

FINAL REPORT

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INCOME

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The INCOME Project

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The INCOME Project

General Introduction

This document is the Final Report for Publication for the INCOME project addressing urban traffic management systems (UTMS). The project was particularly concerned with the integration of three key components: urban traffic control (UTC), public transport systems (PTS) and driver information systems (DIS). The INCOME systems and strategies were tried and evaluated in London, Gothenburg, Turin and Piraeus.

This Final Report for Publication is presented as three separate and self-contained reports describing the INCOME project at different levels of detail:

- 1. The INCOME Book** - describing the INCOME objectives, summarising the INCOME applications, results and main achievements and providing guidance for practitioners in the areas of infrastructure requirements, factors affecting benefits and other implementation issues.
- 2. Annex A – Technical Description, Results and Recommendations** - providing detailed technical description of the INCOME results.
- 3. Annex B** – the 5-page public Summary Report to be introduced into CORDIS, the European Commission’s public electronic database (<http://www.cordis.lu/>).

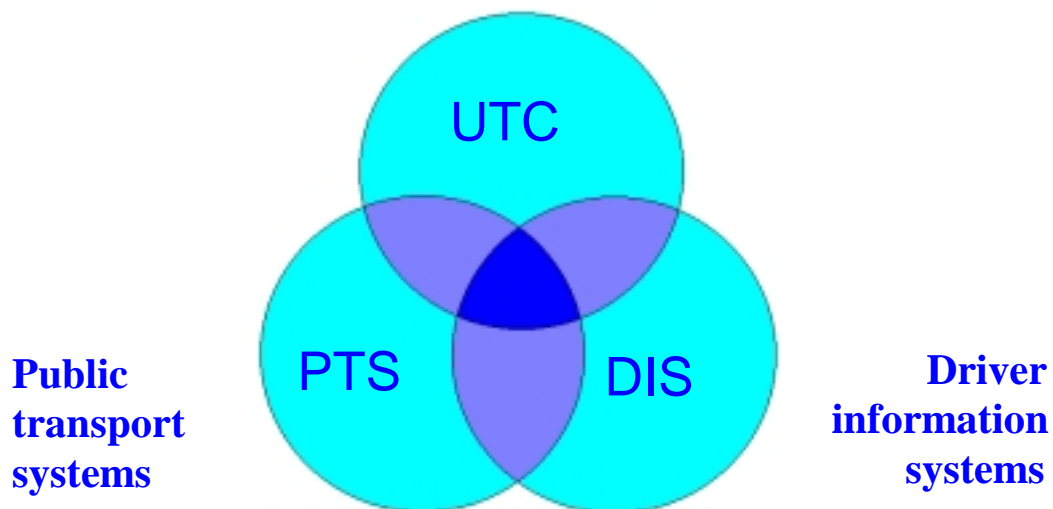
Each section is necessarily a summary of the project’s achievements and full information can be obtained on any aspect of the project from the public Deliverables listed on page 23.

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INCOME BOOK

Integrated strategies for

Urban traffic control



Examples Results Guidelines from 4 European Cities

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INTRODUCTION

The INCOME (INtegration of traffic Control and Other MEasures) project was undertaken within the European Commission 4th Framework, DG VII programme between January 1996 and March 1999. It was concerned with urban traffic management systems (UTMS) and, more specifically, the integration of three key components: urban traffic control (UTC), public transport systems (PTS) and driver information systems (DIS).

UTC is central to the control and management of traffic in cities; PTS and DIS are key UTM systems under the control of city authorities where advanced and integrated strategies could significantly support city transport policies.

The INCOME project was undertaken in four cities: London (UK), Gothenburg (Sweden), Turin (Italy) and Piraeus (Greece), resulting in a focussed consortium with common applications and the desire to develop advanced, integrated strategies.

OBJECTIVES OF THE INCOME BOOK

- To provide a concise overview of the INCOME project: its approaches and applications, how they support European, national and local policies and the results achieved.
- To serve as a **guidebook** for users and practitioners (e.g. city authorities) who may want to apply the INCOME methods: guidance is given in the areas of infrastructure requirements, factors affecting benefits and other implementation issues.

STRUCTURE OF THE INCOME BOOK

The book is divided into two parts.

Part 1 introduces the book in terms of

- (i) The policy context.
- (ii) A summary of the INCOME applications.
- (iii) How INCOME applications support policies.

Part 2 provides more detailed descriptions of the methods adopted by the INCOME cities, results obtained, conclusions and implications. Each method/application is described using a common format of subsection headings for clarity of presentation:

- (i) **INCOME applications**- describing the application;
- (ii) **Evaluation methods**- describing the surveys and simulation methods used;
- (iii) **Main results** – qualitative and quantitative output concerning, where relevant, technical performance, network capacity, travel demand and mode, travel time and delay, travel time regularity / reliability, safety, environment, quality, economic performance and long-term effects.
- (iv) **Other developments** – outlining complementary work and putting the INCOME project into context;
- (v) **Implications for practice** – advice for users who want to put the methods into practice; infrastructure requirements, factors affecting benefits and implementation issues.

The book concludes with a glossary of terms, a list of the INCOME deliverables and other references and contact details for the INCOME partners.

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1. PART 1

1.1 POLICY CONTEXT

A fundamental consideration of the INCOME project was the need to address European, national and local policy objectives. These were reviewed in INCOME deliverable 14, “*State-of-the-art review of urban traffic management systems, policies and strategies*”. The policies which were strongly supported at all levels, European, national (UK, Greece, Italy and Sweden) and local (London, Piraeus, Turin and Gothenburg) were

- *sustainability, particularly with regard to public transport improvement*
- *safety and security*
- *efficiency of movement and mobility*
- *accessibility*
- *protection of the environment*

1.2 A SUMMARY OF THE INCOME APPLICATIONS

The methods/applications adopted by the INCOME project were in the areas of

- Integration of UTC and PTS
- Integration of UTC and DIS
- Integration of UTC, PTS and DIS

Within these broad subject areas the INCOME project addressed the following applications:

Application	Area
1. Public transport priority in UTC	UTC/PTS
2. Integration of public transport priority and automatic vehicle location (AVL)	UTC/PTS
3. Congestion management for buses	UTC/PTS
4. Integration of variable message signs (VMS) and UTC	UTC/DIS
5. Intelligent speed adaptation (ISA)	UTC/DIS
6. Localised integration of PTS and DIS	UTC/PTS/DIS
7. Integrated road traffic environment (IRTE)	UTC/PTS/DIS

In this section the objectives, philosophy and motivation for each INCOME application are described:

Public transport priority in UTC

Increasing car ownership and usage is widely accepted as not being sustainable. *Sustainability, efficiency of movement and protection of the environment* can all be improved by improving public transport provision and operations. Priority to public transport at traffic signals is one traffic management measure which city authorities can take to support public transport and meet their policy objectives. The philosophy is to minimise delay to public transport at traffic signals and improve reliability, while controlling and additional delays to other traffic according to policy.

Integration of public transport priority and automatic vehicle location (AVL)

Automatic vehicle location (AVL) systems are widely used as a platform to provide passenger information about expected arrival times at bus/tram stops. This information is also useful for public transport priority: not only can signal timings be adjusted to suit individual buses or trams, but also fleet management objectives can be achieved, such as regularisation of headways, which reduces passenger waiting times at bus/tram stops. Time spent waiting for a bus/tram is widely perceived as being a major reason for not using public transport. This is partly due to passenger *safety/security*, especially at night time. Reduction in waiting time may also encourage modal shift towards public transport thereby contributing towards improved *sustainability, efficiency of movement and protection of the environment*.

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Congestion management for buses

Congestion management for buses refers, here, to the use of UTC to try to ensure that congestion only occurs at locations where buses are protected, such as alongside bus lanes. A typical scenario is to keep city centre traffic flowing freely by controlling access to it along the main approach roads. Although this delays traffic on the outskirts of the town, movement within and through the town centre is made easier so that the net effect for general traffic can be neutral. Successful congestion management for buses should contribute to *efficiency of movement* for buses. As with the other forms of bus priority described above it is expected that modal shift is encouraged with resulting improvements for *sustainability, efficiency of movement and protection of the environment*.

Integration of variable message signs (VMS) and UTC

Variable message signs (VMS) by the roadside provide drivers with information and/or advice typically about current traffic conditions, scheduled events, transport information, roadworks, accidents, *security* alerts, parking availability etc. VMS can operate independently from UTC, however, there is potential for integration of the two systems and actual integration in some cities: for example, UTC data about current traffic conditions can be used by VMS; specially prepared UTC signal plans can be used in conjunction with VMS messages for special events and emergency situations; co-operative signalling and signing can be designed to cope with congestion and/or incidents; at the highest level of integration, signal plans and VMS messages, affecting route choices, could be optimised simultaneously. It is expected that the integration of VMS and UTC will contribute towards *efficiency of movement*.

Intelligent speed adaptation (ISA)

Traffic speeding is a major cause of deaths and injuries on roads. Intelligent speed adaptation (ISA) involves new, in-vehicle technology aimed at controlling traffic speeds, reducing or preventing speeding and, thereby, improving *safety*. This could be achieved using in-vehicle equipment alone, which could include audible or visual driver information, or by using more advanced ISA and improved UTC to take advantage of the new traffic speeds and platooning.

Localised integration of PTS and DIS

Public transport systems and driver information systems can be integrated in a number of ways including the use of VMS to aid public transport, and the use of enforcement measures to protect bus lanes. VMS can aid public transport by using strategies such as (i) suggesting alternative routes to encourage drivers not to use bus routes, (ii) displaying public transport information, (iii) displaying environmental data to increase driver awareness. VMS can also be used to inform drivers of (i) public transport priority schemes at traffic signals, to reduce the likelihood of red light violations and (ii) camera enforcement measures, to discourage illegal use of bus lanes by private vehicles. Such schemes could contribute to raising the profile of public transport and encourage modal shift with resulting improvements for *sustainability, efficiency of movement and protection of the environment*.

Integrated road traffic environment (IRTE)

The philosophy of the integrated road traffic environment (IRTE) is that maximum network benefits will be achieved by a fully integrated traffic management and control system. The rationale is that by utilising the synergies between the different subsystems in the traffic control centre, through sharing of data, information and control, each subsystem will operate more effectively and the overall traffic environment will be enhanced. There is the potential with IRTE to meet all of the policy objectives stated above, although these policies themselves may sometimes be in conflict (e.g. safety and efficiency of movement).

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1.3 HOW INCOME APPLICATIONS SUPPORT POLICIES

Table 1 indicates how the INCOME applications support the policy requirements.

Table 1 - How INCOME applications support policy

Application	Policy				
	Sustain-ability	Safety/security	Efficiency of movement	Access-ibility	Environ-ment
Public transport (PT) priority in UTC					
Integration of PT priority and AVL					
Congestion management for buses					
Variable message signs					
Intelligent speed adaptation					
Localised integration of PTS and DIS					
Integrated road traffic environment					

Key to Table 1

- Application has primary support for policy
- Application has secondary support for policy

Blank - Application does not address policy

As Table 1 indicates, the INCOME applications were primarily focused towards efficiency of movement of people, and, consequently, the INCOME evaluation (see Part 2) concentrated on measuring these effects, in terms of journey times, delays and other operational impacts. Secondary effects were expected for sustainability, safety, accessibility and the environment; all these impacts could not be quantified in some cases, however, the issues are discussed in Part 2, in qualitative terms, where relevant.

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2. PART 2

2.1 APPLICATION 1 - PUBLIC TRANSPORT PRIORITY IN UTC

INCOME applications - Priority at traffic signals has been provided for buses in London (Figure 1.1) and to buses and trams in Gothenburg and Turin. The fundamental components of the priority systems are (i) detection of public transport vehicles, (ii) linkage with UTC and (iii) the priority algorithm. Detection methods used have included inductive loops under the road surface, communicating with bus-mounted transponders and radio-based AVL (see Application 2). Priority has been undertaken within different UTC systems including fixed time (SPRINT and SPOT) and adaptive (SCOOT, SPOT and UTOPIA) systems. For SCOOT/SPRINT, the priority algorithms consist of (i) estimation of bus/tram arrival times at traffic signals, (ii) extension and recalling of signal phases, (iii) dealing with conflicting priority requests and (iv) resynchronisation of signal timings after a priority request has been serviced. For SPOT/UTOPIA, a longer prediction horizon is used, with the “green window” for the bus/tram being adjusted as the bus/tram approaches the signals. Full details are provided in INCOME Deliverables D18, D19 and D20.



Figure 1.1 – Bus priority in London

Evaluation methods

Public transport priority in UTC was evaluated through full-scale field trials in London, Gothenburg and Turin supported by automatic UTC and public transport data and by simulation modelling. The main performance measures used were bus journey times and delays through the network; effect on other traffic was also measured.

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Main results -

Travel Time and Delay

The following average public transport journey time savings, as a result of priority at traffic signals were measured in INCOME:

- For London, average bus journey time savings of 4%-10% were measured across some 20 junctions using Bus SCOOT compared to normal SCOOT control, with no significant impact on other traffic. This equates to average bus delay savings per junction of some 7%-20%.
- For Gothenburg, the introduction of SPOT with bus/tram priority achieved 5%-15% improvement in journey times for buses/trams and a 5%-10% improvement for private traffic.
- For Turin, the introduction of UTOPIA, incorporating tram priority integrated with SPOT traffic responsive control produced journey time savings for trams of 3%-16%.

Note: the range of public transport journey time savings found are very dependent on congestion levels: congestion not only reduces the scope for this form of priority but also reduces percentage savings because of the high level of base journey time. Savings in journey times are also dependent on the number of junctions where priority is provided.

Reliability and Regularity

All of the priority strategies have produced a saving in bus journey time reliability, as expressed by the standard deviation of the journey times. Typically, savings of between 4% and 13% have been recorded for the different strategies. Greater regularity savings can be achieved when priority is specifically targeted towards late buses (see Application 2).

Environment

Environmental impacts with these strategies principally concern emissions/pollution, fuel consumption and traffic re-routing. These impacts depend on the “strength” of the strategy implemented. For example, results have illustrated how priority strategies can be implemented which provide worthwhile benefits for buses (including savings in fuel/emissions) without any significant impacts on general traffic. On the other hand, stronger priority strategies could be introduced which could cause net environmental disbenefits in the short term, but which offer the prospect of net savings in the longer term through modal change.

Economic Performance

Economic performance has been assessed in these trials through a cost-benefit analysis in which implementation costs have been compared with the strategy benefits of improvements in travel time, reliability and vehicle operating costs. In all cases, the strategies have achieved a pay-back period of less than two years, with some strategies achieving a pay-back period of only a few months.

Implications for practice -

Infrastructure requirements

- Traffic signals under UTC control, either fixed time or adaptive.
- Public transport detection/location system, e.g. loops, radio, DGPS.
- A priority algorithm running within the UTC computer (such an algorithm is included in SCOOT, SPOT and UTOPIA).

Costs

These include installation, operation and maintenance costs, which are all situation-specific. However, as an example, detector/transponder-based bus priority in London has typical installation costs of 15,000 Euros per junction and 150 Euro per bus.

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Factors affecting benefits and transferability

- Type of control: benefits to all traffic (including buses) have been found to be higher with traffic-responsive UTC rather than fixed-time UTC. The benefits of public transport priority to buses/trams relative to cars varies with the two types of control according to, particularly, the priority strategy adopted (e.g. ‘absolute’ or ‘conditional’ priority).
- Congestion levels: priority is most effective at under-saturated junctions; priority may not be feasible at heavily, regularly over-saturated junctions.
- Public transport flow levels: benefits **per vehicle** reduce as public transport flow increases, due to ‘competing’ requests for priority which cannot all be granted optimally; however, benefits totalled over the public transport fleet increase with increasing public transport flow as long as full priority is not given to all public transport vehicles.

Other implementation issues

- In congested networks it is important to combine the bus priority facility with strategies to reduce the congestion along the bus route, or to provide bus lanes which allow buses to bypass queued vehicles (see Application 3). In many cases, a combination of bus lanes over a limited part of the route, together with a congestion strategy to hold queued vehicles in the area provided with bus lanes, will be most effective.
- *Effect on other traffic* - public transport delay savings can be achieved with minimal impact on other traffic. Care must be taken to ensure that priority actions do not oversaturate junctions for too long as this may have a negative effect on all traffic (public transport included). This is possible with the control strategies adopted in the INCOME cities, e.g. degree of saturation constraints can be used to ensure this with Bus SCOOT.

Other developments

Public transport priority in UTC has been the subject of significant study in recent years. References of particular relevance include:

- a European collaborative study on public transport priority at traffic signals containing integrated results from all relevant projects in the European Commission’s 1992-1995 telematics research programme (Hounsell et al, 1996(A)),
- the EC-funded project PROMPT (1992-1995) which dealt specifically with ‘Priority and Informatics for Public Transport (Hounsell et al, 1996(B)),
- more detailed reports of individual city applications. For example, other studies of bus priority in SCOOT in London and Southampton have shown how bus delay savings can be substantially higher (up to 80%) at sites with lower traffic flows (Hounsell et al, 1996(B)).

2.2 APPLICATION 2 - INTEGRATION OF PUBLIC TRANSPORT PRIORITY AND AVL

INCOME applications- Bus location data, obtained from AVL systems, have been integrated into the public transport priority systems in London and Gothenburg following the integrated UTC/AVL application (UTOPIA) which has been operational in Turin for over 10 years.. The AVL data have been used for providing (i) bus detections (complementing loop detector data) and (ii) bus headway information (in London). Bus headway data have been used as a basis for *selective priority*: buses with the greatest headways (i.e. running late) are selected for full priority while other buses, with lower headways, receive little (extensions only) or no priority. The main expected advantage of selective priority over non-selective priority lies in regularity improvements, resulting in reduced passenger waiting times at bus stops.

The integration of public transport priority and AVL, as implemented in London, is illustrated in Figure 2.1; the system architectures in Turin and Gothenburg differ from Figure 2.1 in that integration is directly between the AVL and UTC centres, rather than via the bus and local signal controller.

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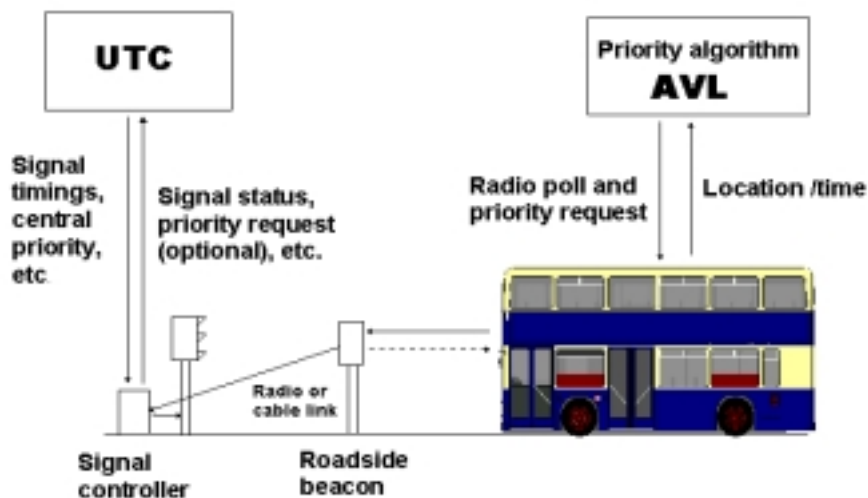


Figure 2.1 - Example of public transport/AVL priority architecture

Full information on this application is given in INCOME Deliverable D18.

Evaluation methods- The impacts of selective priority have been evaluated using the simulation models STEP, SPLIT and HUTSIM. Field trials of selective priority are expected to take place in London during 1999.

Sample results -

Effect on travel and waiting time

Simulation results, illustrated in Figure 2.2, refer to the London situation:

- potential savings in passenger waiting time of up to 22%,
- passenger waiting time savings are maximised when approximately 40% of buses receive priority, i.e. the 40% with the highest headways,
- passenger travel time savings tend to increase as more buses receive priority,
- combined passenger travel plus waiting time savings (expressed as a cost) increase with penetration rate up to around 40% of buses receiving priority. The rate of increase above 40% penetration then becomes marginal,
- overall cost savings are predicted to be up to twice which would be achieved with non-selective public transport priority in UTC (Application 1).

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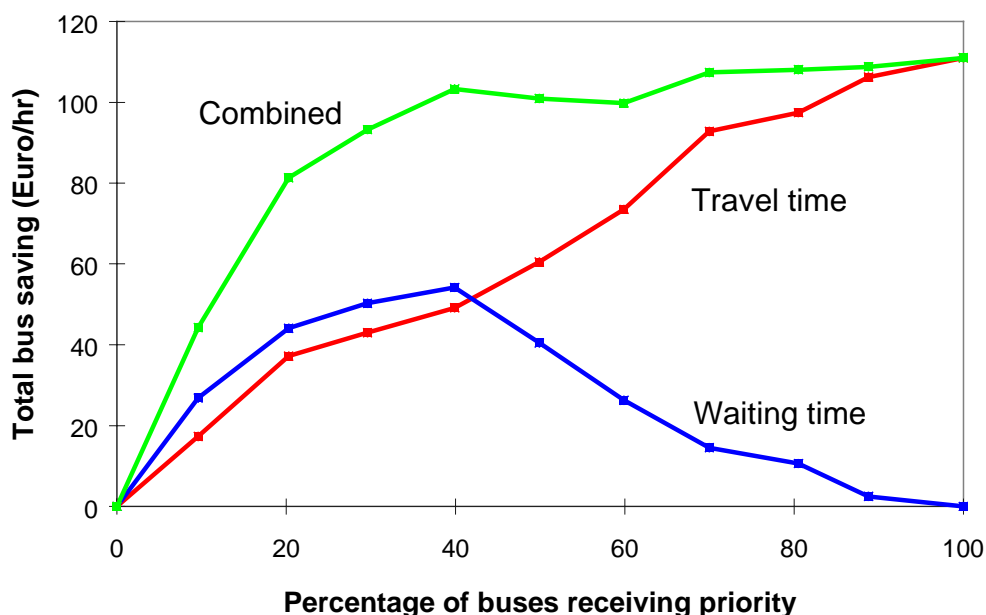


Figure 2.2 Effect of Penetration Rate on Travel and Waiting Time Savings

Implications for practice

Infrastructure requirements

- Traffic signals under adaptive UTC control (selective priority has not been provided within a fixed time system but, in principle, it could be);
- AVL system to provide headway information and, optionally, detect buses;
- (Optional) Bus detection system, e.g. loops or DGPS, if the AVL is not considered to provide sufficient locational accuracy for public transport priority.
- A selective priority algorithm running within the traffic control system which provides priority on a selective basis, e.g. depending on lateness of bus.

Costs

Costs are directly dependent on the architecture chosen. For London, the system is a development and integration of the existing AVL and Bus SCOOT systems. Main additional costs relate mainly to communications and software.

Factors affecting benefits and transferability

- The benefits of selective priority increase with increasing irregularity of public transport services. Note that other methods may also be available to reduce irregularity (congestion management (Application 3), improved ticketing, improved fleet management etc.).
- There is a trade-off between passenger journey time and waiting time saving benefits depending on the numbers (or percentages) of buses receiving priority.
- As for the non-selective priority expected benefits depend on (i) type of control, (ii) congestion levels and (iii) bus flow levels (see Application 1 for more detailed comments).

Other implementation issues

- For effective priority, buses need to be detected accurately and detected at suitable locations (e.g. downstream of bus stops). With AVL systems which use radio polling at fixed time intervals (e.g. every 30 seconds) the detection location cannot be predetermined and is, therefore, non-optimal. This is catered for in Turin through the use of a two-minute forecasting horizon within which a number bus/tram 'detections' occur, whilst, bus detection in London has used roadside beacons with the AVL system providing the headway data used by the selective priority algorithm.
- The comments made for non-selective priority (Application 1) also apply to selective priority.

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2.3 APPLICATION 3 - CONGESTION MANAGEMENT FOR BUSES

INCOME applications- A congestion management scheme for buses was implemented in Twickenham, London during the a.m. peak period using *gating* at traffic signals. The idea of the gating scheme was to deliberately hold queues of traffic on the approach roads to the town centre, protected by bus lanes (Figure 3.1), in order to keep traffic, especially buses, in the town centre free-flowing. The gating actions were controlled by the adaptive UTC system, SCOOT. The gating process consisted of (i) monitoring saturation levels at specified, critical, links within the town centre and (ii) reducing green time for specified *gated* links where queues were held. Full information on this application is given in INCOME Deliverable D18.



Figure 3.1 – Bus lane protection

Evaluation methods

Full-scale field trials - bus and car travel times were measured within the central Twickenham area and on the approach roads. Supporting data were obtained from SCOOT.

Results -

Travel Time/Delay in the Town Centre

Average bus delay savings in the central SCOOT area (all statistically significant) were

- 7% for BUS SCOOT
- 12% for SCOOT + Gating (no priority)
- 13% for BUS SCOOT + Gating

Similar levels of regularity saving (measured by standard deviation of delay) were also found.

Travel Time/Delay outside the Town Centre

It was expected that gating would delay traffic on the approach roads, outside the town centre, while buses would benefit by bypassing the queues, where bus lanes were available. The expected benefits were gained for public transport; mixed results were obtained for general traffic, with delays on some routes but gains on others; there was no evidence of any overall disbenefit to general traffic.

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Economic

A payback period of well under a year was estimated.

Implications for practice

Infrastructure requirements

- An adaptive signal control system with a gating facility (e.g. SCOOT)
- A road network where queue relocation can be applied to benefit buses and where potential traffic diversions due to relocated queues are limited/acceptable.

Costs

- Set-up costs - (i) specification of the gating parameters. A great deal of traffic engineering expertise and network knowledge is required in setting up a successful gating system. The fundamental parameters which must be specified with SCOOT are (i) one or more gating links, (ii) target degree of saturation levels, for each gating link, above which gating is activated, (iii) one or more bottleneck links and (iv) levels of green time reduction which will take place when gating is activated.
- Running and maintenance costs - (i) evaluation and review of gating plans used as they can be sensitive to changing traffic conditions.

Factors affecting benefits and transferability

- Network characteristics: gating is most beneficial to general traffic where there is a substantial amount of cross-movement traffic flow, e.g. where north-south traffic conflicts with east-west traffic. Conversely, gating is less effective on arterial roads where the large majority of traffic are travelling in the same direction.
- Bus lanes: public transport gains most when the gated link(s) has/have a bus lane, allowing buses to bypass queues.

2.4 APPLICATION 4 - INTEGRATION OF VARIABLE MESSAGE SIGNS AND UTC

INCOME applications- The INCOME project has investigated the potential of integration of VMS (Figure 4.1) and UTC in the following areas:

- Integration of VMS/UTC and ferry schedules (Piraeus)
- Effects of re-routeing at a VMS during incident conditions (London)
- Effect of providing estimated route travel time information (Gothenburg)

These applications have mainly involved the use of VMS within UTC networks or one-way integration, with traffic data from UTC being used to select appropriate messages for display; integration in the other direction (from VMS to UTC) was not specifically undertaken, although the adaptive UTC systems would react to changing traffic conditions caused by re-routing after a VMS.

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Figure 4.1: VMS in action in Turin

Full information on these applications is given in INCOME Deliverables D15, D16 and D17.

Evaluation methods Evaluation was carried out mainly by simulation using various models: SATURN and TRANSYT in Piraeus, RGCONTRAM in London and HUTSIM in Gothenburg. These models were supported by questionnaire surveys of driver requirements and responses to VMS in London and Gothenburg.

Results -

The Gothenburg study considered the effect of providing estimated route travel time information to a proportion of the driver population in a small network. The main findings were:

- where a low proportion of vehicles receive information (below 10%), travel speed for these vehicles increased by around 5%,
- at higher proportions (above 30%) network instability occurred and travel speeds were reduced for all vehicles.

These findings illustrate the need with VMS to use messages appropriate to the diversion rate desired.

The following journey time results were obtained from the modelling work in London that considered VMS re-routing after the occurrence of incidents:

Journey times

- *VMS not integrated with UTC* - 23% average journey time saving for drivers passing the VMS, ranging between 14% and 33% for the different incidents modelled,
- *VMS integrated with UTC* - 28% average journey time saving for drivers passing the VMS, ranging between 20% and 37% for the different incidents modelled. Integration here referred to quicker VMS message activation due to the automatic incident detection function of UTC being linked to VMS.
- The impacts of VMS and UTC/VMS integration on the network as a whole depend on the benefits gained by VMS-affected drivers relative to the disbenefits which might be caused to drivers on adjacent routes who are adversely affected by the increased traffic on their routes. There was evidence of network benefits of VMS in some cases and network disbenefit in others. This result was attributed to the relatively congested nature of the London network, offering limited scope for drivers to use free-flowing alternative routes.

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Traffic Safety

Simulation results showed an increase in average distances travelled and speeds for drivers diverting because of VMS of 3% and 3km/hr respectively (from 8km/hr). This occurs as many drivers seek longer, faster routes to their destination to avoid the congested area. This may have a very small negative impact on safety, although benefits could accrue through reduced queuing on the approaches to an incident (which would particularly benefit emergency services and potential casualties) and through the value of the VMS information itself (e.g. reduced stress).

Other developments

VMS are in wide usage throughout the European Community and further afield. Several projects within the 4th Framework of the European Commission, DG VII programme were directly concerned with VMS applications including AUSIAS, CAPITALS, CLEOPATRA, CONCERT, COSMOS, EUROSCOPE and QUARTET+. Areas of application for these projects included real-time information, incident detection, provision of air quality information and pollution forecasts, parking information including park-and-ride, congestion detection and collective route guidance. Developments in these areas are summarised in the CONVERGE Deliverable D3.1.1 Part B (European Commission 1998A).

Implications for practice

Infrastructure requirements

- Variable message signs installed by the roadside
- Communications to control computer (e.g. telephone lines, radio, etc.)
- Controlling computer + communications software
- UTC, preferably adaptive, to respond to any changing traffic conditions

Costs

- Set-up costs - (i) signs: costs vary widely depending on size and technology (light emitting diodes (LED), flip-top etc.). Prices (translated from UK figures) range from 10,000 Euros, for a small sign to 70,000 Euros for a large sign (ii) communications: cabling, computers and software, (iii) planning of what messages are to be displayed and when to display them.
- Running and maintenance costs - (i) evaluation and review of effect of messages if substantial re-routing is expected, (ii) operating staff to decide when, where and which messages are to be displayed; this decision process can be automated in response to traffic conditions (e.g. as in Turin) or operator-controlled.

Factors affecting benefits and transferability

- Availability and capacity of alternative routes: VMS is only effective if drivers are able to re-route without causing major problems elsewhere in the network. Ideally, alternative routes will have spare capacity, be familiar to drivers and not be much longer than the incident-affected route.
- The extent to which (i) optimum traffic patterns can be determined in real-time and (ii) messages can be set which achieve these patterns.
- VMS/UTC integration: integration through data transfer/sharing can increase traffic benefits, while integrated control may increase benefits further, particularly where relatively high diversion rates are involved.
- Frequency of updating/ reliability of information: driver confidence about the reliability of the information they receive is very important. If information is out-of-date or incorrect then compliance will be reduced.
- Type of UTC system: adaptive systems can react to changing traffic patterns resulting from VMS; fixed time systems could be inefficient unless specific and accurate plans are developed for different scenarios or diversion rates are low.

Other implementation issues

- VMS messages must be chosen with care and the likely re-routing effects must be anticipated prior to implementation to avoid creating problems elsewhere in the network.

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2.5 APPLICATION 5 - INTELLIGENT SPEED ADAPTATION

INCOME application

A full-scale demonstration of ISA is planned in Sweden. Alternative methods for controlling vehicle speeds have been proposed. The basic method requires (i) roadside equipment to monitor individual vehicle speeds and (ii) in-vehicle equipment, in communication with the roadside equipment, either to limit the vehicle speed directly, or to issue an audible/visual warning to the speeding driver. In addition to influencing traffic speed, ISA aims to increase the amount of platooning of traffic to reduce delays at signalised junctions. Full information on this application is given in INCOME Deliverable D16.

Evaluation methods - Evaluation was conducted off-line using the micro-simulation model HUTSIM. Developed by Helsinki University of Technology in co-operation with TFK - Transport Research Institute, HUTSIM models different types of intelligent speed adaptation functions. The main focus is on impact studies, as the number of ISA-equipped vehicles increase. Also, combinations of ISA functions have been studied.

Results

The results from the study of DIS/ISA and UTC show that even low levels of implementation have an impact on traffic safety for vulnerable road users (Figure 5.1 gives an indication of how ISA affects travel speeds). More significant impact is reached if 50% of the vehicles are equipped with ISA and it is also shown that short time headway increases the travel speed without reducing the traffic safety effects for vulnerable road users. The average speed at selected measurement points could be reduced by up to 20% depending on implementation levels and the ambition of the road authorities. The travel speed is reduced by 8% using “conventional” ISA, but by introducing short time headway the travel speed will not be changed.

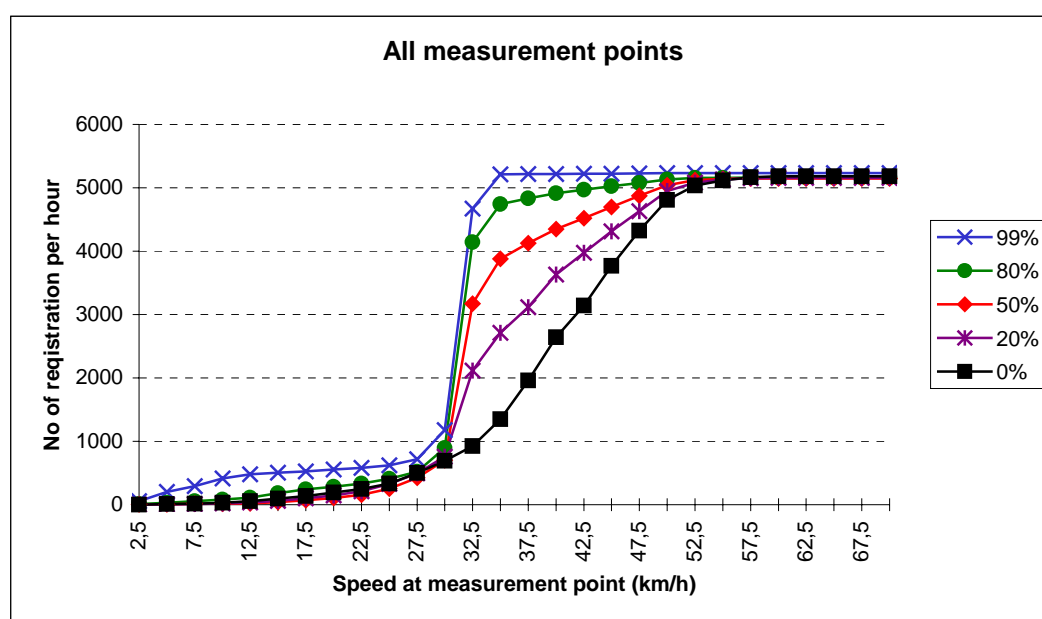


Figure 5.1: Cumulative speed distribution at different ISA implementation levels

Other developments

The ISA technique has only recently become feasible and so there are no other, directly comparable developments to discuss. At a broader level of discussion, the ISA demonstrations should be seen as an effort to meet the requirements of the transport policy, i.e. the zero vision, a decision taken by the Swedish parliament. Local parliaments and authorities have now absorbed the national objectives of safe traffic environment. Several cities, including the City of Gothenburg, are now involved in implementing physical measures in order to reduce accidents in urban areas. These physical measures are often costly and, so, it is hoped that alternative solutions,

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based on intelligent transport systems, should be more cost effective. The Swedish government has now decided that a large-scale demonstration with ISA should start 1999 and end 2001 with a total budget of approximately 10M Euros.

Implications for practice

Public authorities on safety quality management of public transport or transports pay the focus, e.g. taxi for elderly and school transports. The aim is to implement a GPS/digital map-based system on a fleet of public vehicles in Borlänge. The strategy behind the experiment is to use the principle that the buyer of a transport service is always right, i.e. if the buyer wants a safe (non-speeding) transport the seller should be able to have a quality management system to follow up the fleet safety performance. No change in legislation is needed to implement this strategy. In the City of Lund the same technology will be used for positioning. However, the system will not allow the driver to drive any faster than the speed limit using an automatic throttle. The main safety advantage is that the system is not a really an information system, more a control system that makes it impossible to driver faster than the speed limit.

In Umeå trials will be based on an information/warning system in which an alarm signal and a flashing lamp in the vehicle is activated when the vehicle goes faster than the speed limit. The information to the vehicle comes from a roadside transponder placed on the speed sign. The main user group will be private drivers and areas with 30 km/h speed limits.

As the two preliminary field trials in Umeå and Lund have shown good results, in terms of user acceptance and speed reduction for equipped vehicles, these cities will be the first to undertake a large-scale implementation. Each of the four cities will co-operate with SNRA in the implementation and evaluation of ISA.

Factors affecting benefits and transferability

In the Swedish TOSCA-II study showed a high potential in increased traffic safety when all vehicles are using ISA-technologies. One aspects that was not evaluated was the situation where only a portion of the vehicles where equipped and where many vehicle were still speeding. Compensation behaviour and the obvious risk of not getting the real dangerous driver to install ISA equipment needs could reduce the positive effects of ISA.

2.6 APPLICATION 6 - LOCALISED INTEGRATION OF PTS AND DIS

INCOME applications-

- *Using VMS to reassign traffic away from bus routes* - both Gothenburg and London have considered the use of VMS to advise drivers away from strategically important bus routes. This application is also included in the Turin 5T IRTE (Application 7).
- *Analysis of automatic enforcement of bus lanes* - illegal use of bus lanes by private traffic is being discouraged in London by capturing offences on camera with the threat of prosecution (Figure 6.1). Different filming methods have been used including (i) existing CCTV cameras, also used for monitoring traffic and for security and (ii) roadside video cameras, running only when bus lanes are in operation and cameras installed on buses. This latter method is integrated with the bus AVL system: when the bus reaches a bus lane the two bus-mounted cameras (one to capture the general traffic scene and the other to recognise vehicle number plates) are switched on; they are subsequently switched off when the bus leaves the bus lane, as determined by the AVL system. An initial review of issues and opportunities has been undertaken in INCOME, rather than direct involvement in implementation or evaluation.

Further information on these applications is given in ANNEX A.

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Figure 6.1 – An automatic enforcement camera in London

Evaluation methods

Using VMS to reassign traffic away from bus routes - the simulation models HUTSIM and RGCONTRAM were used to evaluate the effects of reassignment in areas of Gothenburg and London respectively. The Gothenburg study considered using VMS to advise drivers not to enter a congested area where buses run in conflict; the London study considered the effect of incidents on bus routes and how VMS could benefit these routes by diverting traffic onto alternative routes.

Enforcement of bus lanes - Technical evaluation of the enforcement system described above have been carried out successfully (externally to INCOME). Field trials are planned but have yet to take place.

Results -

The results of the Gothenburg study showed that:

- the VMS re-routed 200 vehicles per hour
- the red time for buses was consequently reduced (by the adaptive signal control system) by 6 seconds per cycle
- the resulting percentage delay saving was 21%

A potentially negative aspect of the scheme is that increased bus and vehicle speeds may adversely affect safety.

The results of the study in London were mixed, reflecting the location of the incident, the location of the main bus routes relative to the incident and the private traffic diversions initiated by VMS. Impacts of VMS on public transport were found to be positive or negative, depending on the situation. In general, VMS benefits buses on routes passing through the incident, where congestion is reduced by VMS, whereas buses on parallel/diversion routes may suffer increased delay due to diverting traffic. The net impact is situation-specific. Well-targeted

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VMS strategies could, therefore, offer significant benefits to public transport, whereas strategies focusing solely on private traffic could cause significant disbenefits.

Implications for practice

The comments given for Application 4 (Integration of variable message signs and UTC Integration) are also relevant here but are not repeated. This section contains additional comments related to public transport.

Infrastructure requirements

- VMS: the use of VMS for public transport does not require any additional infrastructure than that stated for 'normal' VMS (see comments given for Application 4).
- Enforcement: (i) video cameras mounted on vehicles or by the roadside, (ii) bus lanes.

Costs

- VMS (see comments given for Application 4)
- Enforcement - set-up costs: (i) infrastructure costs (see above), (ii) number plate recognition software
- Enforcement - running and maintenance costs: (i) maintenance of camera equipment, (ii) tape/film for cameras, (iii) processing of video data to produce evidence of offences, (iv) prosecution of offenders.

Factors affecting benefits and transferability

- VMS:
 - (i) The extent to which drivers will re-route. This will depend on the message given and how drivers perceive that re-routing is in *their* interests rather than the interests of public transport,
 - (ii) See comments given for Application 4.
- Enforcement:
 - (i) The number and type of violations (e.g. parking, moving etc.) taking place before and after enforcement, and the effect of violations on bus journey times.
 - (ii) The number of violations after the installation of camera enforcement will be directly linked to the *perceived risk of prosecution*. This will depend on the *visibility* of the system: drivers should be made aware that enforcement is in operation (e.g. static and/or variable message signs) and on the *credibility* of the system: drivers must know (or perceive) it to work effectively. Credibility (or lack of it) will develop with time and will be strongly linked to numbers of successful prosecutions.

Other implementation issues

- As with any VMS, messages must be chosen with care. In this application, the impact of vehicle re-routing on public transport routes should be anticipated prior to implementation.

2.7 APPLICATION 7 - INTEGRATED ROAD TRAFFIC ENVIRONMENT

INCOME applications-

- 5T
- Gothenburg socio-economic study

The integrated road traffic environment (IRTE) concept has been applied in Turin with the 5T (Telematic Technologies for Transport and Traffic in Turin) system. This integrates a number of sub-systems as illustrated in Figure 7.1:

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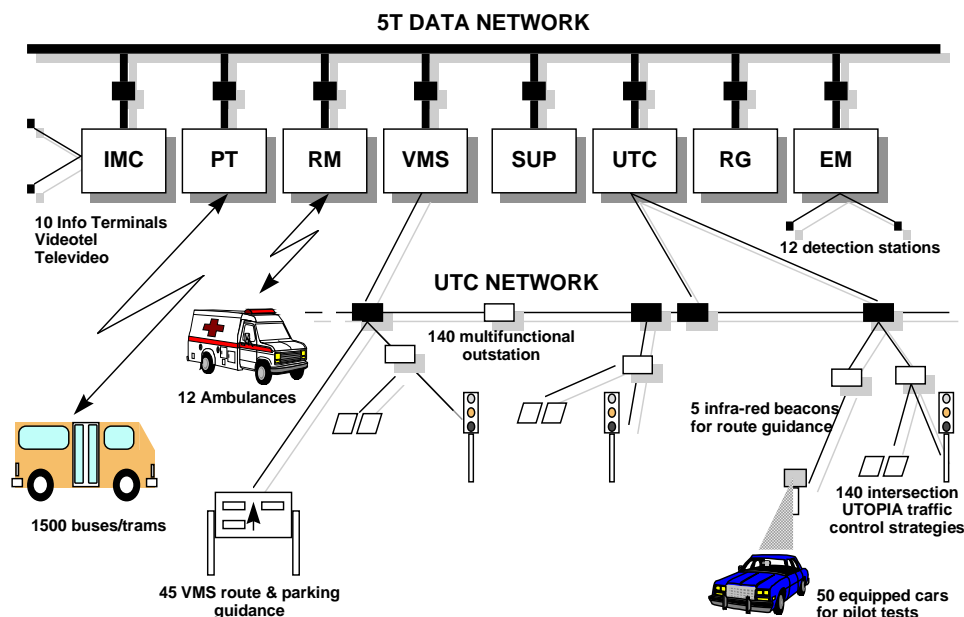


Figure 7.1 - 5T Open architecture schema

The **Town Supervisor** is the most innovative development of the entire 5T system. It supervises the functionality of each sub-system and integrates, in a hierarchically distributed structure, the actions of all of these modules by deploying a co-operative monitoring approach. Data (e.g. flows, travel times, etc.) from different monitoring sources (e.g. loops, public transport probe vehicles, etc.) are fused together facilitating improved network estimation. Good network estimation is important for traffic management and control. The INCOME project has also drawn on a useful socio-economic impact assessment of IRTE in Gothenburg, conducted by the TOSCA (Test-Site Oriented SCenario Assessments) project.

Full information on these applications is given in INCOME Deliverable D22.

Evaluation methods

- Full-scale field trials of the 5T system
- Passenger surveys in Turin
- Estimation and simulation methods for the Gothenburg socio-economic assessment

Results -

Travel demand and mode

There was evidence from the surveys of users of the 5T system in Turin that a modal shift had occurred of 3% in favour of public transport since the system had been switched on (approximately 10 months).

Modelling work in Gothenburg has estimated that, with appropriate IRTE policies, a modal shift from private to public transport (increasing PT usage by 9%) could be achieved.

Travel time and regularity

When compared to a before situation with no UTC, DIS or PT systems, reductions in travel times of general traffic and public transport vehicles of 21.6% and 19%, respectively, were achieved by the 5T system in Turin. There was also some evidence of an increase in regularity for both public transport and private trips.

The modelling work in Gothenburg showed that additional savings in journey times of 3% for public transport and 2.4% for private vehicles could be achieved through integration.

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Safety

No results on the impact of the 5T system in Turin on safety are available as yet. The modelling work in Gothenburg suggests that a reduction in accidents of 2% could be achieved through integration as a result of re-routing onto safer routes..

Environment

On the basis of the trial results and on the assumption that they are confirmed, it was calculated that the implementation of an integrated telematics system such as 5T could contribute to reduce pollutant emissions globally by 10% and locally by as much as 21% (of which 12% are due to environmental routing, 6% to better UTC and 3% to modal shift).

Modelling work in Gothenburg suggested that a reduction in pollutants of about 2% could be achieved through integration.

Implications for practice

Infrastructure requirements

Infrastructure requirements will depend on the users requirements. Typical elements of an IRTE system include:

- UTC
- Public transport priority
- VMS
- Network monitoring
- Environmental monitoring
- Emergency service provisions
- Media broadcasting of traffic information

Costs of integrating the individual systems

- Set-up costs - (i) identifying the potential areas of integration, (ii) designing, implementing and testing the interfaces between systems.
- Running and maintenance costs - (i) checking systems operations, (ii) day-to-day systems management.

Factors affecting benefits and transferability

The individual components of an IRTE will have benefits in their own right. The factors affecting additional benefits due to integration are:

- the usefulness of the shared data, i.e. can one component make good use of data from another ?
- reliability of the integration: robust data communications methods are required for an effective system,
- level of maintenance and monitoring: complex systems are liable to break down so regular care and attention is required.

Other implementation issues

- An *open architecture* approach is highly desirable, if not essential, for effective sharing of data between sub-systems. This will include a common communications protocol between computers.
- The implications of one or more sub-systems failing need to be considered, e.g. effects on other sub-systems, reliability, safety etc.

POLICY RECOMMENDATIONS

UTMS Implementation

The INCOME project has examined, developed and evaluated a range of integrated strategies for Urban Traffic Management Systems (UTMS) which can make a significant contribution to improving transport efficiency in European cities. The key policy objectives addressed with UTMS are to make best use of existing roadspace by efficient traffic management and control, with increased priority given to public transport, thus promoting a sustainable transport system.

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Urban Traffic control (UTC) systems are central to the control of traffic in most European cities and advanced real-time control is becoming commonplace. INCOME has demonstrated how UTC of this sort can now support a much wider range of policies and strategies than has traditionally been required from UTC, particularly when integrated with other forms of UTMS. Real-time UTC also generates valuable network state data through its substantial detection base which has much wider applications.

General policy recommendations for UTMS implementation arising out of the INCOME research are that:

- Public transport priority should become an integral part of UTMS in European cities, taking advantage of advanced UTC systems, new detection/location technologies and their integration. This policy emphasises the efficient movement of people and can provide substantial economic and environmental benefits.
- Driver information systems such as Variable Message Signs (VMS) can contribute to increased network efficiency particularly in conditions of unpredictable traffic incidents and can provide information to road users which has a value in itself.
- UTMS systems and strategies should be implemented with due regard to the needs and benefits of integration, to provide cost effective implementation to ensure that potential benefits of synergies between systems and strategies are exploited and to avoid strategy “conflicts”. This implementation can benefit from an open system architecture and the ability for a modular introduction of new systems/technologies within a framework where system performance can be optimised and verified at each stage.

Research and Development

The INCOME project has demonstrated the benefits of research and development on UTMS in the domain of traffic control integrated with public transport and/or driver information systems. These are each important applications under the control of Public Authorities where technological advances are providing continued opportunities for system improvements to better match Transport policy objectives. It is therefore considered that a continued research and development programme funded at European and national levels is fully justified, both to better understand the opportunities and benefits from enhanced deployment and to ensure that guidelines are available to City Authorities to implement UTMS most effectively.

Taking the INCOME applications as developed, a clear need for further technical research and development has been identified in a range of areas including:

- (i) Enhanced real-time network monitoring to optimally combine data from UTC, PTS and other sources to provide a common database for UTMS applications.
- (ii) Network management for public transport to include the integration of public transport priority at traffic signals, physical priority measures and other demand management measures for private traffic. Applications of network-wide public transport priority should be developed to take advantage of new Automatic Vehicle Location (AVL) technologies.
- (iii) The potential for greater use of ITS to improve public transport operations in an integrated way, including automatic ticketing, automatic camera enforcement systems and new information systems.
- (iv) Variable message sign applications, their objectives, impacts, deployment and potential enhancement to improve their effectiveness.
- (v) The further development and evaluation of Intelligent Speed Adaptation.
- (vi) Architectures and methods for the technical integration of UTMS applications.

Alongside these technical areas, there is also a need for further work on Organisational and Institutional issues to address situations where different organisations are responsible for different elements of UTMS, which can present a barrier for effective UTMS implementation.

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GLOSSARY

Abbreviations used

AVL	Automatic Vehicle Location
CCTV	Closed Circuit Television
DIS	Driver Information System
DGPS	Differential Global Positioning System
INCOME	Integration of traffic Control with Other MEasures
IRTE	Integrated Road Traffic Environment
ISA	Intelligent Speed Adaptation
PT	Public Transport
PTS	Public Transport System
UTC	Urban Traffic Control
UTM	Urban Traffic Management
VMS	Variable Message Sign

Traffic signal control systems used

SCOOT	Adaptive signal control (London)
ACL	Area control logic producing reference plans and weights for bus priority (Gothenburg)
BUS SCOOT	SCOOT with bus priority facilities included
SPRINT	Fixed time control with bus priority (London)
SPOT	Adaptive signal control, based on UTOPIA (Gothenburg)
UTOPIA	Adaptive signal control (Turin)
5T	IRTE system used in Turin (Telematic Technologies for Transport and Traffic in Turin)

Simulation models used

RGCONTRAM	R oute G uidance C ontinuous T raffic A ssignment M odel
HUTSIM	H elsinki U niversity of T echnology S imulation
TRANSYT	T raffic N etwork S tudy T ool
SATURN	S imulation and A ssignment of T raffic in U rban R oad N etworks
SPLIT	S elective P riority to L ate buses I mplemented at T raffic signals
STEP	S COOT T esting and E valuation P rogramme

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REFERENCES AND PUBLICATIONS

European Commission (1998A) CONVERGE Project TR1101, Deliverable D3.1.1 Part B, "VMS in Urban Areas - feasibility report for a potential cross-project collaborative evaluation study".

Hounsell, N.B., Farges, J., Fox, K., Friedrich, B. and Di Taranto, C. (1996(A))
Public Transport Priority at Traffic Signals: Results of a European Collaborative Study. *3rd Annual World Congress on Intelligent Transport Systems*, Orange County Convention Center, Orlando, U.S.A., Vol. 3, pp 1597-1602, October 14-18 1996.

Hounsell, N.B., McLeod, F.N., Bretherton, R.D. and Bowen, G.T. (1996(B))
"PROMPT: Field Trial and Simulation Results of Bus Priority in SCOOT". *8th International Conference on Road Traffic Monitoring and Control*, Conference Publication No. 422, IEE, London, 23-25 April 1996, pp 95-99.

Hounsell, N.B., Landles, J.R., Bretherton, R.D and Gardner, K.(1998) Intelligent Systems for Priority at Traffic Signals in London : The INCOME Project. *9th International Conference on Road Transport Information and Control*, Conference Publication No. 464, IEE, London, 21-23 April 1998, pp90-94.

Hounsell, N.B., Landles, J.R., Bretherton, R.D and Gardner, K.(1997) Intelligent Systems for Priority at Traffic Signals in London : The INCOME Project. *4th World Congress on Intelligent Transport Systems*, Berlin, 21-24 October 1997.

Hounsell, N.B., Landles, J.R., Bretherton, R.D and Gardner, K.(1998) Integrated traffic control and bus priority systems in London: Results from the INCOME project. *5th World Congress on Intelligent Transport Systems*, Seoul, 12-16 October 1998

Hounsell, N.B. and McLeod,F.N. (1998) "AVL and Bus Priority : The London System" *8th World Conference on Transport Research*, July 12-17, 1998, Antwerp, Belgium.

McLeod, F.N. (1998) "Headway-based selective priority to buses", *3rd Institute of Mathematics and its Applications International Conference on Mathematics in Transport Planning and Control*, April 1-3, 1998, Cardiff, UK

Hounsell,N.B. and McLeod,F.N. (1998) Automatic Vehicle Location: Implementation, Application and Benefits in the United Kingdom, *Transportation Research Record*, No. 1618, pp155-162, National Academy Press, Washington D.C.,1998.

INCOME DELIVERABLES

D2 - Recommendations and requirements for UTMS strategies

D3 - Evaluation methodologies

D14 - State-of-the-art review of urban traffic management systems, policies and strategies

D15 - Results of UTC/DIS strategy implementation and evaluation for London

D16 - Results of UTC/DIS strategy implementation and evaluation for Gothenburg

D17 - Results of UTC/DIS strategy implementation and evaluation for Piraeus

D18 - Results of UTC/PTS strategy implementation and evaluation for London

D19 - Results of UTC/PTS strategy implementation and evaluation for Turin

D20 - Results of UTC/PTS strategy implementation and evaluation for Gothenburg

D21 - Results of feasibility studies and evaluations of UTC/DIS/PTS strategies

D22 - Integration of results and recommendations

D23 - Dissemination and exploitation of results

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