E-TOLL: AN INNOVATIVE MACHINE FOR TOLLING OPERATION

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ABSTRACT:

Brisa, the main Portuguese highway operator, developed an automatic payment machine to install on the manual lanes of its toll plazas, in order to operate in periods of lower traffic and also contributing for the increase of the number of available lanes. This machine, called E-Toll, Electronic Toll, allows multiple means of payment: banknotes, coins, bank cards and also electronic tolling. One of the innovative aspects of this machine is the remote assistance made by human remote operators, observing and following remotely all the operation using video cameras and communication via Voice over IP technology.

Brisa Inovação e Tecnologia (BIT), a business unit of Brisa Group, was in charge of all the developments related to electronic, mechanic and software areas. In this development process, BIT used its innovation network, engaging several partners, from the scientific and entrepreneurial domains, in the developing works, maintaining business competitiveness and creating value for the company and the society.

Keywords: Innovation, ITS, Toll Operation, Early Supplier Involvement

Introduction

Brisa - Auto Estradas de Portugal SA, is a reference company among European toll highway operators, because, among others, its technological innovations that Brisa improved and implemented along last decades. As a result, a large amount of the equipment and systems used in the operation and management of its network are developed using internal research and development resources and/or in collaboration with a wide innovation network, enabling greater control and adjustment to Brisa's requirements. Having an Innovation Management System implemented since 2002, Brisa, through its Brisa Innovation and Technology (BIT) unit, ensures the company's innovation process management. One of the distinctive characteristic of Brisa's innovation system is the intense collaboration with a broad network of entities, promoting close cooperation with various partners in order to maximize the innovation outputs, creating an innovation ecosystem based on "open innovation" concept.

One of the most important and innovative project of the last years, is the E-Toll project, an automatic payment machine to install on the manual lanes of the toll plazas. The E-Toll Project began its endeavor with a challenge from Brisa's Operation unit in 2003. Several toll lanes from Brisa's network have very low traffic, being that some of them had periods of several hours without a single customer. As so, the posed challenge was to figure a way to optimize cost without compromising law defined requisites, like the mandatory toll charge collection through money or bank cards.

As suggestion, the motivation behind the project relates to the optimization of operating costs in toll barriers with low traffic at certain times of day (usually overnight). Additionally, it is intended to give managers the solution of a toll station expedient to increase the number of lanes available to cope with unplanned peak traffic, aiming for compatibility with existing payment technology in use in Brisa network along with the ability to adapt to future challenges.

Project Backgrounds

Shortly following the Brisa Operation unit request, works began at the Innovation unit, integrating money handling devices in the lane host system.. Since the idea was to design an "automated manual toll lane", the approach was to keep the current architecture and integrate all of the new devices. And so "eToll Full" came to be – an automated lane, with cash and bank card support, residing on a similar sensor infra-structure and sharing most of the features of the regular manual toll lane. However, its deploy plans were abandoned,

since although it provided the basic functionalities to be successful, it still didn't had the best answer to face exceptional scenarios, like when a customer had no ticket, or if a jam occurred – an operator always had to access the toll lane, thus forcing Brisa to have someone on the neighborhood.
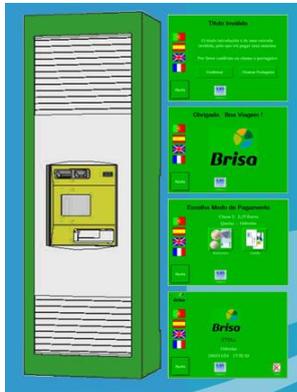
E-Toll early prototype

Following 2004, year on which a major network upgrade program took place (the MIGRAR project), Brisa decided to rehearse a new approach on automatic lanes: this time, the goal was to design an automated exit lane, with DSRC support and bank and exclusive cards support, only for toll Open System scenarios. This time there were several, less ambitious, goals: to design and implement a new concept for remote assistance (on which an operator provided support to any issues that might happen), to test the addition of DSRC support on manual lane systems and to validate the new Java based technology approach that came to reality with MIGRAR. After an early phase of prototyping and pilot tests, a full integration with toll plaza management systems was a reality – the "E-Toll Light" version began its operation on December 12th 2005, and it is still online and running at Carcavelos Toll Plaza, near Brisa's Headquarters, despite being more of a proof of concept than the final version.

In 2007, instead of refining this approach, Brisa chose to ask for a full featured system, with in-depth remote assistance and "all-fail-overcome" characteristics – every possible failure scenario would have to have a predefined flow course so that no customer would be held on the toll lane for more than it would be necessary. With all the inputs from the previous iterations, the project was fully defined and hands-on work began, relying on the team that had previously successfully deployed the new DSRC-based Via Verde System (2004) and the new Manual System (2006). On May 18th 2008, the first fully functional and remote assisted eToll system had its debut, on the A17 motorway.

Early Laboratory Development Prototype

Final E-Toll Machine

Since then, E-Toll systems were deployed all over Brisa's (A1, A2, A3, A4, A5, A6, A9, A10, A12, A13, A14), Brisal's (A17) and AEA – Auto-Estradas do Atlântico (A8 e A15) networks.. All rounded up, eToll systems are available in 14 different motorways, comprising about 300 toll lanes, all being remotely assisted by 4 Operation Centers (3 in Brisa/Brisal and one in AEA). For 2011, as of now, several dozens of machine deployment are planned.

The E-Toll System

This new system is composed by a metal frame, with two levels, for cars and trucks, which houses a set of equipments, one road barrier, communication infrastructure and video cameras to assure the remote monitoring of the process.
This machine has the operation procedure presented in the next image.

Customer Vehicle

1. The driver inserts ticket in the reader
2. Pays with large possible payment means

3. Receives bank card back or exceeding cash. Can ask for a receipt
4. Exits Lane

Remote Operator

1. Camera screen appears automatically

2. Observes and follow remotely the operation

The Operator can dialogue with the driver (VoIP)

The E-Toll project had several goals:

- Provide an efficient replacement of the human toll operator, without compromising service levels

- Provide flexibility to the toll operation service, by allowing to have more lanes available without having to have more operators

- Allow transparent integration with existing systems, in order to minimize the system's introduction impact

- Ability to be used interchangeably with the human operator mode;

- Full integration with the existing infrastructure, and minimal addition of new items to this infrastructure (sharing is a must);

- Use, as much as possible, of the same control interfaces as the other lane types

- Minimization of integration, operation and maintenance costs

The E-Toll system is a modular system, which integrates Brisa products, some already mature and others in the prototype stage, based in a number of technologies:

- Architecture SOA implemented on Linux, Java and Jini framework

- Advanced license plate recognition - ALPR

- Ticket readers

- Road sensors

- DSRC technology

- Smartcard EMV-certified technology (integration)

- Cash management technology (integration)

- CCTV system integrated

In this project there were several critical success factors, including customer acceptance and satisfaction with the new way of providing the service, which was affected, among others, by the quality of the operation and the remote service. Other key factor was its robustness to fraud situations.

Related with costumer acceptance, the user interface is a key feature, because it helps:

- To bring ease of use for a wide range of heterogenic users

- To allow reduced time of operation by the users. The most important feature because the introduction of this machine represents a disruptive innovation in toll payment services in Portugal which could generate user resistance in using it in comparison with the old manual operated system

- To lessen intervention of remote operators helping new users

- To reduce printed instructions needed in the layout surface

- To bring new aesthetic appellative user interface help enhance the positive attitudes towards the machine by the users

Regarding this, the E-Toll user interface undergoes several interactions during the development process, improving its usability.
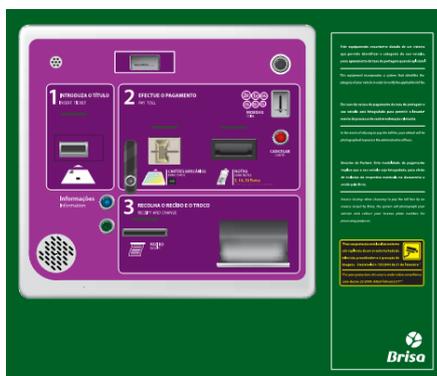
Actual E-Toll user interface layout

One of the innovative aspects of this machine is the remote assistance made by human remote operators, observing and follow remotely all the operation (classifying the ambiguous vehicles and helping the users operate the machine), using video cameras and communication via Voice over IP (VoIP).


Remote Support Center

Development and Production Process

The Development Department of Brisa Inovação e Tecnologia (BIT), was in charge of all the developments related to electronic, mechanic and software areas. In the development of the mechanical design, BIT used Early Supplier Involvement (ESI) practices, a strategy to overcome problems, reduce costs and risks in product development, using a close and active collaboration with a network of partners, integrating them in the early stages of product development, in order to incorporate manufacturing processes knowledge disseminated within the supply chain and materialize it in the product design

   In a broader perspective and considering the innovation framework, ESI should be considered within the wider concept of innovation networks, promoted by client companies, reinforcing the accepted wisdom that suppliers are innovation leaders within such environments.
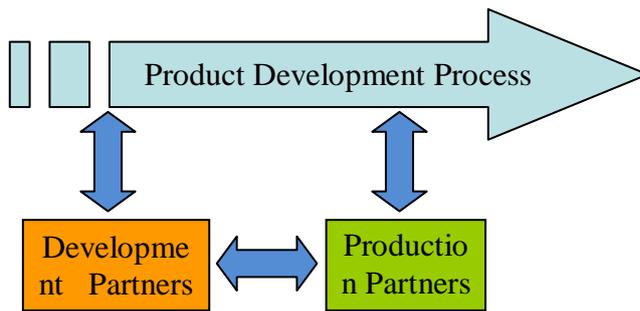
Development and production innovation networks

Usually, manufacturing a product involves a long chain of entities consisting of a set of suppliers and vendors, which manufacture components, modules and systems that are then integrated by client companies or OEM (Original Equipment Manufacturer), providing further distribution companies who in turn deliver them to end users. In the production of the E-Toll, BIT also established a set of partnerships and to manage a set of external entities, adapting a model of "virtual factory". The adoption of this model allowed transferring some risk to each partner, although the greatest risk would always be in BIT, as responsible for managing the entire process. This risk allocation allowed, in a proactively way, to commit all companies to the end result and sharing a common objective, which would meet the production timings..

Value Creation

At Brisa the investment in innovation aims to reduce costs and capture new opportunities, looking for a positive differentiation regarding its competition and following the strategic framework delineated, in order to obtain positive and sustainable results.

The potential for value creation in this project is clear:

- Reduced operating costs by allowing the removal of operators in several toll barriers;

- Flexible operation in the toll station, able to increase the flow of traffic for unexpected peaks or off (providing more lanes on the fly), providing better customer service

In the E-Toll project, the expected results on value creation are around 75 million euros, based on the equipment expected life cycle, concession period, among others. This number only accounts for Brisa gains, because the created value to the society is also relevant, such as the development of partners, jobs creation, know-how gain and import-export budget deficit reduction.
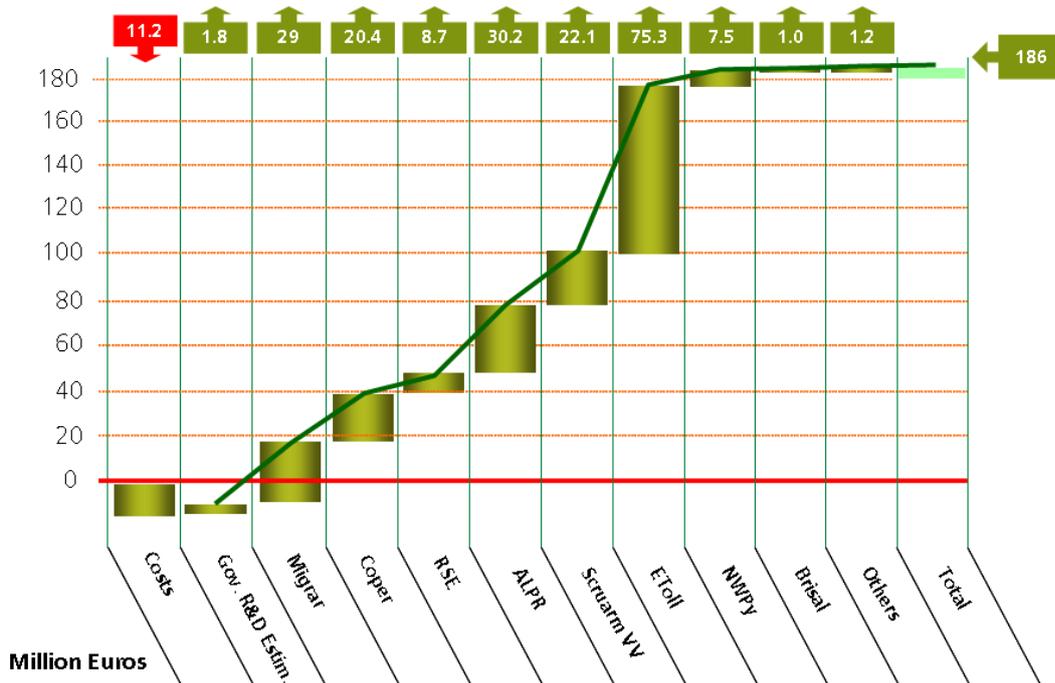
Innovation Results

Conclusions

The eToll was a project that brought large gains in effectiveness and efficiency to the Brisa operation, allowing a reduction in operating costs, increased availability and enhance security, among other benefits.

It also serves as a demonstration of the advantages in having an innovation unit in motorway companies. The independence of critical suppliers and the knowledge of technology have enabled Brisa to have an extra competitive advantage in accessing to international markets, acting as a distinguishing factor.

The concept and potential benefits of innovation networks are easy to perceive, but its application in real work situations is complex, requiring a set of best practices that ensure the best transformation of these experiences into real earnings for all entities involved. This project foresees the construction of an innovation chain that focuses on BIT. In fact, unanswered requirements, materializing its market needs, are the engine of innovation itself, promoting and fostering the development of new skills and new solutions in other partners. These partners in turn will similarly influence the other entities and organizations with which they interact.

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Jorge Sales Gomes has a degree in Industrial Engineering, by the FCT/UNL, is post graduated in Mechanical Engineering - Computer Integrated Production by IST/UTL, Management by the Univ. Catholic and is Master in Management and Industrial Strategy by ISEG / UTL. He was Innovation and Technology Director of Brisa Autoestradas since 2002 and since 2009, he is administrator of Brisa Inovação e Tecnologia, a company from Brisa group. He has a wide experience of working at various functions in companies such as Sorefame and the Papelaco Group and also held positions of teacher in FCT/UNL and as consultant. He is author and co-author of several publications in the areas of road transport telematics, innovation, quality and management. He has a continued collaboration with the sector of moulds, particularly with the Business Incubator Project OPEN.

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Tomé Canas works in product development and innovation management at Brisa Innovation and Technology, a company from Brisa group, the main Portuguese highway company, where he is in charge of the innovation, quality and environment management systems. He is a mechanical engineer (2000) and is also a Master in Science in Engineering Design (2007), both at Instituto Superior Técnico – UTL. His master thesis was about collaboration networks

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