A STRATEGY LEVER FOR ROAD USE CHARGING:
PARKING MANAGEMENT BY SATELLITE

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1 ABSTRACT

Parking management that relies on Global Navigation Satellite System (GNSS) metering systems is described as a way to raise motorist acceptance of Road Use Charging (RUC), prior to the expected deployment of widespread RUC programs. GNSS-parking is also described as enabling a significant new and previously infeasible body of parking demand management tools. Satellite parking takes advantage of several attributes of parking and parking tolling, the relationship of parking to congestion, and some attractive motorist services that can be offered to entice rather than coerce motorists to use a GNSS-based on-board meter. The intention of such programs is to shift motorist attitudes from hostility to acceptance while growing an installed base of vehicle metering “on-board units” (OBUs) in advance of planned urban or regional RUC program deployments.

This paper:
- reviews parking management attributes that provide these opportunities
- describes an ideal parking management system to capture the opportunity
- shows how this approach prepares motorists and road authorities for RUC
- illustrates additional and immediate congestion management opportunities

2 INTRODUCTION

There are a number of barriers to the deployment of regional or national scale, zone-based road use charging such as that advocated for the 2014 timeframe by the DfT and the UK Secretary of State for Transport. In addition to technical and political barriers, there is the all important issue of motorist acceptance.

The technology choice between Dedicated Short Range Communications (DSRC) and GNSS clearly points toward GNSS.¹ The facts of EU control over Galileo, Galileo’s improved accuracy over GPS, and the fundamental flexibility and extensibility of GNSS compared to DSRC influences that choice. The belated success of the German Toll Collect system proves GNSS can work in interurban roadways, while at the same time its expense gives pause. GNSS raises a privacy concern that has a relatively easy technology solution, but still requires regulatory enforcement in tandem with motorists’ education to allay fears. Current difficulties with mitigation of signal path problems in “urban canyon” correctly raise concerns for the management of evidentiary issues and hence assurance issues. This delays our understanding of how to make what works in open sky on German highways also work in high-rise central business districts throughout the EU and elsewhere. Meanwhile, mounting
congestion and little appetite or funding to build our way out of it serves to keep demand management, in the form of road use charging, front of mind.

Simply put, we expect to start deploying wide-spread congestion charging in the next several years, and we are most likely going to use GNSS for this. So what should we do in the meantime?

This paper develops the reasoning for, and implied benefits of, a set of activities and programs that would serve to specifically prepare our motorists and our road authorities for GNSS-based road pricing. “Prepared” means we would maximize the acceptability of these charges as well as the methods we use for metering and collecting them. It would also mean that the project of retrofitting the then-existing fleet of private vehicles would already be underway and largely accomplished, reducing the shock-effect of nation-wide projects to retrofit and test tens of millions of OBU installations before a tight deadline. These programs are specifically targeted at:

- diminishing exaggerated fears of “tracking” and privacy invasion
- improving acceptability of OBUs
- enabling a substantial penetration of OBUs into the existing vehicle fleet
- increasing motorists’ familiarity with ideas of fair pay-per-use
- accrediting a base of outsourcers who can correctly install these meters

The approach proposed takes advantage of a number of currently lost opportunities in the tightly-coupled, but often ignored relationship between parking management and traffic congestion.

The driving innovation for these opportunities is parking-by-positioning-satellite. It is now possible to offer a GNSS OBU that would (in addition to road-pricing, which could remain dormant until required) locate the position of a parked vehicle accurately enough to determine the correct toll for a parking-by-the-minute charge. Within the scope of this are several targeted parking management programs that would provide benefits for participating municipalities, as well as motorists. These would address short-term street parking, residential parking, free-but-time-limited parking, ticket-less escalated pricing for existing street parking, expanded parking pricing on less used streets – all without using additional curbside infrastructure. Finally, some of these ideas will be described.

If put into place over 2007-2012 – with well managed marketing, enforcement, and pricing mechanisms – such programs can erode resistance to on-board metering, develop a significant installed base well before 2014, provide a much-needed revenue source and provide a congestion management tool in advance of RUC.

3 THE TURNING POINT FOR ACCEPTABILITY OF ROAD-PRICING

Experience with road-pricing to date shows a consistent pattern with respect to acceptability. Before deployment there is always a low level of acceptance – with approval somewhat or considerably under 50%; we can
expect such programs to be voted down in referenda; and there are always perceptions of “political suicide”.

London was majority against before February 2003 and majority for by 2004. Stockholm before deployment polled about 55% against use charging; after the trials only 41% were against it. Edinburgh ran a pricing referendum, and its road-pricing proposal was preemptively defeated. By contrast, motorists volunteer for GNSS-based pay-as-you-drive insurance meters, since they perceive a direct benefit for themselves.

Once implemented, RUC acceptance typically rises to a level somewhat above 50%. The shift in approval ratings can range from 10% to 20% once the benefits of uncongested roadways become apparent to a larger segment of the population. This is just enough to shift from resistance to acceptance. Until the benefits of congestion management are widely experienced by very many cities and regions, road pricing will continue to experience low levels of pre-deployment acceptance in every country and city that attempts an RUC program. This will delay the solution, consume significant additional marketing effort, expose leaders to unnecessary political risk, and generate additional enforcement costs in the early phase of each deployment.

In his book *The Tipping Point*, Malcolm Gladwell writes:

> "The line between hostility and acceptance ... is sometimes a lot narrower than it seems. There are simple ways to package [innovation] that under the right circumstances can make it irresistible – all you have to do is find it."

What we seek is a way to influence the perception of per-use pricing and the perception of the use of on-board GNSS meters, and to change this perception from majority hostile to majority acceptance, before deployment.

If we could move the average time table forward by one or two years, reduce early enforcement costs, and bring congestion relief earlier, the collective value to our cities, our commerce and our air would be many billions of euros. From Gladwell, again:

> "What underlies successful change is an absolute belief that change is possible, that people can radically transform their behavior or beliefs in the face of the right kind of impetus. The right action in just the right way can turn resistance to compliance and hostility to acceptance."

If we offered a very compelling service to relieve much of the pain of parking, we might just start an epidemic: the viral spread of GNSS-based RUC OBUs.

4 PARKING USE VS ROAD USE: FOUR OBSERVATIONS

How we pay for road use and parking use varies widely, but there are a few important comparisons that merit examination. Writing from a North American and hopefully an EU perspective, these four observations about differences in perception, optimization, pain and cost are generally true in most countries and jurisdictions.
1. PERCEPTION: Current perceptions tend to make it politically easier to charge directly for parking use than for road use.

<table>
<thead>
<tr>
<th>Motorists think they pay for roads via fuel taxes.</th>
<th>Motorists think they pay for parking at the meter.</th>
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<tr>
<td>Motorists have a diminished understanding of the spectrum of sources for road funding. They are generally not aware of the cost of induced driving externalities such as congestion, emissions, land-use, quality of life etc. Because they believe their fuel taxes pay for the road, they feel entitled to use. The argument for road-pricing is difficult to make to someone who thinks they have already paid.</td>
<td>Motorists also have a minimal appreciation of the real costs of parking provision. Few motorists are aware of the externalities induced by their use of parking spaces, but even fewer are surprised by priced parking – and this is a key difference. Free parking is often perceived as a bonus, incentive or a perk. Free roads are seldom perceived in this light.</td>
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Perceptions of use-entitlement differ. While both road use and parking carry a similar degree of importance to the entire personal transport system, a similar total system infrastructure cost, a similar degree of externalities and even a similar contribution to congestion, motorists’ acceptance of an economic responsibility is entirely different. While we may frequently view parking as a market good, we nearly always think of roadways as a common good. This implies a shorter re-adjustment or re-education gap for pervasive parking-pricing than for road user charging.

**OPPORTUNITY:** It is possible to charge market value for parking in more locations, reduce free parking, reduce spillover abuses, and address congestion (part way) with technology that will be available by 2008. Since this can be done using the same GNSS OBU’s that are proposed for road-pricing, satellite parking programs can be deployed to increase acceptance of GNSS OBU’s for subsequent use in RUC.

2. OPTIMIZATION: Motorists more often think about optimizing parking use (costs) than they think about optimizing road use.

<table>
<thead>
<tr>
<th>Motorists make weekly lump-sum payments for fuel (with its embedded road tax)</th>
<th>Motorists make daily or hourly parking payments directly for the spot they select.</th>
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<tr>
<td>There is no direct economic incentive to drive at non-peak times. The penalty for peak-hour driving is a slower drive while listening to your favorite music, the cost in additional road-tax is negligible and is likely perceived, when it is thought about at all, as a small increment in fuel cost.</td>
<td>There is direct incentive to seek cheaper or free parking. There is incentive to pay at least the correct amount, or an incremental amount and to return to the meter in time to avoid an enforcement fine. In the search for free (or any) parking, there is incentive to “circle” or to park on unmanaged public and private property (spillover).</td>
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Efficiency of market-mechanisms differs. We can use the road as we wish, but we often have to shop attentively and aggressively for parking. While motorists typically complain about congestion in a general sense, they often worry specifically about finding and guarding parking at specific times and places.
OPPORTUNITY: It is possible to provide parking pricing payment services that automatically optimize for the motorist by charging only for the actual minutes used and guarantee that no ticket will be issued as long as a vehicle is legally parked. The system could escalate and de-escalate pricing according to local business rules or current congestion conditions.

3. PAIN: The transaction pain of parking provides a large, untapped, service improvement opportunity for parking that is not present for road-use payment.

Motorists pay for road use in a fully automated fashion. This convenience means motorists are often unconscious of how and how much they are paying. Avoidance of payment, while possible, is sufficiently difficult that it rarely occurs.

Motorists make parking payments, usually at the time of use, using a complex variety of manual mechanisms. Motorists are generally very aware that they are paying on an episode-by-episode basis. Payment avoidance whether accidental or intentional is easy and frequent. In some jurisdictions enforcement means onerous fines.

In any complex and poorly-serviced market, such as parking, the opportunity for service improvement and simplicity provides an opportunity for new revenue. Market-based systems provide their own demand control mechanisms.

OPPORTUNITY: It is possible to remove this pain while reducing the opportunity for payment avoidance. This can be done with pervasive, privacy-assured satellite metering that allows for complete flexibility of variable pricing and location.

4. COST: High transaction costs borne by parking authorities provide a massive opportunity for greater efficiency in managing parking payment services that is not present for road-use payment.

Motorists pay for road use in a fully automated fashion. Since road tolls are collected as a portion of fuel costs by agents that sell fuel, collection costs are minimal to the government. Avoidance of payment, while possible, is sufficiently difficult that it seldom occurs.

Motorists make manual payments. The variety of ways and circumstances in which parking payments are collected means a high cost of collection due to labor, payment systems, access control, and pilferage. Payment avoidance whether accidental or intentional is easy and frequent and generates a large cost of enforcement.

High transaction costs for parking payments ensure diminished retained revenue so that only high-demand streets can effectively support priced parking.

OPPORTUNITY: It is possible to simplify payment systems to dramatically reduce the marginal costs of payment services. This allows for extensibility not currently feasible due to the high marginal cost for managing a new parking spot using current payment technology.
Leverage motorists’ perceptions

Providing a voluntary system with advantages of convenience, billing management, access to additional parking locations, preferred access, line-jumping, freedom from tickets, and loyalty discounts, can attract motorists to the OBU, since they must already pay for parking, anyway. Such a voluntary system can co-exist with other forms of payment devices or permits, or could operate selectively as parking authorities or property managers subscribe.

Leverage motorists’ optimization habits

Motorists generally optimize their parking behavior to save money.
- payment is by-the-minute; risk of overpayment is removed (as is the risk of underpayment)
- payment can escalate after a demand-related length of stay; motorists will tend to stay no longer than necessary, and will not be ticketed if they do
- pricing can be designed to send congestion-related pricing signals to motorists whether they are using the OBU or not

Remove user pain

Motorists dislike the nuisance, inconvenience, lost time, overpayment, and enforcement risks due to underpayment associated with current methods of parking payment systems. Satellite parking can be 100% hands-free allowing a motorist to simply park (legally) and walk away, while exact payment is assured.

Reduce operators’ transaction costs

Satellite parking requires no ground infrastructure beyond signage.
- under-managed parking areas (residential, permit, 1-hour, no-parking, streets subject to spillover, etc) can now be metered and enforced
- currently unpriced streets that would under-perform with curbside meters can be priced modestly and in a gradual roll-out program
- enforcement using license plate recognition can be integrated and enforcement costs covered solely by revenue from infractions

Table 1: Summary of the four reasons GNSS-based parking can help tip social attitudes toward GNSS-based RUC technology from hostility to acceptance.

5 PARKING PRICING MANAGEMENT BY GNSS

By late 2008 it will be possible to meter for parking by integrating four critical technologies: Galileo, GPS, high-sensitivity receivers and receiver autonomous multipath mitigation (RAMM). While this integrated system will work in most places, there may remain some exceptions in areas of extreme signal interference although far fewer than now. It can readily be made pervasive, secure, and privacy-assured. Judiciously applied, it will allow us to commence voluntary per-use pricing programs using an OBU identical to that which is expected to be used for RUC after 2011. The effect of using RAMM processing on GPS signals disturbed by an urban setting is shown to the right. The black points show where a GPS unit believes the stationary yellow car is each second. The red dots show how the position estimate is improved.
5.1 GNSS-parking can improve acceptance of GNSS-RUC

While satellite metering of either road-use or parking-use each represent a major shift, parking pricing requires a less dramatic social and political change. It can be introduced more gradually, as well. The opportunity we have now is to use a friendlier, fairer, and more convenient payment service for what motorists already pay for in order to have:

- the experience that per-use payment is fairer than lump-sum payments
- a well-managed and provable privacy track record to reduce fears
- motorists acclimatized to these new types of meters
- a growing installed base of GNSS meters that can be used for RUC
- a number of service organizations trained in OBU installation

Providing a system with evident benefits for motorists can attract users voluntarily to the new technology. It is always easier to sell by enticement than by coercion. And if this enticement is insufficient, additional motivation can be provided by appropriate ticketing and parking pricing to non-OBU users, essentially steering motorists who frequently pay for parking toward voluntary OBU use.

A system with large efficiency benefits for parking authorities exposes much more than simple revenue opportunities – which alone are a sufficient motivator for any municipality strapped for operating funds. The potential for a greater demand management capability is of far greater long term value. As the pressure of congestion and the value of real-estate push up the value of parking spaces, the utility of parking management increases for both municipalities and private operators.

As an example of more effective enforcement management and revenue turnover, our firm has estimated that enforcement costs (all in), for mobile license plate recognition can be had for less than €0.07 per plate per scan (excluding towing and collection), and the same electronic tire marking enforcement scheme can be used to enforce timed parking on any street, including motorists that are not using the meter as well as those that are. Scanning each plate on average twice a month and assuming a 1% ticketing rate (i.e. 99% compliance) a 200% annual return can be expected given the €25 parking ticket that is current in a city such as Toronto. 8

While the end goal of GNSS metering is the introduction of a fairer pricing technology that allows transport demand management to be fully effective, the intermediate goal stressed in this paper is the acceptance of GNSS-style metering for use in subsequent RUC programs. Satellite parking programs necessary to attract a significant number of motorists to early adoption of this technology must ensure that:

- Pricing does not generally exceed the marginal costs of parking, including externalities. Subsidizing other forms of transport using parking pricing might jeopardize the intention of the earlier introduction of GNSS OBUs. This is independent of the argument to subsidize other forms of transport when using road pricing revenues, which is more readily defended.
• OBU users do not pay more than non-users for parking; in fact, it would be better if they perceive that they are paying less, in addition to the pain-relief and effortless optimization they would enjoy.

• The cost of OBUs is minimized. This can be done by charging a monthly use-fee of, say, three or four euros. This fee needs to pay for the device over a reasonable period, but should not be more than a typical user of parking can expect to save by using the device – i.e. OBU use should be expense neutral. The additional conveniences should be a bonus.

5.2 Interplay between road-pricing and parking-pricing

When thinking about the full balance of these ideas, keep in mind that we seldom take full account of the tight coupling between congestion and parking. There are many who study the relationship between road-pricing and transport demand management and some who study the relationship between parking-pricing and parking demand management, but far fewer examine the potential for integrating road and parking demand management. Perhaps Donald Shoup at UCLA and Todd Litman of the Victoria Transport Policy Institute are among the best known for observing the crossover in these two domains.

In general, the practices of considering demand management for roads and demand management for parking are largely done in isolated contexts, i.e., in independent planning groups, using unrelated regulations, programs, and tools. The motivation to explore synergies is seldom evident or compelling. People who do study one or the other of these knows that each of road-use and parking-use typically generates a high degree of externalities, so that motorists in many circumstances significantly underpay the full costs of both their journey and their parking. 9,10

Uncoordinated management programs may provide for such circumstances as:
• the availability of free-parking may counter the “cost” of congestion for a motorist faced with the decision whether to take transit or her car
• free, relatively uncongested roads might help negate the cost of parking at the destination

Since the full cost of a journey is often largely externalized, the weak pricing signals that might be there are often further diminished by this lack of pricing integration.

If we were to use dynamic parking pricing coordinated with peak road-use times, the effects of parking-pricing on road demand could be made to roughly simulate the congestion effect of road pricing. For example, instead of setting flat hourly parking fees at on-street meters for the business or entertainment hours of the day, these fees could be made higher for arrival times that obviously correspond to travel during peak hours and lower otherwise. This type of dynamic pricing is easily handled by the emerging satellite-parking technology described here.
More interestingly, if we know when a vehicle is parked we can determine trivially when it is being driven; hence it is possible to assess road-access fees on a broad zone-by-zone basis. For example, if a motorist departed her home (unparked), drove to work (parked) and passed through 3 pricing zones, it would be easy to assess a correct, congestion-based toll for that journey. The challenge would be to design pricing maps that are fair for all participants. This approach would not distinguish the exact road traveled or the lane traveled, but it would be a far fairer approach than that currently used for the London Congestion Charge and would require far less infrastructure than that used in Singapore or Stockholm. Most importantly, this approach is far more flexible and extensible than any of those incumbent approaches.\(^{11}\)

5.3 Program potential for satellite parking-pricing

GNSS-based parking metering enables a powerful region-wide parking and transport management tool.

5.3.1 Enrich pricing management while reducing ticketing and towing

Since tolls are calculated in a datacenter and not at the meter, pricing can be more effectively planned and more easily updated.

As a commercial on-street example, it would be possible to:
- Provide 20 minutes free
- 4 cents a minute for the next 100 minutes
- 20 cents a minute thereafter to encourage turnover

As a residential area example, it would be possible to:
- Assess resident vehicles at 2 cents an hour (when on-street) instead of an annual $120 permit cost
- Assess visitors at 1 cent a minute until 11:00 PM and 15 cents per minute thereafter to discourage overnight parking

5.3.2 Parking credits in lieu of road pricing

Wide-area managed parking pricing can be used to manage congestion:
- Parking could be free within 500 meters of a motorist’s residence while tolled everywhere else
- Since wireless toll management allows for negative tolls, any vehicle that is stationary during peak congestion times could have its municipal parking account credited (appropriate parking charges would still apply)

5.3.3 Lower infrastructure costs per transaction

Municipalities would experience a gradual attrition of curbside parking infrastructure while steadily encroaching on spillover and other parking abuses. At the same time, municipalities can offer an increase in convenience for the motorist.

5.3.4 Near-zero transaction costs means all parking can be managed

Wireless toll collection means minimal ground infrastructure – only signage and mobile enforcement via license plate recognition (LPR). Hence, Skymeter
minimizes both transaction costs and new infrastructure costs for converting unpriced parking to priced parking. If a municipality wishes to toll unmanaged or weakly managed residential streets, resident motorists could choose among OBU, annual permit, or parking fines.

Applying tolls everywhere, but priced to address only marginal social costs, is not only fair but can be used to manage spillover on streets and in convenience parking at retail shops. None of this can be accomplished with ground-based payment infrastructure that requires a sufficient number of bays or sufficient demand to justify tolling deployment.

5.3.5 Lower Enforcement Costs
There is a rule-of-thumb about parking enforcement current among some parking managers called the "10-80-10" rule: 12

- 10% of motorists are highly compliant with all parking rules. These motorists may get only one or two parking tickets in a decade.
- 80% of motorists intend to comply but make the occasional error, such as misreading a sign or misjudging time. These motorists tend to get a couple of tickets a year.
- 10% of motorists go out of their way to not pay for parking. While a minority of these are scofflaws, most simply try to park in unpriced areas – usually generating "spillover" problems or tend to underpay meters. It is this group that forces cities to maintain strong and expensive enforcement programs.

The 10-80-10 rule is important for wireless on-board metering. Voluntary participants in a privacy-assured, satellite parking system would come from the rigorously compliant 10% and the well-intentioned 80% of this equation.

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This would allow parking enforcement to dedicate resources toward the latter 10%, making enforcement far more effective, and far friendlier to the 90% high compliance motorists – an additional and gratifying consequence for this class of wireless metering.

5.3.6 Loyalty Programs vs Monthly Parking

Once a motorist has paid for a monthly parking pass, the likelihood of using a travel modality other than a private automobile is automatically reduced – usually to zero. Satellite parking permits much more flexibility such as “park 10 times, get 4 hours free”. This type of loyalty program can provide for discounts for multiple-use but still allows a motorist to occasionally take transit or ride a bike without “wasting” the monthly pass. Removing or reducing monthly parkers also frees up inventory for daily parkers, allowing an operator to design loyalty programs to maximize occupancy, which is otherwise more difficult with monthly parkers, wasting inventory in high-demand garages and ramps.

6 SUMMARY

It is well understood that inefficient market mechanisms for both road-use and parking are a root cause for our current traffic congestion problems. We can take advantage of large relative differences between road-use and parking-use profiles such as:

- entitlement perceptions
- willingness to optimize use
- user transaction pain, and
- operator transaction cost

These differences provide us with an early opportunity to use parking pricing to enhance motorists’ acceptance of per-use pricing and GNSS metering in preparation for a shift from a fuel-tax-based transportation commons to a usage-based, demand-managed commons. At the same time, this technology offers revenue, parking and congestion management opportunities to municipalities and regions.

Notes

1 Report #B321-18, Executive Summary, Frost and Sullivan, January 2004
3 M. Whittles, Urban Road Pricing: Public and Political Acceptability, Ashgate, 2003
6 D. Shoup, The High Cost of Parking, American Planning Association, 2005
7 Non-users would pay as before, purchase permits, or be ticketed
8 This calculation is influenced by rates for labor, insurance, compliance, collection and whether local regulations permit e-ticketing or mailed tickets vs manual tickets placed on the wind-screen. Contact bgrush@appliedlocation.com for the spreadsheet
9 D. Shoup. The High Cost of Parking, American Planning Association, 2005
10 T. Litman, www.vtpi.com
11 This is not offered as a replacement for RUC or HOT or other forms of more exact road-pricing or value-pricing. This is merely an interim approach that is nearly free with GNSS parking meters in place. Parking is an important early enabler of congestion pricing.
12 In conversation with David Hill, COO Winnipeg Parking Authority, Canada. Any misinterpretation is the author's.