



SYSTEM ARCHITECTURE

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Services and Functions: Where do we stand ?

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Technical abstract

In contrast to the US and Japan, European activities related to transport telematics do not make reference to an agreed list of services. On the other hand, the “CORD Functions List” is now increasingly used by the R&D transport projects funded by the European Commission.

Although the terms “services” and “functions” have been used widely in European activities, there are still questions on the difference between service and function as well as on the lists which are already in use. The report presents definitions of different concepts and then describes the different lists of services and functions used in Europe, USA, Japan and ISO. A comparison between these lists is carried out and proposals for refining the current European list of functions are made.

Executive Summary

In contrast to the US and Japan, European activities related to transport telematics do not make reference to a common list of services. On the other hand, the “CORD Functions List” is now widely used by the R&D transport projects funded by the European Commission. This list is more than a “dictionary” for casual reference. It enables a more efficient exchange of information between interested parties, projects and institutions. Further more, it furnishes the basis for a wide range of studies and activities, including architecture development, definition of technologies and systems catering for the envisaged range of services, institutional and legal analyses, and market definition and analysis.

Although the terms “services” and “functions” have been used widely in European activities, there are still questions on the difference between service and function as well as on the lists which are already in use. The present report proposes elements of answers to those questions and restates that whatever terminology is used for naming services, the CORD functions list should remain the common reference for describing the internal structure of these services.

This report contains a first section presenting definitions of different concepts and then describes the different lists of services and functions used in Europe, USA, Japan and ISO. A comparison between these lists is carried out and proposals for refining the current European list of functions are made. These include an extension of the list to other modes of transport and a more comprehensive definition of the functions, including detailed description of input/output data flows. It is also proposed to use the current ISO list of services, which is a consolidation of US, Japanese and European contributions, as a reference for a list of services.

A revised version of the CORD list will be prepared by CONVERGE-SA and issued in 1997. A key condition for the success of this activity will be a constructive feedback from the projects using the CORD-list.

1. Introduction

During the previous Advanced Transport Telematics (ATT) Programme, the understanding of the importance of System Architecture work has increased quite dramatically, and with it also the importance of the Functions List as a provider of the fundamental building blocks for functional architectures. The current version of this Functions List, the so called “CORD Functions List”, was issued in December 1994 [1].

The CONVERGE-System Architecture project is currently maintaining a co-ordinating role in the amendment of this list. This work is entirely based on voluntary input and constructive comments from the 4th Framework Programme projects applying the current list for their system architecture development.

The purpose of this intermediate report by the CONVERGE-SA project is to gather together answers to the following questions:

- What do we know about services and functions?
- What conclusions can we draw from what is currently existing?
- What do we need to do at the European level to further refine the CORD functions list?

The report first presents definitions of different concepts and then describes the different lists of services and functions used in Europe, USA, Japan and ISO. A comparison between these lists is performed leading to a series of conclusions including proposals for improving the current European list.

2. A few definitions . . .

This chapter attempts to provide simple definitions of the concepts of service, application, system and function.

The proposed definition of a service is what could be called an “operational” definition as opposed to the concept of service used in economics (which is often based on the relationships between a client and a supplier). In the context of this report, we consider that transport telematics applications (see below) share common attributes which are independent of their implementation: for example, their purpose, the type of information handled, the use of this information (to control, to warn, to inform the user). They can therefore be clustered according to these attributes. Each cluster will be referred to as a service.

It is important to stress that a service is independent of technology and internal functionality. Examples of transport telematics services include on-trip driver information, route guidance, public transport management, etc.

A service can take different forms. For instance the service “Route Guidance” can be autonomous (the service is performed within the car) or decentralised (route calculation is done in a central computer and the results are transferred to the vehicle). At *the analysis level*, one will choose the way to deliver the service. At that stage, each form of a service is called *an application*. As mentioned in the definition of service, these two applications of route guidance have common attributes: the type of data provided is the same and serves the same purpose: guiding the driver.

A *system* is the *physical implementation* of an application (and therefore of a service) and is a collection of *interrelated* elements which interact with one another towards a common purpose. A system possesses properties different from the collection of properties of the individual parts. Each system element performs a *certain function*.

To complete the definition of a system, it can be said that a system is composed of elements grouped into two main parts [2]:

- the *artefact* which is the the part of the system that will be implemented by means of hardware, software and communication means;
- the *system factors* that allow the artefact to work. System factors include for example staff, organisation, documentation, procedures, etc.

3. What lists of services and functions are already defined ?

For this exercise, the author took into account the material used by the ISO/TC204/WGI to compile its list of services (see below). It may be possible that other lists are available and if so, the author is ready to amend the present document to include them.

3.1. *The CORD functions list*

The CORD list [1] provides a description of current and basic Transport Telematics “functional” (technology independent) terms. Its purpose is to facilitate and support a more efficient exchange of information between concerned actors and provide a common basis for system architecture studies, market definition and analysis, evaluation and institutional analysis. Examples of use of the CORD list can be found for example in [3], where the CORD functions have been used to represent functional architectures of different projects hence allowing an easier comparison of the different architectures.

It is important to note that, in this list, it is assumed that “function” and “service” are synonymous.
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The definitions and classifications used for the list are based on a three-layer hierarchy. These are as follows:

3.1.1. Areas (A)

are sets of functions related by the nature of the services provided. They present complimentary or alternative (sub)functions. Experience has shown that the importance of the Area concept should be reduced, as Transport Telematics has too many dimensions to allow stringent enough definitions or structures at that level. Areas are seen mainly as a tool to structure the Functions List. Real system implementations must normally be built by using functions or subfunctions from several Areas.

The following ten Areas have been identified :

- A1. Road Logistics and General Management
- A2. Demand Management
- A3. Traffic Management
- A4. Parking Management
- A5. Public Transport Management
- A6. Traffic Information
- A7. Travel Information
- A8. Freight and Fleet Management
- A9. Vehicle Control
- A10. Internal services

3.1.2. Functions (F)

are groupings of two or several complementary/synergetic or, in some cases, alternative subfunctions.

Users of this list can combine any relevant set of subfunctions to form the desired *construction* (a kind of a mini architecture). For instance, Intersection Control Computation (SF3.2.2), Intersection Control Actuation (SF3.2.3) and Network Control Computation (SF3.3.5) can, in the context of Urban Traffic Control, be grouped under the different heading *Network Signal Control*.

3.1.3. Subfunctions (SF)

are single elements of a function. Subfunctions can of course be further decomposed into sub-subfunctions. The level of the subfunctions is also unavoidably different in the different areas.

In order to allow maximum flexibility, different (sub)functions can be arbitrarily grouped to constitute the desired result (e.g. *Urban Traffic Control - part of Traffic control*) provided special names are used and a clear definition based on identified functions/subfunctions is given.

It should be clear also that there is no one-to-one correspondence between functions/subfunctions, on the one hand, and technologies on the other hand. The same function may be performed by different technologies and the same technology may perform different functions/subfunctions in different areas.

3.2. The US list of services

In America, Intelligent Transport Systems (ITS) technologies have been encapsulated in a collection of interrelated user services that have been used for the system architecture study [4]. To date, twenty-nine user services have been used in the architecture and a thirtieth one, highway-rail intersection is currently being developed. The user services have been bundled into six categories as shown below.

User Service bundles	User Services
Travel and transportation management	<ul style="list-style-type: none"> • En-route driver information • Route guidance • Traveller services information • Traffic control • Incident management • Emissions testing and mitigation • Demand management and operations • Pre-trip travel information • Ride matching and reservation
Public transportation operations	<ul style="list-style-type: none"> • Public transportation management • En-route transit information • Personalised public transit • Public travel security
Electronic payment	<ul style="list-style-type: none"> • Electronic payment services
Commercial vehicle operations	<ul style="list-style-type: none"> • Commercial vehicle electronic clearance • Automated roadside safety inspection • On-board safety monitoring • Commercial vehicle administration processes • Hazardous materials incident response • Freight mobility
Emergency management	<ul style="list-style-type: none"> • Emergency notification and personal security • Emergency vehicle management
Advanced vehicle control and safety systems	<ul style="list-style-type: none"> • Longitudinal collision avoidance • Lateral collision avoidance • Intersection collision avoidance • Vision enhancement for crash avoidance • Safety readiness • Pre-crash restraint deployment • Automated highway system

Table 1: US User Services

3.3. The VERTIS list of services (Japan)

Similarly to the American list, VERTIS defined 18 user services in 9 fields. They are described in the following table:

Fields	User Services
Traffic control and management	<ul style="list-style-type: none"> • Advanced traffic flow control system
Travel, road traffic and driving information	<ul style="list-style-type: none"> • Road/traffic information system • Integrated traffic information system • Navigation/dynamic route guidance system
Parking management	<ul style="list-style-type: none"> • Dynamic parking guidance system
Transportation management	<ul style="list-style-type: none"> • Vehicle operation management system
Public transportation management, priority and new traffic	<ul style="list-style-type: none"> • Public transportation vehicle operation management system • New freight transportation system
Electronic toll charging and collection	<ul style="list-style-type: none"> • Electronic toll collection system
Traffic demand management	<ul style="list-style-type: none"> • Traffic demand management system
Driver warning and control field	<ul style="list-style-type: none"> • Vehicle/driver safety monitoring and warning system • Safety information warning and control system • Short range obstacle warning system • Driver's visual aid system • Lane departure prevention/lane following system • Automated vehicle system (on dedicated road)
Emergency control field	<ul style="list-style-type: none"> • Incident/accident management system • Disaster management system

Table 2: VERTIS User Services

3.4. The ISO list of services

By combining the work of major contributions such as the CORD functions list and the US list of user services, the ISO/TC204/WG1 defined a set of what has been called fundamental services [5]. The current list includes 32 services which are:

1. Pre-trip Information
2. On-trip Driver Information
3. Personal Information Services
4. Route Guidance & Navigation
5. Shared Transport Management
6. Incident Management
7. Demand Management
8. Traffic Control
9. On-trip Public Transport Information

10. Public Transport Management
11. Demand Responsive Public Transport
12. Public Travel Security
13. Electronic Financial Transactions
14. Commercial Vehicle Pre-clearance
15. Automated Roadside Safety Inspection
16. Commercial Vehicle Administrative Processes
17. Commercial Vehicle On-board Safety Monitoring
18. Commercial Fleet Management
19. Hazardous Materials & Incident Notification
20. Emergency Vehicle Management
21. Emergency Notification and Personal Security
22. Longitudinal Collision Avoidance
23. Lateral Collision Avoidance
24. Intelligent Junctions
25. Vision Enhancement
26. Safety Readiness
27. Pre-crash Restraint Deployment
28. Automated Vehicle Operation
29. Policing/Enforcing Traffic Regulations
30. Infrastructure Maintenance Management
31. Trip Survey and Data
32. Safety Enhancements for Vulnerable Road Users

Each of these services is described in Annexe 1.

4. What conclusion can we draw from these lists ?

This section is an attempt at comparing the four lists previously described and to highlight the strengths and weaknesses of the current CORD functions list compared to the three other lists.

In the matrix given in table 3, equivalent services and functions have been listed. All the elements of each list are included in the matrix.

The following comments can be made:

- the US and the ISO lists are similar and the US list is undoubtedly the core of the ISO list;
 - the VERTIS list presents some gaps compared to the ISO and US lists. This list is however more refined when addressing in-vehicle services dealing with automatic control and safety;
 - the CORD functions list presents a higher level of detail. Compared to the ISO list, most CORD functions can be seen as a refinement or, in other words, as a more precise definition of an ISO service;
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- some ISO services have been included to encompass specifically certain CORD functions (e.g. policing/enforcing traffic regulations); this is not considered as a service itself by the US and VERTIS lists;
- it seems that, compared to the other lists, the ISO list encompasses most of the CORD functions. It can therefore be recommended to use the ISO list of services for high-level system definition bearing in mind that the CORD functions should be used at the next stage when addressing a more detailed service definition;
- the CORD functions list does not include all the aspects covered by the ISO list. For instance, the CORD list does not have specific functions for “public travel security” or “automated roadside safety inspection”. These services may not be seen as high priority in the European R&D Programmes.

The main conclusion of this comparison is the following:

The CORD list does not have services and the ISO list does not have functions. Therefore the two lists could be combined as a single set and used as follows:

- At the mission definition level, the ISO list of services could be used as a common terminology reference to name or classify the user needs identified by a project. This list has been already reviewed by a number of people and is therefore stable.
- For the architecture definition including the functional specifications of the system, nothing so far seems to compete against the CORD functions list. Each service should be described using the CORD functions and subfunctions allowing projects to use a common terminology and to have comparable functional architectures.

US SERVICES	CORRESPONDING ISO ITCS SERVICES	CORRESPONDING CORD FUNCTIONS	CORRESPONDING VERTIS SERVICES
En-route driver information	<ul style="list-style-type: none"> On-tip driver information Personal information services 	F6.1. Mixed mode information F6.3. Dynamic route information	<ul style="list-style-type: none"> Road/traffic information system Integrated traffic information system
Route guidance	Route guidance and navigation	F2.2. Supply control (passenger intermodal interchange) F4.2. Parking guidance F6.2. Navigation F9.9. Vehicle navigation	<ul style="list-style-type: none"> Navigation/dynamic route guidance system Dynamic parking guidance system
Traveller services information	Personal information services	F6.1. Mixed mode information F7.1. Travel planning F7.2. Static route information	Integrated traffic information system
Traffic control	<ul style="list-style-type: none"> Traffic control Safety enhancements for vulnerable road users (?) 	F3.1. Section traffic control F3.2. Intersection traffic control F3.3. Network traffic control F3.4. Localised area traffic control F4.1. Parking space management	Advanced traffic flow control system
Incident management	Incident management	F1.4. Rescue service and maintenance management	<ul style="list-style-type: none"> Incident/accident management system Disaster management system
Emissions testing and mitigation	included in Demand Management (air quality based zone pricing)	F2.1. Demand restraints	
Demand management and operations	Demand management	F2.1. Demand restraints F2.2. Supply control F4.3. Parking reservation and payment	Traffic demand management system
Pre-trip travel information	<ul style="list-style-type: none"> Pre-trip information Personal information services 	F7.1. Travel planning F7.2. Static route information	Integrated traffic information system
Ride matching and reservation	Shared transport management	F2.2. Supply control (SF2.2.1. Car Pooling)	
Public transportation management	Public transport management	F5.1. PT transportation planning F5.2. PT operations management F5.5. Maintenance	<ul style="list-style-type: none"> Public transportation vehicle operation management system New freight transportation system Vehicle operation management system (?)
En-route transit information	On-trip public transport information	F5.3. Passenger information	
Personalised public transit	Demand responsive public transport	F5.6. On-demand service provision	New freight transportation system
Public travel security	Public travel security	not included	
Electronic payment services	Electronic financial transactions	F1.5. Road fee collection management F4.3. Parking reservation and payment F5.4. Fare collection F9.8. Fee payment F10.7. Integrated payment management	Electronic toll collection system
Commercial vehicle electronic preclearance	Commercial vehicle pre-clearance	Not defined	
Automated roadside safety inspection	Automated roadside safety inspection	Not defined	

Table 3: Mapping of equivalent Services & Functions

US SERVICES	CORRESPONDING ISOTICS SERVICES	CORRESPONDING CORD FUNCTIONS	CORRESPONDING VERTIS SERVICES
On-board safety monitoring	Commercial vehicle on-board safety monitoring	F8.3. Vehicle/cargo management	
Commercial vehicle administrative processes	Commercial vehicle administrative processes	F8.2. Fleet/resource management (SF8.2.1. FM business transactions)	
Hazardous materials Incident response	Hazardous materials & incident notification	F1.4. Rescue service and maintenance management F8.4. Hazardous goods monitoring	Vehicle operation management system
Freight mobility,;	Commercial fleet management (includes logistics and freight management)	F8.1. Logistics and freight management F8.2. Fleet/resource management F8.3. Vehicle/cargo management	Vehicle operation management system
Emergency notification and personal security	Emergency notification and personal security	F1.4. Rescue service and maintenance management	
Emergency vehicle management	Emergency vehicle management	Not defined	
Longitudinal collision avoidance	Longitudinal collision avoidance	F9.6. Actuator control	Short range obstacle warning system
Lateral collision avoidance	Lateral collision avoidance	F9.6. Actuator control	Short range obstacle warning system
Intersection collision avoidance	Intelligent junctions	F9.5. Collision risk estimation	Short range obstacle warning system (?)
Vision enhancement for crash avoidance	Vision enhancement	F9.4. Vision enhancement	Driver's visual aid system
Safety readiness	Safety readiness	F9.1. Monitoring environment & road (part of) F9.2. Monitoring driver (part of) F9.3. Monitoring vehicle (part of)	<ul style="list-style-type: none"> • Vehicle/driver safety monitoring and warning system • Safety information warning and control system • Lane departure prevention/lane following system
Pre-crash restraint deployment	Pre-crash restraint deployment	F9.5. Collision risk estimation	Short range obstacle warning system
Automated highway system	Automatic vehicle operation	Not defined	<ul style="list-style-type: none"> • Safety information warning and control system • Lane departure prevention/lane following system • Automated vehicle system (on dedicated-road)
	Policing/enforcing traffic regulations	F3.5. Policing/enforcing	
	Infrastructure maintenance management	F1.4. Rescue service and maintenance management	
	Transportation planning support	F10.1. Strategy formation/implementation F10.2. Detection/measuring F10.3. Modelling F10.4. GIS management	

Table 3: Mapping of equivalent Services & Functions

Annexe I: Description of the ISO/TC204/WG1 services

1. Pre-trip Information

This service provides single mode, multimodal and inter-modal transportation information, provided at home, work, hotels and major public locations such as shopping centres.

Pre-trip Information includes shared transport such as public transport by road, rail, air and sea, mass transit, car pooling and other sharing and matching services.

Private car pre-trip information includes current information on network status, traffic conditions, prevailing traffic regulations and tolls.

2. On-trip Driver Information

This service is provided as:

1. distributed collective information,
2. tailored subscribed information.

On-trip Driver Information includes:

- *incidents*
- *park & ride options*
- *parking*
- *prevailing traffic conditions*
- *public transport schedules*
- *regulations*
- *roadworks, both planned and emergency*
- *tolls*
- *weather*

Service 2 and service 9 (On-trip Public Transport Information) are separable but complementary and can both be used in one trip.

3. Personal Information Services

This service provides information, either in a pre-trip, or on-trip context. This information is complementary to 1 (Pre-trip Information) and 2 (On-trip Driver Information), providing a 'yellow -pages' type function. Examples of the type-of; information provided are as follows:

- *car repair facilities*
- *filling station location and information*
- *hospital locations and information*
- *hotel locations and availability*
- *restaurant locations and information*

4. Route Guidance & Navigation

This service provides information on community and/or individual user optimum route options for specified destinations. Examples include the following applications:

- *autonomous navigation, based on historic data regarding road network and public transport information.*
- *dynamic route guidance, based on real-time network status and public transport information*
- *dual mode route guidance with the capability of either dynamic, or autonomous modes of operation*
- *multimodal trip making including interchange possibilities*

Best route options may be calculated taking account of network and public transport information and may incorporate multimodal options such as Park and Ride.

This service also includes the provision of route guidance to pedestrians, cyclists and motorcyclists.

5. Shared Transport Management

Shared Transport Management provides real-time ride matching or trip brokerage services to users at home, office or other locations.

6. Incident Management

This service provides the capability for detecting and responding to various incidents on the transport network. Examples of incident management functions include the following:

- *anticipation & prevention*
 - *detection*
 - *logging and recording*
 - *post incident management*
 - *response initiation*
 - *type identification*
-

7. Demand Management

The Demand Management service is the development and implementation of management and control strategies designed to influence the demand for travel.

These strategies influence the overall level of demand for travel at different times of the day and relative demand for different modes of transport, through the management of pricing structures, area access control or zone entry regulations. Demand management functions include:

- *access control*
- *air quality based zone pricing*
- *congestion pricing*
- *high occupancy vehicle facility management parking pricing*
- *public transport fares management*

8. Traffic Control

The Traffic Control service covers the management and control of traffic flows through the use of TICS technologies. It includes the following:

- *adaptive traffic signal control*
- *directional variable message signing*
- *implementation of predefined traffic management strategies integration of inter urban and urban control ramp metering*
- *route guidance integrated with traffic control speed control*
- *tidal flow*

9. On-trip Public Transport Information

On-trip Public Transport is provided to the traveller once the trip has started. Examples of 'on-trip' public transport information include:

- *information terminals at bus stops*
 - *information terminals at bus stations, rail stations, car parks*
 - *information terminals in major public places*
 - *information terminals at transfer points*
 - *in-vehicle information displays*
-

The type of information provided may include:

- *boarding point information*
- *fare information*
- *interchange possibilities*
- *route choice*
- *time of next service*
- *where to get off*

This service is complementary to service 2 (On-trip Driver Information).

10. Public Transport Management

This service covers the application of TICS technologies to the operation, planning and management of public transport operations. It includes the provision of real time information on vehicle location and status, enabling the identification of departures from schedules and dynamic rescheduling. This also includes the monitoring of public transport vehicle status such as passenger loadings, engine management system functions, tyre pressures etc. This service also includes the application of multimodal, or super-modal scheduling and planning systems.

11. Demand Responsive Public Transport

This service covers the provision of on-demand transport services to individual travellers.

This will provide demand responsive transport services to the user, while enabling transport operators to dispatch and schedule vehicles.

Typically travellers may request service by specifying destination and any special needs such as pram conveyancing, wheel chair lifts, or other special services for the disabled. Vehicles, covering a corridor, or area, are then despatched to the traveller by a dispatching system. The public transport fleet deployed on this service may include buses, vans and taxis.

This service addresses the needs of commuters, by providing a viable shared transport alternative to the single occupancy private car and also addresses the needs of specific groups such as elderly and disabled.

12. Public Travel Security

Public Travel Security includes the surveillance and monitoring systems for public transport facilities, car parks and on-board public transport vehicles. Systems may be automatic, sending a distress call when specified conditions are encountered, or manually initiated. This also covers the use of security systems designed to protect public transport vehicle operators.

13. Electronic Financial Transactions

TICS Electronic, Financial Transactions services is the use of electronic, or 'cashless' payment systems for transportation. Examples include the following:

- *common shied value ticketing*
- *congestion pricing*
- *parking fee collection*
- *public transport fare collection*
- *road pricing*
- *toll collection*

14. Commercial Vehicle Pre-clearance

Commercial Vehicle Pre-clearance allows commercial vehicles, including trucks and buses to have credentials and other documents, safety status and weights checked automatically at normal road speeds. A principal objective being to effect preclearances with minimal disruption to the vehicle journey and the traffic flow.

15. Automated Roadside Safety Inspection

Automated Roadside Safety Inspection is the use of TICS systems to enable roadside access to safety performance records of hauliers, vehicles and drivers. This will enhance existing systems of spot checks by providing inspectors with easy access to current data relevant to the inspection.

16. Commercial Vehicle Administrative Processes

This is complementary to TICS Fundamental Service 14 (Commercial Vehicle Preclearance). It enables hauliers and shippers to purchase annual and ad-hoc credentials, using communications and computer technologies.

17. Commercial Vehicle On-board Safety Monitoring

This service covers the use of on board monitoring systems to oversee the safety status of commercial vehicles, commercial vehicle drivers and cargo during the entire course of the trip. This may include sensing and collecting data on the following:

- *brakes*
- *driver alertness*
- *driving time*
- *lights*
- *shifted cargo*
- *tyres*

Warning may be provided to both the driver and/or remote monitoring facilities.

18. Commercial Fleet Management

At a multimodal level Commercial Fleet Management includes logistics and freight management systems. It also covers the use of Automatic Vehicle Location (AVL) and vehicle-to-control centre communications to provide vehicle location and other status information to the fleet operators despatched. This facilitates the use of dynamic despatching systems to improve the efficiency of the fleet management process.

19. Hazardous Materials & Incident Notification

Hazardous Materials & Incident Notification covers the use of TICS technologies to provide authorities with data on the nature, location and condition of hazardous goods cargoes. This facilitates the enforcement of routing instructions and the effective response to any incident involving the load. Data to be provided may include:

- *Routing Data:*
 - *route guidance*
 - *route enforcement*
- *Incident Data:*
 - *issuing post-incident instructions to driver*
 - *location of vehicle*
 - *nature of incident*
 - *nature of cargo*

20. Emergency vehicle Management

Emergency Vehicle Management includes the application of fleet management, route guidance and traffic signal priority techniques to the management of emergency vehicles such as fire, police and ambulance.

21. Emergency Notification and Personal Security

This service applies TICS technologies to provide both driver/personal security services and automatic incident notification for private car drivers and goods vehicle drivers. This may include:

- *automatic collision notification*
- *Automatic theft warning systems*
- *user initiated distress calls*

22. Longitudinal Collision Avoidance

Longitudinal Collision Avoidance includes the use of sensors and control systems to detect potential for collisions either prompting the driver to take action, or automatically instigate avoiding action. This includes the application of intelligent cruise control systems and obstacle detection systems.

23. Lateral Collision Avoidance

Lateral Collision Avoidance is the use of systems (such as sensors and control systems) to monitor the potential hazards involved in lane changing, entering and leaving high speed roads and overtaking. Can either prompt the driver to take action, or automatically instigate collision avoidance manoeuvres.

24. Intelligent Junctions

This service covers the application of TICS technologies to the provision of monitoring and warning systems at junctions, both signal controlled and priority. Warnings may include:

- *clarification of right of way rules*
- *onboard echo of warning signs*
- *presence of oncoming vehicles*
- *warning of imminent signalphase change*

25. Vision Enhancement

The Vision Enhancement service is the application of TICS technologies to the enhancement of driver perception through the use of in-vehicle equipment.

26. Safety Readiness

Safety Readiness is the use of monitoring and warning systems for both private car driver and vehicle. Examples include the following:

- *critical component monitoring*
- *driver alertness monitoring*
- *engine temperature*
- *oil pressure*
- *road condition monitoring*

27. Pre-crash restraint deployment

This service uses TICS technologies to determine the velocity, mass and direction of vehicle and objects involved in a potential collision and the number, location and major physical characteristics of occupants. The system uses this data to determine a response strategy which may include the following elements:

- *arming and deploying air bags*
- *deploying lateral protection systems*
- *deploying roll bars*
- *tightening seat belts*

28. Automated Vehicle Operation

This service is the application of TICS technologies to completely automate the driving process, creating a 'hands off driving environment. Examples include the following:

- *automatic lane keeping*
- *automatic parking operation*
- *vehicle platooning*
- *very low speed cruise control (inching)*

29. Policing/Enforcing Traffic Regulations

This covers the application of TICS technologies to the enforcement of traffic laws and regulations. Examples include the following:

- *access control*
 - *high occupancy vehicle facility usage*
 - *parking regulation enforcement*
 - *speed limit enforcement*
-

30. Infrastructure Maintenance Management

This User Service covers the application of TICS technologies to the management of road, communication and computer infrastructure. Included in this service are:

- *highway maintenance management*
- *nature and location from utilities and authorities to TICS control centres the provision of road works*
- *the use of probe car data to guide timing and location of planned road works and road closures.*

31. Transportation Planning Support

This User Service covers the use of TICS systems to provide data regarding traffic flows and travel demand for transportation planning purposes. Examples of such applications based upon TICS data include the following:

- *current traffic flow data from traffic control systems*
- *current utilisation levels from public transport information systems*
- *origin and destination data from route guidance systems*
- *route choice data from route guidance systems*
- *travel demand data from pre-trip information systems*

32. Safety Enhancements for Vulnerable Road Users

This User Service covers the application of TICS technologies to the enhancement of safety levels for vulnerable road user groups. These groups include:

- *motor cyclists*
- *pedal cyclists*
- *pedestrians*

Safety Enhancements measures may include measures such as:

- *smart pedestrian crossings*
- *speed warning systems*
- *vehicle presence detection*