LOCATION BASED MULTI-MODAL TRANSPORT INFORMATION SERVICES BASED ON THE USE OF INTELLIGENT SOFTWARE TECHNIQUES

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Abstract

The advancement of new technologies and the increased demand for mobile data services (infotainment) favours the introduction of innovative information applications for users' transport guidance. These services should be attractive to the user (for example provide personalised information) as well as the business entities that will participate in the service scheme. More importantly, they should cater for social goals such as integration of the EU transport area and demand management. The paper describes two relevant EU IST projects, namely IMAGE (finished in November 2003) & IM@GINE-IT (started in January 2004), and identifies their differences and similarities through a cross-comparison analysis. IM@GINE-IT takes over from IMAGE project and aims to built up a complete e-marketplace for transport information and reservation services, covering all transport modes across Europe, at different environments (urban, inter-urban, within transport terminals) and through various devices (mobile phones, in-vehicle devices etc).

Keywords: Location based services; Mobility services; Transport information; Modal shift; intelligent agents; Web services
Topic area: B2 Telecommunications and Advanced Information Systems

1. Introduction

1.1.Rational

Innovative applications in transport are considered by the European Union, national, regional and city authorities as important tools for a sustainable transport environment. The goals are to achieve modal shift from private car to public transport and consequently, reduce traffic congestion and urban air pollution. One of the emerging "tools" for achieving these goals is mobile information & guidance services based on current user location (*location based services*): The mobile person of today use various Internet and WAP services in order to obtain transport and travel information, route guidance and information about attractions, business and cultural services at the proximity of their current location. This is becoming a continuous upward consumer demand trend as a) mobile telephony market penetration is increasing, b) mobile telecommunications and bandwidth is advancing and c) more and more data services over wireless links become available. Thus, a new window of opportunity is emerging for public transport and traffic authorities: to disseminate available transport content through mobile devices so as to

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satisfy user needs for information and most importantly, increase public transport patronage.

1.2. Aim of the paper

However, a number of this new era business and technical issues are still to be solved, and thus make research and development effort necessary for planning migration paths from conventional (rather "autistic") transport operations to the integration into the new ICT economy world. These issues are:

- Personalisation of the service
- Multi-modality of the transport information
- Efficiency of the service
- Market and financial viability
- Business models

The overall objective is to lever transport content as a useful and profitable "commodity" (i.e. generating financial profit), but on the other hand sustain its important socio-economic value.

This paper discusses two RTD case studies: the IMAGE project (Intelligent Mobility Agent for complex Geographic Environments – IST 2000-30047) duration: 24 months, from 11/2001 to 10/2003, and the IM@GINE-IT (Intelligent Mobility Agents, Advanced Positioning and Mapping Technologies, Integrated Interoperable Multi-modal location based services – IST 50808) duration: 24 months, from 1/2004 to 12/2005, that both produce a system for the assistance of citizens' mobility through mobile multi-modal transport information & guidance utilising artificial intelligence techniques and intelligent agent technology.

The paper describes the technical work carried out –or it is to be carried out- in both projects, assess and cross-examines their contribution to achieving the above mentioned overall two-fold objective, namely a) financial viability, and b) socio-economic value, which actually holds the role of the *Research Hypothesis* for both projects.

2. Methodology

The methodological steps used are three:

1. Crystallisation of the state of the art and identifying the problem: what is the need for the two RTD projects?
2. Description of the projects' objectives, technical & business solutions and their results
3. Cross-comparison of the envisaged impact of the two projects and identifying their differences (strong and weak points)

Obviously with respect to steps 2 & 3 there is a miss-match between the IMAGE project, which has been completed, and the IM@GINE-IT, which its developments are still in course. However, the paper will assess both projects on the basis of their envisaged impact of a possible full-scale deployment; furthermore, IMAGE project is the natural pre-successor of IM@GINE-IT and for this reason its pilot installation results are a useful indication of the IM@GINE-IT future.

The cross-comparison takes place for five areas of criticality (according to the pre-defined Research Hypothesis), namely:

- EU transport systems integration
- End user acceptance
- Transport impact
- Business attractiveness

- Technical innovation and efficiency

The assessment is qualitative, based nevertheless on quantitative findings (such as surveys).

3. State of the art

According to a recent study carried out by the magazine ONLINE TODAY (2002), 69% of the internet users use the internet to compare hotel prices, 28% for booking flight or rail tickets and 25% for booking hotels. This vast market is gradually getting mobile. Experts from the GARTNER GROUP (financial Times, 202) believe that in 2004 Mobile services market will have a gross value of 23 billion €. The figures below display the experienced and foreseen "boom" in the worldwide location-based services as well as mobile consumer service revenues in Europe.

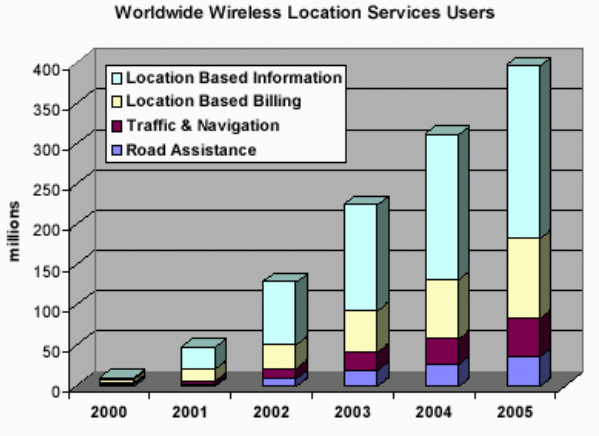

Figure 1: WLS Users worldwide

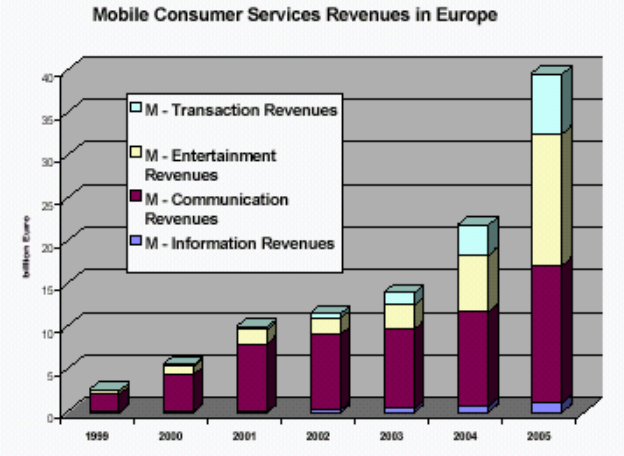

Figure 2: Mobile consumer services revenues by mCommerce sector

And yet, the forecasted rapid gains seem to be more and more delayed and even endngered by strong competition from other regions, such as iMode, the "hyper service" from Japan.

One of the main problems is that the end user ("passenger") perceives the transport network as infinite and seamless, neither the supply of physical transport services nor the proision of travel information services is in reality close as such. For this reason the passenger is obliged to an intermodal chain of transport information, as per the physical movement itself. The ITS industry supporting, or supposed to support, the intermodal transport, on the other hand, is quite segmented, as per geographic boundaries, transport mode (i.e. private vs. public), distribution of content, as well as communication means. Personal end users profiles, differences in culture/language and user interface preferences are rarely taken into consideration. Clearly, there is a need for intelligent and personalised infomobility services, covering the whole travel chain and being Europe-wide and flexible.

4. The IMAGE project

4.1. Objectives

As tourists, on business tours or when taking a trip to the neighbouring town we often are uncertain of where to find a specific activity (for example, restaurant) and/or point of interest (POI), and how to get there. We may also want to reserve a seat and pay in advance to avoid queuing, or pay for the transportation. This may even happen in our

hometown when we are in search for an unfamiliar activity. Ideally, this bundle of services would be user-friendly, un-complex, and sensitive to our personal profile.

IMAGE aims to help citizens and travellers in such situations by providing them with mobile, personalised, location based information on activities and POIs, how to reach them and how to pay for them with flexible mobile and stationary means.

To achieve this goal, IMAGE develops an open and modular service platform, accommodating advanced key services, such as user-positioning, off-board navigation and e-commerce and introduce a new business role, the IMAGE System Operator, that intermediates between the actors involved in service delivery, i.e. the network of content providers, service and e-product providers and the end-users.

The IMAGE system provides European citizens with a wider range of services, made more easily accessible for them, through a common supply channel. Image enhances the mobility of citizens, especially tourists, elderly and disabled and also the mobility of labour. In its strong focus on travel it supports seamless public transport services and may thus have positive effect on the modal split of transport Technical solution

4.2. Technical solution

The IMAGE project developed a modular GIS based internet system, which engages intelligent agent technology, in order to provide location based, personalised transport & tourist mobility services. The IMAGE system collects and stores content from different sources (external databases) and provides information services through a variety of channels to end user devices, such as PC, PDAs and mobile phones. The Image system allows also the purchase and payment of external e-products, such as tickets and on-line reservations, for the end user either through links to various e-shops or potentially via the Image system itself. The IMAGE system comprises of the following modules, which have been developed and tested:

- GS web services, which include mapping, geocoding and intermodal routing
- Payment module responsible for the payment functions related to Image
- Data management module, which interfaces, collects, stores content from data bases, as well as the user, and disseminates the information to other modules
- Intelligent module, a multi-agent system, responsible for managing end user requests and dynamically building user profile
- User interface for PCs, PDAs and mobile phone devices

Furthermore, the following applications complementing the Image services have been developed:

- The OPS application, which manages end user co-ordinates collected from devices' GPS, and has two parts: client side and server side
- Advanced navigation features through the use of 3600 photographs
- Off-board navigation application, which is loaded on end user's PDA, and provides dynamic and continuous end user pedestrian navigation.
- A ticketing application for public transport

Figure 3. Image system

4.3. Results

The suite of services provided to end-users by the IMAGE system can be divided as follows:

- Personalised information services on transport & tourism (personalisation, positioning, routing, mapping, navigation, POIs, events)
- Non-personalised ("guest") information services on transport & tourism (routing, mapping, POIs, events)
- Personalised push information services on transport & tourism (events concerning bookmarked routes and POIs)
- Sale of e-ticketing & on-line reservation products
- Link to external "e-shops" (e-ticketing & on-line reservation products)

The Image platform has been tested and demonstrated at two test beds, namely:

- Tampere, Finland (http://image1.tietoverkot.net/image/)
- Turin, Italy (http://image.5t-torino.it/)

The results of the surveys performed during the IMAGE system's demonstration have been quite optimistic both from the point of view of the end users, as well as the transport operators.

For example, over 47% of the Turin users' sample believes that IMAGE could help a lot with respect to their public transport journey planning, as shown in the next figure.

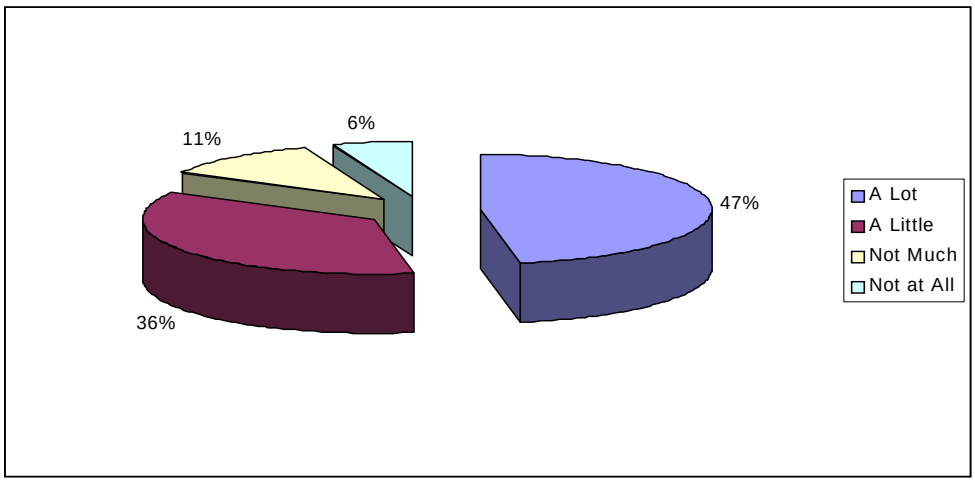

Figure 4: "Would IMAGE help you in public transport journey planning in Turin?"

Furthermore, from the results of survey held at the UITP 2003 conference it seems that public transport operators consider IMAGE as a very helpful tool facilitate public transport patronage.

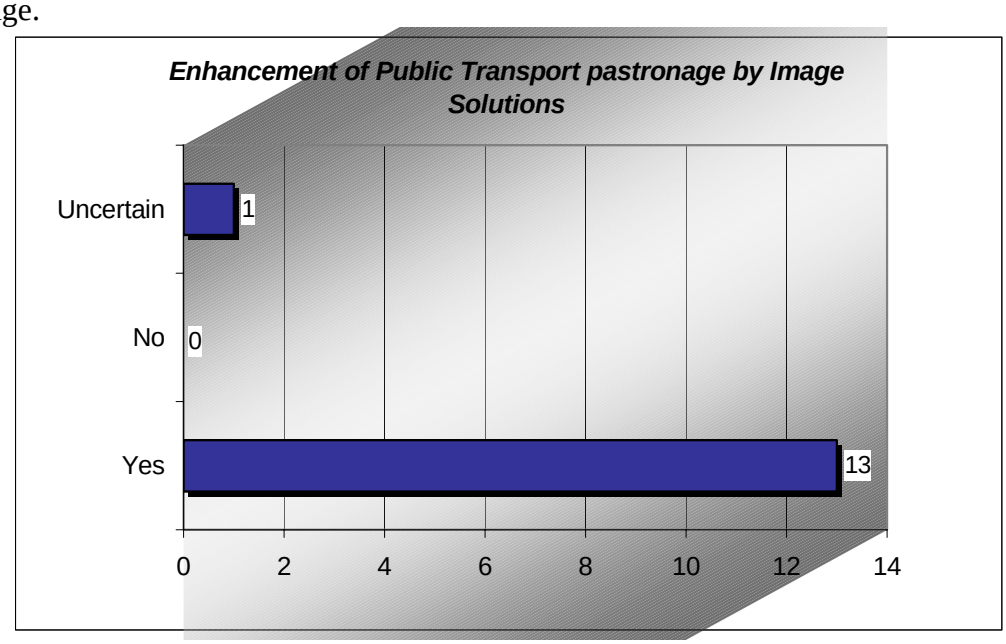

Figure 5: Perception of usefulness of Image solutions to public transport

5. The IM@GINE-IT project

5.1. Objectives

The main objective of IM@GINE IT is to provide one and single access point through which the end user can obtain location based, intermodal transport information (dynamic and static), mapping & routing, navigation and other related services everywhere in Europe, anytime, taking into account personal preferences. Thus, the key phrase behind IM@GINE IT is: ***facilitation of seamless travel in Europe***.

Therefore, IM@GINE IT will:

- Cater for intermodality & seamlessness of travel. The mobility network is in reality seamless, thus IM@GINE IT should synthesise information of all modes, and of both

urban and interurban environments. The constraints and specific requirements of all modes and environments involved should be taken into account.

- Bridge the gap between in-vehicle and off-board information and navigation systems.
- Bridge the gap between vehicle and pedestrian navigation method to provide a seamless intermodal navigation.
- Be capable of collecting and managing data from different sources.
- Cater for interchangeability & seamlessness of communication technologies (access everywhere). The back end (platform) as well as the front end (device) should be able to accommodate and/or switch to different communication networks according to the needs of the moment and place.
- Be able to "roam" between different media providers.
- Be capable of always acknowledging the location of the end user wherever he/she is, thus switch between different positioning methods depending on the special requirements of the place or mode in which the end user is.
- Be capable of navigating the end user at all levels (micro, within an airport for example, middle, within a city or area, and macro), and for the whole intermodal travel.
- Provide other related location based or travel oriented services, such as booking/ticketing and emergency services.
- Perform complex tasks on behalf of the user, and according to his/her preferences. These tasks may include: automatic selection of best travel plan, intelligent filtering & synthesis of information & services, automatic change of travel plans according to unexpected events, booking and ticketing.
- Interface with external systems at the platform and/or the device point.
- Provide an external data editor, which allows to an external content provider to update and enhance a central IM@GINE IT database.
- Increase safety while driving by using IM@GINE IT personalised services to adapt accordingly the warnings and information coming from the vehicles ADAS and IVIS and by automate procedures like route planning, information filtering etc, allowing the driver to focus to its primary task (following the relevant AIDE algorithms). IM@GINE IT platform is directly interfaced to in vehicle network, so its actions are based on vehicle's status and road conditions. Accordingly to these features the platform can understand the level of risk concerning the present driver work, again through AIDE.
- Increase safety also of pedestrians by minimising any disturbing information or confusing tasks, which will reduce the drivers' attention to the possible dangers around them.

5.2. Proposed technical solution

IM@GINE IT has to cater to the personal needs of the consumer in the following areas: "Being", Knowing, Wanting, Acquiring, Enjoying. Formally, IM@GINE IT will cater for the needs of the consumer by providing information ('knowing') that permits a choice of services according to consumer preferences ('wanting'), arranging for the remote booking of those services ('acquiring'), facilitating trip planning according to user preferences ('wanting') through the provision of mobility information ('knowing'), on-line booking and ticketing ('acquiring'), in a way that ensures maximum comfort ('enjoying') and is customised to the consumer's profile ('being'). In essence this is a consumer value chain, i.e. the end user will identify value in a service to the extent that the service caters to

his/her needs in at least one of the above areas. The formulation of the users' objectives will lead to the cataloguing of a set of functional and non-functional requirements, per category, which by being clustered together, can define the scope and objectives of the IM@GINE IT system.

The overall architecture of IM@GINE IT is composed of the following main actors:

- the user;
- the service structure and the modality to access;
- the server side telematic platform, which manages content, services and user profiles;
- the device side application which hosts temporary users' preferences, interaction with other applications and user interface;
- the infrastructure on the field.

In summary, the IM@GINE IT system needs therefore to be able to "know":

- The geographic environment in which the end user is moving. Most important POIs are origin, destination of travel, and current location. The latter can be generated by GPS or by localisation via Wireless Network, Wireless Lan, logical localisation ("Koppelnavigation in car", using the time schedule of a train or plane).
- All the transport network of the area in which it is active, including hubs, stops, PT routes and roads, of all involved modes.
- Always where the end user is and how he/she is currently travelling. That means if he/she is on a transport vehicle of any mode, in a transport hub, in his/her car, on the road, off the road, pedestrian or not.
- What is the best way to communicate the services (network, on-line or off-line).
- Where to find the information and/or service required (i.e. from which external system).

The IM@GINE IT system will constitute a platform comprised of Data management, Web services, Intelligent Agents and Communication gateways. The platform should interface with Content providers, Service providers, GIS systems, Ticketing systems, Added value systems and Media providers.

The platform will be able to:

- Obtain data from different sources.
- Provide a data editor to allow the input of data from external partner.
- Perform data synthesis according to specific requirements of transport modes and environments.
- Obtain external services.
- Perform service synthesis according to personal profile and user position.
- Geo-reference all data and services.
- Perform route referencing and logical localisation.

On the device side four different local applications will be developed depending on the device's type (mobile phone, PDA, in-vehicle, mobile PC; various sizes, OS, communication means, computing resources' capabilities, etc.). In total the four types of mobile devices will provide the same core functionality, and therefore services. The differences between the four types have mainly to do with: a) their technical characteristics (for example operating system, user interface capabilities), b) the usability and context of use aspects (different usability for mobile phones and mobile PC, different context for in-vehicle device – driver – and different for mobile phones – pedestrian or PT user), and c) other local systems with which the IM@GINE IT system has to interface (for example on-board car navigation for in-vehicle device). These variations in characteristics and possible impacts on the final service delivery will be assessed and analysed in the framework;

however, would not affect the functions accommodated by the mobile device, and are envisaged to be as following:

- Local off-line applications, hosted in the device.
- Interface with the platform when appropriate (for example requested by the end user). Client-server as well as peer to peer communication is possible
- Switch to different communication networks.
- Switch to different user positioning means.
- Automatic identification and adaptation to different operational environments (i.e. in a car, in a different transport vehicle – airplane, train, pedestrian, stand-alone).

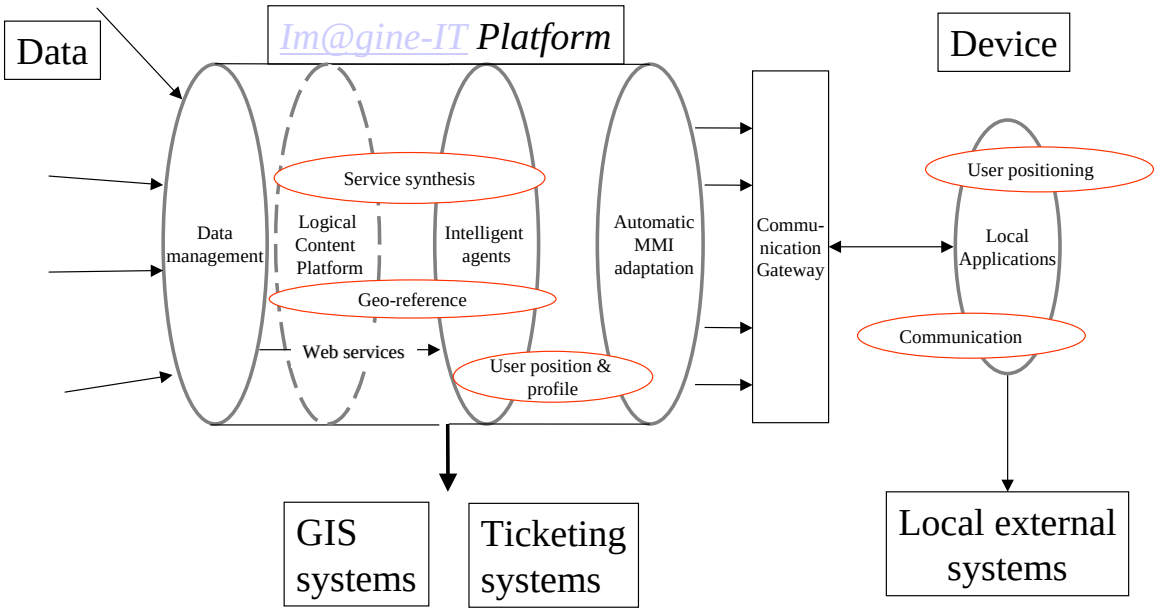

Figure 6 Functions and elements of the IM@GINE IT system

5.3. Envisaged results

Infomobility services are currently very much clustered within Europe. Four different types of services (classic portals, advanced portals, distributed systems and service networks) are competing for supremacy, while a number of problems, such as lack of integration, different business models, legal and technological constraints as well as different platforms and VAS (i.e. in-vehicle systems, PT systems, pedestrian systems) limit the usability and thus market penetration of such services.

IM@GINE IT, developing a common router for data gathering and interfacing (Data Management module), a single batch of georeferenced and navigation services and a common, personalised user interface for infomobility services provision across the whole travel chain, significantly contributes towards a long-awaited dream to come true: **seamless travel and tourism information coverage across Europe**; based upon advanced, reliable and high quality dynamic services.

The necessary competences for it may only be found in a truly pan-European Consortium as IM@GINE IT, that can also bridge the different user needs and infrastructure / technological platforms across Europe; with application sites in North (Finland), Central (Germany), South (Italy, Greece) and Eastern (Hungary) Europe.

6. Cross-comparison

The assessment and cross-comparison of the two projects is taking place for five areas of criticality, namely EU transport system integration, End user acceptance, Transport impact, Business attractiveness and Technical innovation and efficiency. For each area the two projects are compared against a number of specific factors. The results of the cross-comparison are presented in tabular format.

6.1. EU Transport system integration

The relevant factors are:

- Geographical coverage
- Seamlesness
- Transport modes
- Multi-modality
- Transport services

Table 1: Cross-comparison of the two projects as per impact on EU Transport system integration

Factor	IMAGE impact	IM@GINE-IT impact
Geographical coverage	IMAGE provides information for two cities: Turin (Italy) and Tampere (Finland). Both sites are interoperable	IM@GINE-IT will provide information for the transport corridor from Finland-Germany-Hungary-Greece. All sites will not only be interoperable but also integrated
Seamlessness	IMAGE provides information only for urban transport networks	IM@GINE-IT will provide information for urban-interurban environments as well as within transport terminals (for example, airports)
Transport modes	IMAGE covers car, urban public transport and on foot trips	IM@GINE-IT will cover car, urban & interurban public transport, flights, maritime transport
Multi-modality	IMAGE provides information for all modes, but only through mobile devices, not covering directly the “driver user case”	IM@GINE-IT will provide information through mobile devices (relevant for public transport and on foot users) as well as in-vehicle devices (relevant for drivers). IM@GINE-IT will provide information at transport hubs (for example airports) for users ready to travel.
Transport services	IMAGE provides public transport information, routing and e-ticketing	IM@GINE-IT will provide additionally traffic information, dynamic transport information, car navigation and seat reservation.

6.2. End user acceptance

The relevant factors are:

- Usefulness

- Usability
- Personalisation

Table 2 Cross-comparison of the two projects as per end user acceptance

Factor	IMAGE impact	IM@GINE-IT impact
Usefulness	IMAGE provides transport and travel guidance for cities. More useful for tourists visiting another city	IM@GINE-IT will provide services for travel planning and dynamic updates for the whole of Europe. Useful for commuters as well.
Usability	IMAGE provides information through PC and PDA, by utilising GPRS network	IM@GINE-IT will allow the combined & interchangeable use of the services through mobile devices as well as in-vehicle devices, by utilising all available wireless networks.
Personalisation	IMAGE takes into account static profile (set by the user) as well as dynamic profile, built by the intelligent agents according to end user choices	IM@GINE-IT will also include "vehicle profile" and expand the capabilities of the dynamic profile.

6.3. Transport impact

The relevant factors are:

- Public transport promotion
- Traffic information and other driver mode related services
- Dynamic updates

Table 3 Cross-comparison of the two projects as per Transport impact

Factor	IMAGE impact	IM@GINE-IT impact
Public transport promotion	IMAGE provides real time public transport information for cities.	IM@GINE-IT will provide public transport information for urban and interurban environments. IM@GINE-IT will provide demand management services for drivers (for example, park & ride information)
Traffic information	IMAGE provides static traffic information (for example, public works sites)	IM@GINE-IT will provide real time traffic information and other driver related services
Dynamic updates	IMAGE provides dynamic updates for delayed public transport timetables through SMS	IM@GINE-IT will also include continuous monitoring of user's active trip progress. More categories of dynamic updates' content is expected.

6.4. Business attractiveness

The relevant factors are:

- Range of business players
- Public-private partnerships (PPP)
- Interoperability and access

Table 4: Cross-comparison of the two projects as per business attractiveness

Factor	IMAGE impact	IM@GINE-IT impact
Range of business players	IMAGE scheme includes local content providers, services providers and portals. Local or national scheme	IM@GINE-IT scheme will also include in the scheme: mobile device manufacturers, automobile companies. Pan-European coverage is possible
PPPs	IMAGE includes local public content providers as well as private content aggregators. Contractual architecture available	IM@GINE-IT business scheme will allow for the inclusion of any organisation handling data or owning portal regardless of being public or private. More complex contractual architecture is envisaged
Interoperability and access	IMAGE accommodates interoperability between sites. IMAGE provides web services for content providers accessing the platform.	IM@GINE-IT will also accommodate interoperability for any organisation handling data or owning a portal. In fact IM@GINE-IT will become an e-marketplace for transport data. IM@GINE-IT will allow the "logical" publishing of transport data in a standardised way

6.5. Technical innovation & efficiency

The relevant factors are:

- Innovative system architecture and mechanisms
- Location based technologies
- Wireless communication technologies
- Intelligent agents & artificial intelligence

7. Conclusions

The IMAGE and IM@GINE-IT projects have quite similar topics and research objectives; in fact the latter is the follow-up effort of the former. Obviously, and as resulting from the assessment and cross-comparison between the two projects, IM@GINE-IT has an extended scope and increased envisaged impact. The additional value of IM@GINE-IT can be summarised as following:

- EU integration: IM@GINE-IT is integrating cross-border transport information from 5 different member states, covering all transport modes and for all transport environments (urban, interurban and within transport terminals)
- End user acceptance: IM@GINE-IT is providing a full range of location based transport information and reservation services through various mobile and in-vehicle devices.

- Transport impact: IM@GINE-IT is providing dynamic, up-to-date information about all modes, and promoting modal shift and demand management.
- Business attractiveness: IM@GINE-IT ambition is to become a unique e-marketplace for transport information and services accommodating various types of content providers, service providers and portal owners
- Technical innovation: IM@GINE-IT is designing a distributed state of the art system based on semantic web, engaging cutting-edge software technologies.

Table 5 Cross-comparison of the two projects as per technical innovation and efficiency

Factor	IMAGE impact	IM@GINE-IT impact
Innovative architecture and mechanisms	IMAGE was one of the first projects to use intelligent agents, web services and XML/SOAP interfaces in the transport application domain	IM@GINE-IT will be the first project to define and use semantic web and ontologies at the transport domain. IM@GINE-IT is a much more distributed and open system than IMAGE
Location based technologies	IMAGE used only GPS as location based technology	IM@GINE-IT will use interchangeably GPS, cell id and logical localisation
Wireless communication technologies	IMAGE used only GPRS networks. Minimum applications on the devices' side.	IM@GINE-IT will use also Wi-fy and other available wireless networks. More effort on mobile devices' applications
Intelligent agents	IMAGE implemented a state of the art intelligent agent architecture for transport services	IM@GINE-IT will enhance the role of the intelligent agents in the system. More types of agents will be implemented, and will be distributed between the client (device) and server side

Nevertheless, both have accomplished – or expect to accomplish - scientific breakthroughs with respect to the existing state of the art technology for innovative transport systems and services as well as with respect to horizontal technological areas, such as localisation, mapping, intelligent agents and web services. Most importantly, they are both expected to contribute to transport issues with significant social value, namely in EU integration and demand management tools, as detailed in the next paragraphs.

7.1. Contribution to the EU integration

The e-Europe 2002 initiative documents highlight a shortage of new services in the areas of E-commerce and transport, stemming from the fragmentation of relevant infrastructure management between Member states. This creates a barrier to service providers who cannot exploit the economies of scale of the single Market. Both projects' interoperability and cross-sector actions on service provision and common service layout aims at opening this window of opportunity from common service provision by a wide range of transport and non-transport related service providers. This mixture ensures a wide take-up of the ICT systems and the development of innovative business and service-supply partnerships, which will help to ensure that the end-results of Image are self-sustainable systems for the common good of the European citizen.

As the European Community develops into an open society spanning national borders, the mobility of people around Europe will increase for both social and economic reasons. Key to this is the transportation sector. Facilities must be in place to support such movement, the ability for citizens to continue their normal lifelong activities, the ability for citizens easily to refer back to homeland services such as reference to their doctor, as well as the ability for citizens to carry on dialogues with services and service providers in the language of their choice. At the same time, the Community will wish to harmonise services to citizens across European borders but without suppressing cultural differences. IMAGE & IM@GINE-IT directly target the realization of several priorities set within the EU Common Transport Policy document (http://europa.eu.int/comm/transport/themes/mobility/english/en1.pdf).

7.2. Contribution to transport demand management objectives

In most of the urban centres of Europe the space for traffic is scarce and more cannot be gained. If people can be guided, first of all to a service that exactly meets their preference, and secondly along the optimum route we can make transport more effective and the cities more attractive and environmentally sound.

Thus by developing well constructed and useable information services for public transport it is anticipated that users may feel more confident about using public transport and may affect a modal split away from private cars and back towards public-based transport. If such information can be delivered in a information timely and suitable format then the new ICT-based mobile information devices will find a high penetration of use both for the primary services of PT information, trip planning and timetabling – but also for a wide range of other services which could 'hitch' onto the systems established for transport information. This in itself will achieve a great deal of integration and with the correct mix of services (as proposed in for the Image test-beds) generate additional users of the system and additional revenue streams to guarantee the financial viability of the primary service

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