

So, what exactly is a hybrid tolling system? Allow NORBERT SCHINDLER to explain

In the 2009 edition of ETC, etc I observed a growing discussion about “thick” and “thin” clients for GNSS (Global Navigation Satellite Systems) tolling. My colleague Erich Erker and I decided to offer a deeper view on this subject.

This year I feel an urge to address the issue of “hybrid” electronic tolling systems. It sounds catchy, somehow, as though it might even imply something “green.” The use of the word “hybrid” in tolling approaches is appearing with increasing frequency even though there is not really a common understanding about what it means - other than some kind of combination of a satellite-based GNSS technology with microwave technology (based on 5.8GHz Dedicated Short Range Communication, or simply DSRC). You get the best of both worlds for the price of ... well, something like for the price of both worlds. But actually it's not all that simple.

The hybrid onboard unit

In our search for hybrid tolling, we look at the countries that have introduced nationwide electronic tolling schemes. Let's start with Switzerland, that beautiful and deeply-rooted democratic alpine country which decided at the end of the last century to take action and do something about increasing transit traffic. In 2001, the Swiss started what would later become an unstoppable trend in Europe, by charging a distance-based “toll” on each heavy vehicle (above 12 tons). This road-usage fee applies to every single road in the country, something which is still unique in the world.

All Swiss-registered trucks above 12 tons were obliged to install an On Board Unit (OBU) which had GNSS and DSRC functionality, and was also connected to the tachograph - that thing which counts the kilometers driven and, in those days, logged the trip details on a little round piece of paper that various authorities could look at to check up on you. It was the only means to control whether you were compliant to various regulations. So there you have it, GNSS and DSRC in one OBU - sounds like a hybrid, doesn't it? Well, actually, it's quite far from it.

“The use of the word ‘hybrid’ in tolling approaches is appearing with increasing frequency”

Tolling in Switzerland is based solely on the counting of kilometers travelled. GNSS, ie, GPS signals, are merely used to verify the data from the tachograph.

As Charles Hewson recently pointed out in the Sep/Oct edition of *Thinking Highways Europe/Rest of the World* (pages 64-66), GNSS systems can measure the distance with an accuracy of about 0.25 per cent, whereas tachographs are only accurate within 4 per cent. DSRC is used for enforcement, and to signal the OBU when the truck is entering or leaving the country (even though GPS could do that too).

However, once the Austrians had their DSRC-based tolling system running in 2004, the Swiss OBU could actually be used to “roam” into Austria. This was the first case (and until very recently the only case) of “interoperability” we have in Europe, whereby today it works only in one direction - you can't drive into a country using DSRC tags where there aren't DSRC beacons all over the place that can communicate with them. In any case, this makes the Swiss OBU much more hybrid than anything we have on the streets today, but it's still a far cry from a hybrid since GPS is just a back-up feature rather than the basis of calculating tolls.

While the Swiss began earning revenues and witnessing a reduction in transit traffic in their country, their neighbors in Germany and Austria started working on road-pricing schemes of their own. The Germans decided to introduce heavy truck tolling on their 12,000 km autobahn network for all heavy trucks (above 12 tons). They realized that building thousands of gantries across the country to install microwave beacons on each lane of each road section (with an extra beamer on the emergency lane) would require an awful lot of time and money, so Germany was determined to find an innovative new approach. Thus, the new GNSS OBU was born.

In the meantime, the Austrians went for the proven tag and beacon approach for their truck tolling system. By no means a trivial task, building some 400 gantries on 2000 km of motorways on what was to become the largest multi-lane free flow (MLFF) toll system in the world when it was launched in 2004. Whereas 2,000km is indeed a magnitude smaller than the

Theory meets practice

12,000km in Germany, the project was by its own means highly successful. The investment in the tolling system in Austria paid for itself within a year - also thanks to the fact that they made road-pricing obligatory for all vehicles above 3.5 tons.

In Germany, the ambitious toll system was launched a year later, in 2005. However, at this time a genuine GNSS-based OBU was introduced to the market with more than half a million users from the beginning. The German OBU has GPS as the primary source for tolling calculation, a GSM module for communication to the back office (where the final billing is done), a tachograph connection (to help out with calculating the toll more precisely), a display in which the current toll payments are shown in real time, and two additional interfaces: infrared for enforcement and a 5.8 GHz DSRC module. The microwave module was actually never used until now, but there was in fact a good reason to have one from the beginning. Germany already had the foresight for future interoperability issues, so that their customers could one day use their German OBU to “roam” into other countries using only DSRC. Once this eventually happens (the current plan is sometime in 2011), this could also be called a “hybrid” OBU, since it can be used for tolling using either GNSS or DSRC technology. It is a hybrid in the sense that it can be used for interoperability with the DSRC environment like the one in Austria.

“The Czech Republic could be the first country to implement a real hybrid tolling solution”

Allow me to attempt a definition that I think most of us can agree on. A Hybrid OBU is an OBU that can perform multi-lane free-flow electronic tolling using both GNSS and DSRC technologies.

The hybrid tolling system

Getting back to our European tour, we head to the Czech Republic as the next country to introduce a nationwide tolling scheme for trucks. Great Britain had an overly ambitious plan to do it first, but that was shelved for the time being. So in 2007 all of the nearly 1000km of Czech motorways were tolled, and within a year (as defined by the contractual obligations required by the public tender), a selected 1000km of national roads were to be tolled as well. This was the first “phase-wise” approach attempted for the introduction of a national truck tolling scheme. Regrettably, the idea of phases didn’t

materialize as planned, so an Expert Group was called upon to work out a detailed approach for extending the initial tolling network on the motorways to an extended network on the national roads – much more than the 1000 km originally planned - using GNSS technology. Should this be really implemented in the near future, it would make the Czech Republic the first country to implement a real hybrid tolling solution.

Let’s make a further attempt at a definition that could find broad consensus. A Hybrid Tolling System is one in which multi-lane free-flow tolling is realized using both DSRC and GNSS technologies to detect the passage of vehicles on tolled road sections. Both technologies are integrated into one overall concept (within a country), using the same back end of the central system.

You don’t need to deploy hybrid OBUs exclusively for a hybrid system. In fact it makes no sense to have a hybrid system if you have only hybrid OBUs, since you would then pay for DSRC infrastructure which you do not need. Your GNSS OBUs do not necessarily need any DSRC module to work in a hybrid environment - but they will most probably have it anyway (for reasons like enforcement or interoperability with other countries).



Hybrid Tolling

What exactly does a hybrid tolling system mean in the Czech context? There is already an existing DSRC infrastructure on the motorways, in which all trucks are equipped with DSRC tags. To avoid excessive traffic diversion on parallel roads, and to generate revenue for traffic on selected national roads, trucks are obliged to replace their tags with a new GNSS OBU in order to use that extended road network as well. If you stay on the motorway, you can keep your tag. But eventually, a large majority of trucks will exchange the tags for the GPS-enabled device, the hybrid OBU. Like the GNSS OBUs already out there in Germany and in Slovakia (I'll get there a little later), these hybrid OBUs have a DSRC module built inside which can be used both for enforcement purposes and for tolling - by communicating with the existing DSRC beacons. You may ask yourself (I do this all the time, actually) why you would need to use the DSRC infrastructure with your GNSS OBU which can always identify tolled road sections on its own, without any DSRC. The answer is as simple as the favored response of many mountaineers asked why they ascend high mountains: because it's there.

A better answer would be don't change something that already works. But if you try to optimize your costs, you certainly won't want to operate and maintain DSRC roadside equipment that you don't need anymore. Of course, if the investment in the DSRC infrastructure has not yet paid for itself by the time you move to GNSS, this can be a painful experience for the investor - which, in most cases, is the general taxpayer (either directly or indirectly).

Making the right choice

So how to choose between a DSRC system, a GNSS system, or a hybrid system? DSRC is most cost effective if you have lots of vehicles and not so many tolled sections (ie, not so many kilometers). For example in Austria today, you have more than a million DSRC tags in use compared to nearly 2200km (or about 900 sections in both directions). Since the tags are relatively cheap, the investment in all those gantries pays off. In Germany, there are about 800,000 GNSS OBUs in use, but compare that to over 5000 tolling sections! Obviously, the investment in the GNSS OBUs has paid off as well - to the tune of nearly €billion in annual revenues.

Here's a thought

Supposing the Austrians were to theoretically introduce road-pricing for all vehicles, and at the same time introduce legislation in which heavy trucks (ie, above 12 tons) must pay for using all the national roads as well - using GNSS, of course. Then you have an ideal case for a hybrid approach. Just supply the millions of passenger cars with a cheap DSRC tag, but place GNSS OBUs in the hundreds of thousands of trucks to charge them on any or all major roads, depending on the tolling policy to be implemented.



Although truck tolling schemes on motorways have successfully generated much-needed revenue, the amount of income still cannot compensate for the costs actually incurred by the wear of tear trucks on the entire national road network of a country. A logical consequence could be the expansion of road-pricing to a broader road network, in which case the deployment of a tolling system having the greatest technological flexibility would be clearly the most advantageous.

Starting with a GNSS from the beginning

Let us have a brief look at Slovakia, that scenic country at the very heart of Europe that has undergone great changes over the past two decades. At the beginning of 2010, the Slovaks introduced a nationwide truck tolling scheme having a completely different approach than their neighbors. They have only about 500km of motorways, so one could quickly assume that this would be an ideal environment for DSRC, right? Remember: relatively few sections, a fairly large amount of vehicles.

A closer look at the business case in Slovakia revealed that if only the motorways were tolled, much of the traffic would divert to the (free) national road network, which is far more comprehensive - four times the size of the motorway network. If you stuck to tolling the motorways, the revenue generated would be quite low compared to the high investment costs of DSRC infrastructure. Thanks to recent progress of GNSS tolling technology, Slovakia could successfully employ what could be seen as a paradigm shift in the approach to tolling: rather than tolling a specific (motorway) network, a specific group of vehicles was tolled instead. In other words, each truck above 3.5 tons is obliged to be equipped with GNSS OBU. This was a first! The tolls are levied on all the major national roads, not just the motorways. Another first!

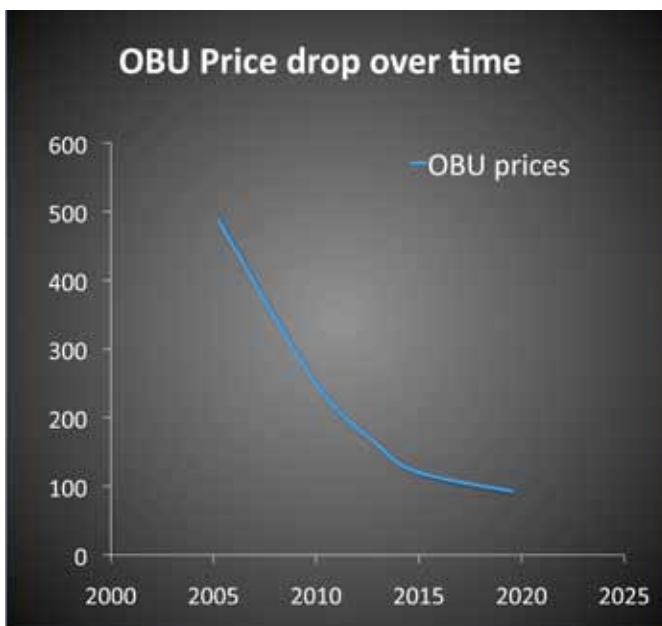


“New technology allows for a paradigm shift: rather than tolling a specific road network, toll a specific group of vehicles”

The GNSS OBU can be installed by the driver in a matter of minutes, just by sticking it on the windshield. Like in Germany, the end users don't even know about the cost of this OBU (which is about half the price of the first German OBU), since they merely pay a deposit. The toll operator covers the

investment in the OBU technology - as opposed to investing in the roadside equipment of a DSRC system, as their neighbors to the North and West had done. Since there are over 3,500 toll sections in Slovakia, this is obviously not a positive business case for DSRC.

So when would it make sense to go hybrid if you have a GNSS system? Once you are ready to introduce distance-based road-pricing to all passenger cars on the motorways. This would, of course, be a very daring political step which no country having nationwide schemes for trucks has attempted until now. However, by the time you are prepared to toll all vehicles in a country, as the Dutch were very close to doing, a much cheaper GNSS OBU will most likely be available (illustrated in the graph below) to implement. In the case of the Netherlands, the toll would have applied to all roads, thus it was planned to introduce the road-pricing scheme based only on GNSS.



Five years after the introduction of GNSS OBUs, the prices halved. They will continue to fall the same manner as was the case with mobile phones. Over time, the installation base will increase dramatically, as more and more countries introduce GNSS-based tolling.

The future of hybrid GNSS OBUs

After the successful deployment of the world's first plug and play GNSS OBU in Slovakia, Siemens is developing a new generation GNSS OBU which is far more compact and cost-effective than anything the market has seen until now. This new "Hybrid OBU" will be distributed by the middle of 2011.

Taking the price development of the (hybrid) GNSS OBU into consideration, it may well happen that the business case for introducing DSRC for passenger cars evaporates completely in the near future. Yet we should not only focus the discussion about cost-effectiveness of DSRC vs. GNSS. We should look beyond the issues of road-pricing, which has been the main motivation for installing all this hardware in the first place. There are a number of other issues which become highly relevant, once you have a wide deployment of GNSS devices which can perform a wide range of tasks. These are options that you can not even dream about if you are still in a DSRC environment.



The newest Hybrid OBU from Siemens, which will be distributed and installed in the middle of 2011

So let's run over just a few of the advantages that a GNSS-based platform could offer:

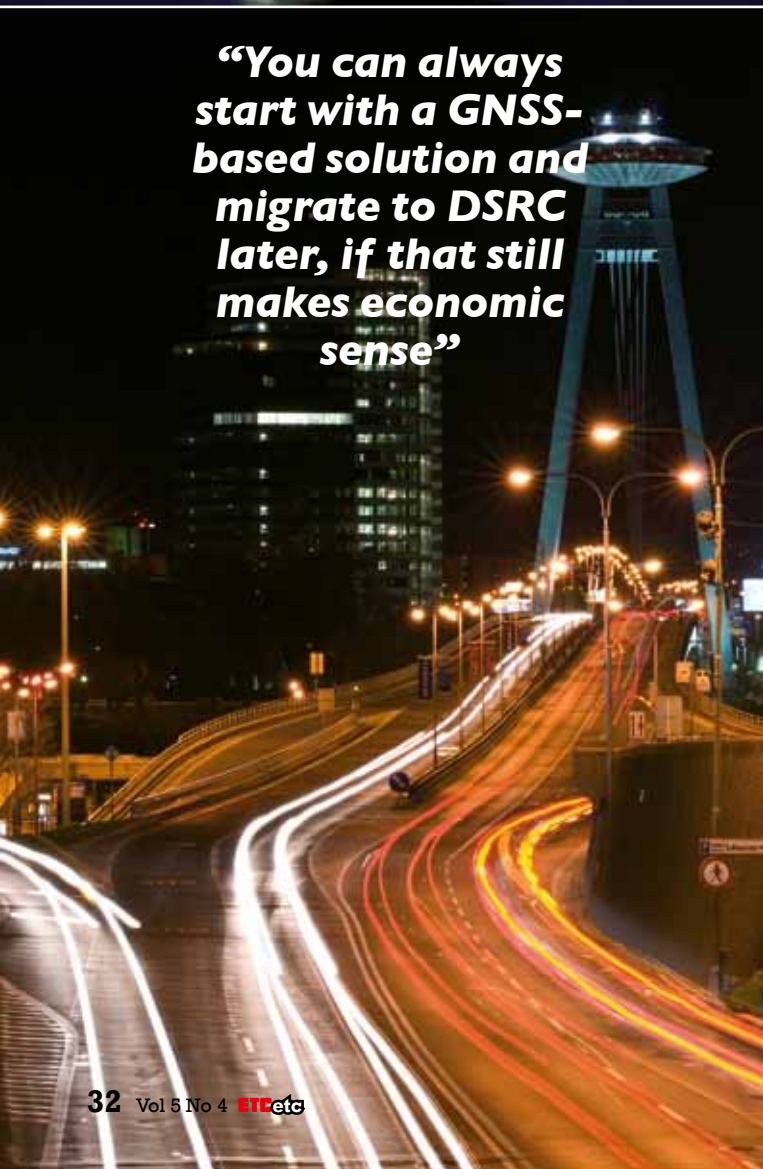
- Quick and easy adaptation to the tolled road network by updating the map information (ie, "overnight").
- No additional or unexpected infrastructure costs for road maintenance work, road-widening, etc, since there are no gantries to deal with.
- The entire spectrum of "intelligence" can be designed into the OBU, from very thin to very fat (as discussed in to last year's article "A Third Weigh," *ETC*, etc Vol 4, No 4, pages 12-15)
- Deployment of any tolling paradigm you choose, not only the "section-based" approach which is used in the nationwide truck schemes of today.
- Parking, or as Bern Grush would say "Sky Metering" (just refer to any of his articles about how a GNSS OBU can direct you to a free parking space and take care of all the payment formalities for you)
- Pay as you drive (PAYD) solutions for car rentals or insurance policies.
- Traffic warnings (eg, for adverse weather conditions in certain areas)
- Real-time traffic information, road closure or accident announcements
- Emergency Breakdown call features
- Traffic safety in general (this could easily fill up an entire issue)
- Tracking the transportation of livestock or of dangerous goods
- Navigation systems with integrated real-time traffic information and alternative routes, saving drivers valuable time every day.

With its new GNSS OBU platform, Siemens is already developing new applications that have an interface to the CAN (Controller Area Network) of the vehicle, allowing the OBU to monitor and even control some of the car's essential characteristics.

This new OBU can also be integrated together with a navigation device, opening the door to a set of features that may motivate many drivers to cover the cost of an OBU themselves. After all, a great number of consumers already pay a relatively high price for their navigation devices, even if they are led by a mechanical voice directly into a traffic jam or, in some cases, into a cul-de-sac.



“You can always start with a GNSS-based solution and migrate to DSRC later, if that still makes economic sense”



Conclusion

In Europe, there are a number of countries with a history of tag and beacon DSRC solutions on their motorway networks, usually in combination with large toll plazas. Some countries have already begun to migrate to DSRC multi-lane free-flow systems. Other countries, like France, are developing innovative new approaches to expand on existing tolling policies, by introducing truck tolling on all national roads.

This may very well start a new trend in countries that also have lots of roadside infrastructure already. There is a clear trend to introduce road-pricing on a national level, particularly on heavy vehicles on all major roads. There simply isn't enough money around to invest and maintain a well-developed road infrastructure.

Fuel taxes alone do not solve the problem of financing road maintenance, never mind road construction. Since heavy trucks cause the greatest road damage, any remaining political resistance to tolling this (commercial) group of vehicles is dwindling. Surely within our lifetimes, we will see wide-scale road-pricing being introduced to a majority of vehicles - even if many of them (hopefully) are truly “green” vehicles.

These indisputable trends also make it rather obvious that the cost of hybrid OBUs (ie, GNSS OBUs) will eventually come close to the kind of levels we currently see in mobile phones which can do a bit more than just making calls. The hybrid OBUs will also do much more than just tolling! So for you Greenfielders out there with no tolling systems deployed yet, it is more than likely that it's advantageous to start with a GNSS-based approach and migrate to a combined DSRC solution (that's the hybrid part, remember) rather than the other way around. However, by the time you get there, you may realize the cost of GNSS OBUs had reached the point where a DSRC-based solution no longer provides any cost advantage in any kind of scenario. You can always start with a GNSS-based solution and migrate to DSRC later, if that still makes economic sense.

Although hybrid tolling may not be any greener than other tolling approaches, most important of all is to establish political measures that address the mounting problems related to growth in individual traffic as well as the increase in global trade and the consequent intensification of goods transportation on the roads. Electronic tolling will certainly find its place in the strategies developed for finding greater environmental responsibility and sustainability.

Furthermore, tolling systems can easily act as a catalyst for the deployment of other environmentally friendly applications (which our industry likes to call “telematics”) as well as significantly improving road safety. GNSS tolling provides the platform for all these kinds of things.

Since there's so much talk of being “green” nowadays, it's worth mentioning that Siemens is not only a leader in the development of state-of-the-art electronic tolling solutions, but is also the largest provider of environmental technologies in the world - with which a reduction of about 270 million tons of CO₂ emissions were realized this past year. We aren't there yet, but eventually we will see that electronic tolling will also play its role in the “greening” of our approach to transportation throughout Europe and hopefully around the world - with or without hybrid systems. **E**

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