The E470 Expressway tolling system uses UK traffic technology

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Drivers using the just-completed final eight miles - US 85 to Interstate 25 - of the E470 Expressway, Denver, Colorado, USA can complete its 47-mile overall length in about 40 minutes, their $8.50 toll collected reliably and efficiently thanks to Idris® technology developed in the UK. Idris - originally standing for Incident Detection for Road Informatics and Safety - is the wholly owned and patented technology of Diamond Consulting Services Ltd (DCS). The technology, which was originally designed to detect stationary vehicles in tunnels, has since been refined to provide accurate data about vehicles for tolling, monitoring and enforcement purposes.

PATENTED TECHNOLOGY

In tolling applications, Idris works by using sophisticated algorithms to analyse data collected through loops installed beneath the carriageway. Each vehicle passing over the loop site creates a unique 'signature' identifying the type of vehicle and allowing its progress through the system to be monitored and differential tolls to be levied.

The Idris algorithm and two induction loop designs - figure-of-eight and coil-in-coil - used for axle detection applications, are all unique to the Idris technology and are protected by patents.

When axle detection is not needed for tolling, Idris can work with existing loop infrastructure such as the UKHA's MIDAS and D17B0 loops. This additional key benefit makes Idris very cost effective in the collection of data for all other applications, utilising the thousands of standard loops which are already installed on highways throughout the world.

Idris technology delivers very high accuracy in the most adverse conditions. It is not affected by bad weather such as fog, rain or electric storms. It copes with slow moving or queuing traffic, with lane changing and straddling, and with high speed traffic and tail-gating. Axle class accuracy for tolling is 99.8%, count accuracy in congested traffic is 99.9% and in free flow traffic 99.5%.

STRAIGHTFORWARD TOLLING

Deployed on all new lanes of E470 Expressway, Idris now makes both ACM (automatic coin machine) and manual toll collection straightforward. But this might not have been achieved without the trouble-shooting skills of DCS. The company was brought in two years ago, during the earlier stages of construction, when Denver's E470 Highway Authority was struggling, following parting company with its former systems integrator.

At that time the Authority needed help with the modification of the lane controller for new ramps (slip roads) and approached Bob Lees, one of the founding partners of DCS, who had worked with the previous

Test loops at the toll plaza, and (right) a manual lane

Vehicles at the manual lanes

systems house to deploy Idris on to the lane controller.

The immediate need was to overcome the progressive loss of real-time monitoring and its implications for lane availability and maintenance. Without such monitoring, correct lane operation, and thus revenue collection, could only be checked by E470 staff driving regularly along the road.

In just two days Lees had reinstated real-time monitoring across the system, to the considerable satisfaction of the Authority's Toll Collection Systems Manager, Benton Tempas, who had been quoted up to $1 million to fix the problem by other contractors.

But this was only the first of the legacy issues DCS went on to tackle and was followed by a review of the entire system from the lane end through the Toll Plaza and up to the Customer Service Centre - including basic operations, redundancy, equipment failure rate, maintenance costs and availability.

TWO-YEAR TRANSFORMATION

In the ensuing two-year period the company's contribution has included making the code base common to the three lane types - Manual, Ramp and Express - instead of three separate source code trees, and separating the input/output devices from the single-lane process.

For example, AVI (automatic vehicle identification) and VES (vehicle enforcement) were divided into sub-systems, such that new sub-systems can be incorporated without affecting lane operation. The system now supports SAIC and Pulnix VES without changes to lane code rather than one large lane process with multiple threads run on LynxOs, as previously.

The ACM communications and operations have been improved for proper remote control. Starting with Express, all lane types have been progressively converted from LynxOs to GNU/Linux. Other modifications include removing extensive hard code parameters, allowing easy configuration via ASCII text files. Previously new lanes could only be added to the Plaza by re-compiling its code.

With this now well documented performance record the Authority, with the help of DCS, has continued to roll out the Idris technology, which was originally only fitted to the remote ACM/interchange lanes, retro-fitting it to all Express lanes and deploying it on all new lanes - Express, ACM and Manual.

SIMPLIFIED AND INTEGRATED

Benefits include the Idris processes and lane controller running on a single computer, reducing component count and maintenance costs. The previous single lane controllers for the Express lanes - dual, non-divided lanes with a fullwidth shoulder running at highways speeds - have been converted to multilane operation with straddle detection. Overhead separators and treadles have been made unnecessary.

AVI tag correlation is now performed more reliably in the Express lanes, generating a 10% plus revenue improvement. This is achieved through more accurate vehicle detection and tag to vehicle correlation.

Tolling enforcement is carried out by photographing the license plates of offending vehicles. This Vehicle Enforcement System (VES) requires a trigger to activate the camera. In order to maximise the capture rate of violators' licence plates the trigger position is required to be precise in all traffic conditions and for all vehicle types.

The Idris trigger is accurate to within +/- 30cm, but typically delivers accuracy of +/- 15cm for all vehicle - speeds from stop-go to in excess of 100mph - and for all vehicle types from the smallest car to the largest truck. This ability to provide an accurate trigger applies equally in single and multi-lane applications.

RESILIENT OPERATING SYSTEM

'We prefer GNU/Linux to other operating systems because of its resilience and good development facilities,' explains Bob Lees of DCS, who has carried out all the on-site work and collaborated on the technical issues with his brother Andy, a systems engineer and largely responsible for the company's research and development.

'Compared with LynxOs, for example, a key benefit of GNU/Linux is its better device support,' he added. 'Whilst Idris and a lane controller are real-time applications, the latest Linux kernel, with appropriate pre-emptive patches, offers a very responsive system. We had no hesitation in recommending the E470 Authority to migrate their complete back-end operation - lane, Plaza, host and CSC systems to Linux.'

Smart award enables company to come up with smart technology

In 1998 DCS secured a £30,000 Government Smart Award towards a £100,000 programme to develop the innovative loop-based vehicle axle classification system.

This resulted in two new patents - for the coil in coil and figure of eight shaped loops - being added to the original patented algorithm. The accurate detection of axles and other distinguishing features enable the identification of cars, commercial vehicles, motorcycles and other vehicle types, using classification tailored to individual applications or locations.

'This funding helped us to develop the technology into a world-beater and has this year led to DCS winning a UK Government-sponsored Smart Achievement Award, recognising our success in developing the technology from its R & D phase through to effective commercialisation,' says Fiona Lees, a founding partner of DCS.

DCS has become an important and valued member of the E470 team, according to Benton Tempas. 'The benefits of working with a small, hands-on consultant, with skills complementary to our own staff, have been immense,' he comments.

INSTALLED BASE SET TO GROW

Benton Tempas is not alone in his positive assessment. Well over a dozen other highway and governmental authorities responsible for commissioning installations in Alaska, Delaware, Florida, Texas and elsewhere in the US have all chosen the Idris Technology, mainly for tolling, but also for data recording.

In Europe, applications, also for tolling, include Portugal and Croatia, and for DBFO (Design, Build, Finance & Operate) installations in Spain and Madeira.

Originally designed to detect stationary vehicles in the Penmaenbach Tunnel, as part of the A55 North Wales coast road update, and later evolved into a similar system for use in the tunnels at Heathrow Airport, the technology has been refined by DCS to provide accurate data about vehicles for tolling, monitoring and enforcement purposes under any traffic and weather conditions. UK installations include DBFO applications on the A19, A30, ASO and A130 and bus detection systems in major towns and cities such Birmingham, Leeds, Leicester, Manchester, Oxford and many others.

Building on their experience with Colorado's E470 and these other installations DCS believe Idris is poised for even greater success when the UK Government gives the green light to more tolling projects.

* Idris is a registered trade mark

Design objectives validated

When Idris was being developed loop detectors typically registered count errors of about 1 in 100 and measured a vehicle's speed and length only if it was that correctly in lane. At that time loop detectors counted one vehicle straddling two lanes as two vehicles unless special loop arrangements were installed.

The Idris Enhanced Detection Specification design goal was set at count errors of better than 1 in 1,000 in congestion. It also had to deliver a vehicle's accurate speed and length irrespective of lane position, operate reliably in all traffic conditions, and deal efficiently with straddling vehicles, using standard loop installations of 2m square loops, 4m leading edge to leading edge.

Initial trials to prove the prototype equipment were staged at a test site on the A34, a two-lane carriageway of free-flowing traffic. Two outstations were then prepared for exhaustive trials on a congested site, in the most difficult situation.

The UK HA co-operated in traffic measurement trials conducted on the M25 clockwise between junctions 15 and 16. More than 50 hours of data was collected in the two-week trials period, covering a full range of conditions including free flowing, stop-start and congested traffic on the carriageways and across all four lanes.

Traffic manoeuvres identified included vehicles straddling two lanes, tailgating and changing lane at 45 degrees in congestion over the loop site. Using the Idris automatic validation process the results revealed error rates of less than 1 in 20,000 during free flow situations and less than 1 in 3,000 excluding motorcycles, in heavy traffic congestion.

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