Cardiff's real-time information system for bus passengers

Cardiff is home to the largest deployment of GPS-based automatic vehicle location technology for buses services in Europe. Surprised? ***Robert Bain*** *was when he went to meet* ***Reg Hill****, Cardiff County Council's Telematics Manager, to discuss the bus tracking, traffic signal prioritisation and real time passenger information capabilities of their system*

This first of two articles explores the development and operation of the technology, and the broader context within which it has been deployed. Next month we report on details of the technology itself and on an independent evaluation of the system's performance.

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AN INTEGRATED APPROACH TO TRAFFIC CONTROL

Cardiff was an early adopter of technological solutions to its transport problems, establishing a citywide urban traffic control (UTC) system in the mid 1970s, soon followed by the installation of CCTV cameras for traffic monitoring purposes. Perhaps the greatest incentive to embrace Intelligent Transport System (ITS) applications came from a recognition, at the outset, of the cost effectiveness of a number of technology-based measures when compared to traditional traffic management/engineering solutions.

A further incentive to explore technology to the full came in the shape of a £70M hole in the ground! In 1995 the County Council decided that, in order to complete an important link in the City's highway network without causing community severance, an 800m, twin-bore tunnel – the Butetown Tunnel – should be constructed, together with a state-of-the-art computerised control centre. This presented an opportunity to integrate the two traffic control functions and their related technologies within one facility, managed as seamless systems through the employment of a common user interface.

Subsequently, local applications of the National Motorway Communication (signing) System (NMCS) have been integrated within the Tunnel and Traffic Control Centre, and the CCTV technology has been updated (to almost broadcast-quality) and extended to include 150 cameras around the city. Some of these cameras are 'crime' cameras, for police use, however all of them – crime cameras, traffic cameras and tunnel cameras – feed into the control centre along an extensive fibre optic network; the police camera images then being retransmitted to Cardiff's central police station. The Tunnel and Traffic Control Centre operates 24-hours a day, seven days a week.

The integrated approach adopted by the County Council required liaison and partnership with a number of stakeholders (the emergency services, the Welsh Assembly and local bus companies, for example) and, over the years, these relationships have strengthened. Reg Hill identifies this as key to the success of many 'hi-tech' projects, and it certainly played a central role in the ambitious plans to install an extensive bus priority and real-time passenger information system in just six months!.

VEHICLE TRACKING AND REAL TIME PASSENGER INFORMATION

The vehicle tracking and real time passenger information technology lies at the heart of a package of measures designed to enhance the role of local bus services in Cardiff. Other components include bus priority measures (including traffic signal prioritisation), bus boarders and an advertising-based, revenue-generating contract to upgrade and maintain bus shelters.

In terms of vehicle location systems, the Council discounted 'tag and loop' or roadside beacon solutions in favour of the differential GPS alternative [see separate text box], as it wanted to retain the ability to know where the buses were at any particular point in time (and not just when the bus happened to be at a specific location on the network).

The timescale was daunting. Reg Hill and his team got the 'go ahead' in February 1999 for a system deployment along Cardiff's northern corridor. Subsequent to competitive tendering, Advanced Communications and Information Systems (ACIS) was awarded the £1.7M system supply, installation and maintenance contract in April 1999 and the equipment had to be fully functional in time for the Rugby World Cup final that October. And it was, despite the challenges presented by the scale of the procurement, the need to bring five bus operators (with different systems) together, the fitting of the on-bus equipment, the integration of the vehicle location technology with the Council's SCOOT system, a considerable data entry requirement and the

Council's high priority to meet the needs of visually impaired people through audio support facilities – in two languages!

SYSTEM ARCHITECTURE

The system is comprised of 191 buses – representing 43 different routes – equipped with DeltaTrak on-board computers, 46 signalised junctions that can be called upon to give priority to buses and 120 shelter-mounted, real time passenger information displays. The DeltaTrak unit contains the GPS receiver and interfaces with various on-vehicle systems including the bus's radio transceiver. Buses are 'polled' every 20 seconds, updating the real-time passenger information databases and the bus's position on a digital map back at the control centre.

In addition, using the GPS information, the bus can automatically register its position within a virtual trigger zone – requiring no detection infrastructure – on the approach to signalised junctions. Precisely what happens then is the detailed subject of next month's article but, in short, the bus can (intelligently) communicate with the signal controller to 'call' the priority required; monitored and controlled within the SCOOT framework.

The shelter-based passenger information monitors are three-line LED displays. The top line gives the route number, destination and time-til-arrival (in minutes) of the first bus. The second line gives the same for the subsequent bus. Note that this is the 'real' time-til-arrival; not simply what the schedule promises. The third line generally displays public information messages. All information is provided in English and Welsh.

Interestingly, the passenger information monitors store bus service schedules, process data and operate independently from the control centre – although they can receive data from the control centre as required. The monitors receive data from an approaching bus and their inbuilt intelligence predicts the time-til-arrival, replacing the timetabled time with a prediction.

Since installation, one of the biggest resource commitments has been devoted to updating the databases, particularly when the bus operators make timetable changes. For this, the Council is leaning towards the ATCO CIF format (see http://www.users.

globalnet.co.uk/~jplanner/datag.html) to ensure that data is prepared and managed to a standard format.

Above: The Tunnel and Traffic Control Centre – additional functionality is already planned'

Left: The building of the Butetown Tunnel in 1995 presented an opportunity to integrate two traffic control functions.

NORTH, EAST AND WEST

Having completed the northern corridor, the Council has recently turned its attention to another main radial feeder coming into Cardiff – this time from the east. Reg points out that, having established the central components of the system architecture, a planned programme of expansion can be rolled-out incurring only incremental costs. At present, DeltaTrak units are being fitted on a further 90 buses, 46 additional bus priority units are being installed at signalised junctions and nearly 110 more shelters are being equipped with passenger information displays. It is hoped that a western corridor will follow suit, making the system countywide within the next 18 months.

Local bus users have responded very well to the real time passenger information service and the County Council has hosted a series of technical visits from officers and members from around the country – keen to learn from the pioneering work in Cardiff.

AMBITIONS FOR THE FUTURE

Cardiff's real time passenger information and bus priority system has to be viewed within the broader context of the County Council's commitment to ITS. 'We see technology-based solutions as central to our ability to deliver our Local Transport Plan', says Reg Hill – who is already planning to extend and add additional functionality to the Traffic and Tunnel Control Centre. Further improvements to the incident detection and management system will be made possible through access to more CCTV cameras - probably mobile facilities co-ordinated with the police - and a huge expansion to the number of variable message signs will help to guide motorists around the network while minimising congestion and delay.

As for information services, it is the Cardiff bus user who stands to gain most. The real time information infrastructure already in place lends itself well to developments such as display

The shelter based passenger information monitors give 'real' time-til-arrivals, not simply what the schedule promises. They operate independently from the control centre.

screens in key public places and a related internet site is already at an advanced stage of design. The Council intends to expand its audio capabilities for the visually impaired, making them more comprehensive and is looking to possibly extend the range of facilities made available at bus shelters.

However, it is in the field of mobile communications where some of the most exciting developments may take place. A phone that rings you to tell you that your bus will be arriving at a particular stop at a particular time is a vision of the near future shared by a number of key people in the Welsh capital.

GPS-Equipped Bus Agencies in NA

Early in 2001, the author conducted a survey of bus companies in North America to learn from their experiences with automatic vehicle location (AVL) technologies. Various bus tracking technologies have been employed in the US and Canada since the late 1960s and some transit agencies have invested considerable sums of money ($10M+) in their acquisition and development.

The results from the survey make sobering reading. In summary:

- The agencies invariably underestimated the ongoing commitment and resources required to maintain and update their systems.
- The levels of employee indifference or resistance to the use of vehicle tracking and monitoring systems were high.
- The agencies acknowledged that they did not have the in-house skills to make full use of the technology.
- Agencies stated that they had moved from a situation in which they had no information about what their buses were doing, to a situation (now) in which they had so much data they did not know what to do with it.
- There had been little (any?) rigorous evaluation of the costs and benefits associated with such systems.
- Despite ambitious procurement specifications, most systems operate – on a day-to-day basis – at the lower end of the functionality spectrum.
- The majority of vehicle location systems were specified as part of a complete communications system upgrade

The author's report concludes that:

'Radio infrastructure is expensive to replace, however estimates from the 2001 survey suggest that AVL-related costs can increase communication system replacement costs by around 25%. At the level of functionality currently being employed, one wonders whether the passenger is benefiting fully from that additional investment?'

Copies of this report can be obtained from rbain@its.leeds.ac.uk

GPS in Summary

What do missile precision targeting systems and Cardiff Bus have in common? GPS! The GPS (Global Positioning System) was originally developed by the US Department of Defence to provide navigation capabilities for military ground, air and sea forces. Today civilian applications outnumber military ones by more than 10 to 1.

The system uses 24 orbiting satellites, essentially transmitting time-coded signals to your hand-held (or on-bus) radio receiver. If you know when the signal was sent and the time it arrived, and you know the speed at which radio waves travel (approximately 300,000km/s) then you can work out your distance from the satellite. Using a process similar to triangulation (trilateration), you can theoretically locate your position when you have a 'fix' on three satellites. In practice, a fourth satellite is brought into play to resolve the receiver's clock error – giving you the time-accuracy of an atomic clock for under £100.

The positioning accuracy of a typical civilian receiver was, until relatively recently, around 100m. However, on May 1st last year, the Department of Defence switched off a procedure specifically designed to degrade the accuracy of civilian GPS receivers – improving the accuracy to around 15 – 25m. Most commercial bus tracking systems use a commonly employed trick called differential correction to improve that figure to around 5m. Differential correction uses a local base station – fixed at a site with a known position – to detect system errors and then feeds those errors back into the system as a form of error correction mechanism. The positioning accuracy of military-grade receivers is impressive beyond the needs of the average bus company. In early tests, a conventional air launched cruise missile (CALCM), guided only by GPS, successfully struck its target after a 4? hour flight - demonstrating precision strike capability.

An excellent and very readable introduction to GPS (and related tutorial) can be found at:
www.trimble.com/gps/index.html