GNSS applications: personal safety concerns

Anna Kolomijeca
Signal Processing for Communication and Navigation
Universitat Autònoma de Barcelona
Bellaterra, Spain

José A. López-Salcedo
Signal Processing for Communication and Navigation
Universitat Autònoma de Barcelona
Bellaterra, Spain

Elena-Simona Lohan
Department of Electronics and Communications
Engineering
Tampere University of Technology
Tampere, Finland

Gonzalo Seco-Granados
Signal Processing for Communication and Navigation
Universitat Autònoma de Barcelona
Bellaterra, Spain

Abstract— **the current study discusses the results of a survey on the topic of "GNSS applications: user preferences". The aim is to understand user preferences of GNSS applications in order to develop competitive research projects, new GNSS products / services and further increases in global GNSS market shares. The questionnaire was conducted during September – October 2015. The results of the questionnaire highlighted strong concerns about security and personal safety-related topics, while LBS were chosen as "least important" applications by almost half of the users.**

Keywords— GNSS applications, personal safety, road appliations, environmental issues, LBS, GNSS market

I. INTRODUCTION

According to the Global Navigation Satellite System (GNSS) market report [1], European companies account for approximately a quarter of the global GNSS downstream market, which consists of component manufacturers (23%), system integrators (26%) and value-added services (21%). Shipment of GNSS devices in Europe are expected to double within next 20 years, increasing revenues up to €20 B by 2023 [1]. One of the goals of EU navigation satellite programs (Galileo and Egnos) is to facilitate the development of new products and services, further increasing EUs GNSS market share [2]. Various EU programs have been created for supporting research and integration of new commercial developments into global satellite navigation market. In order to develop a competitive proposal of the research project or to develop new products and services, it is important that the end product/service is applicable as well as beneficial to the end users. Therefore, information about user preferences in GNSS applications is essential for application developers. This current paper contains a brief overview about European support of different research projects, questionnaire results about end user preferences and suggestions for GNSS products/service developers.

A. Framework programs 1 to 7

Framework Programs (FP) 1 to 7 (FP, 1984-2013): Supported multi disciplinary research and cooperative activities in Europe and beyond. Last FP7 program (2007-2013) had an overall budget of €53,2 B, being a major funding mechanism for EU research and innovative developments [3]. As we can observe from figure 1, development of Information and Communication Technologies (ICT) had the biggest FP funding (16,3% of the total FP budget). This was followed by implementing new ideas (14,4%) and health related topics (11,1%).
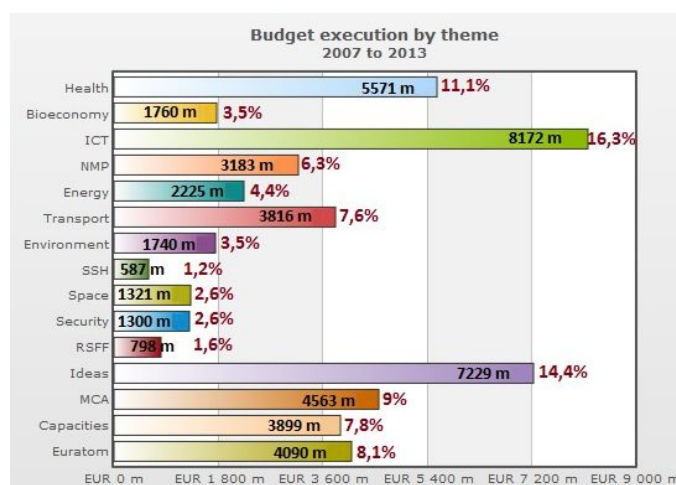

Fig. 1. FP 1 to 7 budget distribution. Source: https://ec.europa.eu/research/fp7/index_en.cfm Example of a figure caption.

B. Horizon2020

Horizon2020 (2014-2020): the biggest research and innovation EU program with a total budget of €77 B. It aims to raise the level of excellence of European science and ensure Europe's global competitiveness [4]. As we can see from figure 2, the biggest financial support in Horizon2020 is dedicated to frontier research (17% of the total budget), this is followed by ICT (10%) and health related topics (9,7%).
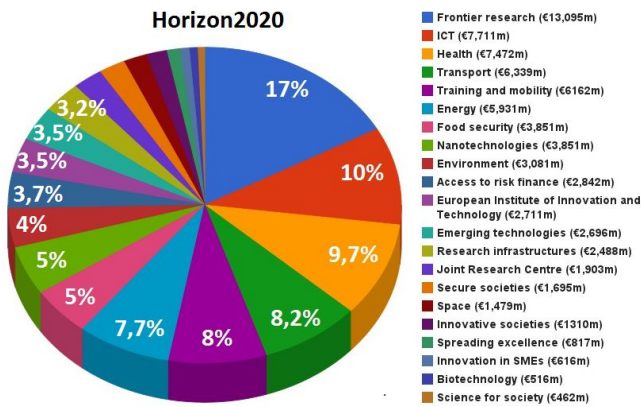
Horizon2020

- Frontier research (€13,095m)
- ICT (€7,711m)
- Health (€7,472m)
- Transport (€6,339m)
- Training and mobility (€6162m)
- Energy (€5,931m)
- Food security (€3,851m)
- Nanotechnologies (€3,851m)
- Environment (€3,081m)
- Access to risk finance (€2,842m)
- European Institute of Innovation and Technology (€2,711m)
- Emerging technologies (€2,696m)
- Research infrastructures (€2,488m)
- Joint Research Centre (€1,903m)
- Secure societies (€1,695m)
- Space (€1,479m)
- Innovative societies (€1310m)
- Spreading excellence (€817m)
- Innovation in SMEs (€616m)
- Biotechnology (€516m)
- Science for society (€462m)

Fig. 2. Horizon2020 budget distribution. Source: https://ec.europa.eu/research/swafs/pdf/pub_public_engagement/manual_H2020_NGOs_Sept_2014.pdf

C. European satellite navigation competition (ESNC)

European satellite navigation competition (ESNC, 2004-present date): A global network of innovation and expertise in the field of Global Navigation Satellite Systems (GNSS). It is searching for new services, products, and business innovations. Competition is opened for enterprises, scientific institutions, and individuals of legal adult age. Each year, the winner is receiving €1 M in prize money for implementing his/her idea [5].

II. PURPOSE OF THE STUDY

The success rate that a proposed project will be funded is: 20% for FP [3], 14% for Horizon2020 [4] and 0,1% overall winner/ 0,6% special prize winners/ 2,4% regional winners for ESNC in 2015[5]. As we can see, competition is high. Therefore, the development of a successful proposal will strongly depend on if the end product is beneficial to the end users.

This current study aims to understand the end user interest about different positioning applications. This was achieved by conducting a questionnaire, inviting users to choose their priority in major GNSS applications, rank the "sale of importance" sub-applications of each major application, and finally, give their opinion about sharing their location for different purposes. Questionnaires, related to geographic information systems (GIS) were conducted before, for example in [6, 7, 8, and 9]. In [6, 7], authors investigate feature preferences of mobile devices with location capabilities (accuracy, cost, size, device design), willing to pay for different LBS services as well as privacy concerns. In [8], authors discuss positioning applications for the road segment and study of driver behavior on two-lane rural roads. In [9], authors compare Global Positioning System (GPS) data tracking and questionnaires in order to measure work-related travel patterns in 56 pregnant women, to study adverse health effects of the traffic-related air pollution. The novelty of the current study includes a broad range of positioning applications, comparison of user preferences (of these applications) to each other under

the assumption that either taxpayer's money or private money is invested in these applications.

III. METHODOLOGY

The survey was prepared applying google forms and distributed electronically between September and October 2015 via research mailing lists, LinkedIn groups, Facebook and friend contacts. Additionally, hard copy questionnaires were printed out and distributed around the economics department at Vrije Universiteit Amsterdam (VUA). The survey was carried out in two languages, Russian and English, and contained 20 questions (average completing time 15-20 minutes). A total of 105 questionnaires were filled in by users (one user did not answer question in sections V*A*, V*B*, V*C*, and V*D*) which consisted of the following distribution: 64 answers obtained electronically through google forms (English version; mostly answered by people from Central Europe, UK, and Ireland), 17 answers, through google forms (Russian version; mostly answered by people from Eastern Europe and Baltic states) and 24 answers filled in and evaluated manually at VUA (mostly answered by people from Central Europe and China). The applicant answers were collected anonymously and the volunteers were notified about the research purpose and survey results publication in the scientific journal.

IV. STATISTICAL DATA ABOUT USERS

Users were classified according to age, education and area of expertise. As we can see from figure 3 (a), the majority of users (84 people, 80%) are between 25 and 54 years old; 15 users (14% of responses) are between 18 and 24 years old and 6 users (6%) are older than 55 years. High education[1] has been achieved by 91 users, which is 87% of responses (figure 1b). Medium[2] education has 9 responders (which is about 8%) and low education[3] has only 5 responders (about 5%).
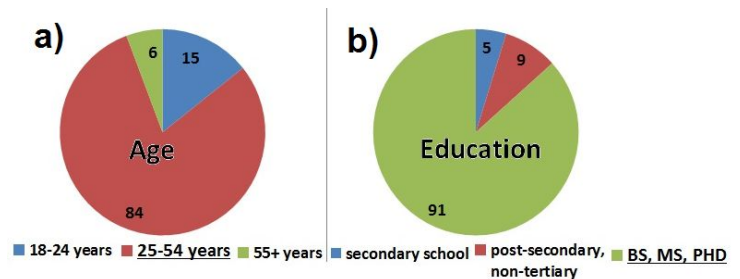

Fig. 3. Aplicants age (a) and education (b) distribution

Regarding area of expertise (see figure 4), almost half of the responders 47 people (45%) are engineers. 12 people (11%) work in the area of finances and accounting; 11 people (10%) in business and management; 9 people (8%) in education; 6 (6%) in art and design, as well as 6 (6%) people work in medicine and health care. 4 (4%) people work in the

---

[1] Internal Standard Classification of education ISCED 5+ (BS,MS, PhD)

[2] ISCED 3-4 (post-secondary, non-tertiary)

[3] ISCED 0-2 (secondary school)

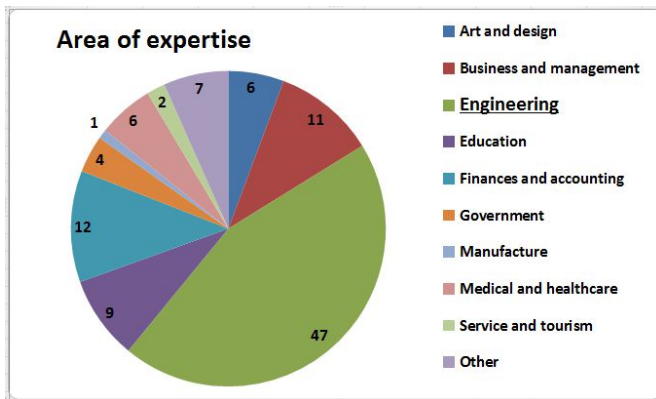govermental sector, 2 (2%) in service and tourism and 1(1%) stated "other".

Fig. 4. Area of expertise of the users.

V. USER PREFERENCES IN LOCATION APPLICATIONS

GNSS applications were divided into four major groups:

- *Location based services (LBS)*: use real-time geo-data from a mobile device or smart phone to provide information, entertainment or 112 emergency service (for example, road navigation and route planning, outdoor activities, geo-tagging);
- *Environment*: environmental related applications, for example, pollution control, wildlife protection, nature preservation;
- *Security and safety of life*: GNSS applications, which support national and personal security/safety (boarder control, civil safety, emergency management);
- *Road applications*: mobility management related topics (traffic management, driving safety).

According to the survey results (see table I), security and safety of life were chosen as the top priority application by 35% of users:

- The difference gap between the top two most important GNSS applications (security and safety of life and environment/LBS) is significant (11 responses, 10%).
- Additionally, 37 (35%) responses are the second highest result for this question.

The "least important" GNSS applications are LBS ones:

- 43 (41%) responses-were the highest response number in this question.
- The difference gap to the "next closest" "least important" application is 19 (18%) answers.

TABLE I. END USER PREFERENCES IN GNSS APPLICATIONS

Application	Responses			
	Most important	*Important*	*Less important*	*Least important*
Security	**37 (35%)**	25 (24%)	25 (24%)	18 (17%)
Environment	26 (25%)	30 (28.5%)	29 (27,5%)	20 (19%)
Road	16 (15%)	35 (33,5%)	30 (28.5%)	24 (23%)
LBS	26 (25%)	15 (14%)	21 (20%)	**43 (41%)**

Taking into account that responders were offered to choose only one option (e.g. most important, important) for every GNSS application, it might be easier to choose the most and the least important applications. But it might not be as easy to choose between "important" and "less important" applications. For simplicity, in order to rank all four applications, we combine answers "most important" with "important" and we get the following distribution:

1. **Security and safety of life** – the most important application, 62 answers

2. **Environment** - 56 answers

3. **Road applications -** 51 answer

4. **LBS** – 41 answer

The same priority order is achieved, combining "less important" and "least important" answers:

1. Security and safety, 43 answers

2. Environment, 49 answers

3. Road applications, 54 answers

4. LBS – the least important application, 64 answers

This current result indicates high users concern about security and personal safety, which is followed by environmental issues. This means that development of such applications are important to people.

Although LBS accounts for more than half GNSS market revenues [1], most of the end users consider LBS as the least important GNSS application. At first glance this result seems to be contradictive. It is worth reminding that answers are based on the assumption that all applications are developed from governmental or third-party funds (i.e., the development does not require the user's individual investment). If development of GNSS applications would involve the individual end user's investment, users could have changed their priorities according to individual (rather than national) interests. For example: "although on a scale of global problems, "friend finder" application is not as important as environmental issues, I will pay x€ for this application (rather than donating it for environmental purposes) because it is matching my specific need at this time period".

A. Security and safety-of-life

After users choose their priority of positioning applications, they were invited to rank sub-applications in order to understand which subject has top priority. For security and safety-of-life, the following choices were offered: Border control (illegal immigration, illegal goods trafficking); Civil safety (anti-terrorist activities); Military developments (defence force of the state), Emergency management (global disasters) and Personal safety (search and rescue).

As we can see from table II, users "least favourite" applications are border control and military developments.

These two applications have almost identical results of "not so important" and "least important[4]" applications.

The answers about civil safety application have very small distribution of 1-5% between choices of "most important", "important" and "moderately important". Possibly, it was difficult for users to decide in which category they should address this issue.

Personal safety and emergency management, both, have 8% gap in answers between next "less favourite" applications, which is civil safety. This is a good indicator to insure Personal safety as nr.1 "the most important" GNSS application and Emergency management as nr. 2 "important" GNSS application.

TABLE II.   SECURITY AND SAFETY OF LIFE APPLICATIONS

Application	Responses				
	Most important	*Important*	*Moderately important*	*Not so important*	*Least important*
Personal safety	**36** (34.5%)	22 (21%)	13 (12.5%)	23 (22%)	10 (10%)
Emergency manag-nt	25 (24%)	**32** (31%)	20 (19%)	12 (11.5%)	15 (14.5%)
Civil safety	28 (27%)	24 (23%)	**29** (28%)	17 (16%)	6 (6%)
Boarder control	9 (9%)	15 (14.5%)	19 (18%)	**26** (25%)	35 (33.5%)
Military devel-ts	5 (5%)	11 (10.5%)	23 (22%)	26 (25%)	**39** (37.5%)

B. Environment

Three choices were offered for environmental application: Remote sensing for pollution control (atmosphere, oceans, soil monitoring), Wild animals' protection and Remote sensing for the preservation of natural resources (forests, fresh water).

Although the question might be difficult to answer, most of the users (56%) think that animal protection is the "least important" GNSS application[5] (see table III).

43% of users think that protection of natural resources is "moderately important" and 46% of users think that pollution control is "the most important application".

TABLE III.   ENVIRONMENT PROTECTION APPLICATIONS

Application	Responses		
	Most important	*Moderately Important*	*Least important*
Pollution control	**48 (46%)**	35 (34%)	21 (20%)
Natural resources	34 (33%)	**45 (43%)**	25 (24%)
Animal protection	22 (21%)	24 (23%)	**58 (56%)**

---

[4] Please note the large gap (more than a double) in answers between "border control/military" and the next "less favourite" application – emergency management.
[5] Environmental section only

User's serious concern about pollution of the environment can be an indicator of health related issues, since the condition of the environment is directly related to public health.

C. Road

Road applications also consisted of three choices: Traffic management (aimed to reduce road traffic), Road safety (driving speed and vehicle movement control (drunk drivers)), Automated systems (automated road tolling, automated vehicles).

Automated systems seem to be the "absolute winner" in the category of the "least important" applications (see table IV). The gap in the answers between automated systems (67.5%) and "next least important" application (road safety, 22%) is more than triple.

Road safety is chosen as the most important GNSS road application by 44% of the users. This application is in "competition" with traffic management (41%), since the gap between the answers is only 3 %. However, almost half of the users (48%) have chosen traffic management as "moderately important".

TABLE IV.   ROAD APPLICATIONS

Application	Responses		
	Most important	*Moderately Important*	*Least important*
Road safety	**46 (44%)**	35 (34%)	23 (22%)
Traffic management	43 (41%)	**50 (48%)**	11 (11%)
Automated systems	15 (14.5%)	19 (18%)	**70 (67.5%)**

This current result indicates that road safety and traffic management are almost equally important to the users.

D. LBS

Since LBS have many applications, users had an option to make the same priority choices for different topics (see table V).

End user choices, in their priority, LBS are very clear, since the gap between the answers about different applications is typically large. In detail:

1. Maps and navigation together with 112 emergency services are chosen as most important applications. The gap between the answers to the "next favourite" application (which is informational service) is more than double.

2. Informational services, outdoor activities and tracking are chosen as "moderately important" by approximately half of the users.

3. Geo-tagging is chosen as "least important" application by majority of the users (56.5%). The gap between the answers to the "next least important" application (which is outdoor activities, 38.5) is 18%, which is very significant.

Application	Responses		
	Most important	*Moderately Important*	*Least important*
Maps and navigation	**74 (71%)**	17 (16.5%)	13 (12.5%)
112 emergency	**63 (60.5%)**	24 (23%)	17 (16.5%)
Informational services	31 (30%)	**53 (51%)**	20 (19%)
Outdoor activities	15 (14.5%)	**49 (47%)**	40 (38.5%)
Tracking	27 (26%)	**44 (42%)**	33 (32%)
Geo-tagging	13 (12.5%)	32 (31%)	**59 (56.5%)**

These results comply with previous studies [7], where authors measured end user willingness to pay extra for different LBS services. According to [7], the end users are willing to pay the most for emergency services, which is followed by navigation.

VI. PRIVACY ISSUE

As we can see from figure 5, ¾ of all users agree to share their location for personal safety purposes and almost as many agree to share their location for traffic management. Nearly half of the users would not mind to be tracked for statistical research purposes. 33.5 % support friend finder, 23% – tourist services, 12.5 % – worker finder, 10% – advertising and only 14.5% do not want to share their location for any reason. This means that importance of privacy of positioning information is **conditional to the application**. Current results partially[6] comply with the previous study [7].
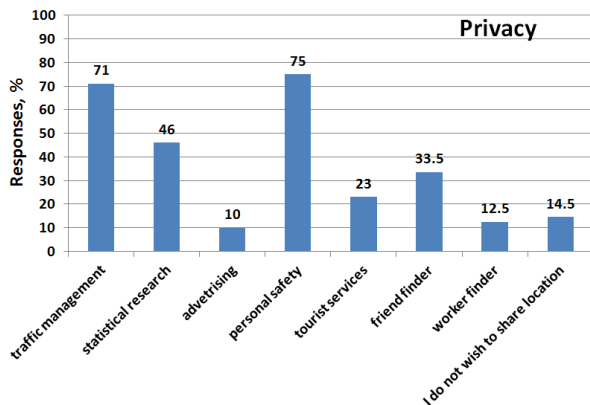

Fig. 5.   Privacy issues.

VII. CONCLUSIONS

The results of the study indicate that the most important GNSS application for the end users is security and safety of life, more specifically, personal safety. This is followed by environment, road and LBS.

---

[6] In [7], 25% of the users did not agree to share their location for any purposes, while 75% of users agreed to share their location conditionally.

In the "environmental section", pollution control was chosen as the "most important" application, which is an indicator of concerns for public health. Similarly, road safety was chosen as "the most important" road application.

This means that development of safety / health related applications and research projects will be applicable as well as beneficial to the end users.

Although LBS are major revenue source in GNSS market, almost half of the end users consider LBS as "the least important GNSS application". The reason for this is that LBS are targeting individual users with specific needs, as well as offering a broad range of services for which users are willing to pay. While other GNSS applications (as environment, road, and national safety) maybe more important to the end users, but end users expect it to be funded by the government (as a national rather than private application). Therefore, LBS maybe successful in commercial applications (especially road navigation), but it does not fully satisfy all user demands in terms of safety and quality of life.

According to the survey, the importance of privacy of positioning information is conditional to the application for 85% of the users. ¾ of end users are willing to share their location for personal safety and almost as many for traffic management. Therefore, if the purpose of sharing locations is acceptable for the user, there is no problem in privacy issues.

REFERENCES

[1] European GNSS agency, "GNSS market report", Issue 4, March 2015.

[2] European commission, "Galileo: why the EU needs Galileo", on-line: http://ec.europa.eu/growth/sectors/space/galileo/, November 2015

[3] European commission, "The seventh framework program", on-line: https://ec.europa.eu/research/fp7/pdf/fp7-brochure_en.pdf

[4] Horizon2020, on-line: http://www.horizon2020.ie/

[5] European satellite navigation competition, on-line: http://www.esnc.info/index.php?kat=about.html&anzeige=about.html

[6] T.M. Noor, D. Skournetou, G. Seco-Granados, and E.S. Lohan, "User preception on Location Based Services: the more you know, the less you are willing to pay?" IEEE, pp. 1-6, doi: 10.1109/ICL-GNSS.2014.6934182, 2014.

[7] E.S. Lohan, A. Rusu-Casandra, O. Cramariuc, I. Marghescu, and B. ramariuc, "End-user attitides towards Loation-Based Services and future mobile wireless devices: the students perspective," Information, 2011, vol. 2(3), pp 426-454.

[8] A.M. Perez-Zuriaga, F.J. Camacho-Torregrosa, and A. Garia, "Appliation of positioning system and questionnaires data for the study of driver behaviour on two-line rural roads", IET, 2013, vol. 7(2), pp.182-189, 7.doi: 10.1049/iet-its.2012.0151.

[9] Wu, C. Jiang, G. Jaimes, S. Bartell, A. Dang, D. Baker, and R.J. Delfino, "Travel patterns during pregnancy: comparison between GPS tracking and questionaire data", Env. Helth, 2012, vol.12, doi: 10.1186/1476-069X-12-8.