Future thinking on the Galileo Authentication Application

Innovating by living mobile

The Galileo commercial service is one of today's challenges towards a successful exploitation of the European Global Navigation Satellite Systems (GNSS). This document underlines actual trends on the mobile market showing that convergence of new breakthrough technologies and GNSS positioning is significantly progressing. In particular, actual and future issues and consequences for the development of a GNSS-based authentication application encompassing the users' identity, positioning, velocity and timing are investigated.

Authentication could result in a "sustaining/revolutionary innovation" allowing the mass diffusion of existing mobile services (e.g. by means of digital signatures and smartphones used as e-wallets). It has been shown that barriers related to security and privacy issues can influence the development rate of this new era of mobile services. Authentication could allow navigation satellites to become definitely a key complement of new terrestrial wireless-based technology. It could contribute to many current EU policies such as the ones for ubiquitous society, smart cities, intelligent transport systems, etc.

The development of a robust authentication application within the Galileo E6b frequency band is a key step for the Europe Union to confirm its ambition to become a leading knowledge–based society. In order to try to achieve this future scenario, the service requirements have to be fixed and proper strategic choices have to be taken by the EU in the upcoming years.

Author: Emanuele Barreca, trainee October 2009 /February 2010

Host Institution: European Commission, DGTREN, unit G3.B3

ACKNOWLEDGMENTS

These few lines report my feeling of gratefulness for my traineeship experience within the European Commission, at the DG TREN, participating at the G.3 B.3 Unit job activities for the Galileo Satellite System programme. I would write here my thanks to the people I have met during my traineeship who has contributed to the creation of this document:

- My formal advisor, Carlo des Dorides;
- My informal advisor Olivier Chassagne;
- All the colleagues of the Galileo Units. In particular, Helmut Spitzl, Philippe Hamet, Ugo Celestino, Anita Pietka, Bernardo Urrutia Garro, Maes Isabelle and Sara Gallardo;
- All the colleagues of the Galileo Supervisory Authority (GSA), in particular, Gian Gherardo Calini, Fiammetta Diani and Boris Kennes;
- All the partners of the Galileo programme (in particular, Roland Berger, FDC and Helios);
- The ISU family (MSc ’09 colleagues and faculty members);
- The Galileo Coordinator at the Premiership of the Italian Council of Ministers, Alessandro Giordani.

Finally, I would share here my feeling of having be a privileged with all the winter 2009 trainees and underline the precious job done by the traineeship committee, the DG TREN trainees coordinator (Josepha Gonzalez) and our port-paroles (Chloe Middleton and Laura Eid).

PREFACE

This document is the outcome of the 5-month traineeship at the European Commission (from here and after EC), Directorate Transport and Energy, unit G3.B3. From October 2009 to February 2010 I had the chance to enrich my knowledge of the current challenges towards the development of the navigation satellites system Galileo. A research task was attributed to me from the start of the traineeship focusing the actual and future scenarios for the Galileo Commercial Service (from here and after CS), in particular, the authentication service.

The research has been carried out on a daily basis by different means such as articles review, internal EC Galileo unit documents review and interviews within its team members. Moreover, I have been able to extract ideas and critical thoughts by attending internal meetings and external conferences such as "user driven open innovation in advanced service-product development (7th December 2009, organized by ESoCE-Net) and "the ambitions of Europe in space" (15th/16th October 2010, organized by the European Commission). During this period, the EC Galileo unit has tackled the challenge of selecting next satellite manufacturers and launch and operations service providers. A recommendation and a communication for the EU Parliament have been created at the end of a 1-year study for the exploitation of Galileo that involved also the GNSS (from here and after Global Navigation Satellite System) Supervisory Authority (from here and after GSA) and external consultants.

My previous research, started in the beginning of 2009 was dedicated to the topic of the convergence of ICT and the space 2.0[1] technologies[2] (latest user-oriented applications and new areas of development). Those topics match the renewed Lisbon strategy targets that see a European Space Policy as a must key for achieving technology integration and convergence and an economic and social progress of Europe.[3]

The results of this previous work have been useful for the analysis of the Galileo authentication service, allowing me to rapidly identify the real potential behind this new element in the GNSS market.

With the hope that this reflection could add value to the ongoing research on the exploitation of the Galileo system, I wish you a good reading.

[1] Please for more information visit the following website: http://www.8cproject.com

[2] Please for more information see "Barreca 2009, Digital Aerospace Business Ecosystem (DABE): a platform based on 2.0 services for the benefit of the space community and applications' users". The value behind this work is in stimulating the use of new tools and approaches for improving the cooperation between actors in the space sector.

[3] To understand better, it could be useful to report below the main achievement of the last (sixth) Space Council (May 2009, the 29th): "Recalling the great results of the ESA Council meeting at Ministerial level of November 2008 and the EU Competitiveness Council conclusions related to the GMES programme of December 2008, the Sixth Space Council recognised the importance of the existing innovation support mechanisms to ensure cross-fertilisation of innovation and ideas between space and non-space sectors, space industry, leading research organisations and universities. This goes instantly in support of the European Economic Recovery Plan and its call for the launch of a European Plan for Innovation which should also include space technology and services derived from it, as one of the main technologies of the future".

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AR	Augmented reality
CS	Commercial Services
DGINFSO	Directorate General Information Society
ESA	European Space Agency
EU	European Union
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	Galileo Supervisory Authority
ICT	Information Communication Technology
IT	Information Technology
LBS	Localized-based services
MID	Mobile Internet Devices
SIS	Societal Information System
SWOT	Strenghts, Weaknesses, Opportunities and Threats

INTRODUCTION

Recently, the Galileo programme is continuing to develop, over passing obstacles at financial, managerial and technical level. In 2014, early service provision should be achieved thanks to the first set of satellites that will constitute the first stage of the Galileo constellation. For this objective the European Commission (from here and after EC) is working hard together with the GSA and external consultants to monitor the respect of the awarded contracts for the satellite manufacturing, launch and operation services provision. In parallel, for the exploitation of the system, strategies and policies have to be set to stimulate innovation and allow market growth. This is particularly true for the exploitation of the E6 band of the Galileo system infrastructure that is designated for the "so called" Commercial Services (from here and after CS). Recent studies, proposed to the EC Galileo Unit team for CS exploitation, underline some categories for CS, such as: high precision, authentication, data broadcast, etc... Under this area of interest, much more have to be analyzed and researched in regard of short-term and long-term consequences of today's decisions. In this respect, the objective of this document is to demonstrate that the Galileo authentication service has the potential to become a key element allowing GNSS to be really complementary to terrestrial wireless technology for future mobile services. The document is structured in two chapters:

Chapter 1. It analyzes "breakthrough" innovative integrated technology and related GNSS-enabled applications for the mobile market. Mobile phones and location based services market forecasts are reported. Key actual and future trends are analyzed and focused as for instance the role of Internet for the mobile world (open collaborative innovation through social network, cloud computing, information and applications availability). Finally an analysis of Apple, Google and Nokia commercial strategies for location-based services (from here and after LBS) allow understanding actual market dynamics. The Strengths, Weaknesses, Opportunities and Treats (SWOT) analysis is applied to identify their competitive positioning under the light of mobile market trends for LBS.

Chapter 2. It represents the analysis of the potential of authentication application for the mobile service market. After describing the technical concept of authentication and its needs, some of the mobile services that could develop through the authentication application are analyzed. To conclude the key requirements and actual issues for the development of the authentication-enabled markets are reported.

CHAPTER 1 – GNSS and the mobile technology convergence

1.1 Trends in the mobile sector: status and perspectives

1.1.1. Smartphones and location based services

Integrated mobile phones will still be the most commonly carried mobile computing devices in 2010, but researchers at Intel and Frost & Sullivan believe most users will still view them as supplementary to devices with bigger screens and keyboards, especially notebooks. To respect user requirements, smartphones are not best suited to extensive computer activity. However, they are developing always more capacities thanks to the convergence of the GNSS and the Internet into the devices. New functions like computing services, location based services, social networking are becoming drivers of a revolution in the mobile sector.

According to Frost & Sullivan (2009), a bigger market share for smartphones is coming up in 2010: 250 million of 1.3 billion mobile phones shipments will be for smartphones. This trend is explained by the huge development of mobile applications in 2008 and 2009, driven by the IPhone benchmark product innovation. One main consequence of the innovating trend is the boosting of LBS that will become mature for 2010 thanks to the achieved maturity of breakthrough technology integration.

A market study conducted by the GSA foresees an amount of 236 billions of euro in 2025 for GNSS-enabled markets worldwide. This forecast includes both GNSS-based services and devices.

1.1.2. Breakthrough technologies for mobile device innovation

The "smartization" of devices is not the only kind of innovation through complex integration and development. Urban areas too are, indeed, becoming more and more smart thanks to the integration and development of new communication infrastructures. Public administration can better manage traffic and transport and citizens have an easier life. Under this light, at the EU level, "e-inclusion" and "ubiquitous information" are some of the actual policy drivers of the environmental and innovation policies for achieving sustainability and knowledge-based society. In this contest, mobile market is just a component of a wider process of innovation under which new breakthrough technologies and applications are reshaping users' behaviours and allowing the development of GNSS-enabled applications.

Recent researches (ABI, 2009) GNSS underline that handsets, digital cameras, Mobile Internet Devices (from here and after MID) and netbooks will increasingly compete with dedicated standalone hardware GNSS solutions driven by advances in GNSS chipset technology in terms of footprint, power consumption, sensitivity and cost[4]. At the same time, a wide range of alternative technologies such as Wi-Fi, inertial sensors and network-based positioning become potential substitutes /complements of GNSS. This is why smartphones can take advantage of a natural potential to become the catalyst product to achieve mass diffusion of LBS/navigation based services.

One of the actual breakthrough technology applied to smartphones is the Accelerometer. It allows to change the screen display from portrait to landscape when the phone is turned on its side, they can simulate the rolling of dice in games, and they turn a phone into a compass for navigation and augmented reality applications. The combination of those technologies allows obtaining a performance of mobile navigation set on instant moving. Some researches suggest that fully one-third of smartphones will use accelerometers in 2010.

Another key technology for today's "smartphonization" and GNSS-enabled

[4] Converged GNSS shipments were not impacted by the actual economic recession, due to soaring GPS-enabled smartphones sales.

applications is Augmented Reality (from here and after AR). It is become a cult technology for having allowed the development of GNSS-based social networking, like the Wikitude. From 2010 AR achievements should be confirmed and is expected a huge development in new areas of applications.

Moreover, the 3D and turn-by-turn voice navigation applications are achieving a wider utilization by GNSS mobile users. The developing of those technologies will be a huge boost for developers of indoor navigation applications and services build on hybrid (integrated) location technology such as the combination of Wi-Fi, GPS and triangulation schemes.

From the side of operation systems and products manufacturers, indeed, there are also main changes. Suddenly, new strategic partnerships are announced regarding value chain vertical integration or scaling. Nokia acquisition of Navteq Company started the trend a couple of years ago. Google, in early 2010, is entered in the smartphones competition in partnership with Taiwanese HTC proposing a new Google branded Nexus One Android. This device proposes to the mass an innovative high-value "free turn-by-turn audio directions" application. Google Internet search engine experience has been transferred to the new software for navigation that also shows semantic elaboration capability (web 3.0)[5].

Mobile application stores, then, are the new on-line markets where user-made applications are offered and purchased or free-downloaded. A huge number of smartphone makers and wireless carriers try to emulate the Apple Store concept, the first and still benchmark mobile application store linked to the innovative smartphone IPhone. Apple Store is become, indeed, a real paradigm and it has contributed to reshaping the application side for the mobile market re-aligning it to the new integrated technologies on the devices. Mobile internet-enabled applications downloads could reach 6.67 billion in 2014, from last Frost & Sullivan research (2009). The market segments covered in this research include pre-paid and post-paid mobile, SMS and MMS, mobile Internet and iPhone, Android, Windows Mobile, Palm, and Symbian kind of devices. The research does not provide an estimation of application categories and direct and indirect benefits and nevertheless the GNSS related share. However, adding this data to the previous forecasts, smartphones for 2010 and total GNSS enabled services and devices for 2025, it is possible to assume a very significant role of LBS in next two decades (2010-2030).

1.2 Internet: the language of the future integrated infrastructure

1.2.1 Cloud computing and availability

Cloud computing is allowing people to store data on-line and use on-line applications for personal and professional activities and projects (Unknown auth. – The Economist, 2009). Evolution towards Computing as a ubiquitous utility is one of the four connectivity technologies trends identified by the DG Information Society and Media (from here and after DG INFSO) in the report of July 2009 on trends on connectivity technology. This report contains the results of the study of the socio-economic impacts of the 'Ubiquitous Internet Society' and its possible policy implications. DG INFSO commissioned it as part of its preparations for the successor programme to i2010 – its current policy framework.

This study set out to review technology trends that relate to the notion of an emerging "Ubiquitous Internet Society" – renamed in this study as 'Internet of X'. It is very important to understand the trends identified under the light of the convergence of the GNSS technology and services such as the authentication by the Galileo system:

1) Development of a *common communications infrastructure* – which can be accessed through different devices and technologies, removing sources of exclusion and discrimination. Technologies that are directly associated with

[5] Requests of a food category, like "pizza", can be enough to the software to propose and drive you to the nearest point of interest to get a pizza. This "handy" technology is adding a new perspective for the mass diffusion of LBS.

this trend are: increasing bandwidth; increasing processing power and performance; increasing electrical power and performance. Related technological development: the increase of Internet capacity.

2) Evolution towards *computing as a ubiquitous utility* - putting computing on the same footing as water, power and telecommunications and creating new demands for connectivity and reducing digital divides associated with differences in access to computing and storage. Technologies that are directly associated with this trend are: increasing digital storage capability and decreasing cost per byte; faster computation; evolving computer architect; grid computing; cloud computing; everything as a service. Related technological developments are: open source software; more Internet capacity.

3) *The convergence of humans and computers* - *making* the 'ends' of the network smarter (e.g. through enhanced decision support), changing the need for active traffic monitoring and management in the network itself and producing new geometries of power and control. Technologies that are directly associated with this trend are: increased deployment of nanotech; cognitive computing; cybernetics, specifically cybernetic organisms; immersive virtual environments; decreasing size and increasing capability of embedded sensors. Related technological developments are: cheaper, faster and smaller RFID technology; more tools for personal identification and authentication; immersive virtual reality environments.

4) *The emergence of the Intelligent Web* - describing the deployment of existing technologies providing 'intelligence' to the protocols, structures and internal functions of the Internet itself, rebalances responsibilities and contributions of different stakeholders to overall socioeconomic impacts and creates a powerful 'pull' factor for further technological, economic, financial and social innovation. Technologies that are directly associated with this trend are: convergence of applications; more, easier and better creating & sharing tools; Web 3.0 tools. Related technological developments are: localisation of applications; decreasing size and increasing capability of sensors.

From the mass market perspective, the cloud computing trend is shaped and led by the Google Company that incrementally offers new free and customizable features to the final users: e-mail box, documents sharing, translate service, drawing tools, groups and task managing, maps and earth images and even recently a embedded social network application.

The Internet availability is becoming more and more wide and reliable through new wireless technology and the use of new communication channels such as satellites. Internet applications and services are becoming stronger thanks to the Apple store concept and are contributing to the rise of GNSS-based applications. Value added applications are today already developed around Internet mobile availability. However, the dependency factor could present a new problem until when full availability is not reached[6].

1.2.2 Applications "made in internet": user-designed applications for user-centred information

The involvement of the consumer in the creation of the applications is a choice transferred from consumer products market strategy where the paradigm of the "prosumer" (producer + consumer) is become the standard approach for new products and innovation. For consumer products, blogs and forums have been set up for achieving feedback on products and services to obtain information on improvement needs and complementary features. While, today, an innovative interface concept and application design have been introduced by Apple together with an on-line environment where, release, discuss and download those applications: the Apple store concept. The user-empowerment allowing a direct and rapid transfer of information

[6] As an example the Google navigation application running on the Android Nexus One is based on Internet availability. Please, find further elements on this argument in the last paragraph of this chapter.

between users have been boosted to achieve applications development sharing.

User role revolution has finally contributed to the growing up of the importance of Internet for the mobile market. The opportunity to have real-time information about a set of 4 variables (4i - identity, positioning, velocity and timing) is revolutionary and knowledge sharing and social networking are becoming key results of technology integration.

For instance, Apple's IPhone application "Wikitude", based on AR, Internet, Camera and GNSS technology (firstly developed for the Google's-HTC G1 Android device), is the representative of a new kind of location based social networking with great potentialities for future mobile services. The combination of camera and GNSS on the device can be used to link different information to a place. AR then allows whoever to access that information left. The future of this kind of social applications is really open to many sectors of activity.

Classic navigation has been revised after the introduction of the digital compass developed as a stand alone application for the IPhone, "Compass", and implemented into the Google maps based application, "Maps", always for IPhone. This is another example of the paradigm of the applications "made in internet". Cartesian user position is identified in respect to the researched destination and the graphic permits a compass based navigation. So, finally, applications are run, downloaded and designed in the web. The "open factor", recurring both in the user-designed creation of mobile applications for LBS and even in the free availability of them allowed by on-line free downloading, is taking the form of a disruptive innovation[7]. This strategic approach, started by Apple Company, is become the new paradigm determining the actual drastic change in mobile market thanks true innovative applications. This step forward allows visioning the future shift towards mobile services. Some more elements should appear. The authentication of the navigation message and 4i could be the key one.

1.3 Location based services arena: Apple, Nokia and Google strategy analysis

1.3.1 Product and market strategies

Today, between the main actors of the mobile arena for LBS, Apple, Nokia and Google seem to be the more dynamic because of introducing new market standards (Apple and Google) or mass diffusion potential (Nokia).

The Apple IPhone has introduced the new standard for mobile internet-based applications through the on-line application store concept, a new "easy" user interface and the integration of key breakthrough technologies as the touch-screen, the accelerometer, the digital compass, etc. I-phone seems already prepared for new geo-localization based applications such as personal photo tagging associated with additional localization information, etc.

Google Nexus One developed in partnership with HTC is introducing a unique semantic navigation application allowing real turn-by-turn voice guided navigation and intelligent street finding system (semantic research). As well as all Google products also this application is delivered for free.

Although it is still the global leader in the fast-growing market for smart-phones, its devices are losing ground. Especially in America, where Apple (iPhone) and RIM (BlackBerry) reign supreme in the smart-phone market, many already see Nokia as a has-been. This is why Nokia GNSS equipped mobiles, a set of different products from the feature and price perspective[8], are now following the

[7] You refer to a disruptive innovation for an innovation that creates a new (and unexpected) market by applying a different set of values. Please, for more information refer to Christensen "Theory of disruptive technology".

8 Nokia has recently announced its most affordable GPS phone yet, the Nokia 2710 Navigation Edition that will cost €110 (excluding taxes) when it launch in the second quarter of 2010. The new phone is expected to be popular in the developed and developing world alike and has been developed for urban environments, small towns, as well as rural areas. Incorporating straight-line navigation with the assistance of an integrated digital compass, it also includes turn-by-turn driving

standards imposed by Apple and Google. In particular the free availability of applications and the application store concept. Nokia executives say what's really exciting is the potential for developers to come up with applications. There are about 1.4 million Nokia developers worldwide. Via the Ovi for Developers Beta Program, applications will be developed and made available through Nokia's Ovi Store. Ovi Maps is immediately available for download for 10 Nokia handsets, including the Nokia N97 mini, Nokia 5800 XpressMusic and Nokia E72, with more Nokia smartphones expected to be added in the coming weeks. Current owners of Nokia smartphones that are compatible with the new Ovi Maps can download it free.

Nokia beats Apple in annual sales ($57 billion versus $37 billion) and market share in smart-phones (39% versus 17%), but it is much less profitable. In fact, Nokia's share of industry profits fell from 64% in 2007 to 32% in 2009 - not much more than Apple's and less than RIM's, according to Brian Modoff, an analyst with Deutsche Bank. Moreover, Nokia's market capitalization is barely a quarter of Apple's.

However, Nokia seems to have some key potential strength points such as its worldwide presence. While Google Maps Navigation is available only in the United States, Nokia's voice-guided navigation is available for 74 countries and works in 46 languages (both male and female voices are available in all those languages). Moreover, the company will pre-load its GPS-enabled smart phone line with local Ovi Map data, drive navigation, and travel guides from Lonely Planet as part of its third party deals. Internet dependency will be not a threat or a limit for Nokia users.

What Apple did for mobile music and what Research In Motion (Blackberry smartphones) did for mobile e-mail, Nokia could do for navigation applications.

navigation with full voice guidance. The device will be loaded with regional Nokia Maps so that it can be used without data connection.

1.3.2 SWOT analysis

The competitive positioning of these three main actors on the LBS market is represented through the matrix in the Figure 1 below. A SWOT analysis approach is used to identify and compare companies' positioning in the market. Strengths, opportunities, threats and weaknesses emerge from the previous analysis of companies market-winning strategies, such as:

- *Strategic partnerships*
- *From SW to HW and viceversa*
- *Key integrated applications*
- *Internet independency*
- *Open applications*
- *Products design and innovation*
- *Products line (différentiation)*
- *Geographic availability*

The Figure 1 results from Table 1 where Apple, Google and Nokia are graphically linked to those strategies. Then, due to different weights assumed for each of these strategies, it is possible to attribute a value to the companies under the SWOT analysis approach.

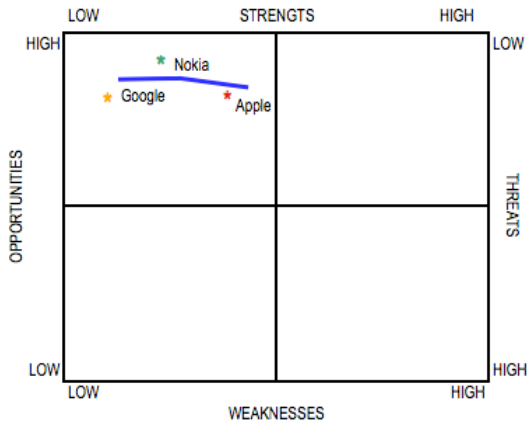

Figure 1. SWOT determined position of Apple, Google, and Nokia for mobile LBS.

Weights	Winning strategies	Apple	Google	Nokia
3	Strategic partnerships		*	*
3	From SW to HW and viceversa	*	*	*
3	Key integrated applications	*	*	
2	Internet independency			*
3	Open applications	*	*	*
2	Products design and innovation	*	*	
3	Products line (differentaition)			*
2	Geographic availability	*		*

Table 1. Winning strategies of Apple, Google, and Nokia for mobile LBS.

CHAPTER 2 - Galileo authentication: mobile trends catalyst

2.1 Authentication application: what is it and why is it needed?

2.1.1 Security issues for navigation message and information

The authentication service is foreseen as one application of the Commercial Service of the EC Galileo program. Mobile and car applications and services involving payments and depending on personal positioning, timing and velocity need the authentication of not only the navigation message[9] but also the position. This assumption will materialize in the future. To understand its value, a parallel could be done with the Internet paradigm. The on-line business soon grew up as Internet developed. It took a certain number of years to become a new paradigm in our society because of security issues, but finally with the introduction of secure protocols (HTTPS) and applications (overall the Pay-Pall service) the web allowed the explosion of commercial transactions "on line". As is the case for the secure Internet, transactions depending on positioning or mileage require a secure GNSS-positioning and timing.

Threats from hackers such as spoofing and meaconing (Lo 2009) are ready to disturb actual and future services. To achieve more security, it is needed a standard protection system. Under this consideration, the authentication of navigation message and related set of information could be that standard.

The authentication application could result in a sustaining and revolutionary innovation allowing the creation of new markets (mobile services) changing the people way to do things. It could reveal itself as the element that allows navigation satellites to become part together with terrestrial wireless-based technology of a complete integrated people-centred information system.

2.1.2 Authentication solutions

Two protection layers are needed:

1. *Range code encryption to authenticate the navigation message;*
2. *Information in device authentication.*

Range code encryption allows the authentication of the signal transferred from satellites to receivers. The navigation message is transmitted through a cryptographic key secure enough to assure a high degree of reliability. This layer of protection, once developed, through the right choices of cryptographic technology and mitigating plan for hackers, could enable trustable mobile GNSS-based applications and services. However, it is needed another layer of protection for entrust the authenticity of the position calculated. Hackers could indeed modify it after. The protection of the in-device information is the second level of authentication service needed. It could be represented by a 4i (information) concept: identity, positioning, velocity and timing. This security layer could allow mobile services to be based on reliable information.

9 Boris Kennes from the Galileo Supervisory Authority (GSA) interview quote: “As more and more business critical and safety critical applications rely on satellite navigation (e.g., logistics, fleet management, road user charging, remote patient monitoring) users want to be able to rely on the position (secure position stamp). Users therefore need accuracy and reliability but also trust. In particular, protection against spoofing and other types of fraud is essential. Authentication of the GNSS signal provides an important building block in a secure and reliable satellite navigation application. Similarly, trusted timestamps are essential in many applications including financial transactions. Other aspects like user authentication, communication security are other essential building blocks”.

2.1.3 Mobile services enabled by authentication service

A part from the already well known fields of application of the authentication concept such as the transport management[10], the high-value dangerous/ sensitive goods tracking and more, authentication seems, overall, to have a great potential to be a complementary service for actual and future GNSS-enabled mobile applications. For instance, the free turn-by-turn audio directions from Google Nexus One show that GPS applications can expand their frontiers thanks to the integration with other technologies such as the internet, the semantic research, the accelerometer, etc... Once big issues as the technical definition and legal value of authentication will be solved together with the marginal problem of the privacy, richer LBS will come and people will be able to use their smartphones to find a place, pay the bills in restaurants, have information during the visit in a museum, being trucked for working or commercial reasons, sign contracts, transactions and protect IP.

The transition from unilateral or social networking mobile applications to business or public mobile services can be achieved through such a complementary service.

Considering, some of the actual innovation policies at the European Union level, for instance the "ubiquitous knowledge in smart cities", a breakthrough element such as the authentication application in a GNSS would be the fundamental catalyst for the needed convergence of policies, investments and technology development.

Some of the key mobile services that are not flying today, due to the limits of the actual technology system, and that could start developing through the authentication application are listed below:

- *Digital signature;*
- *People tracking;*
- *Mobile health monitoring;*
- *Mobile payment by near field communication (cash less);*
- *Mobile advertising.*

Authentication can usefully complement digital signatures[11] by adding to it time and position stamps that could be included e in an easy way into documents, photos, videos, and transactions, thanks to integrated applications.

Tracking and location applications for lone worker, rescue operative and children will expand. Those new services are ready to grow through added complementary guarantees and services[12].

Mobile health monitoring is another key service could take off thank to an augmentation on the trustiness of navigation applications. Alzheimer affected people are just one example.

Position-dependent transactions could be a future breakthrough service supported by the Galileo authentication application. This could allow GNSS-enabled transactions to become the standard thanks to information on device guarantee. The applications of the cash less payment could be affecting so many sectors that it could really be considered as a new innovative technology: leisure (museums, restaurants), transport (parking, bus, metro and trains), etc. In this way, the smarthphone becomes an also an e-wallet.

Another piece of the puzzle of LBS is that advertisement is also becoming part of

10 As a clear example we can take the road pricing strategy of Netherlands. The principle nehind is that fixed car taxes (motor vehicle tax and vehicle purchase tax) should be eliminated through the use of navigation satellites. A base tariff per kilometre driven in the Netherlands will apply and its amount will be based on vehicle's CO_2 emissions. In addition, you may pay a per kilometre surcharge on driving particularly busy routes during rush hours.

11 No proof of place and time is given by actual digital signature systems. A new service could then finally introduce a radical innovation in life (business transactions, IP protection, etc.

12 In this respect authentication could be the key service together with high precision. Please, find the reasoning in the next chapter.

the mobile convergence led by GNSS-based applications due to the technology for embedding advertisements in mobile applications. For example, if you ask for Italian restaurants near your location, you may get not only an on-screen map with pushpins showing restaurant locations, but also pop-up windows, videos, contact tools for the selected ones.

The integration of localization and communication technologies for developing not only outdoor but also indoor services will definitely take up as a parallel process towards innovation led by authentication. The creation of an integrated people-centred information management system will be the key tool for public administration to face the future challenges of climate change, sustainability, knowledge-based society, digital divide, etc.

2.2 The shadow areas: requirements and actions needed

2.2.1 Legal value for authentication

The European Commission plans technical research and demonstration for authentication for 2010 and 2011, together with research and study on the legal value and market analysis. There is a need for the authentication concept to be accompanied by a legal recognition of the value of trusted timing and positioning. Authentication needs this step to become an asset for public policies and private business catalyzing the technology jump towards smart cities, clean economy etc... Interviews of the European Commission taskforce members, running the development of the Galileo system programme, show that there is a certain understanding of the importance of analyzing legal aspects surrounding authentication. 2010 and 2011 will be dedicated to procure and analyzed studies for demonstrating authentication trustiness and legal value; urban transport management (road tolling, tax-by-km, etc.) seems to be the candidate case of study. However, a mobile service should be also taken as a case study to understand another fundamental field of application and add more elements to the political choice.

2.2.2 Authentication service development strategy

Which solution will be developed and which will respect the security requirements is not yet known? This is another chapter that goes in parallel and can even aliment the studies on legal consequences of the authentication. For the development of standard solutions of authentication, at the different layers previously identified, the commitment of all the stakeholders is needed: research centres and academia, international associations of technology manufacturers and integrators, public dialogue with third parties and internal effectiveness, etc.

The incorporation and the development of the authentication application on the Galileo E6b band is a challenge from many points of view. Requirements have to be fixed and respected and proper strategic choices have to be undertaken by the Galileo management to allow authentication service to be run and then authentication-based services creation.

In light of these challenges, the strategy for developing the authentication application is being defined inside the European Commission (Galileo Unit) and the GSA.

There are many emerging risks and issues. For instance, the authentication service could be developed by a private entity under a concession scheme including also the future management of the service. However, this solution could be risky from the market and service potential exploitation side. A monopolistic condition could emerge and an early concession of the service could eliminate the opportunity to identify and demonstrate cryptographic and communication technology able to achieve the authentication service in a more effective and efficient way.

Public procured development of the authentication application could be the right solution in order to give a boost to the commercial service. However, this choice would be probably more time-consuming then the first option because of the lacking of experience in running space projects. Moreover, even though the Public Private Partnership scheme, used at the start of the Galileo programme, is failed, an opposite kind of approach could result unproductive, if not well structured. However it could be a key choice if a perspective for the private will be well depicted and the public role will be still that of an "enabler".

In conclusion, a service provider should be identified trying to avoid monopoly condition in the market and ensuring the maximization of investment and the most effective solution from the technical point of you. The dilemma is: privatization should be the solution to take from the start or it could come in later after the authentication service will be launched?

The right management decision should be taken in 2011 after technical, legal and demonstration studies have been conducted. First of all, the involvement and the commitment of mobile devices and receivers' manufacturers are essential. They have to collaborate together with those researchers and technology developers proposing those cryptographic and communication solutions to use the Galileo system E6B band and guarantee the authentication of the navigation message and data after transmission. Secondly, some selected technology options for the authentication application should be demonstrated and financed and its legal value needs studied and applied to road and LBS cases. Legal value study is important as important problems can be prefigured and avoided (see the Internet case where legal value was not there at the start) and awareness could be much more achieved (e.g. privacy). Moreover, in some years, once the service provider will be identified, a strong collaboration between technical parties is needed for the integration and convergence of hardware and service elements. The EC should be aware of achieve this cooperation, whatever management solution will be taken.

2.2.3 Authentication markets stimulation

Public commitment is a key on the achievement of today's challenges for technology policies development and implementation. If at the EU level, excellent decision-making choices will permit the development of the GNSS-authentication technology, at national, regional and local level, the diffusion of the authentication application should serve as a catalyst for industry, small and medium enterprises (from here and after SME), academic and research communities. Moreover, citizens need to be informed of such an important innovation-enabler. It is fundamental to allow the shifting to those new services and life behaviours enabled by the revolutionary innovation of authentication. The "so-called e-inclusion or e-citizens policy should start from communication and involvement on policies achievements.

The tremendous impact of future authentication-enabled services will need new legal basis to allow the rapid diffusion and the outcome of services inefficiencies (security issues) or developments (contracts, Intellectual Properties, etc.). Moreover, it would be the need of integrating GNSS technology with the new wireless and short communication technology (ubiquitous city) in order to achieve the LBS paradigm between the 2020 and the 2030 (please see Figure 2).

For allowing the development of mobile services based on GNSS and terrestrial telecommunication networks a coordinated action has to be taken from 2014, after demonstration and legal studies are done. Towards this target, the financing and the investment of capital and the sharing of human resources are necessary conditions. Once again the commitment has to be at all political levels. The EU, through the next Framework Program 2014-2020, should rise

up the results of the previous FP7 and continue investing in technology for sustainability and knowledge involving the different actors of innovation. Nations, regions and local administrations have to introduce incentives to allow the diffusion of authentication-enabled mobile services innovation.

Economic incentives, cooperation programs financing and new law regimes will allow private sector, research and academic institutions and citizens to take up the benefits of Galileo. To the case the innovation policy of the ecosystem could be applied to favour the sharing and optimization of resources together with the development of new services (Barreca, 2009).

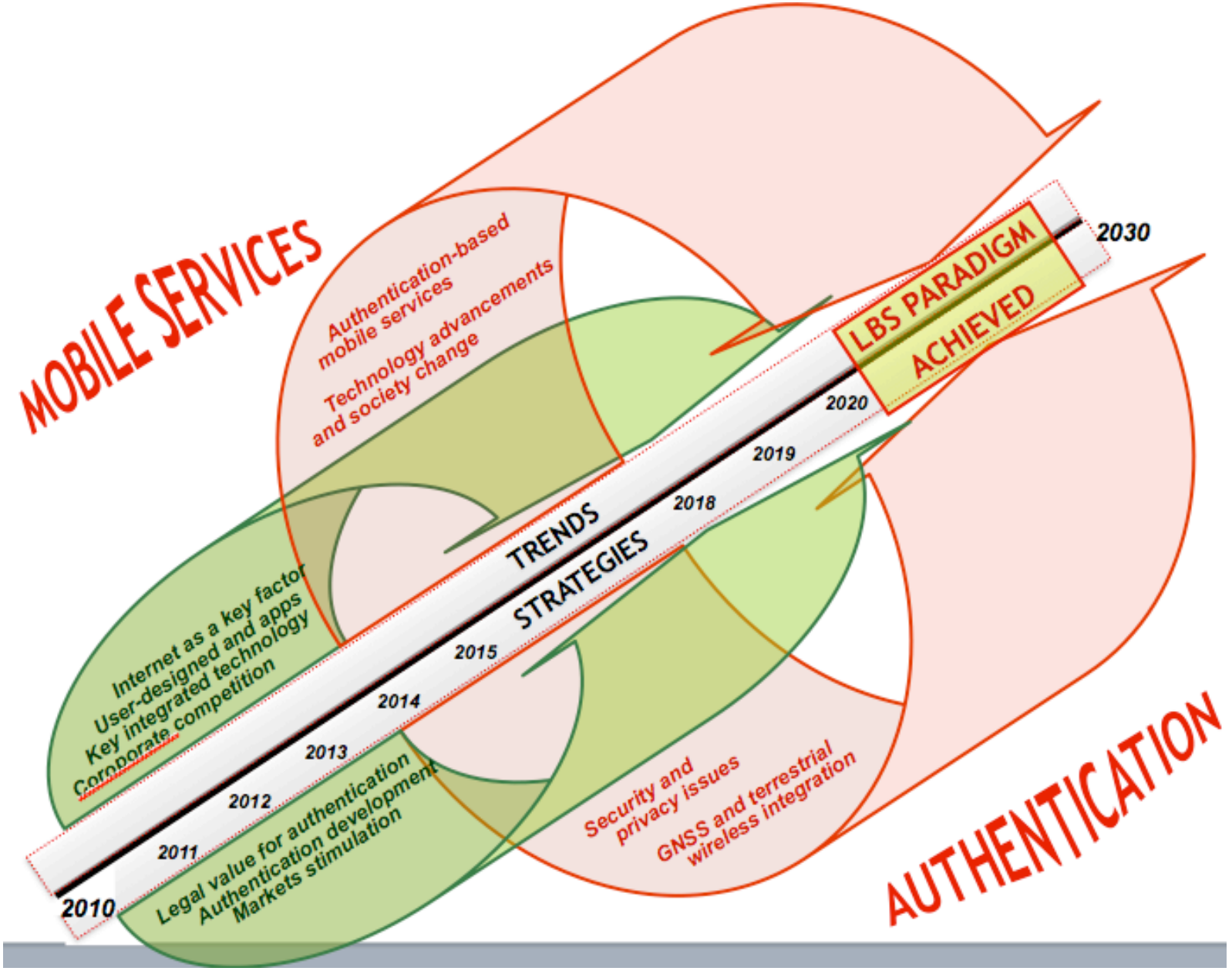

Figure 2. Timeline: authentication towards mobile services

CONCLUSION

During the last decade, space technology-enabled applications have contributed directly to human progress (e.g. in-car or mobile navigation) and gradually empowered Internet and telecommunication applications. The way towards a future knowledge-based society is taken. Internet and GNSS-integrated applications are adding value to the mobile market progress and constitute a main pillar in the trend. Although, Internet dependency (see Google turn-by-turn guided voice navigation) represents today an issue, improvements in wireless technology together with the diffusion of satellite-based provision of the Internet allow to believe those applications will be the future.

GNSS business is evolving at different levels worldwide and demand creation mechanisms are necessary to involve directly final users. This is the only way to speed up the process of innovation and technology integration. The satisfaction of users' current and potential needs, led by autopoietic environments is the key behind the progress. Application stores (see Apple I-Tunes and Nokia-Ovi) represent, indeed, the farms where GNSS-enabled value added applications for mobile devices are developed through a virtuous user-driven cycle allowing behavioural change in consumers.

In 2010, the shift from mobile applications to mobile services should advance. This trend will need to be supported by future perspective of a technology convergence. In 10 years the Galileo authentication service could contribute, indeed, to the ongoing process favouring breakthrough applications to boost the massive expansion of smartphones or multifunctional hand devices (see the IPad) leading the start of innovative mobile services allowing new life improvements and progress.

Sectors where this concept will be welcome are for instance transports (metro, train, parking, etc..) and leisure (restaurant, museum, sky-pass, hotels, etc.. Moreover last socio-economic trends towards smart cities and a ubiquitous Internet society will benefit of the potential applications enabled by the authentication service. Authentication, finally, could reveal itself as the element that allows definitely navigation satellites to become a complement of new terrestrial wireless-based technology. The creation of an integrated people-centred information management system will be the key tool for public administration to face the future challenges of climate change, sustainability, knowledge-based society, digital divide, etc..., even though, barriers related to security and privacy issues can influence the development rate of the new era of mobile services.

The need for authentication as a complementary service to support future breakthrough applications and services could become real as soon as the potential of this element is correctly perceived by the entity (-ies) in charge of the development and exploitation of the system. Good strategies have to be sought out for the success of the Galileo programme and the achievement of a technology jump at global level. In this context, authentication can strongly contribute on a global level to the value attributed to Galileo and other GNSS. It can enhance the European Union's target to soon become a knowledge–based society.

LIST OF REFERENCES

ABI research group, *"Global Navigation Satellite Positioning Solutions"* study, December 2009.

Backeberg C., *"Mobile predictions for 2010"*, December 2009

Barreca E., *"Digital Aerospace Business Ecosystem (DABE): a platform based on 2.0 services for the benefit of the space community and applications' users",* International Institute of Space Commerce, September 2009.

Cave J., Van Oranje C., Schindler R., Shehabi A., Brutsher Ph-B., Robinson N., *"Trends in connectivity technologies and their socio-economic impacts",* DG Information Society and Media, European Commission, July 2009.

Dennehy K., *"Nokia's Decision to Offer Free Navigation: Defensive or Offensive? "*, GPS World, February 2010.

Frost & Sullivan, *"An Insight into the U.S. Smartphone Application Storefront Market",* http://www.wireless.frost.com, 2009.

Gartner Inc., *"Gartner Identifies the Top 10 Consumer Mobile Applications for 2012",* November 2009.

Jubak J., *"The great Google-Nokia-Apple war",* article from MSN money website.

Lo Sherman, De Lorenzo David, Akos Dennis, Bradley Paul, *"Signal Authentication, a secure Civil GNSS for today", Stqnford University and Colorado University,* 2009.

O'Brien K.J., *"Nokia Fires Back at Google With Free GPS on 10 Phones",* article from The New York Times, January the 21st 2010

Pietka A., Urrutia B., *"How Galileo can help Europe recover from the economic crisis",* GNSS Forum, January 2010.

Siegele L., *"Big SIS is watching you"*, article from The Economist 24th annual collection *The World in 2010,* December 2009.

Unknown author, *"Battle of the clouds",* article from The Economist, October the 23rd 2009, *The battle over cloud computing.*

Unknown author, *"Cash remain king but mobile phones are the revolutionaries in the battle for change",* January the 5th 2010, article from The Times (p. 51).