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The paper assesses the development of the market for navigation services and devices based on the results of a recently held Foresight exercise on monitoring of global technology trends. The future of the market for Global navigation satellite systems (GNSS) devices is largely influenced by grand challenges (i.e. lifestyle change, technical safety, urbanization, rural development, food security, etc.) that determine the pathway for extending use of GNSS signal in different sectors of the economy. Today, satellite positioning technology is used by transporters, carriers, motorists, surveyors, builders, etc. through a wide array of devices — like mobile phones or multimedia devices with built-in receiver modules.

Different Foresight methods and tools were used for analyzing the market structure and volumes of navigation services and devices and to detect potential future market developments. The main technical characteristics of GNSS are compared in order to reveal their impact on the quality of the navigation signal essential for the end-users. Investigating the future dynamics of this market in Russia on the basis of expert estimations and governmental strategic documents, the authors conclude that the commercialization of GNSS in Russia is possible only in certain segments, mainly navigation modules for personal vehicles, surveying and mapping equipment as well as consumer electronics.

KEYWORDS: navigation services and devices, market development, GNSS, vehicles, consumer electronics, surveying and mapping equipment, Foresight.

JEL classification: L80, L92, L16, O38, M31.

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1. Introduction

Global navigation satellite systems (GNSS) allow the exact location of objects on land, water and in the air. Originally developed for accurate location of military installations, the satellite signal was later opened up for civilian use, providing navigation data for objects on land, water surfaces and in the air. In this article the largest market segments for GNSS are identified: ground transportation (vehicles with built-in satellite navigation, personal autonavigation devices), and LBS-services (the user's location provided by the integration of GNSS in mobile phones). Among other segments are agriculture, aviation (commercial, regional, business and civil aviation) and maritime transport.

Over the next years, all existing global navigation satellite systems are scheduled for upgrading their technical infrastructure to meet the demand from commercial and non-commercial use. A number of business opportunities will arise from these undertakings as these signals provide the basis for intelligent systems for traffic management to reduce the number of traffic accidents, route optimization and the reduction of operating costs.

This paper provides the results of a recently held Foresight exercise on monitoring of global technology trends. A number of different methods and tools of Foresight analysis (Sokolov, 2007) are applied such as scenario analysis, expert judgments, clustering and structuring, literature review, environmental analysis, bibliometric analysis, cutoff technology allocation, roadmaps, system and factor analysis, SWOT-analysis, identification of forecasting scenarios. While the exercise also discussed the technological solutions to improve characteristics of navigation signal reception devices, this paper discusses the potential growth of sales of equipment and devices based on satellite navigation receiver (OEM) modules in Russia including the possibilities of their application in large public infrastructure projects.

The paper is structured as follows: in the first part an introduction to characteristics of foreign GNSS solutions is given. Firstly the methodology of the analysis and the basic characteristics of GNSS solutions such as GPS, Galileo and BeiDou NSS (Compass/BeiDou) is defined. Secondly the technical characteristics of these systems are compared and thirdly the market structure and volumes of navigation services and devices are analyzed. Subsequently, the development of the international and Russian markets for GNSS-based devices and services is described. The final section summarizes and discusses the findings.

The main research questions of the paper are to reveal major areas of GNSS applications driving the development of the market of navigation services and devices in Russia and to compare the similarities of the world and Russia market structure. The underlying assumption is that the road transport and consumer electronics will be the most promising high-growth

segments in Russia. In addition the hypothesis that the Russian market of GNSS devices follows the global trends was tested.

2. Background and methodology

Previous research has already discussed the impact of GNSS on business model innovation (Cavalcante, 2013). The investigation of the current GNSS systems allows identifying the key technical parameters and revealing opportunities for their improvement (Rao, 2010; Bhatta, 2010; Kaplan & Hegarty, 2006). For instance, the creation of the next generation of GNSS (Rizos et al., 2005) is aimed to reach the advanced characteristics, e.g. accuracy, reliability and availability. Such improvements will make possible to get better performance for GNSS applications essential to the end-users of navigation devices and services (Rao & Minakakis, 2004).

It is worth exploring the world trends, major risks and windows of opportunities of the development of GNSS systems for determining the pathway for future development of the market of navigation devices and services (Jacobson, 2007; Sand et al., 2007).

The most important applications of the navigation systems are used in the transport sector (Mathieu et al., 2005; Santa et al., 2006; Kaplan & Hegarty, 2006), surveying and mapping (Kleusberg & Teunissen, 1998; Dow et al., 2009; Gleason & Gebre-Egziabher, 2009) as well as consumer electronics (Rao & Minakakis, 2004; Virrantaus et al., 2001). Besides new market niches for navigation devices and services might arise in the medium- and long-term, e.g. tracking sheep, monitoring of buildings and constructions, guiding blind people, monitoring of mail and personal luggage, etc. (Jacobson, 2007). The high competition on the market of the navigation devices and services drives companies to seek ways to expand the number of applications and to improve their quality by implementing new technologies.

This micro-view on companies and their way of pursuing profit-making opportunities based on new technologies showed e.g. a strong usage of methods like Scenario or STEEPV analysis to include such changes in the technological environment in their strategic planning (Ho & Chen, 2009; Lynch, 2009; Rowe & Wright, 1999). In this paper scenario analysis helps to identify alternative paths of the market development as it takes into account the variety of parameters – from the macro- and micro view. The result of STEEPV analysis is that the key factors are ranked according to the importance for the development of the market. What is left out is decision making on the policy level processes which lead to the creation of such technological infrastructure like GNSS. These decisions have far reaching consequences for future economic activities as they provide the basis on which companies adjust their business models and seek profit-making opportunities, develop application and provide employment.

In order to determine the future demand for space navigation devices with certain characteristics as the base unit for the forecast of market development were identified. The market for services is estimated through the quantity of the navigation devices sold to the end-users. In the first phase scanned publicly available sources of information, like relevant reports of foreign and Russian agencies, marketing reports of consulting companies, as well as national policies and programs for the sector were scanned. The literature review formed the basis for discussions with the expert panel (more than 50 experts specializing in different areas of knowledge), which identified priority areas for the development of navigation markets and devices. In these expert groups, participants identified key trends, drivers and barriers for the sector. Subsequently a first estimate of the market for navigation services was developed. In the second phase of the exercise a series of roundtables and workshops was organized in which the interim results were presented to representatives of educational institutions, research organizations, as well as manufacturers of equipment. Accordingly the initial assessment of market size based on the feedback and further redefined the most promising technological opportunities for navigation equipment was adjusted. At the third stage questionnaires about the schedules of different project implementations around GNSS were sent out to more than 30 experts. Here, special attention was given to public authorities and their planned large scale projects. This allowed to assessing the newly introduced technologies as well as forecasting the development of technologies in Russia under different scenarios. Final results have again been discussed with experts from science, industry and relevant government agencies. The outcome of the exercise has also been presented during a roundtable on "Improving the management of space activities: international experience and prospects for the Russian Federation", organized by the HSE in 2013.

Government initiatives are vital for the demand of satellite navigation services. The development of the market for GNSS devices is largely determined by grand challenges (for example lifestyle change, technical safety, urbanization, rural development, food security etc.) that determine, in turn, a number of trends in the development of the market of navigation devices.

Macroeconomic conditions were defined on the basis of estimations published in the Ministry of Economic Development of the Russian Federation's Scenarios for the formation of variants of the socio-economic development in 2013–2015 (Scenarios of long-term socio-economic development of the Russian Federation until 2030), as well as projections of the Long-term forecast of the development of the Russian economy: key indicators, opportunities and barriers (Center for Macroeconomic Analysis and Short-Term Forecasting, 2012).

3. Characteristics of GNSS solutions

3.1 GPS

The development of the U.S. Defense Navigation Satellite System began in 1973, which was later renamed NAVigation Satellites providing Time And Range; Global Positioning System, and finally shortened to GPS (Global Positioning System). The first satellite was launched a year after the start of the program, and by 1993, 24 satellites were orbiting. The system's original function was to guide missiles, initially towards standing, later also towards moving targets. In 1983 GPS has been opened for civil use. The system was designed for a minimum of 24 satellites, but for increased accuracy GPS currently operates with 31 satellites.

The GPS system is maintained from the Main Control Station on the U.S. Air Force Base Schriever, Colorado. The satellites orbit at an altitude of 20,200 km in a circular orbit with an inclination of 55°. The difference of the orbits of satellites is the longitude of the ascending node, which allows rotating satellites in six different planes (The Official Standard Positioning Service Specification, 2008). Currently, at least six satellites are visible simultaneously. The core constellation is formed by GPS Block II and Block IIA satellites. Since 1999, the Block IIR was used, and in 2010 the fourth generation satellite GPS-Block IIF was launched.

GPS provides general purpose navigation signals free of charge for civil use, and high precision signals for military use. Also, an own frequency is used by intelligence services to detect nuclear explosions, missile launches or other events with a high level of infrared radiation. The new IIF satellites transmit an own signal for civil emergency application. GPS III is already in development and this new generation of satellites is planned to replace existing devices in the years 2017–2018. Their expected life span will increase to 12–18 years with improved position accuracy (up to 1 m). One crucial GPS feature is the right of US military agencies to switch of civil use in certain constellations, e.g. if military needs the channels and data for own purposes.

3.2 Galileo

Galileo is a joint project of the European Union and the European Space Agency and was originally implemented to improve the transport of goods through the European Union. The project involves non-EU partners like Russia, China, Israel, South Korea, and the Ukraine. Currently, negotiations are underway with Argentina, Australia, Brazil, Chile, India, and Malaysia. The Galileo system is planned to start between 2014–2016 with 30 satellites (27 operational and 3 spares). The infrastructure on the ground will include three control centers and a global network of transmitting and receiving stations. The Galileo system is based on the same technology as the GPS, and provides a similar capability. The space segment consists of 30 medium-altitude satellites covering the whole globe, including the Polar Regions. Galileo

navigation signals should provide good coverage even in the range of 75 degrees northern latitude, which corresponds to the location of the North Cape. A large number of satellites including three spare ones ensure signal availability and accuracy. The main 27 satellites operating on three circular orbits at 29,994 km and an inclination of 56 ° complete one turn in 14 hours 4 minutes and 42 seconds. Satellites way between 700–800 kg, with a lifetime of 10–12 years.

Galileo transmits openly for commercial organizations and government agencies, and uses encrypted signals for authorized users. Most importantly, the transmission of information through the Galileo system is at a higher frequency which provides better accuracy of measurement data than its competitors. In contrast to the GPS, the European system has a different structure of its narrowband and broadband signals. In addition, the combination of Galileo signals with GPS will open up opportunities for new applications that require a higher level of accuracy than what its competitors currently offer. These include, for example, applications for the blind, rescue operations in the mountains, detect the location of people with Alzheimer's disease, etc. Search and rescue services are available to all domestic and international operators. Each satellite will transmit signals back to the sender of the distress signal. This feature is considered a major innovation compared to existing systems that do not yet provide feedback functions. Galileo, unlike GPS, generates direct financial income through commercial services for companies or public organizations (Rizos et al., 2005).

Galileo has not been initiated nor is it under the control of any national military authority. Despite the fact that the accuracy of GPS can be increased by using additional systems and equipment, the precision levels provided by Galileo will be superior due to the structure of its satellite and ground-based monitoring and control systems. Galileo also provides signal message integrity and is therefore predestined for commercial use (compared GPS). Less applications have yet been developed for the Galileo system than for GPS, but this is about to change. Due to the European financial crisis, the development of the Galileo may face a number of problems caused by under-funding of the program (Dow et al., 2007).

3.3 BeiDou Navigation Satellite System (Compass/BeiDou)

Already in 1983 a regional navigation system based on the Twinsat technology was tested in China and showed an accuracy level comparable with GPS (BeiDou, Encyclopedia Astronautica — http://www.astronautix.com/craft/beidou.htm). BeiDou, officially launched in 1993, utilizes DFH-3 satellite platforms and displays similar characteristics with GPS. The system provides basic services to the Chinese government and military, including positioning, timing and short message transmission all over East Asia. As of May 1, 2012 in geostationary

orbit, 13 satellites determine the location of facilities in China and neighboring territories. According to plans, the orbital group will expand to 35 satellites in 2020. BeiDou is used by government agencies, logistic service provider and public transport. The system is planned to grow through cooperation with other countries to provide high quality services for a global clientele free of charge.

The Public-Industrial Committee approved the final plan for the project in January 2003 and the BeiDou system received funding of the Ministry of Science and Technology as part of China's Development Plan. In June 2006, the commercial project was extended to maritime vessels. The Ministry of Defense estimates the accuracy of up to 20 m in China and surrounding areas. More than 50 thousand terminals are currently used by the Chinese military, border guards and other public institutions. Due to geostationary operational constraints with BeiDou, China revealed plans for BeiDou-2/COMPASS.

BeiDou-2 relies on 35 satellites orbiting at three planes: Five satellites in geostationary orbit and three satellites in geosynchronous orbit (launched in December 2010 and April 2011) at 38,300 km. 27 satellites are placed in three planes with an inclination of 55 degree to the equator at an altitude of 21,500 km. In addition, the satellite will be equipped with laser reflectors and the functionality for sending short messages. BeiDou played an important role in disaster management (Sichuan Earthquake, Yushu, Qinghai Province earthquake), marine navigation systems (Offshore Fishing Ship Control System, Offshore Tide Monitor, Marine Search and Rescue, Data Transmission) and traffic management (Qinghai-Tibet Railway Monitor and Control System, Truck Tracing with hazardous goods).

BeiDou will gradually spread throughout the Asia-Pacific region, and by 2020 BeiDou is projected to be a fully fletched international player. The commercial potential of BeiDou depends largely on China's growing economic potential and its appetite for cars, mobile phones etc. By the end of 2009, BeiDou has provided location services to 330 million users, communications services to 220 million users.

3.4 Comparison of the technical features of the systems

The main technical parameters (see Table 1) of the navigation systems have the impact on the key characteristics of navigation signal (accuracy, availability, integrity and continuity of the signal). These characteristics are essential for end-users when they consume any navigation services. Accuracy is one of the most important characteristics of GNSS. This increase in the demand for accuracy of navigation signal is the driver for the development of GNSS.

Table 1. **Technical parameters of the Navigation Satellite System**

	GPS	Galileo	BeiDou
Country	USA	EU	China
The number of satellites (reserve)	24 (base) increasing to 48	30 (base)	35 (base)
Number of orbital planes	6	3	3
The number of satellites in each plane	4	9	9
Orbit altitude, km	20,200	23,222	38,300 (IGSO), 31,500 (MEO)
The warranty period of the satellite (in years)	10	10	8
Covering signal	The globe	The globe	The globe
Location accuracy consumer signal	2.6 m	4–8 m	up to 10 m (global); 1 м (local)
Accuracy velocity (m / sec).	10 (civil signal), 0.1 (military signal)	0.2 m / sec	0.2 m / sec

Source: HSE research

Based on the analysis it can be concluded that the most developed and well-known to users all over the world is the satellite navigation system GPS. It becomes evident that the GPS system offers the highest location accuracy so far. At present, the Chinese BeiDou system is under trial operation on a national scale and the European Galileo system is also under development. However, it can be concluded that Galileo and BeiDou have sufficiently high degree of development (see Table 1). These systems are composed of three orbital planes and the warranty period of the satellites is 10 years.

4. Market analysis of navigation services and devices

The market of navigation devices and services consists of 6 major segments: ground transportation (personal car navigators and built-ins GNSS), LBS-services (location-based services provided with the location of the user), air transport (commercial, regional, business and civil aviation), agriculture, maritime transport and surveying.

Currently, 20 % of GNSS devices are sold in the EU while 30 % in U.S. and rest 15 % in Japan. On a world-wide level, private consumers will drive demand for satellite navigation systems on the medium and long term. A large number of GNSS devices will be used for individual transport, mostly in built-in solutions. A second segment with large sales volumes comes from mobile devices which use GNSS signal for various applications (location-based

services - LBS), like smartphones, PDAs or internet tablets equipped with GNSS receivers. The review of the market of global navigation satellite systems 2012 European GNSS Agency (European GNSS Agency, 2012) predicted an average annual growth rate of GNSS devices of 13 % in 2013–2016. The market will peak by 2020 at a volume of more than $ 200 billion.

According to the new GSA report, the global market for GNSS will grow significantly over the next decade, reaching up to €200 billion for the overall GNSS enabled market in 2020 (accounting for the full retail price of the GNSS enabled devices). The GNSS core market (including only the part of the retail value attributable to GNSS, e.g. chipsets) will reach some €165 billion in 2020, with a compound annual growth rate (CAGR) of 11 %. Delivery of GNSS devices will exceed one billion per year by 2020.

The key driver of the global market development is an increase in demand of GNSS devices for transportation and consumer electronics with navigation chipsets. Large-scale government projects will be of major importance as well. Currently, all over the world a number of initiatives are being developed aiming at equipping vehicles with responders to achieve various goals. For example, the US-American NG911 (USA's continuation of the project E911) coordinates mobile phones and other devices, including automotive navigation-connected terminals. The European Union plans to install eCall which will equip cars with Galileo/GPS receivers, which — in the case of an accident — will automatically inform on-duty dispatcher services. The project is planned to start 2014 for all new vehicles. Russia plans a similar project for 2014.

The biggest turnover from GNSS device will be generated in the segment of ground transportation (vehicles with built-in satellite navigation, personal auto navigation) with an estimated 54 % of the market share, followed by LBS-services (devices for location-based services, including GNSS in mobile phones) 43.7 %, and a small share for other usages (agriculture 0.6 %, aviation 0.2 %). Most GNSS devices will be sold for LBS-services (87 %), followed by devices for cars (13 %). Aircraft, maritime transport, agriculture will account for only 1 %.

The experts predict the growth of GNSS penetration in different markets by 2020 (*Table 2*).

Table 2. **GNSS penetration by market segments (%)**

	2012	2020
Smartphones	30–35	90–100 (Europe; USA) 67 (rest world)
Road	60	90 (USA, Japan)
Aviation	36	97
Maritime	40	95
Agriculture	16	33

Source: European GNSS Agency, GSA GNSS Market Report — Issue 2, May 2012.

Among the trends in the individual segments of the world market of GNSS devices the most significant were identified:

- the proportion of personal navigation devices will gradually decline;
- aviation and commercial use in agriculture are areas of strong growth;
- in the field of surveying and mapping, GNSS devices still have a great potential in replacing the traditional equipment;
- GNSS devices will be widely used in the marine sector, especially for search and rescue application;
- deferred purchases of cars and consumer electronics during due to the financial crisis of 2008–2010 will play an important role in raising sales of navigation devices.

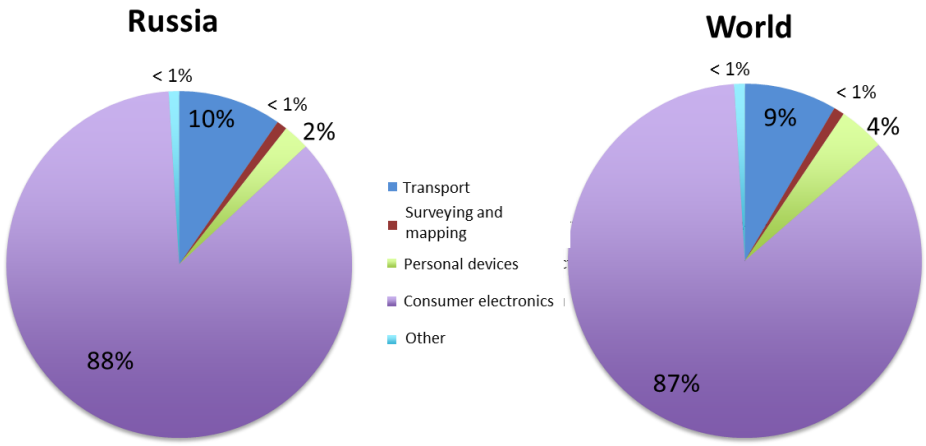
5. Development of the Russian market for navigation services and devices

The Russian market accounts for less than 1 % of the global market share. In our exercise, the different types of GNSS devices are divided into five segments of usage:

- transport and transport infrastructure (built-in GNSS);
- consumer electronics;
- personal navigation devices;
- surveying and mapping;
- others (social direction of the use of electronic devices equipped with GNSS chip, monitoring the movement of goods, infrastructure, state of the natural complex, and so on).

Figure 1 compares the Russian and world markets of GNSS devices (such as smartphones, tables, built-in car modules, etc.). The total market represents sales of GNSS devices in real terms cumulatively from 2012 to 2020.

Figure 1. **Comparison of the market in Russia and in the world (cumulatively from 2012 to 2020)**



Source: (Russia) HSE research, (World) European GNSS Agency

It is obvious that the structure of the Russian market is similar the structure of the world market. Data on the structure of the world market are based on assessments of the European GNSS Agency. Data on the structure of the Russian market are get by summing up the forecast volumes of GNSS devices for the period 2012–2020 and support the hypothesis that the Russian market of GNSS devices follows the global trends.

In this study, experts estimated the factors affecting the development of the navigation satellite systems by using STEEPV-analysis (covering social, technological, economic, ecological, political and valuable factors). Participants were asked to rank various factors of importance for the development of the Russian market. The ranking of Top 10 factors are presented in Table 3.

Table 3. **STEEPV-analysis: Top 10 factors affecting the development of the navigation satellite systems**

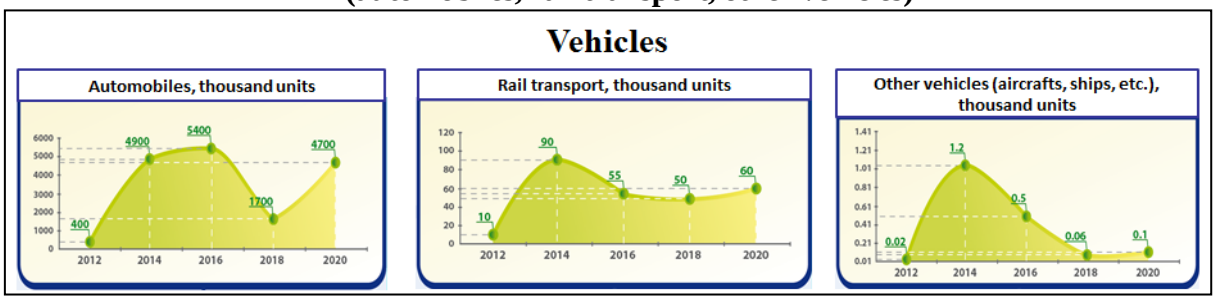
№	Factors	(max 10)	Type of factors
1.	National security of the country	9.6	Political factors
2.	Public funding of the sector	9.4	Political factors
3.	The level of demand from the government and the military	9.2	Economic factors
4.	The development of space technology	8.8	Technological factors
5.	Competition in the market of space navigation	8.6	Economic factors
6.	Distance control technology	8.4	Technological factors
7.	High potential demand	8.2	Economic factors
8.	Availability of navigation services for the majority of citizens	8.0	Social factors
9.	The number of experts and scholars in the field of satellite navigation and sharing of experience between countries	8.0	Social factors
10.	Active R&D	8.0	Technological factors

Source: HSE research

The results of analysis show that most experts agree that political, technological and economic factors have strong influence on the development of satellite navigation, while experts' estimation regarding the impact and significance of environmental factors varies significantly.

It is worth noting that political factors are playing an important role in the market development of the devices built into vehicles. The Russian market will benefit especially from a number of law initiatives on realization of large public infrastructure projects. Figure 2 illustrates the expert estimations of sales of navigations modules for the vehicle segment.

Figure 2. **Future development of Russian vehicles market (automobiles, rail transport, other vehicles)**



Source: HSE research

According to experts, a further increase in the consumption of GNSS devices in the segment of vehicles is possible on condition of a stable demand stimulated by the government and the increase in sales of passenger cars and commercial vehicles, railway vehicles, water and air of commercial vehicles.

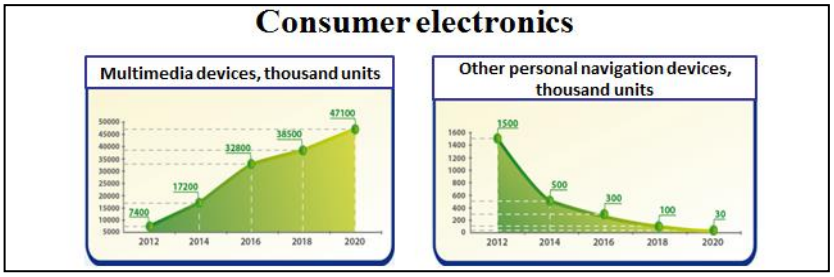
According to the experts' estimations, the government initiatives to equip the vehicles (new and exploited) with the navigation modules are planned to implement in 2014–2016. In addition, this period the market of automobile transport will experience growth due to increased loans for car purchases in line with recycling programs. The effect of the implementation of the government project will be exhausted by 2018. In addition, there will be a significant decline in domestic production and imported vehicles in connection with the projected economic crisis.

After 2017–2018 the government plans to complete the equipment of trucks, passenger vehicles, rail, water and air vehicles with GNSS modules, and therefore the reduction in the demand for embedded devices GNSS is expected.

In addition, infrastructure projects will majorly increase the demand. Examples of those projects are the implementation of system of emergency call in case of car accidents, based on the European standard eCall/E112, Moscow ITS, transport and logistics center of the Olympic games 2014 in Sochi and series of social projects. Below the most promising of these projects are listed subsequently.

Another trend in the market of GNSS is the growth in the use of navigation multimedia devices. Figure 3 shows the decline of sales of personal navigation devices as they become more and more replaced through smart phones or integrated navigation modules.

Figure 3. **Future development of Russian electronics market**



Source: HSE research

To the year 2020, more than 60 % of the cars will have a satellite navigation system on board. These devices will be integrated into multi-media solutions and provide other functions like DVR-function, Navigation Recorder, GPS Tracker, geotagging etc.

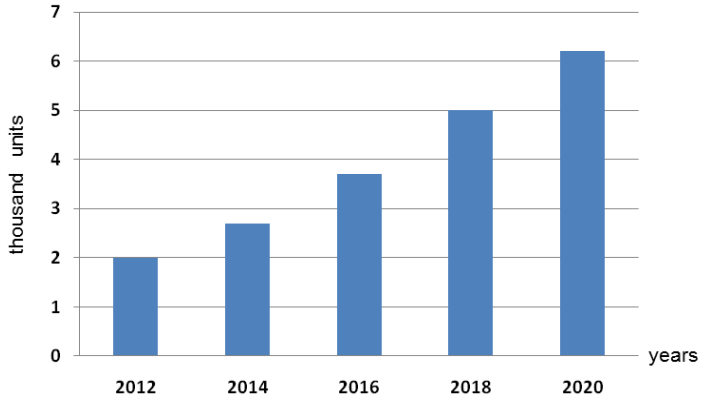
The "Consumer electronics" market can be divided into segments:

- multimedia devices (such as smart phones , PDAs, Internet tablets, equipped with GNSS receiver);
- other (specialized personal navigation devices intended for personal use in order to determine the location on the road, during sports, hunting and tourism activities (including car navigators).

The growth of segment of GNSS devices is provided by the increase in real disposable cash income, a quick update the product line, lower prices for devices of this class, the popularization of new communication means, etc.

The third large segment of the market of navigation devices and services is surveying and mapping equipment (in Geodesy and Cartography). Public measures to improve the development of Geodesy and Cartography by 2020 (approved by the Decree of the Government of the Russian Federation from 17.12.2010 № 2378-P) will attempt to raise the efficiency in geodetic support of the Russian Federation. The list of measures includes the creation and development of a high-precision geocentric coordinate system of the Russian Federation, integrated into a new international terrestrial reference system ITRS (International Terrestrial Reference System). With the implementation of geodetic and cartographic works (Beutler, Moore & Mueller, 2009), supporting space flights and navigation problems with the use of measuring devices are in use by various federal executive agencies and scientific organizations. Figure 4 shows the dynamics of the forecasted sales of surveying and mapping equipment with navigational chips.

Figure 4. **Annual sales of surveying and mapping equipment with navigation chips (thousand units).**



Source: HSE research

The usage of location-based services provides a series of benefits for customers in different activities through:

- improved efficiency of economic activities like construction, agriculture, logistics, etc. (Osterman, Godeša, Hočevar, 2013). Especially Russia in its role as an exporter of agricultural commodities, the use of "Precision Agriculture" in combination with improved logistic systems can have a lasting impact on the Russian economy;
- improving the high technology sector in the Russian economy through increased production of technology-intense goods and services;
- social innovation supported by GNSS like natural protection zones or protection from natural disasters.

Demand for GNSS-enabled devices is strongly influenced by the rate of growth of e.g. the construction sector. The same is true for the use of built in devices and the car market. In the consumer electronics segment sales of smartphones, tablets, PDAs, and other personal navigation devices depends on the rate of growth of real disposable income.

Factors influencing the dynamics of the segment of surveying and mapping equipment with respect to the use of GNSS signal in geodesy and cartography are:

- the effect of substitution of traditional equipment for navigation devices;
- the gradual decline in the price of equipment.

Interestingly, the experts identified a number of niches with have market potential, namely:

- **Buildings and construction** to gain information about the condition of the building. This is especially important given the high number of causalities from collapsing buildings. GNSS applications can visualize the movement of buildings and also indicate problems with water or changes in the sub structure.

- **Monitoring of mail and personal luggage**: equipping valuable shipments with cheap transmitters allows ensuring delivery. Losing both luggage from airlines and postal deliveries constitute a serious economic problem. The "Russian Post" for example has lost 5–7 million shipments in the year 2011 in Russia. Such services could be particularly important in the handling of classified documents.
- **Control of individuals' travel** which are part of high risk social groups, like children, people with disabilities or mental illnesses. People with court orders could also be closely supervised if they have to spend a term at home for petty crime. Also, the technology is suitable to monitor the absence times of students from their lectures. Employers could use the technologies to monitor the activity circles of sales personnel. For example, agreed visits to customers could easily be verified. Local governments will be interested to use satellite technologies to monitor the movement of taxies on which they base their taxation.
- **Control of athletes' travel during sport events**: The use of navigation tools at sport events has seen great interest both from sportsmen and spectators alike. GNSS could be used both as a highly precise method for measurement and as a possibility to control the movement of athletes to prevent doping.

In addition, infrastructure projects will majorly increase the demand. Examples of those projects are the implementation of system of emergency call in case of car accidents, based on the European standard eCall/E112, Moscow ITS, transport and logistics center of the Olympic games 2014 in Sochi and series of social projects. Below the most promising of these projects are listed subsequently.

"12-tonniki" ("12 ton" cars)

The system, which is based on a German design, is in use since 2005 and provides an automatic registration of heavy duty vehicles. Russia plans the adoption of a toll of 3.5 rubles per kilometer for trucks weighing over 12 tons on federal roads. Russia is also expected to equip trucks with suitable navigation devices.

"Pay-as-You-Go Tax"

This technology enables the introduction of a general toll fee per kilometer. The Netherlands introduced a similar system in 2011. The price of the kilometer travelled is depending on both the quality of the road and the performance of the cars. This system requires the installation of on-board equipment for satellite-supported tracking of the car. Russia plans the adoption of such a system by 2020.

Logistic transport center in Sochi (LTC)

Sochi will host the Olympic Games in 2014. To support the building sites and supply routes, a logistic transport center will enable real-time control of freight and passenger transport during preparation and execution of the Olympic Games. Also this service will be integrated into the security system for this major international event. In accordance with the technical requirements for LTC, all navigation and communications equipment will operate with multisystem receivers for different GNSS signals, which significantly improves the accuracy of determining the coordinates of the vehicle and increase the reliability of satellite navigation signals in mountainous terrain.

Intelligent Transport System for Moscow (ITS)

Intelligent Transport Systems monitor and analyze traffic conditions in a city and provide data for traffic management. City authorities in Moscow hope that the implementation of ITS will result in a reduction of accidents by nearly 25 %. Also, ITS provide customized navigation and information services, which includes:

- public transfer and high priority traffic (police department for the city of Moscow, Ministry of Emergency Situations of Russia in Moscow, ambulances, etc.)
- Active communication with the subscriber (user) of mobile electronic devices

Digital tachometers (tachographs)

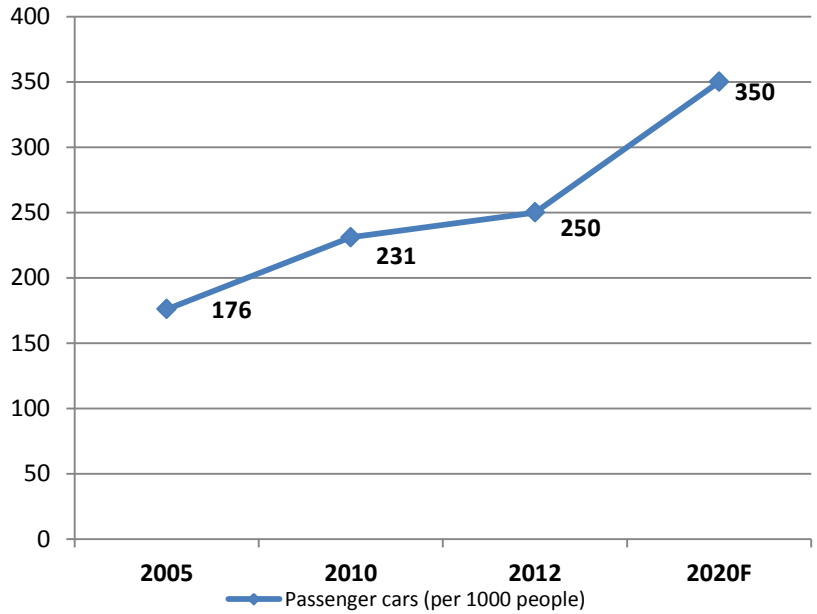
Tachometers (tachograph) measure an object's speed of movement but also provide related services (digital projection of display, entertainment). Using GNSS signals for the measure of speed would provide an independent measurement free of unintended manipulation for traffic regulation. Installation and use of the digital tachograph is already required in accordance with the European legislation to protect the driver and avoid too long driving which violates the traffic safety regulation. Russia introduced digital tachographs on June 16, 2010, following an international agreement with AETR. Truck drivers without the necessary equipment are not permitted to enter the territory of AETR's member states, including Russia. Tachographs are to be installed in vehicles of the categories M2, M3, N2 and N3 for commercial usage. Also in buses with more than eight passenger seats with more than 5 tonnes of weight, and vehicles used for transportation of goods with more than 3.5 tonnes.

System of emergency call in case of car accidents, based on the European standard eCall/E112

Russian plans to use GNSS devices for the state system of emergency call, scheduled to start in 2013. The created infrastructure will provide the basis for further development of the Russian navigation and information systems and should act as a technological starting point to enhance the competitiveness of Russian companies. The system provides services to all users (public authorities, businesses, citizens), and will be equally deployed throughout the entire country through using the latest technologies providing reliable and secure communications, centralized billing, high-quality mapping, communication protocols coordinated with European standards, etc. For other countries like EU, China and Brazil, the development of such systems is still in the design phase (European eCall system is scheduled for 2014, the Brazilian system SIMRAV-postponed 2015). New cars will be equipped with special terminals System of emergency call from 2014 onwards. These systems will automatically report the site of the accident and to ambulance, police, and rescue workers. According to estimations, the System of emergency call will reduce the response time in case of an accident by 30 %.

Due to increased importance of built-in GNSS devices, the demand for these devices will be largely driven by the growth of car sales (Figure 5).

Figure 5. **Dynamics of car sales in Russia (units per 1000 people)**



Source: Strategy of development of automobile transport till 2020 (Ministry of Transportation, Russia).

Here experts mentioned the appearance of the connected car as a big potential improvement for the number of cars sold. The "Connected Car" is the technological advancement from a pure network device installed in the car. Such a car offers a large number of solutions, like early warning systems for traffic jams, adverse weather conditions, etc.

The concept "Connected Car" is used for:

- creating a wireless local area network of built-in equipment and portable electronic devices;
- connecting the vehicle with the outside (Internet) via the mobile telecommunications technologies (GPRS, 3G, LTE);
- obtaining the key information by purpose of security, governance and location-based services.

6. Conclusions

This paper discussed the results of recently held Foresight exercise and provided a comprehensive picture of the development of market of navigation services and devices. After investigating the global market development for GNSS, the prospects of the Russian market of navigation services and devices were elaborated. The Foresight analysis shows that the new market niches for navigation devices and services might arise by 2020, e.g. the monitoring of buildings and constructions, monitoring of mail and personal luggage, control of socially vulnerable and socially dangerous population groups, control athletes' travel during sporting events, control of animals' travel , etc. Moreover, the analysis supported the hypothesis that the Russian market of GNSS devices follows the global trends.

The study found that the commercialization of GNSS in Russia is possible only in certain segments, mainly navigation modules for personal vehicles, surveying and mapping equipment as well as consumer electronics. It should be noted that road transport and consumer electronics are the most promising high-growth segments until 2020. In the case of Russia, large-scale government-driven investment programs will be key drivers for market growth prospects.

To conclude the whole system of navigation signals should be maintained as a public good. GNSS capabilities can be used in various sectors of economics, improving the effectiveness of social policy and life standards.

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