INTELLIGENT TRANSPORT SYSTEMS

Reference Material
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COMPETENCE

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For the use of the following material:

The aim of this material is to strengthen the knowledge of local / regional managing agencies in the transport field and to accelerate the take up of EU research results in the field of local and regional transport. The beneficiaries of the project are managing (energy) agencies who want to play a bigger role in the transport field.

Due to the size and (in some cases) the number of individual projects, it is not possible to explain each single result in detail and include it into these written materials.

The following set of material should rather act as a portal and facilitate the access of single projects and detailed results.

Therefore the material in hand doesn't lay claim to completeness.

The following compendium contains results of EU research-projects and complementary results of national research-projects. The authors thank the partners and collaborators of the COST 342 project. A complete list of the projects, consortia, and cited literature is given at the end of the material.

The material for the topic **"Intelligent Transport Systems"** was compiled by Tom RYE (Napier University, Edinburgh) for the STEER training project COMPETENCE **in 2006**.

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1. Introduction

1.1 What are Intelligent Transport Systems (ITS)?

ITS is the application of computer technology to the transport sector. ITS systems gather data about the transport system, process it, and then use the processed data to improve the management of the transport system, and/or to provide the transport user with more and better information on which to base their transport decisions.

1.2 What can ITS help us to achieve?

ITS can help transport planners to achieve policy objectives in many different ways. It can help to tackle congestion, pollution, poor accessibility and even social exclusion. It can also help to reduce journey times and improve reliability – either in actuality, or simply by changing people's perceptions. And it can improve the efficiency with which transport systems function. In certain circumstances – for example, parking guidance systems – it can help to support economic and retail vitality.

When thinking about ITS it is vitally important to consider it, not as an end in itself, but as a means to achieve your (transport) policy objectives. It is possible that in some circumstances ITS may not be the best means of achieving transport policy objectives, but in other circumstances, it will. The trick is to select it for the latter situation, not the former.

Examples of ITS

Chapter 4 of this Unit will provide some detailed examples of ITS in action, including costs and evaluations, where available. However, in this introduction it is worth giving an idea of some of the applications of ITS.

- Real time information, both for public transport and private road transport, so that users have up-to-the minute information on services, where they are, and on incidents/delays and how to avoid them. On the roads, such information can also improve safety.
- The use of geographical information systems (GIS) and relational databases to keep inventories of transport infrastructure in an area (e.g. the condition of the road network) to better manage and prioritise maintenance work.
- "Smartcard" ticketing on public transport, to give the passenger the best deal for the bundle of trips that they might be making in a particular period of time, and to provide the operator(s) with detailed information about their passengers' travel habits. The latter information can be useful for apportioning revenue between operators, as well as for service planning.
- Detailed route planning information (often in real time) for both public transport and car users.
- Parking guidance systems, to reduce parking search time.
- Public transport information in various formats (e.g. audible) for disabled people.

- Traffic signal control, in real time, to improve the efficiency of traffic flow, or to afford priority to particular user groups such as bus passengers, or pedestrians, within a network.
- Sophisticated booking and scheduling software can help to maximise vehicle utilisation in a demand responsive transport (DRT) scheme.

1.3 Learning outcomes

When you have completed this Unit you should:

- Have an understanding of the main applications of ITS.
- Be able to set out the principles of an appraisal of possible ITS applications.
- Be aware of examples of key ITS applications in actual locations around Europe.

1.4 Structure of rest of this document

The other chapters in this document describe in more detail the different Intelligent Transport System applications – what they are, and how they work. They then go on to look at how ITS applications can be appraised to ensure that they meet policy and other objectives. The final, and longest chapter, provides information on a range of actual examples of ITS applications that have been implemented, and their effects.

2. ITS applications in more detail

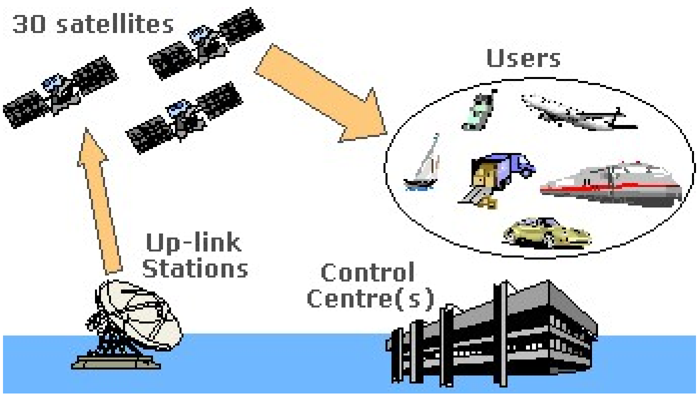
2.1 Introduction

Here in this chapter we look in turn at different ITS applications, how they work, and how they can contributing to reducing transport's energy use.

2.2 Galileo

It should be noted that several ITS applications, about which you will read more in the subsequent pages, depend on satellite communications. Typically these have been provided by the USA. However, you should be aware that the EU is embarked on one of its biggest research, development and delivery projects in order to put in place its own satellite communications system, GALILEO. You should have a look at http://europa.eu.int/comm/dgs/energy_transport/galileo/index_en.htm, from which the following diagram is taken. You will note that all the "users" in this diagram are forms transport – demonstrating how many ITS implications that GALILEO has.

Figure 2.1 – Schematic Diagram of GALILEO



2.3 Incident detection

ITS can be used to detect when there has been an incident on any transport system, and to communicate this knowledge to a control centre. ITS can, further, be used to put into effect information and/or traffic management strategies in response to certain types of incidents, in order to reduce their impact. For example, an accident may occur on a motorway. This is detected by roadside CCTV cameras, and picked up in the control room. Variable message signing (VMS) is then activated to: (a) manage the traffic that is too close to the accident to take another route (by e.g. lane closures, lane control, temporary speed limits); and (b) the VMS is used to advise traffic further away from the accident to take another route. Similar concepts were developed by the GOTIC project in Sweden in incident detection and management on Gothenburg's tram system. Clearly, roadside incident detection can save considerable energy by re-routeing traffic away from the area that is congested due to the incident, and by managing speeds of traffic on approach to the incident, to reduce congestion.

2.4 Variable speed limts

Due to the speed flow relationship in traffic, above a certain speed (around 80 kph on motorways), flow in vehicles per hour past a given point begins to decline – the effect of higher speed is cancelled out by the larger gaps that drivers leave between vehicles. Therefore, at peak periods, it can be effective to lower speed limits to maximise road capacity and also to reduce congestion caused by the over-reaction of drivers to changes in speeds, and the "wave propagation" effect that this has. In order to do this, variable speed limit signing is required together with, if possible, some form of automatic enforcement (e.g. average or point speed cameras). The reduced congestion and speeds have a knock-on benefit on energy consumption.

2.5 Ramp control

Ramp control is used at peak periods to regulate the flow of traffic along a slip road (ramp) onto a motorway or other grade-separated road. Sensors on the main road detect traffic density and then the optimum level and spacing of joining traffic is calculated, and its access onto the main road regulated by traffic lights. This should in theory minimise the congesting effect on the main road of the joining traffic.

Figure 2.1 – Ramp metering
(source DfT 2004)

2.6 Traffic signal control

ITS is used to manage linked and isolated traffic signalled junctions more efficiently, in relation to actual demand on the network in real-time. Inductive loop detectors in the pavement surface detect traffic levels, speeds and queue lengths. They communicate this to a local signal control computer and this in turn if necessary communicates with a computer controlling the signals for a whole area of a town or city (a "cell") – but communications are kept as local as possible to minimise communication times and costs. The signal controllers compute the most effective cycle times and green times for their signals, but these have to be within user-defined maxima and minima – so if the maximum cycle time is 120 seconds, the signal controller cannot override this. The introduction of real time signal control of this nature – commercial systems in use around the world include SCOOT and SCAT – typically increases the capacity of a group of linked signals by around 10%. In the short term, at least, such capacity increases should reduce congestion and therefore energy consumption (although these benefits may be eroded if traffic levels increase as a result of the reduced congestion).

Such signal control systems can be adapted to give priority to certain vehicles – most typically, trams and/or buses. Detectors note when a priority vehicle is on approach and (again within user-defined limits) can bring a green signal forward, or delay a red signal, in order that the priority vehicle does not have to wait to get through the junction. Increasingly, the identification of the priority vehicle is by satellite (GPS – geographical positioning system) linked to the public transport operator's control room. This means that priority can be given only to those vehicles that need it (ones running late) whereas, with inductive loop detection, all public transport vehicles are given equal priority, which is less efficient. Emergency vehicles can also enjoy priority, similarly.

Signal control systems can also be linked to real time information for drivers through variable message signs. Thus, when detectors pick up particularly bad congestion at one junction or in one street, they can relay this information (possibly via a human controller) to variable message signs, which can then be used to advise drivers of alternative routes and/or modes (e.g. *"City centre congested, use park and ride!"*). Smart signal control systems can also be used as a form of access control, or "gating" to certain sensitive areas. For example, one road may be used by a large number of public transport vehicles, or be particularly environmentally sensitive – therefore, queueing traffic may be particularly undesirable in that location. Signal timings can be used to "move the queue" from the sensitive area to a less sensitive one, and then only to permit through the optimum amount of traffic into the sensitive area. This system of "gating" – in real time – is used in Kingston, a suburb of London, UK. The same technique can be linked to pollution monitoring, so signals react in real time to "move" queuing traffic around, such that pollution hotspots do not build up in certain parts of town.

2.7 Parking Management

Parking management may seek to achieve the following in relation to parking:

- Inform drivers about parking opportunities.
- Assist in the distribution and management of limited numbers of parking spaces, including their pricing.
- Assist in the enforcement of parking.

ITS has a number of possible applications in relation to these objectives.

Figure 2.2 – Parking Guidance using VMS (source DfT 2004)

Parking guidance systems have traditionally linked counters (microwave, inductive loop or infrared) at the entrances and exits of off-street car parks (which monitor occupancy and queueing) to variable message signs on key links into and around the town or city centre, in order to advise drivers where they are most likely to find a space, close to their final destination. These systems work as long as the car park operators maintain the car park counters and keep the local authority (which is normally responsible for the signs) updated about any alterations to their car parks, such as a change in the number of spaces, of the entrance points or, indeed, whether the car park has completely closed down! These systems also depend on the car parks having discrete entry and exit points where it is possible to install directional traffic counters, so that it is possible to keep a continuous, accurate measurement of the number of cars in the car park at any one time. This is why, to date, there have been no examples of parking guidance systems that inform drivers about where to park *on*-street. In addition, parking guidance only merits the investment where the distribution of parked cars between car parks is skewed, so that a few car parks are very popular, with others remaining only part-full. If there is low demand at all car parks, or demand is evenly-distributed at most times of day, then parking guidance may be of less use.

That said, parking guidance systems in Southampton were shown to reduce parking search time by 50%, to 1.1 minutes; and in Valencia, 31% of drivers changed their parking destination in response to parking guidance information (CONVERGE project Deliverable 3.3.1 – see http://www.cordis.lu/telematics/tap_transport/research/projectsum/converge.html).

Parking space management does not have to rely on ITS. However, it can be more efficient and more targeted where ITS is used, normally in order to more accurately relate information about the user to their access to a space. For example, it can be used:

- In company car parking space management, to allow a member of staff access only to certain car parks, at certain times of day, on certain days of the week. This would also allow that member of staff to be charged on a "pay as you go" basis for parking, depending on how often they park and for how long. This has a much greater impact on travel behaviour than does a flat rate monthly or annual charge.
- Also in company car parking space management, "parking cash out", where the employee receives a daily payment from the employer, which they can keep if they travel to work by a means other than by car on their own, but which they forfeit if they drive alone.

Enforcement of parking space management is another area where ITS can be very useful. Paper parking permits are relatively easy to copy and so fraud can be a problem. It is much more difficult to copy permits that contain microchips and electronic checking equipment can also decide whether a permit has been obtained or is being used fraudulently than can a parking attendant who is relying on checking paper permits by eye. In a situation where, for example, a business may be allowed to use one permit but switch it between vehicles, electronic enforcement makes it much easier to detect whether a permit has been fraudulently copied to use on more than one vehicle at time.

Finally, parking payment systems increasingly use ITS. Across Europe it is more and more common to find towns and cities that allow the payment of on-street parking by mobile phone – Tarragona in Spain makes this system available at 112 locations across the city, for example. The user registers and then sends an SMS to an on-street ticket machine when they wish to park, paying the bill through their bank account later on. In Singapore, where there is an electronic pay as you go road pricing system, it is also possible to use the smartcard used for road pricing to pay for parking and public transport as well.

2.8 Demand Responsive Transport Management

Demand Responsive Transport (DRT) is a form of public transport that, instead of operating on fixed routes at fixed times, operates with some level of diversion/flexibility to take users where they want, when they want. From the user perspective, the most flexible form of public transport is the taxi, but it comes with a matching price tag. DRT normally comes some way between a taxi and a conventional bus and, to maximise the flexibility *and* the efficiency of the service, a sophisticated booking/scheduling system is frequently employed. This has a number of objectives:

- To ensure the highest possible utilisation of the vehicle and the driver(s).

- To keep journeys convenient for the user. For example, since a DRT is by its nature shared, someone already on the vehicle may have to put up with some inconvenience as it diverts off their most direct route to pick up someone else. ITS makes it easy to put constraints into the scheduling system, such as defining a maximum diversion, and maximum journey time, for passengers already on the vehicle.
- To allow users to make bookings by a variety of means – not only by phone, but by SMS and internet.
- To make sure that no trips are forgotten. With a paper schedule, there is a risk that a driver may miss out a pick-up by mistake, or drop people off in the wrong order. With combined scheduling/routeing software and a communications link between driver and the control/booking centre, the router can indicate to the driver where they must go next.
- To incorporate additional bookings at short notice, once a vehicle is out on the road. If someone calls in needing a trip, scheduling software can quickly calculate whether a vehicle nearby can pick them up and, if it can, this can be communicated to the driver whilst he is *en route*.
- To alert users when a vehicle is close by, so that they can get ready to be picked up. This can reduce dwell times and so increase vehicle utilisation.
- To store user details (address, most common trips, disabilities etc.) in a database, to simplify and speed up the booking procedure.

2.9 Freight and Fleet Management

Fleet management is an immensely important activity for any organisation that has even a small fleet of vehicles. It is therefore relevant to even small local authorities, as well as to bus operators (which may or may not be owned by the public sector). Fleet management is used to ensure that a fleet of vehicles is utilised to maximum efficiency. It depends on each vehicle being able to communicate its location, journey purpose and state (e.g. running normally, malfunctioning) to a central control room. This is normally done using satellite and radio technology, although certain bus only automatic vehicle location (AVL) systems use roadside beacons – clearly these are suitable only if you are locating vehicles within a limited geographical area (e.g. a single city).

By monitoring how vehicles are used, fleet managers can:

- Schedule and re-schedule vehicles more efficiently.
- Assess the need for more or fewer vehicles to carry out a set number of tasks (e.g. deliveries) – since it is possible to see the average time taken and how far different drivers deviate from the average.
- Assess individual driver behaviour e.g. the time taken to carry out a delivery; fuel consumption in relation to driving style.
- Manage services in real time. If for example a controller of a bus operation finds, from AVL, that all the buses on one route (line) in one direction are running late, he can use radio control to stop one or more of the buses before they reach the route terminus, and put them back into service in the opposite direction, to ensure that large gaps in service do not develop. Bus operators who have implemented AVL for fleet management reasons have realised fleet efficiency savings of around 9% (GOTIC, 2002).

2.10 Speeding Detection

Speeding is a major contributory factor to road accidents, and it increases both the risk of an accident occurring, and the severity of that accident. All EU countries are seeking to reduce the number of road accidents on their territory, as is the European Commission. Sweden has the most radical reduction target, with its "Vision Zero" (i.e. that there should be no road deaths). Many others have quantified targets for reduction. ITS can make a major contribution to the achievement of such targets, as follows:

Figure 2.3 Speed camera (source DfT 2004)

- Point speed cameras. These measure the speed of a vehicle at a short point on the road, such as at an accident blackspot, using radar detection, and conventional camera film (which is not always installed, so the camera is not effective 100% of the time). Vehicles exceeding the speed limit are sent a fine and in some member states a driver's licence is also endorsed. A study of 38 UK sites where speed cameras were introduced between 2000 and 2004 found that, at these sites, "Both casualties and deaths were down – after allowing for the long-term trend, but without allowing for selection effects (such as regression-to-mean) there was a 22% reduction in personal injury collisions (PICs) at sites after cameras were introduced. Overall 42% fewer people were killed or seriously injured. At camera sites, there was also a reduction of over 100 fatalities per annum (32% fewer). There were 1,745 fewer people killed or seriously injured and 4,230 fewer personal injury collisions per annum in 2004. There was an association between reductions in speed and reductions in PICs." (http://www.dft.gov.uk/stellent/groups/dft_rdsafety/documents/downloadable/dft_rdsafety_610816.pdf - page 4.)
- Average speed cameras. Installed over a stretch of road, these are linked to numberplate recognition systems that calculate the average speed of a car over that stretch. These are installed, for example, on the A77 national road in Ayrshire, Scotland. Similar enforcement to point cameras, but they use digital technology, so they are "on" all the time.
- Signs that alert drivers to their speed, but without any enforcement. For example, on the entry to a town, vehicles exceeding the urban speed limit will be detected by the sign which will flash a message "Slow Down – 50 kph Speed Limit". These have been shown to reduce speeds by 2 to 20 kph at a range of sites (Winnett and Wheeler, 2002).
- Intelligent Speed Adaptation (ISA) uses satellite GPS technology to indicate to a vehicle its own location relative to speed limits. "Active" ISA then introduces automatic control to the vehicle's engine and braking system so that the driver cannot exceed the speed limit. There are trials of ISA underway in the UK, the Netherlands and Sweden. Evaluation of the UK trial indicates that mandatory active ISA could produce (given a 1998 vehicle fleet) annual fuel savings of 2.3 billion litres of petrol and 1.4 billion of diesel in the UK alone (Carsten and Tate, 2005). The key European Project on ISA is PROSPER – see http://www.rws-avv.nl/servlet/page?_pageid=121&_dad=portal30&_schema=PORTAL30&p_folder_id=7737.

The link between speeding detection and energy use is twofold: firstly, above a certain point, vehicles travelling at higher speeds consume more energy; and, secondly, a reduction in accidents will tend to make the use of "slow" modes (walking, cycling) more attractive, thus contributing to modal shift. This has been observed in many cities where rates of cycle use have increased – a "virtuous circle" of safer roads and more cyclists leads to even safer roads for cyclists, and so more cyclists feel tempted to give cycling a try.

2.11 Vulnerable Road User systems (e.g. Puffin crossings)

"Vulnerable" users include children, the elderly and disabled people. They are all disproportionately represented in road accidents, especially as pedestrians. In addition, because disabled people have reduced mobility and/or sensory perception, a conventional transport system may not fully meet their needs. ITS can be used to adapt our transport systems to make them easier and safer to use for these groups of people. For example:

- Pedestrian crossings that sense, using cameras, how long people are taking to cross the road, and giving them more time if they need it.
- Audible public transport information for blind/partially sighted people. In some cases, this can be provided only when needed – blind and partially sighted people are given a pocket-sized device that activates a bus stop or other information point to give them audible information when they need it.
- Auditory location finder for blind/partially sighted people.
- Real time next stop indicators (visual and audible) on buses and trains.

2.12 Multimodal Trip Planning

Many public authorities are concerned to provide ever better (public) transport information in order to encourage a mode shift from car to public transport in order to achieve other wider objectives. Multimodal trip planning services – available on the phone, internet, WAP and/or SMS – may do this. The basic idea of a multi-modal journey planner is simple and can be observed, for example, by going to www.transportdirect.info, http://www.travel-and-transport.com or www.ns.nl. The user is able select their origin and desired destination, and the interface then produces a variety of trip options on a variety of modes of transport. The actual technical back-up required is considerable, but an example is provided at http://www.utmc.gov.uk/research/index.htm. The most difficult issue is to ensure that all the information on the system (or systems into which it links) is up-to-date, and then that it provides accurate information (e.g. shortest route).

Impacts of multimodal travel information

Blokland and Mouris (2005) report on research that was commissioned because the Dutch government is interested in stimulating travel behaviour change (in terms of mode, route and time of travel) through the provision of multimodal travel information. This paper explores Dutch and international experience through a literature review, internet searches and interviews with key individuals, mainly in the Netherlands.

The literature review was structured around a number of key questions. This meant that information was gathered, as far as possible, on the way in which information is provided; the type of information; the media used; the costs; whether the information is aimed at specific client groups; and the nature of the evaluation. Some 15 studies were reviewed – these are listed at the end of this report. The key conclusions were that:

- Little evaluation of multimodal travel information systems has been carried out, and many of the studies that do exist are based on limited data, making it difficult to be confident of their conclusions. (The study found that no evaluation is even planned for Germany's pilot multimodal travel information systems in four test cities.)
- The behavioural changes that were observed were marginal in all cases. However, the study points out that this may not always be the case for all client groups – but the general nature of the studies makes it impossible to see, in most cases, whether different client groups will respond differently. There is however some limited evidence to show that business travellers are more willing to change mode, travel time or route in response to travel information; and that the more unknown the journey, the more likely that the travel information will be heeded.
- It was also clear from the literature that the provision of information will not of itself lead to its use. This may link to another finding, that the vast majority of such systems are provided publicly – private companies appear unwilling to invest at present.
- The study mentions a number of multimodal portals including http://www.utrecht.nl/smartsite.dws?id=13776&mw=1003&w=18&p=3352&parFrom=3352&infFrom=3352 (in Dutch), http://www.bayerninfo.de/index_e.html (in English), http://www.smarttrek.org/index.html (in English, Seattle area) and http://www.vmzberlin.de/vmz/ (in German). It notes that a cost-benefit analysis of the Bayern (Bavaria, Germany) case showed costs of €9 million per year and benefits of around €700 million (based on stated preference data).

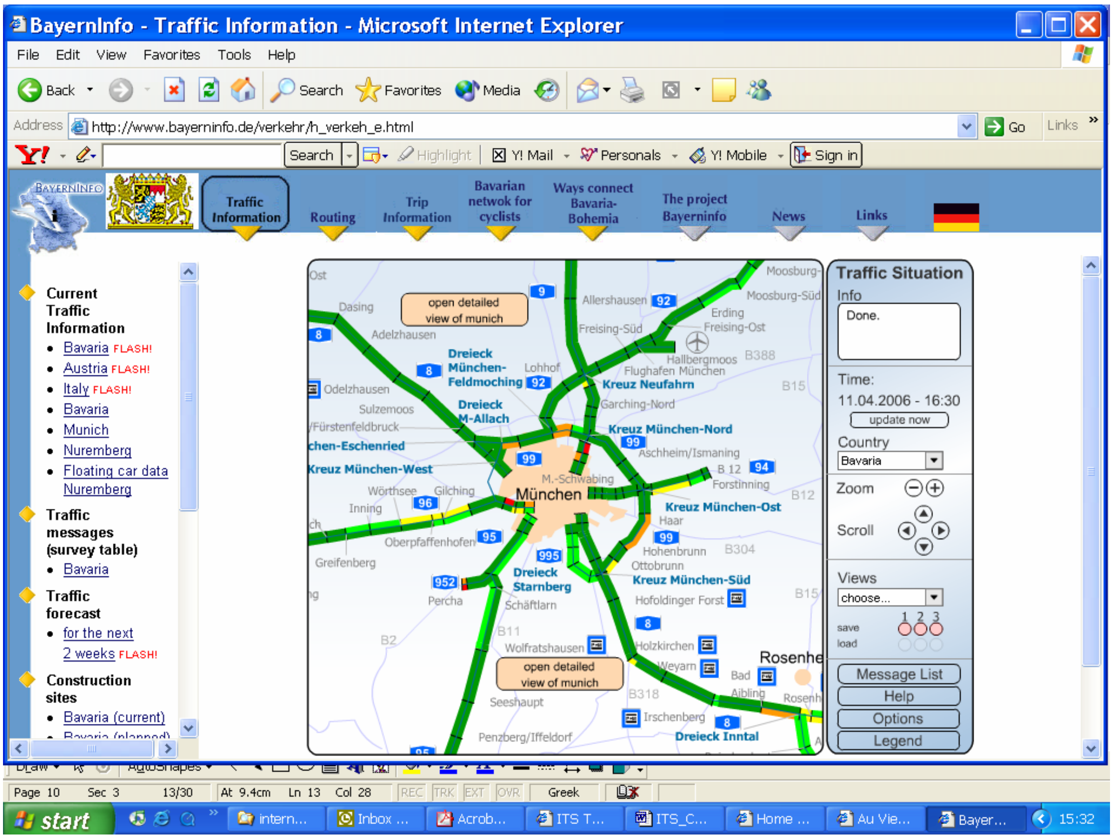


Figure 2.4 – Bayern Info Real Time travel and traffic information

Results of particularly pertinent studies that were reported in this study are listed below:

- Route-Compass (CD ROM multimodal traveller information, launched 1998 in the Netherlands). An evaluation of 156 users, carried out in 2000, found that 5% used public transport more as a result of the information on the CD, and 32% of users changed route.
- The mobility effects of the 06-9292 information line, March 1994 (Netherlands). This information line provides multimodal public transport information plus information on walking and cycling links. A survey of 4,549 callers found that 271 (6%) had changed their behaviour as a result of the call. A third made a different trip, but still by public transport; a third used public transport instead of a private mode; a sixth made a trip that they would not otherwise have made; and a sixth made the trip by car instead of by public transport.

2.13 Passenger Information Systems

When linked to AVL (see above), ITS has the ability to provide real time information to public transport passengers (RTPI) through a variety of media such as at-stop displays, SMS messaging and the internet. A schematic representation of a typical system is shown below. Theoretically, these systems should lead to some energy saving by promoting modal shift from car to bus, but the evidence to demonstrate such a shift is limited – although a few schemes, including those in Leicester and London (UK) have found, in surveys, a small number of additional passengers using the bus as a result of RTPI.

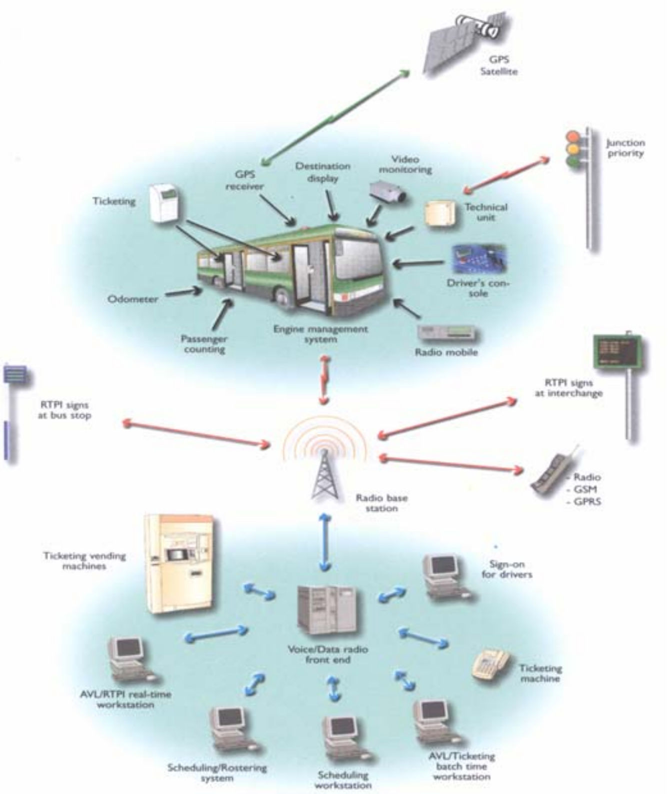


Figure 2.5 – Schematic representation of RTPI system (source – City of Edinburgh Council)

2.14 Route Guidance and Navigation

Global Positioning Satellite (GPS), as used in fleet management and AVL (see above) can also be used to provide drivers with very detailed route guidance information. This is increasingly commonly fitted to cars as standard. It obviously has a beneficial effect in terms of energy consumption as it can reduce the number of kilometres driven (when navigational errors are made in manual navigation) and can be used in tandem with congestion information to give drivers advice on how to choose routes to avoid incidents.

2.15 VMS

Variable Message Signs (VMS) are a form of ITS that provides information to travellers. As its name suggests, the message on a VMS can change in real time. This is usually achieved by means of a display that can be programmed from a control centre remote from the sign. The advantage of VMS is, of course, that the sign can change to reflect prevailing conditions. They are used predominantly to advise drivers on main roads of difficult driving conditions (e.g. “Bridge closed to high vehicles due to high winds”), to give notice of incidents (e.g. “accident at Junction 12”) and also to advise of diversionary routes that can be taken when an incident has occurred.

2.16 Road user charging (RUC), tolling and access control

Tolls are collected from road users in order to collect all or some of the costs of constructing a road, bridge or tunnel. Road user charging is applied to existing roads as a way of managing demand (congestion) and/or raising money for new infrastructure and services. In any event, a means of collecting the money is required, and of enforcing non-payment. ITS can be an extremely useful tool in so doing. Some examples of the way in which it used are as follows:

- The London Congestion Charge (www.cclondon.com) is enforced by automatic number plate recognition (ANPR - cameras photograph number plates and then a computer compares the number plate with those stored in a database of people who have paid their charge that day). ITS must be used for the number plate recognition, but also to allow people to register on the database when they pay. They can do this by paying in cash at a paystation (e.g. a petrol station), or by pre-registering and then paying on the internet, by SMS or by phone. Clearly all these systems have to be interlinked and this is a very good example of a complex ITS application. With complexity comes cost; system set-up was around €300 million, and the operating costs are around €3.20 per charge payer.
- Many toll bridges, toll motorways and all four congestion charging schemes in cities in Norway use a tag-based system for collecting revenue. Vehicles whose owners register for the scheme carry an electronic tag that is “read” by beacon when the car passes through a charging point. They are then billed monthly according to the number of charged trips they have made. ANPR is used for enforcement.
- In Singapore, a congestion charging scheme uses an in-car unit (IU - see Figure 2.3), with which every vehicle must be equipped. The user buys a card rather like a phone card and must insert the card in the IU before driving into a charged area. Charges in Singapore vary by location and by time of day, but a beacon activates the IU when the vehicle drives

past a charging point, and the correct amount of money is deducted from the card in the IU. Once again, ANPR is used for enforcement. An IU is shown below.

Figure 2.6 – Singapore Electronic Road Pricing In-vehicle Unit

2.17 Public Transport Payment

ITS facilitates public transport fares payment in several important ways:

- Electronic ticket machines on buses and trains allow the issue of more specific ticket types, which benefits the passenger. However, they also collect a great deal of management information (e.g. with certain ticket machines it is possible to measure the speed of a bus along a route) which is of use to the operator.
- Ticket issuing machines at stations and stops reduce boarding times and time spent waiting for tickets, thus shortening the overall public transport journey.
- Smartcards retain information about the individual user (e.g. that they have a concessionary permit) as well as facilitating a wider range of fares options than is possible with paper-based tickets. They can also be used to reduce ticketing fraud where this is a problem. They can, therefore, have benefits for the passenger as well as for the operator.

2.18 UTMC Systems and the System Architecture on which they depend

The EU FP6 project STREET-WISE is concerned in particular with Urban Traffic Management and Control (UTMC) systems, which combine many aspects of ITS. It explains that a typical UTMC system will be made up of:

- **Some link with external systems** – an external system being something like a counter, or maybe another UTMC system;
- **A database**, to store information collected from external systems;
- **Communications links** between the different parts of the system;
- **Some way of communicating information** from the system, to users.

The UTMC approach is about the exchange of information within and between systems. This is illustrated schematically in Figure 2.4, below.

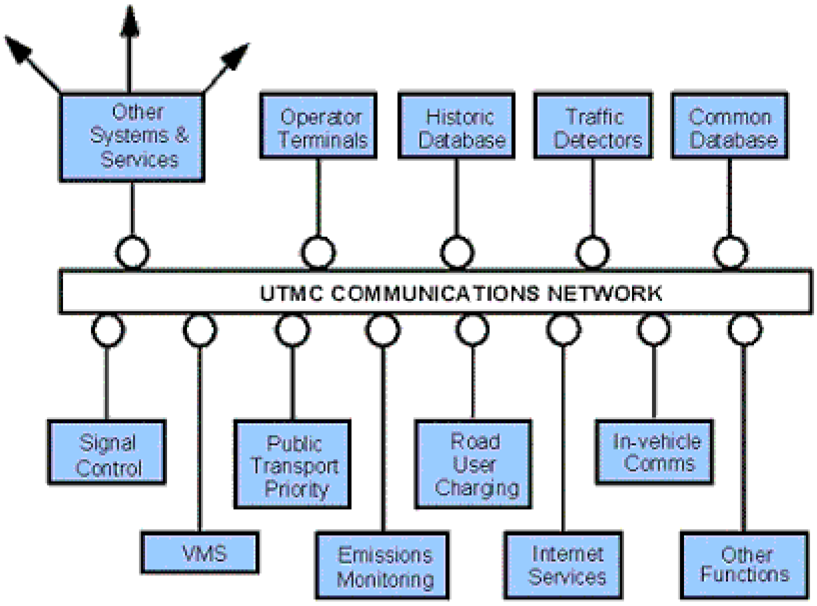


Figure 2.7 – Schematic representation of UTMC system

- Node A: other systems from which information is received;
- Node B: UTMC traffic management centre – there should be one in the system, although it may be distributed around several locations;
- Node C: “intelligent outstations” – used to control elements of the system that interact with users, the “controlled units”;
- Node D: “controlled units”, such as VMS, traffic signals, parking signals, road pricing enforcement cameras and so on;
- Node E: mobile units – the Singapore IU, for example.

(Sourced from http://www.utmc.gov.uk/guidance/index.htm (UK DfT))

3. Appraising ITS

3.1 Introduction

As noted in the introduction, when appraising ITS, it is crucial to start with the questions: what are the transport problems that I am seeking to solve, and what – therefore - are my objectives? If in answering this question you find that ITS is *not* the answer, then this is not a failure – it merely indicates that you have been through an adequate appraisal process.

3.2 A useful tool for appraising ITS

Although not the product of a European Project, the UK Department for Transport's ITS Planning Guide (2004) is a very useful resource for transport professionals who are thinking about schemes with an ITS element. It helps with the appraisal of ITS applications as a means of solving transport problems and achieving transport objectives. It includes, in particular, a directory of ITS tools with guidance about their use; case studies of ITS in action; and some reviews of the evaluation of ITS tools around Europe.

As the Guide says,

"It is envisaged that the information contained within this section will assist transport practitioners to develop scheme options identifying:

- key requirements for developing systems;
- order of magnitude of costs and benefits;
- key risks; and
- best practice. "

The guide is available free from:

DfT Publications,

PO Box 236, Wetherby,

West Yorkshire, LS23 7NB, UK

E-mail: dft@twoten.press.net

Quote Product Code: **45RVD02310.**

3.3 Exercise

This exercise is intended to get you to think about what ITS measures you might use in order to achieve certain policy objectives, in the context of a fictitious town and its transport policy.

St. Maria is a small city in a southern European country, with a population of 180,000 and 420 cars per 1000 people. After years of depopulation in the surrounding rural area, this is finally starting to increase in population, due in part to an influx of British people trying to escape the “rat race”. However, much of the rural population remains elderly and at risk of social exclusion due to poor transport links. Santa Maria itself had an industrial base that was historically based on textiles and ceramics, but this has now gone into decline and tourism is now a key industry. However, the service sector is also growing in importance, with much of the employment in that sector now concentrated on a business park on the edge of town, close to the main junction with the national motorway network. Major retail development is also planned here. Economically, St. Maria is performing at a level that is below average, but not so far below average that it is seen to merit major government intervention – there are other higher priorities.

Although the motorway bypasses St. Maria to the south and east, the main road from the motorway to another major town to the northwest runs right through the middle of the city. Through traffic, including heavy goods vehicles, has a negative impact on the city’s historic core. In addition, congestion is compounded by many local trips made by car within the city and by the British incomers from their rural hideaways, coming into St Maria to shop. Consequently, the city centre is at risk of breaching the EU’s 2010 limits on oxides of nitrogen, and the poor environment threatens the town’s tourist industry. However, due to the redistribution of structural funds away from southern Europe towards the ten new EU member states, the regional government has made it clear that there is unlikely to be money available within the next ten years to pay for a bypass for the city.

St. Maria’s Transport Plan for the city and the surrounding area has the following objectives:

- Environment – protecting historic built environments as well as the natural environment.
- Economy – to use transport to ensure that the economy prospers.
- Safety – to ensure the safety of all road users, but especially vulnerable road users and pedestrians, who are disproportionately represented in accident statistics at present.
- Social inclusion - to meet the transport needs of all social groups.
- Accessibility – to make sure that, as far as possible, all destinations become easier to reach, although not necessarily by all modes of transport.

Currently there are no ITS applications in use in St. Maria. Given a limited budget (i.e. one in which not every item on a “wish-list” could be funded), what ITS applications might you choose to investigate for use in St. Maria? How well do they perform against the objectives, on a scale of 7 (major positive impact) to 1 (major negative impact)?

4. Examples of ITS in action

4.1 Public Transport Payment - Oystercard

The Oystercard is a public transport smartcard used in London, UK. Some Oystercards are used like season tickets (abonnements) but they can also be used as stored value tickets – passengers can charge them up with money (even if they also use their Oyster as a season ticket on another part of the network). It is contactless, using radio frequencies for the card to communicate with the card reader. It is also the world's first public transport ticket to feature price-capping – passengers can use it to pay single fares but, if the cash value of their single fares in a day exceeds the price of a one-day ticket, then they are only charged for that one-day ticket. The same is true of travel over a week. Oystercard also gives passengers a roughly 33% discount compared to buying cash fares. There is therefore a major incentive for passengers to move over to the Oystercard, which is particularly important on buses in London, where traditionally passengers have paid the driver if they want a cash fare, which slows down the buses (at stops) very considerably. The use of a Smartcard also gives operators much better data about how many passengers travelled on which trains and buses, which can (depending on the nature of the financial contract between operator and public transport authority) make the distribution of revenue to operators much more accurate than if there are only paper tickets.

To make Oystercard work, all ticket barriers at all underground stations had to be equipped with card readers, and ticket machines installed on all buses and trams. In addition, machines for selling tickets had to be equipped, in some cases, to sell or top-up (add cash to) Oystercards. All this work had to be carried out whilst keeping the existing magnetic strip ticketing technology active.

Oyster was launched in 2003. In 2004, 27% weekday Underground journeys were made using an Oyster card, including a fifth of journeys paid for as single fares and almost half of all period tickets. On buses, 18% of weekday journeys were paid for using an Oyster card. There are now 2.9 million Oystercards in use and 2.2 million journeys a day made using an Oyster.

It is difficult to ascertain the cost of Smartcard projects. The knowledgeable UK transport journalist, Christian Wolmar, writing in Transport Times, states that "TfL and its predecessors have spent a cool £1 billion [€1.44 billion] developing and implementing the Oystercard" (http://www.christianwolmar.co.uk/articles/transport_times/jan13,06.shtml, accessed 11/04/06). Transport for London on their website cite a cost of £200 million, however[1]. On the other hand, in Greater Manchester, the implementation of a less advanced

Figure 4.1 – Oystercard and reader
(source: TfL website)

[1] See (see https://transportforlondon.custhelp.com/cgi-bin/transportforlondon.cfg/php/enduser/std_adp.php?p_sid=rs4TvL4I&p_lva=&p_faqid=101&p_created=1081699150&p_sp=cF9zcmNoPTEmcF9ncmlkc29ydD0mcF9yb3dfY250PTEyJnBfc2VhcmNoX3RleHQ9ZGV2ZWxvcG1lbnQgY29zdCZwX3NlYXJjaF90eXBlPTQmcF9wcm9kX2x2bDE9NTgmcF9wcm9kX2x2bDI9fmFueX4mcF9wYWdlPTI*&p_li=) accessed 11/04/06

Smartcard for 650,000 elderly people (who travel at a reduced fare) was estimated to cost around €2-3 million.

4.2 Parking guidance system, Aalborg

The following is a direct quote from the Jupiter project website (http://www.euroweb.net/jupiter/). Jupiter was a targeted transport project under the European Commision's THERMIE programme.

"Aalborg's parking guidance system is based on real time information of the number of unoccupied parking places in each parking facility of the system. Parking information is displayed on number of Variable Message Signs (VMS) on the main roads leading to the city centre as well as on the circular roads around the city centre. The circular roads distribute car traffic to the parking spaces on the periphery of the city centre.

The parking guidance system embraces 9 parking facilities (7 parking grounds and 2 parking houses) containing around 3000 parking spaces around the city centre. A total of 39 VMS and 8 conventional signs are linked to the system Figure 4.2 shows the main VMS of the parking guidance system and the location of the 9 parking facilities.

Behavioural impacts

Changes in travel patterns

Prior to the implementation of the parking information system 21% of visiting car traffic did not find an unoccopied parking space at the given parking facility. After the implementation of the information system this number has been reduced to 9%.

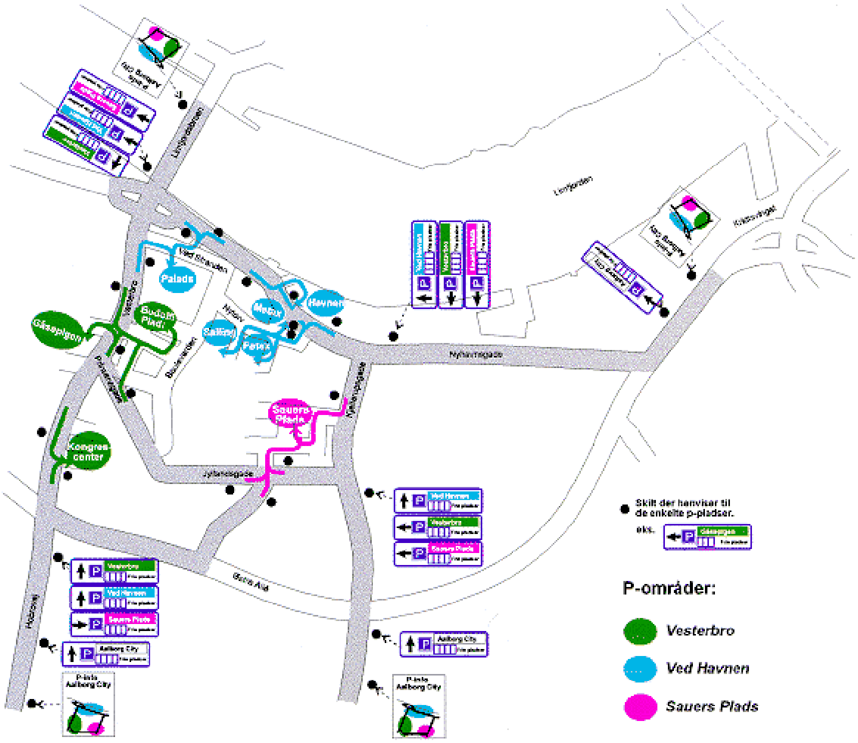


Figure 4.2 – Parking Guidance System in Aalborg

About 7% of motorists stated that their parking habits changed. Some 97% of users of the parking facilities said that they would have made their journey even if the parking information system had not been installed, while 3% answered that they now carry out more trips and park more often in the city centre area. The occupancy rate and average parking duration are similar before and after the installation of the parking information system.

Changes in public perceptions and attitudes
A survey of Aalborg motorists showed that:

- 67% of car users found the system to be an improvement;
- 47% found the system's information to be trustworthy - 23% do not;
- the amount of motorists who found the parking information either "Very good" or "Good" increased from 33% to 47%;
- the amount of motorists who found it "Very easy" or "Easy" to find a parking space has increased from 44% to 51%.

Efficiency impacts

Reduction in vehicle-km
The total amount of reduced vehicle-kilometres is 930 km/day, or equivalent to 232,500 car-km per year (assuming 250 work days a year). Compared to the total amount of vehicle-km in the city centre this is equivalent to about 0.3%.

Reduction in average journey time
Assuming an average travel speed of 30 km/h, the reduction in average journey time as a result of the parking information system has been calculated to 7,750 hours per year.

Environmental impacts

Parking information affects only a minor segment of all private car transport in Aalborg. For all pollutants the reductions are about 0.1% of total. Although the overall percentage reduction may seem to be small, they take place in some of the most environmentally loaded and sensitive roads of the city.

Energy

The parking information system's effect on private car energy consumption originates from reductions in parking search traffic. It has been calculated that the parking information system has led to a reduction in private car fuel and energy consumption by about 0.1%."

The JUPITER site does not say how much the system cost to implement.

4.3 Access control, Rome

To quote directly from the EU FP5 project PROGR€SS (http://www.progress-project.org/Progress/rome.html):

"Technology

Rome adopted in 1994 the access limitation to the LTZ of the city centre sectors east of Tiber (area of 4.6km2). In 1998, the payment for a yearly permit to access the area only for specific users was introduced. In October 2001, during the PRoGR€SS demonstration, the electronic full scale Access Control System and flat-fare Road Pricing scheme (ACS+RP) called IRIDE was switched on with the use of 23 entrance gates and a complex control centre located in STA. The automation of the access control system is accomplished through the use of a series of gates that can effectuate, without user intervention, the identification and/or the applicable tariff for vehicle entrance into the restricted area (vehicle-ground beacon). The enforcement is active during the weekdays from 6.30am to 6.00pm and on Saturday from 2.00 to 6.00pm.

The following types of technology infrastructure, based on the technology used for the TELEPASS system:

- TV Camera and infra-red Illuminators
- Microwave Transponder
- On-board Unit with Smart Card

Scale

- Full real pricing scheme-real charging, real users, real revenues
- Area covered by system: 4.6km^2
- Number of charging points: 22+1 entrance gates
- Number of users: 30,000 resident vehicles, 30,000 service vehicles (free access), 50,000 plates for disabled peoples (free access), 29,000 authorised individuals and 8,000 freight delivery vehicles (have to pay for access)
- Number of trips per day: about 70,000."

The effect of the scheme was to lead to a 10% decrease in traffic during the day, a 20% decrease in traffic during the restriction period, a 15% decrease in the morning peak hour (8.30-9.30), 10% increase of two wheels and a 6% increase in public transport use. Full details of the scheme, apart from the cost of its implementation, are available at http://www.progress-project.org/ and then by going to Project Reports and downloading Deliverable 5.2.

More up-to-date information, in Italian, is available at http://www.atac.roma.it/ and then by following the link to "Permessi centro storico - ZTL". A diagram of the scheme, from the PROGR€SS website, is shown below:

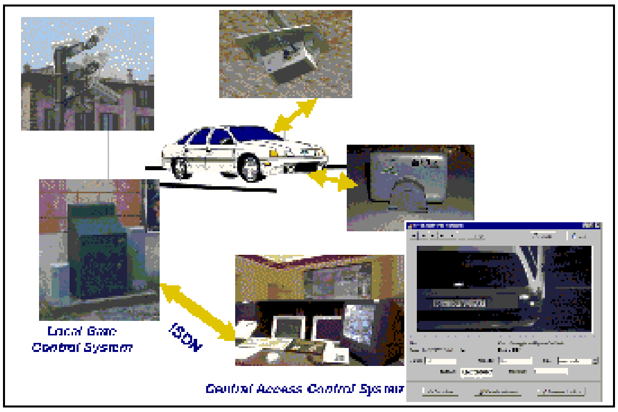


Figure 4.3 – the Rome System

4.4 Road pricing, Stockholm

You can refer to http://www.stockholmsforsoket.se/templates/page.aspx?id=2453 for information on the Congestion Charge Trials which were implemented for Inner Stockholm on 3/01/06 and will end on 31/7/06, after which (on 17/09/06) a referendum will be held to ask citizens whether they wish the trials to become permanent. The scheme has cost around €350 million to implement, funded entirely by the Swedish national government.

Vehicles passing any one of 18 points at the boundary of Stockholm city centre (inbound or outbound) have their numberplates photographed during scheme operating hours (0630-1829, Monday to Friday). The charge varies by time of day between €1 and €2 per pass (maximum payment €6 per vehicle per day). If the driver does not pay the relevant charge within five days, they receive a reminder and administrative charge of around €7 Euros. If another 4 weeks elapses, they are fined €50.

ITS comes into play because the easiest way to pay is via a transponder, fitted to the car, which communicates with the gantries at the charging points. The vehicle owner then pays the charges by direct debit. There is a video about installing transponder at the webpage shown above.

The scheme has reduced traffic levels within the cordon by about 25% compared with the same period in 2005.

4.5 Multimodal trip planning

Thanks to the EU IST project TRANS-3 and the earlier CAPITALS PLUS project, a multi-modal trip planning website http://www.transbale.com/index.php was set up and ran for the duration of the project, to 2002. The website is still active although the journey planning element is not, as funding was not continued. Some 64% of the total project budget of €940,000 was spent on the development of the website and journey planner.

To quote from Rapp and Baudez (2003:2, found at http://www.rapp.ch/documents/papers/TransBasel.pdf),

"The transport policy objective of the partners has been to achieve a shift from the individual car to the alternative modes. The solution proposed by Transbasel is centred on a multi- and inter-modal journey planner. The journey planner proposes a choice of trips with different modes in response to each request… It intends to demonstrate to a habitual car driver hat public transport, bicycle, Park and Ride are often comparably fast and sometimes faster than the car. A second mouse click leads to the necessary details for the proposed trips.

The journey planner covers a diameter of 30 km: the agglomeration and its surroundings. The goal is to cover the trips which are part of daily life of the residents, and which have their origin or destination or both within the agglomeration.

The information is based on a superposition of static data… public transport timetables, and real time data. The latter are available for car park occupancies and dynamic road travel times on certain links. The journey planner is embedded in a website."

Transbasel was evaluated by a variety of means, but the largest evaluation involved a sample of only 88 users who completed a pop-up questionnaire on the website. Of these, 83% did not change their behaviour as a result of the information, 7% changed route, 6% changed travel time and 4% changed mode. These results are indicative only due to the small sample size.

4.6 VMS and route guidance

The EU's TEMPO programme funds ITS projects across Europe. In the current tranche, SERTI (www.serti-mip.com - Southern European Road Telematic Implementations) covers long distance road operations across parts of France, Spain, Italy, Germany and Switzerland. There are some 25 partners involved in the project, including 7 public authorities and 14 motorway companies. Some examples of their work, quoting directly from the website, are described below. No costs or quantified benefits are included on the website.

"Web Traffic

Eight road operators have decided to group together in order to offer drivers a unique interface whatever the network operator. All the operators involved in the website are linked on one unique map ensuring web-users the most up-to-date traffic information. What makes the Web Traffic unique is its coverage. With the Italian operator AdF (Autostrada dei Fiori) having joined, it covers 7500 kilometres of motorway in France and Italy. In 2004, the web-traffic coverage was extended to the Paris urban area and to the ACESA motorway network in Spain (Catalonia). Further developments will include information points on rest areas giving drivers access to traffic information free of charge and offering them the opportunity to adapt their journey according to the conditions.

Travel time prediction

Travel time prediction is a key demand of drivers in order to manage their trip better and save time. Since the beginning of 2004, travel time has been available on about 1000 km of the SERTI network (motorway corridors in South-Western France, in Andorra, around Lyon, Barcelona, Valencia and Madrid). Soon the coverage will be extended (e.g.: South-East of France) and the first studies to provide travel time between two different countries will be carried out.

Access VMS

The Access VMS are located upstream of a motorway in order to give drivers accurate information about the related network and to reinforce peri-urban and inter-urban continuity. This enables drivers to choose their way taking into account the real time traffic conditions."

4.7 Conclusion

This section has shown how ITS can be implemented and bring real benefits in various different contexts in various European countries. It has also shown that ITS projects can be expensive! This reinforces the lesson of Chapter 3: that ITS solutions can be very useful, but that you must be convinced that they will meet your transport objectives, before investing in them.

5. Literature and Websites

The following literature and websites have been used to set up this written materials. Here you can find further information, project results and good / best practice case studies. Please note that websites may be closed after a certain period.

http://www.utmc.gov.uk/research/index.htm

http://www.utmc.gov.uk

http://www.its-assist.org.uk/links.htm

http://www.trafficlinq.com/its.htm

http://www.eu-spirit.com/

http://www.itsnetwork.org/

http://www.cordis.lu/telematics/tap_transport/home.html

Blokland, M., Mouris, R. (2005) *Gedragseffecten multimodale reisinformatie* (Behavioural Effects of Multimodal Travel Information). Report to Dutch Ministry of Transport, *AdviesDienst Verkeer en Vervoer* (Travel and Transport Advisory Service), Rotterdam

Carsten O.M.J. and Tate F.N. (2005) Intelligent speed adaptation: accident savings and cost–benefit analysis *Accident Analysis & Prevention, Volume 37, Issue 3, May 2005, Pages 407-416*

Winnett M A & Wheeler A H (2002) Vehicle-activated signs – a large-scale evaluation, TRL Report 548.

6. Glossary

The contents of the glossary are taken from the UK Department for Transport (2005) publication *Understanding the benefits and costs of Intelligent Transport Systems – A Toolkit Approach*.

AADT: Annual Average Daily Traffic flow.

AAWT: Annual Average Weekday Traffic flow.

ADIS: Advanced Driver Information Systems; vehicle features that assist driver with planning, perception, analysis, and decision-making.

ANPR: Automatic Number Plate Recognition.

ANSI: American National Standards Institute.

AVCS: Advanced Vehicle Control Systems.

AVI: Automated Vehicle Identification.

AVL: Automated Vehicle Location.

AVLS: Automated Vehicle Location System.

ATCO: Association of Transport Coordinating Officers.

ATCO.CIF: Association of Transport Coordinating Officers Common Interchange Format (data structure for timetable data exchange).

Beacons: Short-range roadside transceivers for communicating between vehicles and the traffic management infrastructure.

B&W: Black & White.

CCTV: Closed Circuit television.

CEN: Comite European de Normalisation.

CH_4: Methane.

COBS: Control Office Base Station.

CO_2: Carbon Dioxide.

DAB: Digital Audio Broadcasting. Digital radio.

Dead-Reckoning: A technique that calculated the current location of a vehicle by measuring the distance and direction that the vehicle has travelled since leaving a known starting point.

DGPS: Differential GPS.

Differential Correction: A technique for overcoming GPS position determination errors; GPS receivers are placed at precisely identified control locations to measure the difference between indicated GPS positions versus actual positions.

DRIVE: Dedicated Road Infrastructure for Vehicle safety in Europe.

e-GIF: Electronic Government Interoperability Framework.

ETC: Electronic Toll Collection.

Geocode: A code representing a political or geographic unit incorporated into a GIS.

FQP: Freight Quality Partnership.

GIS: Geographic Information System.

GPRS: General Packet Radio Service.

GPS: Global Positioning System.

GSM: Groupe Speciale Mobile.

HGV: Heavy Goods Vehicle.

HIOCC: High Occupancy Algorithm.

HOV: High-Occupancy Vehicle.

IHT: Institute of Highways and Transportation.

INGRID: Integrated Incident Detection.

IR: Infrared.

ITSO: Integrated Transport Smartcard Organisation.

KSI accidents: Killed or Seriously Injured. Part of the DfT's (formerly DETR's) 10-year plan to reduce KSI accidents.

LAN: Local Area Network.

LCD: Liquid Crystal Display.

LED: Light Emitting Diode.

MIDAS: Motorway Incident Detection and Automatic Signalling.

MOVA: Microprocessor Optimised Vehicle Actuation.

N_20: Nitrous Oxide.

NO_x: Oxides of Nitrogen.

NPV: Net Present Value.

OCR: Optical Character Recognition.

OS: Ordnance Survey.

OSGR: Ordnance Survey Grid Reference.

OTU: Outstation Transmission Unit.

P&D: Pay and Display.

PM_{10}: Air Pollutant - particle with a aerodynamic diameter of less than or equal to 10 microns.

PMR: Private Mobile Radio.

PDA: Personal Digital Assistant.

RDS: Radio Data System.

RDS-TMC: Radio Data Systems incorporating a Traffic Message Channel (see TMC).

RFID: Radio Frequency Identification.

RTI: Road Transport Informatics; a European term for ITS.

RTPI: Real Time Passenger Information.

SCATS: Sydney Coordinated Adaptive Traffic System.

SCOOT: Split, Cycle time and Offset, Optimisation Technique. An urban traffic control system.

Smart Card: An electronic information carrier system that uses plastic cards, about the size of a credit card, with an imbedded integrated circuit that stores and processes information.

TAG: Transport Appraisal Guidance.

TCC: Traffic Control Centre.

TFT: Thin Film Transistor.

TMC: Traffic Message Channel (with RDS); transmits, on FM subcarriers, digital codes representing standardised traffic information messages to be decoded and displayed (or spoken) in any given language by in-vehicle receiver.

TOC: Traffic Operations Centre.

TRO: Traffic Regulation Order.

TSRGD: Traffic Signs Regulations and General Directions 2002.

UTC: Urban Traffic Control.

UTMC: Urban Traffic Management and Control.

VMS: Variable Message Signs; highway signs which can change the message they display. Strategic VMS - Give drivers information about key problems on the network well before they come across them e.g. "Accident ahead". Tactical VMS - Give drivers more local information to allow them to re-route or alter travel plans.

VOC: Volatile Organic Compound.

VRU: Vulnerable Road User.

VSL: Variable Speed Limits.

WGS-84: World Geodetic System 1984; a widely accepted, standardised system of geodetic co-ordinates of latitude and longitude. Used by the Navstar GPS.

WIM: Weigh-In-Motion; a technology for determining the weight of a commercial vehicle without requiring it to stop on a scale; uses AVI to identify the vehicles; employs technologies that measure the dynamic tyre forces of the moving vehicle, and then estimates the corresponding tyre loads for a static vehicle.

XML: Extensible Markup Language.