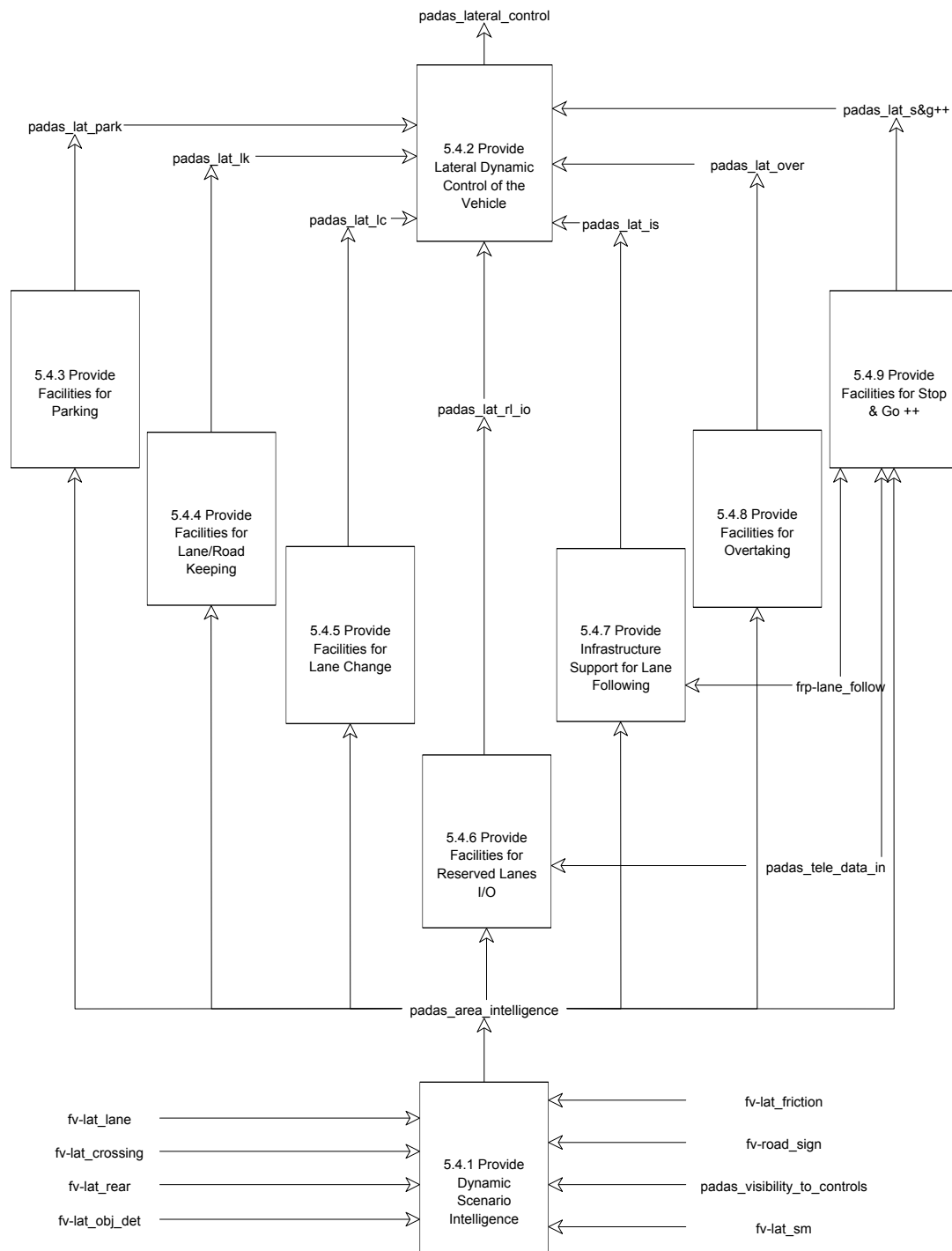
10.7. Function 5.5 Provide Safety Readiness

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enable safe operation of the vehicle. It is divided into seven lower level Functions that are as follows:

> F 5.5.1 Monitor Driver Status

F 5.5.2 Enhance Driver Alertness

F 5.5.3 Monitor Vehicle Status

F 5.5.4 Record Operational Data

F 5.5.5 Provide Automatic Take-over of Controls

F 5.5.6 Provide Warnings to Surrounding Traffic

F 5.5.7 Provide Mayday Call

These seven Functions provide facilities that enable the vehicle to operate in a manner that is safe for both its occupants and its surroundings. In the event of there being an emergency situation, then one of the Functions can initiate a call to the Emergency Services. Data Flows are provided that enable the Functions to exchange data with each other, with other High Level Functions and with the terminators. The Functions and Data Flows are contained in the DFD for Function 5.5 - DFD 5.5.

All the functionality in this DFD exists at the same level. The seven Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). The central Function in this DFD is the fifth (F 5.5.5), which is responsible for automatically taking over the control of the vehicle. It can do this as a result of input from the first Function (F 5.5.1), which monitors the driver's status, and/or the third Function (F 5.5.3), which monitors the status of the vehicle. When the fifth Function takes over control it sends output to the automated vehicle operation Functions in DFD 5.2. It can also pass warnings to the surrounding traffic through the sixth Function (F 5.5.6) and/or initiate a Mayday call through the seventh Function (F 5.5.7). The Mayday call can be sent to Functions in the Provide Safety and Emergency Facilities Area (2) - see Chapter 7, to ensure that help is provided to the vehicle and driver. All driver and vehicle status data provided by the first and third Functions is sent to the fourth Function (F 5.5.4) for storage. As an alternative to requesting the fifth Function to take over the vehicle controls, the first Function may send data to the second Function (F 5.5.2) so that alert status of the driver can be improved. The output of the second Function is sent to the driver-vehicle interaction Function (F 5.6) for the actual interaction with the driver and/or the vehicle.

The Data Store (D 5.1) contains data about the driver and vehicle status that has been recorded by the first and third Functions. This data is used by the first and fourth Function in their monitoring of driver and vehicle status respectively. The contents of the Data Store are described in Annex 3.

Figure 34 DFD 5.5 Provide Safety Readiness
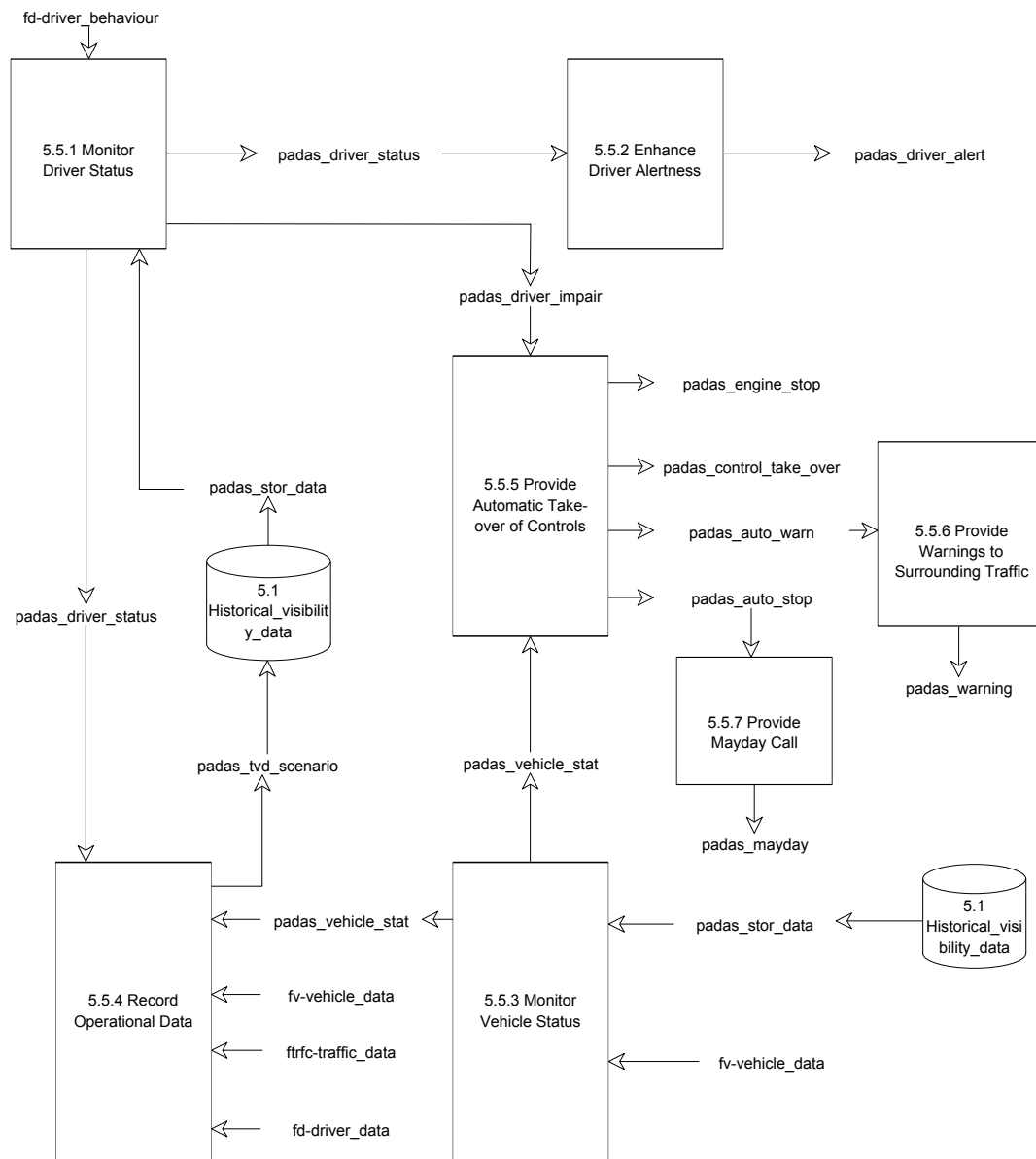
10.8. Function 5.7 Provide Vehicle-Telematics Integration

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enable the vehicle to communicate with other parts of the Functional Architecture. It is divided into four lower level Functions that are as follows:

F 5.7.1 Provide Vehicle-Infrastructure Communication

F 5.7.2 Provide Vehicle-Vehicle Communication

F 5.7.3 Provide Vehicle Position Determination

F 5.7.4 Provide Vehicle Telematic Architecture

These four Functions enable the vehicle to communicate with other functional Areas so that data to and from some of the facilities that they provide can be exchanged with Functions in the vehicle. Data Flows are provided that enable the Functions to exchange data with each other, with other High Level Functions in Area 5 and with the terminators. The Functions and Data Flows are contained in the DFD for Function 5.7 - DFD 5.7.

Figure 35 DFD 5.7 Provide Vehicle-Telematics Integration
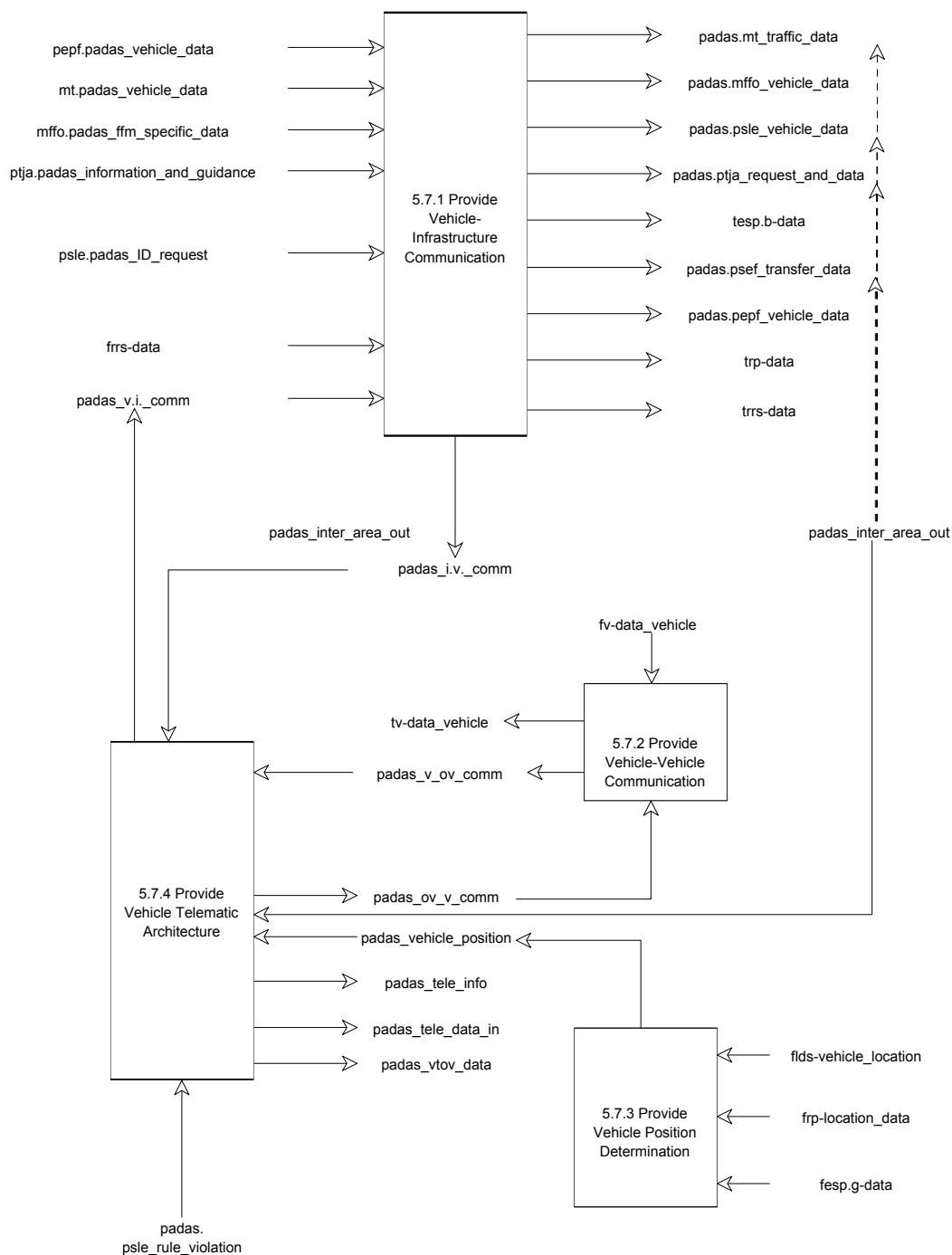
All the functionality in this DFD exists at the same level. The four Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). The first Function (F 5.7.1) provides the interface through which the Functions in other parts of this Area can exchange data with Functions in other Areas. It also provides interfaces for the exchange of data with the Broadcaster and Road Related System terminators. The data that it receives from outside Area 5 is sent to the fourth Function (F 5.7.4) for distribution to other DFD's in Area 5. The fourth Function also collects data that is to be sent through the interfaces provided by the first Function from the Functions responsible for integrating the vehicle into the traffic - see the description of DFD 5.8 in the next section (10.9). The second Function (F 5.7.2) provides the interface through which data is exchanged with other systems within the vehicle. These systems will provide facilities that are not related to ITS, or may be provided with the vehicle regardless of whether or not it includes the Functions in this and other DFD's in Area 5. Finally, the third Function (F 5.7.3) is responsible for determining the vehicle position using data from the Geographic Information Provider and Road Related System terminators. The positional data is sent to the fourth Function for use by other Functions within Area 5.

10.9. Function 5.8 Integrate Vehicle in Traffic System

This high level Function in the Provide Advanced Driver Assistance Systems Area provides functionality that will enable the vehicle to be integrated into the services and facilities being provided by other Functional Areas within the System. It is divided into ten lower level Functions that are as follows:

> F 5.8.1 Provide Pre-Trip Information
>
> F 5.8.10 Provide LAN Interface
>
> F 5.8.2 Provide Dynamic Route Guidance
>
> F 5.8.3 Provide Travel Information
>
> F 5.8.4 Provide Road Assistance
>
> F 5.8.5 Provide Road Regulations
>
> F 5.8.6 Collect Floating Cars Data
>
> F 5.8.7 Provide Stolen Vehicle Tracking/Prosecution
>
> F 5.8.8 Provide Detection of Law Violations
>
> F 5.8.9 Provide (EFT) Electronic Financial Transactions

These ten Functions enable the vehicle to generate and use data used by or produced from other parts of the Functional Architecture. This integration enables data such as floating car data to be provided to these Areas, as well as making some of their facilities such as route guidance and electronic payment available within the vehicle. Data Flows are provided that enable the Functions to exchange data with each other, with other High Level Functions and with the terminators. The Functions and Data Flows are contained in the DFD for Function 5.8 - DFD 5.8.

Figure 36 DFD 5.8 Integrate Vehicle in Traffic System
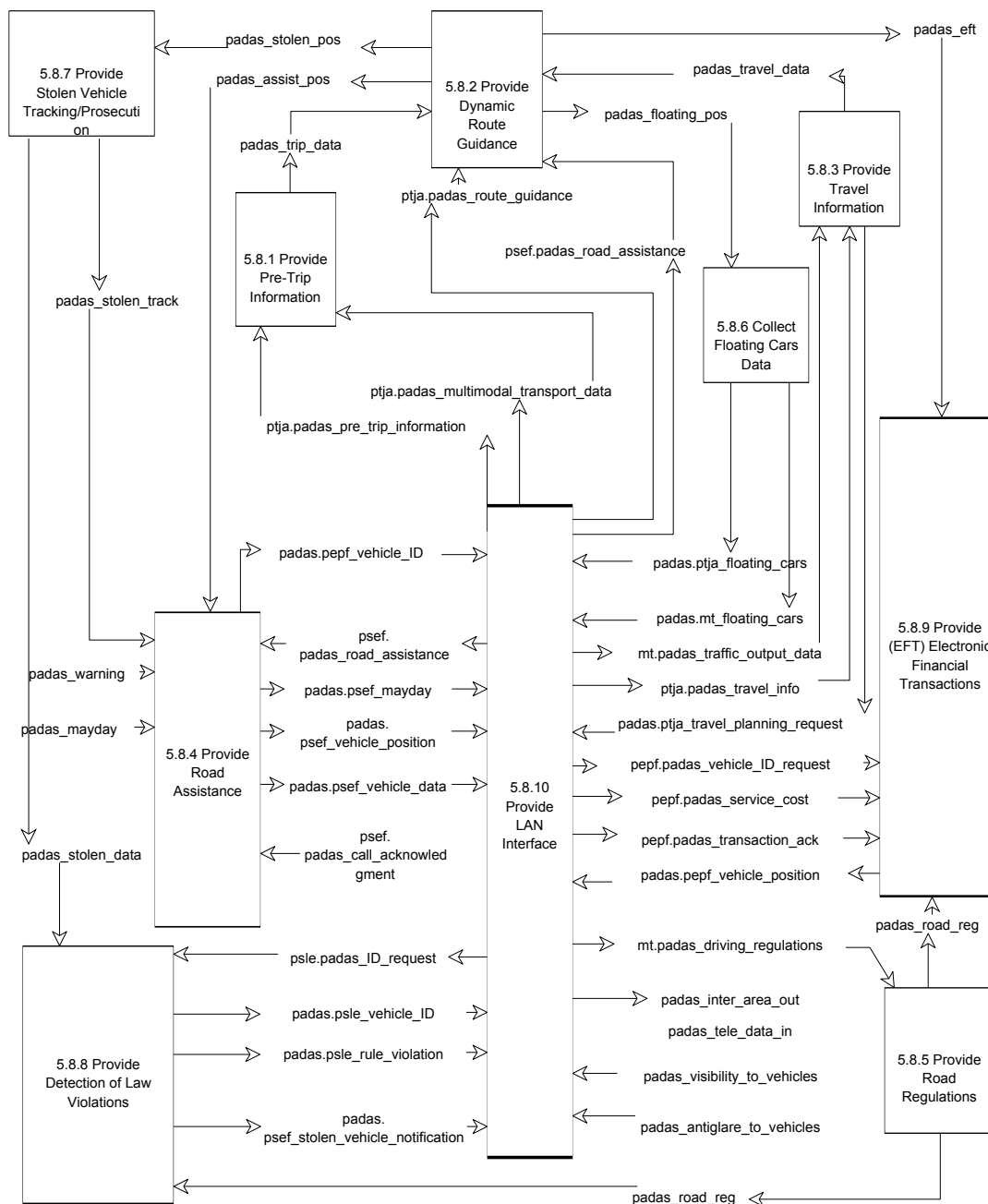
All the functionality in this DFD exists at the same level. The ten Functions are described in the part of Annex 1 that is devoted to the Provide Advanced Driver Assistance Systems Area (5). All of the data used and produced by the Functions in this DFD goes through the tenth Function (F 5.8.10). It receives data from other Areas of the Functional Architecture through a Function in DFD 5.7 and distributes it to one of the other nine Functions in this DFD. These nine Functions each provide a facility that is associated with one of the other Functional Areas. Data produced by these nine Functions returns to the appropriate Functional are using the same route.

11.   Area 6. Provide Traveller Journey Assistance

11.1. Introduction

This chapter describes the functionality in Area 6 Provide Traveller Journey Assistance. This Area 6 provides functionality that enables Travellers to plan and complete trips. Once a trip is in progress, the contents of its plan (the itinerary) can be adjusted if changes (perturbations) in the condition of the travel network occur. The implementation of the trip plan can include the provision of driving instructions to the Traveller as a Driver, otherwise known as "dynamic route guidance".

11.2. DFD 6 - High level functions in Provide Traveller Journey Assistance

At the highest level the functionality for this area is divided into the following High level functions :

> F 6.1 Define Traveller's GTP
>
> F 6.2 Plan Trip
>
> F 6.3 Support Trip
>
> F 6.4 Evaluate Trip

The Functions communicate with each other using the small number of Data Flows that link them together. A larger number of Data Flows that enable the Functions to exchange data with other Areas and with the terminators. The Functions and the Data Flows are contained in the highest level DFD for Area 6 DFD 6.

The four Functions in this Area form a logical chain that enables the Traveller to plan a trip using General Trip Preferences (GTP's) and/or Actual Trip Preferences (ATP's). This activity is interactive so that the Traveller can change the ATP for the trip if the originals do not provide the optimum trip. Bookings for other services, such as accommodation and other modes of transport (heavy rails, air flights, etc.) can be included in the trip. The Traveller can make payment for these services if required. The result is a trip plan that can then be implemented and updated in real time if perturbations occur within the travel network. At the end of the trip, the GTP data can be updated as a result of experiences on the trip. If requested by the Travel Information Operator, a trip evaluation report can also be produced. This will show how successful the trip plan was, and what changes were needed to accommodate perturbations in the travel network.

The Functions in this DFD and the other DFD's are responsible for the management of the GTP and Trip File Data Stores. The Travel Information Operator interfaces are defined in DFD 6.2 (for D 6.1) and DFD 6.3 (for D 6.2).

As will be seen from the DFD, the two High Level Functions divide into Low Level Functions. The traveller's GTP definition and trip evaluation Functions (F 6.1 and F 6.4 respectively) are simple ones (Low Level) that do not need to be sub-divided for their functionality to be understood. All of the High Level Functions are described in the following sections.

Figure 37 DFD 6 Provide Traveller Journey Assistance

11.3. Function 6.2 Plan Trip

This high level Function in the Provide Traveller Journey Assistance Area provides functionality to enable a Traveller to plan a trip. It is divided into seven lower level Functions that are as follows:

> F 6.2.1 Define Traveller's ATP
>
> F 6.2.2 Define Prime Criteria
>
> F 6.2.3 Propose Trip Alternatives
>
> F 6.2.4 Select and Define Bookings
>
> F 6.2.5 Plan Road Trip(s)
>
> F 6.2.6 Perform Bookings and Payments
>
> F 6.2.7 Produce Itinerary and Trip File
>
> F 6.2.8 Provide GTP Store Operator Interface

These eight Functions enable a Traveller to plan a trip. They are linked by a few Data Flows and also have single Data Flows that enable them to load and read data to and from the Data Stores. Several Data Flows are provided for the exchange of data with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 6.2 - DFD 6.2.

All the functionality in this DFD exists at the same level. The eight Functions are described in the part of Annex 1 that is devoted to the Provide Traveller Journey Assistance Area (6). The first Function (F 6.2.1) obtains the ATP data from the Traveller and (if required) from the GTP Data Store. Actual trip data in the form of primary and secondary criteria are then obtained from the Traveller and the initial trip plan defined through the second and third Functions (F 6.2.2 and F 6.2.3).;

The Traveller can modify the initial plan as an iterative process until the desired result is achieved.

Next the Traveller is asked to specify any bookings for other services, such as accommodation, use of transport modes not supported by the System such as heavy rail, air flights, etc. This is achieved through the fourth Function (F 6.2.4) and is completed before any road segments of the trip are planned by the fifth Function (F 6.2.5). Then the other services are booked and paid for by the sixth Function (F 6.2.6).

Finally the trip plan is approved by the Traveller for immediate or later use through the seventh Function (F 6.2.7). A copy of the approved trip plan is sent to the Traveller as an itinerary and it is also loaded into the trip file Data Store.

The two Data Stores (D 6.1 and D 6.2) contain details of the GTP data and the eventually agreed trip plan. Their contents are described in Annex 3. The Operator Interface Function for D 6.1 (F 6.2.8) is shown in this DFD for clarity, rather than in any other DFD. IT enables the Travel Information Operator to monitor and manage the contents of the Data Store.

Figure 38 DFD 6.2 Plan Trip
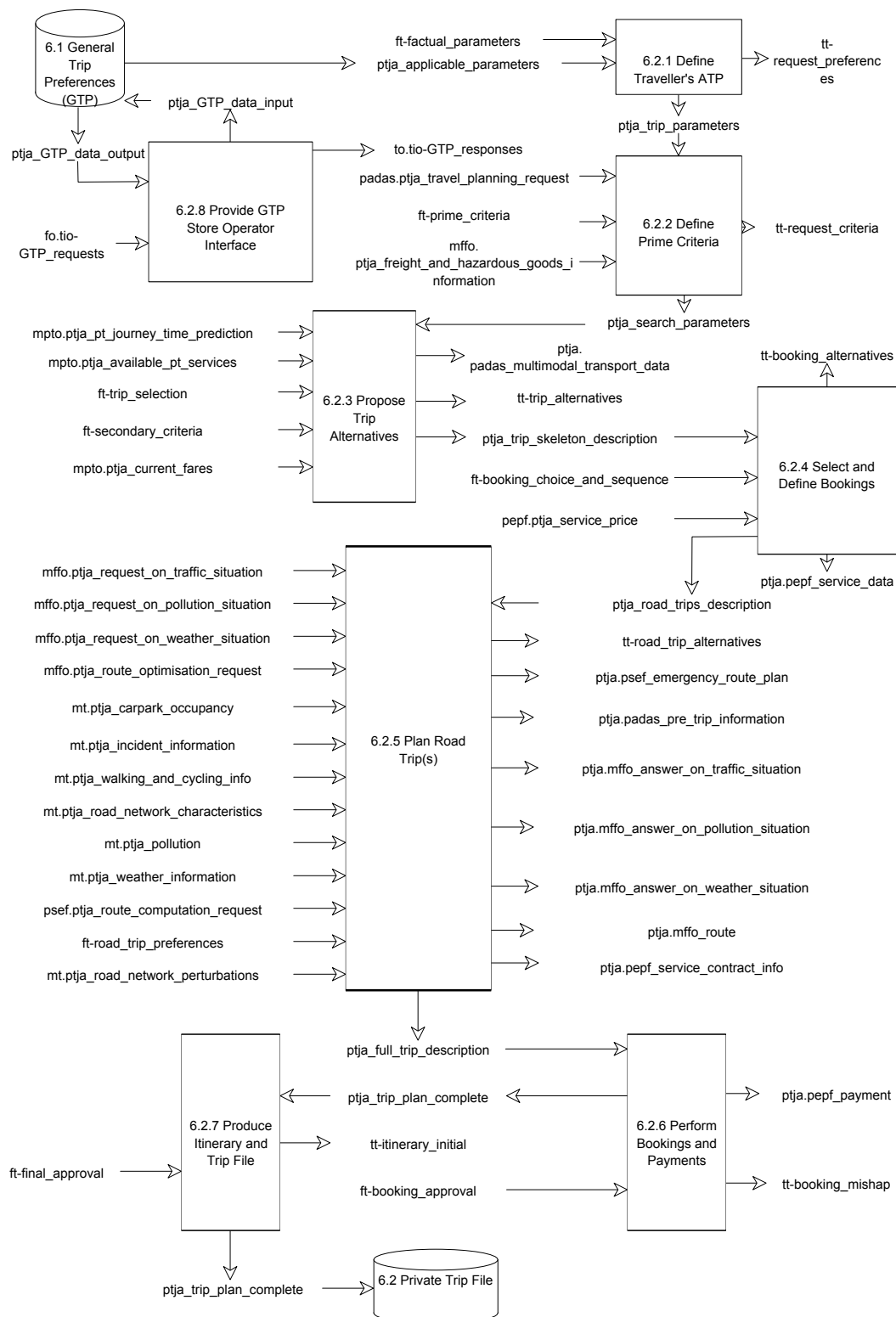
11.4.　Function 6.3 Support Trip

This high level Function in the Provide Traveller Journey Assistance Area provides functionality to support the implementation of a trip plan. It is divided into five lower level Functions that are as follows:

>　F 6.3.1 Track Traveller and Implement Trip Plan
>
>　F 6.3.2 Assess Perturbations
>
>　F 6.3.3 Inform Traveller
>
>　F 6.3.4 Provide Route Guidance
>
>　F 6.3.5 Provide Trip File Management Operator Interface

The four Functions are linked by single Data Flows and also have single Data Flows that enable them to load and read data from the Data Store. Several Data Flows are provided for the exchange of data with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 6.3 - DFD 6.3.

All the functionality in this DFD exists at the same level. The two Functions are described in the part of Annex 1 that is devoted to the Provide Traveller Journey Assistance Area (6).

These five Functions track a Traveller through the trip. The first Function (F 6.3.1) uses data from the Location Data Source terminator to determine the current Traveller location. The second Function uses this data in conjunction with updates about current travel conditions provided by the Manage Traffic Area (3) to propose to the Traveller updates of the trip plan if they are needed. When these updates are approved by the Traveller using the third Function (F 6.3.3), they are implemented by updating the Data Store.

If required, dynamic route guidance is also provided from those parts of the trip during which the Traveller becomes a vehicle Driver. If can be provided to drivers of both Freight Vehicles and private cars through the fourth Function (F 6.3.4).

The single Data Store (D 6.2) contains details of the plan. This data is provided by the Functions in the second DFD - see previous section. The contents of the Store are described in Annex 3. The Operator Interface Function for D 6.2 (F 6.3.5) is shown in this DFD for clarity, rather than in any other DFD. It enables the Travel Information Operator to monitor and manage the contents of the Data Store.

Figure 39 DFD 6.3 Support Trip
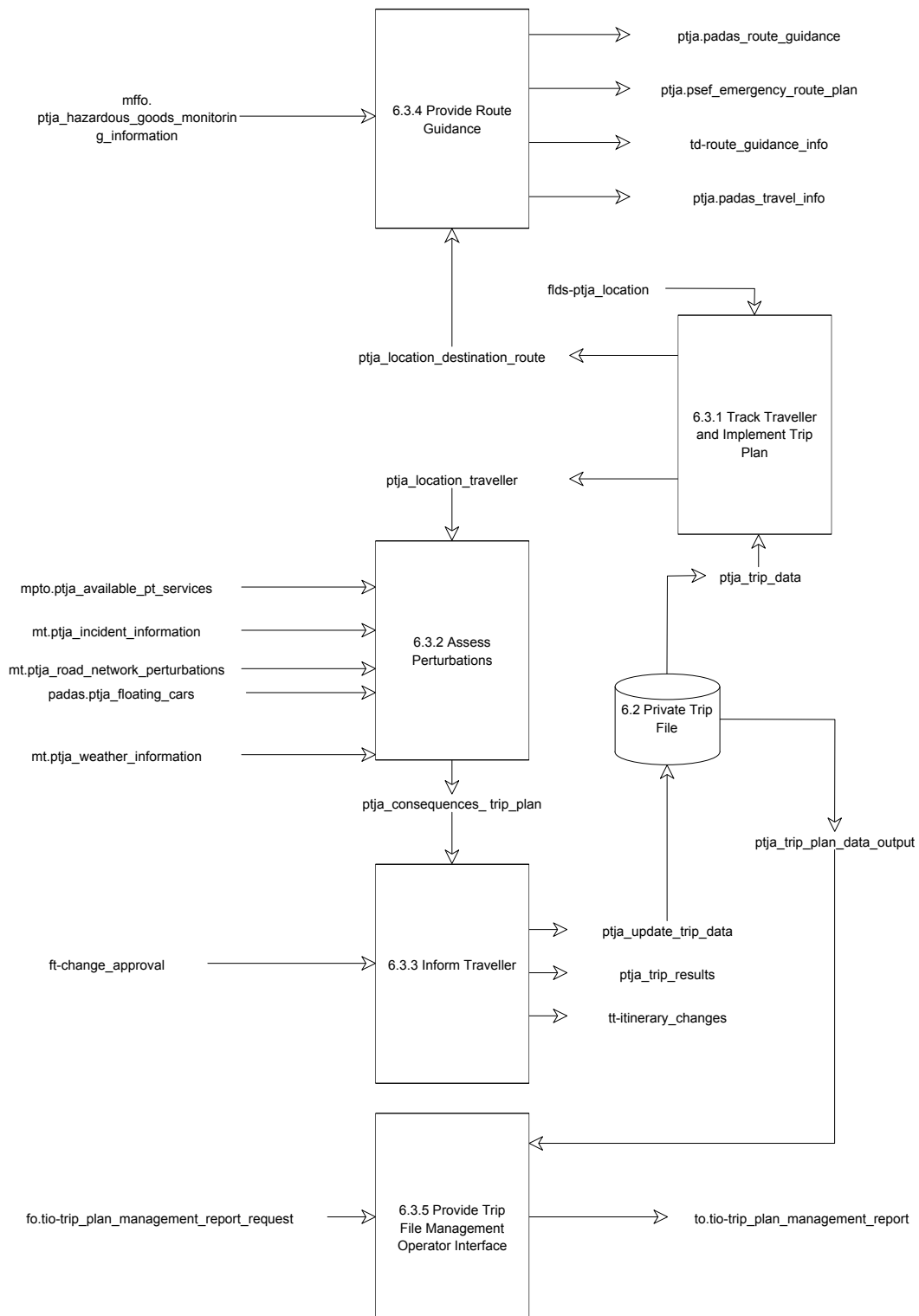
12. Area 7. Provide Support for Law Enforcement

12.1. Introduction

This chapter describes the functionality in Area 7 Provide Support for Law Enforcement. The functionality in Area 7 has prime responsibility for reporting of violations to the Law Enforcement Agencies. With the exception of over-weight vehicles detected using way-in-motion, and individual vehicle pollution levels, these violations will have been detected by functionality in other Areas.

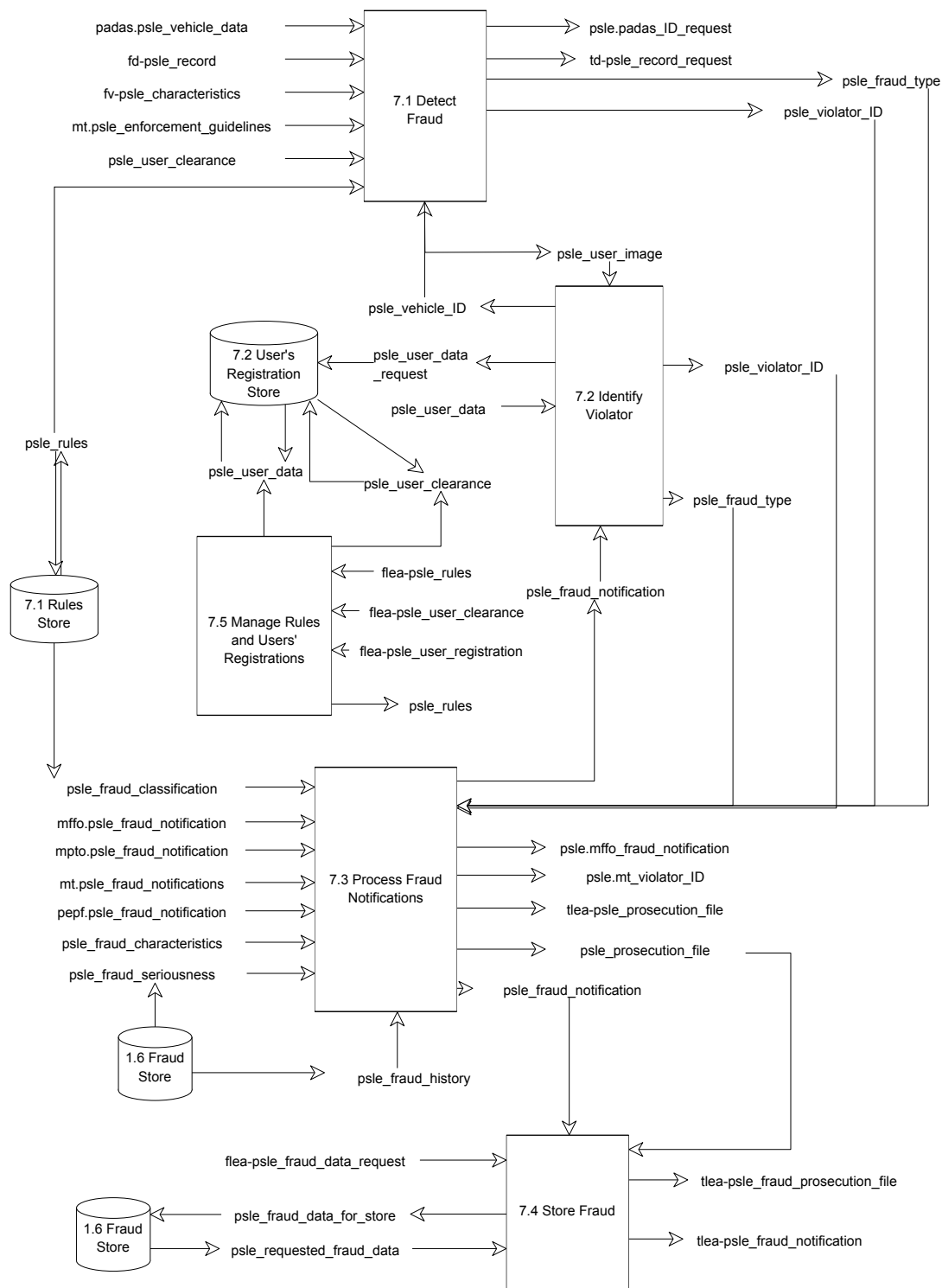## 12.2. DFD 7 - High Level Functions in Provide Support for Law Enforcement

At the highest level the functionality for this area is divided into the following High level functions :

> F 7.1 Detect Fraud
>
> F 7.2 Identify Violator
>
> F 7.3 Process Fraud Notifications
>
> F 7.4 Store Fraud
>
> F 7.5 Manage Rules and Users' Registrations

The Functions communicate with each other using the small number of data flows that links them together. There also a larger number of Data Flows that enable the Functions to exchange data with other Areas and with the terminators. These Data Flows and the Functions are shown in the highest level DFD for Area 7 DFD 7. This appears as the Figure on the previous page.

The five Functions in this Area are charged with processing violations of the transportation system rules. They collect fraud notifications from the other functions, identify the violator, prepare the prosecution file and send it to the appropriate Law Enforcement Agency through the terminator. For some types of fraud (weigh in motion, individual vehicle pollution), the Functions also detect the fraud. The Functions are also responsible for the management of the fraud Data Store, and for the updating of rules and users' registration Data Stores.

As will be seen from the DFD, with one exception these High Level Functions divide into Low Level Functions. The fraud storage Function (F 7.4) is a simple one that does not need to be sub-divided for its functionality to be understood. All of the Functions are described in detail by the following sections

Figure 40 DFD 7 Provide Support for Law Enforcement


12.3. Function 7.1 Detect Fraud

This high level Function in the Provide Support for Law Enforcement Area provides functionality to detect fraud. It is divided into two lower level Functions that are as follows:

F 7.1.1 Perform Measure

F 7.1.2 Check Compliance

These two Functions collect vehicle identities and check to see if a violation has occurred. The two Functions are linked by a single Data Flow and also have single Data Flows that enable them to read data from Stores. Several Data Flows are provided for the exchange of data with other Areas. The Functions and Data Flows are contained in the DFD for Function 7.1 - DFD 7.1.

Figure 41 DFD 7.1 Detect Fraud
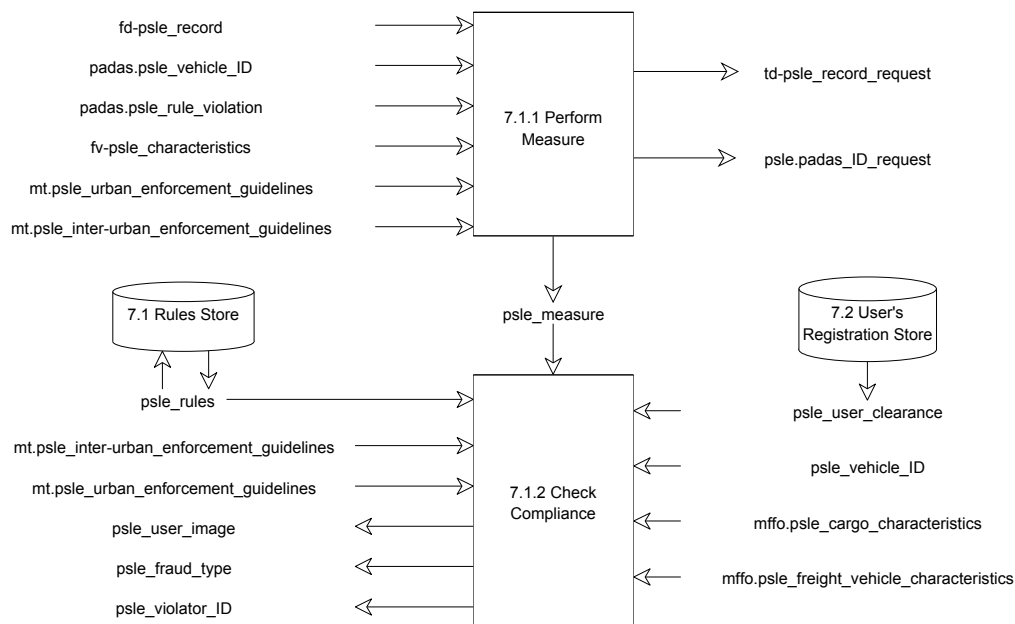
All the functionality in this DFD exists at the same level. The two Functions are described in the part of Annex 1 that is devoted to the Provide Support for Law Enforcement Area (7). One Function collects data about the vehicle suspected of committing the fraud and passes it on the second Function. This second Function checks to see if a fraud has occurred and if so passes the data on to another High Level Function within the Area. The two Data Stores (D 7.1 and D 7.2) contain details of the rules for fraud detection and users' registrations. They are set up by other Functions within the Area and are described in Annex 3.

12.4. Function 7.2 Identify Violator

This high level Function in the Provide Support for Law Enforcement Area provides functionality to identify a violator who has committed a fraud. It is divided into two lower level Functions that are as follows:

F 7.2.1 Analyse Image

F 7.2.2 Determine Violator ID

These two Functions determine the identity of the violator based on visual image analysis. There is one Data Flow to link the two Functions and a few Data Flows that enable them to

obtain data from a Data Store and communication with other functionality in the Area. The Functions and Data Flows are contained in the DFD for Function 7.2 - DFD 7.2.

Figure 42 DFD 7.2 Identify Violator
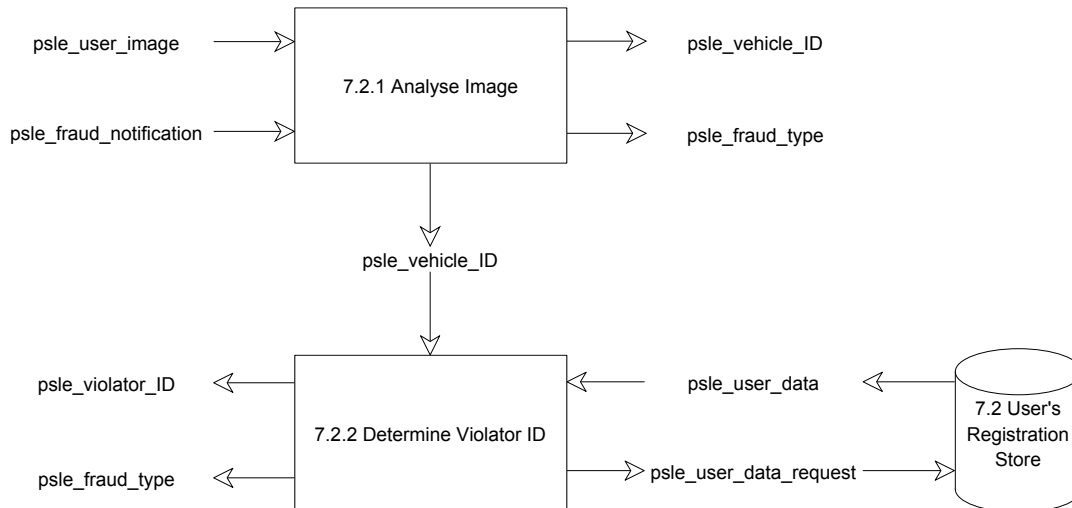
All the functionality in this DFD exists at the same level. The two Functions are described in the part of Annex 1 that is devoted to the Provide Support for Law Enforcement Area (7). The first Function analyses the image of the violator when a fraud has been detected. It passes data about the vehicle identity and type of fraud to the second Function so that it can add more data about the violator. The resulting data is then passed on to the High Level Function that processes the fraud notifications. The single Data Store (D 7.2) contains details of the users' registrations and is described in Annex 3.

12.5. Function 7.3 Process Fraud Notifications

This high level Function in the Provide Support for Law Enforcement Area provides functionality to process fraud notifications. It is divided into two lower level Functions that are as follows:

> F 7.3.1 Sort Fraud Notifications

> F 7.3.2 Establish Prosecution File

These two Functions process the data about the fraud that has been received from other Areas to produce a prosecution file. There is one Data Flow to link the two Functions and a few Data Flows that enable them to obtain data from Data Stores. There are several other Data Flows that enable the Functions to communication with other functionality in the Area and with the Law Enforcement Agency terminator. The Functions and Data Flows are contained in the DFD for Function 7.2 - DFD 7.2.

Figure 43 DFD 7.3 Process Fraud Notifications
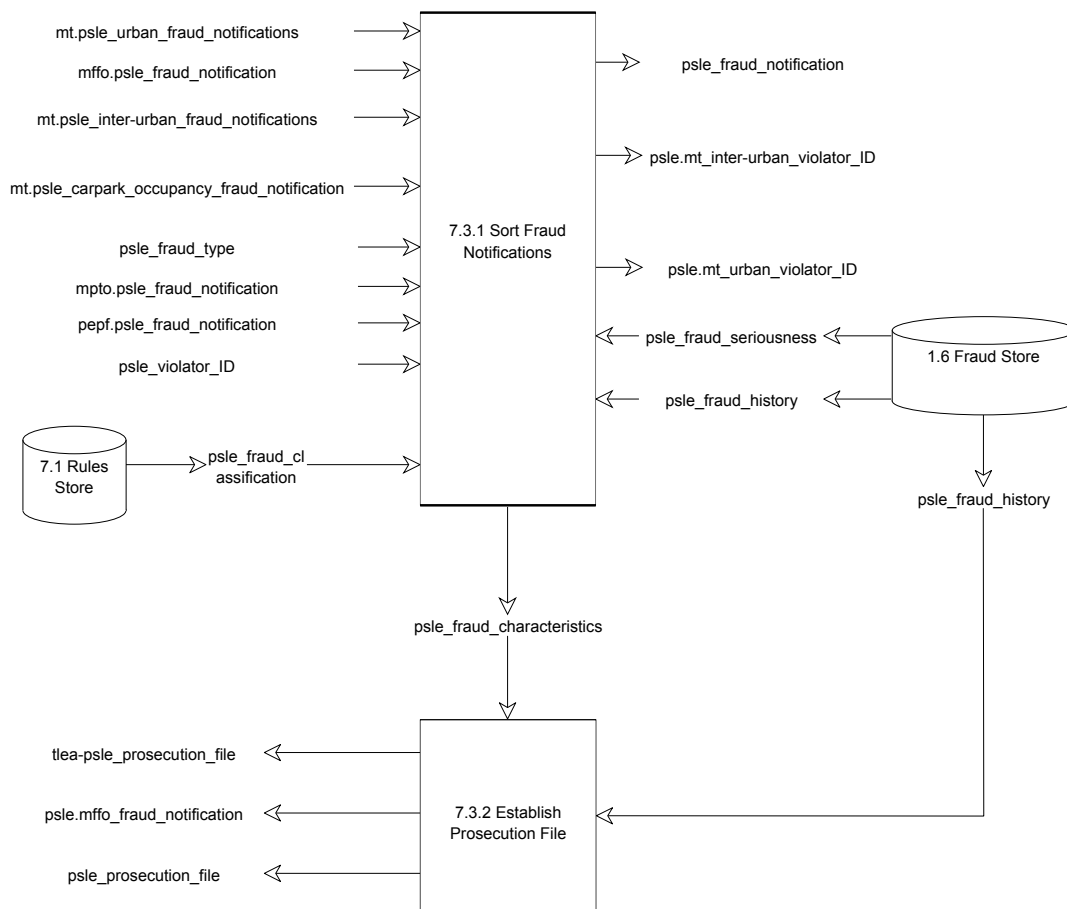
All the functionality in this DFD exists at the same level. The two Functions are described in the part of Annex 1 that is devoted to the Provide Support for Law Enforcement Area (7). The first Function receives the data about frauds that is provided by other Areas. It looks up the rules about fraud detection and determines the next course of action. It uses data obtained from other functionality in this Area to establish data from which the prosecution file can be built by the second Function. This prosecution file is sent to the Law Enforcement Agency terminator and when freight vehicles are involved to the Manage Freight and Fleet Operations Area (Area 8). The file is also sent to the fraud storage Function (F 7.4). The two Data Stores (D 7.1 and D 1.6) contain the rules for fraud processing and the history of frauds that have been detected. They are maintained by other functionality within the Area (D 7.1) and within the Provide Electronic Payment Facilities Area (D 1.6). Both are described in Annex 3.

12.6. Function 7.5 Manage Rules and Users' Registrations

This high level Function in the Provide Support for Law Enforcement Area provides functionality to maintain the Data Stores of rules and users' registrations. It is divided into two lower level Functions that are as follows:

F 7.5.1 Manage Rules

F 7.5.2 Manage Users' Registration

These two Functions maintain their Data Stores. They each have two Data Flows, one to receive data for the Store and the other to load data into the Store. The Functions and Data Flows are contained in the DFD for Function 7.5 - DFD 7.5.

Figure 44 DFD 7.5 Manage Rules and Users' Registrations
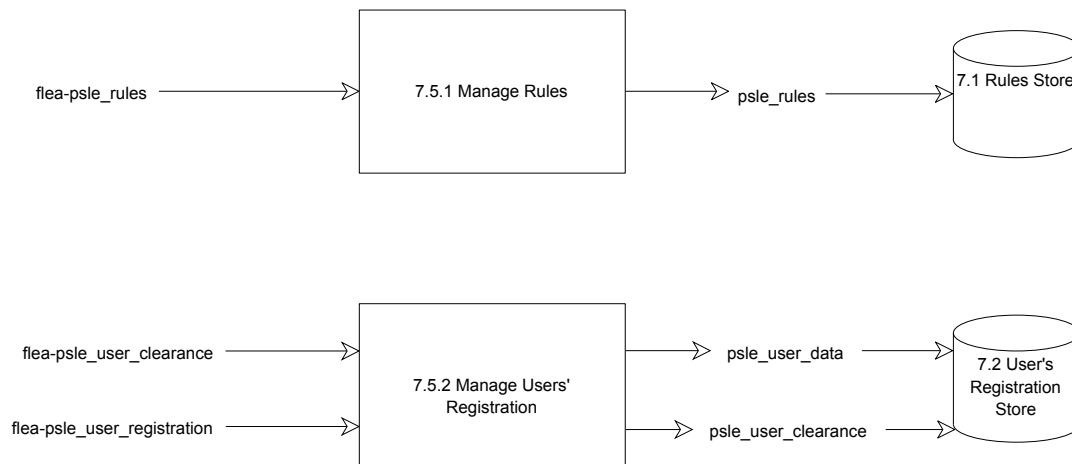
All the functionality in this DFD exists at the same level. Each Function is described in the part of Annex 1 that is devoted to the Provide Support for Law Enforcement Area (7). The Functions do nothing else but maintain their own Data Stores (D 7.1 and D 7.2), which are described in Annex 3.

13.   Area 8. Manage Freight and Fleet Operations

13.1. Introduction

This chapter describes the functionality in Area 8 - Manage Freight and Fleet Operations. The functionality in Area 8 enables goods to be transported from one location to another and for the operation of fleets of freight vehicles to be managed.

13.2. DFD 8 - High Level Functions in Manage Freight and Fleet Operations

At the highest level the functionality for this area is divided into the following High level functions :

> F 8.1 Manage Logistics and Freight

> F 8.2 Manage Commercial Fleet

> F 8.3 Manage vehicle/driver/cargo/equipment during trip

The Functions communicate with each other using the four Data Flows that link them together. There is also a larger number of Data Flows that enable the Functions to exchange data with other Areas and with the terminators. These Data Flows and Functions are contained in the highest level DFD for Area 8 DFD 8.

The three Functions in this Area provide facilities for the management of freight and fleet operations in two situations. The first two Functions (F 8.1 and F 8.2) provide functionality for a static freight and fleet operations centre. This centre can accept goods (freight) for transportation from one location to another. The route will be chosen and this may involve the use of modes other than that provided by road transport. If necessary, the goods can be stored at points along the route to enable the most optimum scheduling to be used. The second Function (F 8.2) can also manage the operation of a fleet of freight vehicles. This includes the scheduling and specification of drive duties and vehicle maintenance.

The third Function (F 8.3) provides functionality for the management of freight and fleet operations that are on-board a freight vehicle. It receives instructions about route plans and schedules and other information from the second Function (F 8.2). It also provides that Function with information about vehicle status, incidents and payments that have been made for things such as tolls.

Figure 45 DFD 8 Manage Freight and Fleet Operations
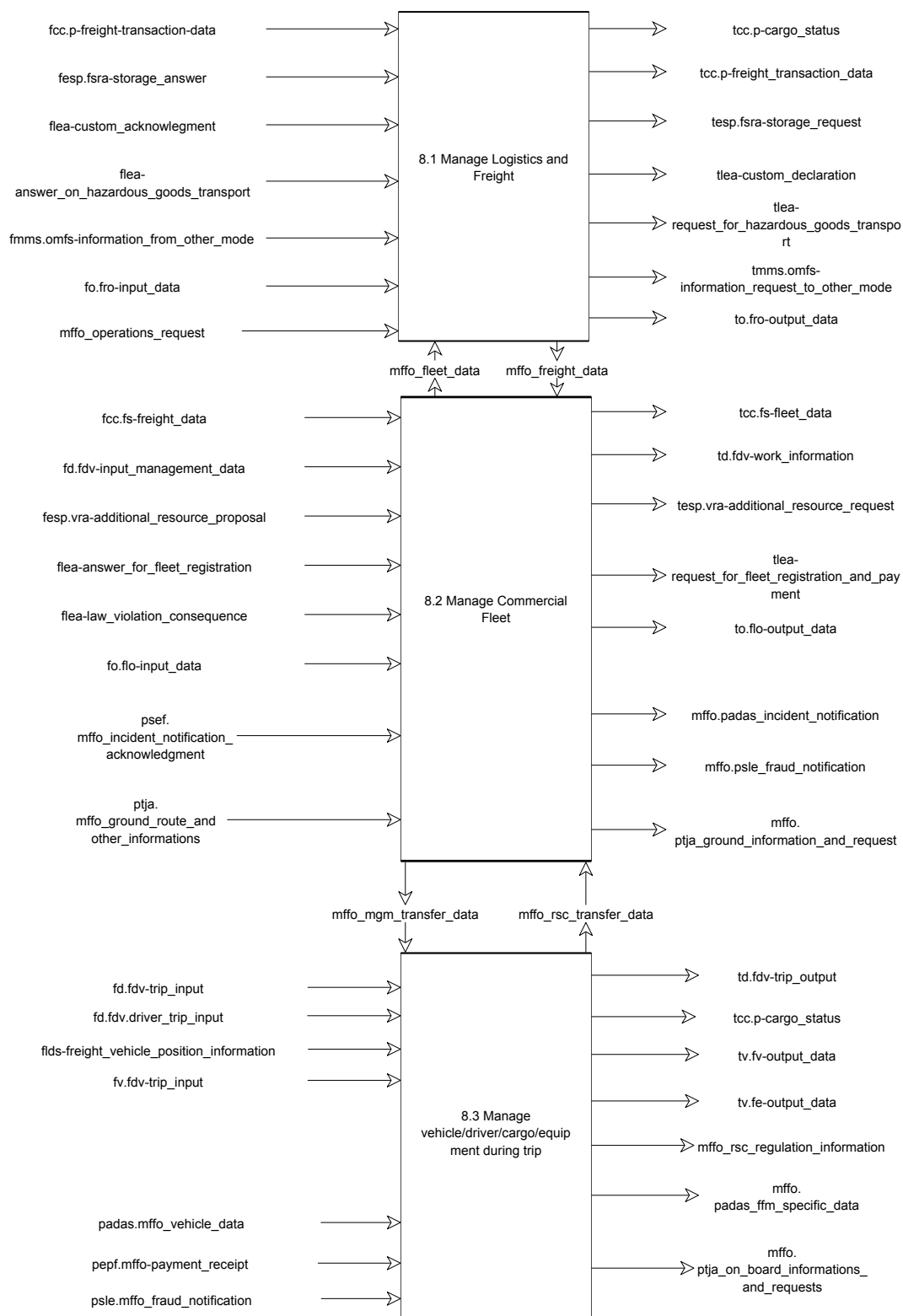
As will be seen from the DFD, the first two Functions divide into low level Functions. These are described in the following sections of this Document. The low level Functions for the third high level Function (F 8.3) are not included in this Document or others produced by the KAREN Project. They are described in the Deliverable Documentation that has been produced by the COMETA Project - see the last Chapter of this Document for the reference.

13.3. Function 8.1 Manage Logistics and Freight

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for logistics and freight management. It is divided into five further Functions that are as follows:

> F 8.1.1 Manage Freight Business Transactions

> F 8.1.2 Prepare Freight Operations

> F 8.1.3 Control Freight/Cargo Operations

> F 8.1.4 Evaluate Freight Operations Performance

> F 8.1.5 Manage Inter-modal Transport Synchronisation

These five Functions split the management of goods (freight) transport and fleets of freight vehicles between them. They communicate with each other, with other parts of the Manage Freight and Fleet Area and with the terminators using many Data Flows. These together with the Functions and the common Data Store are shown in the DFD for Function 8.1 - DFD 8.1.

All the functionality in this DFD exists at the same level with three exceptions. Each of the remaining two Functions is described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8). The other three Functions (F 8.1.1, F 8.1.2 and F 8.1.5) are high level Functions that have been divided into lower level Functions covering different aspects of logistics and freight management. These are described in more detail by later sections of this Chapter.

The first Function (F 8.1.1) is responsible for the management of business transactions. It does this in response to requests received from the Principal actor in the Consignee/Consignor terminator. Data about each consignment that is being processed by this Function is kept in the Containment Data Store (D 8.1). Request for the appropriate documentation to enable the consignment to be shipped is sent to the Prepare Freight Operations Function (F 8.1.2). The transport route may require the use of modes other than road, in which case services are requested from the Manage Inter-modal Transport Function (F 8.1.5). The activities of the Function (F 8.1.1) are managed by the Freight Operator through an interface within the Function.

Other Functions in this DFD provide control of the freight/cargo operations (F 8.1.3) and enable an evaluation of the handling of the consignment to be produced (F 8.1.4). This second Function produces its evaluation in response to a request from the Freight Operator. The first Function (F 8.1.3) maintains an update of the current status of the consignment, which it can provide to the Principal on request. This Function is again managed by the Freight Operator through an interface contained within the Function itself.

The Consignment Data Store (D 8.1) holds all the information about each consignment being shipped by the rest of the Functions. It is therefore crucial to their successful operation. Details of this Data Store will be found in Annex 3.

Figure 46 DFD 8.1 Manage Logistics and Freight
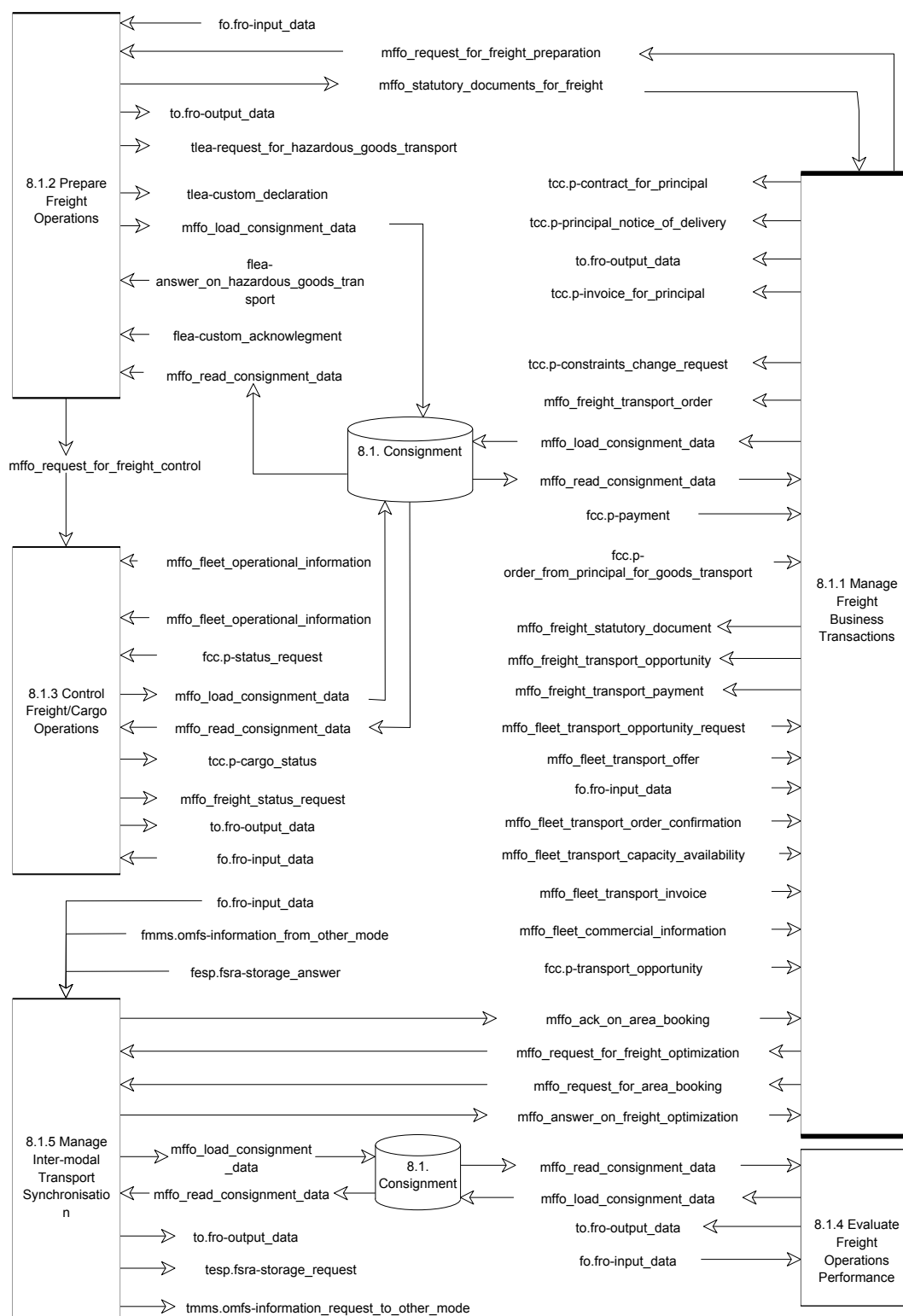
13.4. Function 8.1.1 Manage Freight Business Transactions

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of the business transactions needed to enable goods (freight) to be transported. It is divided into three low level Functions that are as follows:

F 8.1.1.1 Negotiate Principal Requests

F 8.1.1.2 Choose a Fleet Supplier

F 8.1.1.3 Administrate Freight Transactions

These Functions are responsible for the preparation of a plan for the transport of goods (freight) to fulfil the needs of the Principal actor in the Consignees/Consignors terminator. They directly communicate with each other using several Data Flows, but have a large amount of communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.1.1 - DFD 8.1.1.

All the Functions in this DFD exist at the same level. They are described in detail in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The Negotiate Principal Requests Function (F 8.1.1.1) enables the business transactions needed for the transport of the consignment (freight) to take place. This includes negotiation with the Principal over the details of the actual consignment, its route, schedule and use of transport modes other than road.   An order from the Consignor part of the Consignees/Consignors terminator is also required before the negotiations are complete.

If transport by road is involved, the fleet best suited is selected by the fleet choosing Function (F 8.1.1.2). Its choice will take into account the route, type of goods, and other factors, including the availability of suitable vehicles from fleets.

Once the details of the transport of the consignment have been successfully negotiated, payment is required. This is collected by the Administrate Freight Transactions Function (F 8.1.1.3).

The activities of all three Functions can be managed by the Freight Operator. Each Function has its own Operator interface for this purpose.

Again the Consignment Data Store (D 8.1) is crucial to the successful operation of the Functions in this DFD. Details of this Data Store will be found in Annex 3.

Figure 47 DFD 8.1.1 Manage Freight Business Transactions
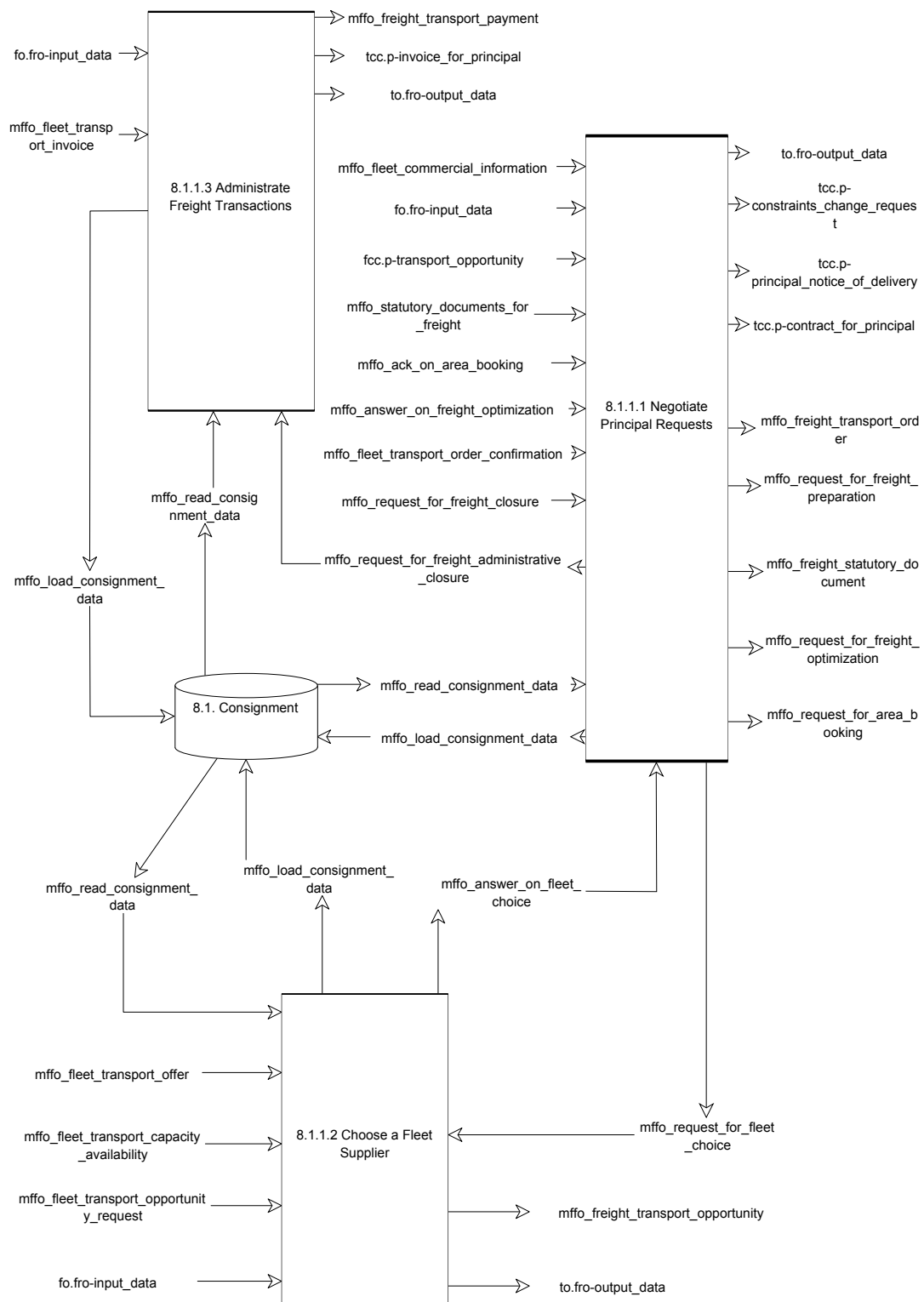
13.5. Function 8.1.2 Prepare Freight Operations

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for preparation of the official documentation needed by the freight operations plan so that goods (freight) can be transported. It is divided into three low level Functions that are as follows:

F 8.1.2.1 Handle Customs Declaration

F 8.1.2.2 Handle Hazardous Goods Transport Declaration

F 8.1.2.3 Prepare and Deliver Official Transport Documents

These three Functions are responsible for the using the results of the business negotiations with the Principal actor in the Consignees/Consignors terminator to prepare to ship the consignment. They directly communicate with each other using four Data Flows, and have some communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.1.2 - DFD 8.1.2.

All the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The Functions enable the official documentation needed for the transport of consignment (freight) to be produced. The management of the document preparation process is handled by one Function (F 8.1.2.3). It will obtain some of the documentation from the other two Functions. They will provide customs declaration documents (F 8.1.2.1) and hazardous goods declaration documents (F 8.1.2.2) if required by the route that the goods will take and the type of goods being transported. Both these Functions obtain the information that they need in order to prepare the documentation by interaction with the Law Enforcement Agency terminator.

Once the documentation has been produced by these Functions it is loaded in the Consignment Data Store (D 8.1) for use by other Functions in this part of the Area. Thus the as noted earlier, the Data Store is crucial to the successful operation of the Functions.

Figure 48 DFD 8.1.2 Prepare Freight Operations
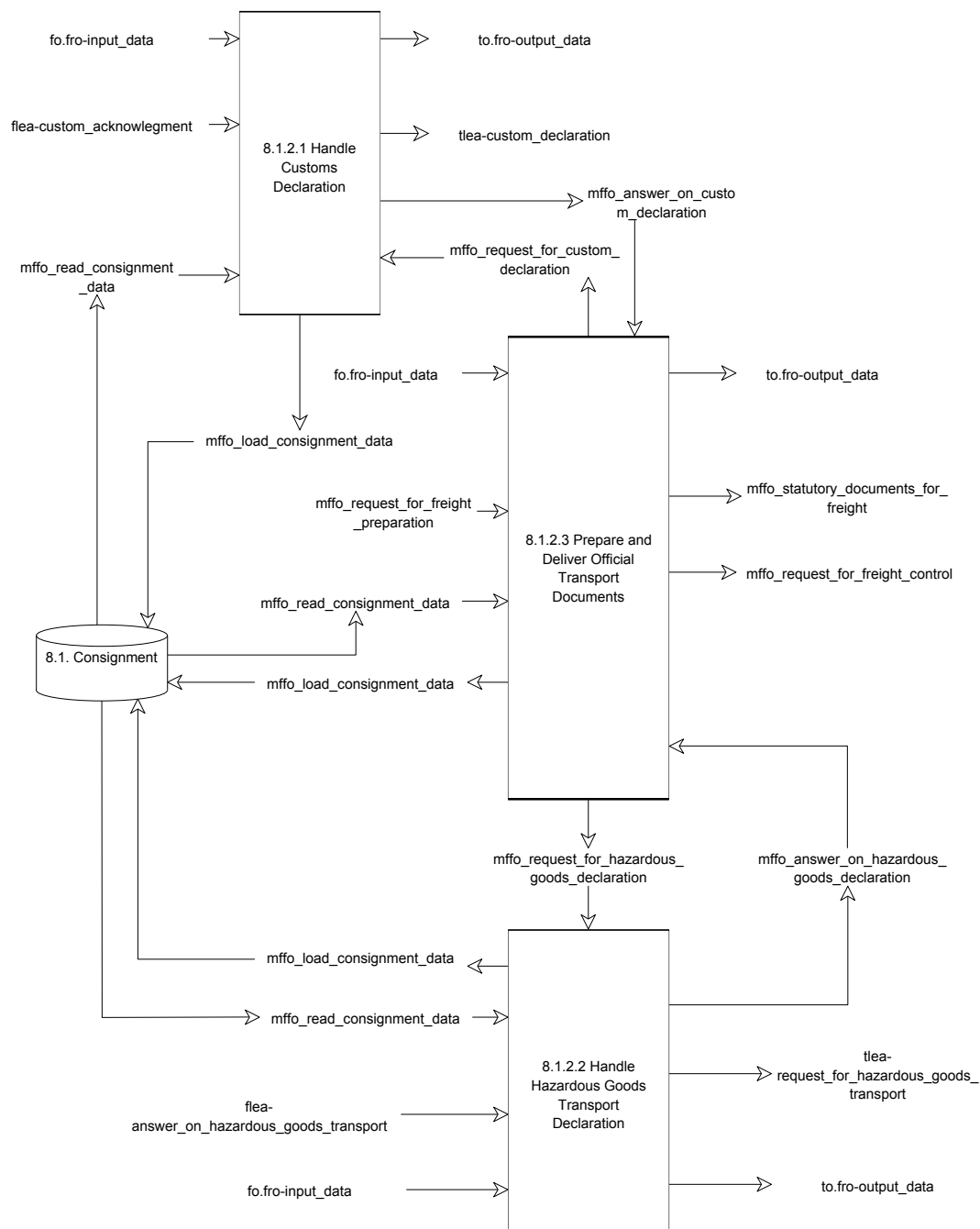
13.6. Function 8.1.5 Manage Inter-modal Transport Synchronisation

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of any non-road transport mode(s) needed by a particular goods (freight) movement. It is divided into two low level Functions that are as follows:

F 8.1.5.1 Identify Possible Transport Optimisations

F 8.1.5.2 Book Storage Places

These two Functions are responsible for the preparation of a plan for the transport of the consignment using other (non-road) transport modes and for the booking of any storage space that may be required during the shipment. They do not directly communicate with each other, but have some communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.1.5 - DFD 8.1.5.

Both the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).*

The first Function (F 8.1.5.1) obtains information about other (non-road) modes of transport that could be used for the transport of the consignment. If appropriate it optimises the use of these modes so that to avoid un-necessary delays. This is achieved through communication with the Multi-Modal Systems terminator. Where a delay cannot be avoided, the second Function (F 8.1.1.5.2) books storage space at the appropriate modal interchange points. This booking is achieved through an interface with the freight storage reservation agency part of the External Service Provider terminator.

The results of the work of each of these Functions is loaded into the Consignment Data Store (D 8.1) and is used by other Functions in the Area.

Figure 49 DFD 8.1.5 Manage Inter-modal Transport Synchronisation
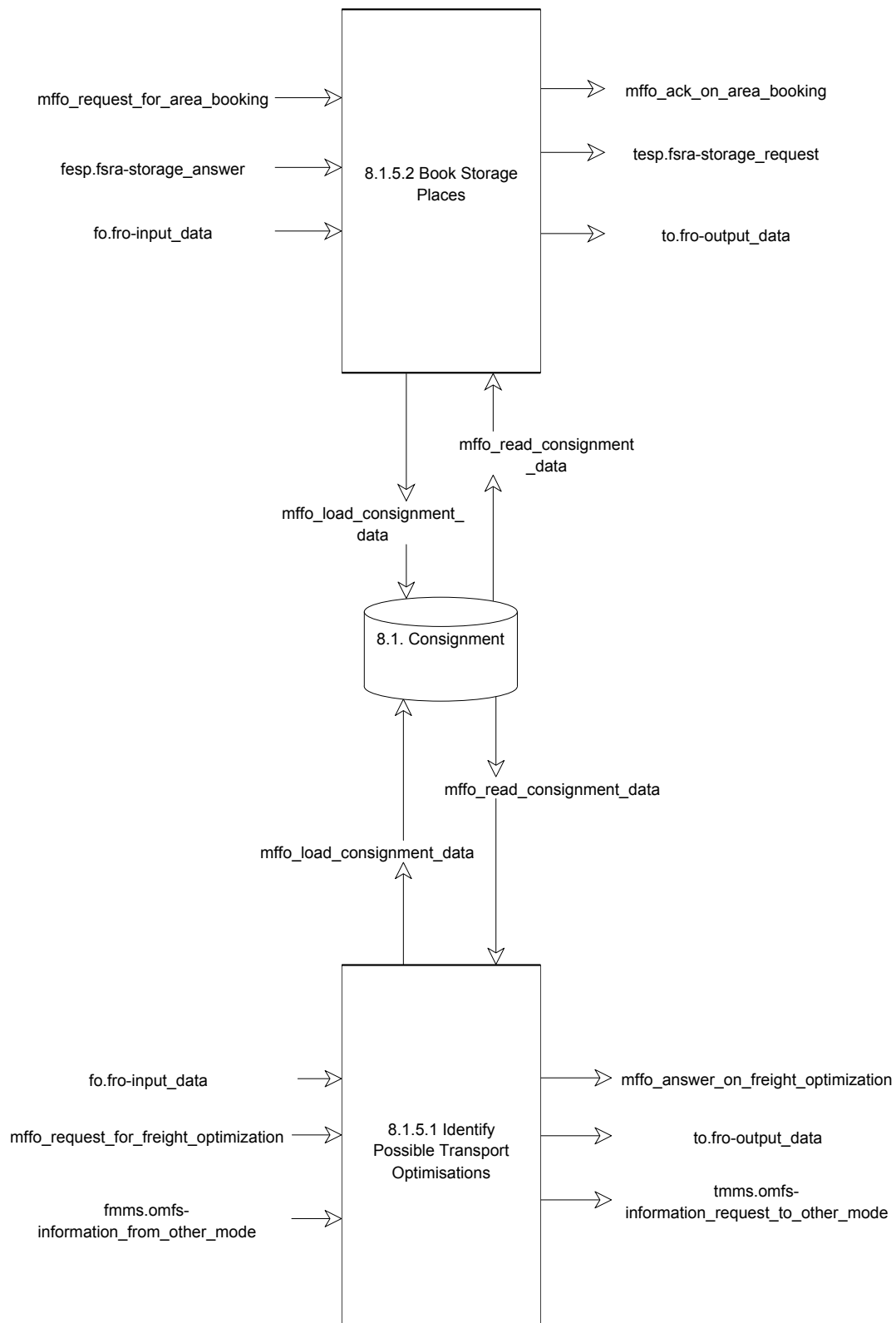
13.7. Function 8.2 Manage Commercial Fleet

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of the transportation of goods (freight). It is divided into three Functions that are as follows:

F 8.2.1 Manage Fleet Business Transactions

F 8.2.2 Manage Fleet Operations

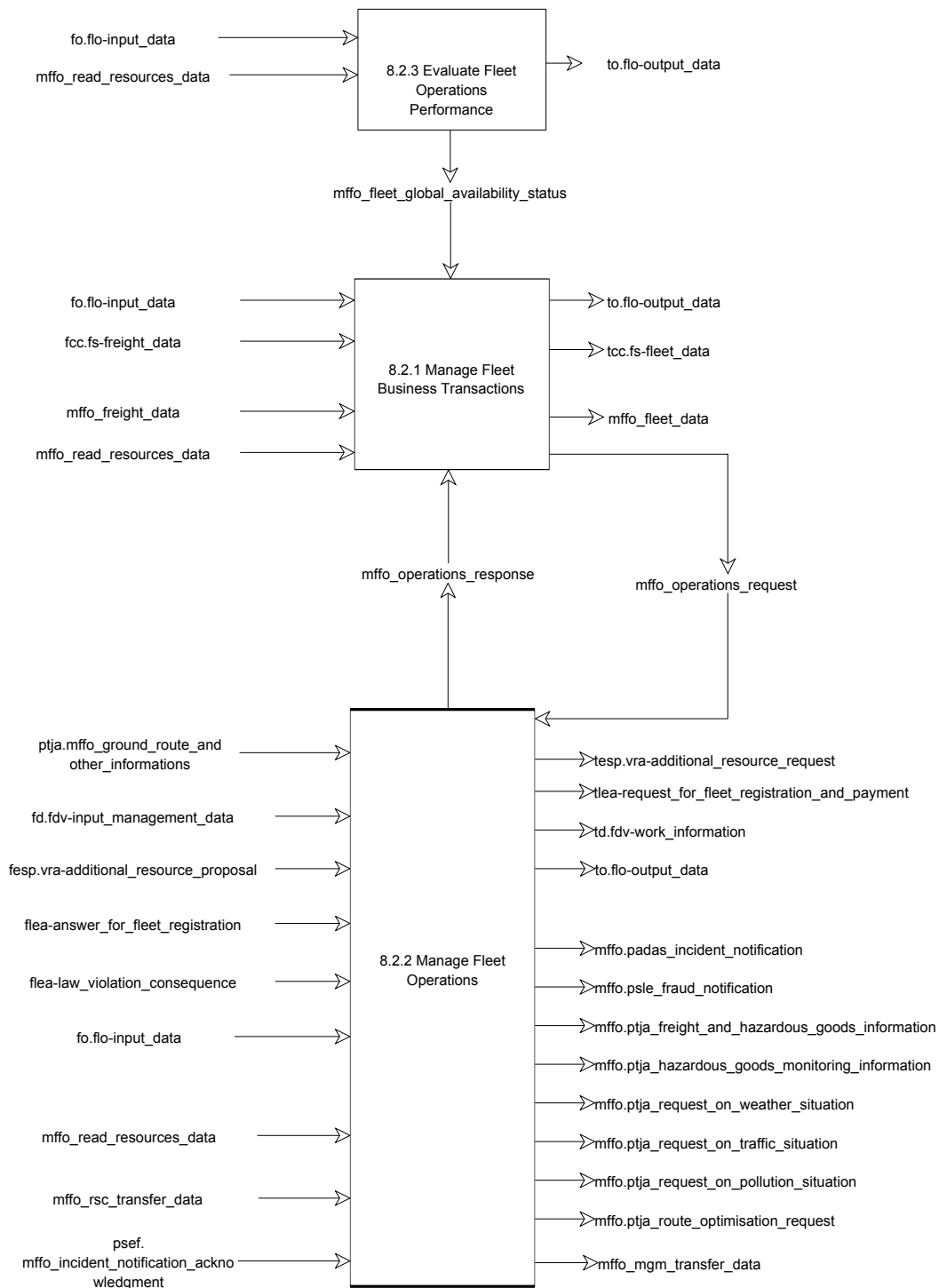F 8.2.3 Evaluate Fleet Operations Performance

These Functions are responsible for the management of the freight vehicle fleets. Only three of them directly communicate with each other using three Data Flows, but they have a large amount of communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.2 - DFD 8.2.

The Functions in this DFD exist at different levels. Two of them are high level Functions that divide into lower level Functions. These are described in the following sections of this Chapter. The remaining Function is already at its lowest level and has no further division. All of the Functions are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The two high level Functions (F 8.2.1 and F 8.2.2) manage fleet business transactions and fleet operations respectively.   The first of these agrees details of the part(s) of the consignment shipment that will need transport by road with the freight management functionality - see section 13.4. Once completed, the second Function uses the information to produce plans and schedules for the freight vehicle route that is to be used.   The implementation of the freight vehicle plan and the control of the use of fleet resources for particular transport plans are also carried out by this Function. The progress of the execution of the freight transport plan can be monitored by the Fleet Operator through interfaces to these Functions.

The Fleet Operator can request an evaluation of the performance of freight fleet operations through an interface to the low level Function (F 8.2.3). This uses data about the use of the fleet that is retained in the Resources Data Store (D 8.2).

All three Functions use the Resources Data Store (D 8.2) to hold information about the use of the freight vehicle fleet. This information is also used by other Functions in this part of the Area.

Figure 50 DFD 8.2 Manage Commercial Fleet

13.8. Function 8.2.1 Manage Fleet Business Transactions

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of the business transactions needed for the freight vehicle fleet. It is divided into two low level Functions that are as follows:

F 8.2.1.1 Negotiate Freight Operator Requests

F 8.2.1.2 Administrate Fleet Transactions

These Functions are responsible for the management of business transactions that are needed to enable the freight fleet to transport the consignment of goods. They directly communicate with each other using a single Data Flow, and have a some communications with other functionality in the Area and with the Fleet Operator terminator. The Functions and Data Flows are contained in the DFD for Function 8.2.1 - DFD 8.2.1.

Both the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The Functions enable the business transactions needed for the operation of the freight fleet to take place. This includes the identification and assignment of fleet resources to transport the consignment (freight), plus the preparation of invoices and the receipt of payment for that work. The work carried out by both Functions can be managed by the Fleet Operator through internal interfaces.

All the data that is produced by these Functions is held in the Resources Data Store (D 8.2). It is available for use by other Functions in this part of the Area.

Figure 51 DFD 8.2.1 Manage Fleet Business Transactions

mffo_commercial_event

mffo_freight_transport_order

mffo_freight_status_request

mffo_freight_transport_opportunity

fcc.fs-freight_transport_opportunity

fcc.fs-freight_transport_order

fcc.fs-freight_statutory_document

fcc.fs-freight_status_request

fo.flo-input_data

mffo_commercial_incident

mffo_fleet_global_availability_status

mffo_read_resources_data

8.2.1.1 Negotiate Freight Operator Requests

mffo_fleet_transport_order_confirmation

mffo_fleet_transport_offer

mffo_fleet_transport_capacity_availability

mffo_fleet_commercial_information

mffo_fleet_operational_information

mffo_fleet_transport_opportunity_request

to.flo-output_data

8.2 Resources data store

mffo_request_for_fleet_administrative_closure

mffo_read_resources_data

fcc.fs-freight_transport_payment

mffo_freight_transport_payment

fo.flo-input_data

8.2.1.2 Administrate Fleet Transactions

mffo_fleet_transport_invoice

to.flo-output_data

tcc.fs-fleet_transport_invoice

13.9. Function 8.2.2 Manage Fleet Operations

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of the freight vehicle fleet. It is divided into three lower level Functions that are as follows:

> F 8.2.2.1 Plan & Prepare Fleet Operations
>
> F 8.2.2.2 Control and Monitor Fleet Operations
>
> F 8.2.2.3 Manage Fleet Resources

These three Functions are responsible for the management of the fleet of freight vehicles so that they can transport goods. They directly communicate with each other using the Data Flows between them, and have a some communications with other functionality in the Area and with the Fleet Operator terminator. The Functions and Data Flows are contained in the DFD for Function 8.2.2 - DFD 8.2.2.

All of the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The three Functions enable the fleet of freight vehicles to be managed so that they can transport goods by road. This includes planning the way in which the vehicles will be utilised (F 8.2.2.1), control and monitoring their operation (F 8.2.2.2) and managing the resources of the fleet as a whole (F 8.2.2.3). The planning Function (F 8.2.2.1) will take into account traffic, weather and pollution conditions. If vehicles are not available from within the fleet then it will attempt to obtain extra vehicles through the vehicle renting agency, which is an actor in the External Service Provider terminator. The monitoring Function (F 8.2.2.2) collects information about frauds (violations) and incidents. It forwards details of both of these to Functions in the Provide Support for Law Enforcement and Provide Safety and Emergency Facilities Areas (A7 and A2 respectively). The fleet resources management Function (F 8.2.2.3) communicates with the Law Enforcement Agency terminator to get the fleet registered and to pay for the registration. The activities of all three of the Functions can be managed by the Fleet Operator through internal interfaces.

Data that is produced by these Functions is held in the Resources Data Store (D 8.2). It is used by the Functions themselves and by other Functions in this part of the Area.

Figure 52 DFD 8.2.2 Manage Fleet Operations
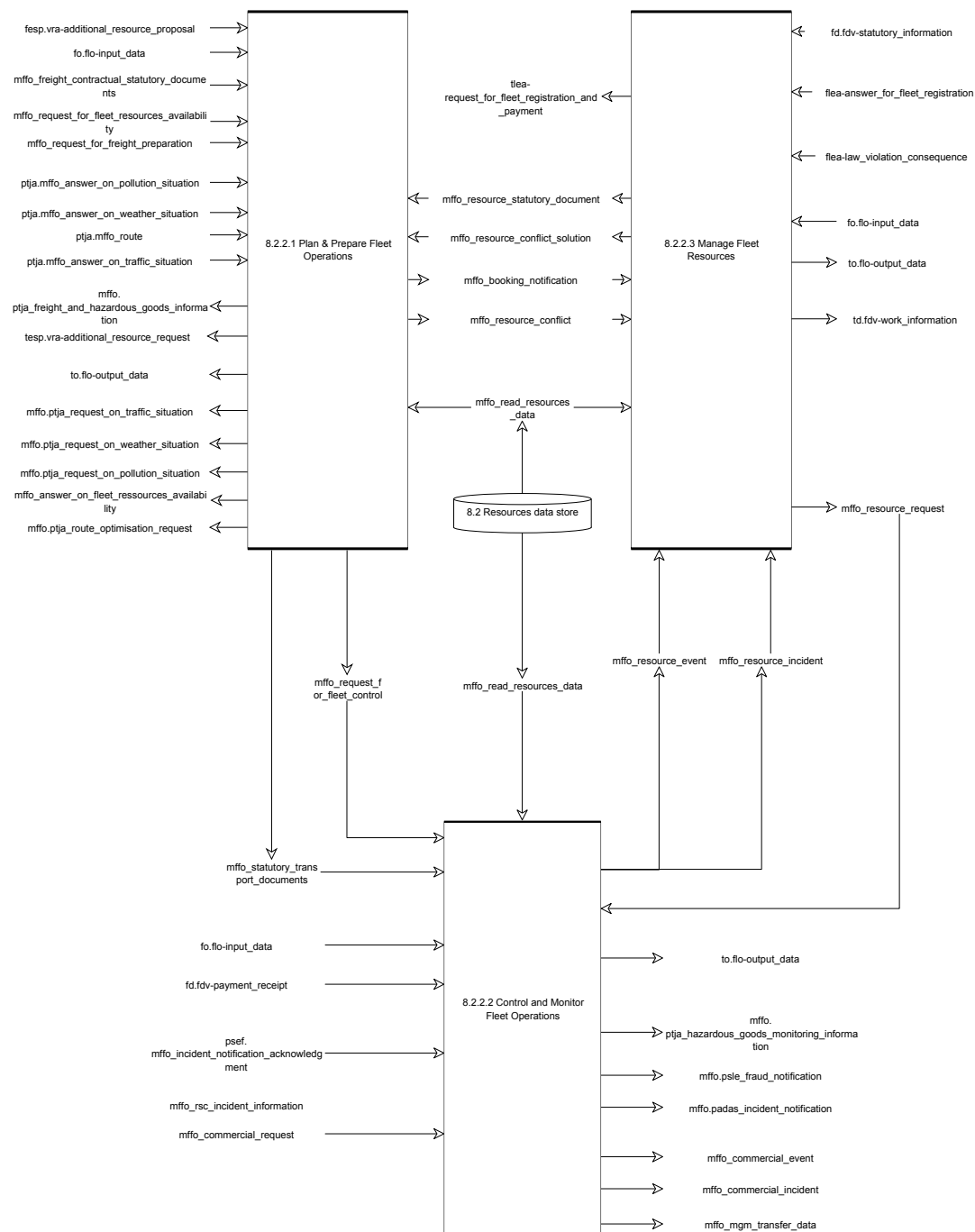
13.10. Function 8.2.2.1 Plan & Prepare Fleet Operations

This high level Function in the Manage Freight and Fleet Operations Area provides functionality to plan the transport of goods (freight) by road using freight fleet resources. It is divided into three low level Functions that are as follows:

F 8.2.2.1.1 Elaborate and Store Operational trip and load plan

F 8.2.2.1.2 Determine Compliant Resources

F 8.2.2.1.3 Prepare and Deliver Operational Transport Document

These three Functions are responsible for the determining fleet resources, vehicle trip and load plans (routes), and the documentation enabling the consignment to be transported. The Data Flows enable one Function to communicate with the other two, and all the Functions to communicate with other functionality in the Area, with other Areas, plus the Fleet Operator terminator. The Functions and Data Flows are contained in the DFD for Function 8.2.2.1 - DFD 8.2.2.1.

All the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first of the Functions (F 8.2.2.1.1) produces the route for the freight vehicle to transport the consignment. This may be combined with the transport of other consignments if that is the most efficient way to utilise the vehicles in the fleet. It uses information on current atmospheric pollution, weather and traffic conditions that it obtains from functionality in the Provide Traveller Journey Assistance Area (Area 6). The second Function (F 8.2.2.1.2) determines the resources in the freight vehicle fleet that can be used to transport the consignment by road. If necessary, the use of extra vehicles is enabled through communication with the vehicle renting agency actor in the External Services Provider terminator. The third Function (F 8.2.2.1.3) prepares all the statutory documentation needed for the consignment to be transported. It then sends it and the route information to the in-vehicle functionality in Function 8.3.

All of the results from the activities of these Functions are loaded in the Resources Data Store (D 8.2). It can then be used by other Functions in this part of the Area.

Figure 53 DFD 8.2.2.1 Plan & Prepare Fleet Operations
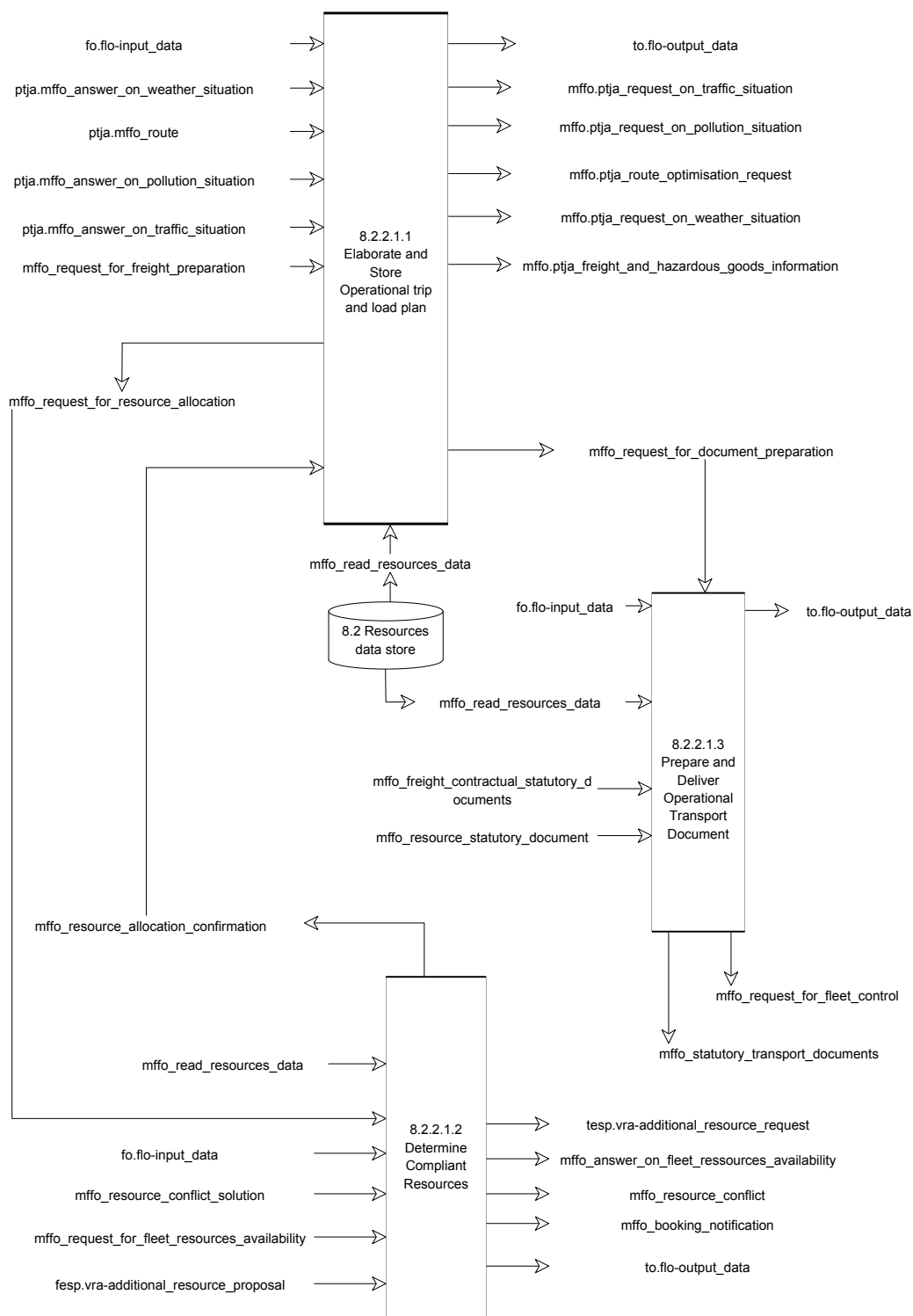
13.11. Function 8.2.2.2 Control and Monitor Fleet Operations

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the control of the use of freight fleet resources needed by a particular goods (freight) movement. It is divided into five low level Functions that are as follows:

F 8.2.2.2.1 Prepare/Process information to/from board

F 8.2.2.2.2 Manage Incident

F 8.2.2.2.3 Process onboard Payments

F 8.2.2.2.4 Evaluate Transport Conditions

F 8.2.2.2.5 Evaluate and Record Safety Status

These five Functions are responsible for controlling and monitoring the implementation of a plan for the transport of consignment by freight vehicle fleet resources. Four of the Functions directly communicate with each other using two Data Flows for each link. These and the other Function use remaining Data Flows to communicate with other functionality in the Area, with other Areas and with the Fleet Operator terminator. The Functions and Data Flows are contained in the DFD for Function 8.2.2.2 - DFD 8.2.2.2.

All five of the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first Function (F 8.2.2.2.1) obtains information about the status of the vehicle that has been assigned to transport the consignment. It achieves this by obtaining data from facilities in the on-board vehicle Function (F 8.3). Anything that has a safety implication is sent to the fifth Function (F 8.2.2.2.5) for evaluation. Information about incidents is sent from the first Function to the second Function (F 8.2.2.2.2), which confirms that there is an incident. It informs the functionality in the Provide Safety and Emergency Facilities Area and issues instructions to the vehicle for action by the driver.

The third Function (F 8.2.2.2.3) records the payment of tolls made by the freight fleet vehicle. It uses data that has been provided by facilities in the on-board vehicle Function (F 8.3) through the first Function (F 8.2.2.2.1), but which are now available from the Data Store. Transport conditions are evaluated by the fourth Function (F 8.2.2.2.4), this time using data provided directly by the first Function (F 8.2.2.2.1). The Fleet Operator is able to manage the activities of these Functions through the internal interfaces that they contain.

The Resources Data Store (D 8.2) contains the results of the work of all of these five Functions. It is used by other Functions in this part of the Area as a mechanism for the transfer of data between them.

Figure 54 DFD 8.2.2.2 Control and Monitor Fleet Operations
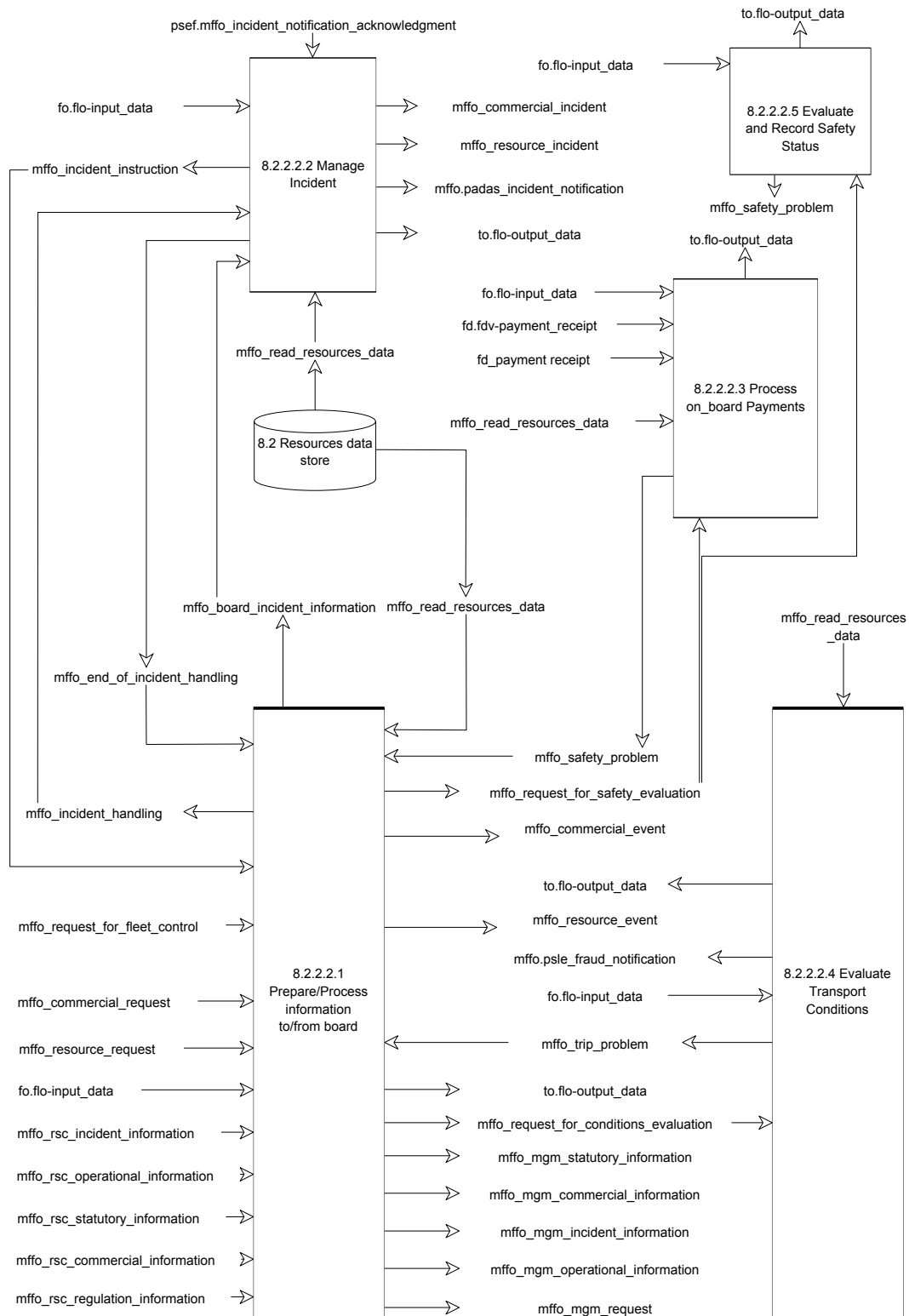
13.12. Function 8.2.2.3 Manage Fleet Resources

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of resources of the freight vehicle fleet. It is divided into three low level Functions that are as follows:

F 8.2.2.3.1 Manage and Schedule Maintenance Activities

F 8.2.2.3.2 Manage Vehicle and Equipment

F 8.2.2.3.3 Manage Driver Employment

These Functions are responsible for the management of freight vehicles and freight drivers that are part of the freight vehicle fleet. They do not directly communicate with each other, but use Data Flows to communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.2.2.3 - DFD 8.2.2.3.

All three of the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first Function (F 8.2.2.3.1) is responsible for managing and scheduling the maintenance activities for vehicles in the freight fleet It does this using data about vehicle use that it reads from the Resources Data Store (D 8.2). The Function will also resolve conflicts with vehicle allocation that it receives from functionality in the Plan & Prepare Fleet Operations high level Function - see DFD 8.2.2.1 in a previous section of this Chapter. The second Function (F 8.2.2.3.2) is responsible for the registration of the vehicles in the fleet. Registration includes any payment that is needed and the Function sends this and the required information to the Law Enforcement terminator. The third Function (F 8.2.2.3.3) manages the drivers of vehicles in the freight fleet. It is responsible for keeping records of their work up to date, including the recording of the consequences of any violations processed by the Law Enforcement Agency terminator. As with other Functions the Fleet Operator is able to manage the activities of these Functions through the internal interfaces that they contain.

The results of the work of these Functions is loaded in the Resources Data Store (D 8.2), It can then be used by other Functions in this part of the Area.

Figure 55 DFD 8.2.2.3 Manage Fleet Resources
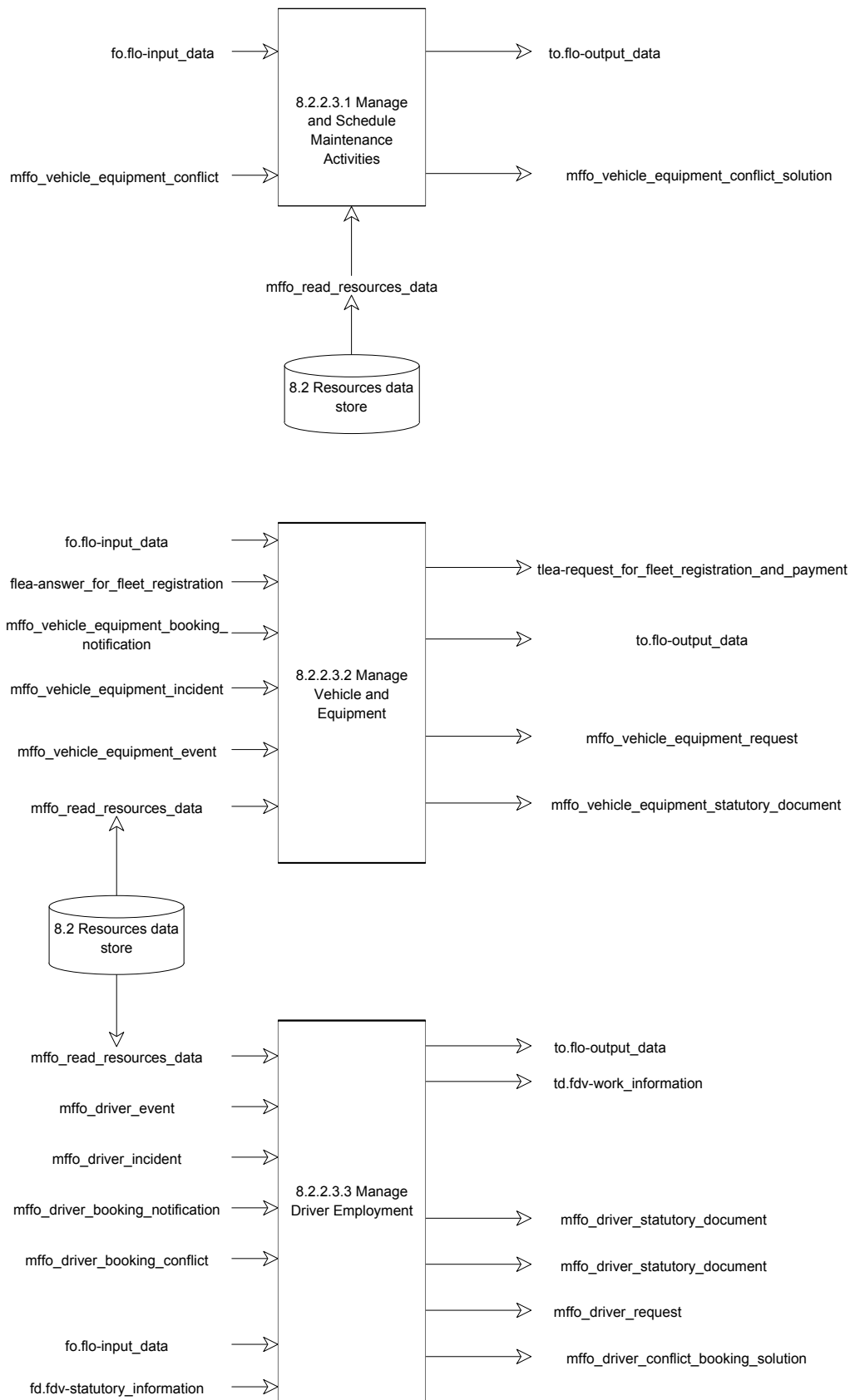
13.13. Function 8.3 Manage vehicle/driver/cargo/equipment during trip

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management on-board the freight vehicle. It is divided into three further Functions that are as follows:

F 8.3.1 Manage Task and Transport Order

F 8.3.2 Manage Resources

F 8.3.3 Comply with Regulation

These three Functions split the on-board vehicle functionality between them. They communicate with each other, with other parts of the Manage Freight and Fleet Area and with the terminators using many Data Flows. These together with the Functions and the common Data Store are shown in the DFD for Function 8.3 - DFD 8.3.

Two of the Functions (F 8.3.1 and F 8.3.2) in this DFD are high level Functions that have been divided into lower level Functions covering different aspects of logistics and freight management on-board the vehicle. These are described in more detail by later sections of this Chapter. The third Function (F 8.3.3) is a Low Level Function and is described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first Function (F 8.3.1) is responsible for the management of transport order covering the shipment on goods (freight) by the vehicle. It does this in response to details of the order that it receives from other Functions in the Mange Freight and Fleet Area. It also receives data from the second Function (F 8.3.2) as a result of its management of resources. The third Function (F 8.3.3) checks for compliance with all applicable regulations. These will cover such areas as social responsibility, speed limits, the use of lanes/ carriageways/roads prohibited to freight vehicles and weight limits. Access to the data resulting from the check is provided for the Driver and for the Legal Authorities. This access includes suitable protection and checks to prevent it being seen or copied by un-authorised persons.

The activities of all of the Functions are managed by the Freight Vehicle Driver through interface within each of them. Note that in many cases, the Driver can be performing the activities that are associated with the Fleet Manager. This is because these Functions are concerned with activities on-board the Freight Vehicle to which a Fleet Manager in a Fleet Control Centre may not have access.

The On-board Database Data Store (D 8.3) holds all the information about each goods (freight) shipment that is being carried by the vehicle. It is therefore crucial to their successful operation. Details of this Data Store will be found in Annex 3.

Figure 56 DFD 8.3 Manage vehicle/driver/cargo/equipment
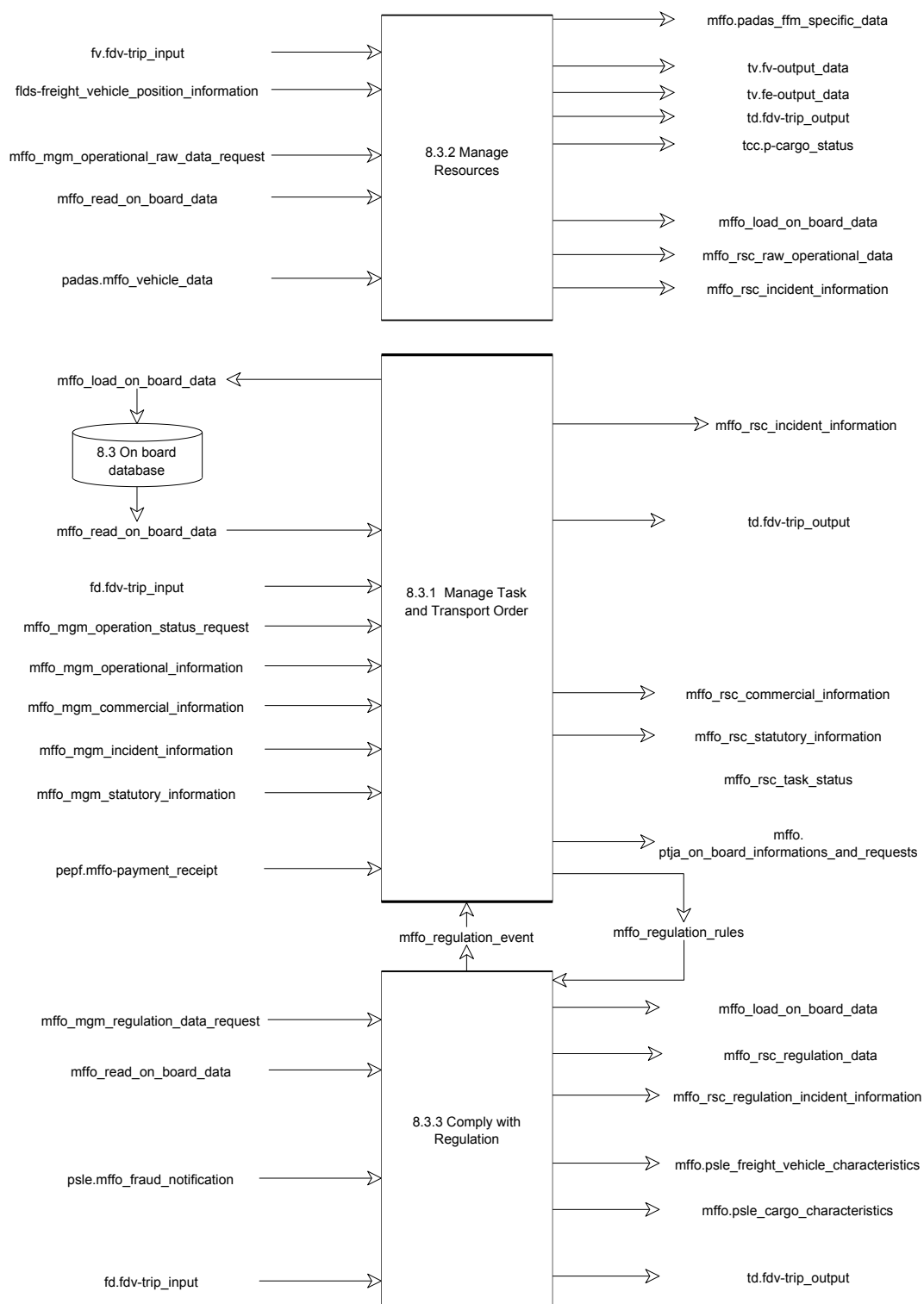
13.14. Function 8.3.1 Manage Task and Transport Order

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for the management of tasks and transport orders by a freight vehicle. It is divided into for low level Functions that are as follows:

> F 8.3.1.1 Check Transport Order
>
> F 8.3.1.2 Create New Transport Unit
>
> F 8.3.1.3 Monitor Transport Order
>
> F 8.3.1.4 Monitor Operational Task

These Functions are responsible for the management of tasks and transport orders being carried out by freight vehicles. The first second and fourth Functions communicate with the third Function through one or two Data Flows. Each Function uses several other Data Flows to communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.3.1 - DFD 8.3.1.

All three of the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first Function (F 8.3.1.1) is responsible for checking that the goods (freight) to be transported and/or the object in which the goods are to be transported (trailer, swap body, or container) correspond to what is in the transport orders that are received from the third Function (F 8.3.1.3). It does this at the request of the Driver. Any non-compliance is recorded in the On-board Database Data Store and used to request new instructions.

The second Function (F 8.3.1.2) will enable the Driver to accept a new transport unit if and when required. If necessary the Driver is provided with the facility that enables an identifier to be added to the new unit.

The third Function (F 8.3.1.3) enables the transport order to be monitored throughout its period of use. Functionality is provided to enable the transport order to be updated if and when significant events or changes in location occur. Updates can be requested from the Driver if necessary. The Function is capable of producing reports about the transport order whenever required by the Driver.

The fourth Function (F 8.3.1.4) provides support for the monitoring of tasks, in much the same way as transport orders are monitored by the third Function (F 8.3.1.3). An interface is provided by the Function to enable the Driver to update the data stored for each task, so that significant events may be included. A task report can be automatically triggered by the Function. Each Function contains its own internal interface that enables the Freight Vehicle Driver to provide input and receive output.

The On-board Database Data Store (D 8.3) holds all the information that is used by each of these Functions and is crucial to their successful operation. Details of this Data Store will be found in Annex 3.

Figure 57 DFD 8.3.1 Manage Task and Transport Order
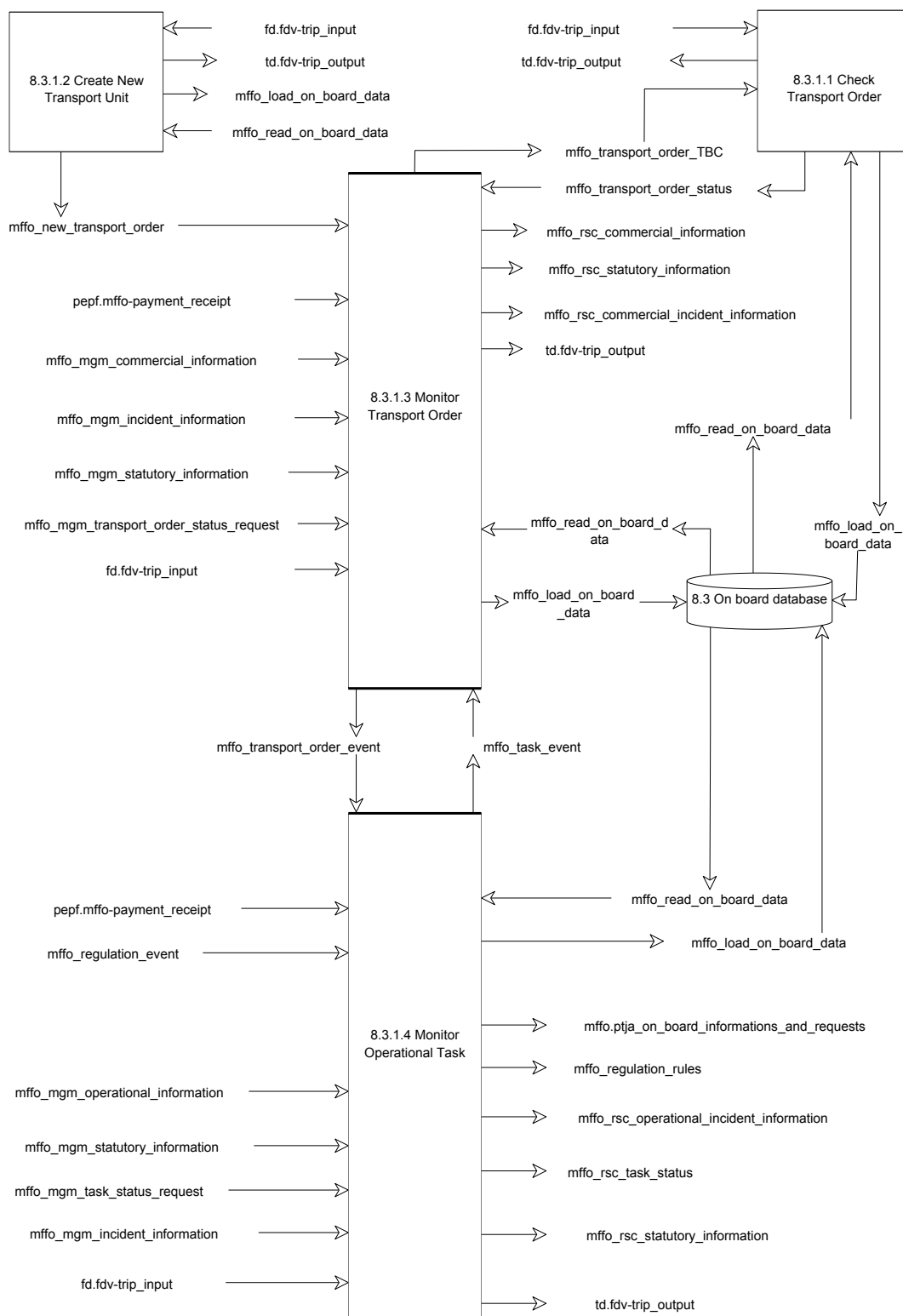
13.15. Function 8.3.2 Manage Resources

This high level Function in the Manage Freight and Fleet Operations Area provides functionality for to monitor things (Driver, Cargo, Freight Equipment) that are on-board a freight vehicle, as well as the vehicle itself. It is divided into for low level Functions that are as follows:

F 8.3.2.1 Monitor Driver

F 8.3.2.2 Monitor Vehicle

F 8.3.2.3 Monitor Cargo

F 8.3.2.4 Monitor Equipment

These Functions provide facilities that enable Freight Vehicles, plus their Drivers, Cargoes and Freight Equipment to be monitored. These facilities only cover things that are specific to Freight Vehicles. The more general Vehicle monitoring facilities are provided by Functions in the Provide Advanced Driver Assistance Systems Area (5).

The Functions do not communicate with each other, but with the On-board Database Data Store using two Data Flows.   Each Function uses several other Data Flows to communications with other functionality in the Area, with other Areas and with the terminators. The Functions and Data Flows are contained in the DFD for Function 8.3.2 - DFD 8.3.2.

All three of the Functions in this DFD exist at the same level. They are described in the part of Annex 1 that is devoted to the Manage Freight and Fleet Operations Area (8).

The first Function (F 8.3.2.1) is responsible for monitoring the Driver during a trip. The data about the Driver that is monitored may include such things as physical state, expenses, behaviour, etc. All data is stored in the On-board Database Data Store and is available for access by the Driver. The other Functions (F 8.3.2.2, F 8.3.2.3 and F 8.3.2.4) each perform similar monitoring activities for the Vehicle, the Cargo and the Freight Equipment respectively. Each Function contains its own internal interface that enables the Freight Vehicle Driver to view the data that has been obtained from the monitoring activities.

The On-board Database Data Store (D 8.3) holds all the information that is used by each of these Functions and is crucial to their successful operation. Details of this Data Store will be found in Annex 3.

Figure 58 DFD 8.3.2 Manage Resources
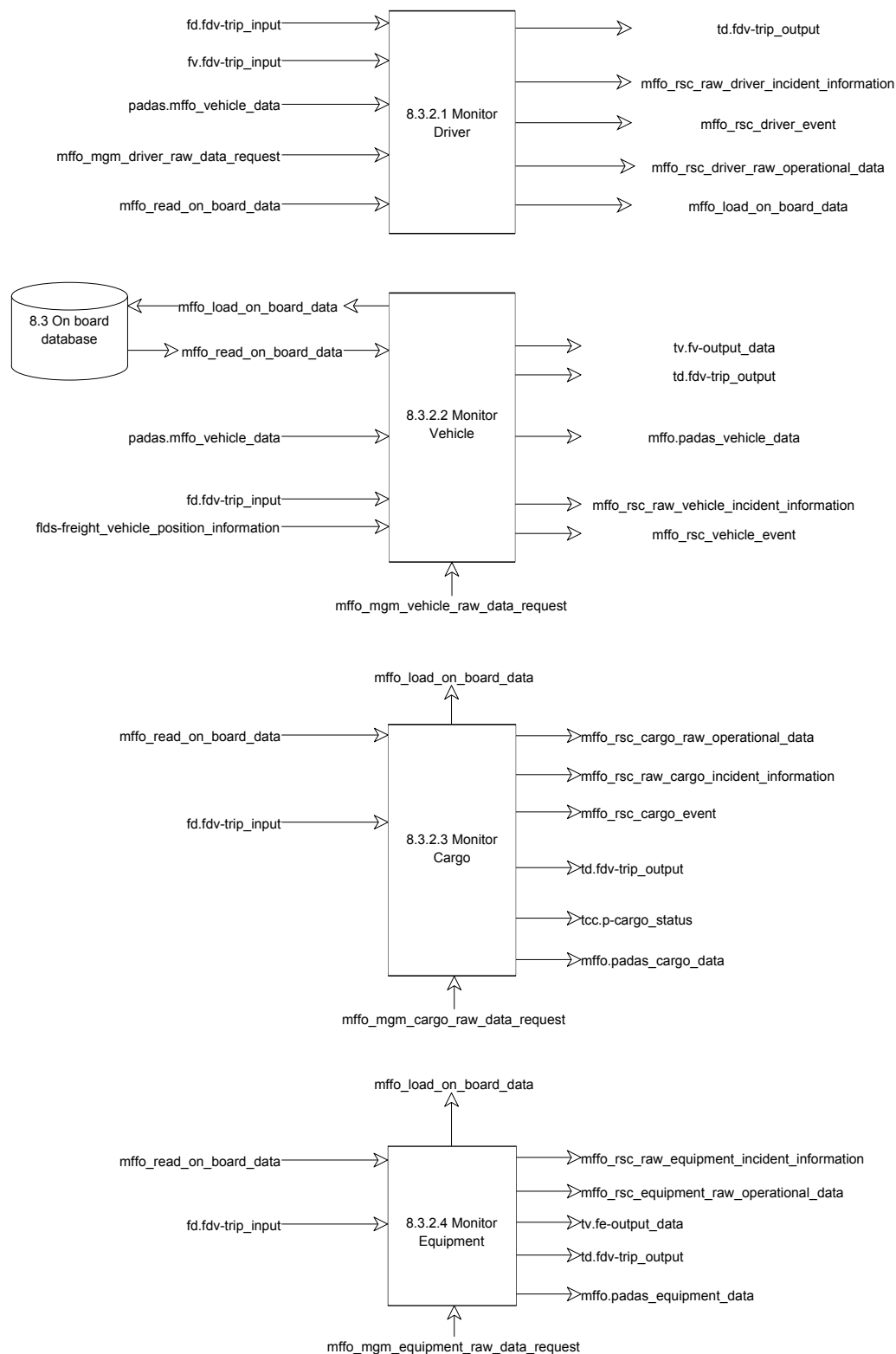
14. Links to other parts of the Framework Architecture

14.1. Introduction

The Functional Architecture will have direct links with two other parts of the Framework Architecture. These are the Physical Architecture and the Reference Models. There will also be links with the Communications Architecture, but these will be made through the Physical Architecture.

14.2. Link to the Physical Architecture

The link from the Functional Architecture to the Physical Architecture will be achieved using simple cross reference tables. There will be two tables, one for Low Level Functions, the second for Functional Data Flows. The Data Stores will be included in each "example System" as needed and will not need to be in a Table.

The first table will enable Functions to be allocated to the various parts of the "example Systems" that are shown in the Physical Architecture. Only Low Level Functions will be used in the table, as including High Level Functions may lead to the some of the "example Systems" in the Physical Architecture including unused or unwanted functionality. The second table will enable Functional Data Flows to be assigned to each of the Physical Data Flows in each "example System".

Details of the use of the Low Level Functions from the Functional Architecture by the "example Systems" in the Physical Architecture will be found in the Physical Architecture document - D3.2.

14.3. Links to Models

Others activities within the KAREN Project will study Models of ITS deployment. These Models enable "real-life" situations to be modelled so the User Needs that they need for functionality to be provided can be identified. The "real-life" situations shown in the Models include such as organisations structures and scenarios for the actual use of ITS, e.g. in making a trip. It will be possible to determine the Functions that are needed by each Model by looking up the User Needs in the Trace Tables. These are contained Annex 1 (separate Document) of the Overview Document (D 3.6).

15.   References

[UN]
This is the European ITS Framework Architecture User Needs Deliverable Document produced by the KAREN Project. A copy of this Document can be obtained from the European Commission Web Site at: http://www.frame-online.net/home.htm by selecting "Deployment Information" and then "System Architecture".

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COMETA Freight Vehicle On-board Systems Architecture – documentation of this Architecture can be obtained from the COMETA Web Site the English version of which will be found at: http://www.cometa-project.com/uk/default.htm

KAREN Physical Architecture and any references to other similar Documents – these are the Documents that have been produced by the KAREN Project that describe parts of the European ITS Framework Architecture. A copy of this Document can be obtained from the same European Commission Web Site as for the User Needs Document – see top of this page.

Annex 1 - Functional Architecture - Function Descriptions

This Document is the first Annex (Annex 1) to the Main Document describing the European ITS Functional Architecture. It provides a description of all the Functions in the Functional Architecture. A separate Chapter is provided for the Functions in each of the eight Functional Areas. Structure charts (called Hierarchy Diagrams) are provided so that it is not necessary to refer to the Data Flow Diagrams (DFD's) in the Main Document to gain an understanding of how the Functions relate to each other.

Annex 2 - Functional Architecture - Data Flow Descriptions

This Document is the second Annex (Annex 2) to the Main Document that describes the European ITS Functional Architecture. It provides a description of all the Data Flows in the Functional Architecture. The Document is organised so that there is one Chapter for the Data Flows in each of the Functional Areas. The Data Flows to and from the terminators are in separate Chapters. The first of these Chapters is for high level terminator Data Flows that appear on the Context Diagram and DFD 0. The second of these Chapters is for the terminator Data Flows that appear in the DFD's for the Functional Areas. It is divided into sections, one for each Functional Area. Finally there is a separate Chapter devoted to Data Flows between Functional Areas.

Annex 3 - Functional Architecture - Data Store Descriptions

This Document is the third Annex (Annex 3) to the Main Document that describes the European ITS Functional Architecture. It provides a description of all the Data Stores in the Functional Architecture. The Document is organised so that there is a separate Chapter for the Data Stores in each of the eight Functional Areas.