Chapter 1

The Geopositioning Concept

1.1. A revolution is announced

The term *geopositioning*, coined by ALLCOMM[1] in 2003, was used to translate the new digital revolution characterized by the development of universal access to coordinates and geographical location in all places, at any time, automatically and at a low cost.

Geopositioning is understood to be any solution or function that allows the positioning, localization and production of geographical information and coordinates by a person, vehicle, a good or any other object, particularly during mobility, traveling or movement.

Geopositioning now includes an open group of essentially digital solutions producing explicit geographical coordinates or those integrated in databases, digital maps or geographic information systems (GIS).

The term geopositioning aims to be more universal than other names such as positioning, localization, geolocalization and navigation.

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1 www.allcomm.eu.

1.2. The basis of powerful technological systems

1.2.1. *US creation of a GPS economic industry*

Geopositioning emerged with the rise of an economic industry associated with the Global Positioning System (GPS) satellite system, financed and led by the North American military. Many widely used civilian applications were developed on the basis of free access to unidirectional signals (without a return path to the satellites), this access being free, anonymous and without the risk of saturation. For the civilian end user, the direct costs of access to the GPS system were essentially limited to royalties paid for the *ad hoc* components included in terminals. These usage costs are in essence indirect and essentially comprised those from the terminal, *hardware* and *software*, and their content, essentially being digital maps.

Currently, GPS offers strong limitations in service quality, in terms of continuity, integrity, precision, vulnerability to interference, etc. This limits its use in demanding applications, especially those associated with security. For example, at the moment, GPS has limited use and certification for civil aviation.

GPS is a continually evolving system and a new satellite system; GPS 3 is being prepared to be launched in the middle of the next decade. The end user has access to several types of improvements, founded on hybridizations. These consist of introducing other complementary Hertzian signals from terrestrial or satellite networks, such as, for example, using differential GPS (DGPS) or Assisted GPS (A-GPS). Closed hybrid systems, for example, in a small area like a Formula 1 circuit will, from now on, enable centrimetric precision.

The European Geostationary Navigation Overlay Service (EGNOS) system, or the European Navigation Service using geostationary recovery, has recently been used as the European constituent of a world trilogy launched for civil aviation (Wide Area Augmentation System (WAAS) for the US). It opens the way for metric precision and widespread European development benefiting from this precision.

A current technological issue with GPS resides in the development of its interconnections with other positioning solutions to ensure service continuity, especially indoors (i.e. inside buildings), in tunnels and urban canyons (i.e. in narrow town roads).

The main added value of several GPS services, applications and usages for the end user is not in the space domain. Receiving the space signal is necessary but is not sufficient for several geopositioning domains. The intelligence that interests the end user comes from many mobile terminals, by means of their functionality and embedded data, and their interconnections with other terrestrial Hertzian communication systems.

Although the GPS satellite system itself is in a monopolistic position, competition is strong in terms of the terminals themselves. Benefiting from short performance improvement cycles, the electrical components and equipment for receiving GPS signals are priced extremely low. A GPS "chip", destined for widespread use, such as those integrated in mobile phones and smart-phones, only costs a few euros.

In terms of devices, various tendencies co-exist, either specific terminals by profession (portable or integrated electronically) or GPS modules integrated in multifunctional terminals, particularly those from the mobile telecommunication economy. Note that the multimodal receiver modules are becoming widespread (e.g. GPS-Egnos and GPS-Galileo). The interoperability of satellite systems, at the end user reception level, allows an increase in the number of satellite signals received in some zones, which could lead to poor signal receptions.

1.2.2. *The European momentum introduced with Galileo which can rely on Egnos from now on*

Galileo is a second generation Global Navigation Satellite System (GNSS). Galileo is a migration strategy based on the experience curve of GPS and its hybridizations (Egnos, in particular). Continuity of the architectural principles of the satellite system, invented three years ago for GPS, the future European GNSS, which is also for worldwide coverage, will however be innovative in several ways.

Galileo is particularly aiming to make technological breakthroughs in terms of precision, auto-control of service quality and performance and the creation of several forms or levels of interoperability.

At the European level, Galileo is a leading program in the political community. It embodies one of those truly trans-European networks. Costing a few billion euros, Galileo is comparatively cheap to the trans-European rail or road networks. It has strategic use for European defense and its industry, especially with diverse types of challenges for independence to overcome. Galileo, a result of the nations who form the European Space (France, Germany and Italy), is also an important vector for international cooperation. Since the beginning of the decade, discussions and cooperation agreements have been initiated with China, India, Brazil, Canada and Israel.

Galileo was the first economic utility to supply the workload for the European space industry, with 30 constellation satellites to manufacture and launch. Beyond this, Galileo created a truly innovative dynamic service for civilian society and has the ambition to not solely be a tool reserved for the Defense Service, however essential as these uses of Galileo are.

The idea of Galileo was partly conceived in France during the 1990s, from the convergence of strategic visions of defense (mainly held by the CNES) and manufacturing objectives (particularly rejected by the group Alcatel at that time). From then on, its continental and civilian dimensions were acquired, and it remained to develop them operationally and economically through new civilian value chains and virtuous incubation procedures of new services, applications and usages.

Note that Galileo's link, at the political side, at community level to the Ministers of Equipment and Transport, to the Commission and to the Directorate General for Transport and Energy (DG TREN) has an essential symbolic value from this perspective.

1.2.3. *An open dynamic beyond the space industry sector*

The production of universal access to geographical coordinates and positions does not only stem from GNSS. Other location-based services (LBS) solutions are competitive and/or complementary. They are particularly supported by diverse types of Hertzian terrestrial communication networks, through, for example, triangulations on mobile telecommunication cellular networks (Global System for Mobile Communications (GSM) or 3G), or of local networks (WiFi, for example). Other technical support may compete in the production of positioning data, notably those using short-scope Hertzian technologies, radio-frequency identification (RFID) or ultra large band (ULB).

In relation to geopositioning, the operators of mobile telecommunication networks are in an ambivalent position. They are partners in value chains, applications and services provided by GNSS. The telecommunications sector is increasingly incorporating GPS receiver modules in mobile telephones which are becoming true multifunctional "Swiss knives". The movement began in Japan several years ago and has reached Europe. Nokia understood it well and clearly displays, in its strategy for penetration of the down-streaming of services and content, ambitions regarding GNSS (see their buyout of the Navteq maps manufacturer). Telecommunication operators also provide the "return path" to communicate with mobile devices and enable applicative chains, in competition with other Hertzian communication solutions, such as current PMR networks (professional radio-communication), TETRA or TETRAPOL, the new digital mobile radio (DMR) networks or future vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communications. Telecommunication operators also offer hybrid solutions to improve precision or reduce the start-up time. But they are also rivals as producers of marginal costs, through triangulations on their own networks, of geographical positions of their mobile devices.

The telecommunications industry, particularly mobile telecommunications operators and device manufacturers, will supply essential actors for the development of GNSS mass market applications. It is a sector, which has already migrated (operators) or is in the middle of migrating (industries) toward services, especially through the rise of the power of mobile Internet and machine-to-machine (M2M) communications. This sector:

– knows how to manage invoicing chains;

– disposes of a fleet of subscribers and knowledge associated with customer relations;

– can produce devices for widespread broadcast and their tools of content integration;

– has terrestrial mobile networks to manage "return paths";

– disposes of well-placed European operators in emerging countries;

– can manage associated products and their complex *business*;

– is stimulated by new forms of internal (between operators and manufacturers) or external (between operators and content firms and with new arrivals, such as Apple, Google and PC manufacturers) competitions.

1.3. The fundamentals of geopositioning development

1.3.1. *The universalism decentralizing of the Internet*

The concept of the "big web" appeared since the 1960s in the US with a new idea of decentralized network, allowing it to function despite the breakdown of one or more machines. It is a hybrid system based on star and mesh connectivities in which data transfers dynamically, by searching for the least congested path and by splitting up the information into packets (according to the technology called *packet switching*). Since its first realization, the experimental network ARPANET by the Advanced Research Projects Agency (ARPA) dependent on the Department of Defense (DOD), diverse fundamentals of electronic communication and technological organization were imposed. These universal foundations are the keys to the success of the Internet today. One or more network nodes can be out of order without affecting the function of the rest of the network. Communication between machines takes place without an intermediary centralized machine. Basic protocols give way to automatic exchanges.

Electronic mail appeared, with the “@” character, at the beginning of the 1970s, as well as the term *internetting* to describe the embryonic Internet. At the end of the same decade, the protocol tandem TCP/IP also appeared. In 1984 a naming system “DNS” followed, in 1969 the request system RFC and in 1980 a hypertext navigation system. At the beginning of the 1990s, the protocol HTTP, as well as the language HTML was created to give birth to the World Wide Web (WWW).

Universality and the power henceforth acquired from the Internet or Internet protocol (IP) systems were based on five decades of structuring electronic worldwide communication. Currently, we use IPv6 which, in particular, supports mobility. The IP world will affect geopositioning value chains.

The production of geographical coordinates directly concerns a small number of users, such as professional pilot of a plane or recreational yachtsman using the chart table on his boat (*i.e. if the chart table remains in future square sailboats*). In general, the challenge of developing land applications of geopositioning, of Galileo in particular, is to offer key applications to end users who are no longer navigators with their compass, pencil, Cras rule and maps. Geopositioning applications will be less and less used solely for navigation and will become a building block of digital value chains integrated in diverse types of digital terrestrial systems, strongly “IP” influenced.

This tendency to put terrestrial communication protocols under the guidance of GNSS applications is seen as a real cultural challenge for GNSS promoters and the sector of space industry, dominated by cultures which are technical in essence and not easily inclined to adopt exogenous normative contexts.

1.3.2. *The trend toward “service” of the electronic communication economy*

A second series of fundamentals that affect widespread applications of Galileo is also of North American origin. They are no longer to be found in the history of computing but in that of telecommunications. This happens before computing, telecommunications and television (or data, voice and the image) began their widespread convergence during the 1990s, with massive and widespread digitization equipment. Remember, for the record, that the digitalization of telecommunication networks took place in the 1970s and the 1980s. It was then that France had its hour of glory, under the drive of CNET (National Center of Telecommunication Studies), the ancestor of current R&D Orange division. The transition to digital audio-visual broadcasting networks is now in progress.

The defining event is of civilian origin, dating from 1984, with the decision antitrust of the US justice to separate the industrial activities of the American Telephone and Telegraph Company (ATT), and those developing telecommunications networks and services. This split gave rise to the explicit identification of the operator business, with the birth of regional companies, the *Baby Bells* (ATT preserving R&D activities, the *Bell Labs* and the profession of long-distance network operator).

This starting point in the identification of service function was accompanied by a powerful move in the regulation of this civil electronic communications sector. This regulation was notably supported by the creation of a powerful *ad hoc* organism, Bellcore (Bell Communications Research) in the US.

The strategic added value of this structure is having created analytical detailed settings acting as a framework for the collective management of telecommunications networks. The rules of universality have been initiated to particularly enable an operator's customer to have access, on a worldwide scale, to any subscriber connected to the network. The constraint is that the operator managing the customer subscribed to their network only controls – except for communication between their own customers – the "*demi-liaison*" of the value chain. The works of Bellcore surpassed the necessary rules for the physical flow of communication to deal with the rules for sharing margins between operators and invoicing the end client (which notably includes a way of invoicing third parties).

The foundations of the modern telecommunications regulation come from Bellcore productions during the second half of the 1980s. It was at that time that the basis of the telecommunication services economy was born, and particularly notions such as:

– portability of services on diverse technological platforms;

– platform interconnectivity and their subsequent normalizations/ standardizations;

– *unbundling* or de-grouping of telecommunication networks.

This movement begins in the US and has penetrated Europe through Scandinavian countries, nations of excellence in terms of electronic communication. Since the beginning of the 1990s, Sweden and Finland have adopted telecommunications regulations of "services".

These years of telecommunications sector experiencing forced migration toward services must serve as a reference for the future of geopositioning services and applications.

We should note that the IT sector has also made its move toward services. To give just one example, in practically a decade, IBM has changed from an industrial enterprise to a service operator.

1.3.3. *The dynamic and lessons of the European GSM success story*

European GNSS can lean on the modernity of the European mobile telecommunications sector and the GSM *success story*.

The innovative impetus took place in November 1982 during a Franco-German summit between Presidents François Mitterrand and Helmut Kohl. The author personally, as representative of the French ministry PTT (Postal, Telegraph and Telephone) Louis Mexandeau, proposed to his West-German counterpart, Christian Schwartz-Schilling, to create an agreement to build a new mobile telephone digital system (as a replacement, for France, of the analogical system Radiocom 2000).

After a cooperation phase that was developed within the public administrations at that time, the GSM adventure took on its true dimension with the Scandinavian countries in the running. It was their operators and manufacturers (notably Ericsson and Nokia) who were the true artisans of this European *success story* that we know. This success is directly due to the basis of the Scandinavian digital economy, namely:

– business management at the highest worldwide level, notably including from very early on, iterative planning procedures and sophisticated management;

– functioning in regional *clusters* with high levels of public/private, university/enterprise, industrial/developing cooperation or big group/SMEs;

– a culture of innovation made as a national sport (e.g. 3G mobile telephony licenses 3G were free there – in contrast to the high prices in England, France and Germany – in order to not hinder innovation);

– advanced telecommunications regulations based on services;

– advanced policies on local employment oriented to R&D and knowledge.

The lesson that Galileo should learn from the GSM European adventure is that it is not sufficient to create a basis using an infrastructure (the GSM systems function principles such as those initiated by the group of Franco-German civil servants or the Galileo satellite system), but it is necessary to control every aspect of the system's value chain, including, in particular, interconnectivity, terminals, even from now on, the content. Nokia's strategy is exemplary for more than one reason.

The strategic and marketing challenge for GNSS in Europe is that the Galileo network goes beyond just building a satellite infrastructure, *a fortiori* since the latter has the insurance of being done using public funding. The competitive risk is that, in the end, Asian manufacturers or operators will monopolize margins and relationships with the end users of geopositioning services and applications. Their assets are through their command of digital economies, in particular for GNSS downstream, for devices and their integrated added value.

1.4. Prospective visions of large geopositioning markets in transport and land transport

1.4.1. *Multiple factors for geopositioning growth*

This new digital revolution of geopositioning is underpinned by multiple factors of strong growth:

– the basis of the current GPS economy;

– short innovation cycles of terrestrial technologies;

– the needs of mass markets (e.g. Telecoms, automobile and public services) within easy reach;

– progress in the receiver and device modules economy;

– the takeoff of automatic M2M communications;

– the improvement in digital cartography and GIS;

– the dynamic of security and defense markets (less and less independent from the civil market);

– the stimulation of several types of competition;

– the international and European dynamic surrounding Galileo.

We have already seen strong development in markets, activities and jobs. They have been delayed due to the hard challenges they need to overcome, especially in developing countries, transport systems and sustainable mobility and their new demands for management (for more security, less energy, more intermodality, fewer risks and more standardization in Europe). As was the case for GSM, this new digital revolution is an opportunity for Europe, which has several trump cards, thanks to the quality of its manufacturers and space operators, software, terminals or Hertzian systems, thanks to the relevance of its land-based transport systems and thanks to the experience and quality of its public services.

We mention below a few important innovative markets, which seem particularly key for GNSS regarding services, applications and usages in road and urban travel and in nature activities (on foot, on two wheels and in automobile or public transport). These visions are a medium-term aim, roughly estimated for the next decade.

1.4.2. *Toll systems*

The domains of access control, tolls and surveillance of transport on infrastructure, areas of activity or living areas (e.g. routes, airports, campus, industrial spaces and leisure parks) are key tools for the management of land-based and urban transport, with several systems in place and relatively new realizations in Europe (e.g. urban tolls in London or Stockholm; tolls for heavy loads in Germany and also being considered in other European countries and current practices for motorway or parking). Tolls respond to these growing needs:

– to regulate, especially using tariffs, traffic and/or access to infrastructures;

– to generate private finance, based on the use of these networks or infrastructures.

Tolls involve several types of stakeholders, such as the State, motorway companies, the owners of inter-urban public road networks and urban areas. Motorway operators deserve special attention when they are:

– decision-making which is already "services" oriented;

– system information operators;

– at the heart of several interconnection and/or interoperability elements (e.g. merging with other road networks in terms of traffic control and coordination of stakeholders regarding emergency systems);

– companies using *business models* and explicit economic strategies (notably through *road pricing*) to which the costs of geopositioning may be compared (e.g. in toll systems, the cost of embedded devices is popular in a more global financial model, notably including the costs of boxes, subscription and access to infrastructure);

– entities of advanced needs and cultures in terms of security, this leads to needs of quality of service, precision or reliability.

Through motorway companies, visions of "intelligent road infrastructure" are created, according to terms that are progressively similar to those of public transport. The potential long-term schemas are those of collective organization of traffic flow, in the form of management "trains" of vehicles, booking access to its networks in advance, etc.

Visions of "services" of motorway operators clash with the visions of "intelligent vehicles" produced by car manufacturers. The latter prioritizes the "product" vision at the expense of the "infrastructure" vision. Their tendency is to only consider functions carried out by built-in electronics and:

– only have mediocre guidance "services";

– be reluctant to share strategies on margins and customer relations with others;

– cultivate very individual visions of the car.

It has poor approaches of car manufacturers on the vehicle/infrastructure interface.

Toll systems should be seen as a service of collective interest, central to the development of GNSS. Tolls are a function that will occupy a growing and structured position in systems of sustainable transport. Toll systems will make quick advances; new types and/or content of public service delegations are expected:

– Road traffic is now growing quicker than the capacity of urban and inter-urban infrastructures.

– Invoicing for demand or use is applicable to countless application to sustainable transport (e.g. toll access to motorways, parking, town centers, insurance and public transport).

Toll system solutions, based on short-range Hertzian technology dedicated short-range communications (DSRC) reliant on stable protocols, have really matured and they are essentially offered to users in the motorway company sector. But this technology has since been considered an old-fashioned solution, with a short life expected. Their demand in terms of investment and infrastructure (in the form of gantries) considerably reduces the advantage of low-cost inbuilt technology. They have a very limited service and application potential. They only allow slight integration with inbuilt intelligent systems in vehicles. They also present severe limitations to geographical coverage, given that it can only be developed on single roadways, whose access is strictly controlled by gantries.

Toll systems using satellite positioning (currently GPS and Egnos and, in the future, Galileo), combined with communications with the vehicle through cellular telecommunications networks (GSM and increasingly 3G), are open, interoperable, evolutive, modern solutions and respectful of the environment, which:

– are not highly dependent on the investment of physical infrastructure that is only required to ensure geographical coverage of mobile telecommunications and therefore derive from the external *business models* of the toll system economy itself;

– allow flexibility in terms of modeling multiple road statuses;

– open the way, through developing advanced *geofencing*[2] concepts for varying control logic (of vehicles, transported materials, traffic, etc.) and for various purposes of security and respect of residents or the road network economy, seeking, for example, to avoid unwanted delays and/or dangerous traffic carrying heavy loads on unsuitable roads.

With Egnos, the precision of a meter guarantees 95% of cases in all of Europe, several types of applications, such as the real-time detection of vehicles traveling the wrong way on the motorway. Integrity messages will enable a reduction in tarification errors in the coverage area.

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2 *Geofencing*: modeling aiming to create a virtual barrier of geographical coordinates around certain areas needed to be protected vis-à-vis an alarm system is triggered when an unauthorized vehicle crosses it.

Toll systems using GNSS are also very flexible in time, with quick deployment, because of the absence of the direct need for infrastructure. The general architecture of the system essentially falls under the domain of computer technology, not only with significant adaptation potential but also with many limitations and external risks (e.g. congestion, weather and pollution) as dynamic and divided customer relations for the service operator.

Europe thoroughly understood the issues of toll systems, particularly in terms of demand for interoperability and started a community regulation (e.g. European Directive of April 29, 2004).

Finally, we note that satellite toll systems represent an opportunity for Europe to engage itself with sustainable pioneering innovation strategies in terms of services for collective interest, based on:

– the capitalization on an experience curve acquired in Germany through the development of an open toll system, GNSS, Toll Collect;

– the acceleration of international agreements, not only with Franco-German, but also with, for example, the Dutch who are equally very interested in the subject;

– preparing for the future by developing the potential interconnections and interoperability of GNSS, including road transport and European communications needs;

– a public innovation policy concentrated, more than technologies, on objectives and visions of “provided services” for all, to managers of infrastructure, carriers, etc.;

– networking, on the basis of cooperation and sharing of visions, expertise and potential objectives on a European scale, notably with the expertise of the European Commission.

1.4.3. *Transport control and surveillance*

Several other geopositioning applications for the following and control of the mobility of people, goods or vehicles are expected. The field is very open, in particular ensuring:

– the control of dangerous materials;

– managing insurance contracts and use;

– flight handling, heavy loads in particular;

– help for a choice of journeys and/or driving assistance;

– business management of fleets of vehicles and their drivers;

– route optimization to reduce time, fuel consumption or environmental effects;

– localizations in case of a breakdown or accident;

– monitoring of live animals in the context of the current application of European directives;

– monitoring dangerous materials that will be regulated by new directives;

– applications for the management of public transport;

– applications for road development (e.g. use of snow ploughs).

This field is loaded with applicative innovations of GNSS, which are susceptible to increase short- and medium-term entrepreneurial initiatives of essentially following logical integration of existing solutions and not requiring high levels of industrialization.

These GNSS applications are the preferred targets for these activities:

– “B to B” innovations;

– combined development of small- and medium-sized businesses (SMB) belonging to information and communication technologies (ICT) or business users;

– niche strategies.

Although these inbuilt applications are vectors of rapid innovation, they nevertheless risk creating business vertical applications with low interoperability. The issue with long-term innovation and structural strategies resides in the development of multidiscipline service platforms and their tools and generic solutions.

Other risks linked to these solutions reside in the proliferation of digital interfaces around the driver and the creation of personal or work environments with low usability, even dangerous (like from recognized hazards mediated by mobile phones). This ergonomic issue is a serious challenge of these GNSS applications, which must integrate prospective visions of ergonomics ranging from the cockpit to safe driving. The spread of inbuilt mobile equipment is currently increasing, to the detriment of safety. In a road transport economy with several low margin mobile businesses and/or modest cultures of electronic systems, deviations are easy (e.g. usage in the cockpit with a heavy load with systems initially created for light vehicles, rudimentary and/or ill-adapted human/machine interfaces, as we see in the case of mobile telephones that are not linked up with hands-free devices).

Pioneering activities are being researched in terms of security and, notably, e-call. New approaches and research will be realized especially through the FP7 (Seventh Framework Program 2007–2013) through the collaborative program TELEFOT (Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles, www.telefot.eu). TELEFOT involves telephone devices equipped with a GNSS function. It is led by the VTT (Technical Research Centre of Finland). A "FrenchFOT" on a wide scale is being developed by the University of Technology of Belfort-Montbéliard (UTBM) and Geoposis (www.geoposis.eu).

1.4.4. *The production of information*

The vehicle of the future will be a vehicle that communicates:

– with external infrastructure;

– with its occupants, driver and passengers (seen as ex-pedestrians and/or owners of mobile devices).

To do this, the future vehicle needs to develop:

– vehicle/infrastructure interfaces (which constitute, as indicated earlier, a vital part as well as a large field of work and progress for countries, such as France);

– data and content (e.g. traffic data and maps), with respect to which the creation of activities and new operators are expected.

Several public services are concerned and involved in the production and organization of the spread and access of mobility information. Public services are equally large potential consumers of these solutions resulting from geopositioning data information (e.g. traffic information systems, organization of emergencies, traffic control, congestion and incidents, assistance to users for their choice of route and preparing their travel). Public services, notably those concerning safety, demand the highest degrees of quality of service and performance.

The production of such information and the supply of data of simulation, optimization programs or prediction of traffic, are likely to generate the growth of activities to be measured using a device or a tracking vehicle, as endogenous applications (or are not very useful for the end client) of geopositioning.

The stakeholders who are currently present in this market of the communicating car and the production of information using geopositioning come from multiple professions, notably including:

– mobile telecommunication operators who already have, from endogenous management of their traffic, databases of such mobility information;

– motorway companies, which are already service owners and operators of information systems;

– car manufacturers (provided that they develop "service" strategies);

– managers of public roads and local authorities, exploiting through their dual functions (directly or by delegating services) of infrastructures and public services linked to mobility;

– companies producing content in the form of databases and/or maps, which invest and innovate to update maps, must do it even more quickly, even in real-time.

If, in addition to these markets producing information, the domain of digital cartography has made important breakthroughs in recent years, several challenges remain to be resolved, notably in terms of:

– optimization of costs of collection (e.g. the cost of cartography represents a significant share of widely distributed mobile solutions);

– relevance of the quality of data, in terms of the diversity of content (e.g. information on road signage), precision of frequency updates, etc.;

– aggregation of data from diverse sources, with the underlying questions of commercial property, sharing costs, confidentiality, etc.

In the production of information on traffic and mobility, a major challenge clearly lies in the breakdown of game players for consuming geoposition service (e.g. mobile telecom operators, producers of maps, local authorities, motorways, regional or local roads, emergency services, site managers, business areas or campuses, and public transport operators).

1.4.5. *Intelligence systems in vehicles*

Geopositioning will also be directly integrated in inbuilt equipment in "intelligent vehicles", in particular for purposes of convenience, driving assistance, even in terms of optimization elements and certification control (see "black" "orange" boxes).

In the domain of intelligent transport system (ITS), which includes air, rail or land transport, we ask the same generic questions:

– the place of intelligence and/or power, namely in ground infrastructures (e.g. aviation control tower and rail signaling along the track) versus in the car, train or the airplane;

– content and modalities of the vehicle-infrastructure liaison;

– the rise of new architectures, from V2V;

– innovation cycles of differing lengths of time, long for inbuilt systems in vehicles and infrastructures or short for mobile terminals.

Developing the "intelligent vehicle" revisits the particular interest in inbuilt equipment or an on-board unit (OBU). In the long-term, geopositioning will contribute to the birth of a box with two areas in vehicles:

– an open area for the driver/customer;

– an “orange box” encrypted and for reserved police access.

The automobile sector is campaigning for more intelligence in the vehicle, and producing an “intelligent vehicle”, particularly in order to retain command over its design and production procedures, at the same time as its margins and customer relations.

In relation to OBU, barriers to innovations are no longer in terms of technology (these being available to buy) among ICT manufacturers, but deal with the incubation of new services and usages, especially those requiring multi-stakeholder cooperation, and sharing margins and customer relations The question is knowing what will be the *killer application* that will generate margins for manufacturers, while still being reasonably priced, to allow market growth.

For the record, let us remember that car manufacturers are slowly intervening in the GNSS market with:

– applications which are often closed (without extensive vehicle/infrastructure liaison) and high margin inbuilt GPS navigation;

– small advances regarding emergency calls, based on open partnerships with professional assistance to people;

– a car industry that still has a cautious attitude vis-à-vis Galileo and the vehicle/infrastructure relationship;

– R&D studies on driving assistance (ADAS) which still only have a modest place in GNSS.

The challenge is naturally related to standardizing several manufacturers. The key question is to know when the arrival of electronic buses and vehicles will operate and when the car will apply the universal principle of *unbundling* inherent in modern electronic communication networks.

1.4.6. *Individual mobility (tourism and recreation)*

In recent years, Egnos has paved the way toward "precision tourism", based on integrated solutions allowing access to multimedia content enriched and geopositioned with metric precision, as well as cultural services "*sans couture*" and available anywhere in tourist and recreational areas, when on the move.

Access to such applicative GNSS fields is permitted by:

– the expected spread of mobile telecommunications terminal parks equipped with GPS/Egnos modules;

– the development of the Internet service practices (*web services*) which are standardized and interoperable;

– the opportunity to develop databases with geoposition based multimedia content.

Such GNSS applications should be facilitated, in particular, by tapping into the potential of free software in the domain of SIG.

The development of "precision tourism" as an opportunity for a widespread GNSS application rests on:

– new precisions and performances now enabled by Egnos;

– powerful trends in the global telecommunication industry (see Nokia's strategy), which consists of localizing not just through a "simple application" but a "motor of Internet service creation";

– short innovation cycles in scientific research in mobility software systems in substandard Internet.

The potential of Egnos *chipsets* should enable the development of localizations in "three dimensions" in the economic sector of mass tourism and recreational nature.

1.5. The challenge for the future of the European GNSS incubation services

1.5.1. *The need for downstream marketing "services, applications and uses"*

The split in geopositioning that is in progress is more in terms of applications and civilian than the technology itself. From a global architecture of the Galileo satellite constellation, similar to that of GPS, the paradigm shift resides in the economy of usage, with a move from geopositioning jobs reserved for a few sectors (e.g. aviation, maritime and scientific research) to output in countless jobs and services for the end users.

Services should be placed at the center of the Galileo *business model* and the success of civilian geopositioning will strongly depend on downstream factors such as:

– the level of quality of service and performances as seen by customers/users;

– the relevance of associated content (see what is said elsewhere on geographic information);

– the quality of the entire value chain constituting the service to the end user (see the question of the quality of the "return path", often represented by mobile communications, genre GSM);

– the relevance of standardization organizations, networking, service portability, etc.;

– the adequacy of regulation;

– harmonization of approaches to security.

The incubation of geopositioning services should be seen as a European project, whereas GNSS is still, notably part of the space industry and/or R&D programs, mainly approached with a culture that is technical in essence.

The growth of GNSS services, applications and uses when on the move and in land transport are part of a set of exogenous standards, and GNSS applications will be impregnated with characteristic trends of the digital economy and wireless communications, namely:

– the widespread "services" migration of ICT industries, with the development of new business service operators, as well as parts manufacturers or infrastructure operators;

– obligation for attractive data and content so that applications and users exist, and so customers adhere to it;

– ergonomic terminals (global products) so that access to services is possible;

– access to integration of technological "building blocks", globalized and available to purchase;

– the need for essential transverse functions, such as the customer relationship, the invoice chain or the control of complex models for calculating cost prices, especially for products and associated services, but also in the potential setting of sophisticated external public regulations.

In a digital and terrestrial economy, a significant part of innovation is not done proactively, concentrated on *top–down* instincts. The virtuous encounter between products and customers relies on *bottom–up* innovation methods, varied experimental procedures and interesting roles in these short cycles of innovation, driven by SMB.

1.5.2. *The obligation of "system" strategies*

The development of Galileo services, applications and usages in mobility and land transport is to be seen in the prospective context of creating ITS markets, for which we propose the following strategic levers:

1) The ITS proposals only interest the end user if, and only if:

– they satisfy the important demands of quality approaches to security issues for end users or widespread industrial processes, like those of the car industry;

– they provide measurable responses to European societal challenges, such as transport security (in the sense of *safety* and/or *security*) or traffic flow (versus traffic jams in a growing context of an infrastructure deficit).

2) The development of ITS applications is primarily a “system” approach, to integrate the particular car in its environment and to bring several communities or stakeholder lobbies together, in comprehensive and above all unifying approaches, notably including:

– the automobile sector;

– the telecommunication sector;

– all of the road managers and/or city infrastructures;

– device manufacturers;

– producers of content, especially cartographies;

– the various end user segments.

3) To reach mass markets, it is vital to be innovative in a partnership (one territory + a manufacturer), to create European-wide research and to make the ITS *clusters* work in a network.

The objective must be for the European GNSS policies to:

– work on an open basis (something that the car industry finds difficult to envisage) respecting:

- inter-modality,

- the transformation of a pedestrian into a motorist,

- the transborder;

– work on creating standards;

– largely invest in digital content (data, maps, etc.).

4) The Franco-German couple constitutes, in ITS systems, a precious priming lever in Europe among worldwide competition as minimum size effects exist, especially for tax standards.

1.5.3. *The requirement to include GNSS in the new intelligent digital architectures*

The development of services, applications and uses of Galileo in mobility and land-based transport should be seen in the trends of new digital architectures. Remember that, from a computing perspective, a service is a software component with a well-defined interface that allows access to the use of one or several resources or functions according to the business logic of the service. It is directly accessible by users via networks of various kinds in order to create services components located on a single site or across multiple geographically distributed sites.

Therefore, geopositioning services should particularly benefit from:

– the universality of IP systems;

– the rapid progress of embedded intelligence brought by the widespread terminal equipment manufacturing industry;

– the mix and diversity of information sources for management systems, of data to meet end user needs, and information destined for invoice or commercial purposes;

– the intervention of geopositioning at various stages of service production, including endogenous upstream functions of resources optimization and network support;

– the concepts of multidimensional service quality that can be formalized in terms of precision, radio signals receiving in shadow areas, integrity, quality of data and content, frequency of updates, etc.

In particular, *business models* and the underlying roles of stakeholders of these GNSS applications will be particularly affected by the ongoing progress and migration of structures and paradigms of information systems and user occupations.

We will mention a few recent works which will influence “ecosystems” in which the applicative services of GNSS will be created in the future.

The concepts of "ubiquitous and pervasive computing" give rise to the development of new approaches, with self-regulation, self-adaptation and emergence features [GAB 00, GAB 06, BAK 06, NAI 07]. A classification of interaction paradigms has been proposed in [GAB 00] and [GAB 06] to emphasize the objectives to be attained to meet the new challenges and expectations. According to Gaber's classification, two new alternative paradigms to the traditional client-to-server paradigm (CSP) were identified: the adaptive services-to-client paradigm (SCP) and the spontaneous service emergence paradigm (SEP) [GAB 00, GAB 06].

The first paradigm SCP can be considered as the opposite to CSP. In the traditional CSP paradigm, it is the user who should initiates a request, should know *a priori* that the required service exists and should be able to provide the location of a server holding that service. SCP is the opposite; it is the service that comes to the client, who needs a resource or service without necessarily knowing its existence and its location *a priori*. This first paradigm involves ubiquitous computing in a large-scale dynamic network, resulting from the convergence of mobile, wired and wireless networks. In ubiquitous environment, the user accesses services regardless of the time, location and terminals or available physical resources.

The second paradigm implements the principle of self-regulation, to enable the spontaneous emergence of new *ad hoc* services in an environment without any prior planning in an unpredictable manner. This paradigm is more adapted to pervasive and ambient computing to implement self-organization, such as, for example, in the context of *ad hoc* mobile networks and wireless sensors [BAK 06, NAI 07]. In this environment, the end user has self-organized means which could be prefigured in advance and recomposed on the fly (in accordance with concepts, for example, of "*ad hoc*" networks particularly relevant to terrestrial communications).

Research in the software domain today is investing in deepening the concepts linked to services and their implementation as much as in languages of description and development as in the specification and modeling of advanced mathematical tools [DUM 08, ROX 08].

On top of that there are tendencies such as the assembly and/or filtration of content and data from diverse sources, notably though "data fusion" and/or "stacking layers of information" and/or "blending real and virtual data".

The development of GNSS applications and usages began to be recognized as a strategy by the ex-Galileo Joint Undertaking (GJU), with several initiatives dedicated to the "user segment" (the small initiative GIROADS – GNSS Introduction in the Road Sector – or the GRAIL program, dedicated to rail, for which the author was an external evaluator from the GJU*)* and by the European Space Agency (ESA), with the principle of an activity program dedicated to covering GNSS applications and demonstrators. It is now amplified by the European GNSS Supervisory Authority (GSA), with resources dedicated to service visions and using the first assignments to provide innovation on the second call for proposals for the "Galileo" project of FP7. However, there is still a lot of work to do. The current risk is that the public funding of the constellation will outshine the priority for downstream marketing of Galileo, and technical and emergency operational construction priorities and putting the satellite constellation into orbit does not detract from applicative priorities and services, especially civil.

One of the objectives during the creation of the European Institute of Geoposition (EIG) was, as proposed by ALLCOMM, to develop an innovative "service laboratory", dedicated to applications and usages of geopositioning in sustainable transport and land transport, and to offer new geopositioning services and usages to the creators, developers and promoters:

– knowledge, expertise and capitalizing on experience, "service" oriented;

– access to experimental areas;

– resources for the federal management of complex projects, notably public/private, and, still being susceptible to intervene in diverse levels of the value chain, in upstream support for R&D programs as a downstream facilitator of implementing operational services.

The process was studied, and then launched in 2006 in synergy with the competitive hub Franche-Comté – Alsace "VEHICLE OF THE FUTURE" and with the support of the competitive urban community of Montbéliard, Belfort and Doubs. The initiative was productive. It notably allowed the development of expertise, sharing regional experience and collaborations which have enabled the production of this shared book. The EIG played an active part in the preparation of the French response to the European Green Paper on the downstream applications of Galileo in April 2007. The EIG facilitated the creation of a research group within the UTBM dedicated to geopositioning in transport, the GSEM (Geopositioning, Embedded System and Mobility). Actions and means of communication with strong strategic value were established between 2006 and 2008, including the creation of a bilingual site www.geoposis.eu). Finally, close collaboration between the EIG, the GSEM and PME have ensured French participation in two FP7 programs:

– Advanced Safety and Driver Support for Essential road Transport (ASSET) in "SST 2007 (sustainable surface transport)", a program linked to road security that was selected to be presented in the "European Cities of Sciences" event at the *Grand Palais* in Paris in November 2008;

– Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles (TELEFOT).

The capitalization on expertise, experience and public/private collaborations benefiting every level of the value chain, the creation of new services, applications and usages of GNSS in the domains of sustainable transport and land transport are being developed with the author through Geoposis (www.geoposis.eu).

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