Developing Sustainable e-Business Models for Intelligent Transportation Systems (ITS)

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Abstract. Intelligent Transportation Systems (ITS) are technologies for efficient traffic management, e.g. accident and congestion prevention, reduced emissions, traveler information etc. Despite the potential benefits identified by previous research, there is a remarkable lack of a robust e-Business case for ITS. Although the necessary technology exists and the internet provides opportunities for more cost effective integration of systems and services, many ITS are not sustainable and great ideas do not develop further. Many applications are still too expensive to purchase and install, they require substantial upfront investments and the returns will take many years to materialize. This paper emphasizes the need for ITS to take advantage of the developments in Information and Communication Technologies (ICTs) and the internet, and proposes some e-Business model framework for ITS. We also address sustainability issues and aspects of the network economy for ITS companies. Finally, we present a stakeholders' analysis and a future research agenda.

Keywords: Intelligent Transportation Systems, e-Business model framework, sustainability.

1 Introduction

ITS were invented to improve transportation systems operations, by increasing productivity, improving safety, reducing travel time and costs and saving energy [1]. Such systems also open up significant opportunities for new services for drivers, travelers, as well as infrastructure providers. ITS is an umbrella term that cannot be limited to a certain number of systems and applications. There is no commonly accepted taxonomy of ITS, as there are hundreds of systems and applications, each of them designed for a very specific purpose, as well as, a growing number of new devices, or, devices under development. However, attempting to categorize it, we could distinguish ITS into two wide groups: intelligent infrastructure and intelligent vehicles. This taxonomy was introduced in the early 1990s, when the U.S. Department for Transportation adopted the "Intelligent Transportation Systems" project [2]. Intelligent infrastructure includes systems and applications designed for road and transpor-

tation infrastructure, such as loop detectors, electronic toll collection (ETC) and variable message signs (VMS). The term "intelligent vehicles", on the other hand, refers to in-vehicle systems and applications, such as satellite navigation devices, intelligent speed adaptation (ISA), adaptive cruise control (ACC), forward collision warning (FCW), pedestrian detection systems (PDS) and lane departure warning (LDW).

Despite the fact that a few studies have discussed issues of sustainability in the broader transportation sector [3, 4], not enough research exists on ITS sustainability. A systematic literature review on ITS showed us that the business side of ITS has been ignored, as the vast majority of journal papers target ITS from an engineering perspective. Search of journal databases, such as the Web of Knowledge and Business Source Premier, over all time periods, provided us with a very small number of business related studies on ITS, and no recent papers on business, or e-Business models. The systematic review was based on the algorithmic methodology proposed by Lee [5], which produces a large number of potential references by searching journal databases using specific keywords, and then, eliminates less relevant publications during filtering stages.

The main aim of this paper is to provide a robust e-Business case for the sustainable development of ITS. This research is part of a multi-million research project funded by the Research councils of the United Kingdom (RCUK), aiming at improving social inclusion with the use of digital technologies in many facets of everyday life, including transportation. The paper is organized as follows: in the next section we present a brief overview of ITS. Section 2 presents past business studies on ITS and transportation and shows the apparent lack of business model understanding in the literature. Our analysis on a sustainable e-Business model for ITS is given in section 3. Section 4 gives a preliminary stakeholders' analysis, section 5 highlights some ideas on future research, and finally, section 6 presents our conclusions.

2 The Lack of a Sustainable Business Model

In the last 40 years ITS has been mainly studied from the technological perspectives, and despite previous research and experiments, it has so far failed to take off. The technological possibilities have failed to be translated into real benefits to providers, users and to society. With rapid technological developments, in ICTs in particular, the time has come for ITS to take off. One of the main barriers is the lack of a robust business case, shown by the lack of previous studies in business and economics.

The only recent work on e-Business models in ITS and transportation we identified is the paper by Zografos et al. [6], which discusses business models for flexible passenger transport services (FPTS), i.e. customized transportation services characterized by special features, such as options on type of vehicle to use and online booking selection of routes. Zografos et al. [6] present a methodology for ranking and selecting the most appropriate business model, based on criteria such as, legal and regulatory framework, market opportunities, business vision and business mission. Most of the business related studies on transportation and ITS, however, do not even discuss business models. They are focused on describing examples of ITS projects and their eco-

nomic evaluations. Cost-Benefit Analysis (CBA) is the most popular methodology for these economic evaluations. Odeck and Welde [7] use CBA for the automatic Oslo toll collection system, Naniopoulos et al. [8] use CBA to evaluate the results of the TRAVEL-GUIDE project, a European project aiming to provide guidance in the implementation of ITS, Melkert and Van Wee [9] use CBA for the "Superbus", a conceptual high-speed vehicle for public transportation running from Amsterdam to Groningen. Leviakangas and Lahesmaa [10], on the other hand, highlight the deficiencies of CBA in evaluating and selecting ITS investments and promote multicriteria analysis (MCA), which take into account more factors than CBA, such as experts' preferences and goal settings.

The lack of a robust business case for ITS is evident in most of these studies. The next section describes the e-Business model framework we propose for ITS.

3 Towards an ITS e-Business Model Framework

A business model defines how a business works and the logic that creates its value. It provides the vital links between an organization's vision and strategy with its structures and processes [11]. The term e-Business model, on the other hand, was first defined by IBM in the 1990s as "the transformation of key business processes through the use of internet technologies" [12]. It is broader than e-Commerce, i.e. buying and selling items over the internet, as it involves customer service, business collaboration and utilization of online services for a wide array of business transactions [12]. Business models are essential for translating commercial opportunities into revenue generating activities, but despite the apparent focus on commercial sustainability, any sustainable business models in ITS need to take into account the divergent nature and unique characteristics of the sector. In particular, the business models need to effectively address the tensions between creating commercial value and generating wide social and economic values; and the distribution of the benefits amongst different stakeholders.

There is no commonly accepted definition for a business or an e-Business model. Several authors have studied e-Business models and provided taxonomies based on general features of these models [12]. Although it is difficult to define what an e-Business model should and should not include, and no universal business model exists one of the most complete e-Business model frameworks has been conceived by Osterwalder and Pigneur [13]. They propose an e-Business model that contains four main pillars: a) Product and services, b) infrastructure and network of partners, c) relationship capital and d) financial aspects. In addition, the sustainability of any business model also depends critically on e) stakeholder credibility, which include both internal and external stakeholders [11]. For any ITS project to be sustainable these elements must be adequately addressed.

3.1 Products and Services

Products and services provide the basis for revenue generation and the effects are transversal to several layers within the society. Fig. 1 is presenting the value proposition for ITS. The value creation starts at the level of providing intelligent vehicles and infrastructures, by ITS providers. The created value passes on to the users level in the form of safety, reduced travel time, reduced congestions and all the benefits associated with the use of ITS. This layer includes the direct benefits to the people, for which they are prepared to pay. Hence, that creates business opportunities for more companies to enter the market as mediators and service providers. Next, the value passes to a higher level, namely the "Economy & Society" layer. This is translated into external benefits (e.g. positive economic externalities) such as, reduced spending for new roads, improved traffic management, less congestion, less costs and need for accident response and treatment. It also results in reduced pollution, better social inclusion for disadvantages transport users (e.g. elderly and disabled) and better quality of life.

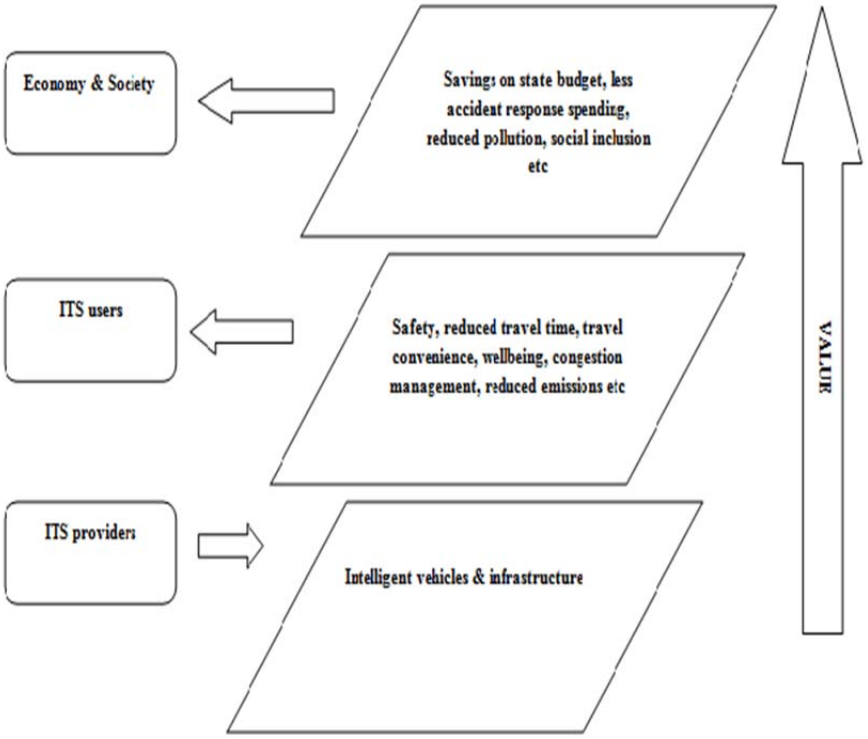

Fig. 1. Value proposition for ITS

3.2 Infrastructure and Network of Partners

This element refers to the intelligent infrastructure and the key stakeholders behind ITS development and management. An ITS network could include stakeholders like the government, funding bodies, transport groups, automobile companies, communication technology companies, the energy sector, the road users and others. More about the stakeholders' analysis of ITS is described in the next section. It is about how the intelligent infrastructure can be used in order to create value. It also shows who the main partners are, what their responsibilities and incentives are and what kind of relationships and partnerships they may develop. The internet provides opportunities to companies to develop e-Business models that make minimum use of physical infrastructure and handle their relationships and contacts with suppliers and partners. ITS companies can benefit from such opportunities, especially in the case of companies that manipulate the digital services of road infrastructure (e.g. variable sign messages, automatic road signs, road cameras, electronic toll collection, satellite navigation systems, and traveler information). However, special attention must be paid to compatibility issues with vehicles. ITS infrastructure incompatible with intelligent vehicles will add no value; it will only mean waste of resources. Therefore, intelligent vehicles should be considered as part of the infrastructure when adopting a particular e-Business model. That also relies on the following element, the relationship capital, which is about forming a network of customer and managing the relationships with those customers.

3.3 Relationship Capital

This element is about customer relationship and the impact of ITS networks on the road users, how the ITS providers can win the users' trust on their products and services, how this trust is measured, through which channels the users' information is collected and utilized, and how the feedbacks from the users are gathered and manipulated by the service providers. Never before had the growth of the internet given the firms such an opportunity to reach a vast network of customers and provide products and services on a global basis at a minimum cost. For ITS companies, the World Wide Web constitutes an ideal marketplace to promote themselves and create rapidly a critical mass for their digitized products and services.

3.4 Financial Aspects

It is about converting the value that the ITS providers offer into revenues and profits, i.e. the pricing models they adopt, how the company makes efficient use of its tangible and intangible assets, how it converts the value of its products and assets into money. In the internet era companies' interest is shifting more rapidly to investments in intangible assets (e.g. reputation, network of suppliers, intellectual property, value of information), while tangible or physical assets constitute a decreasing percentage of the total company value [12]. This in turn also serves the tasks of cost reduction and

of working more effectively with the same or even fewer resources. Some ITS companies are capital intensive due to the nature of their line of business. Although an ITS company might need huge upfront spending and often take a long time to recover the costs and make profits, an e-Business model that takes advantage of the facilitation that the world wide web offers can speed up the process of recovering the costs and making profits. There are numerous examples of online firms that experienced exploding profitability and corporate value within a few years through proficient use of the internet (e.g. Google, Amazon, e-Bay, Facebook etc). The financial aspects sit upon all previous three elements and affect them. It is therefore necessary to secure a sustainable business plan, able to offer satisfactory returns and benefits to the investors and provide assurance that the contributors will be rewarded. Any business plans must also be self-financed after some point.

3.5 Stakeholder Credibility

The sustainable development of ITS also depends critically on the support of all key stakeholders, which goes beyond financial sustainability. A particularly important aspect of the stakeholder credibility in ITS is about the distribution of potential benefits amongst different interest groups, and the wider social and economic benefits at the society level.

3.6 Sustainable e-Business Models for ITS

The main challenge for an ITS company, as implied from the analysis above, is to take advantage of the opportunities offered by the internet. There is growing development in the ITS technology, both for transportation infrastructure and vehicles, and several examples of products and services in the ITS industry that could be integrated with, or make use of the internet and digital technologies. Nevertheless, the ITS sector has not taken off and the opportunities offered by the ICTs have remained rather unexplored. In the following, we present a few examples of ITS technologies, where the internet could create business opportunities.

Advanced Traveler Information Systems (ATIS). They are systems that provide customized information to the user, such as on route selection, options about public transport, information about the destination and warning messages for potential dangers during travelling [14, 15]. Many of them are GIS-based, like in-vehicle navigation devices and rely on digital technologies in order to operate. They offer an excellent opportunity for e-Business model development, through for example, offering information on products of third parties (e.g. adverts), or even operating as platforms for added services, such as reporting defects on the road and updating online information about routes. They could also incorporate tourist information for popular destinations, such as suggestions for sightseeing, or, online hotel booking.

Electric Vehicles. With the increasing environmental concerns of the future, there is growing research on electric and hybrid vehicles [16]. Digital technologies could contribute to the establishment of online business for these vehicles, for example by

providing online information about charging posts, or, by selling online credit for vehicle charging on a pay-as-you-go basis with a registered smartcard.

Electronic Toll Collection. Electronic Toll Collection (ETC), also known as Electronic Payment and Pricing System, is a topic of growing interest [7, 17, 18]. It is technology that enables the collection of congestion charging automatically, by recognizing the vehicle's registration number. Neither have the drivers to stop at toll plazas, nor are cashiers required for the collection of tolls. Through the internet, public authorities, or, private companies could enable prepayment of tolls, or even discounts, for frequently used routes, by allowing the road users to set up online accounts through their websites. ETC could also be used as supportive mechanism for tracking down vehicles linked to illegal activities and facilitate law enforcement.

Public Transportation. It is one of the areas where ITS have already started to have an impact and to revolutionize public transportation services [19, 20]. Widely used examples of ITS are passenger information systems at bus stops or train stations, bus-mounted cameras, online bookings and automatic payment systems. There is room for further developments of internet-based technologies on public transportation, such as improvements in the integration of traveler information with mobile technology and enforcement of Wi-Fi networks, which could create new business opportunities for third parties.

4 Stakeholders' Analysis

In order to map the network of ITS stakeholders in a simplified way, we list the following main players:

- Government & Policymakers (G&P)
- Funding Bodies (FB)
- Transport Groups & Organizations (TG&O)
- ITS Designers & Manufacturers (ITS-D&M)
- Automobile Suppliers (AS)
- Key Shareholders (KS)
- Energy Sector (ES)
- Environmentalists (E)
- Local Authorities (LA)
- Users (U)

We classify government & policymakers, funding bodies, ITS designers & manufacturers, key shareholders and the energy sector as the **primary stakeholders** and all the rest as the **secondary stakeholders**. In Fig. 2, we present the influence-interest grid mapping technique, developed by Imperial College London. The horizontal axis measures the level of interest of the stakeholder in the technology. The vertical axis measures how much the stakeholder can influence these developments. Each circle, or

bubble, represents a stakeholders group, with red for the primary stakeholders and green for the secondary. The size of the bubble is indicative of the size of the group.

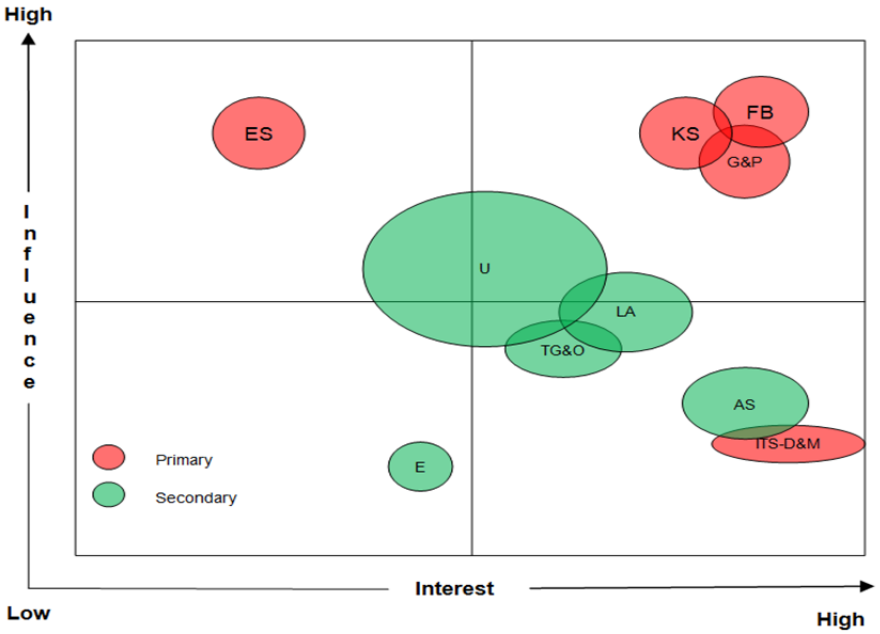

Fig. 2. Influence-interest grid mapping for ITS stakeholders

4.1 Government and Policymakers (G&P)

A rather small not-for-profit group, with moderate interest in ITS limited to the extent that ITS could be a source of public funds or a means to more efficient traffic management. They can have great influence for the implementation of ITS projects as they have legislative power under their control. However, their influencing power might be limited, because of conflicting interests with other key stakeholders, such as funding bodies and the energy sector.

4.2 Funding Bodies (FB)

It is also a small group, but with great influence on ITS implementation, as they are the ones who provide the funding. They could also be characterized by increased interest as long as they foresee significant returns in their investments. They have overlapping areas and collaborations with the Government & Policymakers and the key Shareholders.

4.3 Key Shareholders (KS)

They have many common characteristics with the previous two groups in terms of interest, influence and size. They also constitute another source of funding and that assigns them both with high influence and interest.

4.4 Transport Groups & Organizations (TG&O)

A middle size group with moderate interest in ITS, as long as ITS does not threat vested interests. They have not much level of influence either, as their role is usually restricted in researching the transportation field or creating revenue by entrepreneurship in transport operations (e.g. university research centers, public transport cooperatives, freight transport or leisure transportation companies).

4.5 Automobile Suppliers (AS)

They are very interested in the ITS developments, as they can change radically the market conditions they operate in, but have no much influence in these developments. Their role is mainly to intermediate between the manufacturer and the final customer. They have some overlapping areas and collaborations with designers and manufacturers.

4.6 ITS Designers & Manufacturers (ITS-D&M)

They are amongst the most interested groups in ITS developments, in many cases they are the driving force of these developments, but with very little influence in getting ITS out in the market.

4.7 Energy Sector (ES)

They are not interested in a positive way in ITS, especially if they compromise their interests in the energy supply (e.g. electric vehicles that render petrol obsolete). Nevertheless, due to their financial power, they might exert large influence to the ITS developments, either positively, or negatively.

4.8 Environmentalists (E)

A rather small group, with moderate interest in ITS and very little influence as well. Their ITS interest is sparkled either if ITS poses threats to the environment, or, if it is deployed for more environment-friendly transport. In any case, their power is very limited.

4.9 Local Authorities (LA)

A large group with also moderate interest in ITS and average power to influence the developments. In many countries their power is restricted to executing the central government's decisions.

4.10 Users (U)

They are the largest group of stakeholders. They sit somewhere in the middle of the grid, meaning that in most of the cases they have a passive role in ITS developments. They are interested in ITS according to their needs for transport, but they do not have much influence. They are affected by all stakeholder groups, but they have closer interactions with the Transport Groups & Organizations and the Local Authorities.

The mapping we presented is based on the evidence we found in the literature. Part of our empirical research is going to provide a real mapping of such stakeholders, which to the best of our knowledge, has not been attempted yet. Such a piece of research could be extremely valuable in our efforts to establish a holistic framework for the ITS. It will also provide a real picture of the industry and will initiate comparisons between the current state-of-the-art and the ones that should be targeted.

5 A Future Research Agenda

Researching ITS as a whole has provided us with useful insight. It also highlighted the absence of a sustainable business model framework, regarding a wide spectrum of systems and applications with increasing popularity. Nevertheless, as mentioned in section 2, ITS is a very broad term, each category of ITS applications has its own special characteristics and involves the action of specific groups of stakeholders. The e-Business model framework presented in this paper can serve as a generic guideline for constructing future business models, but empirical research is also necessary in order to facilitate the full-scale development of the field.

There are various ITS examples that provide fertile ground for e-Business research, e.g. advanced traveler information systems (ATIS), electric vehicles, wireless networks for inter-vehicle communication, public transportation, and we have shown examples how some of them can operate as platforms for third parties' services. Empirical research will need to narrow down to particular examples and collect data with several types of research. Three types of research are needed: surveys to understand general patterns and emerging trends; case studies to develop deep insights; and simulation to build on surveys and case studies and allows us to explore different scenarios and generate insights in different contexts.

- Surveys: both online and by contacting real-life key stakeholders, like system designers, traffic authorities, users, policymakers, funding bodies, academics etc.

These contacts could be through interviews or by using questionnaires. Through surveys, useful information can be extracted on the market size, current business strategies and on the key stakeholders in the market.

- Case studies: targeting of specific companies who have excelled in the internet economy and careful examination of their e-Business models. This part of research could focus on companies that operate in the transportation sector, but it could be expanded to companies of other sectors as well, whose e-Business models can be adapted to the ITS industry and expanded.
- Simulations: another important part of our research would be simulated studies of particular scenarios. Simulated firms and stakeholders will provide realistic information on business behavior under certain circumstances.

6 Conclusions

This paper addressed business and economic issues of ITS and discussed aspects of developing a sustainable e-Business model framework. We also presented a preliminary stakeholder analysis, on which we would like to develop our empirical research. The business model framework we proposed consists of five main elements: products and services, infrastructure management, customer relations, financial aspects and stakeholder credibility. Empirical research is necessary in order to gather primary data from businesses and social groups, able to inform any future research avenues through surveys, case studies and simulations.

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