THE URBAN ENVIRONMENT:
THE NEW CHALLENGE FOR DSRC

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ABSTRACT

Electronic fee collection systems that use DSRC are normally implemented on inter-urban highways. However, urban areas can be very different and can be highly constraining. This paper sets out the challenges and constraints which must be overcome when implementing a DSRC solution in the 'urban' context, provides a definition of the what is 'urban' and describes the work conducted by Transport for London (TfL) to define and assess Urban Charge Point solutions. Finally the paper presents a set of requirements for Urban DSRC which have been derived from consideration of the urban constraints.

KEYWORDS AND TOPICS

Aesthetics, Charging, Constraints, DSRC, EFC, Requirements, RUC, Urban

INTRODUCTION

This paper describes the work conducted by TfL (Transport for London) as part of the Technology Trials Programme to define the requirements for the Urban Charge Point and in particular the implications for DSRC equipment [1].

Electronic fee collection (EFC) systems that use DSRC are normally implemented on inter-urban highways (motorways and expressways). Referring to the use of "normal" DSRC installations and specifications, therefore, pre-supposes that the way in which they are implemented will be similar, or can be made to be similar to the inter-urban highway environment. However, urban areas can be very different and can be highly constraining. These constraints may affect the specification and implementation of DSRC EFC systems in these areas, such that there is a perceived need to be able to define DSRC requirements that are specific to the "urban" context.

URBAN CONSTRAINTS

Aesthetic Impact

The physical appearance of the roadside installations is a much more politically sensitive issue in urban areas than in inter-urban contexts. There are generally tighter restrictions as well as existing visual, environmental and historical contexts. Street furniture needs to be sympathetic to such contexts, including colour, style, size and location. Only rarely will it be possible to even contemplate the use of gantries and thick structural elements in these locations. This reflects the fact that many more people live and work in urban areas and they have some degree of ownership of that landscape. As a policy, road user charging is sensitive enough without the controversy associated with physical changes to the local built environment. Therefore, any system that is deployed in the urban environment must be discreet, have minimal impact and be sympathetic to the surrounding environment.

Chaotic Traffic Behaviour

The traffic characteristics in urban areas are different from inter-urban contexts, including much more chaotic patterns of movement and behaviour. The urban road can be just as much a destination as it is a through-route, for a wide range of people and goods. With road works, building works, parked or static objects, contra-flow bus lanes, slow traffic, overtaking and general chaotic driving behaviour in urban areas, there is often no real concept of a left or right hand "side" of the road, no real concept of a lane, and the potential for unusual manoeuvres (e.g. u-turns and reversing) at any location on the road at almost any time. Unlike inter-urban roads, urban thoroughfares have a very diverse range of traffic restrictions and traffic management measures on them, including segregated lanes, traffic islands, chicanes, barriers, rising bollards, road humps, textured surfaces, pedestrian crossings and roundabouts. There may also be greater congestion, leading to slow-moving, closely-spaced traffic. Finally charges may be applied which are direction dependant. Therefore, any system that is deployed should provide complete carriageway coverage for the monitored directions and have the capability to determine the direction of travel.

Diversity of Road Users

The range of objects using, or adjacent to roads in urban areas is different from inter-urban contexts, reflecting the greater diversity of travel activities taking place in urban areas. This includes a much wider range of powered and un-powered vehicles, pedestrians, static objects (e.g. refuse skips, parked vehicles, trees) and animals. It is also reasonable to expect that for any particular urban charging scheme there will be a mixture of DSRC tag equipped and non-equipped vehicles legally using the road, with potentially a relatively high proportion of non-equipped users. Again this reflects the fact that, as a destination, the urban area cannot always be by-passed, unlike most inter-urban routes and it is unlikely that all objects using the road will be subject to a charge.

Highly Variable Road Topology

The topology of a road in an urban area is much more likely to vary between different charge point locations than in an inter-urban context. Road widths are highly variable ranging from as little as 3m through to 5 or 6 lanes in each direction at busy intersections. Footways, narrowing roads, bends, skew junctions and roundabouts all reflect the extent to which urban roads are as much multi-purpose spaces between the buildings (and the subject of historical precedent and shared usage) as they are a thoroughfare designed to move traffic.

Figure 1 – Examples of Variable Road Topologies (courtesy of TfL)

Challenging Installation

With lower traffic speeds, urban roads are much more likely than inter-urban roads to have other physical structures immediately adjacent to, over and below the road / road surface. This will include railway lines, tram lines, power lines, telephone lines, buildings, sewers, ducts, water, gas and electricity supplies.

Figure 2 – The Challenge Below the Surface (courtesy of TfL)

The works involved in constructing charge points may require a degree of consultation with the owners of such assets in terms of disruption and future access. This creates straightforward physical as well as logistical and administrative challenges in trying to erect structures, tune performance and maintain systems. Ultimately this may limit the range of locations where charge points can be erected. It may also limit the range of engineering fixes that can be deployed at particular locations. The complexity of services beneath urban streets underlines the need for flexible positioning of communication zones and the desire to minimise the size of the cabinet and the associated equipment.

Electromagnetic Interference

Urban roads are much more likely to contain structures (e.g. building facades, cabinets, rubbish bins, lamp posts, trees, traffic lights, bollards), large vehicles (e.g. double deck buses, lorries, delivery vans, trams) and radio sources (e.g. consumer electrical equipment, business equipment, wireless communication equipment) that are capable of making the electromagnetic environment for DSRC considerably more complex than it is in inter-urban contexts. There is also the opposite interference problem to overcome – the potential for charge point equipment to interfere with equipment in homes, shops, offices, etc. Such equipment may be very old or defective. Any interference may not only be a nuisance or an inconvenience, solving it may present real engineering challenges and it may also fuel (possibly unnecessary) concerns about health and safety impacts of such equipment.

Health and Safety

Most people live and work in urban areas. The urban context changes the nature and extent of the potential exposure. On a regular basis, people will be walking under and potentially working, living and sleeping within range of the radio emissions from such equipment. The use of normal engineering fixes may also be restricted. For example it may not be possible simply to increase transmitter or transceiver power output to overcome localised problems. The DSRC specifications must take full account of the existing regulations, standards and recommendations to ensure the health and safety of urban road users as well as those performing maintenance activities.

Wider Policy Context

Unlike many inter-urban routes, management of urban road networks takes place within a broader social and transport policy context. Increasingly such policies are seeking to achieve a higher degree of integration of transport modes and to promote the use of public transport. New technologies and payment means are being developed and implemented to this end, such as contact and contact less chip cards and there is a desire to support ‘interoperability’ from the user’s, operator’s and central government’s perspectives.

DEFINITION OF URBAN

The definition of urban can be taken to be any location where some or all of the following constraints apply:-

- There is an existing aesthetic (e.g. architectural, historical) context;
- Many people not only travel past, but also live and work near to the installation; seeing and experiencing it close up on a daily basis;
- The physical proximity of people passing by and using shops, homes and offices nearby presents a different type and extent of exposure in terms of the health and safety characteristics of the installation;
- The road in the vicinity of the installation may be a destination for people and goods as well as a through-route;
- There may be no obvious left or right hand side of the road, no concept of lanes, and unusual manoeuvres will not be infrequent or illegal events;
- Frequently there may be slow-moving, closely-spaced traffic;
- The widest possible range of vehicles may use the road legally;
- The road in the vicinity of the installation may be occupied temporarily or permanently by a variety of static objects, such as trees and parked vehicles;
- Not all objects passing through the charge point will be eligible for the charge;
- The topology of the road may be highly variable from one installation to the next reflecting the spaces between buildings as much as the needs of the thoroughfare;
- The physical location and configuration of the installation represents a compromise between the needs of the DSRC transaction, of the local electromagnetic environment and of the existing local built environment both above and below ground; and
- The urban charging system, of which the DSRC element is a part, will be required to fit within a wider social and transport policy context.

DEFINING THE URBAN CHARGE POINT

A key part of the TfL Technology Trials programme [2] has been the definition and subsequent testing of an integrated Urban Charge Point which combines both camera based Automatic Number Plate Recognition (ANPR, including triggering) and DSRC subsystems mounted on a single pole, that provides complete carriageway coverage and monitors a single direction of travel.

The UCP provides three separate data streams to the central system; ANPR Passage Data, DSRC Transaction Data and Matching Data. The matching data stream provides an association between ANPR and DSRC events generated from a single vehicle passage, that is used to separate out image based events created by equipped vehicles from those created by unequipped vehicles. Currently three matching methods are being evaluated by TfL:-

- Spatial Matching – Matching based on Tag and Numberplate spatial-temporal localisation
- Declared Matching – Temporal Matching based on declared Vehicle Registration Mark (VRM) from the Tag and the ANPR result

- Lookup Matching – Temporal Matching based on VRM stored in a database and the ANPR result.

Figure 3 shows a schematic of a UCP and Figure 4 shows examples of UCPs implemented as part of the TfL Trials Mini-zone (which include additional monitoring equipment which would not be required for an operational system).

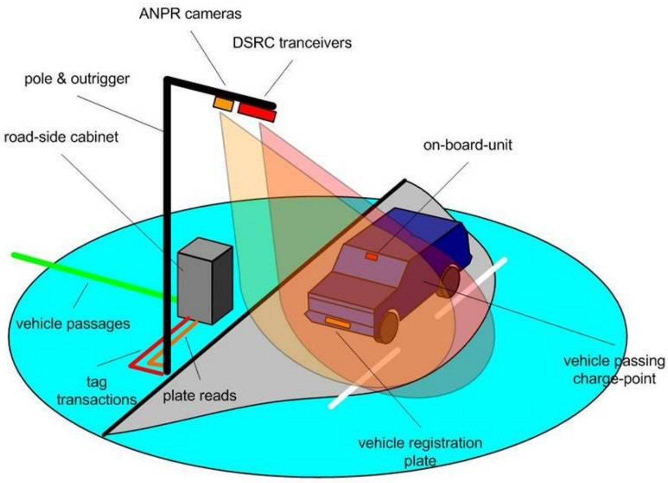

Figure 3 – The Urban Charge Point (courtesy of TfL)

Figure 4 – Three UCP examples from the TfL Tag & Beacon Mini-zone Trial

REQUIREMENTS FOR URBAN DSRC

The urban constraints identified have been used to derive a set of requirements for a DSRC installation in the urban environment.

Performance Requirements

Roadside DSRC transmitters, receivers and/or transceivers are needed that:-

(i) From an asymmetrically-mounted position above the road;

(ii) From shallower angles and/or from greater heights than normal (not less than 6m and up to 8m);

(iii) For vehicles travelling at speeds from 1-70 mph and in stop-start conditions;

(iv) While equipped vehicles are repeatedly parked in the communications zone for protracted periods (i.e. up to 1 month);

(v) While meeting the physical and functional requirements;

Can:

(a) Achieve appropriate coverage of the road (i.e. the communication zone(s) must cover the entire road width, with comparable performance across the full zone) for carriageways up to 12m wide from a single pole, and from two poles up to a maximum carriageway width of 24m;

(b) Complete transactions successfully for not less than 99.5% of equipped vehicle passages in the chargeable direction;

(c) Determine the location of tags accurately to within 1m [i.e. +/- 50cm] both longitudinally and laterally at the time of transaction, for not less than 99.5% of equipped vehicle passages in the chargeable direction;

(d) Determine a vehicle’s direction of travel correctly for not less than 99.5% of equipped vehicle passages, via the roadside DSRC equipment only and at UCP level;

Physical Requirements

Roadside DSRC transmitters, receivers and/or transceivers are needed that:

(i) While meeting the performance and functional requirements;

Can:

(a) Be as light as possible;

(b) Present the smallest possible, or the most aerodynamic, cross-sectional profile to minimise wind loading;

(c) Be available in various colours;

(d) Appear as small as possible to minimise visual impact;

(e) Be associated with roadside cabinets that appear as small as possible to minimise visual impact.

Functional Requirements

Roadside DSRC transmitters, receivers and/or transceivers are needed that:

(i) While meeting the performance and physical requirements;

(ii) While equipped vehicles are repeatedly parked in the communications zone for protracted periods (i.e. up to 1 month);

Can:

(a) Act autonomously to prevent the rapid drain of tag battery power or be capable of providing information about tag identities that have been in the communication zone for protracted periods (as defined above), and the length of time they have been there;

(b) Trigger other sub-systems (e.g. vehicle detection, classification or image capture) based on DSRC event information;

(c) Be capable of being re-configured via remote control (i.e. without requiring physical access to the transmitters, receivers and/or transceivers at the urban charge point) to optimise the DSRC communication zone to the specific conditions of the UCP location, including equipment alignment and/or electromagnetic adjustment;

(d) Supply time stamp information for DSRC events to all interlinked roadside systems accurate to 0.1 seconds and consistent to within 2 seconds over a 7 day period;

(e) Be capable of synchronisation with a central time source / signal (to maintain a time and date across all interlinked systems) accurate to 1 second and consistent to within 5 seconds over a 7 day period;

(f) Be capable of synchronisation with other devices within the UCP (to maintain consistent time-stamping between devices at the UCP) accurate to within 10 milliseconds.

CONCLUSIONS

It cannot be assumed that DSRC equipment and configurations suitable for the interurban environment can be applied without modification in the urban environment. Careful consideration must be given to the applicable urban requirements and constraints which can have a significant impact on the resulting installations. The impact of the minimisation of the visual impact, as a key constraint, has been illustrated in this paper through the example of the development and testing of the Urban Charge Point as part of the TfL Technology Trials Programme. These trials have demonstrated that DSRC solutions have the potential to be deployed successfully in the urban environment.

ACKNOWLEGEMENTS

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