ITS FOCUS REPORT ON SYSTEM ARCHITECTURE

Evaluation of the US National ITS Architecture
and
Recommendations for the U.K.

ITS Focus Task Force on System Architecture

May 1997

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TABLE OF CONTENTS

ITS FOCUS

TASK FORCE ON SYSTEM ARCHITECTURE

EXECUTIVE SUMMARY

This report reflects the findings of a task force set up by ITS Focus to study the US National ITS Architecture and consider whether the UK should develop or adopt such an architecture.

The task force was made up of representatives from local and national highway authorities, t&communications companies, ITS designers and system integrators, motor manufacturers, academics and transport consultants. The strengths of the representation and the time and effort contributed demonstrates the importance attached to this issue by both public and private sectors (see list of Task Force D Members - Page 3).

During the course of the review the team examined the approach and content of the US architecture and analysed its strengths and weaknesses with respect of the UK and European situation. The members considered the benefits of describing and adopting a formal architecture, the lessons that could be learnt from the US experience and proposed a strategy for taking forward an architecture within the UK and Europe.

The report concludes that if no action is taken many transport applications will be implemented as independent stand alone systems. Duplication, failures and incompatibilities may impose a burden on both the consumer and industry. Export opportunities will be lost to the US. An ITS architecture will emerge in due course but the cost of retrospective development of standards and interfaces will be high.

On the other hand the early adoption of a defined architecture will yield many benefits. An architecture will provide an environment in which industry understands the market place and can confidently invest time and effort to develop relevant technologies. It will guide and encourage Government departments, local authorities and road operators to specify standardised equipment. Standardised interfaces will encourage the development of new services and improve the efficiency of existing services.

The US has invested over $30 million in this process. The resulting architecture has many merits and its free publication and availability is an intelligent marketing move. The architecture has many merits but does not necessarily deal with the European and UK context because of the geographical and cultural differences between the US and Europe. The UK and Europe can learn much from the approach taken but there are omissions and important areas requiring further development.

The Task Force hopes that the Departments of Transport and Industry will work closely with ITS Focus to develop a top down vision for the UK and Europe. It

recommends that the Government commissions a project on system architecture development that will guide ITS deployment over the next ten years.

This project should take current UK proposals such as UTMC, RTCCs, NMCS2 and NADICS as a starting point. The approach would be to concentrate on existing systems, take into account the results emerging from the European Telematics Research programme and match these to the US architecture. The architecture should be informed by the use of an "enterprise model", which details the overall objectives in terms of the activities to be undertaken, the roles of the actors and the interactions required. It must identify important interfaces and standards and describe them sufficiently to ensure compatibility and interoperability but it must not be over-prescribed or it will inhibit innovation and therefore fail. A UK architecture must be capable of being put in place at an early stage.

The willing commitment of this task force indicates the strength of support amongst the leading stakeholders and that they recognise the potential for operational savings and increased export markets. They are likely to lend time and resource to such a project, but Government funding and support will be required to ensure that the work involved is well managed, properly documented and distributed. The Government may also be in a position to encourage the EU to divert some of its research and development resources to architecture development work.

The task force's main recommendation is that a consortium is formed to provide leadership and co-ordination of the architecture development activities. ITS Focus members will be pleased to participate and provide assistance as required.

CHAPTER 1

1. INTRODUCTION

1.1 Aims and objectives of this review

In June 1996 the US National ITS Architecture team delivered the final results of a three year study into the system architecture requirements for implementing Intelligent Transport Systems in America over the next 15 years. This was a major piece of work **involving** some $30 million of effort. Measured by **its** breadth and comprehensiveness the ITS Architecture study was breaking new ground. In the early stages the challenge of delivering Intelligent Transport Systems across the USA was compared with the project to put a man **on the** moon. In some respects the transport system being studied was even more complex, because of the many agencies involved in road transport, the numerous interactions that occur between them, plus the scope and variety of different user needs.

The study was based on an a specification of 29 planned ITS user service-s (some already in place) developed by the US DOT. The study team was given a remit to understand the potential co-dependencies, data-sharing and communications requirements that could make these ITS services happen, and conduct a comprehensive evaluation of costs and benefits, to pave the way for implementation. The project was carried out in close consultation with major sector actors, in particular through a series of regional consultation and outreach meetings that took place in 1995 and 1996.

The purpose of the ITS Focus review was to summarise key aspects of this major study to establish whether there are important lessons for the UK, concerning how ITS should be implemented, what the implications of the US work might be for world markets, and whether the UK might benefit from adopting some or all of the US architecture. Terms of reference for the Task Force are at Annex A. The review team was made up of ITS Focus members, chosen to represent a wide cross-section of those involved in implementing ITS and Road Transport TeIematics (RTT) systems in the UK.

This report has been prepared during a period when the government was consulting on the role of new telematic technologies for road transport and is submitted to the Department of Transport as part of that response. The conclusions and recommendations in Chapter 5 have therefore been framed with reference to the questions posed in paragraphs 103 and 130 of the DOT's December 1996 document.

1.2 Review procedure

The review team brought together a group of ITS practitioners with a breadth of practical "hands-on" experience of designing and implementing ITS systems for the UK transport scene. Members were drawn from local and national highways authorities, telecommunications companies, ITS system designers and integrators, the automobile industry, motoring organisations, an urban public transport authority, transport consultants and the transportation research community. Each brought their own expertise to the review, many having been participants in the European DRIVE and Advanced Transport Telematics research programmes. The review team benefited greatly from the information exchange which took place during the course of three one-day meetings held at approximately ***2*** month intervals between October 1996 and February 1997. A number of the review team also participated in the informal exchanges which took place with members of the US National Architecture Team at the TRL International Workshop on system architecture which took place in May 1996

Individuals (and their parent organisations) gave their time to the study on a voluntary basis. Inevitably, with the time and very limited resources available, the review team was not able to go into the subject in great depth. There have been no resources for supporting analysis and so the review team's findings are based largely on a reading of key documents (see Annex C) augmented by each individual's own experience of ITS. The results therefore represent the consensus view of this group concerning the US National ITS Architecture and its relevance to the UK. The Task Force felt it would have benefited from a stronger input in some areas, for example public transport operations, inter-modal transport, public transport operations and commercial vehicle fleet management and logistics. Nevertheless great progress was made in a short space of time, for no other reason than the group itself now has a far better idea of the scope and potential role of ITS system architecture and why it is an important subject. We hope this report conveys some of that acquired expertise. Our overall impression of the US National Architecture study was for the most part very positive.

1.3. What is System Architecture?

ITS Architecture is the framework within which the individual telematics services and functions - like traffic monitoring, incident detection and emergency support - can be developed. The system architecture shows how the basic building blocks fit together to produce a totality which is greater than the sum of the parts. Different architectures can be evaluated and compared to discover the most efficient distribution of functions and necessary interconnections, in much the some way as a complex building, like a theatre or modern office block , can be designed. Just as theatres and office blocks vary in their degree of sophistication (and hence their cost) so too can telematics systems.

In most., if not all examples of ITS certain common functions - more or less essential - can be recognised, such as the organisation of databases, the transmission of data to a control system, or the presentation of data to a user. For example in the case of the Integrated Road Traffic Environment (IRTE) - a development of today's motorway and urban traffic signal control - the system architecture will need to show, inter ***alia:***

a how urban and inter-urban control functions can be inter-linked (UK, VMS, ramp metering, incident detection and management); or

- **how** pre-trip and on-trip traffic and travel information services can be supplied with up to date information;

- how traffic control and demand management functions can be integrated with dynamic travel information services;

- how information from a variety of sources (e.g. streetworks registers, police control room reports) can be combined with other data sources (e.g. traffic detection loops) to deliver more effective control and management strategies.

Although the term system architecture has been used widely of late there is a great deal of confusion about what constitutes an architecture and how it differs from a system design. ITS in any form should be capable of analysis in system architecture terms. The essential point is that the architecture is constructed at a higher level than a design with the possibility that there might be a number of different conforming designs.

1.4 Why is system architecture so important?

The main strength of a system architecture analysis is that it provides the strategic framework through which the activities of various players can be integrated together. Recent research into the history and development of telecommunications suggests that for certain technologies - especially where there are network connections - a measure of central direction and a great deal of co-ordinated effort is needed to help the market choose sensible solutions. The highly successful development of the GSM digital cellular telephone network across Europe demonstrates the point. Planning began more than a decade ago between the national telecommunications operators even before privatisation. Once the GSM system architecture and standards were settled it was then possible to open up national markets to competitive GSM services through different independent service providers (ISPs).

System architecture can therefore provide a framework within which the key actors can operate: this includes the local roads and highway authorities but also the motor industry, ISPs, telecommunications providers, etc. It is a kind of road map, showing the interfaces and the information flows between enterprises. A well specified architecture will have a number of features.

It will:

- build on the legacy of existing traffic control, information services and fleet logistics support systems which are already operational;
- allow system evolution over time;
- support different user goals across many regions;
- be open to many entities contributing to its implementation and to development in parallel;

- accommodate new solutions (products / functions) and allow product and system innovation;
- be open to changes and evolution in user needs and technology;
- reduce the costs of individual components;
- lead to standardisation;
- accommodate many alternative system designs;
- have sufficient support within industry to gain consensus and be self-enforcing.

Considerations such as these have led many to the conclusion that key components for the common telematics infrastructure for ITS should be developed to a so-called “open” architecture (i.e. non-proprietary and non-exclusive), which can be designed in modular fashion. As long as the component modules do not have to be closely connected and can make use of standard communications links to exchange data and other information successfully, (like components in a hi fi system) then in principle, inter-operability will be achieved. The DOT proposals for new Urban Traffic Management and Control systems (UTMC) [3] follow this approach. The view of government as given in the December 1996 consultation document (paragraph 114) is that a planned system architecture is called for in three main areas:

- inter-urban tolling
- urban traffic management and control
- vehicle-based telematics.

There are strong counter-influences which may frustrate the achievement of an open, modular architecture. Among the obstacles which may get in the way of achieving some of the more far-reaching and ambitious targets for ITS are:

- non-compatible starring points (e.g. the legacy of different toll tag and electronic charging schemes already in place or being planned across Europe);
- disinterest in open systems and standardisation on the part of companies wanting to establish a market stronghold with their own “bespoke” products;
- the presence of proprietary ITS systems in the market that perform well but with architectures that are incompatible with a broader range of functions or which are not accepted widely within the industry;

budgetary constraints on the part of transport operators and highway agencies in upgrading non-standard existing systems which work effectively;

- institutional and organisational factors which militate against inter-operability and open information exchange (e.g. reluctance to give up operational autonomy or to accept solutions which are not home-grown).

This last point is developed by the CONVERGE project as part of the EU Transport Telematic Applications Programme 4. They draw attention to the importance of recognising potential conflicts between the goals of the different actors involved in operating ITS-based services. In the CONVERGE approach these goal conflicts and other control issues need to be identified and resolved at a strategic level in the architecture.

1.5 A note on the Enterprise Model

As they develop, Intelligent Transport Systems will deliver a wide range of services and support a diversity of activities in many different organisations. The technology, which is the combination of computers, information technology and telecommunications called telematics, is purely a means to an end. Therefore when looking at system architecture it is necessary to keep in mind exactly what functions the ITS system is required to perform and for whom. This helps to define the boundaries for the system and determine what performance is needed.

The interplay between computers, people and organisations has been studied by the Advanced Networked Systems Architecture team (ANSA) in the UK who observe that that the needs of large organisations for computing and IT systems are extremely diverse. Moreover those needs evolve over time as the activities of the organisation change. The diversity of activities is significant because each will have its own operational needs which will place certain performance requirements on the telematics support. Thus traffic police and broadcasters of travel information services, for example, both need to know urgently about serious traffic incidents, but their operational procedures may dictate different requirements for incident reporting, incident details and other data all of which will influence the system design. It is important to be able to capture these differences and build them into the architecture, because these user requirements will be fundamental to the design and specification of the ITS systems.

The ANSA team recommend that the requirements of users for system characteristics and performance should be analysed by means of an “Enterprise Model” which details the overall objectives of a system in terms of

- the activities that take place
- the roles that people are required to play
- the interactions that take place, between the organisation, the system and the environment in which the system and organisation are placed.

In the context of this report concerning the work of the US National ITS Architecture team, the Enterprise Model translates into a Theory of ITS Operations which informs all subsequent stages of the architecture analysis. The Theory of Operations is therefore fundamental to the architecture and is a foundation for the detailed systems analysis work. In the case of the ITS Architecture it was developed iteratively through consultation meetings with representatives of the users of the ITS systems which were being studied by **the** US DOT. **It should therefore be noted at the outset that, at the very least, the US Theory of ITS operations needs careful review for its suitability as an Enterprise Model for the UK's road transport scene. Much of the comment in Chapter 3 is therefore about identifying operational requirements that are significantly different between the two countries. Local (UK) transport network management standards and operating requirements will be a major factor.**

CHAPTER 2

2. THE US NATIONAL ITS ARCHITECTURE

2.1. Background

The US National ITS Architecture study follows the adoption by the US Congress of the Intermodal Surface Transportation Efficiency Act in 1991 which had as its goal:

> "to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner."

Congress requested the US DOT to prepare a strategic plan and US DOT in turn asked IVHS America (now ITS America) to prepare its own strategic plan taking inputs from Federal, State and local government agencies, industry, academic, trade associations, consumer and public-interest groups. The IVHS America Strategic Plan was published in 1992 and covered a time-span of 20 years[5]. One of the many recommendations to the US DOT was to try to ensure effective integration of the key IVHS products and services as they become available. To this end M-IS America proposed that the US DOT should develop a national system architecture with open interfaces.

The US DOT responded positively to this recommendation [6 7] and drew up the specification for the National ITS architecture study. This project began in September 1993 and was completed in the summer of 1996 at a total cost of some $30 million, all federally funded.

The main development work was done following an initial play-off between four consortia, two of which were retained after 1994 for phase II of the project. During phase II there was extensive consultation with a wide range of road transport sector actors as an input to the study, in addition to the direct inputs from the two very broadly based consortia. They included a number of State DOTs as well as academics, defence systems analysts, transit system operators, etc. Project management on behalf of the US DOT over the three years 1993-96 was provided by the US Jet Propulsion Laboratory.

2.2 Architecture summary

The formal documentation for the US National Architecture [8] extends over some 5,500 pages and can be accessed on the Internet . Two volumes, the Executive Summary and Theory of Operations, provide the easiest gateway for the new reader and were included in our review.

The very extensive documentation describes the logical architecture, the physical architecture and the theory of operations, backed up by a comprehensive implementation plan. Logical architecture shows all the inter-dependencies between the ITS market packages, the data dictionary and the data transfer requirements. Physical architecture considers the communication links and networks and any special performance requirements needed from these links (e.g. speed and data transfer rate of vehicle to roadside communication for tolling transactions). The physical architecture also needs to reflect the assumptions which are written into the theory of operations. Figures 1 and 2 provide very simplified high-level summaries of the communications requirements and logical architecture.

The analysis of 29 user service requirements specified by the Federal Highway Administration 9 yielded a total of 19 major sub-systems and 53 market packages. The US architecture study therefore shows the potential for inter-operability and system integration on a scale which has not been attempted before. Tables 2 and 3 show the breadth of coverage envisaged. The process specifications and interconnect diagrams that underpin the architecture provide an analysis in systems terms of what is needed to accomplish this specification. Some 353 different process specifications have been developed with over 258 1 entries for the dictionary of data items. They offer a precise, formal summary of the US DOT's requirements but not a definitive design. Performance requirements are specified but not how the design should meet those requirements; nor is the architecture constrained by existing organisational structures or technology. However the groupings of sub-systems offered make sense intuitively and provide the starting point for further systems design and development work.

2.3 How will it be used?

The analysis of how Intelligent Transport Systems might develop in the USA by the year 2012 is substantial but there are many factors which could frustrate the ambition to achieve integrated systems. In the real world, agency autonomy and independence of control for the operating units may prove to be stronger influences than the economies and efficiencies to be gained from sharing data information, equipment and communications, Agencies may well have widely different perspectives on the importance, value and desirability of inter-connectivity. Nevertheless, ITS architecture will have an influence on deployment strategies, as Figure 3 shows.

The US DOT's response to these pressures has been to launch a demonstration programme to win support for the concept of Intelligent Transport Systems. There is political interest in rapid investment into nine core ITS technologies for up to 75 metropolitan areas in the USA (see Table 4). This package is described as the Intelligent Transportation Infrastructure (ITI) which is seen as the major plank in the US DOT policy initiative called "Operation Timesaver". The target is to complete deployment of the ITI within a decade **and to this** end a model deployment programme in four cities was announced on 24 October 1996 , These four were successful out of 23 applications submitted and evaluated against a number of criteria, including consistency with the National ITS system architecture. New national goals to accelerate the deployment of ITS and RTT services related to Commercial Vehicle Operations and in-vehicle products in the consumer and commercial market place are also in the pipeline.

The ITI showcase projects will follow the example of the successful Atlanta Olympics showcase for Advanced Traveller Information Systems. As Table 4 shows, they are intended to be examples of public-private partnership, with the public sector responsible for establishing the telematics infrastructure whilst the private sector develops products and services that can utilise the data. The four showcases will be used to carry out a thorough assessment of RTT costs and benefits and will be vehicles for public relations and outreach activities concerning ITS.

A significant part of the architecture is concerned with establishing performance and benefits, but it is claimed - with some justification - that the main strength of the ITS architecture is to provide a framework that supports the development of open standards. Evidence of this can be seen in the energetic way the US DOT is now supporting a large ITS standards progmmme. There is an unprecedented five year programme of funding from the US DOT aimed at securing a comprehensive set of public domain standards for ITS. The results of the ITS Architecture study have enabled the US DOT to support five leading US standardisation bodies with $16m, targeted with an eye to strategic priorities. The immediate objective is to settle public procurement standards in support of IT1 deployment be followed by the remaining priority standards identified by the architecture team. In addition the US DOT is considering:

- promoting pre-standards for ITS systems as they become available
- maintaining and updating the architecture models as real-life deployment evolves,

CHAPTER 3

3. EVALUATION OF THE US NATIONAL ITS ARCHITECTURE

3.1. General observations

The US National ITS Architecture documentation provides an excellent source of reference on ITS systems. It provides a strong vision of how Intelligent Transport Systems might be deployed in the USA over the **next** 15 years. It also forms the basis of a very imaginative piece of marketing by the US DOT to distribute the information freely on the WWW. Those with a need to implement ITS anywhere in the world can have full and free access to the results and can adopt some or all of the US National architecture for their purposes. In this way the US can also establish a world-wide basis for future marketing of ITS products and services by US companies in years to come. This strategy is also supported by up to 80% funding of selected demonstration schemes.

The authors of the US National Architecture are to be congratulated on the impressive amount of work undertaken to define the interfaces between different ITS applications, establish the requirements for data flows and to specify priority standard interfaces wherever appropriate. The main strengths of the work are that it is comprehensive, coherent, internally consistent, well-documented and sensible. It would be very surprising if the ITS Focus Task Force had not found something there of relevance to the future development of intelligent transport systems in the UK because of the breadth of the study - particularly the ambitious range of ITS services it covers.

The US initiative is deliberately wide-ranging and intended to evaluate and define the technical basis for an integrated approach to road transport investment in the USA. However its all-embracing comprehensiveness is also a source of weakness. Despite the impressive volume of text it does not seem to say anything very specific, particularly about some of the thornier issues. For example section 5.5.5 of the Theory of Operations is typical: “In the near-term a mixture of public, private and public-private partnership operated ISP’s (Independent Service Providers) are expected to serve this [the traveller information] market”. Much of the commentary is of this form, leaving all of the policy options open. We judge that in the effort to be non-prescriptive the architecture has, with some important exceptions (see section 3.4 below) become almost totally permissive and all-encompassing. It provides a framework into which one can map almost any ITS deployment option: nothing is forbidden. The architecture of itself therefore cannot prevent the proliferation of different systems by the market. To achieve that objective it must be supported by follow-up actions, as explained in Chapter 2. The US DOT strategy is to promote the architecture so that it will be adopted as the basis for product and service development, used by industry and the standardisation bodies to direct standardisation efforts and referred to by the public authorities as the basis for service development and ITS procurement.

Some features of the architecture are very far-sighted. For example it decouples the main ITS applications from the choice of communications networks, since different ITS applications will choose between different communications media based on price and performance considerations. The architecture therefore takes advantage of existing and planned communications systems. In general it does not recommend DSRC (Dedicated Short Range Communications) and other dedicated ITS communications infrastructure without ruling these out for specific applications. It also places great emphasis on the concept of the Independent Service Provider (ISP) as the starting-point for many ITS services. As we note above, the ISP can grow out of a public, private or partnership-based enterprise.
The following paragraphs list various key features of the US approach and some of the main contrasts with the UK scene.

The USA Context

Most parts of the USA have a high investment in expressways and freeways - more so than in the UK. Arterial roads tend to be wide and the urban road networks are often lower density and grid-based with fewer radials. Public transport does not play such a prominent part of the urban transport scene, although van-pooling (car-pooling) is encouraged through high occupancy vehicle lanes on the freeways. There is not the same competition for road space between moving and stationary traffic as occurs in traditional town centres and shopping high-streets of the UK. Off-street parking in garages and parking lots is more plentiful and out-of-town shopping malls are commonplace, often with access directly from and to the local expressways. The long distances between cities and the heavy Federal investment in freeways makes it possible to contemplate investing in automatic highway systems. Inter-modal connections mainly occur at the airports although some cities have purpose-built park and ride schemes based on rapid transit or express bus.

Although this transportation context is very different from the UK the US Architecture study provides a vision for the future of road transport systems with some valuable insights.

- There is very strong support from the US DOT Federal Highway Administration (FHWA) for all stakeholders to adopt systems which conform to the National ITS architecture. The US DOT are investing heavily into standards development to provide framework for investment - initially by the public sector - into ITS systems..

- US policy is not to promote a dedicated ITS infrastructure, including Dedicated Short-Range Communications (DSRC) and Variable Message Signs (VMS) outside the main metropolitan areas. The use of wireless communications is proposed for inter-urban and rural deployment for almost all applications and services for geographical reasons.

- Because of potential litigation there is a very strong bias towards making advisory systems which do not take away the responsibility for controlling the vehicle from the driver, for example speed control or dynamic route choice.

- Notwithstanding the planning behind the recommended architecture, the US approach is fundamentally market driven and allows a range of market packages to develop, for example a basic public driver information service will be provided through RDS, VMS and Highway Advisory Radio (Low-power local broadcasting along freeways) with the market for commercial products and services providing more sophisticated options.

- The level of commitment by the US DOT and industry to support standards work is moving the standard setting machinery forward across the whole of the ITS areas as distinct from more specific targets in Europe.

Features of the US National ITS Architecture approach.

- The ITS Architecture has been specifically designed to be independent of any underlying organisational structure. This means that the functionality is divided up so that it can be arranged into physical sub-systems to suit almost any jurisdictional arrangements.
- The market package approach examines each service in context with other ITS services, and identifies common features, shared functions and other synergies
- The study takes a clean sheet to ITS and make-s little reference to results of US research or of adopting experience gained in other countries - including results from Europe.
- The architecture rests heavily on an assumption of data driven control. Data arriving from one application feeds into another process. This means tracability of data connections through the architecture and the attention to the integrity of data is high on the agenda and is reflected in the architecture.
- Electronic services for freight management have been ‘given a very high priority because of regulatory controls on commercial vehicles at State borders.
- The in-car systems will support MAYDAY call-out facilities because roadside telephones are not commonplace.
- Most of the urban and inter-urban motorway corridor applications are influenced by and interconnected with ITS systems for the urban networks.

What has the US National ITS Architecture Study achieved?

A strong message has been given by the US DOT to all the actors and major stakeholders that investment in ITS starts now, and that there is a consistent market place into which industry can place products.

- A long term vision has been produced based on the need to implement ITS based on the user needs.
- Extensive risk analysis procedures have been developed.
- All systems, sub-systems and interfaces for all the interacting ITS services have been identified and a basic specification developed for implementation purposes.
- There is a solid basis for determining national and international ITS standardisation priorities.

Notable features of the US National ITS Architecture:

- The architecture covers a full range of ITS user services - not all relating to transport policy issues, for example Yellow Pages information services.
- The physical architecture reflects the US requirements for minimum dedicated ITS infrastructure (like pavement loops and overhead sensors) and anticipates a

considerable increase in the use of on-vehicle sensors and other technology in the vehicle.

- The use of floating vehicle "traffic probe" data has been written into the architecture at a fundamental level, e.g. for the collection of weather-related road condition data, journey times and speeds, etc. However the concept does not appear to have been fully proven, even in US demonstration projects.
- The notion of an Independent Service Provider (ISP) appears in nearly every section of the traveller and traffic management market package and is central to the flow of information for traveller services and control. The architecture allows for open access to all types of information whether from the roadside **or the** control centre.
- The policy of using of ISP influences greatly the structure of the architecture and will inform any future International Standards Organisation (ISO) standards based on the American architecture.
- Pollution monitoring has been given a higher profile in the US documents than in any UK or EU work so far.
- One of the key points about the architecture for freeway management is a requirement when an incident occurs for a predictive incident mitigation strategy to be automatically implemented.

3.2. Contribution to ITS Standards

One of the principal reasons why the US DOT sponsored the architecture study was to help identify standards requirements It is already being used to prepare US national standards but with an expectation that these may also become international standards. The architecture supports the selection of standardisation priorities and expedites standards by providing a framework for setting a policy on standards and technical direction to the standardisation bodies. Architecture and standards priorities are therefore developed at every level.

The Standards Requirements Document (SRD) collects information from other parts of the architecture and presents it in a way to support the development of standards. The SRD describes the process of determining what standards are required. This is a very logical and comprehensive exercise looking at all services and interfaces. It considers types of standards, purpose of standards, nature of the technology, existing standards. It also explains how the architecture fits with the ISO-OSI model in the communications reference model It concludes by identifying the following 11 priority areas for standards.

1. Dedicated Short Range Communications
2. Digital Map data Exchange & Location Referencing
3. Information Service Providers (ISP) Wireless Interfaces
4. Inter-centre Data Exchange for Commercial Vehicle Operators

5. Personal, Transit and HAZMAT Maydays
6. Traffic Management Subsystem (TMS) to other Centres
7. Traffic Management Subsystem to Roadside Devices and Emissions monitoring
8. Signal Priority for Transit and Emergency Vehicles
9. Emergency Management Sub-systems (EMS) to Other Centres
10. Information Service Provider Subsystem to other Centres (Not EMS & TMS)
11. Transit Management Subsystem to Transit Vehicles and Transit Stops.

There is a standards requirement package which describes each one in detail. These all follow a similar format and identify:

Message Transactions

Interface Definition (Logical and physical architecture data flows, type

of communications)

Data dictionary elements.

The documents are specified to a level appropriate for a first committee draft for the standard. This is highly significant as it is often easier to generate the resources to develop a standard from an existing specification, rather than starting de novo. These are very detailed documents and will be very useful to the US national standardisation bodies at the appropriate stages. **The National ITS architecture therefore provides a good basis for ITS standardisation work. It is comprehensive and logical, and in principle it could be used as a starting point for much domestic and European standards work. However it would need to be tailored to match UK requirements.** The UK could not use the US Architecture simply to identify what standards are required and then ignore it when preparing the standard. To influence the outcome of standardisation requires participation and that means frnding ways of increasing the effectiveness of the UK's input. As a first stage it is sensible to concentrate on what standards are proposed by the US and determine their priority for the UK.

UK approach to ITS standards

Standardisation is a resource hungry and lengthy activity but the consequence of failing to participate effectively in international standards work will be a loss of influence over the development of the IS0 standards which are needed in key areas. Meanwhile, US and Far-Eastern manufacturers and suppliers will be/are doing so, and those standards will eventually have to be accepted in UK and Europe, to the probable disadvantage of the UK automotive and traffic control industries.

The ITS research and demonstration programme of the US DOT is no better aligned with the ISO TC204 programme than the EU and UK research is with CEN TC278, with the possible exception of work on architecture itself. It is, of course, easier to produce national standards to the level envisaged than international standards. The study proposals clearly form the basis for US national standards and it is obvious that the funding is targeted towards standards for the US even though standards have much less force in the US than they do in Europe, where they **support** open competition in public procurement. Indeed there may well be UK equivalents of the US standards requirements already in use for equipment procurement. In America it is left more to industry to determine whether or not to adopt a standard.

BSI is responsible for British Standards, but BSI does not have a separate national standards programme for ITS, rather it is tied to the CEN and ISO programmes. Any national UK interest therefore has to be exerted through the international standards bodies CEN and ISO. CEN TC278 began work in 1991 and after an initial study divided their work into applications (e.g. fee collection, traveller information) and technology (e.g. DSRC, databases) and established 13 Working Croups. Subsequently TC 278 has identified the following priority areas

Toll and Fee collection.

Dedicated Short Range Communications.

Digital Mapping and Location Referencing.

Travel and Traffic Information.

Automatic Vehicle Identification.

CEN also considers the Human Machine Interface (HMI) to be a priority area but as the work is being conducted in the IS0 vehicle technical committee (TC22) it is not always quoted These priorities were established before ISO/TC 204 was formed and CEN is still leading here, with the expectation that the CEN standard would be adopted by ISO.

Although the precise breakdown of the standards activity is different, the CEN priority areas roughly cover 1,2 & 3 of the US priorities listed above. There has been some consideration of European standards in the areas 4, 6, 7 & 11 but for various reasons it is not well established nor has significant progress been made. Very little attention has been paid to standards covering areas 5, 8, 9 & 10.

It would not be practical to fully resource all areas so the UK must target those of greatest interest while being aware of developments in those remaining. The UK is already participating through CEN in the negotiations to agree tolling, short range communications, driver information and HMI priority standards areas. Issues of national interest which are not being covered adequately are best identified by those closely involved in the applications. Traffic control systems is a case in point: this is a new area that is becoming increasingly active where the UK does have a very significant interest. Action is needed to determine the UK strategic needs and how these are best progressed.

The issues for UK can therefore be summarised by way of a series of questions:

- **Is the US approach to standardisation acceptable ? This will vary from one ITS application area to another.**
- **Does the US architecture correctly identify interfaces for standardisation?**
- **Does the US approach conflict in any way with the approach being taken on ITS standards in CEN and ETSI?**
- **Are the priorities correct ?**
- **What UK national interests are not adequately covered? and**
- **How can UK promote and protect these national interests with limited resources?**

Much of the detail will be for the individual application areas and ITS services (see chapter 4).
The UK has only very limited options available because of both the resource needed to propose anything radically different and the expectation that all new standards will be European. For many ITS applications either the US approach - or more practically the CEN approach with minor amendments and modifications to overcome the obvious omissions - is probably acceptable at this stage. Doing nothing is not a sensible option.

Standards in ITS are too important to be left to private-sector volunteers to develop. The chances of attracting the right people for this task grow more remote as financial pressures increase on the margins at which the private sector must operate. Resources for international standardisation work should be targeted according to an assessment of the UK's priorities. To be effective in influencing the outcome of standards it is essential to ensure continuity of input through regular attendance at the meetings of CEN and ISO.

Recommendations on Standards

1. **Government should make available some form of financial assistance on a selected basis to support attendance at the CEN and ISO committees. This is essential if there is to be any participation in standardisation work from local authorities and SMEs who may be the major users of standards.**

2. **Government and industry should also ensure that UK interests are strongly represented in the relevant standards processes by targeting support for individuals to participate in standardisation work.**

3.3. Communications Architecture

The largest element of the US communications architecture relates to the use of wireless communications whether for tolling, connection to the roadside equipment, roadside to vehicle or for the vast area of information service. Only passing comments are given to most significant mobile future communications systems for the UK, namely GSM, GPRS and DAB. Moreover there is no highlighting of explicit hybrid solutions such as RDS plus radio paging. The UK starting position is also quite different from the US in a number of other respects:

- US mobile communications are much more fragmented than UK or EU. Some US mobile systems are more advanced (e.g. LEO satellites); others are somewhat dated (e.g. CDPD).
- Public Service and Commercial Broadcast data options are significantly different between US and Europe.
- European licensing agreements prevent mobile communications network deployment to US specifications. The UK will therefore follow European mobile standards.
- Fixed communications (PSTN, PSDN and ISDN) are mainstream to ITS and are applicable in UK

Events in the communications world are moving quickly and already the communications options are overtaking the US Architecture's approach. For example, Internet/Intranet solutions which could be used as alternatives to traditional Telecommunications protocols are understated. Thus US technology is driving a revolution in information access and exchange - but it is missing from the ITS Architecture. Developments still in the pipe-line in the field of distributed computing may revolutionise the way ITS will happen. Examples include Network Computing, JAVA and object oriented methodologies (e.g. Common Object Request Broker Architecture or CORBA). In seeking a way forward perhaps the UK should study the output of the UK's Alvey ANSA (Advanced Network Systems Architecture) programme. Here, architecture is treated as a set of projections - starting with an Enterprise projection as outlined in Section 1.5 of this report.

Communications Architecture for the UK

When considering the mobile communications context for ITS it is clear that the UK will have a more integrated set of bearers than the US by virtue of European agreements. The digital cellular telephone network, GSM, gives UK and Europe significant advantages, followed by other pan-European mobile communications systems including GPRS (General Packet Radio Service based on GSM), DAB (Digital Audio Broadcasting), HIPERLAN (High Performance Radio Local Area Network) and TETRA (trans-European Trunked Radio, a new standard for digital private mobile radio, as opposed to GSM). However, the UK is closer to the US market-driven approach to telecommunications services than is the rest of the EU. The US Architecture for fixed-link communications does not present a problem in general.

Novel use of Internet communications protocols & software may also offer low cost answers to many ITS applications (e.g. travel information, virtual tickets, freight and fleet management) making a top-down US-style architecture less essential.

Perhaps the most promising scenario for a European variant of an agreed architecture would be the integration of DAB and GSM. When DAB is deployed in 2-3 years' time the UK will then have a ubiquitous wide band mobile downlink to deliver multimedia with a GSM uplink to handle service requests (by interactive voice response preferably), billing, user profiles, vehicle status etc.

The key communications architecture issues for ITS system developers in the UK can be therefore be summarised as follows:

- **Fixed Communications used by ITS must conform to ubiquitous global standards.**
- **Developments in Network Computing (JAVA) and Intranets will be very significant for data and information exchange in the future.**
- **GSM (digital cellular telephony) is moving towards increased data rates and is falling in price. In the medium term a GSM-based positioning system is likely to emerge.**
- **There should be a recognition that message sets and exchange standards are the keystone to ITS developments**

Recommendations on Communications Architecture

1. **The UK should make the most of the European ETSI standards GSM, DECT, TETRA, ERMES, HIPERLAN and DAB and the Broadcast standards RDS and DAB. A complete Integrated Intermodal Transport Environment can be supported by these standards, which could outperform at lower cost the US architecture proposals.**
2. **Those involved in architecture development work in the UK should take note of the** output **of the Alvey ANSA (Advanced Network Systems Architecture) programme which is based on an Enterprise projection.**
3. **ITS systems developers in the UK should take note of and, where appropriate, adopt European recommendations on ITS data dictionaries (DATEX, DATEX-NET) as a basis for information exchange.**
4. **Authorities and commercial sponsors who are involved in information distribution and exchange using the emerging technologies (e.g. WWW, DAB) should collaborate to achieve a common architecture and information exchange protocols.**
5. **The parties involved in formal and informal standards development activities should ensure their interests in communications architecture and application-to-application data exchange are adequately covered. They include:**

   Government Departments and Agencies: DOT Highways Agency /Scottish Office /Welsh Office /Northern Ireland DOE

Public Transport Operators - bus, rail, coach, air, ferry

Electronic publishers

Motoring organisations

Equipment suppliers and telecommunications companies.

3.4 Dedicated Short-Range Communications (DSRC)

A very limited view of the potential role of DSRC has been taken in the US National Architecture Study, mainly because of cost implications and the human geography of the US. The US authors therefore have a very different perspective to current UK thinking. Many in-vehicle applications would be suited to DSRC in the UK and it is important that applications are not ruled out because they do not appear in the US National Architecture. In this respect the US is over prescriptive and appears only to really consider present applications which can use DSRC. However, DSRC to the emerging CEN standard will be far more versatile than earlier DSRC systems. Trials have shown that it can be the carrier for various ITS applications such as electronic fee collection transactions, information services, parking, entertainment and hotel bookings. It is not evident that the data structure within the US Architecture allows the transfer of unspecified information in these multiple DSRC applications that have been developed in Europe.

Section 3.1 above portrayed the US Architecture as a general framework that incorporates all options, but DSRC is an important exception. Specific choices have been made to restrict the role of DSRC For example it is implied that Information Service Providers (ISPs) will generally supply information to vehicle sub-systems via wireless wide area communication. However in many instances there will be a requirement for highly localised driver information (e g petrol prices) which is more suited to DSRC communication. Furthermore the National Architecture does not support certain driver applications using DSRC.

- ***Electronic Fee Collection***

  Recent tolling trials in Europe support the view embodied in the US architecture that electronic fee collection can be undertaken efficiently using DSRC. To that extent US and UK thinking is in agreement. However the US Architecture does not appear to allow for the rich variety of payment options likely to appear throughout Europe. In addition, there are distinct and incompatible US and European DSRC standards being developed with different frequencies and protocols.

- ***Medium Range Pre-Information (MRPI)***

  The US National Architecture has a weakness in terms of MRPI. We gained the impression that some DSRC beacons would remain un-networked in the US ‘Dumb’ approach which is not appropriate for the UK as we envisage speed limits dependent on traffic flow, weather conditions etc.

Medium Range Pre-Information has the **scope to** improve driver safety and reduce travel times. It is recommended that European standardisation work continues to be conducted in this area of CEN TC278 Working Croup 4.2. A non-exclusive list of possible MRPI applications which would be suitable for standards development is as follows:

road and traffic conditions related to the immediate route of the vehicle;

fleet management;

services based on dynamic announcement; and

inter-connection with other models of transportation.

- ***Route guidance***

In the National Architecture, route guidance using DSRC is specifically not supported. While it would be unfeasible to transfer all route guidance information to a vehicle, it is possible that dynamic information (from DSRC beacons) could be transmitted to vehicles in order to supplement static route information stored in vehicle (e.g. CD-ROM maps). It is anticipated that dynamic route guidance information will occur in this way in the shorter to medium term. However, in the long term centrally determined route guidance may become prevalent.

UK position on DSRC

The Task Force is of the opinion that the detail offered by the National Architecture definitions is too tine and that the lower level DSRC communications protocols should be developed by European/International standards workgroups, and not specified as part of the architecture. The US specification for DSRC is too restrictive for use in the UK and Europe. For example Electronic Fee Collection is based on credit card transactions and omits a range of pre-payment options. The logical approach is for the UK to adopt CEN standards as they are developed, providing that they address sufficiently the UK situation.

Vehicle manufacturers, fleet operators, motorists and many others would all benefit from a decision to support a common, versatile DSRC link to serve all of these functions, especially if it became universally adopted. The development of DSRC Communications for ITS will require a lead application such as motorway tolling to justify the investment. However an agreed DSRC architecture supported **by** common standards might be developed to support payment for parking charges, bridge and tunnel tolls and even paying for petrol at supermarkets, as well as being a carrier for navigation directions etc. However none of this will happen until standards for the DSRC beacon and communications protocols are in place. At present there are no firm guidelines on which to base investment decisions.

This leads us to the following conclusions:

- **The CEN approach appears to be the most sensible route towards roadside-vehicle Electronic Fee Collection harmonisation in Europe. With the** CEN

proposed pre-standard, on-board units are able to transmit eight different vehide attributes to the tolling infrastructure and there is in-built flexibility which allows the transmission of an unspecified attribute.

- **Tolling standards need to be settled for the UK and for Europe, and a decision taken on which standards will be adopted.**
- **There is potential for a much wider role for DSRC than is supported by the US but this will depend on more versatile communications protocols and flexible data structures than is supported by the US Architecture.**
- **A dedicated ITS infrastructure is likely to become attractive only if a national tolling infrastructure based on DSRC is installed, thereby bringing down production costs for the roadside equipment. .**
- **Some form of partnership is the obvious way forward. Even so, the economic case and commercial viability needs to be studied and compared with other communications media. It is clear that without a decision to support a national ITS infrastructure UK firms will be unlikely to invest money developing (DSRC) applications.**
- **New applications for DSRC are still under development; for example DOT have recently awarded a contract to study external vehicle speed control which can also make use of data transmitted from roadside beacons.**

The UK is committed to contributing to the ongoing work within CEN to develop the required data structures for richer information exchange. The “CEN approach” aims to facilitate pan-European DSRC applications (including tolling) and is our preferred option. Even in the US, there is debate about whether to adopt the CEN approach. If DSRC to this specification is adopted this would become a significant feature of the ITS architecture in the UK. However, the discussion on communications architecture shows that the communications options are still developing and there must inevitably be some caution and careful evaluation before embarking on a major investment in a common ITS infrastructure.

Recommendations on ITS Common Infrastructure

1. **It is in the UK’s interest to ensure that the CEN approach to tolling standardisation is adopted in preference to more limited applications of DSRC.**
2. **Projects, such as Road Traffic Advisor, are investigating both the technology and the “enterprise model” to determine the role of the public sector, SMEs and larger companies. Similarly, field trials of GSM-based information dissemination need to be monitored and cost-benefit studies undertaken.**
3. **A consortium, perhaps building on the Road Traffic Advisor project, should investigate the feasibility of developing a dedicated infrastructure for ITS application using a DSRC link to CEN TC278 open standards. Such a study needs to have both DOT and DTI as customers, because it straddles the interests of the transport and telecommunications industries as well as finance and**

banking sectors. The scope for commercial applications of DSRC links needs to be evaluated, as well as public sector applications.

4. **In the meantime, information provision by DSRC should not be prevented by adopting overly-restrictive architectures or standards. Activity within CEN and ISO is therefore required by UK equipment suppliers to influence the outcome of the DSRC standardisation process.**

3.5 System Safety Issues

Implementing any ITS systems must take account of the requirement that the system shall incorporate safety features to protect individuals, property and the surrounding infrastructure. Critical operations, operator interfaces and safe service operation have all been identified by the US Architecture Study as requiring special attention. Nevertheless the one set of real safety-related and safety-critical services, namely the Advanced Vehicle Safety Systems, are not yet fully developed.

The higher level issues of a System Architecture are primarily concerned with command and control within a system and deal with issues such as conflict resolution, as well as graceful degradation in the presence of equipment failure or maintenance. The US National ITS Architecture appears to rely heavily on the concept of data driven control This means that functions monitor their data inputs and take the appropriate defined action when any data arrives. In some cases they may take action if data does not arrive after a set period. The advantage of this approach is that it removes the need for a set of control diagrams, although it does require a more thorough definition of functionality. However data driven control is prone to deadlocks and, so far as we are know, there has been no study done on the ITS Architecture to see if there are any potential problems of this nature.

Specific UK Considerations

The subject of safety-critical and safety-related computer-based systems has been particularly active in the UK during the last 10 years, encouraged by the passing of the Consumer Protection Act 1988. Although strictly this Act only applies to direct injury caused by a product, there is a growing consensus that indirect command and advice systems, like many in ITS, cannot be ignored. The ill-fated London Ambulance system is often cited as being one to which certain basic parts of the safety life-cycle should have been applied. Another example is microprocessor traffic signal control, where the reliability of the software is safety-critical.

The Health and Safety Executive (HSE) have taken the lead in producing guidelines for British Industry and are chairing the international group creating IEC 1508 “Functional System Safety of Safety-related Systems”. Although orientated to production engineering, this draft standard will be offered as a basic safety publication for all industry sectors. The UK Motor Industry Software Reliability Association (MISRA) have produced “Development guidelines for Vehicle-based Software” which follow the philosophy of draft IEC 1508.

Basically it says that a preliminary hazard analysis should be performed on all systems as early as possible in their development cycle. If any hazards are identified then the remainder of the system life-cycle should contain preventive measures which depend upon the severity of the risk.

Whilst there will undoubtedly be some products developed with the US Architecture in mind which are suitable for the European market, they should be introduced with care, especially if they are concerned with any form of control. Even Market Packages created specifically for Europe should have a safety impact analysis done on them in order to confirm the absence of any inherent system-related safety hazards. We note that The Risk Analysis document for the US study contains an interesting statement on the Advanced Vehicle Safety System: "New safety standards needed by the architecture may not be attainable or may result in unacceptable technical performance".
An ITS Architecture for the UK therefore needs to adopt a systematic approach to safety hazard analysis as described in Draft IEC 1508, the MISRA Guidelines, and in the Task Forces supported by the European Commission (SATIN, PASSPORT, CONVERGE-SA etc.)

Recommendations on System Safety

1. **In order to comply with current UK safety regulations a systematic approach must be taken with respect to functional system safety.**
2. **All UK System Architecture work should be subjected to a Preliminary Safety Analysis in order to identify both the obvious and the less obvious safety hazards. Any development of the US Architecture for UK conditions should be subject, at least, to an safety impact analysis.**
3. **If the data driven approach is adopted for UK applications then any system architecture should be checked for potential deadlocks and livelocks.**

3.6 US National ITS Architecture: Conclusions and Recommendations

The US National ITS Architecture is a top-level framework which will require much more work before complete implementation is feasible, although some parts will go ahead rapidly with the support of the US DOT. In its vision it describes a very broad range of Intelligent Transport Systems some of which are also being developed in Europe through EU-funded research, as well as some long-term concepts which are not being actively considered in Europe at present. On the other hand there are European and UK requirements which are not covered, and these will be detailed in Chapter 4 of this report. The current US DOT programme to sponsor ITS standards notwithstanding, it is intended that much of the future development work should be left to market forces. It is also intended by the US DOT that the Architecture will be updated to reflect future developments, so that it is a "living" document, rather than something that becomes obsolete with age.

The National ITS Architecture is specifically designed for the USA. The underlying political agenda is one of creating a market for ITS products, as well as attempting to **create** a series of functions that encourage the modifications of peoples' approach to transport. Benefits, such as reduced pollution and greater transportation efficiency, will be obtained by improving the way in which current activities are carried out, e.g. traffic control, as well as by introducing novel facilities for the management of peoples' travel.

The top-down approach adopted in the US National Architecture is quite unlike that which has been taken so far in Europe, with quite different aims and objectives. The result certainly identifies the main standards that will be needed to enable certain products to be developed and brought into the market place. However there is much in the American approach which is not relevant to European priorities and needs, for example commercial vehicle inter-State permits and other administrative requirements.

Our overall conclusion is that the overall structure of the US Architecture is broadly acceptable and in the main does not conflict with UK requirements but the detail does not meet UK needs in a number of important respects. The main points have been indicated here and will be developed in greater detail in the next chapter.

To avoid any misunderstanding we must stress that our conclusion in no way negates the value of taking a system architecture approach; nor are we saying the American work should be passed over completely in favour of "home grown" options. The US analysis holds much that is of value. For example the implementation strategy, the benefits and costs analysis and the standards development plan will all repay in-depth study. **Nevertheless, our review suggests that the UK must to develop its own approach to ITS architecture. A comprehensive ITS architecture and strategy project could be funded for the equivalent cost of one major highway or rail scheme.**

The USA is treating Intelligent Transport Systems architecture as a national issue. The reason is that ITS is an important means of supporting major transport policy innovations through technologies such as electronic tolling, congestion charging, environmental pollution monitoring, public transport information systems and multi-modal freight logistics support. ITS will have "efficiency" implications for all transport users and for all personal, commercial or business-related travel. The key players in ITS, like the national and local authorities and operators of the transport infrastructure (motorways, ports, airports, as well as urban road networks, bus stations, etc), together with the transport operators themselves, all need a coherent framework to work with and guide their investments in ITS. An overall architecture will provide direction for investment. But it will also help to remove inefficiencies and prevent system discontinuities, both of which will lead to higher ITS implementation costs, judged on a whole life basis.

- **We therefore recommend that the Department of Transport, in consultation with the Department of Trade and Industry, Welsh Office, Scottish Office and Northern Ireland Office, develop proposals for ITS system architecture development work for the UK, building on what has already been achieved**

through the US National Architecture, and drawing on the results of EU studies and the main UK ITS projects up to now.

In our view, a common view of the European-level requirements for ITS system architecture is also required, especially with respect to the communications architecture and any priorities that architecture analysis reveals for standardisation work. Moreover, certain ITS applications will be marketed world-wide and the UK's ITS industry will need to be competitive globally.

- **We recommend that where international standards can support global markets for ITS products and services the UK should, on a selective basis, actively promote its own proposals for open architecture standards through the international standardisation bodies.**
- **We also recommend that ITS Focus develops its contacts with similar national European ITS co-ordination bodies like ITS Netherlands, and with ERTICO in order to promote a UK viewpoint on European ITS architecture requirements.**

We give further consideration to these issues in Chapter 5 where we discuss the questions posed in the December 1995 government consultation document on telematics for road transport.

CHAPTER 4

4. ITS ARCHITECTURE REQUIREMENTS FOR THE U.K.

In this chapter we consider the major headings for ITS applications included in the government consultation document of December 1996 and offer a commentary on the main system architecture issues with references to the US Architecture. In each case we offer our recommendations to ITS Focus and government on a possible way forward and which might form the basis for any follow-on study.

4.1 Inter-urban Applications

Inter-urban ITS applications are one area where the DOT is sympathetic to the idea of a planned architecture. There is a long history of departmental (Highways Agency, WO, SO, NI DOE) specifications for engineering works on trunk roads and motorways, making use of European standards when they are available. The National Motorway Communications System (NMCS2) is well developed and follows Open System principles. The specifications are freely available. In future the private sector will be increasingly involved in the operation of motorways and trunk roads, including the RTCCs. The government's objective for this domain has been to secure improved tactical and strategic traffic management on motorways and trunk roads through the Highways Agency Regional Traffic Control Centre initiative. In Scotland this is the responsibility of the National Network Control Centre. Wales has similar proposals.

The means to achieve this include:

- improving response to incidents and congestion through Incident Detection, Speed Control and Ramp Metering Systems
- providing information to broadcasters and information service providers for the benefit of drivers before and during their journeys. The RDS-TMC service is seen as one important way of achieving this.
- collecting and co-ordinating real-time traffic information on traffic conditions to manage traffic strategically using Variable Message Signs and through assessment of network control strategies
- developing traffic management tools for the longer term: access control, High Occupancy Vehicle Lane management, etc.

Recommendations on Inter-Urban Traffic Management and Control:

1. **Inter-Urban Traffic Management and Control operations will embrace a growing number of agencies and players. This makes an overall system architecture framework all the more necessary, in order that the key inter-**

connections between agencies (e.g. between DBFO or RTCC concession-holders and an group of ISPs) can be adequately specified, contractually if necessary.

2. **A common UK architecture for Inter-Urban Traffic Management and control should build on the strengths of US Architecture but at the same time accommodate the recommendations of European work such as the TELTEN2 study. It must also be consistent with architecture proposals for urban traffic management and control (UTIMC), motorway tolling, and traveller information services. The architecture should specify the key areas that will allow compatibility between different applications but will also enable different centres to superimpose additional requirements if required.**

3. **The organisational model for the inter-urban ITS applications should be supported by an analysis to determine the key data exchange interfaces, for example between RTCCs, and commercial Information Service Providers, cable TV and Internet-based travel information services.**

4. **Once the basic architecture is agreed by the main interested parties (HA, WO, SO, NI DOE, RTCC and DBFO concession-holders, and representatives of Independent Information Service providers) the industry should be involved in agreeing the data transfer mechanisms and data dictionaries as required, extending their scope to ensure all areas of interest to the UK are addressed.**

5. **Those involved in the control of inter-urban trunk roads and motorways should study the way in which any enhancements of the communications infrastructure (e.g. for motorway communications) could migrate naturally using advanced communication technologies, as they become available.**

6. **The UK traffic control industry would benefit if the UK communications architecture and message protocols for traffic control were harmonised with US proposals, including the National Transportation Communications/ITS Protocol (NTCIP). However, the proposals are not "state of the art" in IT terms and therefore the UK (industry and government), should negotiate to improve these.**

Motorway tolling

A principal concern of government has been to develop the means of free-flow tolling for network-wide installation on some 3,000 miles of road, for use by some 20 million vehicles. This represents an ambitious specification and the official UK trials at the TRL will address some of the technical and operational issues. It also represents a major potential development affecting millions of vehicle owners and the manufacturers of motor vehicles. The latter are seeking clarity over the mobile communications links including RDS-TMC, DSRC, GPDS, etc. that will be adopted, the in-vehicle data and communications architecture (not only for ITS applications), the design of the Human-Machine Interface and the nature of any communications transponders that need to be built into the vehicle.

At this stage the UK is not committed on the choice of technology for tolling applications. The indications are that microwave systems using the 5.8 Ghz waveband allocated for

Dedicated Short Range Communications Systems hold the greatest promise, but systems using Global Positioning Satellite (GPS) technology are also being developed. However questions concerning the accuracy and reliability of equipment and the ease of enforcement, protection of privacy and the availability of equipment remain to be solved. The December 1996 government consultation document states that vehicles should be equipped with a single unit which is inter-operable for urban and inter-urban systems.

Recommendations on Motorway Tolling

1. **Government needs to establish a UK policy and priority programme for implementation of electronic tolling and fee collection facilities followed by development of effective standards which will assist the UK/European automotive industry.**
2. **Government and the motor industry needs to ensure that DSRC and Automatic Fee Collection links to the vehicle are versatile and cost-effective, both in terms of the road infrastructure, the number of applications which can be supported and the suitability of in-vehicle equipment.**

4.2 Urban Applications

The Department of Transport is promoting the concept of an open modular architecture for UTMC as the framework for developing a new generation of cost-effective traffic management systems to make better use of the road network. Government has also been concerned that UK industry should have the opportunity to export to the world market and has carried out a consultation exercise with industry to determine the way forward. A L5 million development programme is now under way. Details have been widely disseminated and a summary is at Annex C. The draft specification provides a basic framework for the UTMC infrastructure and a common data dictionary. The full list of functions that TJTMC will support is shown in Table 4. It can be seen that many of these functions also appear in the list of US market packages for ITS shown in Table 2. . DOT has said that the UTMC specification will, so far as possible, be compatible with the relevant European and international standards and this position is welcomed by the Task Force.

Recommend&ions on Urban Traffic Management and Control:

1. **There is a need for the new UTMC architecture to gain acceptance internationally and for UTMC implementation to adopt appropriate standards such as those coming from CEN TC278 and IS0 TC 204**
2. **The UTMC specification is already quite comprehensive. We recommend that it is audited in the iight of the US National ITS Architecture and the recommendations in this review, to develop it as the basis for the urban ITS architecture for the UK**

4.3 Monitoring and Enforcement Applications

These were not studied by the Task Force.

4.4 Public Transport Travel Applications

The US Architecture considers bundles of user services, of which the following are relevant from a public transport point of view.

Travel & Transportation Management	**Public Transport Operations**
- Traveller services information	- Public Transport management
- Pre-tip travel information	- En-route Transit information
- Ride-Matching and reservation	- Personalised Public Transit
- Public Travel Security	- Electronic Payment services

The coverage of urban transit requirements is somewhat thin and lacking in detail. This is surprising because there has been a renaissance in investment in public transport in many US cities and some significant ITS projects. Possibilities for inter-modal connections and combined road/rail transport are also largely ignored. Nor does the US Architecture study, examine or address the complex issues in ticketing that are typically found in the UK. In particular, the potential for multiple ticket types, multi-modal ticketing and discounting etc. is not examined in sufficient detail If the US Architecture was adopted here the UK's public transport operators would find themselves unable to employ the range of ticketing options to which our passengers are accustomed because of constraints imposed by an inappropriate systems architecture. There also appear to be some misconceptions as to how new forms of ticketing technology might be implemented. Furthermore, there appear to be disparities as to what is encapsulated by the architecture and what is not. For example, whilst 'ticket payment' from a tag (for tag read smartcard) is included the addition of a 'ticket' to a tag is not.

Our assessment is that the UK and Europe is more advanced than the US when addressing public transport issues. However, the US documentation is comprehensive and a similar approach, addressing all the items listed in the service bundles would be a **useful exercise to establish the long term deployment of ITS for public transport in the UK. These would cover current knowledge and experience relating to bus priority systems, public access terminals etc. in the public transport area and how this may be linked with other ITS applications, particularly information services through a network of Information Service Providers.**

Government policy for use of telematics for public transport has emphasised the provision of reliable, comprehensive and up-to-date information about public transport services on a multi-modal basis at the initiative of the operators, local authorities and through commercially provided information systems. The possibility of obtaining real-time information about services has been demonstrated through the COUNTDOWN and Bus Tracker systems, but it is not yet clear how these will be funded and maintained in the deregulated environment. New real-time information systems, such as the portable electronic travel guide are seen as one way to promote public transport as a seamless journey, to encourage use as a substitute for using the car. Smartcard ticketing is another key area of interest for government and operators, both for the convenience of users and also because they can bring greater flexibility to fare structure and revenue allocation schemes. Government has been less interested in questions of telematics to support the operational logistics of public transport, believing that is more matter for the operators. Certainly an ITS architecture must offer the opportunity for deregulated operators to maximise the benefits of any investment in nationwide systems.

The main issue concerning public transport in the U.K. remains how to attract the public onto the service and this is heavily influenced by the frequency cost and efficiency of the services available for travel door-to-door. Interoperability of all modes of public transport services is one of the key issues which any system architecture for public transport study must address. Operators in different parts of the country will gain if ITS systems for their vehicle fleets can be made inter-operable, for operational economy. The level of success will be dependent on a number of developments in the following areas.

Travel and Transportation Management

- traveller service information
- pre-trip travel information
- ride matching and reservation

Public Transport Operations

- public timetable accuracy
- public transport operations management
- en-route information

Ride-matching and reservation,

- Demand Responsive Transport Systems (DRTS) need to be tested to a larger scale in a wider range of environments.
- The effectiveness of the core DRTS reservation and allocation software needs to be established as this is critical to the quality of service offered and the costs incurred.

Public Travel Security

There is little evidence to indicate that there has been any effort to standardise security facilities on public transport, or that there is a proven need to do so. However, the level of security provided is a factor in retaining public transport patronage and tends to reflect the need for some features due to local problems. A common system architecture may lead to more cost-effective solutions. For example:

- Providing basic standard security facilities on all transport systems, easily recognised by all the travellers, might be seen as an obligation on operators.
- These systems should be seen primarily as deterrents against vandalism and personal attacks, but with standard facilities that can be used by the travelling public - anywhere in Europe - to seek assistance, catering also for the needs of the handicapped and elderly.

Public transport ticketing

In the UK with deregulation and multi-modal journeys, reconciliation of fare-box revenue will always be required. However, there are two aspects to reconciliation; that of inter-company monetary transfers (i.e. settlement) and that of revenue apportionment. The regulatory structure of UK public transport will demand apportionment systems. None of the above is addressed in the US ITS requirements.

In the UK a combination of legacy methods and smartcards will be used for ticketing and both may be personalised to the individual traveller or non-personalised. Smartcards will also potentially have encoded a range of ticket types (i.e. season ticket, carnets and stored value tickets). The ticketing structure will also be complex with such facilities as multi-modal discounts and group ticket discounts.

There will be a need to define a Stored Value Ticket as opposed to a Stored Value Card. The use of stored value “money” to pay for travel, with the possibility that insufficient credit on the card will cause a negative balance, is likely to cause nervousness within the UK Financial Community. Although credit, debit or charge cards may potentially be used for travel purchase they are more likely to be used only for the charging of ‘stored ticket value’ on to a stored value card.

An analysis of the current ticketing systems, and anticipated future ticketing programmes is essential to inform any UK version of an ITS system architecture. Ticketing practices and requirements of UK and European transport operators (particularly those in UK) are more flexible and varied than (it appears) are those of their US counterparts. A journey can comprise a number of intermodal trips and is associated with a passenger or group of passengers There are particular requirements for fare revenue reconciliation and apportionment between several operators (as, for example, is necessary with the buses in London) the UK, in the light of our mainly deregulated public transport. The trend in Europe towards multi-modal journeys also needs to be addressed

Other Issues

- Institutional barriers between authorities and operators need to be addressed, especially where public transport has been deregulated.

- Application of Public Transport Passenger Information Systems require the availability of communications systems that are appropriate for the size of database and speed of interrogation.
- Databases must be of high quality in terms of coverage and accuracy and information and must be frequently updated.
- Improved HMI and the use of multimedia will bring system improvements, for example to instruct the public on use of public transport terminal facilities.
- Large scale, long term trials are needed to prove system performance. and reliability.

Recommendations on Public Transport Applications

1. **The leading public transport operators (bus, rail, ferries and domestic air), with support from the PTEs and government, need to set the framework for a system architecture to be developed for telematic applications in support of public transport operations in the UK. The work being undertaken by CEN TC 278 WG 3 provides a starting point for public transport vehicle scheduling and control systems.**
2. **The institutional and operational aspects of multi-operator and multi-modal environments need to be examined as part of this approach. The study should also identify key areas for integration or formation of partnerships to improve the exchange of information and strengthen the future role of public transport.**
3. **The system architecture needs to address all the issues listed above. Attention should be placed on defining functional and technical applications and installing/optimising software and on potential problems with user acceptance including HMI.**
4. **Major operators need to liaise with organisations dealing with electronic payment and standardisation issues on the following.**
    - **Develop a model to evaluate the relevance of the interfaces and data flows to the UK transport environment. This should represent the wide range of current and foreseen future ticketing variations, test to confirm its compatibility with UK practice or to highlight inconsistencies.**
    - **Public Transport ticketing and electronic toll administration should be treated as separate items in any UK ITS architecture.**
    - **Since passenger *type* is significant in ticketing in UK (eg. group fares; senior citizens/young persons tickets) the architecture should recognise this.**
5. **So as far as traveller information and electronic payment is concerned the system should be compatible with the emerging European systems.**

6. **A business case is needed both for the implementation of Demand Responsive Transport Systems and for the broader use of transport telematics in support of DRTS operations.**

7. **On the travel impacts side, all interested parties need to be made aware of the potential for ITS to influence mode shift. Integration with other modes, and increase in personal mobility needs to be established.**

4.5 Traveller Information, Navigation and Guidance

The government consultation document refers to driver information, navigation and guidance services. The Task Force has taken a somewhat wider remit of traveller information services of a multi-modal nature as well as in-vehicle systems, in order to discuss the system architecture issues. This follows the practice in the US Architecture where driver information services are bundled together as part of the Advanced Traveller Information Services market package in the Implementation Strategies document.

Reference has already been made in Chapter 2 to the Atlanta ATIS (Advanced Traveller Information Systems) showcase which was a large-scale demonstration of the concepts, with a number of products relevant to the UK scene. However, the perspective on market development implicit within the US architecture is that the commercial possibilities for traveller information is still immature. Thus, for example, the user service bundles are defined in terms of what the network operator wants from information, namely travel demand management. However, the information service market could change very rapidly over the next few years and the architecture documents will need to be actively maintained if they are not quickly to appear dated.

All traveller information services have to solve the problems of making efficient use of communications. Moreover all information systems need a coherent system of location referencing in order to position information geographically. A large effort in DRIVE I and II went into solving the problems of data exchange in support of information services. European projects also looked at the need for standardisation in the presentation of information from a user's perspective.

In the UK, government policy on traveller information, navigation and guidance has been to encourage developments on two fronts. The first is through information to encourage highway authorities to make cost-effective provision for driver information (VMS, radio broadcasts, etc.); the second is to encourage the private sector to provide commercial telematics-based services for users who are willing to pay.
The technical and institutional issues surrounding the development of these Advanced Traveller Information Services (ATIS) include:

Quality of information and data.

- the difficulties of collating diverse multiple sources of information pointing to the need for common data dictionary, interface standards, geographic location referencing standards;
- the variable accuracy, consistency and coverage of current data sources;
- the need for reliable data sources governed by service level agreements between one agency and another (particularly if the information service is being charged for).

Traveller service *information.*

- the need to provide the traveller **with** continuity of service relating to the ***journey*** undertaken even when using different transport modes, possibly through different countries.
- the need to deliver current information to terminals - over fixed link or through mobile communications - and to support multi-media formats.
- the need to provide information in a form which can be displayed in a variety of ways, using a range of platforms: permanent, transportable, mobile and vehicle mounted.
- the need to make available a broad base of yellow pages services to allow for hotel bookings etc.

Pre- trip travel information.

- the need to make available to the public accurate and up to date information that can be readily accessed from the home or office using PCs or mobile communications, such as:

  the availability of Park & Ride schemes;

  parking information - location and space availability;

  public transport route information - number of service and location of stops (buses, trains).

Recommendations on Traveller Information, Navigation and Guidance

1. **Government should take a view of the organisational basis which can support the travel information market in the UK as well as the essential public information free services covering all modes of transport (like RDS-TMC and VMS).**
2. **Government and industry should support EU efforts to develop common standards for the data dictionary, geographic referencing and interfaces to facilitate the development of an information market.**
3. **All concerned with traveller information systems should be encouraged by government to develop basic standard information facilities for all transport systems that are easily recognised by all travellers.**

4. 6 Freight and Fleet Management Applications

The US Architecture focuses mainly on the needs of the administrations and is concerned with automating the USA's principal regulatory functions for inter-state and international trucking. Combined transport operations and multi-modal freight transhipment that are developing in Europe appear to be completely missing. The use of ITS to support the logistics of road/ rail (e.g. Channel tunnel) road / maritime (Southampton, Tilbury, etc.) and other major freight distribution centres like major airports (Heathrow, Manchester, etc.) also seem to be overlooked. European work, particularly by the Dutch, is probably following more advanced concepts. In any event, the freight haulage, commercial delivery and service vehicle operations are characterised by a large number of small and medium sized enterprises as well as the big vehicle fleets. Their needs are more likely to be served by low-cost (possibly Internet-based) systems. The key question for operators is how will ITS benefit their businesses in terms of operational and regulation costs? Will ITS lead to an extension of regulation rather than an increase in operational efficiency?

The commercial vehicle operators involved in freight and fleet management in the UK are private companies whose focus must be efficiency for themselves and their customers. An architecture must support this objective for it to be credible with the users. Many are small businesses that will used shared services rather than develop bespoke systems of their own. Freight and fleet management applications of telematics will therefore share technology with other applications and will only need a limited amount of technology development in their own right. The areas that most need attention are the institutional, commercial and regulatory issues associated with creating viable, working systems.

Much of the US Architecture concerns regulatory functions and paperless administration. In the US environment more efficient and effective application of regulation can provide for operational efficiency for both enforcer and operator. For the UK the same conditions do not prevail and an architecture focused on regulatory objectives is not seen as a **priority.** However if one is developed it would need to be concerned with the interface between a number of actors, e.g. police, Local Authority, Vehicle Inspectorate, as well as the haulers. Any regulation and enforcement functions that are supported, particularly at ports and border crossing, needs a coherent approach with an associated architecture.

Other ITS systems which are used to enhance operators' efficiency can be designed such that they can operate in parallel to, but independent of, any regulatory systems being used. There are policy reasons to encourage the development of such systems for long-distance inter-modal freight operations and the development of these systems is being supported by the EU.

Recommendations on Freight and Fleet Management Applications

1. **The freight and commercial vehicle industry needs to agree the non-technical aspects of the architecture with the regulatory authorities at a European level.**
2. **System and service suppliers should be encouraged to develop cost-effective solutions which will serve the needs of commercial vehicle operators, although a competition to develop a de facto technical standard within the framework of the architecture might be just as valid a route.**

4.7 Vehicle-based Applications

The level of detail provided in the US architecture stops short of addressing the type of features that may be used to prevent primary or secondary road accidents. All the market packages relating to safety are concerned with advanced vehicle safety systems.These are as follows :-

On board safety monitoring (vehicle check)

Emergency vehicle management (Priority control)

Longitudinal collision avoidance

Lateral collision avoidance

Intersection collision avoidance

Vision enhancement for crash avoidance

Pre-crash restraint deployment.

The above services are not fully addressed by the architecture and many are still being explored. There has also been no attempt to define the architecture within the vehicle on the grounds that this is the responsibility of the vehicle manufacture.

Based on the available information we judge that the UK and many European states have more advanced state of the art in roadside safety and warning systems and the advancing technologies will refine the level of safety further As these develop there will need to be a dialogue between the authorities and the vehicle manufacturers to agree the communications architecture and any in-vehicle equipment. The UK PROMOTE Association and TRL are co-ordinating the Road Traffic Advisor project which will address some of these issues. Furthermore, the work undertaken in the European DRIVE, PROMETHEUS and ATT programmes has produced a number of safety related recommendations. If the advanced vehicle safety systems are to be progressed as detailed above then it would be appropriate to rely on this work to determine which of the results obtained would be appropriate to use in Europe.

Recommendations on Vehicle-based Applications.

1. **The UK and European motor industry should collaborate to develop an international standardisation process covering the following topics:**

- **In-vehicle Human Machine Interface - to develop a common philosophy of design giving instinctive/ intuitive use of the equipment, the same in all vehicles.**
- **An open system architecture for vehicle -to-roadside communications covering the major communications bearers, message formats and protocols;**
- **A standard location referencing system at lowest level;**

- **A seamless implementation of key ITS systems across international borders - both systems for private cars (like RDS-TMC) and for commercial vehicle operations.**

2. **The government and the motor industry should keep a watching brief on topics which may become relevant in Europe at a later date - ag.. Automotive highways, indirect and co-operative sensing.**

4.8 Applications for the vulnerable road user

These were not **studied by the** Task Force.

4.9 Summary of the recommended UK approach

Inter-urban Applications

The Highways Agency, Welsh Office and Scottish Office need to proceed on the basis of common functional specifications for inter-urban traffic control systems. Integration of English, Welsh and Scottish inter-urban systems to a common architecture will be beneficial in both operational and technical terms, although given the existing investment in motorway and trunk road traffic control infrastructure the choice of upgrade path will need careful evaluation. Motorway tolling could be the lead application for developing a dedicated ITS architecture based on DSRC. If so, DSRC would become a major feature in the UK's ITS architecture, capable of delivering a wide range of services. The question of whether or not there should be an investment in a dedicate infrastructure for ITS needs further in-depth study.

Urban Applications

Greater integration between urban and inter-urban applications as the Scottish Office is now trialing in the TABASCO project is highly desirable. UTMC architecture specifications, together with those for the RTCCs can become the foundation for ITS in the UK. Potential providers of independent ITS-based services will find any major incompatibility in the architecture and data interfaces for local authority traffic control centres and RTCCs a costly overhead. A detailed, costed review of the issues is needed.

Public Transport Travel Applications

There is considerable scope for deploying ITS systems in support of public transport operations and adopting the architecture approach could bring big dividends to large operators, although bus deregulation could take away some of the advantages. Nevertheless the lead for system architecture work in this area should come from the leading operators with support from the PTEs and government. The system architecture for electronic ticketing should receive priority attention.

Traveller Informalion, Navigation and Guidance

The organisational basis for these services requires attention first and system architecture requirements will follow. The American model of the Independent Service Provider tits this group of applications well and is already present in the UK in embryo form with SCOTIA. European research is delivering Publicly Available Specifications and standards for data dictionaries, geographic referencing and data interfaces. Adopting these international specifications will help the development of the information market. Use of the Internet and Internet protocols offers another way forward.

Freight and Fleet Management Applications

This is an area which can largely be left to the market to develop. The exception is load tracking and tracing through modal interchanges and for inter-modal freight operations, where the development of common European systems is being sponsored by the EU and which government may wish to support for policy reasons.

Vehicle-based Applications

Many of the applications in this area will be developed on a pan-European or global basis. The main stakeholders - mainly the motor industry, but also the public authorities responsible for road safety - will need to keep track of developments world wide. Government may need to ensure that industry does full validation work to prove the applications are suitable for UK and European road conditions.

Electronic tolling, fee collection and ticketing

These payment technologies will underpin many ITS applications that have been described and they need to be developed at a national level, in preference to local isolated systems. The technology is still undergoing development, but many of the pieces are beginning to fall into place. The enterprise model (section 1.5) can be used to analyse the architecture requirements, recognising that electronic payment methods, particularly the use of stored credit smart cards, will generate a revenue stream which can be finely tuned to the payment circumstances. This will be beneficial in developing commercial ITS applications as well as efficient pricing policies for transport facilities and ITS services.

CHAPTER 5

5. TASK FORCE CONCLUSIONS AND RECOMMENDATIONS

Our overall conclusion, stated in Chapter 3, is that the basic structure of the US Architecture is broadly acceptable. Chaper 4 elaborates on the changes and developments required.

5.1 Response to the Government Consultation Document

The government consultation document of December 1996 "A Policy ***for using new Telematic Technologies for Road Transport"*** poses a number of questions about ITS System Architecture. Based on this review of the US Architecture our response is as follows.

What do we expect an architecture to achieve for UK ?

A national system architecture for ITS would act as a broad framework for ITS developments in the UK and guide local policy-making, procurement and other deployment. The strategic view, as we can see from the American work, is needed to identify essential interactions between the agencies involved in ITS, to guide system design for specific deployment projects and to communicate to all parties unambiguously how they will need to interact with one another. In particular the Task Force believes the architecture analysis should be used to inform the priority-setting for European standardisation work, as has happened for ITS standards in the USA.

To date in the UK, individual ITS systems have (with a few notable exceptions like NADICS in Scotland) been deployed as stand-alone systems where the compatibility of their respective system architectures and any mutual interoperability considerations are ignored. It is not until organisations like Hampshire County Council and their ROMANSE partners come to integrate several different ITS systems that architectural compatibility becomes important and advantages of being able to exploit all necessary features of each system (and the associated cost of doing so) become apparent.

We therefore look to a UK system architecture to offer a deployment path for ITS system development and integration, especially where multiple agencies and actors are involved. The architecture will show how each party relates to the total picture. It will show where standard interfaces are important and where effort can be directed to maximise the potential of the new technology. It will help to create the climate of confidence necessary to stimulate investment. Various high-level benefits can be expected to flow from this approach:

- greater business confidence to invest
- better integration of transport telematics services
- earlier productivity and efficiency gains from implementing ITS

- solutions meeting the demands of the wider community
- more choice and expansion for the user
- more input from small and medium-sized companies
- multiple use of products, data and delivery systems.
- fewer technology dead-ends.

Is a separate UK ITS architecture viable? How do we judge ?

An **ITS** systems architecture for the UK is inevitable. It will happen de ***facto*** as the result of incremental deployment of ITS products and services. The question is how far should the system architecture be arranged with foresight to take account of UK **transport** policy objectives and other requirements or whether these matters should be left to Europe, USA and “the market”? The issue of how autonomous a UK architecture should be needs to be judged not only for its relevance to transport policy, but also to the UK’s industry policy. In our view the consequence of not taking a view on the basics for a planned architecture for the UK will be a greater need in future years to adapt ITS systems that have been developed abroad, especially Japan USA **and** Korea.

The US Architecture specification is comprehensive and will serve very well as a starting-point, but seen from a UK national perspective the US study has a number of weaknesses. Some market packages, for example DSRC and tolling, are over-prescriptive and therefore exclude possibilities that are actively being considered here. In other cases, like public transit management, the treatment seems over-simplistic for the UK’s more complex deregulated environment. Finally, some of the US market packages, like those for commercial vehicle State border clearance, are not relevant to UK conditions.

Our conclusion is that the UK must develop its own approach to ITS architecture. This will mean taking current UK proposals for UTMC and other Traffic Control Centre (TCC) **operations including further enhancements to NMCS2, electronic tolling and traveller information services, etc, and modifying them in the light of the US architecture study findings. At the same time it will be appropriate to adopt some European concepts, particularly on communications and standards requirements. Moreover we think the UK needs to proceed quickly, involving the main stakeholders in order that they can have influence and full ownership.**

- **The Task Force recommends that the UK architecture should address the requirements of those ITS systems likely to be deployed together in the UK as an inter-operating group.**

If it is viable, is it necessary - or merely desirable ?

Almost any system is capable of being integrated to any other, to a greater or lesser extent. However, if systems have not been designed with the need for subsequent interoperability in mind, the cost of achieving this, the limitations resulting from inability to access information due to architectural incompatibilities **and** the risks of achieving interoperability will be considerable. Experience in the defence procurement environment suggests that it is not unusual for the cost increase to be around an order of magnitude greater.

For example, during the procurement of the UK’s current air defence command, control and communications system (IUKADGE), we understand it proved impossible to specify the message and data formats for the input of early warning information from warships at sea. The lowest cost, acceptable solution was to procure additional computer/communications facilities as translation processors, at a cost estimated at L7M. In this case, both message standards and individual system architectures were misaligned.

The kinds of problems that must be expected when integrating individual systems so they will inter-operate effectively are as follows.

- the cost of interconnecting appropriate parts of each individual system involving an exchange of information will be significantly higher because of the lack of standard interfaces.
- because the architectures of individual systems are not aligned, it is probable that information required for exchange will require substantial translation beforehand or worse, simply will be inaccessible.
- system performance will almost certainly suffer.

Chapter 4 shows that the UK has various specific requirements for ITS. We must ensure that the architecture is capable of incorporating a range of urban and inter-urban ITS facilities such as UTMC, TCCs, urban bus operations, motorway tolling, public transport ticketing, park & ride/pre-booked parking place availability systems and traveller information services. All of these systems can be made viable individually but an overall architecture will support the attainment of a more integrated ITS infrastructure. Above all there should be a seamless urban/inter-urban inter-face.

The availability of a UK compatible ITS systems architecture and appropriate standards will ultimately be reflected in reduced system development costs and risks overall, through economies of scale and, therefore, in lower cost products for customers (in UK and overseas). In particular, it will enable local authority traffic departments to procure their future ITS system requirements, confident that individual systems will be sufficiently inter-operable.

Is it more important to have an identified architecture to work with rather than the "perfect" architecture ?

The UK (and Europe) needs an appropriate and effective enabling framework for ITS which is not over-elaborate, nor is over-prescriptive, but which at the same time is dynamic (and therefore will need maintenance and updating) and not overly futuristic. The architecture should permit flexibility, but it also needs to be sufficiently definitive to act as a guide and benchmark. A perfect system architecture will be impossible to achieve because there is so much in ITS that is a moving target.

In our view it is unnecessary and impractical to commission the same kind of de novo analysis as the US DOT conducted. We believe instead it should be possible to accept the basic US National architecture framework and adapt it to UK requirements. For example it would be worth re-working some major parts of the US analysis, relating to theory of operations, market package synergy, risk analysis and deployment strategies, and following the same kind of documentation structure but not document length!

Should it be European or global in outlook ?

The matter of architectural compatibility with ITS systems employed on the European mainland and elsewhere in the world is an aspect that would clearly provide enormous benefit to the UK's ITS systems exporters whilst, of course, opening even further our domestic market to competition from ITS system imports. Communications specifications for example are developing rapidly on a global scale and will influence ITS deployments world-wide.

In our view the most efficient way to make progress will be to start from the US architecture, identifying major national and regional differences. UK work on system architecture for ITS also needs to take account of results from European research, particularly SATIN and CONVERGE funded by DG XIII, the DG VII proposals on Telematics for the Trans-European Road Network and the ERTICO project on ITS City Pioneers. In addition it should look at the UK position on ITS deployment strategies and user service requirements, to determine how much convergence there is with US and European proposals.

Gzn there be national variations within it - if so, how and what ?

To minimise the cost and effort required for the development of an architecture for the UK and for it to be serviceable for the foreseeable future, we think any architecture must take full account of local needs and ITS systems already operating. For example:

- Our existing legacy of urban and inter-urban traffic management and control systems, travel information services and fleet management systems provides great variation in the starting position for ITS deployment.
- Dynamic Urban traffic control is highly advanced in the UK but the UTMC architecture is being developed to accommodate a variety of control strategies, according to local needs.
- There is an increasingly devolved approach to traffic regulation and enforcement systems, but national type approval is needed. Some local authorities are moving towards traffic restraint policies in which ITS technology can play a part, as with high priority and multi-modal public transport. The architecture needs to respect all of these local variations.
- The UK starts with a set of pan-European communications options like GSM and RDS/TMC but we also have experience of mix-and-match low-cost communications possibilities tailored to the commercial requirements: e.g. mobile packet data networks and paging.
- The legal and institutional setting in the UK shows great variety: there is institutional autonomy, numerous stakeholders, and an increasing amount of contracting out to the private sector. The greater number of actors makes the system architecture analysis all the more important and urgent.

Should it be comprehensive or only encompass selected applications ?

We think the architecture should be the minimum necessary to enable effective inter-operation between those ITS systems likely to be deployed in ***integrated configurations*** within the UK nationally (not only for European interoperability). This is especially true in the light of the UK's Open Systems procurement policy and continuing pressure to limit public sector expenditure.

We think the analytical approach to system architecture in the UK should be informed by the enterprise model summarised in paragraph 1.5 of this report. For example the exchange of data between the Area Traffic Control Centres (RTCCs in England, NNCC in Scotland and the Welsh TCCs) and Independent Service Providers, police, urban and metropolitan traffic authorities, needs attention to determine what interfaces should be provided by the TCC concession holders. Any architecture developed for TCCs should be compatible with an overall UK ITS systems architecture. As a minimum, we believe that this architecture should specify the functional elements and how functional requirements are allocated to physical components, the relationship between functional elements, the communication protocols and a data dictionary defining terms and message formats. The architecture should also specify the messages between systems and their sequencing and address and define the interfaces between different ITS systems. There should be an agreement with private TCC operators to observe these requirements.

With regard to pan-European interoperability, the priority is to link the emerging Area Traffic Control Centres with counterparts across national frontiers (cross channel and into **Eire). A** convincing case for linking other systems (e.g. SCOOT, UTMC) on operational grounds alone, cannot be made but there will be industry benefits if common systems are adopted.

Who would be responsible for championing/maintaining/selling it ?

The Task Force hopes that government will work closely with ITS Focus to develop a top-down vision that could provide an opportunity for convergence between the European, UK and US work on system architecture. In parallel, the various authorities involved in deployment of ITS (especially local authorities, PTEs, DOT and its Agencies, DTI, and the government regional offices) need to identify key stakeholders for long term partnerships on ITS, and establish a framework for long-term implementation, including amongst other things agreements on areas of responsibility, financial commitments, etc. Government can greatly facilitate the taking of a strategic view of the architecture relating to both Inter-Urban and Urban applications by working with industry and those in ITS procurement Having done so, Government and industry jointly need to devise a plan that maps out how it is going to work and be implemented,

- **We believe that ITS Focus has a role to play in bringing together the major parties and recommend that an action plan is developed in dialogue with government.**

Who would "own" it, initially and in the long term ?

ITS Architecture will be owned and maintained by the principal actors involved in ITS deployment. They are the ones who need to be convinced that a system architecture approach adds value and is worm supporting. Therefore these parties must be closely involved in any UK initiative to develop system architecture proposals. Since their involvement will come mainly through ITS deployment projects, we recommend that any architecture development work involves at least the UK agencies already engaged in ITS deployment. A list of current UK project in ITS participating in the EC Transport Telematics Applications Programme is at Annex D

During the next few months we think ITS Focus should consult within its membership and beyond on the results of this review and in dialogue with key actors should identify priority ITS application areas for early deployment and exploitation in the UK. These priority applications should be the subject of a UK-orientated system architecture analysis.

Over the same time period DOT is urged to single out specific areas of sensitivity that merit further attention for transport policy reasons, such as electronic fee collection, air pollution, in-car display systems, information service provider concepts, and driver assistance systems.

- **When these two preliminary actions are complete, it is recommended that DOT commission a project on system architecture development that can guide ITS deployments in the UK over the next 10 years. A steering group should be formed from the principal oveseeing government departments.**

This should include a more in-depth analysis and systematic comparison of the European and US recommendations on system architecture than this Task Force has been able to do.

Who would pay to develop, maintain and sell it ?

Government funding (including funding via the EU) will be needed to progress the areas of primary importance to government transport policy and where government agencies are a major customer, as has happened with UTMC and the motorway tolling programme.

Where there are operational savings from the deployment of ITS, the leading stakeholders may be willing to second staff or allocate their time to the architecture project. However any work needs to be well managed and coordinated.

o **We recommend that in order to keep the project manageable the market package structure derived from the US study should be taken as a reference framework, so that any UK studies can be targeted at the market sector level, which if necessary can be tackled one-by-one over a period of time.**

In effect this would develop a set of architectures for the groups of market packages shown in Table 3. Each market sector would require participation by a different composition of partners.

Who are the "actors" and what is their role

The actors include:

1. Various government departments, especially DOT, DTI, DOE, SO, WO, and Nl DOE plus Government Regional Offices: in respect of their role setting policy and regulating the development and investment in ITS in the UK.
2. National and local highway authorities i.e. Highways Agency /Scottish Office /Welsh Office /NI DOE /: in their ITS procurement activities.
3. Local and Regional authorities, PTEs, and LTE: as sponsors of ITS demonstration projects in support of local transport policies.
4. The European institutions, especially the EC, in determining European ITS deployment policies and standards.
5. British Standards Institute CEN and ETSI: with respect to ITS standards,
6. UK-based and European motor vehicle manufacturers: car, bus, truck and other commercial vehicles as designers and suppliers of ITS systems to their customers.
7. Major telecommunications service providers and network operators: in relation to the ITS communications architecture.
8. Private DBFO and TCC concession-holders: as operators of ITS systems with an interface to other ITS system providers,

9. Public Transport Operators - bus, rail, coach, air and ferry: **in** their role as fleet operators, in revenue collection and **in** providing traveller information services.
10. Digital map-makers and electronic publishers: as major information content providers.
11. Enforcement **agencies,** including traffic police, Vehicle Inspectorate and the Driver and Vehicle Licensing Agency: as users of ITS systems.
12. Motoring organisations and other private **service** providers: as providers of ITS "added value" services.
13. Operators of major transport interchanges such as the British Airports Authority, EuroTunnel, ports and ferry terminal operators: to develop ITS for improved inter-modal connections.
14. ITS equipment manufacturers, suppliers, designers, software developers and system integrators.

What resources are needed and where will they come from ?

If the Government take the lead and encourage private sector involvement it does not necessarily have to involve large sums of money, (such as the 220 million spent by the USA). ITS Focus believes the key issue is the leadership role that the government play in removing any uncertainty in the market place. All actors can then build around the strategy in a controlled and sensible fashion, with confidence, in the knowledge that this will lead to reliable procurement and investment decisions This in turn will lead to manufacturers having confidence to build compatible equipment to achieve economies of scale and to supply it to local authorities as cheaply as possible

- **We recommend that a consortium and core team is formed - to secure funding and provide the necessary continuity in project management.**

5.2 Other Recommendations.

Reference should be made to the recommendations included in the text for Chapters 3 on ITS Standards, Communications Architecture and a Dedicated ITS Infrastructure. In Chapter 4 there are detailed recommendations on the approach to be taken for each application area under the appropriate heading. In addition we make the following recommendations regarding international collaboration.

Europe needs an effective European equivalent to the US public-private partnership between ITS America and the Federal Highways Administration, to give effective committed leadership. This must cover both automotive and infrastructure segments - private and public transport.

- **We recommend that the European Commission considers the organisational model provided by the US DOT Joint ITS Programme Office. This would have as one of its primary tasks the development of European-level proposals on ITS system architecture.**
- **ITS architecture development work in the UK should proceed in close liaison with those appointed to develop ITS system architecture at the European level.**

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GLOSSARY OF TERMS AND ACRONYMS

ANSA: Advanced Network Systems Architecture
ATIS: Advanced Traveller Information Systems
CD-ROM: Compact Disk Read Only Memory
ISP: Independent Service Provider
CEN Comite Europeen de Normalisation Electrotechnique
DAB: Digital Audio broadcasting
DBFO: Design, Build, Finance and Operate
DRTS: Demand Responsive Transport Systems
DOT: Department of Transport
DG: Directorate General (European Commission)
DRIVE: Dedicated Road Infrastructure for Vehicle safety in Europe
DSRC: Dedicated Short-Range Communication
DOE: Department of the Environment
DTI: Department of Trade and Industry
EC: European Commission
EMS: Emergency Management System
ETSI: European Telecommunications Standards lnstitute
EU: European Union
ERTICO: European Road Transport Informatics Co-ordination Organisation (ITS Europe)
FHWA: Federal Highways Administration (US)
GPRS: General Packet Radio Service (GSM-based)
GSM: Global System for Mobile Communications
HIPERLAN: High Performance Radio Local Area Network
HMI: Human Machine Interface
HSE: Health and Safety Executive
IEC: International Electro-technical Commission
IRTE Integrated Road Traffic Environment
ISO: International Standards Organisation
ISP: Independent Service Provider
ITI: Intelligent Transportation Infrastructure
ITS: Intelligent Transport Systems
IVHS: Intelligent Vehicle-Highway System
LT: London Transport
MISRA: Motor Industry Software Reliability Association (UK)
MRPI: Medium Range Pre-Information
NADICS: National Driver Information System (Scotland)
NMCS2: National Motorway Control System version 2 (England)
NNCC: National Network Control Centre (Scotland)
NIDoE: Nor-them Ireland Department of the Environment
NTCIP: National Transportation Communications/ ITS Protocol (US)
OSI: Open Systems Interconnection
PTE: Passenger Transport Executive
RDS: Radio Data System
RTT: Road Transport Telematics
RTCC: Regional Traffic Control Centre
SCOOT: Split Cycle Off-set Optimisation Technique
SMEs: Small and Medium Enterprises
SO: Scottish Office
SRD: Standards Requirements Document
TETRA: Trans-European Trunked Radio
TC: Technical Committee
TCC: Traffic Control Centre
TMC: Traffic Message Channel (RDS)
TMS: Traffic Message Subsystem
TRL: Transport Research Laboratory
UTC: Urban Traffic Control
UTMC: Urban Traffic Management & Control
US DOT: United States Department of Transportation
VERTIS: Vehicle, Road & Traffic Intelligence Society (Japan)
VICS: Vehicle Information & Communication System (Japan)
VMS: Variable Message Sign
WO: Welsh Office
WWW: World Wide Web

TABLES

Table 1 User Services for Intelligent Transport Systems (ITS) as specified by the US DOT.

User Services Bundle	User Services
Travel and Transportation Management	• 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	• Public Transportation Management • En-Route Transit Information • Personalised Public Transit • Public Travel Security
Electronic Payment	• Electronic Payment Services
Commercial Vehicle Operations	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspection • On-board Safety Monitoring • Commercial Vehicle Administration Processes • Hazardous Materials Incident Response • Freight Mobility
Emergency Management	• Emergency Notification and Personal Security • Emergency Vehicle Management
Advanced Vehicle Control and Safety Systems	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-Crash Restraint Deployment • Automated Highway System

Table 2 Market Packages derived from the US National ITS Architecture Study

Traffic Management
- Network Surveillance
- Probe Surveillance
- Surface Street Control
- Freeway Control
- HOV and Reversible Lane Management
- Traffic Information Dissemination
- Regional Traffic Control
- Incident Management System
- Traffic Network Performance Evaluation
- Dynamic Toll/Parking Fee Mgmt
- Virtual TMC and Smart Probe
- Emissions and Environmental Hazards Sensing

Emergency Management
- Emergency Response
- Emergency Routing
- Mayday Support

ITS Planning
- ITS Planning

Traveller Information
- Broadcast Traveller Information
- Interactive Traveller Information
- Autonomous Route Guidance
- Dynamic Route Guidance
- ISP Based Route Guidance
- Integrated Transportation Management/Route Guidance
- Yellow Pages and Reservation
- Dynamic Ridesharing
- In Vehicle Signing

Commercial Vehicles
- Fleet Administration
- Freight Administration
- Electronic Clearance
- Electronic Clearance Enrolment
- International Border Electronic Clearance
- Weigh-In-Motion
- Roadside CVO Safety
- On-board CVO Safety
- CVO Fleet Maintenance
- HAZMAT Management

Transit Management
- Transit Vehicle Tracking
- Transit Fixed-Route Operations
- Demand Response Transit Operations
- Transit Passenger and Fare Management
- Transit Security
- Transit Maintenance
- Multi-modal Co-ordination

Advanced Vehicles
- Vehicle Safety Monitoring
- Driver Safety Monitoring
- Longitudinal Safety Warning
- Lateral Safety Warning
- Intersection Safety Warning
- Pre-Crash Restraint Deployment
- Driver Visibility Improvement
- Advanced Vehicle Longitudinal Control
- Advanced Vehicle Lateral Control
- Intersection Collision Avoidance
- Automated Highway System

Table 3 Showcase technologies for the US Intelligent Transportation Infrastructure

First-wave Showcase Projects in USA

Location	Project	Federal Grant	State/Local + Private
Pheonix (AZ)	Aztech	**$ 7.5m**	$10.9m
San Antonio (TX)	TransGuide	$ 7 . lm	$ 6.3m
Seattle (WA)	Timesaver	$13.7m	$41.2m
Metropolitan New York (NY/NJ/CN)	TRANSCOM	$10.4m	$ 8.6m
TOTAL		**$38.7m**	**$67.0m**

ITS Technologies for Metropolitan Areas

Regional multi-modal traveller information centres
Traffic signal control systems
Freeway management systems
Transit management systems
Incident management programmes
Electronic fare payment systems
Electronic toll collection systems
Highway-rail crossing protection
Emergency management services

Table 4. Functions to be supported by the UTMC specification

Traffic signal control	Monitoring of the network
Mandatory sign control	Network performance evaluation
Physical network control (e.g. tidal flow)	Traffic control strategy selection
Direct vehicle control (e.g. limiting vehicle speeds)	Static database management (street inventories, etc.)
Enforcement	System modelling
Public transport management	UTMC system operation
Emergency services management	Building control systems
HOV management	Inter-urban monitoring and control
Freight management	Police systems
Parking management	Local authority systems
Weather monitoring	Pollution monitoring
Road nricine	In-car route guidance

Figure 1 US National ITS Architecture: Main Subsystems and Communication Elements (Source: US National ITS Architecture Study)

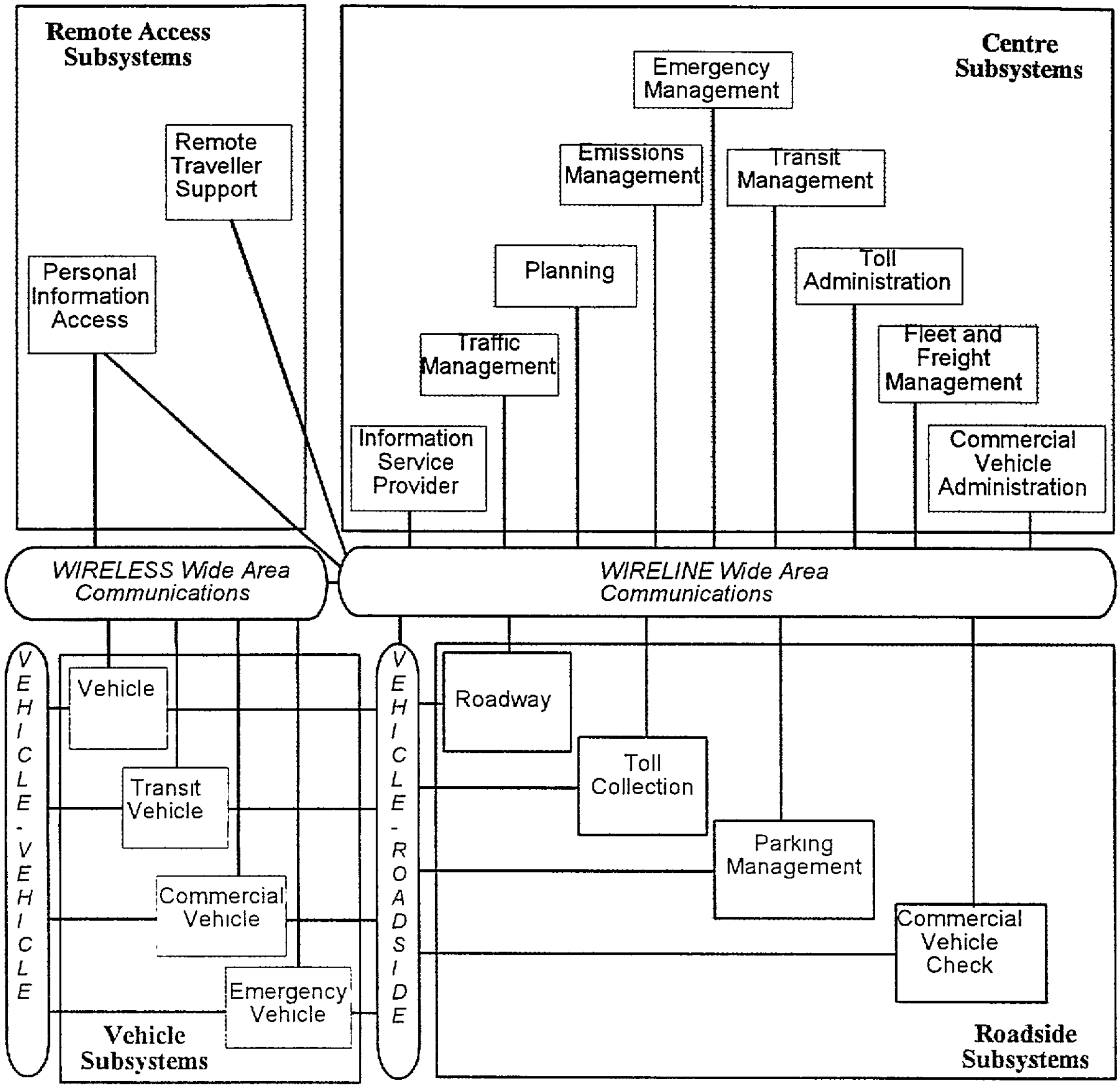


Figure 2 US National ITS Architecture Study: Simplified Top Level Logical Architecture (Source: US National ITS Architecture Study)

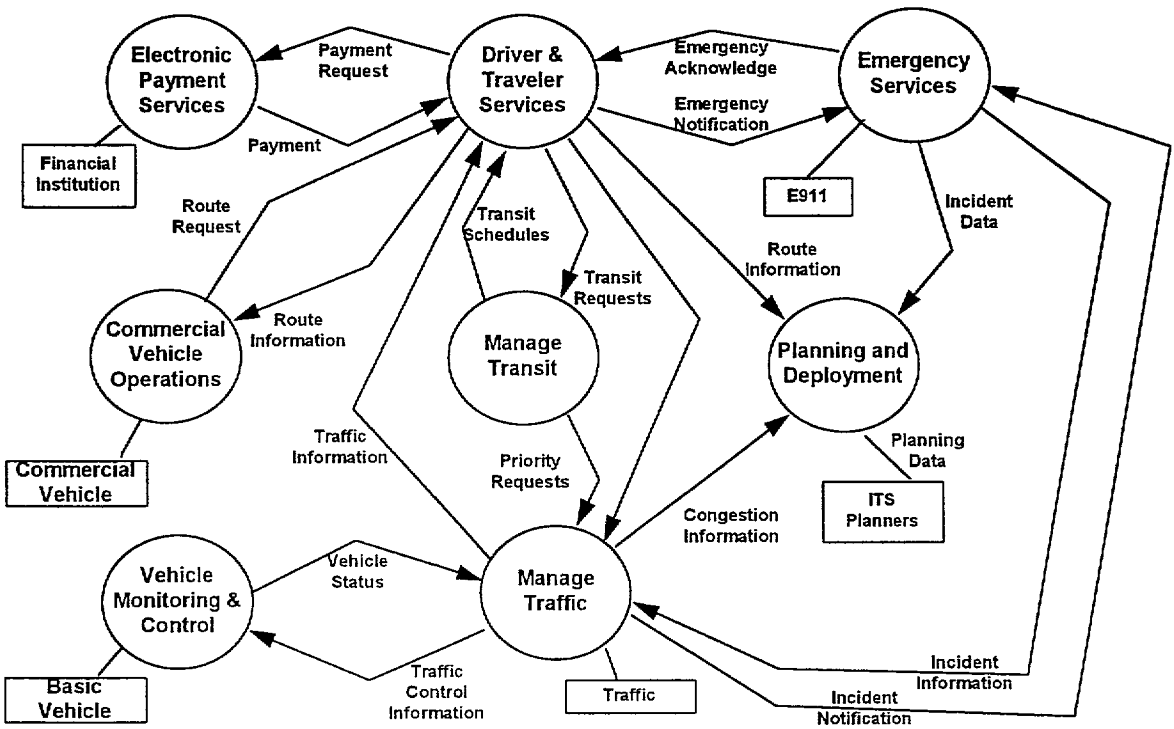
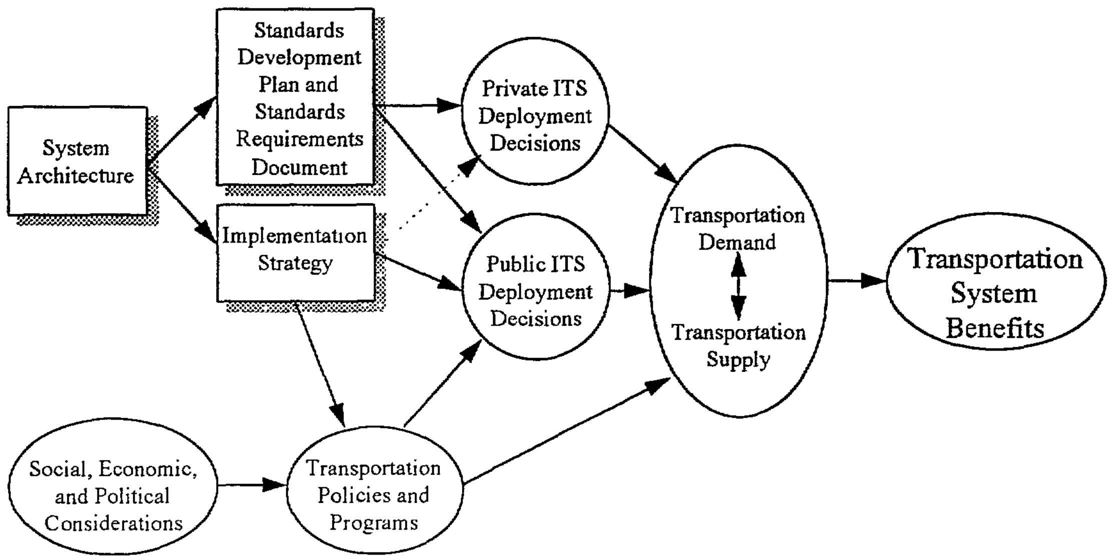


Figure 3. Influence of system architecture on ITS deployment decisions. (Source: US National ITS Architecture Study)



ANNEX A TASK FORCE TERMS OF REFERENCE

1. To summarise key aspects of the work carried out on behalf of the US Department of Transportation for a National ITS Architecture.

2. To comment on the relevance of the US National ITS Architecture to the UK, identifying strengths and weaknesses of the US approach.

3. To show how UK/European developments on IT coincide wit our diverge from the US National Architecture, including potentially important consequences (eg. for standard setting and world markets for ITS products and services).

4. Where appropriate, to offer recommendations on the development of system architecture in the UK and Europe, which can be sent forward by ITS Focus to the appropriate organisations (UK Government Departments and Agencies, European Commission, ERTICO etc).

5. To prepare a report for ITS Focus summarising the work of the Task Force.

ANNEX B SUMMARY OF DOCUMENTATION REVIEWED

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ANNEX C SUMMARY OF DOT PROPOSALS ON UTMC

AN INTRODUCTION TO URBAN TRAFFIC MANAGEMENT AND CONTROL (UTMC) SYSTEMS

1. Background to the Development of UTMC Systems

The UTMC Specification has been developed for three major reasons:

- transport **policy** has evolved considerably in recent years to such an extent that it is now **becoming necessary** to manage transport to achieve a much wider of objectives than just minimising delay to vehicles. Existing UTC Systems cannot support this management role well enough to meet evolving needs;

- there is increasing pressures on system users (local authorities and other **system** operators) to reduce expenditure; and

Existing UTMC systems have a number of operational limitations including:

- users are often “locked in” to the original suppliers with little opportunity for competition;
- existing systems cannot be easily integated to work to together and reduce costs;
- the provision of information and its storage/management is generally poor; and
- best use is not made of technological developments, for example recent improvements in communications.

2. The UTMC Vision

UTMC systems will be modular, made up of components that can work together through a common “network” and share a standard operator interface The components could comprise:

- specific applications. for example a traffic control strategy or a database or

- separate systems which could include existing UTC or associated systems.

Existing systems will be able to migrate to become components in UTMC systems, so protecting existing investments and expertise.

Most UTMC systems will have a common data base to analyse and store information collected from components or imported from other systems, holding this information for use by other components or dissemination to other systems or travellers.

UTMC systems will adopt a mainstream computing approach which will enable the benefits of the research and development efforts in this field to be utilised.

3. The UTMC Specification

The UTMC specification defines, utilising international or de-facto computing and communication standards:

- the basic infrastructure requirements of UTMC systems, for example the operator interface; and

- how data is transferred between components. This is achieved by specifying:
  - a data dictionary (based on DATEX) which defines the structure/meaning of data;
  - the communication protocols; and
  - the physical interfaces

The specification does not define any requirements for components of a system, only how they communicate The specification does not specify any requirements for system architectures other than systems should comprise links and nodes.

The UTMC specification: because it adopts mainstream computing approaches, can also be used to develop modular systems for use in fields outside transport

4. Transport Policies supported by the UTMC Specification

The UTMC specification has been developed to accommodate a wide range of possible system types that will support a wide range of transport policies including those that involve payment,
using information as well as control Possible applications include:

- route guidance
- strategy selection
- parking mangement
- UTC
- road pricing
- access control
- incident management
- network control
- enforcement
- information dissemination
- public service vehicle priority
- bus and tram priority

The Role of Information

The **use** of information in the future is likely to increase because it:

- provides the information **necessary** to "manage" transport;
- can be used as a tool to influence traveller **mode choice,** the time at which journeys are made and the route selected, and
- has a potential value and/or could be sold or exchanged for other goods or services.

6. UK Developments

A draft specification has been produced in the UK by the Department of Transport (DOT) in association with the Traffic Director for London. This draft was circulated for comment in Autumn of 1996 and appears to have been well received by users and industry. The DOT have also allocated L5M for additional development and demonstration projects over the next five years.

The Role of UTMC in International Standards Development

Transport is now an international business and suppliers require international standards in order to make the necessary levels of investment with the confidence that they will make appropriate returns. International standards will also encourage *competition*

Many countries particularly the USA have invested considerably in developing "top down" requirements for system architectures whilst in Europe the approach has been "bottom up". The UTMC specification could provide a way forward that would integrate both approaches by defining how components of systems communicate but leaves architecture issues to be determined at a national level or if there are no national requirements at a local level.

ANNEX D UK ORGANISATIONS INVOLVED IN EU (DG XIII) TRANSPORT TELEMATICS PROJECTS

This list, showing organisations andproject names, is drawn from the **EUROPEAN** COMMISSION DGXIII. *Telematics Applications for Transport: Project Summaries.* Brussels, 1996

Associated British Ports Research and Consultancy Ltd	POSEIDON
Atkins Wootton Jeff'reys Consultants Ltd	CODE, CONVERGE, EUROSCOPE, SCRIPT, VADE MECUM
Austin Analytics	INFOPOLIS
Avon County Council	CONCERT
British Airports Authority	CROMATICA
British Airways	EOLIA
British Rail Research	MARCO
British Teleconmmnications Plc	PROMlSE
Brunel University	AUSIAS
Central Research Laboratories Ltd	CHAUFFEUR
City of Edinburgh Council	TABASCO
Cityline Bristol Omnibus Co Ltd	CONCERT
Civil Aviation Authority	FARAWAY
Community Network Services Ltd	EUROSCOPE. POSEIDON
Cranfield University	TELSCAN, WISDOM
Defence Research Agency	AATMS, CINCAT. EUROSCOPE, POSEIDON. TABASCO
Department of Transport	FORCE 1 & 2
Dept of the Environment, Northern Ireland	TABASCO
Devon County Council	SCRIPTGEC
Marconi Avionics	AATMS
General Information Systems Ltd	ADEPT II
Glasgow City Council	TABASCO, GIGA
Information Group	MULTITRACK
Golden River Traffic Ltd	EUROSCOPE
Graphic Data Systems Limited	IN-RESPONSE
Hampshire County Council	EUROSCOPE
HBC Consulting	INTIK-NOW
Hoskyns Group plc	INFOPOLIS
Ian Catling Consultancy	TABASCO, TEAM
Imperial College of Science &Technology	ADEPT II
International Mobile Satellite Organisation	POSEIDON
Jaguar Cars Ltd	AC ASSIST, UDC
Ring's College London	CROMATICA
London Transport Buses	INFOPOLIS
London Underground Ltd	CROMATICA
Loughborough University of Technology	SAVE, TELSCAN
Lucas Advanced Engineering Centre	UDC
Lucas Applied Technology Ltd	AC ASSIST
Matra Marconi Space	GNSS
Mattisse Consortium	QUARTET PLUS
Mercury Communications Ltd	TRACAR
Microsense	TABASCO
Molynx Ltd	CROMATICA
MVA Consultancy	COSMOS

MVA Systematica	TABASCO
Napier University	COSMOS
National Air Traffic Services	CINCAT, EOLIA, GNSS, ProATN Navstar, GNSS
Newcastle University	COSMOS
Orchidnote	CARDME
Ordnance Swey	EUROSCOPE
Oscar Faber	TABASCO
P & O Containers Ltd	TILEMATT
Peek Traffic Ltd	VADE MECUM
Philips Research Laboratories	.SAVE
Racal	ProATN
Racal Avionics	MAGNET A
RACAL Radar Defence Systems	POSEIDON
Railtrack East Anglia	CROMATICA
Rover Group Ltd	AC ASSIST
Scottish Office	TABASCO
SERCO Systems Ltd	TABASCO
Siemens Environmental Systems Ltd	EUROSCOPE
Siemens Plessey	CINCAT, GNSS
Siemens Traffic Controls Ltd	EUROSCOPE
South West Information Services Ltd	SCRIPT
South West Trains	EUROSCOPE
South Yorkshire PTE	TABASCO
Southampton City Council	EUROS COPE
Southampton Container Terminals	EUROSCOPE
Traffic Control Systems Unit	CLEOPATRA, COSMOS. TABASCO
Traffic Director for London	COSMOS
Traffic Solutions Ltd	TELSCAN
Transpennine	VADE MECUM
Transport & Travel Research Ltd	CONCERT
Transport Research Laboratoq	COSMOS, EUROSCOPE. MOVE-IT, CARDME
Transtech Parallel Systems Ltd	CROMATICA
United Kingdom Hydrographic Office	ECHO
University College London	CROMATlCA
University of Eseter	SCRIPT
University of Leeds ITS	CLEOPATRA
University of Newcastle upon Tyne	
Transportation Operation Research Group	ADEPT II. CLEOPATRA
University of Reading	TITAN/ 1
University of Southampton	
Transportation Research Group	EUROSCOPE. CLEOPATRA
University of Westminster	SURFF
West Devon Borough Council	SCRIPT
West Sussex County Council	SCRIPT