On Minnesota’s MnPASS Express Lanes on I-394 and I-35W, rates are determined based on the number of vehicles in a lane, the speed of the vehicles as well as the rate of change of traffic conditions.
In the drive toward smarter tolling charges, sophisticated pricing algorithms are being rolled out to better reflect supply and demand on the ground. This is especially evident in the case of urban high-occupancy toll (HOT) lanes, which are regarded by an increasing number of DOTs and agencies as a highly effective way of smoothing operations on their existing roadway infrastructures.

Minnesota DOT is one of the leading exponents of dynamic pricing, as shown by its MnPASS Express Lanes on I-394 and I-35W, both of which serve downtown Minneapolis. I-394 originally went live back in May 2005 and was a conversion from high-occupancy vehicle (HOV) lanes to HOT. “Following the success we experienced on I-394, we turned our attention to the I-35W corridor,” reveals Brian Kary, freeway operations engineer at MnDOT. “The first phase opened in September 2009 and was followed by the second in November 2010,” he says.

I-394 and I-35W are bidirectional corridors during peak inbound and outbound periods, which makes them ideally suited to the HOT lane concept: “They initially had carpool lanes,” Kary adds. “Unfortunately they were only operating at half the anticipated volumes, with just 1,000 vehicles in the peak hour.” Having converted to HOT, single-occupant users can now pay a fee to take advantage of that spare capacity, and in doing so enabling MnDOT to move more vehicles on the critical arteries: “For each lane we are probably seeing another 400-600 vehicles an hour on top of the normal carpool,” Kary estimates.

MEASURE FOR SUCCESS
As to the finer details relating to actual pricing, the MnDOT traffic engineer reports that aside from some minor tweaks, the department is essentially running the same algorithm today as it did on day one: “We apply dynamic pricing to control the

ADDRESSING THE PITFALLS AND PRACTICES OF DYNAMIC PRICING SCHEMES

There are numerous critical elements that need to be factored in to the equation in order to keep the wheels of dynamic pricing turning on today’s high-occupancy toll lanes.
number of vehicles that go into each HOT lane in order to keep it flowing, as well as to ensure capacity isn’t exceeded,” he explains. The MnDOT algorithm has been set up to only take account of traffic detected in the HOT lanes themselves. “If demand is low, the price goes down and if it’s high, it increases; different thresholds are set based upon the level of service and that is crunched in a table to establish what a particular price should be.”

For the most part the algorithm works fine, Kary suggests. The only real significant change along the way has been to raise the prices slightly after around three months. “They were initially too low so at the upper end folks were deterred from using the lanes, hence there was a risk of creating wider congestion.” But of course there’s a flipside to that scenario. Underlining the balancing act that dynamic pricing presents, at the low end Kary points out that some people simply weren’t moving into the HOT lanes because they failed to see the value of doing so. “If the toll was only priced at say 25 or 50 cents, for example, drivers took this to mean the general-purpose lanes were fine so they just stayed where they were.”

**LESSONS LEARNED ON I-85 EXPRESS LANES**

When the State Road and Tollway Authority developed a US$56m HOT lanes facility in the Metro Atlanta area – the I-85 Express Lanes – certain parameters of the pricing algorithm were tweaked, leading to motorists realizing lower toll rates by day four of the opening.

Central to the ongoing success of the project – and one of the hurdles that SRTA executive director Christopher Tomlinson (pictured left) acknowledges was a real learning curve for him and his team along the way – was how best to implement dynamic pricing on the route. “On the first three days we received feedback that the prices were simply too high,” Tomlinson recalls. “In our case we look at data coming from the general-purpose – non-tolled – lanes as well as our HOT lane.” Initially there was more of an emphasis placed on the traffic volume and level of congestion in the general-purpose lanes. “The rationale here was that if you look at the level of congestion in the non-tolled lanes, it should be a fairly good indicator of the anticipated demand to use the toll lane,” Tomlinson says. Although he still believes this to be a valuable approach, Tomlinson acknowledges SRTA should have more closely balanced the amount of people who had transponders and the volumes in the managed lane. “We saw a relatively high price because the general-purpose lanes were congested and it was showing what we thought the anticipated value of a trip was at free-flow conditions during that time.” The remedy SRTA implemented was to adjust some of the pricing parameters. “We changed the emphasis to focus on the volume in the HOT lane itself and that immediately dropped the price because there were relatively few cars in the lane at that time.”

Overall, Tomlinson is positive about the impact that the I-85 Express Lanes project is having two years on, with transponder and trip numbers at an all-time high. “There were 75,000 Peach Pass transponders in circulation when we opened; now we are at more than 250,000 and we’re set to surpass our 10 millionth trip in the lanes. We continue to set record numbers of daily trips at around 20,000, which contrasts with just 7,500 in our first month of operation.”
TRAFFIC SIMULATIONS
From Kary’s perspective, I-35W and I-394 are far from the end of the dynamic pricing journey for MnDOT with – if all goes according to plan – further potential to open MnPASS HOT lanes on the I-35E just north of downtown St Paul by November 2015.

In addition to this, Kary is acting as the technical liaison for MnDOT in ongoing research being conducted with the University of Minnesota on the so-called MnPASS Modeling and Pricing Algorithm Enhancement study, which is looking to develop and calibrate a microscopic traffic simulation model that can accurately depict MnPASS operations.

If systems such as Minnesota’s MnPASS Express Lanes were deployed universally, congestion could potentially be a much rarer occurrence.

“ALTHOUGH TECHNOLOGY ENABLES IDEAS ON PRICING TO BE IMPLEMENTED, IN ONLY A FEW CASES IS THE EFFECT ON A DRIVER’S LANE CHOICE FULLY UNDERSTOOD”

John Hourdos, director of the Minnesota Traffic Observatory, University of Minnesota, USA

The principal investigator for that project is the University of Minnesota’s John Hourdos, director of the Minnesota Traffic Observatory, who feels that even today HOT lanes are still a relatively new concept. “Although technology enables ideas on pricing to be implemented, in only a few cases is the effect on a driver’s lane choice fully understood,” he suggests. Given this knowledge gap, Hourdos says the project is aiming to not only understand and improve the MnPASS pricing algorithm itself but – at a more holistic level – to build a simulation tool for testing and evaluating a pricing strategy on any freeway (see Effective measures sidebar).

“The MnPASS algorithms were first set up in 2004,” reveals David Levinson, who in addition to being the co-investigator wanted to see how sensitive demand is to price,” he adds. “It turns out raising the price attracted more users. Our belief is that people are actually using the price as a signal of the time savings as they have no other way of gauging the situation. So when the price goes up, they think they’ll save more time so consequently people on the margins are more likely to use the system.”

MAXIMIZING CAPACITY
Way out west, Washington state is home to the SR 167 HOT Lanes project, which is also built around a dynamic pricing model where the pricing adjusts to ensure the lanes remain free-flowing. Now in their fifth year of operation, the lanes offer sole drivers the option of using what are otherwise HOV lanes.
Tyler Patterson, toll operations engineer at Washington State Department of Transportation (WSDOT) says the conversion was an attractive option since adding extra lanes wasn’t practical nor was it cost-effective in most areas of the network: “Our idea was to better use our existing infrastructure, to move more vehicles and ultimately more people. We began looking around and then the HOT lanes concept started to gain momentum.” Similar to the situation in Minnesota, the HOV lanes on SR 167 were underutilized. “I think we were at about 1,000 vehicles per hour in the HOV lane when our car-carrying capacity was something nearer 1,900,” says Patterson.

As to how the dynamic pricing implemented by WSDOT is calculated, Patterson says the key is looking at speeds and volumes of traffic and paying particular attention to how that changes and, crucially, the absolute value. “It’s actually a rolling five-minute average. We did struggle to get the price to come down after the morning peak. The trailing-off of the volumes was so small that the change for every five-minute increment wasn't enough to trigger our algorithm to lower the price, hence we had to put in something that we refer to as ‘the depressor,’” Patterson reveals. “This essentially looks at the absolute volumes and acts as a kind of ‘reality check’.”

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IN THE RIGHT LANE
Increasingly popular though dynamic pricing may be, what’s clear is that the roll-out of the initiative is not without its complexities and challenges. The good news for agencies considering going down the HOT lane route themselves, however, is that we know far more today about how algorithms can be applied and refined to keep prices at the appropriate levels for the HOT lane conditions than we did five, four or even as little as two years ago. We are also now acutely aware of the need to assess whether looking at what is happening in adjacent lanes is actually going to be a help or hindrance to this process, as well as – vitally – the importance of ensuring that drivers feel they are being treated fairly as prices rise and fall.

Annual performance reports on WSDOT’s SR 167 HOT Lanes indicate significant increases in volume as well as speed, showing the positive effect on higher vehicle throughput and reduced congestion

At the heart of the SR 167 HOT Lanes project is the formula-driven, predictive RITE Dynamic Pricing Module that calculates the toll rates

“PEOPLE ARE ACTUALLY USING THE PRICE AS A SIGNAL OF THE TIME SAVINGS AS THEY HAVE NO OTHER WAY OF GAUGING IT”

David Levinson, professor of Civil Engineering, University of Minnesota, USA

Jaimie Sloboden, senior simulation manager at Cambridge Systematics, is well acquainted with the concept of dynamic pricing, having been involved with 95 Express in Miami, Florida.

More recently, the Massachusetts-based company has worked on toll express lane projects in Washington State and Colorado. “Our independent study for the eastside corridor in Washington (an extension of the SR 167 HOT Lanes) went into the revenue and operational risks for express toll lanes,” reveals Sloboden. After being given a tolling policy from WSDOT, Cambridge Systematics then developed a pricing algorithm to meet the policy to use with its microsimulation analysis of the corridor.

Sloboden says one of the ‘takeaways’ coming out of Cambridge Systematics’ work with DOTs – as well as from being a partner on an FHWA research project investigating dynamic pricing algorithms – is that there isn’t much consistency across the USA in terms of the overall approach. “It’s an emerging market and everyone is still trying to figure it out – every corridor is different, even in the same metropolitan region,” he says. Ultimately, Sloboden feels it’s vital for an agency to understand the pricing objectives (maximize revenue or mobility, for instance), understand the minimum and maximum toll prices and increment of change, and then try to establish how drivers will interpret this information.

MODELING MATTERS

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