European ITS Framework Architecture

-

Models of Intelligent Transport Systems

D3.7 - Issue 1

August 2000

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

KAREN partners contributing to this report are:

UNIVERSITY OF LEEDS
TNO
ERTICO
RIJKSWATERSTAAT
SIEMENS TRAFFIC CONTROLS LIMITED
MIZAR
ALCATEL SPACE INDUSTRIES

Document control sheet

Activity name:	KAREN
Work area:	Framework Architecture Development - WP3
Document title:	Models of Intelligent Transport Systems
Document number:	D3.7
Electronic reference:	
Main author(s) or editor(s):	Peter H Jesty
Other author(s):	Jan Giezen, Jean-François Gaillet, Jean-Luc Durand, Victor Avontuur, Richard Bossom, Gino Franco.
Dissemination level[1]:	Public usage

Version history:

Version Number	Date	Main author	Summary of changes
Version 1	May 2000	P H Jesty	None - first version
Issue 1	August 2000	P H Jesty	Comments from Peer Review

Approval:

	Name	Date
Prepared	*P H Jesty*	*May 2000*
Reviewed	*Gino Franco*	*June 2000*
Authorised	*Jan Willem Tierolf*	*August 2000*

Circulation:

Recipient	Date of submission
CEC	August 2000

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

Table of Contents

Figures

Tables

Executive Summary

This document provides an introduction to ITS Architectures and Models, and describes the relationship of the European ITS Framework Architecture to National, Local, Service and System Architectures.

A variety of Models have been developed which present some of the possible ITS services from a variety of viewpoints. Each model is described with an Overview, Scope, Description and short list of the main European ITS User Needs that it satisfies. These can be used to produce an Architecture or System that implements the Model.

Reference Models, e.g. ‘Tower Models’ capture both the constructional relationship between the functions, and the overall behaviour of any system that conforms to them. A top-level Traffic Control System Pyramid Model is described, followed by the SATIN tower models for Inter-Urban, Urban and In-Vehicle systems, as well as a Traffic Control Cycle Model.

Enterprise Models show the structure of the relationships that exist between organisations, persons, services and/or functions, and models are described for the Transport and Traffic Market, Freight and Fleet Management, Public Transport, Automatic Fee Collection and Institutional and Legal issues respectively.

Primary Process Models describe the way in which a process takes place. Models have been created to describe an ITS and its Environment, the Traveller's Progress, the Vehicle's Progress, the Information Creation Chain, the Information Provision Chain and Emergency Services.

ITS development models have been included. These show how Traffic Control Policy can be created, an ITS can be created, and how an ITS can be improved.

The final chapter identifies five different type of user of these models, namely Decision Makers, End Users, Project Engineers, Infrastructure Operators and Service Providers, and the models that will be of relevance to them.

1. Introduction

1.1 Outline

This document is part of the set of deliverables produced by the KAREN Project to describe the European ITS Framework Architecture. This particular document (D3.7) provides a description of the Models that have been developed by the Project Team. The Models provide scenarios of how Intelligent Transport Systems (ITS) that conform to the Framework Architecture will behave, in particular from the viewpoint of the user. The background to the development of the European ITS Framework Architecture as a whole 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 six documents by the KAREN Project to describe the complete European ITS Framework Architecture. The other documents in the set are as follows:

D3.1 European ITS Functional Architecture
D3.2 European ITS Physical Architecture
D3.3 European ITS Communications Architecture
D3.4 European ITS Cost Benefits Report
D3.5 European ITS Development Study Report (internal use, but included in D4.2)
D3.6 European ITS Framework Architecture Overview
D3.7 European ITS Models of Intelligent Transport Systems - this document

Full details of these, and all the other, references used in this document are provided in Section 8.

1.3 Definition of a Model

Models are the way we think about things. When you have a mental image in your mind about what a system looks like, or the way that a system behaves, that is a model. High-level descriptions of systems that satisfy certain criteria, for example that represent or simplify an issue, or present overall relationships, can be called a conceptual model. A conceptual model becomes a reference model if it turns out to be a fundamental part of either the communication between the participants realising the system, or a basic construct during system realisation.

The models in this document describe various scenarios in the (road) transport area, and from different viewpoints. They provide a top-level view of the functions and services that can be achieved using ITS, and also how to improve them. Further discussion on modelling can be found in Chapter 2.

An Architecture or System can be created to implement any of the models in this document using the functionality in the European ITS Functional Architecture [D3.1 2000]. This can be achieved by following the methodology described in Chapter 3 of the document that describes the Physical Architecture [D3.2 2000]. The starting point for this creation process is a set of User Needs, and those for each model are listed after its description.

1.4 Overview of the Document Structure

The document begins by introducing the subjects of architecture and modelling, and there then follows a number of different descriptions, from a variety of viewpoints, of some of the architectures, systems and services that can evolve from the Framework Architecture. It starts with the relationship of the European ITS Framework Architecture itself to other architectures. There then follows a series of models of ITS services, categorised into four main types; each model being described in the same way for ease of comprehension. The document finishes with some models of the way in which ITS can be created, deployed and improved.

1.5 List of Abbreviations

EU	European Union
ITS	Intelligent Transport Systems
KAREN	Keystone Architecture Required for European Networks
OSI	Open System Interconnection
RDS-TMC	Radio Data System - Traffic Message Channel
TCC	Traffic Control Centre
TIC	Traffic Information Centre
TICS	Transport Information and Control Systems

2. Introduction to Modelling and Architectures

2.1 Why have a system architecture

The designers of all systems make assumptions about the environment in which their system will operate, and will build certain features into their systems that both give them a ‘character’ and are usually very difficult to modify at a later stage. One objective of defining a specific architecture for a system is to ensure that the assumptions and the ‘character’ are, respectively, correct and wanted.

Another objective is to provide ***a stable basis for a working and workable system***. The requirement that a system should be ‘working’ is obvious. A working system is one that not only has a set of fully functioning sub-systems, but for which these sub-systems co-operate fully to provide the full functionality required by the goals of the system. However, the need for a system that is ‘workable’ is often overlooked in the rush to produce a system that can be seen to be doing something. A workable system is not only pleasant to use, but is also easy to manage and maintain for its planned lifetime. A system architecture therefore encompasses both the goal oriented functions that provide the ‘working’ objective, and also the supporting functions that provide the ‘workable’ objective.

[CONVERGE 1998] also shows that there are a number of different sets of people for whom these objectives must be satisfied. They are likely to be interested in different attributes, in particular the Problem Owner, the Service Providers, the End Users and the organisation that is going to take the financial risk and provide the money to pay for it.

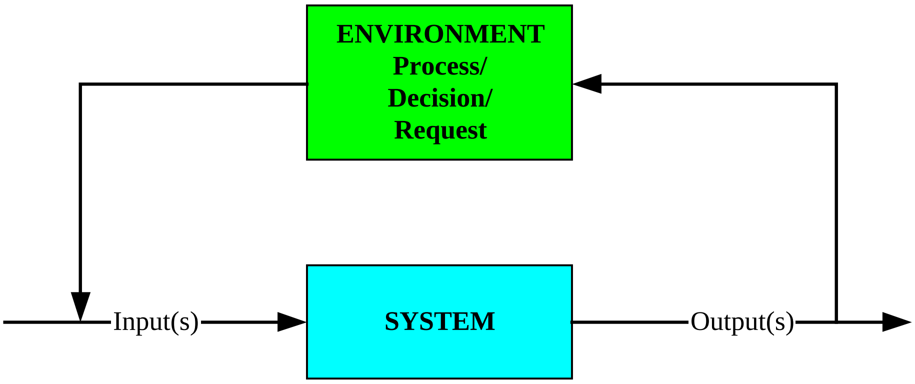
2.2 Systems, and Models of Systems

Systems can be considered from three different perspectives:

- Constructional - A system is built up from a number of sub-systems, which in turn are constructed from $(\text{sub-})^n$sub-systems and/or components (non-divisible units);
- Functional - A system is able to perform one or more specific functions in order to meet a (set of) goal(s).
- Behavioural - A system performs its functions, and interacts with its environment, in a manner that results from the combined effect of the way in which the functions have been implemented, e.g. as expressed by the quality requirements, thus exhibiting behaviour.

This document is mainly concerned with the last two perspectives. Most systems take inputs from their environment, and provide outputs to their environment. Usually something, or somebody, in that environment will ‘do something’ with the output and then make some consequential changes to the inputs (see Figure 1).

Figure 1 - A System and its Environment



The amount of 'feedback' that may occur will vary depending on the nature of the application. We will describe three possible degrees of feedback, but in reality the variation can be from nil, e.g. when no input is possible, up to full continuous control, e.g. drive-by-wire.

- **Low Level** - An information system based on the Internet, say, provides information to a user who may then ask for further information.
- **Medium Level** - A (route) guidance system provides high-level instructions to a driver, who then makes low-level decisions in order to carry them out. The system monitors their effect and then provides further guidance.
- **High Level** - A (traffic) control system provides commands to drivers (performing the driving process) who must obey them. The system continuously monitors the (traffic) situation and then provides further commands.

In order to be able to reason about a system it is therefore necessary to be able to understand both the system and the environment in which it is expected to perform. We do this using models.

Models are the way we think about things. When you have a mental image in your mind about what a system looks like, or the way that a system behaves, that it a conceptual model. However, there is one universal characteristic about all models, and that is that they are always approximations to the real world situation, i.e. an exact 'model' of a system would be a complete copy of the system itself down to every last detail [Carroll 1939]. Since a model is an approximation, it is therefore important to decide which parts of the real world need to be as close to reality as possible, and which parts can be ignored. Over the years a variety of types of model have been developed each one normally highlighting a different issue. This section describes those that are being used in this document, and elsewhere in the documents produced by the KAREN Project.

2.2.1 European ITS Framework Architecture

A *Framework* brings together isolated fragments and discrete items of knowledge to create some kind of pattern, and to identify relationships and deficiencies [Anthony 1965]. A *Framework* can also form the basis for future action. The European ITS Framework Architecture proposed by the KAREN Project encompasses both definitions with its creation forming being the former, and is its intended use being the latter. It mainly addresses the ‘constructional’ perspective described above.

The European ITS Framework Architecture defines and describes what needs to be included in a System that can fulfil the requirements of the European ITS User Needs [D2.2 2000]. The Framework Architecture expresses a System in number of ways. These are provided by the different parts of the Architecture and as follows:

- *Functional Architecture*: the functionality needed by the System to fulfil the User Needs [D3.1 2000].

- *Physical Architecture*: the way in which the functionality can be implemented as Applications to fulfil the User Needs [D3.2 2000]. These example Systems may also fulfil the User Needs in ways that cannot be expressed in functional terms, such as physical characteristics. They represent one way of implementing the functionality, there may of course be others, but the existence of these will depend on such things as implementation constraints for individual Systems.

- *Communications Architecture*: the links that enable data to be exchanged between the example Systems in the Physical Architecture, and between the example Systems and the outside World [D3.3 2000].

The European ITS Framework Architecture also includes other things such as the Cost Benefit Study [D3.4 2000] and the Deployment Study [D4.2 2000]. These describe the benefits that can be expected to accrue from the deployment of the Architecture, and some of the means by which existing systems can be migrated to conform with the Architecture.

2.2.2 Reference Models

Any high-level description that is able to:
- represent a certain system issue;
- ease communication and understanding about an issue;
- simplify a subject or an issue;
- present overall relationships;
- define certain constructs;

can be called a Conceptual Model. A Conceptual Model becomes a Reference Model if it turns out to be a fundamental part of either the communication between the participants realising the system, or a basic construct during system realisation.

A Reference Model usually exists at a very high level of abstraction, e.g. higher than the European ITS Framework Architecture described above (Section 2.2.1). It will usually capture both the constructional relationship between the functions, and the overall behaviour of any system that conforms to it, and hence is very rich in information. Probably the most well known Reference Model is the Open System Interconnection (OSI) model for communication systems [Zimmerman 1980], which is briefly reviewed in the document that describes the European ITS Communications Architecture [D3.3 2000].

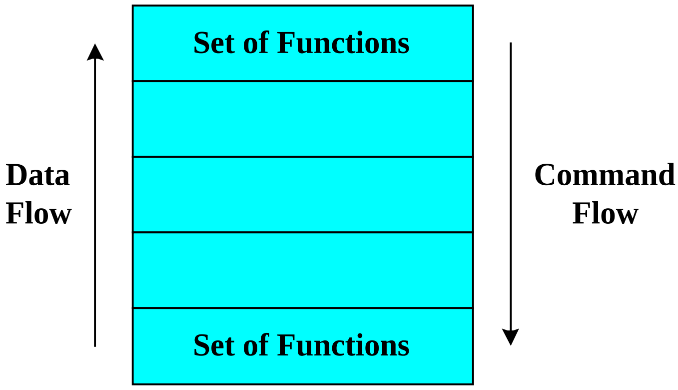
A number of different types of reference model have been used to describe ITS, in particular:

Layered Reference Models

Layered Reference Models, sometimes known colloquially as “Tower Models”, have been developed for a number of ITS areas. They are formed by grouping the functions into sets such that (see Figure 2):

- each layer may take input data for transformation from lower layers, or from the environment outside the system;
- each layer may generate commands for itself or for lower layers;
- output data may be sent to lower layers for display or for transmission outside the system, but not for transformation.

Figure 2 - Layered Reference Model



The rationale for the development of these models includes (see also [CONVERGE 1998]):

- **Decomposition of functionality** - whilst functionality has to be decomposed in some manner or another, there is an advantage in using a structure that has some organisational, structural or functional benefit.

- **Simplicity** - the layered model is fairly simple and easy to understand, and produces the desired properties.

- **Time horizon** - as one proceeds from the bottom layer to the top layer, there is an increase in the time horizon being considered, thus, for example, those functions with severe time constraints will be located in the lower layers.

- **Geographic horizon** - as one proceeds from the bottom layer to the top layer, there is an increase in the size of the geographic horizon being considered. This can lead to different functions and services at the various layers, and hence a decomposition of the services offered.

- **Data management** - there tends to be a consolidation of data as one proceeds up the layers.

- **Localisation of safety issues** - it is possible to localise the safety functions into one or more layers, thus facilitating their design and maintenance.

Enterprise Models

Many ITS either form, or are part of, a business activity. An *Enterprise Model* will show the structure of the relationships that exist between organisations, persons, services and/or functions. It may also show the processes that are, or will be, used to undertake a commercial activity, though sometimes this is called a *Business Process Model*, i.e. a primary process model of the business.

Primary Process Models

In order to ensure that a system will match its environment in a proper manner, it is necessary to have a suitable model of that environment. One such is the *Primary Process Model* which was originally developed for use in the process control industry to describe the processes that have to be controlled. This model not only shows the processes that take place, and their relationship to the system, but it also indicates the information that needs to be provided (from the system outputs) to make them operate efficiently and safely, as well as the information that will be available (to the system inputs). It will also provide a target against which the system designers can check the products of their work. It should be noted that, for ITS, a primary process model will always contain one or more of the European ITS Framework Architecture terminators, and will thus usually include people as travellers, operators, etc.

Development Models

ITS are usually complex systems that require the expertise from a number of different disciplines, and even those who have professional experience in managing and controlling road traffic and travellers will be working at the limits of their knowledge. Development models provide a means of understanding the development and deployment processes of which the experts themselves, rather than traffic and travellers, will be a part.

2.3 Relationship with the European ITS Framework Architecture

The models provide a top-level view of the types of services that are possible using ITS, without showing any of the details as to how they might be achieved. They are scenarios of typical activities associated with road transport, indicating where ITS facilities might be of assistance. Consequently each model demonstrates a manifestation of part of the European ITS Framework Architecture.

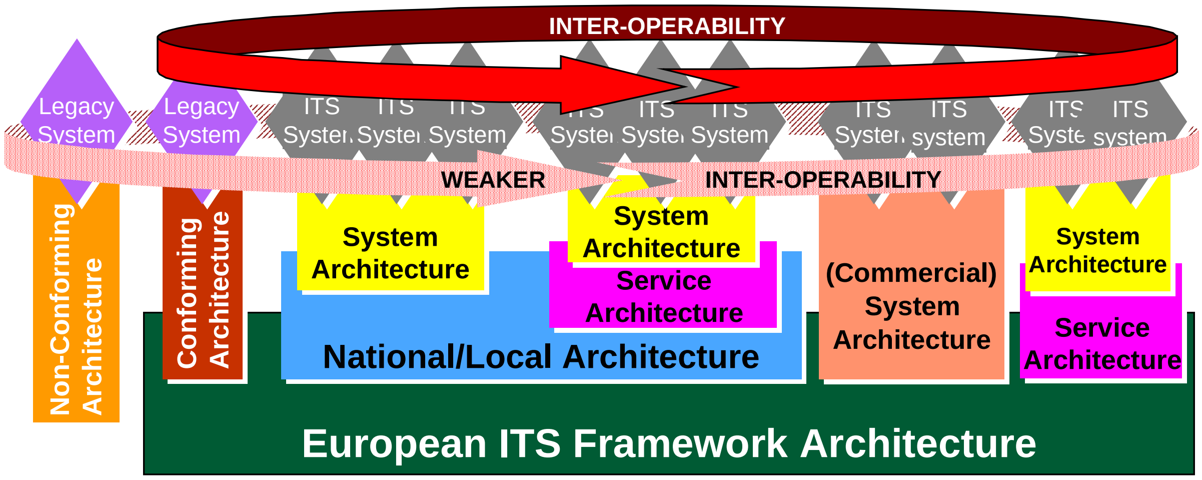
However, too much must not be read from the models. They are ***not*** similar to the example systems in the Physical Architecture [D3.2 2000], and therefore no attempt has been made to ensure their exact consistency with the Functional Architecture. They should therefore be treated as a “artists impressions” rather than engineering drawings. A study has been done on the consistency of some of the models and the results can be found in Appendix A.

Although the models do not cover the entire Framework Architecture, they do cover most of it. There is also some overlap as different models view similar scenarios from different viewpoints. At the end of each is a list of the User Needs that approximately cover the model in question. Once again care should be taken not to infer that ***every*** User Need in the set is automatically satisfied though most of them will be.

2.4 Overview of European Intelligent Transport Systems Architectures

It is important to be able to distinguish between the various categories of architecture that are possible in a European setting. Whilst they all have the same objectives (see Section 2.1), they do have different relationships one with another (see Figure 3).

Figure 3 - Relationship Between Architectures



The following is taken from [D4.2 2000]:

- **European Framework Architecture -** an architecture that is developed for the application of ITS within Europe. It is based on a set of User Needs for Europe produced by the KAREN Project [D2.2 2000]. The Framework Architecture is currently available as part of the results (deliverables) of the KAREN Project.

- **National Framework Architecture -** an architecture that is developed to cover the application of ITS within a European Nation, or an autonomous State within a Nation. It can be based on those parts of the European ITS User Needs that are relevant to the Nation and be developed from the European ITS Framework Architecture. This Architecture will define the ITS applications that are to be provided within the Nation (or State) to serve those User Needs.

- **Local Framework Architecture -** an architecture that is developed to cover the application of ITS in a specific place or area like a region or a city within a State. It can be based on a sub-set of the European ITS User Needs used for the National (or State) Architecture, or if these do not exist, on those for the European Framework Architecture. The User Needs will be those that only define the services that the local area requires. This Architecture will therefore contain ITS applications that are specific to the locality where it will be used. The starting point for any Local Architecture will be either a National (or State) Architecture, or in the absence of either of these, the European ITS Framework Architecture itself.

- **Service Architecture -** an architecture that is developed for a specific ITS service independently of any geographical context. The KAREN Project has identified a set of Fundamental Services [D2.2 2000]. ISO TC204 WG1 has also proposed a set of 32 Transport Information and Control Systems (TICS) Fundamental Services [D2.2 2000].

Thus, for example, a service specific architecture can be defined for the Tolling or Route Guidance Services.

- **System Architecture -** a system structure that consists of system elements, interfaces, processes, constraints and behaviour [CONVERGE 1998]. A System Architecture covers a particular part of a European, National, Local or Service Framework Architecture. It will show what is required to deploy a particular ITS application, e.g. Urban Traffic Management, Electronic Fee Collection, Public Transport Management, etc. The contents will be at a level that provides the starting point for the generation of specifications that enable the purchase of the System itself.

It is important to distinguish between the three different rôles of an "Architecture" in the European scenario. They can be defined as follows:

1. At the level nearest the design there is the **System Architecture** which is of fundamental importance when systems are created by integrating two or more sub-systems. The system architecture provides the structure around which a class of systems may be developed. It is the level at which the basis for "Working and Workable Systems" is set up [CONVERGE 1998].

2. **National, or Local, Framework Architectures,** or **Service** (specific) **Architectures** are being defined for EU Member States, regions or cities, or for a specific service to create the conditions for a market of compatible and modular solutions, and for establishing the implementation of nation, region or city-wide inter-operable solutions and services. Two or more systems are inter-operable if they can pass data between each other to their mutual benefit, i.e. to provide harmonious and/or complementary functionality: inter-operability includes the technical, operational and organisational aspects.

   These architectures are also the tool for guiding national research initiatives, and for providing the reference document for standards and rules to be used for their applications. They also provide the common terminology for specifying systems, and possibly to recommend the standards and interfaces to be used to achieve compatibility at the European and national level.

3. The **European Framework Architecture** is at a "level" such that it can be used as a reference by all ITS architects in EU member states. It is intended to be the foundation for building the other categories of architecture. It will enable them to guarantee compliance at the interfaces of other systems so that seamless services can be provided to cross-border travellers, and an open European market of compatible components can be established.

The KAREN Project had the task of creating the key elements of the European Framework Architecture, and whilst it must take account of what exists already, it must also look to the future and the desires expressed in the List of European User Needs [D2.2 2000], which may not be fully satisfied by existing systems. Thus, whilst the Framework Architecture will concentrate on the functionality and other features that are needed to satisfy the user needs, it will not "re-invent the wheel" if there is an existing solution.

Figure 3 provides an overview of how the various architectures will relate to each other. Initially, there will be two main categories of ITS system co-existing:

1. Those that will conform fully to the European Framework Architecture. These will be made up of:

    a) new systems that have been designed to conform to the Framework Architecture: they will eventually be in the majority;

    b) legacy systems that do conform to the European Framework Architecture: some legacy systems will be in this category.

    These systems, by ensuring this conformance, will have completed the first major step towards providing inter-operability with each other.

2. Those legacy systems that do not conform completely to the European Framework Architecture of other ITS. Whilst they may not be fully inter-operable with those systems that do conform, once can expect there to be a useful degree of mutual functionality especially for those systems that are not very old.

In order to make legacy systems fully inter-operable with other ITS, there will be a migration strategy to inform their owners on how they can become compliant with the European Framework Architecture. It should be noted that whilst ‘migration’ is often assumed to mean ‘replace’, in practice it can also mean ‘enhance’ or ‘add to’, which is usually less contentious and expensive!

3. Layered Reference Models, or "Tower" Models

The first model introduces the basic control system model that forms the basis of the following three ITS "Tower" models. The final model in this section is a different interpretation of the basic model.

3.1 The Traffic Control System Pyramid Model

3.1.1 Overview

All systems are controlled in some manner, either directly or indirectly, and/or they may be a 'control system'. It is therefore important that the nature of the various types of possible control is understood. [Anthony 1965] identified a number of layers of control and these have been interpreted for the Traffic Control scenario.

3.1.2 Scope

The model describes an hierarchical control framework for the control of traffic. An inherent feature of the model is that higher levels control the lower ones, but that feedback from the lower ones is necessary to confirm the validity of approach (see also Section 6.3). Note that the levels differ in their planning horizon, i.e. longer time spans at the top, their level of detail, and in the number of staff involved (unless the bottom level is automated).

3.1.3 Description

The Traffic Control System Pyramid consists of four layers (see Figure 4):

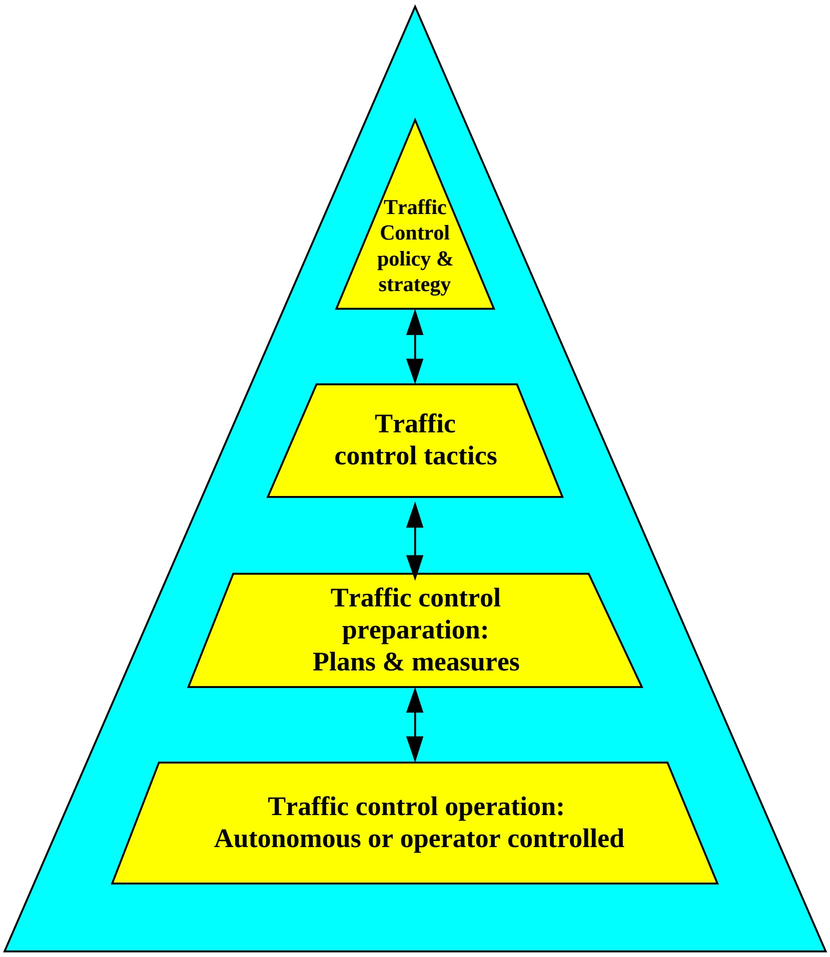
1. At the top level strategy and policy plans are made that capture the vision of the properties that are desired from the whole traffic control system. It is likely that the vision and policy decisions will be made by politicians, whilst the strategy to implement them will be devised by senior traffic engineers: this will be an iterative process. (see also Section 6.1)

2. Once the policy and strategy has been agreed, they will be passed down for traffic engineers to devise the control tactics that will achieve them. There are likely to be a number of such tactics for different traffic scenarios.

3. The tactic for each scenario will manifest itself as a plan of control measures, and these have to be prepared in detail.

4. The bottom level relates to the execution of the control measures, either autonomously or through the action of operators.

Figure 4 - The Control System Pyramid Model



3.1.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
7	Traffic, Incidents and Demand Management

3.2 Inter-Urban Reference Model

3.2.1 Overview

A layered reference model for inter-urban ITS [SATIN 1995] which contains most of the functions and services that might be expected in such a system.

3.2.2 Scope

The Inter-Urban Reference Model covers the functions and services that one might expect to be provided on a regional or national motorway, and possibly a trunk road, network.

3.2.3 Description

The Inter-Urban Reference Model is shown in Figure 5. Functions and services are allocated to each layer, and each layer relates to a geographic region as follows:

- *Peripheral* - the contact with the traffic, road surface and the environment;
- *Point* - a logical point on a road;
- *Section* - a part of the road between two points;
- *Link* - the connection between two motorway intersections;
- *Regional Network* - a set of motorways within a defined physical region;
- *National Network* - a set of motorways within a nation or other super-regional area.

A brief description of the contents of each layer is shown in Table 1.

Figure 5 - Inter-Urban Reference Model

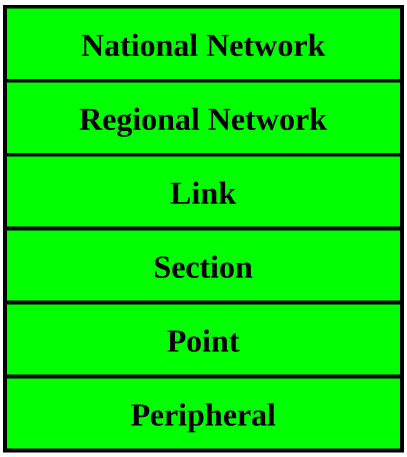


Table 1 - Inter-Urban Reference Model

	Scope of Control	Objective	Example of Services
6	National Network	Network efficiency	Network control Hazardous goods transit management
5	Regional Network	Traffic flow Incident management	Traveller information services Network monitoring services Re-routing control services Route guidance Incident management services Hazardous goods monitoring
4	Link	Throughput optimisation	Link traffic monitoring Incident verification Speed harmonisation Lane closure management Co-ordinated ramp metering
3	Section	Traffic safety management	Driver awareness warning services Section traffic monitoring services
2	Point	Logical contact with road and traffic	Local ramp control services Local lane control services Local traffic monitoring services Local monitoring of road conditions Local traffic surveillance services Enforcement services
1	Peripheral	Physical contact with road and traffic	Actuator device control Sensor device control Vehicle flagging systems

3.2.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
3	Law enforcement
5.3	Hazardous materials and incident notification
7.1	Traffic control
7.1.1	Traffic control - Monitoring
7.1.4	Traffic flow control
7.1.5	Exceptions management
7.1.7	Speed management
7.1.8	Road-side to vehicle communications
7.1.10	Lane management
7.2	Incident management
6.2	On-trip driver information

3.3 Urban Reference Model

3.3.1 Overview

A layered reference model for urban ITS [SATIN 1995] which contains most of the functions and services that might be expected in such a system.

3.3.2 Scope

The Urban Reference Model covers the functions and services that one might expect to be provided within a city or large town.

3.3.3 Description

The Urban Reference Model is shown in Figure 6. Functions and services are allocated to each layer, and each layer relates to a geographic region as follows:

- *Peripheral* - the contact with the traffic, road surface and the environment;
- *Point* - a well defined location in the network;
- *Segment* - a logical stretch, or area of the network, which acts as a pipe for vehicle, i.e. with single entry and exit points;
- *Local Area* - a group of Segments;
- *Service Network* - each manifestation of the Service Network layer deals with one specific service;
- *City* - the urban conurbation.

A brief description of the contents of each layer is shown in Table 2.

Figure 6 - Urban Reference Model

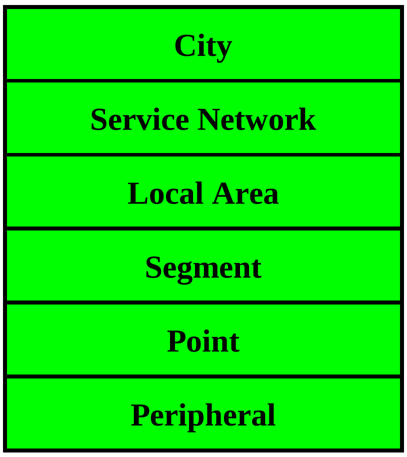


Table 2 - Urban Reference Model

	Scope of Control	Objective	Example of Services
6	City	Co-ordinated policy	Demand management O/D estimation
5	Service Network	Service quality Revenue collection	Public transport management Parking management Road pricing
4	Local Area	Throughput optimisation	Public transport regularity Signal plan optimisation Junction priority Individual route guidance
3	Segment	Emission control	Public transport journey time estimation Dynamic speed control/advice Automatic incident detection
2	Point	Road safety Enforcement	Traffic counts Signal set control Pollution level detection
1	Peripheral	Physical contact with road and traffic	Actuator device control Sensor device control

3.3.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
4	Financial transactions
7.1	Traffic control
7.1.1	Traffic control - Monitoring
7.1.2	Traffic control - Planning
7.1.4	Traffic flow control
7.1.6	O/D computations
7.1.7	Speed management
7.1.9	Adaptive traffic control
7.1.11	Parking management
7.2	Incident management
7.3	Demand management
7.3.2	Pricing management
6.1	Pre-trip information
6.2	On-trip driver information
6.4	Route guidance and navigation
10.1	Public transport management
10.1.4	Public transport management - Information handling

3.4 In-Vehicle Reference Model

3.4.1 Overview

A layered reference model for in-vehicle ITS [SATIN 1995] which contains most of the functions and services that might be expected in such a system.

3.4.2 Scope

The In-Vehicle Reference Model covers the functions and services that one might expect to be provided within a vehicle.

3.4.3 Description

The In-Vehicle Reference Model is shown in Figure 7. Functions and services are allocated to each layer, and each layer relates to a set of functions as follows:

- *Peripheral* - the contact with the vehicle's sensors and actuators, the road surface and the environment;
- *Driving/Steering* - immediate control to ensure the safety of the passengers, vehicle and cargo;
- *Stretch Ahead* - the provision of comfort, assistance and short term information;
- *Trip Efficiency*- the provision of information to optimise the total trip;

A brief description of the contents of each layer is shown in Table 3.

Figure 7 - In-Vehicle Reference Model

Table 3 - In-Vehicle Reference Model

	Scope of Control	Objective	Example of Services
4	Trip Efficiency	Efficiency of trip, subject to desired constraints	Route selection Circumvention of congestion Freight management Hazardous goods management
3	Segment	Comfort of driver and passengers	Vehicle behaviour smoothing Comfort oriented information
2	Driving/Steering	Safety of vehicle, occupants, cargo and the environment	Traffic rule enforcement Collision avoidance Safety oriented information
1	Peripheral	Data collection and command execution	Collection of data within, and in the vicinity of, the vehicle Control of vehicle systems

3.4.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
5.3	Hazardous materials and incident notification
6.2	On-trip driver information
6.4	Route guidance and navigation
8	In-vehicle systems
8.2.1	Automated vehicle operation - collision avoidance
8.2.5	Speed control
8.3	Longitudinal collision avoidance
8.4	Lateral collision avoidance
8.5	Safety readiness
8.5.3	Environmental monitoring
9.5.2	Road Freight Fleet Management

3.5 The Traffic Control Cycle Model

3.5.1 Overview

The Traffic Control Cycle Model uses an alternative version of the layered reference model, but it is still an example of the application of the Control System Pyramid (see Section 3.1). It shows how knowledge can be built up until there is sufficient to provide suitable commands to the drivers and/or vehicles.

3.5.2 Scope

The model describes the sources of data or knowledge, the value that will be added, the intermediate results that will be obtained, and the order in which they will be assembled.

3.5.3 Description

The Traffic Control Cycle Model consists of five stages (see Figure 8):

1. Sensors at the road-side or in vehicles will provide data on the movement of vehicles, and by this means it is possible to build up a picture of the current traffic situation.

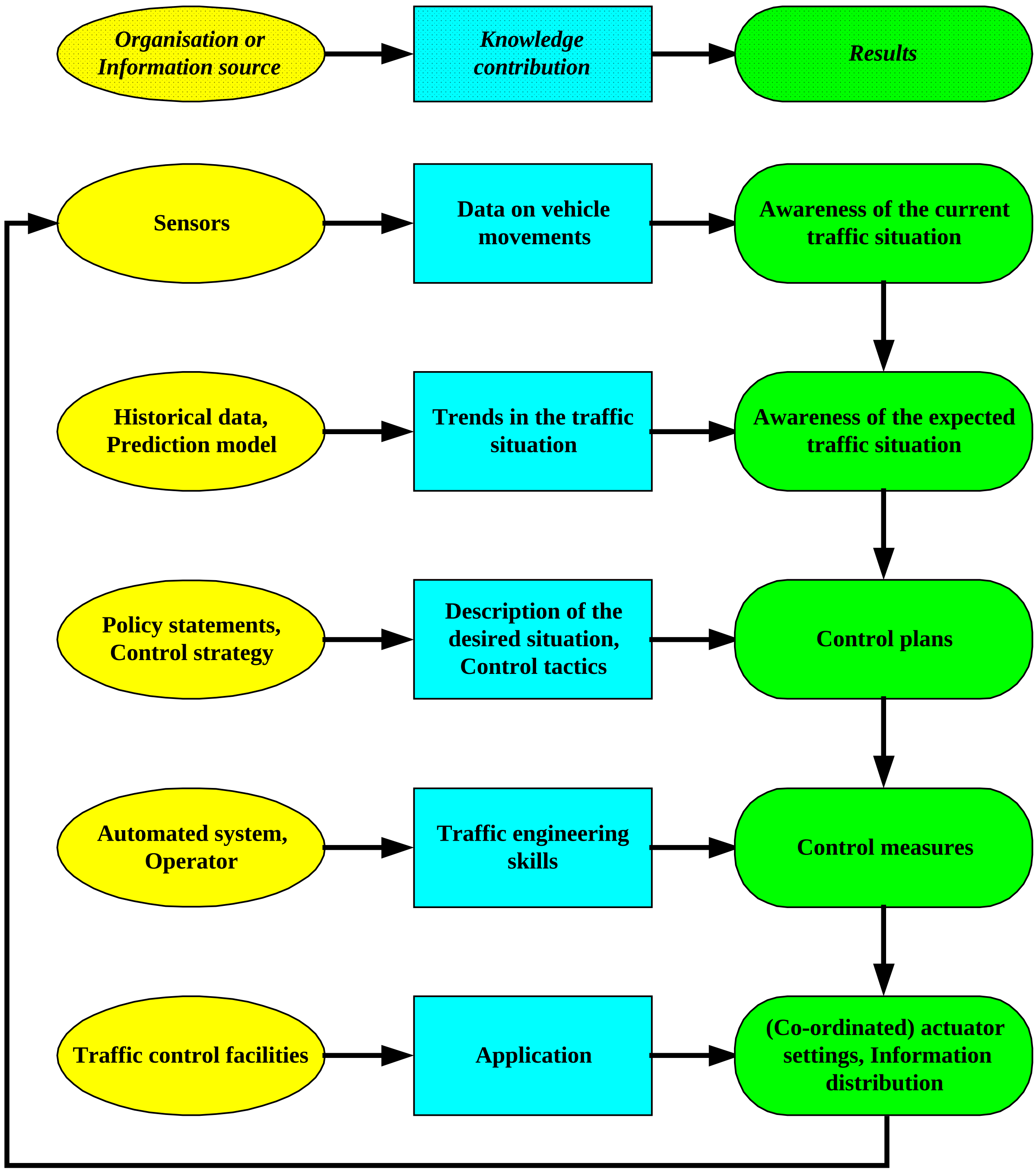
2. From a knowledge of the current situation, and the use of historical data, it is possible to predict trends in the state of the traffic, and to build up a picture of the expected traffic situation.

3. The expected traffic situation is then compared with the overall traffic control policy, and the strategy to achieve it, and a suitable traffic control plan is chosen.

4. The resulting control plan is then passed to an automated system, or to operators, who will apply their skills to effect the necessary control measures.

5. These control measures are applied to the traffic control facilities to provide commands and/or information to the drivers and/or vehicles. The affect that this has on the traffic situation will be detected by the sensors.

Figure 8 - Traffic Control Cycle Model



3.5.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
7	Traffic, Incidents and Demand Management

4. Enterprise Models

4.1 Transport and Traffic Market Model

4.1.1 Overview

The Transport and Traffic Market Model shows the relationship between transport and the means by which it is achieved, i.e. road traffic. It also shows the relationship between vehicle fleets, and their owners; and the individual vehicles, and their drivers. It also shows that part of the domain in owned by private persons or companies, and part is owned by public authorities, or operated on behalf of those authorities.

4.1.2 Scope

The Transport and Traffic Market Model (see Figure 9) is one of contrasts:

- ‘Person/Organisation’ versus ‘Artefact/Attribute’ - there is a distinction between an individual or an organisation (in stripes - behind), and the artefact that is owned or operated, or the attribute possessed (in front).

- ‘Collective’ versus ‘Individual’ - there is a distinction between individual, and identifiable, vehicles belonging to an identifiable person or company, and the collective phenomenon of traffic.

- ‘Short term’ versus ‘Long term’ - there is a distinction between the short term, and volatile, activities of traffic as each driver makes tactical decisions, and the longer term, and more stable, mechanisms that achieve strategic objectives.

- ‘Demand’ versus ‘Supply’ - there is a distinction between the demands of the vehicle owners and their desire/need to travel, and the infrastructure owners who provide the roads and the means of controlling the traffic.

Whilst this model encompasses the entire road transport and traffic domain, not all aspects may be implemented by a given architecture or system.

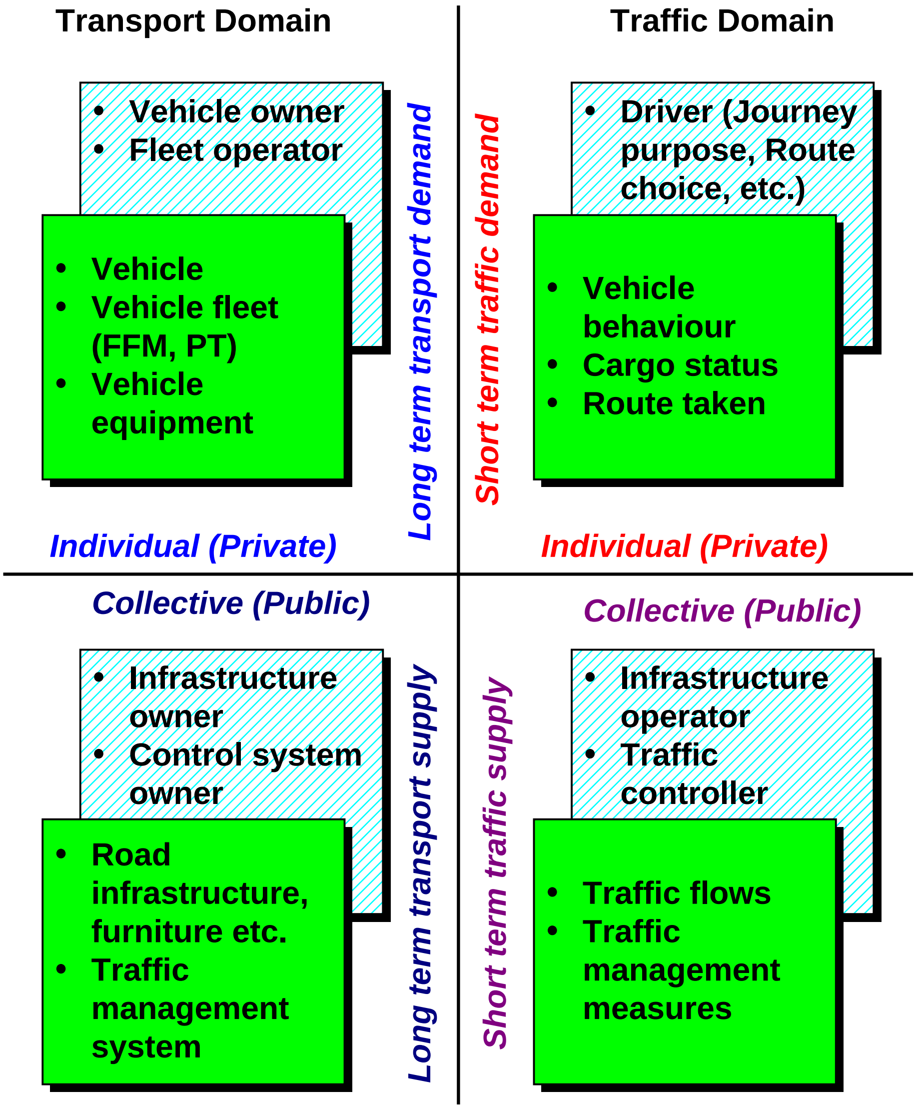
4.1.3 Description

Figure 9 is divided into four quadrants:

- The top left hand quadrant contains the individuals, or companies, that own the various different type of vehicle. They do so because they have a long term demand for transport.

- The bottom left hand quadrant provides the means to satisfy the demand for transport. It contains the owners of the infrastructure, e.g. roads, street lights etc. and the systems that enable it to be managed.

Figure 9 - Transport and Traffic Market Model



- The top right hand quadrant contains a use of a vehicle (from the set or artefacts defined in the top left hand quadrant). A driver makes a particular journey for a reason and thus continuously changes the attributes associated with the vehicle, e.g. its location, speed, etc. The driver thus creates a short term demand on the current status of the traffic.

- The bottom right hand quadrant provides the means to satisfy the current traffic demands. It contains the infrastructure operators and the traffic controllers who will manage the current flow of traffic with appropriate measures (using the artefacts defined in the bottom left hand quadrant).

4.1.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
2	Management activities
5	Emergency services
6	Travel information
7	Traffic management
9	Freight and fleet operations
10	Public transport management

4.2 Freight and Fleet Management Models

4.2.1 Overview

At a high level of abstraction, the concept of freight and fleet management can be described using two different models. The first model presents the main functional areas which need to co-operate to ensure proper business transactions. The second describes the rôles of the parties, and the main phases of the business scenarios which apply in freight and fleet operations.

4.2.2 Scope

The scope of these models is twofold:

- To describe the whole transport chain, from the perspective of the different parties exchanging data. Specific functions performed by each party can be allocated to each element of the chain.

- To describe the freight and fleet operations from the perspective of the main ITS functional areas which are needed.

4.2.3 Description

The first model (see Figure 10) describes the different parties of the transportation of goods chain and their relationships in terms of information flows. The different parties are:

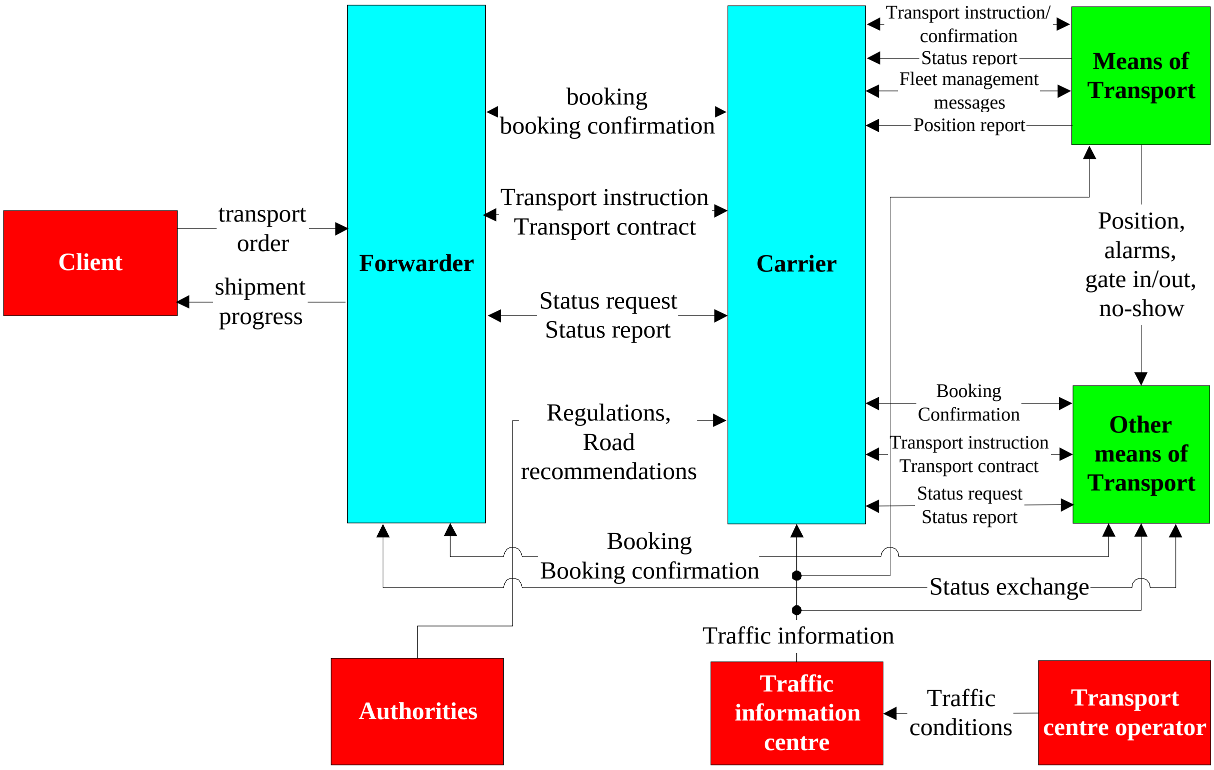
- **Client** - there are two possible clients
  - the consignor who wants to transport goods from one location to another, or
  - the consignee who wants to receive and accept the goods.

  Main functions performed: transport order issuing and shipment progress control.

- **Forwarder -** who manages a distribution warehouse and the loading/unloading of goods. This party plays an intermediate role between the client and the carrier. In simple cases, the client communicates directly with the carrier.

  Main functions performed: order planning and execution and order control.

Figure 10 - Goods Transportation Model



- **Carrier -** who undertakes the transport of goods from one point to another using a Means of Transport with a driver assigned to it. If the carrier does not have the proper means of transport, it can use Other Means, especially for inter-modal transport. A forwarder can also directly select a specific means of transport different from the conventional means it uses.

  Main functions performed: dynamic dispatching process, trip/tour planning, fleet/vehicle monitoring.

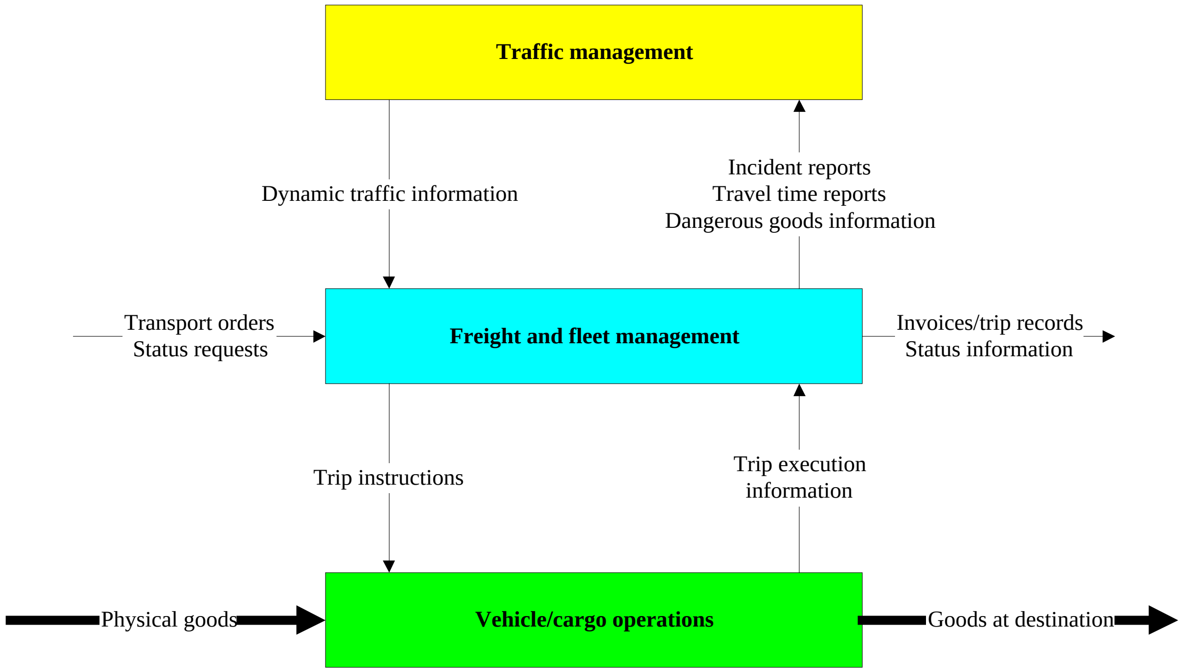
- **Authorities** - who are in charge of traffic control, technical inspection, social inspection and customs clearance.

- **Traffic Information Centre** - provides traffic information.

- **Transport Centre Operator** - manages transhipment and storage process (e.g. for multi-modal platforms).

The second model (see Figure 11) shows the physical flow of goods, the management of that process, and its relationship to traffic management in general, and basic information flows between them.

Figure 11 - Freight and Fleet Management Model



4.2.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
9	Freight and fleet operations

4.3 Public Transport Reference Model

The Urban Reference Model (see Section 3.3) includes some services that are specific to Public Transport, and the In-Vehicle Reference Model (see Section 3.4) covers both private and commercial vehicles. They therefore offer one view of Public Transport as an hierarchical control model (see also Section 3.1).

An alternative model has been proposed by the project TRANSMODEL [EUROBUS 1993 and EUROBUS 1994]

4.3.1 Overview

This reference model can be used for any public transport company. All the functions necessary can be allocated to one or more cells.

4.3.2 Scope

The TRANSMODEL Public Transport Reference Model describes the public transport company areas according to strategic, tactical, operational and statistical components.

4.3.3 Description

This model describes a Public Transport company in terms of its high-level business entities, namely:

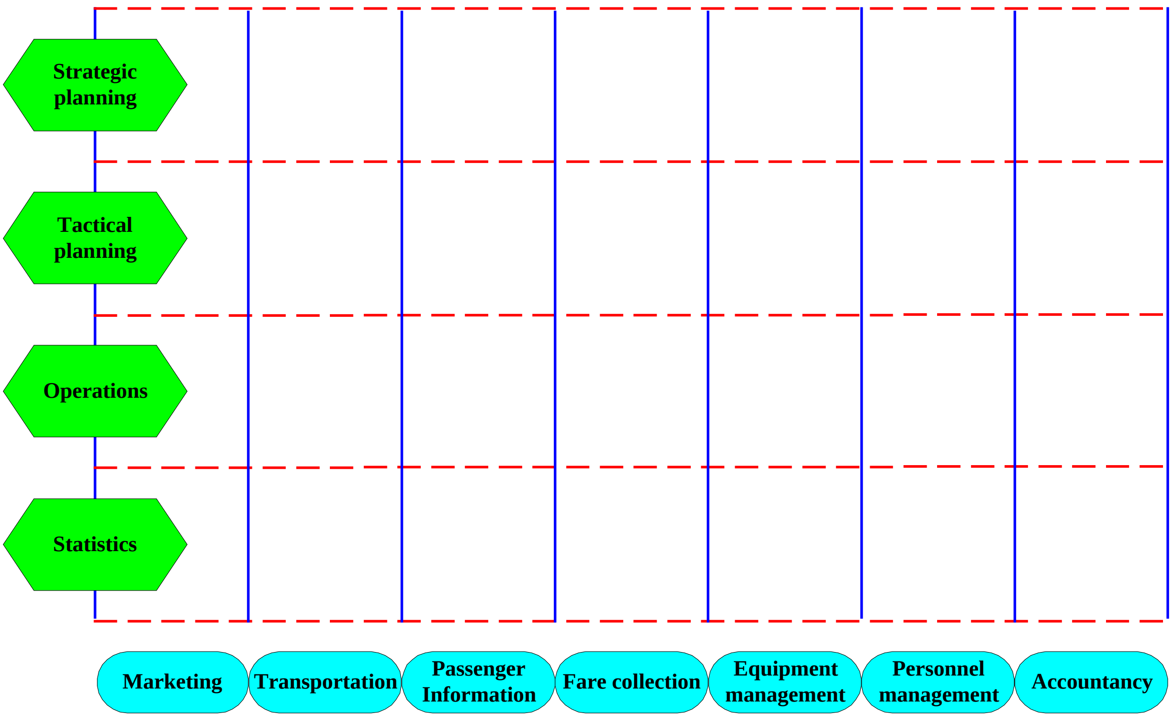
- Marketing
- Transportation
- Passenger information
- Fare Collection
- Equipment management
- Personnel management
- Accounting

Each entity performs actions which have different time horizons:

- Strategic planning - long-term planning
- Tactical planning - short-term planning
- Operations - activities performed daily
- Statistics - activities performed after operations (subsequent)

Those two dimensions can be put together as shown in Figure 12.

Figure 12 - TRANSMODEL Public Transport Reference Model



4.3.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
4	Financial transactions
10	Public transport management

4.4 Automatic Fee Collection Model

4.4.1 Overview

[ISO 14904] separates the two main processes concerned with the handling of money and the paying for services.

4.4.2 Scope

The Automatic Fee Collection Model is suitable for all forms of electronic payment, and covers:

- multiple payments for the same service;
- multiple payments for many services, that may or may not belong to many providers.

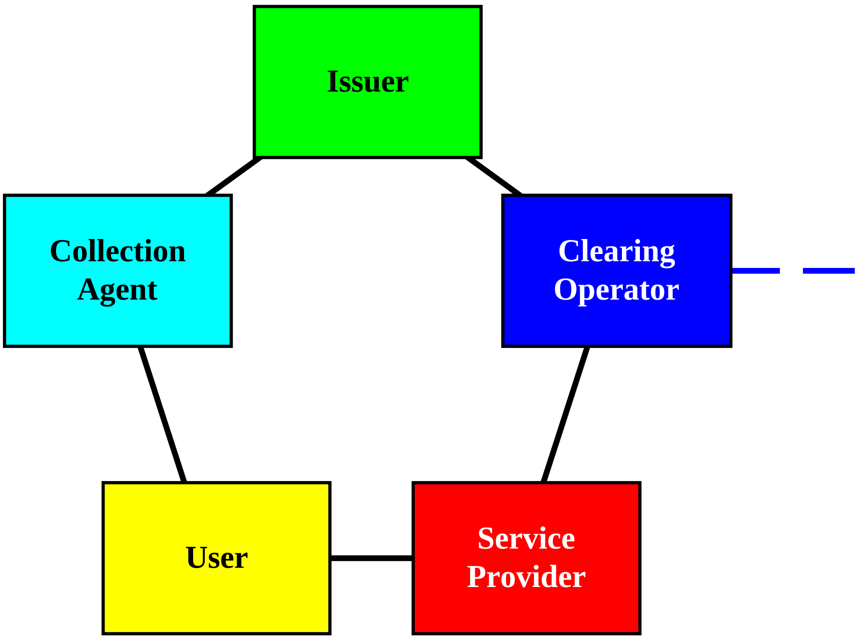
4.4.3 Description

The basic Automatic Fee Collection Model is shown in Figure 13. The payment system is divided between five distinct parties as follows:

- **Collection Agent** - is responsible for selling, reloading and delivering the *payment means* to the User, and for collecting payment from the User.
- **User** - uses the *payment means* to obtain the services offered by the Service Provider.
- **Service Provider** - makes a debit from the *payment means* on each occasion the User makes use of the service, and passes the data on all transactions to a Clearing Operator. There may be many Service Providers.
- **Clearing Operator** - aggregates the data on all transactions from all the Service Providers, apportions the money between them, and arranges for that money to be passed to them.
- **Issuer** - is responsible for the entire payment system and for ensuring that the money with which the User paid for the *payment means* ultimately goes to the correct Service Provider.

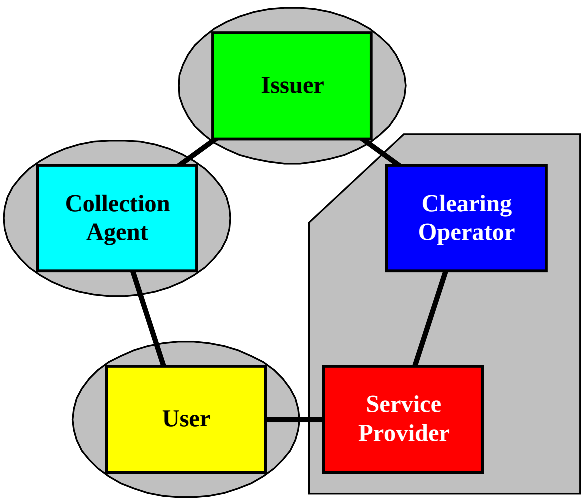
Two, or more, payment systems can inter-operate via their respective Clearing Operators.

Figure 13 - Automatic Fee Collection Model

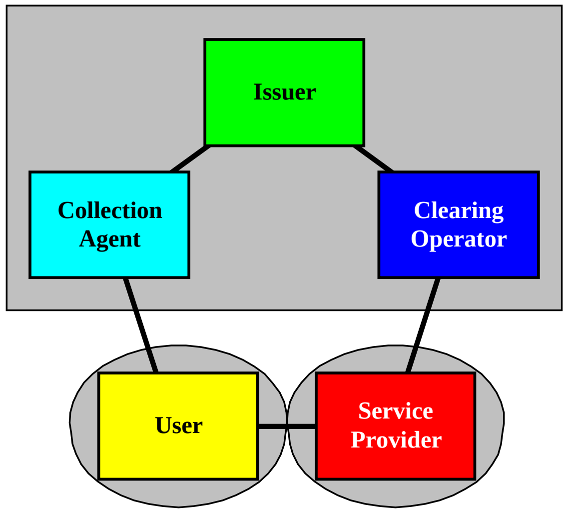


The five entities can be combined in a variety of ways in order to reflect the contractual and technical arrangements between the organisations involved in a given payment system (see Figure 14).

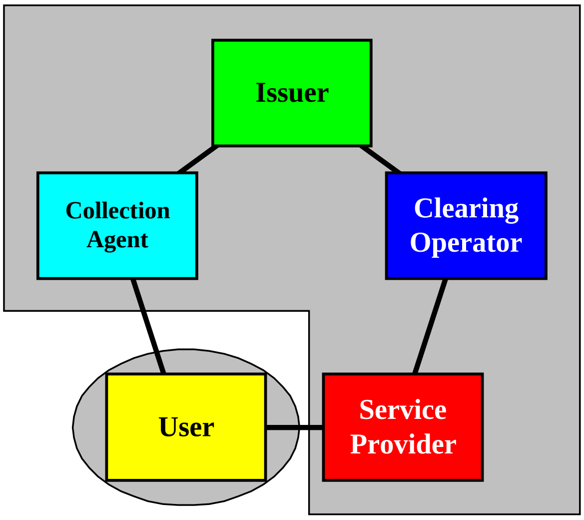
Figure 14 - Example Organisations for Automatic Fee Collection



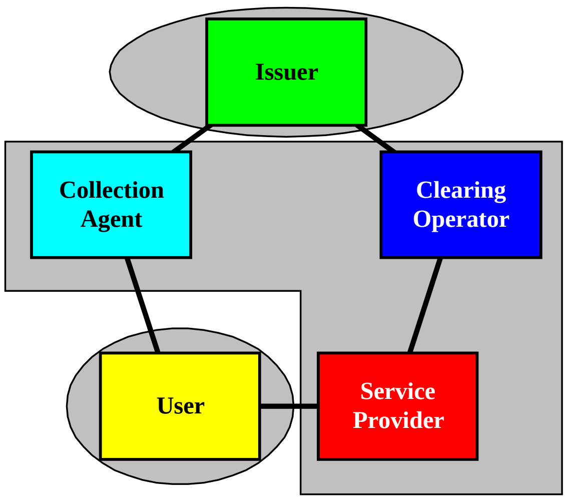
(a) The Service Provider operates its own clearing function to send data to the Issuer



(b) A single organisation controls the *payment means*. The Service Provider accepts the *payment means*



(c) A single service single Service Provider closed payment system



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

4.4.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
4	Financial transactions

4.5 Institutional and Legal Model

By defining the information flow and the contractual relationship necessary to provide an ITS service, the JEEP study suggests the rights and obligations of public authorities and potential service operators according to the rôles they intend to take [JEEP 1995]. This production chain offers the advantage of limiting the respective area of responsibility in that the prime contractor in each phase is accountable solely for his own activity.

4.5.1 Relationships Between Actors

The production line for the supply of road condition or route guidance information is as follows (see Figure 15). It should be noted that this model may not apply exactly as shown in all member states.

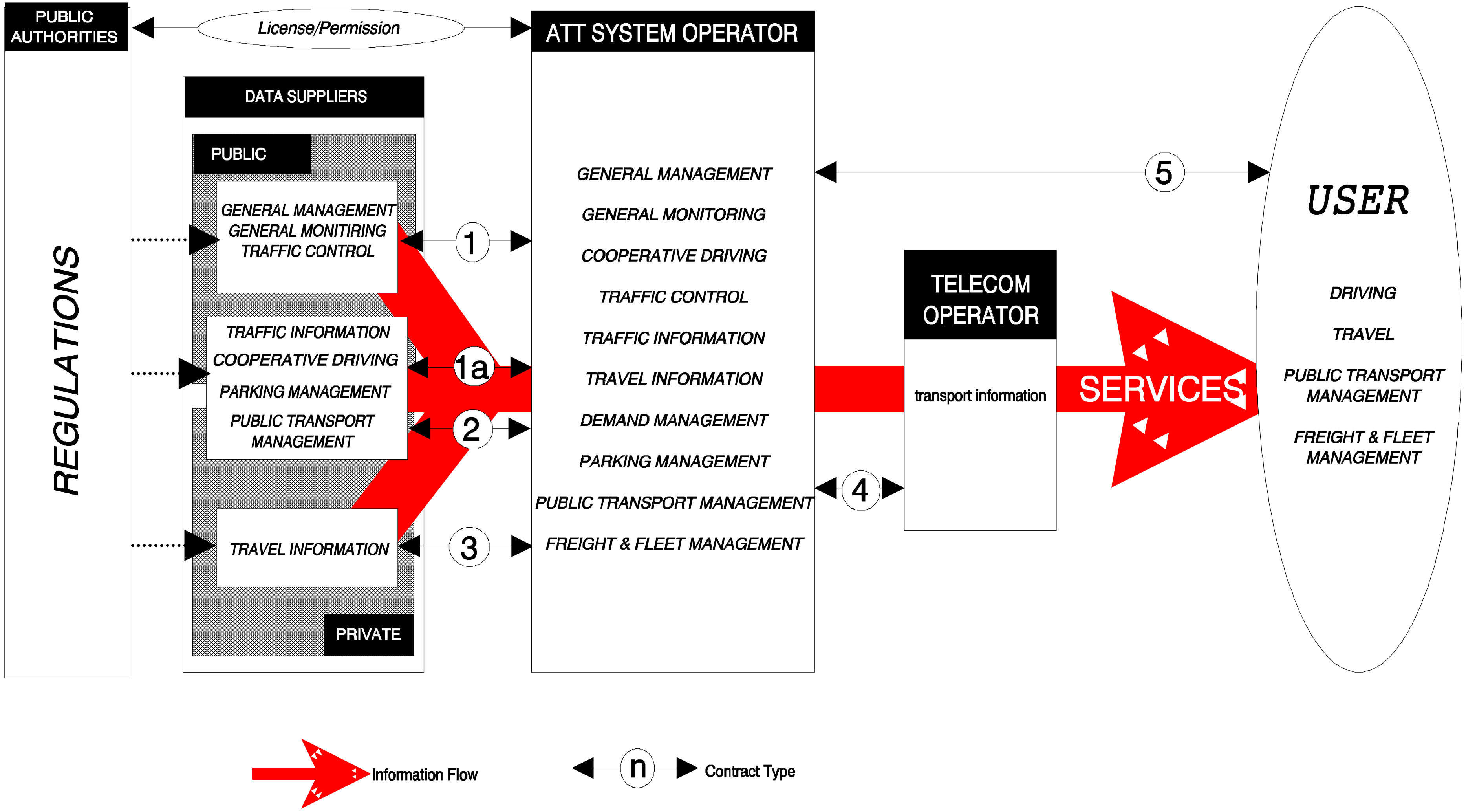
- data collection;
- initial processing to meet the specific requirements of each supplier;
- forwarding of data to the “public data provider”;
- where necessary, validation of data by the public data provider;
- transfer of data to the ITS operator;
- formatting of data by the ITS operator;
- transfer of data to the radio broadcasting or telecommunications system operator, or transmission by the ITS operator's own facilities;
- data received by the end user from an appropriate terminal.

This production chain offers the advantage of limiting the respective areas of responsibility, in that the prime contractor in each phase is accountable solely for his own activity. It would be advisable, however, to delimit the exact scope of responsibility in the contractual documents, i.e. the contracts, which establish the relations between individual actors.

At any rate, the introduction of ITS, which require public departments to adopt a more coherent policy on the use of data and standard data formats, will undoubtedly lead to greater centralisation of data.

Centralised data collection is one of the corner-stones of any ITS. Centralisation of all traffic data, or at least the bulk of such data, within a given geographical area is an essential condition for operation of an ITS. However, even at national level, different ministerial departments organise data input according to their own requirements and using their own methods. The same is true of local government and the independent authorities responsible for managing infrastructure.

Figure 15 - Institutional/Legal Flow Framework for ITS



(a) At a national level

At least two Ministries are involved:

- the Ministry in charge of the police force;
- the Ministry responsible for roads (transport, public works, communications, depending upon the State concerned).

Two others are frequently involved too:

- Defence Ministry (armed police);
- Ministry of Justice;

The creation of centralised data providers requires a protocol to be signed between the above Ministries. Such a protocol must make provision for at least the following:

- creation of an inter-ministerial body responsible for preparing and monitoring decisions taken by the government. The protocol will define the rôle of each party and may, where applicable, designate the administration or individual responsible for dealings with private entities;

- co-ordination of the respective data transmission systems;

- definition of terms used;

- definition of the legal status of the national data centre (a purely technical centre managed by one of the administrations on behalf of the others, creation of a public corporation managed jointly by all the administrations concerned, creation of an independent entity (non-profit agency) whose expenses will be reimbursed by all parties, concession).

(b) At local level

Driver information systems, and route-guidance systems in particular, cover specific geographical areas. If the services supplied to road users by the ITS operator are to be effective, it is essential that operators be given access to data which in many cases are the property of local government or highway management authorities.

The objective is therefore to set up local public data centres and, to this effect, to vet and adapt the data supplied by the national data centre (where one exists), local government departments, and all autonomous local authorities.

It is also possible to envisage bodies of differing status at this level:

- A given authority (local government department, municipal department) might be given the task of managing the local centre on behalf of the other parties. The authority would therefore sign the same agreement with each of the parties, and would be empowered to deal with partners from the private sector. A management committee would decide upon the contributions and rights of each party;

- The State and other public authorities could set up a public corporation to which they would contribute resources and pay for services rendered;

- A concession could be granted to a comparable technical organisation.

4.5.2 Organic Links Between the Actors

This description (see Figure 15) outlines:

- the flow of data from the provider to the user;
- the links between:
  - the provider and the ITS operator;
  - the ITS operator and other data suppliers;
  - the ITS operator and the operators of telecommunications networks.

This gives us a clear picture of the operational flows (ranging from basic data to driver information) and legal links between all actors in the chain. Each legal link has been given a number identifying the category into which it falls, as follows:

1. With the public sector data provider
2. With the road operator where this is different
3. With a private data supplier if one is present
4. With the telecommunication operator
5. With the end user

Each type of link, referred to simply as a "contract" must comprise a number of obligatory clauses aimed not only at setting out the rules governing the relationships between the parties, but also at providing third parties, and end users, with the requisite guarantees, ensuring procedural transparency and making it easier to establish liability in the event of a dispute. These clauses are as follows:

Purpose of contract

The purpose of this clause is to set out the objectives of the two parties in order to explain the rationale behind the more practical provisions made subsequently.

Parties to contract

Each party, particularly when the party consists of a group of (public or private) bodies, must specify here the corporate or natural person empowered to enter into a contractual arrangement on behalf of the partner as a whole.

Legal framework

The legal framework may vary according to the legal status of the partners and the purpose of the contract: either a unilateral authorisation supplemented by a specification, in the case of dealings with a State; or, on the contrary, freedom of trade and industry between private operators.

Prior conditions

In many cases, the agreement of one or more third parties will be required. Such agreement may take the form of public authorisations or the provision of a private network, etc.

Rights and obligations of parties

This clause is the central part of the contract. It provides details of the services which each party expects to receive.

Financial provisions

These are the provisions underpinning the rights and obligations of the parties. The problem of whether or not services to the public should be free must be dealt with here. Furthermore, giving the ITS operator access to the “provider’s” data will generate added expenditure for various public departments. Considerable attention will need to be paid to this point:

- which costs should be imputed, i.e. full, direct or marginal?
- should users be charged on a lump sum (subscription) or itemised basis?

The choice of lump-sum or itemised invoicing systems must be given very careful consideration.

A **subscription system** may make the operator pay for services which, in the final analysis, he does not require but whose availability will thus be ensured.

Itemised billing for services (at first glance) allows the operator to restrict expenditure to those services which he has actually requested, but does not allow the operator to make accurate budget estimates and gives the public data provider the right to discontinue certain services without warning. In addition, it raises the problem of how fixed charges, and charges which vary over time, should be imputed.

Settlement of disputes

Given that the legal status of contracts can occasionally prove to be a highly complex issue, it is useful to provide details of the procedure to be used to settle disputes. It would also be helpful to consider the possibility of using simplified procedures (arbitration).

4.5.3 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
1.1.11	The Framework Architecture shall allow current organisational responsibilities and legal liabilities to be retained.
1.10.4	The Framework Architecture shall require all

	systems developed from it to be reliable with respect to the legal and/or quality requirements necessary for each application.

4.6 The Well-Timed study

This study is about the organisation and operation of advanced travel information services in Europe [WELL-TIMED 1998]. It includes trip planning services, dynamic navigation and route finding services as well as real-time information on congestion, accidents, traffic incidents, parking, etc. All of these are examples of ITS and are part of a much wider development brought about by the merging of modern digital telecommunications and information technology.

The organisational model used in this study is based on Figure 16.

Figure 16 - Well-Timed Study Model

This model is similar to the one presented in JEEP, and the study presents different types of Public-Private Partnership which have been developed to manage services implementing this model.

5. Primary Process Models

5.1 An ITS and its Environment

5.1.1 Overview

The traffic and state, and the decisions made by the transport user, or traveller, are dynamic elements of any ITS implementation, and are subject to unpredictable behaviour [QUARTET+ 1998]. These two elements interact to create flow patterns in a road transport network. Measures can be introduced to regulate the flow patterns, and attempt to achieve equilibrium between the demand for mobility by the transport user, and the restrictions on the supply (or the level of service) of the road network. The speed with which changes to the levels of supply and demand can take place, and the need for accurate monitoring of the changes and the application of suitable measures, both over a wide area, has resulted in the development of ITS.

5.1.2 Scope

This ITS and its Environment model shows the principle features of a typical ITS and their relationships with the end users. It starts from the time that a traveller wishes to make a journey and shows that he or she can choose both the mode of travel and the route from information provided by the ITS. Once road travel has been chosen the vehicle, be it private or public transport, becomes part of the traffic and transport network which is monitored and controlled either individually or collectively.

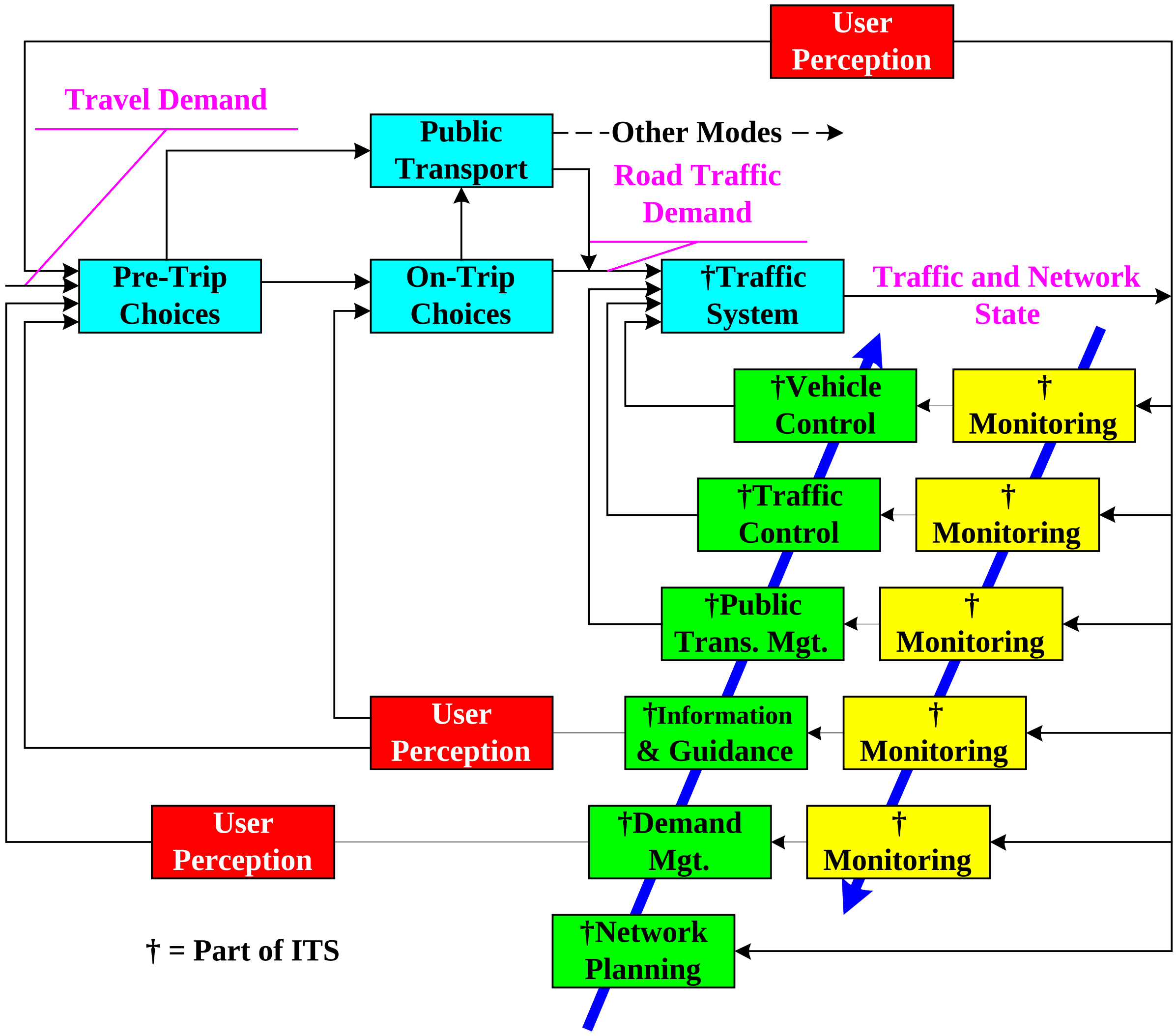
Note that the choices made by the user are based on his or her perception of both the state of the traffic and the network, and of the information provided by the system; this may not necessarily result in the expected or desired overall objective.

5.1.3 Description

This ITS and its Environment model consists of the principal features of an ITS and the decision making processes of the end user (see Figure 17).

In this model the ITS manages and controls individual vehicles, public transport and the traffic as a whole. It also provides both pre-trip and on-trip information and guidance to the traveller, as well as a mechanism to manage the demand for different types of travel. Each of these sub-systems monitor the relevant parts of the changes in the traffic and network state in order to keep on top of events. The two thick arrows illustrate the fact that each specific sub-system of the ITS co-operates with the others in order to produce a total coherent set of commands and advice. Co-operative monitoring is achieved by the sharing of data between sub-systems; co-operative control by an agreement between sub-systems on a single reference strategy. There is one system that helps to plan for new strategies and changes to the network; note that it is also essential for this activity to co-operate with the rest of the system if it is to be effective.

Figure 17 - An ITS and its Environment



The end user, or traveller, makes decisions based on his or her perception of events. This perception is built up with data from three main sources, namely experience of the overall traffic and network state and information provided by the ITS. The ITS can influence the choices made by the traveller both before and during a journey. Whenever the traveller chooses to use public transport for part, or all, of a journey this will have a different effect on the traffic and network state than when a private vehicle is used.

5.1.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
2	Infrastructure Planning and Maintenance
6	Travel Information and Guidance
7	Traffic, Incidents and Demand Management
10	Public Transport Management

5.2 The Traveller's Progress

5.2.1 Overview

The Multi-Modal Travel Model describes the primary process that occurs in the real world when a person wishes to travel to a certain destination. This process can be optimised with respect to a number of factors, e.g. time, cost, ease etc., according to the desires of the traveller. During this process various information sources may be consulted and, as a result of the decisions taken by the traveller, certain outputs and actions will result.

5.2.2 Scope

The Multi-Modal Travel Model describes the primary process of a traveller from the point where a person begins to decide to make a journey to the execution of the activity for which that journey was undertaken, i.e. the model does not finish with the arrival at the destination because a journey usually serves a certain purpose, which is subject to change and so may influence decisions made during the journey. The decision to make a journey is included because tourist information, for example, may create a destination.

A journey may be split into a number of trips (single mode, no change of vehicle within the mode) to cater for the possibility of a multi-modal travel. Note that walking could be considered as a special mode.

The model is generic and applies to all types of travel, and is thus independent of location, time, age or physical abilities of the traveller, and of organisational, financial or other restrictions.

5.2.3 Description

The Multi-Modal Travel Model consists of four main phases (see Figure 18):

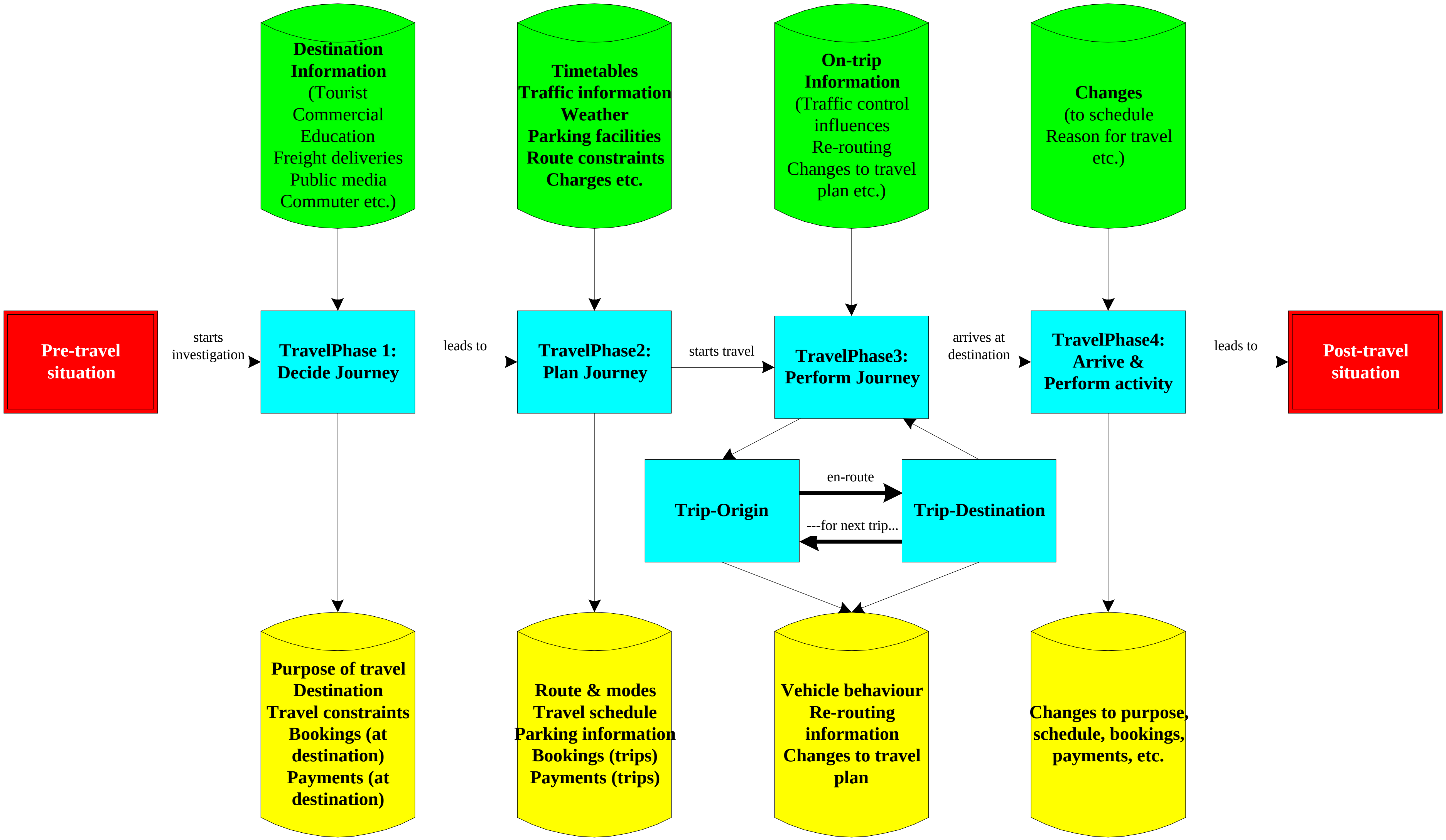
1. **Decide journey**: the selection of the destination(s) and the determination of the travel constraints. A journey may be undertaken for a variety of reasons, both private or commercial, and it may also be necessary to make reservations at the destination during this phase.

2. **Journey planning**: the determination of the sequence of trips, schedules and routes using various criteria for optimisation. This phase is of particular importance for travellers with special needs, e.g. elderly or disabled, who may need some special facilities.

3. **Perform journey**: the undertaking of an unspecified number of trips, each using a single mode of transport. During this phase the traveller may receive information that results in a change of route, or even a change of destination.

4. **Arrive and Perform activity**: Arrival at the final, and desired, destination, and performance of reason of travel.

Figure 18 - The Traveller's Progress: The Multi-Modal Travel Model



5.2.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
5.3.2	Hazardous materials and incident monitoring - Planning
6.1.0	Pre-trip information
6.1.1	Pre-trip information - Modal choice
6.1.2	Pre-trip information - Information handling
6.1.3	Pre-trip information - Traveller interaction
6.2.0	On-trip driver information
6.2.1	On-trip driver information - Mode change
6.2.2	On-trip driver information - Information handling
6.2.3	On-trip driver information - Traveller interaction
6.3	Personal information services
6.4.0	Route guidance and navigation
6.4.1	Route guidance and navigation - Information handling
6.4.2	Route guidance and navigation - Traveller interaction
7.3.0	Demand management
7.3.4	Demand management - Vulnerable road users
7.3.5	Car sharing

5.3 The Vehicle's Progress

5.3.1 Overview

The Road Travel Model describes the participation of a driver/vehicle combination in road traffic during a journey. The model covers traffic as a whole, a vehicle of one or more vehicle categories and an individual vehicle.

Some vehicles may collect information about the traffic in general, road and weather conditions, and vehicle behaviour. This information may be used by the driver and/or transmitted to a traffic information/control centre. Other vehicles can receive this data from the traffic information/control centre as a command, route guidance information, advice or for information only.

5.3.2 Scope

The model describes a single vehicle as part of road traffic from the beginning of a journey until its arrival at the planned destination and the information flows that are generated and used during this process. A vehicle may be subject to:

- traffic control commands, either as a single (automated) vehicle, or as belonging to one or more vehicle categories, or as belonging to traffic as a whole;
- the reception of information prior to a journey;
- the reception of information during a journey;
- the providing of information during a journey;
- the providing of information after a journey;
- certain restrictions (as a driver, a vehicle, a vehicle category, or traffic as a whole).

The vehicle may be of any vehicle type and with any level of automation (within legal limits). Platooning may be considered as a special case of a set of individual vehicles which have been combined into one, i.e. the platoon with a leading vehicle.

5.3.3 Description

The Road Travel Model is shown in Figure 19.

Before a journey is undertaken the vehicle/driver is able to receive pre-trip information from a traffic information/control centre about the current conditions on the roads. Once on the road the vehicle is both part of a particular set of vehicle categories, and part of the total traffic.

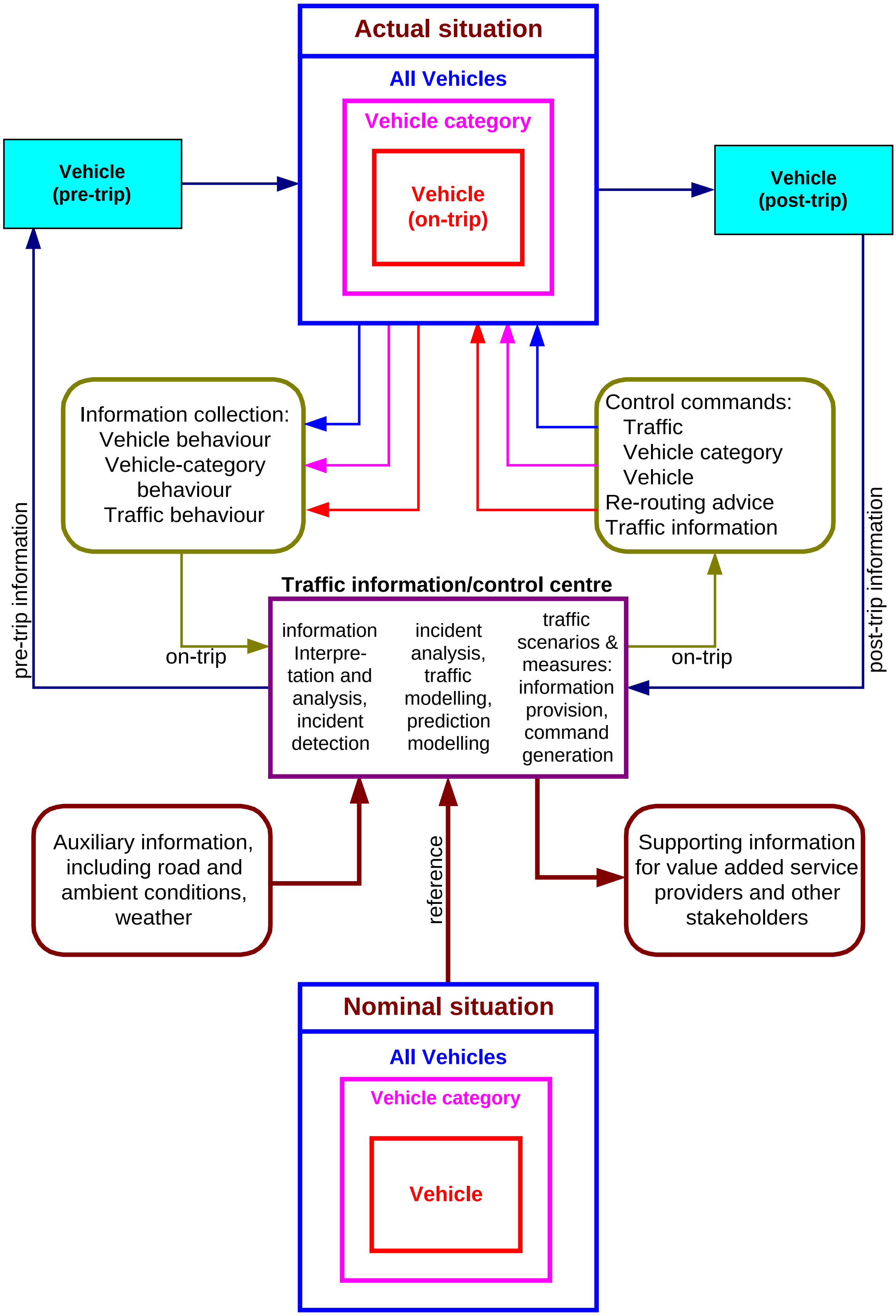
During the journey some vehicles will be monitored for aspects of their behaviour, e.g. speed; information will also be collected from some categories of vehicle, e.g. weigh in motion; and at the same time information will also be collected about all the vehicles on the road, e.g. traffic flow.

All this data is collected and passed to the traffic information/control centre, where it is combined with auxiliary information, e.g. weather. By analysing this information and comparing it with a model of the nominal road situation, the centre is able to detect incidents, for example, and initiate particular strategies when required. The centre is also able to consolidate the information for dissemination to both the traffic on the road, and to other service providers.

Whilst vehicles/drivers are on the road they will receive commands and information from the traffic information/control centre, some of which will apply to individual vehicles, e.g. as part of dynamic route guidance, some to certain categories of vehicles, e.g. to keep heavy goods vehicles away from certain areas, and some will apply to all vehicles, e.g. traffic flow control.

At the end of a journey the vehicle may provide post-trip information to the centre, e.g. to ‘sign off’ or to provide statistical data.

Figure 19 - The Vehicle's Progress: The Road Travel Model



5.3.4 User Needs

The following sets of User Needs are included in this model

Set N°	Title
3.1.1	Law enforcement - Evidence collection
5.3	Hazardous materials and incident notification
6	Travel information
6.4	Route guidance and navigation
7	Traffic, Incidents and Demand Management
8.2.4	Short range communications
9	Freight and fleet management (loaded vehicle)
10	Public transport management (individual vehicle)

5.4 The Information Creation Chain

5.4.1 Overview

The Information Creation Chain Model depicts the process of adding value to the basic data collected from traffic sensors until it reaches the traveller. The model is based on, but not identical to, the ‘Well Timed Study’ [WELL-TIMED 1998].

5.4.2 Scope

The model describes the various steps that can, but not necessarily will, be taken during the transformation of data from sensors in or alongside the road to information that is meaningful for travellers; it includes both traffic control and travel information. Whilst the model presents the complete chain, it is not necessary for each link to be present in given deployment.

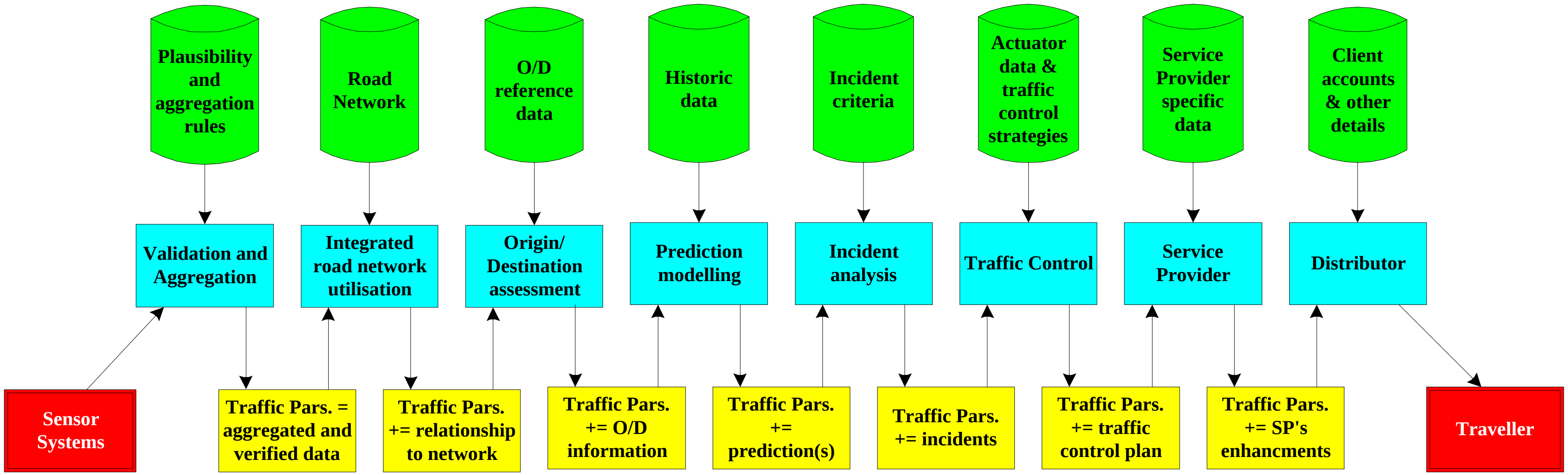
5.4.3 Description

The model comprises three different lines (see Figure 20):

- Top - the information sets that are used by the functions and actors;
- Middle - the functions and actors in the process;
- Bottom - the ***Traffic Parameters*** which are systematically refined, improved and extended during the chain.

The full chain consists of nine stages:

Figure 20 - The Information Creation Chain Model



1. Raw data is collected from sensors (sensor system). These sensors may provide three basic types of data:
   - Data on individual vehicles;
   - General traffic data about all vehicles;
   - Statistical data from floating vehicles.

2. This raw traffic data needs to be checked for plausibility and then aggregated to provide collated information about different parts of the road network. Variations in data accuracy must also be handled at this stage.

3. The traffic data is then combined with information about the road network.

4. At this point O/D matrices can be created.

5. The current situation is then compared with historical data in order to predict short term trends.

6. The data can then be compared against incident criteria in order to identify those incidents that need special attention.

7. The data can then be passed to a traffic control centre where specific strategies can be chosen for the current situation, and the corresponding control signals sent to the actuators, e.g. traffic signals, VMS. The total information now includes the current traffic control plan.

8. (Some of) this data may then be sent to a Service Provider who may provide their own specific enhancements.

9. The final version of the information is then distributed to the traveller, possibly for payment, and possibly personalised.

5.4.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
2.1.0	Transport planning support
2.1.1	Transport planning support - Information management
2.1.2	Transport planning support - Planning
2.1.3	Transport planning support - Evaluation
3.1.0	Policing/enforcing traffic regulations
3.1.1	Evidence collection
4	Financial transactions
5.2.0	Emergency vehicle management
5.3.1	Hazardous material incident management
7.1.1	Traffic control - Monitoring

Set Nº	Title
7.1.2	Traffic control- Planning
7.1.3	Traffic control centres
7.1.6	Traffic control - O/D computations
7.1.7	Speed management
7.1.9	Adaptive traffic control
7.1.10	Lane management
7.1.12	Traffic control - Vulnerable road users
7.2.0	Incident management
7.2.1	Incident management - Emergency services
7.2.2	Incident management - information management
7.2.3	Incident management - Reporting
7.2.4	Incident management - Post-incident management
7.2.5	Incident management - Pre-incident management
7.2.6	Incident management - Hazardous goods
7.3.1	Demand management - Zoning

5.5 The Information Provision Chain

5.5.1 Overview

The Information Provision Chain Model depicts the process of collecting data from all relevant sources, including from other modes, adding value and distributing the resulting information.

5.5.2 Scope

The model describes the steps that can, but not necessarily will, be taken to collect data from various sources, e.g. road traffic data, ambient conditions, data from other regions and modes, etc., and to distribute the resulting information to travellers. It includes the Information Creation Chain Model (see Section 5.4) as a special case. The model also shows the organisations involved at each stage.

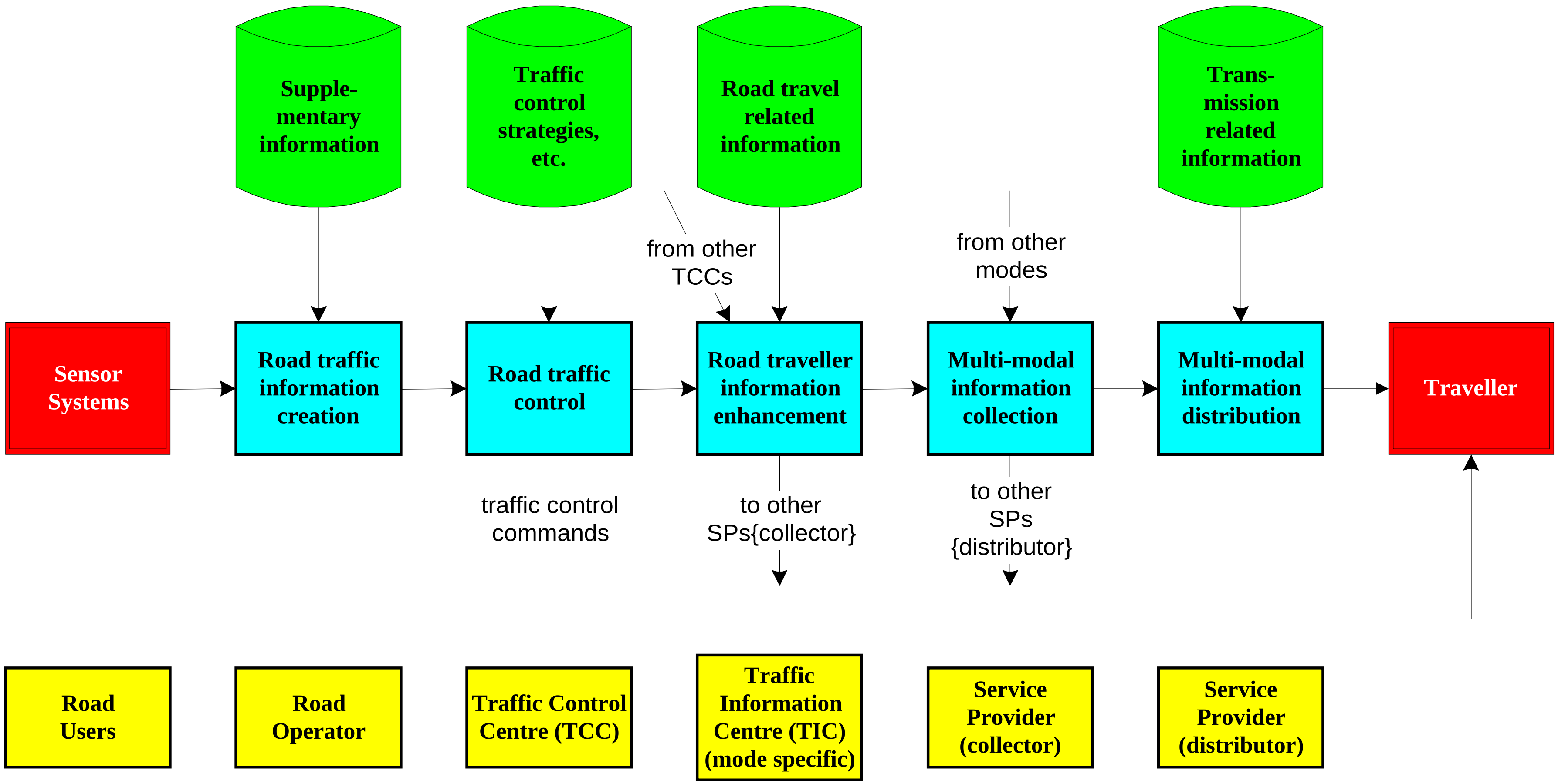
5.5.3 Description

The model comprises two main lines (see Figure 21):

- Top - the functions and the information sets that they use;
- Bottom - the organisations that are involved at each stage.

The chain consists of six stages:

Figure 21 - The Information Provision Chain Model



1. Data is collected from sensors in vehicles and at the road side, these provide information about the current activity of the Road Uses, and the conditions that they are experiencing.

2. The Road Operator combines this data with information about the road network etc. (see also Section 5.4) to provide an overall view of the current situation in the region under consideration.

3. The Traffic Control Centre (TCC) uses this information to choose suitable plans, and to provide commands to control the traffic.

4. A Traffic Information Centre (TIC) collects information about the local region, e.g. traffic conditions, weather conditions, and from other (adjacent) regions, and enhances the information as necessary. The TIC could be a public or private organisation, or a public/private partnership.

5. A Service Provider will receive the information on the road situation from the TIC and collate it with corresponding information from other transport modes. There may be more than one such Service Provider.

6. Another Service Provider(s), or the same one(s), will then distribute the information in various forms to the traveller, e.g. via radio, Internet, RDS-TMC etc.

5.5.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
6	Travel information
7.1	Traffic control

5.6 The Emergency Services Model

5.6.1 Overview

The Emergency Services Model describes the primary process that will occur when an emergency call is raised after any incident, e.g. a road accident. It captures the following phenomena:

- The collection of information about the incident and its transmission to an Emergency Centre

- The consequential procedures in the Emergency Centre

- The consequential procedures within an Emergency Vehicle.

5.6.2 Scope

The Emergency Services Model starts from the time of the incident is reported and continues until the emergency intervention is over, and any incident information has been recorded. The model covers:

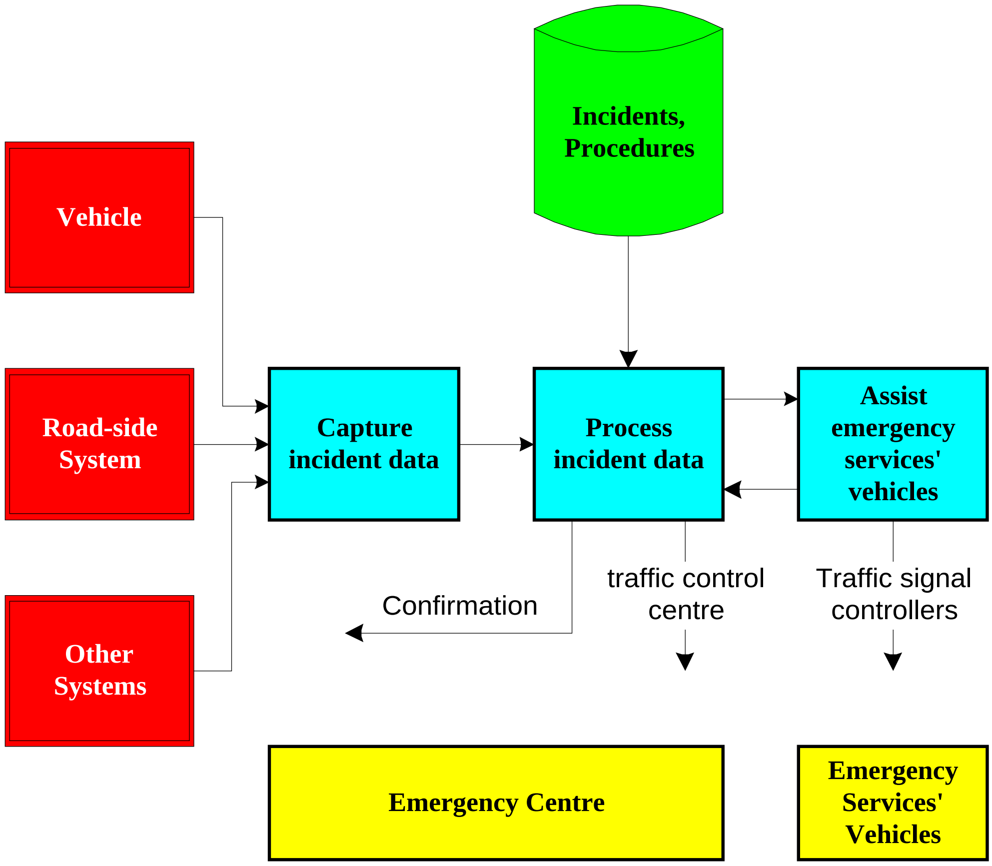
- Emergency Service - any service that is set up to provide emergency intervention for a specific aspect, e.g. doctor, ambulance, fireman, police etc.
- Emergency Centre - a place that receives emergency calls and that organises the different emergency services according to the nature of the accident.
- Road Incident - any event that can have consequences on road traffic.
- Accident - any incident where human life or health is at risk.
- Emergency Services may process accidents that create consequential traffic management problems, or that do not do so, e.g. a fire at a factory.
- A road incident can be simple, with only one vehicle involved, or very complex with several vehicles involved, and with some of them carrying hazardous goods that needs specific procedures.
- A non-road incident can be ‘simple’, e.g. a forest fire, or very complex, e.g. an earthquake.

5.6.3 Description

The model consists of three stages (see Figure 22):

- The incident data can be transmitted to the Emergency Centre by a number of means. The vehicle can transmit a “may day” message, either on command of a vehicle occupant, or automatically. Alternatively a vehicle occupant could use a road-side system. Data can also be sent my other means, e.g. (mobile) telephone, or from other persons, in particular for non-road incidents.
- The incident data is then processed. Additional data is sought if required, multiple calls about the same incident are resolved, and an attempt it made to ensure that a call is not a hoax. As soon as the incident has been confirmed, the relevant services are activated and the caller is informed that help is on the way. The Emergency Centre may also inform the local traffic control centre about the incident, and provide navigation data for the Emergency Service(s)’ vehicle(s). The Emergency Centre maintains a database of incidents, and standard procedures for certain types of incident.
- The incident data is sent to the Emergency Service(s)’ vehicle(s), and progress reports are sent back to the Emergency Centre. The vehicle is able to send commands to traffic signal controllers to obtain green light priority.

Figure 22 - Emergency Services Model



5.6.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
5	Emergency services

6. ITS Development Models

6.1 Create Traffic Control Policy Model

6.1.1 Overview

The Create Traffic Control Policy Model is an example of the application of the Control System Pyramid (see Section 3.1). It shows how knowledge can be built up until there is sufficient to provide suitable commands to the drivers and/or vehicles.

6.1.2 Scope

The model describes the sources of knowledge, the value that will be added, the intermediate results that will be obtained, and the order in which they will be assembled.

6.1.3 Description

The Create Traffic Control Policy Model consists of four stages (see Figure 23):

1. A high level group, probably consisting of politicians and senior traffic engineers, recognises that there is a traffic related problem and decides on the top-level policy goals for a traffic control system.

2. The policy is then passed to developers who will create the control strategies needed to produce the desired situation.

3. The regional traffic engineers will then interpret these strategies for their region and produce a set of tactics, and plans, for different traffic scenarios.

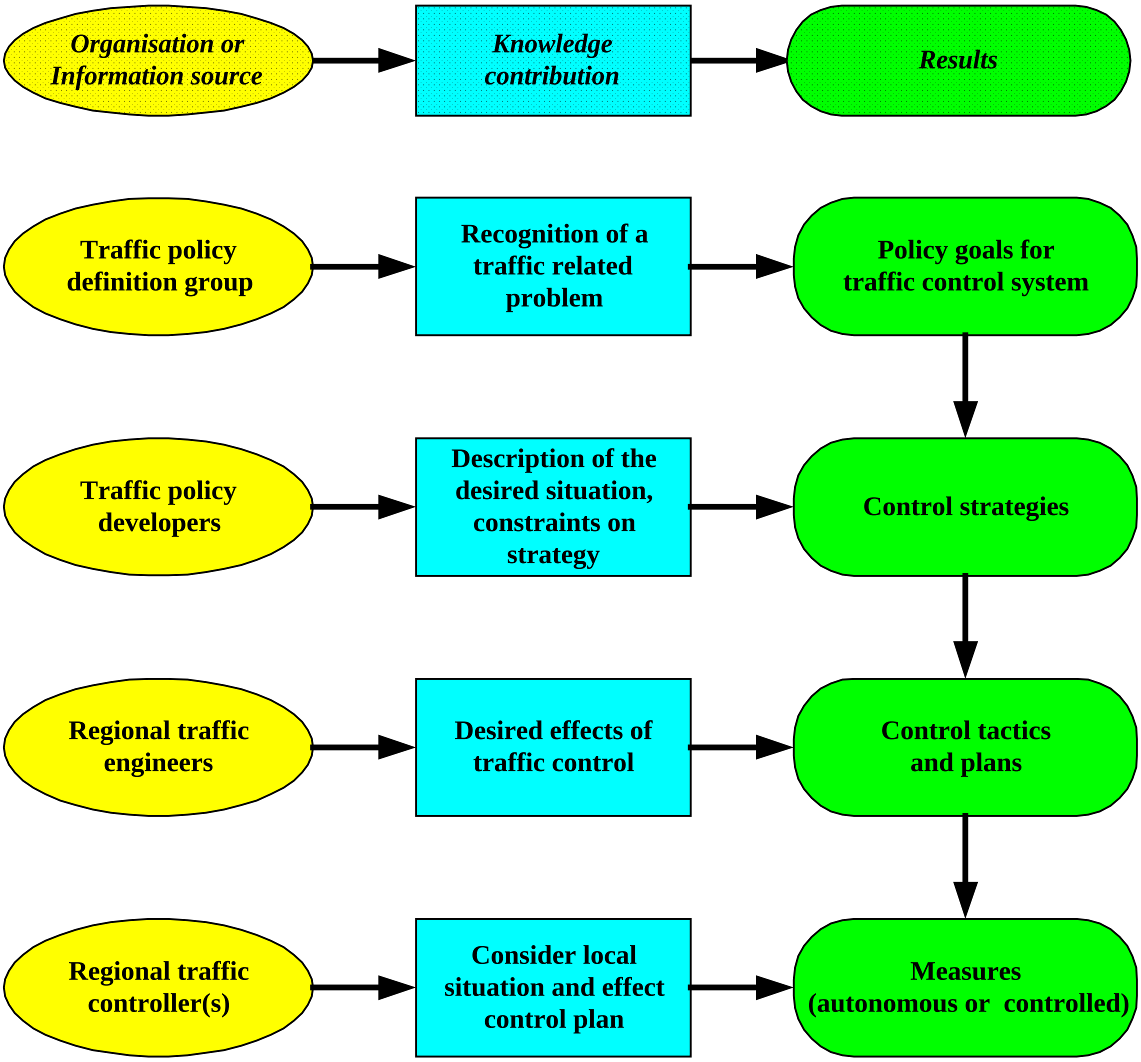
4. The regional traffic controllers will apply these plans to their local conditions to effect the necessary control measures.

6.1.4 User Needs

The following sets of User Needs are included in this model

Set Nº	Title
7	Traffic, Incidents and Demand Management

Figure 23- Create Traffic Control Policy Model



6.2 Create ITS Model

6.2.1 Overview

The Create ITS Model is an example of the application of the Control System Pyramid (see Section 3.1). It shows how knowledge is expanded in greater and greater detail until a compete working system has been created.

6.2.2 Scope

The model describes the sources of knowledge, the value that will be added, the intermediate results that will be obtained, and the order in which they will be assembled. The model distinguishes between the creation of the 'hard' artefacts (hardware and software) and the organisation of the 'soft' people who will manage, operate and use them [Checkland 1990].

6.2.3 Description

The Create ITS Model comprises five main stages (see Figure 24):

1. Using their knowledge and expertise, politicians and traffic engineers will create a set of user needs for the ITS.

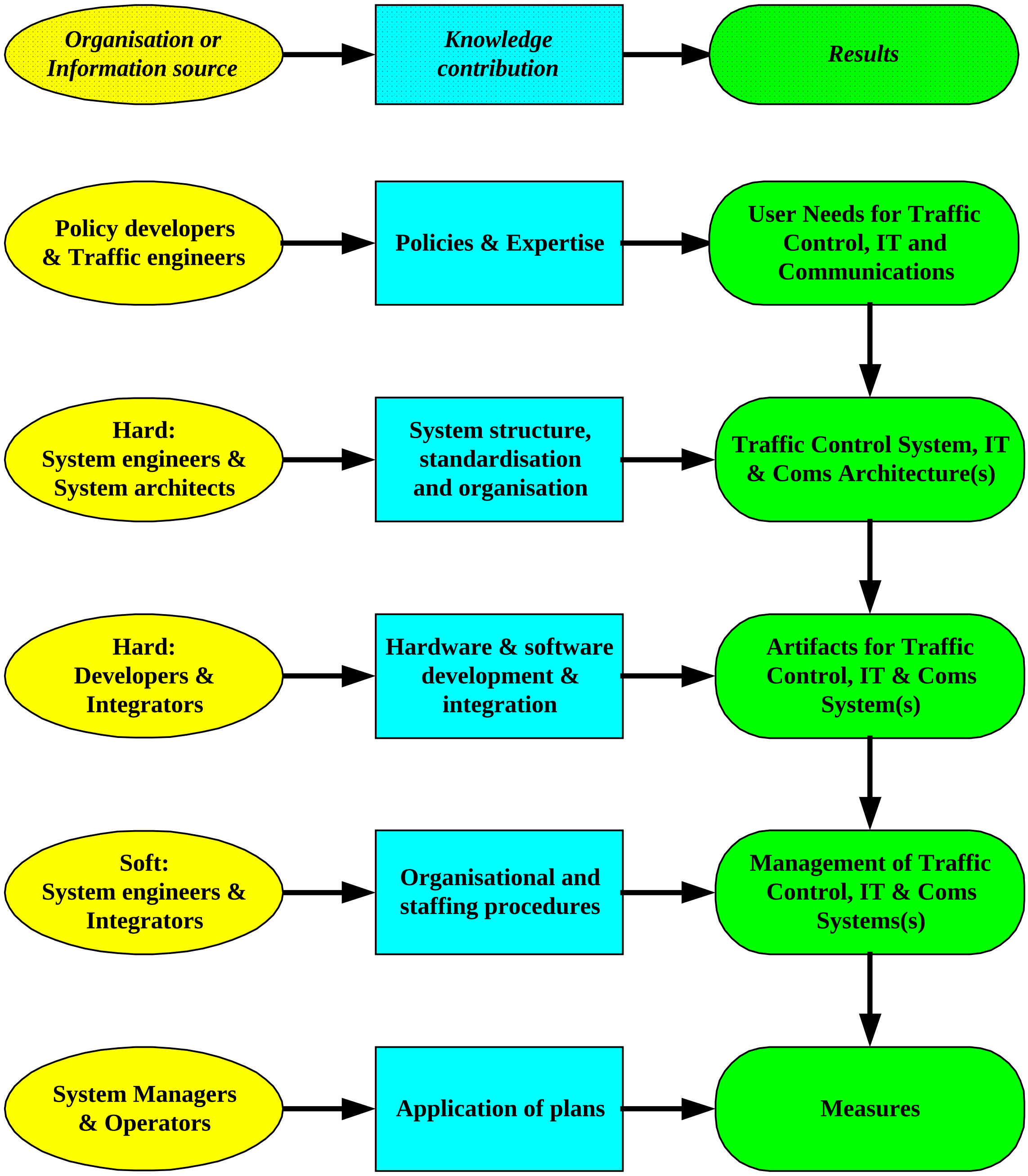
2. System engineers and system architects will then create a system architecture that will satisfy these user needs. For an ITS is may be necessary to distinguish between the traffic control, information technology (IT) and communications aspects.

3. System developers will then design and build their respective parts, which will then be integrated together to form the complete ITS.

4. At the same time consideration should also be given to the organisation, managerial and other human related aspects of operating and maintaining the system.

5. Once both the ‘hard’ and the ‘soft’ aspects of the ITS have been tested and accepted, the day to day operation of the system can take place.

Figure 24 - Create ITS Model



6.3 Process Improvement Model

6.3.1 Overview

A major issue concerning the development of traffic control systems is that the traffic engineering knowledge currently existing is likely to be improved and refined as more experience is gained. The operational systems themselves will be used to identify opportunities for improvements, and the systems will then be upgraded to incorporate this new knowledge. This is a feedback loop, albeit a weak one (see Section 2.2). In fact there are a number of possible feedback loops due to a number of factors, e.g. corrective maintenance, policy changes, progressive insight, etc.

6.3.2 Scope

The model depicts the feedback loops that exist between organisations, professional workers and the users, and the ITS that have been created. Its purpose is to indicate the nature of the feedback loops, their actors, and how the system evolution process can be presented.

6.3.3 Description

The model assumes that there is a part of the real world upon which control can be exerted and an environment which influences this part, but upon which no control can or will be exerted (see Figure 25). Thus if there is a desire to control road traffic, the environment will include the road pavement itself, the weather, other road users, the atmosphere (pollution) etc.

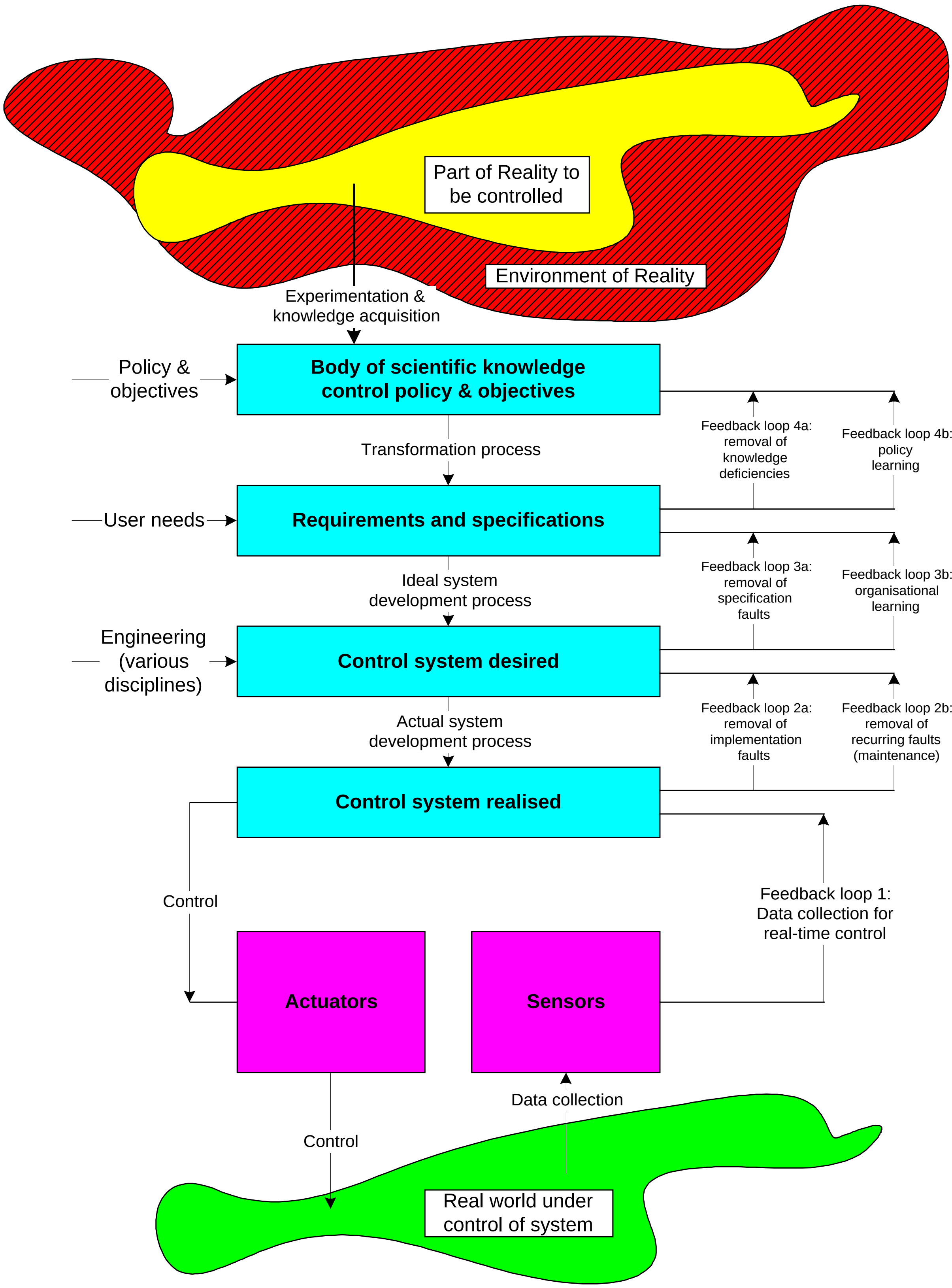
From experience and experiments a certain knowledge has been acquired, and there is an expectation that this knowledge can be use to improve the situation. This body of knowledge is then combined with certain policy objectives, and user needs, to produce a set of system requirements which will, theoretically, lead to a system with the desired properties. Engineers will attempt to produce this desired system, but due to financial, organisation, technical etc. restrictions, or even errors during the development, a slightly different system will actually be realised.

When the system is in operation Feedback loop 1 will provide the real-time control that is needed to make it function. However, it will soon be realised that the functionality is not exactly what was expected, and Feedback loop 2 can be used to provide corrective maintenance to fix faults in components, or that were made during the development.

As more experience is gained Feedback loop 3 may be used to correct some of the original specifications either because they were wrong to start with, or because it is recognised that there is a better way to achieved the desired objectives.

After some time, and possibly after the evaluation of many similar systems, a better basic understanding of the total problem being addressed it gained. This can lead either to improvements in technical understanding and/or to improvements in policy objectives.

Figure 25 - Process Improvement Model



7. Uses of the Models

Models can provide a high level description of an ITS service, or set of services. They provide a mental image of the features that a user might see and experience without going into any technical detail. As such they can be used by a variety of different persons as a means of communication:

- **Decision Makers** - These can be local or national politicians, local authority senior engineers or senior civil servants, or senior managers in a company that either manufactures or integrates ITS. These persons are not normally interested in the fine details of design, but are concerned with the impact that the total system will have both on its users and on their financial plans. Models provide a description of the system that will often support these aims; they also are easy to understand and thus suitable for use in presentations where is necessary to describe the total impact of an ITS in a short time. All the different types of model presented in this document can be used to describe different aspects of the system, though the Enterprise and Primary Process Models are likely to be the most relevant.

- **End Users** - Most end users, and in particular the “general public” are not interested in the fine details of design, but are concerned with the services that they might receive from an ITS. Primary Process Models, in particular, provide a comprehensible overview of the various services that may be offered and these can be used to form the basis of any discussion with, or presentation to, to the end users.

- **Project Engineers** - An ITS may be built up from many individual sub-systems and it is likely that there will be many engineers and technicians, probably from a number of different disciplines, involved in its creation. It is therefore essential that they all “sing from the same hymn sheet”, and the models described in this document provide a means to achieve this. Whilst all types of model will be useful to some degree, the Layered Reference Models and the ITS Development Models will be particularly relevant.

- **Infrastructure Operators and Service Providers**- ITS operators need to be able to understand all the capabilities of the system that is under their control, i.e. they must have a correct mental model. All the different types of model described in this document should be considered for this purpose, though the Layered Reference Models and Primary Process Models are likely to be the most relevant.

Although the set of models in this document is by no means complete, all the major areas of ITS are covered from at least one viewpoint, including the creation, deployment and improvement of the systems themselves. Thus, whilst this document can act as an introduction to ITS architecture, and the types of system that are supported by the European ITS Framework Architecture proposed by KAREN, it is to be expected that specific versions of the models will have to be created for a given ITS.

8. References

[Anthony 1965]
Anthony R N, *Planning and Control Systems: A Framework for Analysis*, Harvard University, Cambridge, 1965.

[Carroll 1939]
Carroll L: *Sylvie and Bruno Concluded*, in The Complete Works of Lewis Carroll, The Nonesuch Press, 1939 (First Published 1893).

[Checkland 1990]
Checkland P and Scholes J, *Soft Systems Methodology in Action*, John Wiley & Sons, 1990, ISBN 0-471-92768-6.

[CONVERGE 1998]
Jesty P H et al, *Guidelines for the Development and Assessment of Intelligent Transport System Architectures*, Deliverable DSA2.3, TR 1101 CONVERGE support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 1998, {www.trentel.org/transport/deployment/architecture/arch.html}.

[D2.2 2000]
Jesty P H et al., *List of European User Needs*, Deliverable D2.2, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 2000, {www.trentel.org/transport/deployment/architecture/arch.html}.

[D3.1 2000]
Bossom R A P et al., *KAREN Functional Architecture*, Deliverable D3.1, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 2000, {www.trentel.org/transport/deployment/architecture/arch.html}.

[D3.2 2000]
Bossom R A P et al., *KAREN Physical Architecture*, Deliverable D3.2, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 2000, {www.trentel.org/transport/deployment/architecture/arch.html}.

[D3.3 2000]
Bossom R A P et al., *KAREN Communications Architecture*, Deliverable D3.3, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 2000, {www.trentel.org/transport/deployment/architecture/arch.html}.

[D3.4 2000]
Bossom R A P et al., *KAREN Cost Benefits Report*, Deliverable D3.4, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth

Framework Programme (1994-98), 2000,
{www.trentel.org/transport/deployment/architecture/arch.html}.

[D4.2 2000]
Gaillet J-F et al., *Deployment Approach and Scenarios*, Deliverable D4.2, TR 4108 KAREN support project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 2000,
{www.trentel.org/transport/deployment/architecture/arch.html}.

[EUROBUS 1993]
EUROBUS/TRANSMODEL, *EC-Data Model V3*, Deliverable N º 11, V2025 EuroBus project of the Advanced Transport Telematics (ATT/DRIVE II) sector of the TELEMATICS APPLICATIONS Programme, Third Framework Programme (1991-94), 1993.

[EUROBUS 1994]
EUROBUS/TRANSMODEL, *Definition of Main Functions V2*, Deliverable N º 8, V2025 EuroBus project of the Advanced Transport Telematics (ATT/DRIVE II) sector of the TELEMATICS APPLICATIONS Programme, Third Framework Programme (1991-94), 1994.

[ISO 14904]
DD ENV ISO 14904, *Road Transport and Traffic Telematics - Automatic Fee Collection - Interface Specification for Clearing between Operators*, 1997.

[ISO TC204 WG1 Pt1]
ISO TC204 WG1, *Transport Information and Control Systems - Reference Model Architecture(s) for the TICS Sector - Part 1: TICS Fundamental Services*, ISO/TR 14813-1, 1998.

[JEEP 1995]
Camus J-P and Fortin M, *Road Transport Informatics - Institutional and Legal Issues*, Study for the European Conference of Ministers of Transport and ERTICO, 1995,
ISBN 92 821 1205 5.

[QUARTET+ 1998]
Franco G, et al., Comprehensive Evaluation of Urban/Regional IRTE: the User View and Suggestions for Exploitation, Deliverable Nº D02.1, TR 1044 QUARTET PLUS project of the Transport sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 1998.

[SATIN 1995]
SATIN, *Proposals for Urban, Inter-Urban and In-Vehicle Architectures*, Deliverable Nº AC13 - Part 7, SATIN Task Force, V2056 CORD project of the Advanced Transport Telematics (ATT/DRIVE II) sector of the TELEMATICS APPLICATIONS Programme, Third Framework Programme (1991-94), 1995.

[WELL-TIMED 1998]
Miles J C and Walker A J, *West European Legal Arrangements for Transport Information Management and Exchange of Data*, TR 1102 ANIMATE support project of the Transport

sector of the TELEMATICS APPLICATIONS Programme, Fourth Framework Programme (1994-98), 1998, {www.trentel.org}.

[Zimmerman 1980]
Zimmerman H, *OSI Reference Model - The ISO Model of Architecture for Open Systems Interconnection*, IEEE Transactions on Communications, COM-28(4), pp. 425-432, 1980.

Appendix A Correspondence with the Framework Architecture

The models described in this document are three basic types, and some models belong to more than one type. The three types are:

- Primary Processes - these are a description of what happens in actual practice, and are therefore bound to reality;
- Reference Models (tower models) - these capture the internal structure of the system
- Context Models - these capture the external conditions and structures with which the system has to comply, and include the manner in which traffic engineers may wish to control the system.

The following sections describe the degree of correspondence that exists between some of the models and the framework architecture and highlight non-compliance of a significant nature, though it should be noted that they are not the result of detailed consistency checks. Sometimes it has been found that the models themselves add to the process of satisfying the original User Needs [D2.2 2000].

A.1 Primary Processes

The Freight and Fleet Management Models (Section 4.2) mainly describe internal operations. There is no inconsistency between the current models and the European ITS Framework Architecture.

The Traveller's Progress Model (Section 5.1) describes the steps a traveller may take between the situation prior to any specific knowledge about transport mode(s), routes, schedules and costs, until final arrival at the destination (the origin and destination are presumed to be known). This model is relevant for Area 6 (Provide Traveller Journey Assistance) of the Functional Architecture [D3.1 2000]. For the road transport environment, which is the scope of the European ITS Framework Architecture, there is a seamless correspondence between them. Whilst the Traveller's Progress Model also include travel by other modes, the Framework Architecture only contains the necessary links to receive the information.

The Vehicle's Progress Model (Section 5.3) depicts what a vehicle can do prior to, during and after the trip and how traffic control can be applied to an individual vehicle, a vehicle category or the traffic as a whole. The traffic control part collects information from various sources and produces traffic control commands and supporting information. There are, however, some inconsistencies between it and European ITS Framework Architecture Function 3 (Manage Traffic) [D3.1 2000]. Manage Traffic addresses traffic as a whole and does not explicitly cover the handling of individual vehicles or vehicle categories, although these are included in the User Needs (e.g. 7.1.4.5 ('priority to selected travellers'), 7.1.5.6 ('certain classes of vehicles'), 7.1.9.3: ('selected vehicles') and 7.1.10 ('HOV vehicles') [D2.2 2000]. However, functionality is provided to service the Needs of some categories of vehicles (e.g. Public Transport and Emergency), in a global sense. In the case of Public Transport vehicles, functionality is included in the Manage Public Transport Operations Area (4) that enables some selection to be provided, e.g. priority will only be given to vehicles that are behind on their service schedules. The needs of 'HOV vehicles' have not been included, as there is no way to detect them. It is possible using the functionality that exists in the Architecture to apply physical lane segregation at junctions and then to control the HOV lane separately, giving it priority if required.

In the Vehicle's Progress Model the vehicle may send information to the control centre prior to, during and after the trip, either on a voluntary or a mandatory basis. This can apply in particular to non-standard vehicles or transport, e.g. those carrying hazardous goods. This is not clearly included in the functional architecture, although mentioned in the User Needs [D2.2 2000]

The Information Creation Chain (Section 5.4) describes the steps necessary to provide the traveller with all desired road traffic related information. It does seem to conform to the Framework Architecture, though not always explicitly, e.g. the use of O/D reference data is not explicit in the Functional Architecture.

The Information Provision Chain (Section 5.5) presents the various systems that are necessary for the provision of multi-modal travel and traffic information in a wide area. Generally speaking, the European ITS Framework Architecture complies with this model.

A.2 Reference Models ('Tower Models')

At the highest level there is consistency between the Reference Models, or 'Tower Models', (see Section 3) and European ITS Framework Architecture Function 3.1 (Provide Traffic Management) [D3.1 2000]. However, the tower model prescribes a decomposition scheme that is different from the one applied in the functional architecture. The tower models primarily describe management responsibilities and only then extend into the spatial domain. This results in the provision of different services at different levels of the tower model. In the European ITS Framework Architecture the decomposition paradigm is function oriented, not service oriented. Hence an inconsistency between the tower model and the decompositions in the functional architecture, though not immediately visible, can be expected to exist. However, the inconsistencies may be resolved by further decomposition of the functionality provided in Function 3.1. This would make it easier to apply single Functions to different layers of the Model, instead of one or more functions covering several layers.

A.3 Context Models

The Transport and Traffic Market Model (Section 4.1) captures all the factors that contribute to, or participate in, the road traffic and transport environment. The diagram shows three dimensions: individual – collective, short term – long term, artefact/attribute–individual/organisational. The European ITS Framework Architecture proposed by the KAREN Project as a whole covers the technical side of the system only, i.e. the traffic and transport issues, it does not cover the human and organisational side. It is primarily geared towards the daily operation of the traffic and transport system, with the very short reactions times during emergencies included. Longer term issues such as the transformation of traffic policy into traffic engineering principles, the transformation of traffic engineering principles into day to day operations and maintenance activities are only superficially addressed.

In User Needs [D2.2 2000] Group 2.1 (Transport Planning Support) a number of user needs refer to the existence of a traffic policy, i.e. the rules defined by the authorities that indicate how the system should be developed, function and behave. This approach is reflected in the

Transport and Traffic Market Model and the Create Traffic Control Policy Model (see Section 6.1) covers some of the other aspects. Between them they help to satisfy this particular set of user needs.

The Create Traffic Control Policy Model also helps to satisfy User Needs [D2.2 2000] Group 7.1 (Traffic Control) in which a number of user needs refer to traffic management strategies that have to be transformed into traffic control measures.

The fundamental premise of the Process Improvement Model (Section 6.3) is that, for the class of systems to which traffic control systems belong, the initial system is, nor cannot be, perfect from the beginning. The system itself will be the instrument through which insight and knowledge will be improved, which, in turn, will lead to system improvements. The desire to be able to do this is expressed in the User Needs 2.1.3 (Evaluation) "The system shall be able to measure the effect of a strategy and to modify it when necessary" [D2.2 2000]. The European ITS Framework Architecture is not really inconsistent with the Process Improvement Model, though it is not expressed explicitly.