MULTI-LANE FREE-FLOW ELECTRONIC TOLLING IN THE SLOVAK REPUBLIC

AN OVERVIEW

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Summary
On January 1st, 2010 the Slovak Republic introduced a multi-lane, free-flow electronic tolling system on all motor- and expressways and on some 1st class roads. In principle all commercial vehicles with a maximum allowable mass exceeding 3.5 tons are subject to a distance based toll charge. This toll is depending on the road category, the vehicles category, which is established through the number of axles and the emission class of the vehicle. The data to calculate the toll is generated using an „On-board-Unit (OBU)“. The OBU is available to every user for a refundable deposit of EUR 50. It can be obtained at all major border crossing leading on tolled roads or at marked distribution points along the tolled network. Users can pay the tolls either through a „pre-pay“ or „post-pay“ procedure. All tolls received from users directly go to the budget of the National Slovakian Motorway Company (Národná diaľničná spoločnosť, a.s. or „NDS“). These tolls directly fund the maintenance and development of the Slovakian road network managed by NDS.

The concept and the tender phase
The fully electronic tolling in the Slovak Republic had to fulfil some basic requirements:
• It had to replace a vignette based charging mechanism through free-flow distance based tolling.
• The tolls have to be collected in an effective way minimising effort for the users while maximising flexibility for the authorities to shift and change tolling when considered necessary.
• The tolling had to be established in a way that traffic shifts to parallel roads and unwanted negative environment effects for the public are avoided.
• The tolling has to be fully compliant with European regulations and directives.

In 2007 a public tender process was prepared and in parallel the national legal framework was introduced. It was decided that NDS will outsource the toll collection through a service contract with a third party. NDS established a functional requirements framework for a multi-lane, free-flow electronic tolling system taking into account the requirements stated above. Through an open tender process managed by NDS interested bidders were invited to submit an offer for the tolling service for 13 years. Offers were received in March 2008. After evaluations and legal proceedings a service contract was signed between NDS and the company SkyToll a.s. on January 13th 2009.

Mandated by law the electronic tolling system had to be put into operation from January 1st 2010.

The implementation phase
During the first weeks of the implementation phase a project governance team consisting of representatives from NDS, SkyToll, later the Independent Engineer and the major contractors of SkyToll (Q-free, Siemens and Tempest) was set up. Four working groups were established to address the major parts of the system and services:
• the automatic tolling collection,
• customer services,
• enforcement, and,
• central services.

These teams kept working in this setup until the start of the service. Effective communication and micro-management practices were put in place and executed throughout the complete implementation phase. This was to ensure that issues and risks were properly and timely addressed and managed.

The operator SkyToll chose to use GNSS/CN technology (i.e. GPS) as the primary means for toll data collection. Therefore the Slovakian tolling system is the second satellite based system used for national wide-area, multi-lane, free-flow
tolling. The first system of this kind, although there have been numerous smaller scale trials, was put into operation by Toll-Collect in Germany in 2005.

However compared to Germany the Slovakian scheme introduced a few important challenging aspects:

- It is deceived as a system with an obligatory OBU which is self-installable to meet EC non-discriminatory regulations. This posed technical challenges on the design of the OBU. It resulted in an OBU which is fitted to the windscreen of the vehicle and draws its power primarily from the cigarette lighter socket. However it can be permanently fitted to the vehicle power system with little additional effort. Except for electrical power the OBU requires no external connections (e.g. a tachograph) or external antennas.

- Toll data is continuously collected through the OBU using GNSS (i.e. GPS) and transferred to the back-office through GSM/GPRS. Special algorithms ensure that data cannot get lost and any tampering is recognised and tracked. In the back-office the actual toll calculation is done following principles very well established in the modern cellular phone industry.

- Also 1st class roads are subject to the tolling. This poses very special quality requirements for the usage of GNSS to collect tolling data. The distance travelled is established based on road segments. As this principles is known to work well on roads like motor- and expressways it is a challenge on 1st class roads as the segments get shorter. Again special algorithms ensure correct recognition under all circumstances. It turned out that using the latest receiver technology available no additional road-side infrastructure had to be put in place to support the GNSS.

Apart for the mentioned challenges it was obvious that three essential risk areas had to be managed. The last point is a persisting area of risk and can only be solved over time and through the implementation of the right measures:

- Although some of the system and service components existed or had been developed many parts were to be localised or modified (e.g. legal procedures handling VAT, languages, etc.). Also important interfaces to other stakeholders (banks, police, petrol stations as part of the distribution network) had to be established. Given the amount of tasks and the uncertainties involved 12 months implementation time posed a high risk. Nevertheless as mentioned before through micro-management procedures it was ensured that inherent uncertainties and risks were mitigated as much as possible.

- The number of OBUs necessary for the start of the system and during the first weeks had to established and the supply and distribution needed to be managed. In that respect one of the major existing challenges of GNSS/CN based tolling system came to bear. In order to be financially effective only those users should be supplied with an OBU who actually need it. Therefore a large scale pre-distribution to every potential user and lorry involving at least the neighbouring countries of Slovakia was off limits. Especially for international users a distribution of OBUs at the borders was the most reasonable way to go. However in that respect, given the procedural and infrastructure limitation faced at borders, some queuing at the beginning was unavoidable but it needed to be limited in length and duration. To address both OBU supply management and queue management and to establish a viable strategy extensive statistical and mathematical modelling, also known as „operations research“, was used. The management established resources, procedures and tactics to cope with expected demand and available infrastructure. In addition to queue management and to ease distribution of OBUs especially for international users a temporary adoption (until end of March 2010) of manual payment (i.e. issue of ticket) for the main transit routes has been adopted.

- For those users using the Slovakian tolled network only very occasionally (for example users transiting Slovakia between the Czech Republic and Hungary on the D2 once or twice a year) using an OBU is probably the second best option and overall, given the current cost of a new OBU of around EUR 200, not the most cost effective solution for the operator. Although OBUs get returned to get the EUR 50 deposit and unused toll refunded, data from the the first month of operation suggests that many transiting users adopt the temporary ticketing option. It has to be seen how the OBU return and ticket issuing trends evolve during the next weeks. In any case and although the OBU cost will drop over time tolling occasional users by electronic means (regardless of using satellite or DSRC technology for primary

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toll data collection) will stay relatively expensive for a foreseeable time. Only the „European Electronic Tolling Service (EETS)” as decided by the European Commission and the establishment of an effective „on board equipment (OBE)” based interoperability between adjunct tolling networks (being mainly Czech Republic, Hungary, Poland, Austria and eventually Germany) using similar technology will mitigate the financial risks associated to occasional toll network usage by transiting trucks. These two measures will provide an effective means for a truly user friendly and most cost effective and flexible tolling solution.

The tolling system and service established by SkyToll was conditionally accepted by NDS end of December 2009. It went live as planned on January 1st 2010. Full acceptance of the system and service is expected within 3-6 months.

During the first weeks there have been queues at the certain borders and users were understandably not amused about it. However through the measures implemented the queues were mostly limited to a few kilometres (with one exception being the Czech border crossing of Svrčinovec north of Zilina because of missing parking capacity to due civil works and exceptionally bad weather). The queueing situation however improved after the second week completely disappearing since.

The OBU attached to the windscreen

„Virtual” objects used to model the road segments

The system

The toll system consists for three major functional blocks:

- The „Trip Collection System” includes the usage of the „public” satellite positioning data received from the GPS system, the OBUs, the GSM/GPRS communication link and a back-office component called „Electronic Tolling Back-Office (ETBO). The ETBO manages all OBU activities.

- The „Central Information System (CIS)” consists of the rating, billing, invoicing, money clearance, web portal, logistic and customer relation management subsystems (including the call centre). Attached to it are management information, archiving and enterprise resource management systems. From the CIS there are interfaces to NDS, the banking / card providers, the OBU vendor(s), the national vehicle registry and the printshop for all aspects for paper-based user communication.

- The „Enforcement System” includes the roadside equipment, mobile enforcement units and an enforcement back-office component. In the enforcement back-office enforcement events are analysed for further prosecution and the data about user and OBU status is maintained through lists.

1 The toll collected per issued ticket on transit routes in the first month of operation was EUR 14. To be cost effective an OBU would need to cost about EUR 2 per trip. To achieve this low a cost the best solution seem to be a ticket.
The Toll Data Collection is based on segments with predefined lengths using GPS positions for reference. The logic of segment detection is implemented in the OBU using simple geo reference objects (entry point, control point and direction of travel). The actual tolling is done in the back-office (very similar to the principles followed in the mobile phone industry). The following simplified scheme shows the principles of the segments recognition. The recognition logic is based on two consecutive control points which are detected using GPS based position referencing assisted by direction of movement.

Theses principles even allow the handling of very close parallel roads and crossings of tolled and not-tolled segments. To handle special situations the segment is divided into smaller sections as shown in the following two pictures.
Handling of parallel roads

Crossings between tolled and non-tolled segments

**Key numbers from the first month of operation (January 2010):**

After the first month of operation the following key operational figures were observed:

- **Tolled network:** 571 km (motor- and expressway) and 1 455 km of 1st class roads; total: 2 026 km
- **Enforcement:** 46 fixed and portable roadside installation supported by more than 25 mobile enforcement units manned by a police officer assisted by a SkyToll operator.
- **Registered Vehicles:** 72 094 domestic and 54 184 foreign; total: 126 278
- **Active accounts:** 59 217 domestic and 34 852 foreign; total: 94 069
  - 2 568 post-paid and 91 501 pre-paid
- **OBUs:** issued: 66 438 domestic and 53 041 foreign; total 119 479
  - returned: 11 057
  - tickets issued: 14 779
- **Toll rates**
  - lorry 3.5t - 12t: EUR 0.063 to EUR 0.093 depending on road and emission class
  - lorry 12t or more: EUR 0.136 to EUR 0.206 depending on road, axles and emission class
  - bus 3.5t to 12t: EUR 0.020 EUR to EUR 0.060 depending on road and emission class
  - bus 12t or more: EUR 0.040 EUR to EUR 0.110 depending on road and emission class
  (for more details refer to: [www.emyto.sk](http://www.emyto.sk))
- **Total tolled kilometres:** 81.1 million km
- **Transactions:** 27.6 million
- **Tolls collected:** EUR 8.2 million from 787 778 vehicles (i.e. individual „trips“) with OBUs
  - EUR 0.2 million from 14 779 tickets

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2 However from January 14th toll collection on 1st class roads is suspended. This is mainly because of political debates concerning the splitting of certain long segments. The tolling on 1st class roads will resume when consensus is achieved and the changes are implemented.