

SPECIAL ISSUE

FORUM
«OPEN INNOVATIONS»

WHERE THE TECHNOLOGY MARKET IS HEADING: PROSPECTS FOR RUSSIA





**OPEN
INNOVATIONS**
Forum and Exhibition

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MEDICINE & HEALTHCARE

Modern medicine is one of the areas where the results of breakthrough developments in science and technology are most clearly seen. New biological products enable precisely directed correction of this or that disorder in the body without damaging other organs. In future, nanorobots the size of a molecule will be used for targeted drug delivery.

There is a shift from standardized methods of treatment to personalized selection of medicinal products based on the genetic characteristics of each individual patient. Genetic technologies are being developed that will allow the correction of genetic abnormalities before birth or the use of a few injections to cure diseases previously considered incurable.

The development of regenerative medicine, including the preparation and use of stem cells and 3D-bioprinting, is bringing closer what were previously fantastic-seeming possibilities for growing and replacing tissues and organs, and the development of ideas at the intersection of medicine and information technology is changing standard approaches to health monitoring and treatment. For instance, the spread of portable medical and testing devices allows the efficient collection of a large amount of data which can be used for the effective prevention of

diseases, as well as early diagnosis and timely treatment. Developments in laboratory technologies lead to dramatic improvements in the accuracy and speed of tests and expansion of the range of analysis methods, including at home.

In order to create an effective system of health care, many countries introduce unified information systems that facilitate a patient's access to health care at various hospitals. The development of telemedicine involving the remote provision of medical advice increases the accessibility of quality health services by dwellers of remote areas, while at the same time optimizing the costs involved in organizing health systems.

Trends observed in modern medicine are present in Russia, too. For example, Russian companies and research institutes are producing internationally recognized results in the field of 3D-bioprinting, cell and gene therapy, personalized medicine, and targeted drug delivery; Russian hospitals are implementing medical information systems and adapting to the use of telemedicine. However, because of the social importance of the sector and the high level of regulation, government policy is of great importance for the development of the medical industry. Thus, financial support from the government is needed to eliminate the incipient technological lag in medicine caused by the lack of the infrastructure funding in the 1990s, and the development of cellular technologies and active incorporation thereof into medical practice is limited by the underdeveloped legal framework in this area. It is important, therefore to implement strategic programs of the

Government of the Russian Federation aimed at the development of the pharmaceutical and healthcare sector through the promotion of innovation and technological advances in the industry.

The Federal Target Program for the Development of the Pharmaceutical and Medical Industry up to 2020 was adopted with a view to introducing an innovation-based developmental model for the pharmaceutical and medical industry. According to the stated aims, by 2020 domestic production must account for at least 50% of the total volume of the domestic market in value terms, and at least 80% of goods produced must be innovative and under patent protection. It is also anticipated that, in the course of the implementation of the program, 75% of pharmaceutical companies and 85% of companies producing medical equipment will be upgraded.

To achieve these goals, the state program envisages the allocation of RUB 1.5 trillion for the funding of research and development activities. Another instrument of partnership between the government, innovation-oriented indus-

trial companies and research and education entities is the creation and development of scientific and industrial clusters. The program resulted in seven medical and pharmaceutical territorial innovation clusters being set up in Russian regions (in the St Petersburg, Moscow, Kaluga, Tomsk and Novosibirsk Regions and the Altai Territory), bringing together the most active organizations in the area of the development and production of innovative pharmaceutical and medical products.

One of the first examples of the successful development of innovative medical products demonstrating the ability to compete with international corporations is presented by BIOCAD, whose pharmaceutical complex is situated at the Neudorf site in the Saint-Petersburg. In early 2014, company registered with Roszdravnadzor (the Federal Service for the Supervision of Public Health and Social Development) a bioequivalent of Rituximab, Trastuzumab and Bevacizumab – anticancer medicines based on monoclonal antibodies. The production capacity of the existing plant will meet the Russian demand for biological medi-

cines used for treatment of cancer and autoimmune diseases, and will replace the imported medicines Herceptin, Avastin and MabThera. Today, federal budget expenditures on purchase of the three medicines are RUB 13 billion per year, and BIOCAD's bioequivalents will be 30% cheaper than foreign medicines¹.

In order not to lose their share in the growing Russian market, 54% of foreign importing manufacturers are considering the possibility of contract-based production on the premises of Russian manufacturers.

¹ <http://www.kommersant.ru/doc/2474182>

NIKOLAY SHIMANOVSKY

Head of the Academician P.V. Sergeyev Chair
of Molecular Pharmacology and Radiobiology, MBF,
the N.I. Pirogov Russian National Research
Medical Institute

“The main reasons why Russia is lagging behind the West in the development of modern methods of treatment and diagnosis, and not achieving definitive results, are improper organization of research teams, the lack of contact they have with the production sphere and inappropriate imitation of the Western system. It is essential to create expert groups consisting of niche specialists who are capable of taking a holistic view of the various lines of development within medicine and offering ways of creating more effective and safer treatment methods. Expert groups would set specific tasks for research laboratories, monitor their performance and be responsible for practical implementation of solutions.”

EVGENY ZAYTSEV

Managing Partner at RMI Partners

“The biopharmaceutical industry can no longer function as it has done for the last few decades. It is well known that most drugs (90%) help only 30-50% of patients. Accordingly, the remaining patients do not receive any therapeutic effect, while the world's health systems spend hundreds of billion of USD on useless drugs every year. That is why doctors, patients, insurance companies and regulators today are demanding a personalized approach from drug developers. Often, companion diagnostic products for a medicine are developed before the medicine gets to the market. If previously medicines were designed to attack the disease mechanism, and such attacks were increasingly carried out at a deep molecular level, today medications even at the research stage are aimed at specific categories of patients with particular biomarkers – metabolic or genetic characteristics – which influence the effectiveness of the medicine. Today, medicines are targeted and delivered precisely to those organs and tissues where they are most needed, and means of controlled release allow the effects of a medicine to be adjusted over a certain period of time.”

PERSONALIZED MEDICINE

“Treating the person, not the disease” is a key principle of personalized medicine (PM) and an approach that affords great opportunities for improving the efficiency and safety of medical services.

The purpose of personalized medicine is to ensure that every patient receives the medical product that is best for their needs. This is achievable through the use of suitable diagnostic tests which reveal specific mutations in the patient and the development of drugs (e.g., anti-cancer drugs) that are effective against specific mutations. Although it will take time to realize the potential of personalized medicine, it is now widely believed that the days of the “one drug for all” principle are numbered.

Personalized medicine is a fast-developing field. For example, in the USA, the market for commodities and services related to personalized medicine is estimated at USD 232 billion and is set to grow by 11% annually, doubling by 2015.

This trend is aided by the big pharmaceutical companies (e.g., Roche has already made PM the center of its strategy since 2006 by making investments in 2 areas: pharmaceuticals and diagnostics), as well as by new players. Sony is embarking on a new venture connected with the study of the human genome and the application of the results in personalized medicine (the company is known as P5 Inc.). Google has also made an appearance on the market (its subsidiary Calico, established in 2013, investigates problems of aging and concomitant diseases).

Personalized medicine begins with research into the nature of a disease and its patterns as defined by means of biomarkers (e.g., proteins, genes and other biological markers in the body's liquids and tissues that could be indicative of disease or response to drug therapy). Biomarkers help to reveal targets for drug action and facilitate the selection of the drug and dosage.

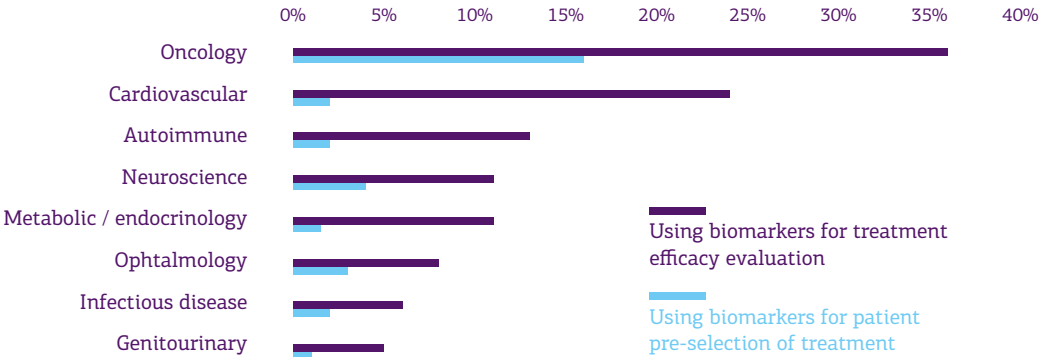
Biomarkers are critical for the development of personalized medicine. They can be used to evaluate the risk of progression of the patient's disease and predict the most probable course of progression, to divide patients into categories based on biological signature and probability of response to treatment, to monitor treatment and to check disease progression and response to treatment to determine whether a drug has had any effect or whether there has been a relapse.

One of the main lines of research in the area of personalized medicine is the search for new biomarkers, and particularly protein biomarkers or DNA-based biomarkers. The appearance of new biomarkers enables a pharmaceutical company to develop and commercialize innovative drugs and improve diagnostic tools. For example, in 2014, a new biomarker, TMAO (Trimethylamine N-oxide), was found to identify the risk of cardiovascular diseases, which could help to predict the probability of heart attack or stroke, and there is ongoing research into biomarkers for the treatment of Alzheimer's disease and oncological diseases.

Biomarkers will play much a more significant role than now in the medicine of the future. At present, companion tests are required or desirable for the prescription of only a small proportion of drugs. Market players believe that, in the long term, the number of new drugs used in combination with companion tests will grow rapidly.

Russia has strong scientific potential in the area of personalized medicine: relevant research is conducted at Pirogov Russian National Research Medical University, the P.A. Herzen Moscow Cancer Research Institute and the Orekhovich Institute of Biomedical Chemistry.

Biomarkers Use for the Treatment
of Different Diseases



GENE THERAPY AND SOFTWARE DEVELOPMENT

The study of an individual's genetic features is one of the fundamental elements of personalized medicine, enabling the identification of a patient's predisposition to specific diseases and the provision of tailored medical treatment, including the selection of drugs and the scheduling of treatment. Today, the majority of clinical trials in this area are focused on cancer control, since one of the causes of the appearance of malignant tumors is the abnormality of the gene structure. In order to keep the prescribed treatment and its negative impact on the body to a minimum, gene therapy has been actively developed. Gene therapy may be defined as treatment by means of direct impact upon and modification of the human cell genetic apparatus.

Gene therapy may involve the introduction of new DNA into the affected cell, as well as stimulating the functioning of the body's own genes through the introduction of a therapeutic gene. This is a fundamentally new approach to the treatment of diseases, focusing on elimination of the initial cause of the disease rather than its effects.

Gene editing is a safe and effective method of treatment of serious diseases, as it eliminates the need to take drugs that have a negative impact on the entire body. Scientists are looking at gene therapy as a possible method of treatment for diseases such as AIDS and the restoration of eyesight in patients with hereditary progressive forms of blindness.

Specialists at Washington University have developed a mechanism that can be used to perform procedures with artificial DNA molecules. It may lead to the creation of a universal cell programming technique based on the mathematical description of the chemical system (a set of instructions for the programming of chemical reactions in the cell with the aid of DNA).² Such systems could work as "smart" suppliers of drugs or disease sensors at the cellular level.³

CASE

THE GENETICO MEDICAL CENTRE NETWORK

The joint project undertaken by the Human Stem Cells Institute (HSCI) and Biofund RVC involving the creation of the Genetico Centres Network in Russia to carry out work in the sphere of personalized medicine may serve as an example of the realization of the personalized medicine approach.⁴ The main purpose of the project is to prevent diseases with a genetic component, to provide patients with timely information about the possible development of hereditary diseases, to provide consultation, diagnosis and individually tailored drug therapy, and to prevent cancerous diseases. The total amount of investment in the project in the first two years will be RUB 180 million. The project will be implemented through the Centre for Genetics and Regenerative Medicine, an HSCI subsidiary.

⁴ <http://ria-ami.ru/read/25933>

Scientists at Berkley University have developed the CRISPR methodology which makes it possible to edit (program) the genome and change the genetic code as desired. The new technology enables any part of the human genome to be "repaired" with maximum precision without provoking gene mutations.⁵ This methodology helps not only to treat or prevent inherited diseases, but also to edit the genome even at the embryo stage.⁶

² <http://habrahabr.ru/post/196048/>

³ <http://www.qwrt.ru/news/520>

⁵ <http://russian.rt.com/article/17940>

⁶ http://medvestnik.by/ru/issues/n_8658.html

USE OF NANOROBOTS FOR TARGETED DRUG DELIVERY

Scientists worldwide are conducting research aimed at the creation of systems for targeted drug delivery. The delivery of a drug directly to the primary site of a disease makes it possible to reduce adverse reactions of the body to the impact of the drug (e.g., in the context of chemotherapy), as well as to reduce the therapeutic dose of the drug and increase its efficiency.

A wide range of targeted drug delivery technologies has been developed, from localized drug delivery to chemical modification and encapsulation.⁷

One of the most promising trends in the development of targeted drug delivery is nanorobots — molecule-size robots that can move, process and transfer data, accurately locate the site of a disease and deliver the necessary substances⁸. Nanorobots can be used for the removal of thrombus and concretions, the treatment of atherosclerosis and the diagnosis and treatment of diabetes through control of the blood glucose level; nanorobot capabilities can be also used for oxygenation of tissues, restoration of the vascular system and monitoring of the concentration of various nutrients in the human body.⁹

Nanorobots could be used to diagnose and treat cancerous diseases without the need for chemotherapy. The first nanorobot was developed in 2014 by Korean scientists at the Chonnam National University.¹⁰

Russian scientists at the Prokhorov General Physics Institute, the Shemyakin-Ovchinnikov Institute of Bioorganic Chemistry and the Moscow Institute of Physics and Technology were the first in the world to be able to program nanoparticles to carry out logical operations with the aid of biochemical reactions. A specially adapted outer layer enables nanoparticles to react to the presence of a specific substance, acting as a signal.

CASE

CREATION OF ARTIFICIAL CHROMOSOMES

The creation of an artificial chromosome is one of the methods of DNA programming. Researchers at the Human Stem Cells Institute (HSCI, Moscow), in cooperation with the Institute of Cytology RAS (Saint Petersburg) and the National Health Institute (Bethesda, USA), have developed an artificial chromosome that can fight against hemophilia.

Scientists from Japan, the USA and other countries are conducting research aimed at the development of artificial chromosomes programmed to treat various diseases. Chromosomes contain necessary genetic information and transmit it to cells. If the testing and practical application of artificial chromosomes proves successful, they could be of great significance for the treatment of various diseases, including inherited diseases.

Despite the wide range of possibilities, the absence of corresponding mechanisms for controlling nanorobots was impeding active development and implementation. This problem was successfully solved by the use of propeller engines which make nanorobots move in the required direction, passing through vessels and penetrating into cells by virtue of the action of the magnetic field on the screw mechanism.¹¹ If the results of animal testing are successful, nanorobots will probably be used for the treatment of human diseases in the near future.

⁷ <http://cyberleninka.ru/article/n/napravlenyy-transport-lekarstvennyh-preparatov-sovremennoe-sostoyanie-voprosa-i-perspektivy>

⁸ <http://nanorobotics.insa-cvl.fr/WorshopICRA2014/tc-biorobotics.com/icra2014/docu.php/start.html>

⁹ <http://www.azonano.com/article.aspx?ArticleID=2035>

¹⁰ <http://www.techandinnovationdaily.com/2014/01/16/cancer-fighting-nanorobots/>

¹¹ <http://www.epochtimes.ru/uchenye-sozdali-nanorobotov-s-dvigatelem-v-forme-shtopora-98930605/>

REGENERATIVE MEDICINE

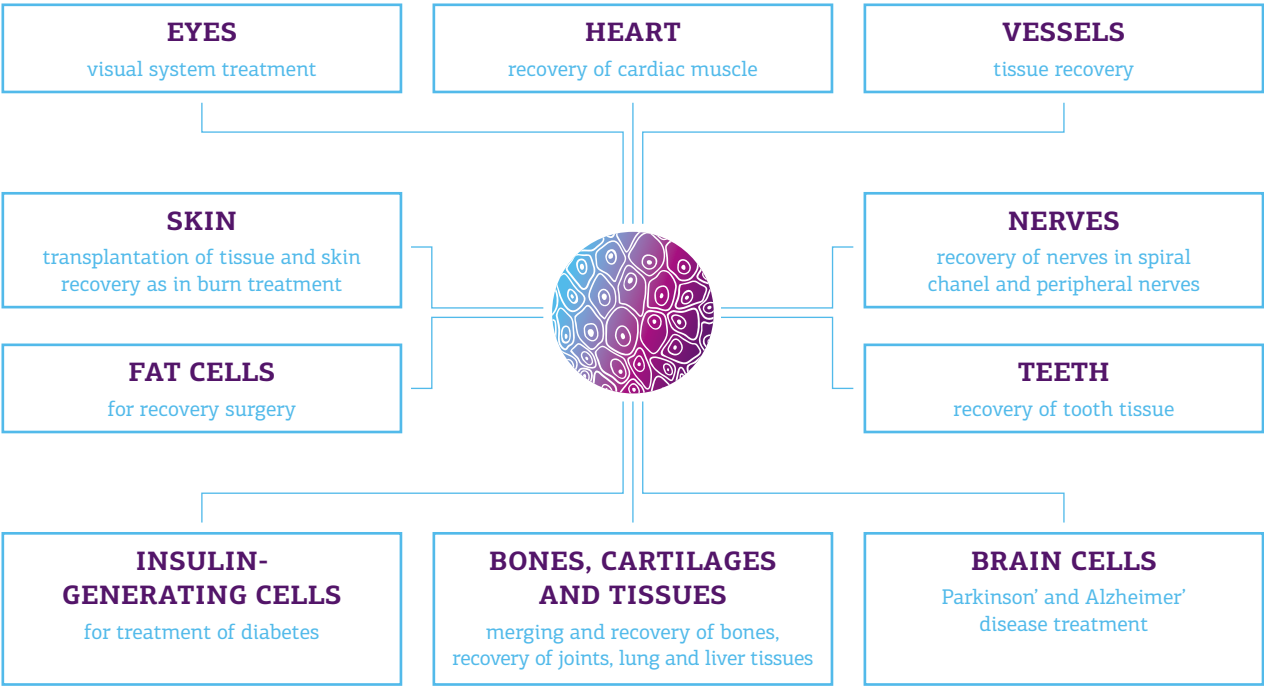
TREND USE OF STEM CELLS

Stem cell therapy is a relatively new medical trend. Active research in this area has been conducted since 1998, when American scientists discovered human embryonic stem cells and demonstrated their ability to differentiate into almost any type of human body cells¹².

Stem cells can help to restore any organ, and the use of such technology in regenerative medicine, reducing the need for the use of donor organs, has great prospects: in 2013, Russian doctors performed about 1400 transplantation surgeries, which accounted for around 16% of the demand at most. Today a great deal of faith is put in the potential of stem cells to treat such socially significant diseases as diabetes, diseases resulting in loss of skin integrity, myocardial infarction, muscular dystrophy and neurodegenerative diseases.¹³

So far, scientists have been able to use stem cells to produce tissues of the liver, muscles, eye cornea, heart and other organs. In April 2014, researchers managed to create artificial blood cells in vitro from induced stem cells. Industrial production of sterile artificial blood may commence in 2016.¹⁴.

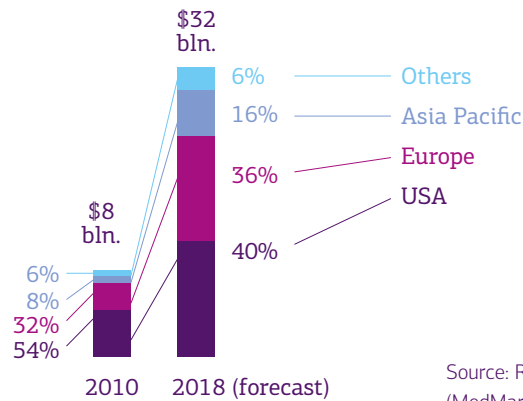
Applocation of Stem Cells



¹² <http://www.cellmed.ru/page.php?id=14>
¹³ <http://vnauke.by/news/Stvolovye-kletki-i-regenerativnaya-medicina>
¹⁴ <http://www.rg.ru/2014/04/16/krov-site-anons.html>

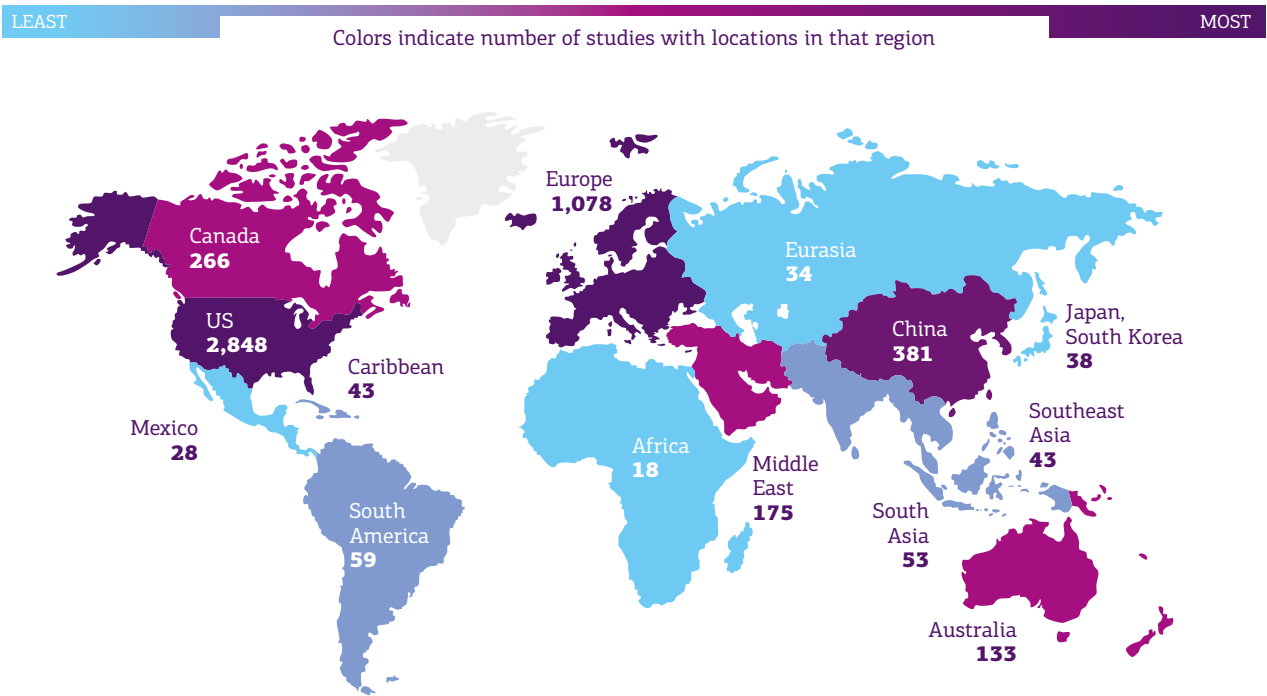
Scientists at the Novosibirsk Scientific and Research Institute of Traumatology and Orthopedics were the first in the world to develop a technology for culturing human bone tissues from stem cells. The first sample of bone grown in vitro was presented at the International Symposium held in Novosibirsk. At present the development is at the in vitro stage, but it may become possible to perform surgical operations to restore damaged parts of bones and joints using cultured tissues, providing a possible alternative to prosthetics.

The Global Stem Cell Therapy Market by Region



Source: Report #S520
(MedMarket Diligence, LLC.)

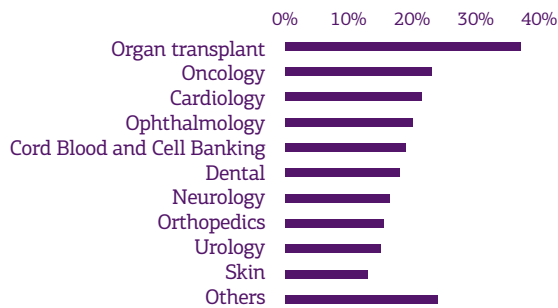
Number of Stem Cell Researches



The number of stem cells in an embryo is 1 cell per 10 thousand, while in an adult it is 1 cell per 5-8 million.¹⁵ This is a key factor in the main area of research in this field, which is the search for new methods of producing stem cells in vitro. Until recently it was only possible to clone stem cells taken from embryos and newborns. In 2014, American scientists managed for the first time ever to clone stem cells obtained from the tissues of adult humans.¹⁶ They have also found a new method for deriving stem cells from dental pulp cells.

The discovery by Japanese scientists of a method for producing stem cells from adult cells using acid constitutes a significant breakthrough, and the further development of this method will provide simple and affordable ways of obtaining pluripotent cells.

Annual Growth Rates of the Cell Therapy Market by Clinical Area



Source: MedMarket Diligence, LLC.

Promising research results are conducive to increased investment in cell technology development by the big pharmaceutical companies, private investors and government agencies. . “The volume of investment and the quantity of research into stem cells are growing” says Yusef Hesvani, CEO of 3D Bioprinting Solutions. “The quantity of clinical stem cell research at the National Institute of Health is increasing by 10% annually.” As a result, experts predict that the global stem cell therapy market will exceed USD 96 billion by 2015¹⁷.

CASE

CREATION OF CELL BANKS

Programs for the creation of cord blood cell banks have been established in many countries of the world. However, this type of cell suits only the donor or his/her immediate family. This is why high priority is being accorded to research relating to the creation of multipurpose stem cells of non-embryonic origin.

Japan announced the creation by the Center for iPS Cell Research and Application at Kyoto University of the first national bank of multipurpose stem cells of non-embryonic origin which do not cause host reactions. At present, cells are produced using skin cells taken from the patient; however, this takes too long and the costs exceed USD 100 thousand. Applying methods developed by Professor Shinya Yamanaka will make it possible to grow and store cells in advance. It is expected that, by the end of 2014, materials will have been accumulated which could be used to grow any human tissues and even organs without a host reaction from the body. In ten years’ time 80-90 % of the population will be able to benefit from transplants of organs grown in such banks. The Japanese Government intends to allocate up to USD 300 million to finance the professor’s activities over 10 years.¹⁸

¹⁸ <http://itar-tass.com/nauka/814785>

¹⁵ <http://izvestia.ru/news/569643>
¹⁶ http://www.gazeta.ru/science/news/2014/04/18/n_6092145.shtml
¹⁷ <http://www.forbes.ru/reklama/249846-kletochnye-tekhnologii-stanovyatsya-vse-bolee-privlekatelynymi-dlya-vlozheniya-investi>

TREND:

APPLICATION OF 3D PRINTING IN REGENERATIVE MEDICINE

One of the trends in the development of innovative medical technology that focuses on satisfaction of the demand for donor organs demand is bioprinting — 3D printing using living cells. "Worldwide there are currently around 80 companies, research groups, and various organizations working in the field of bioprinting. Among them are three academic groups and our privately owned company engaged in the development of this field in Russia", – says Youssef Hesuni.

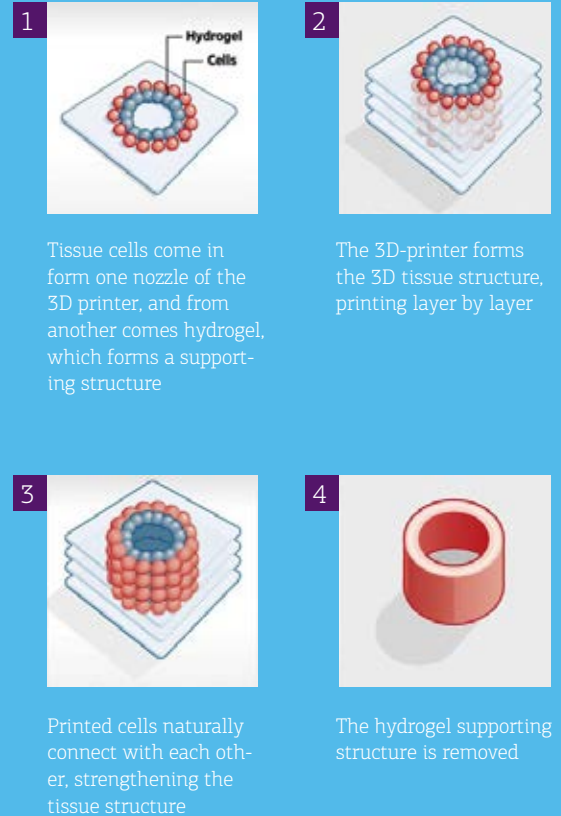
According to some forecasts, the 3D market for products based on complex materials such as living cells will grow hundreds of times over the next 10 years. It is expected that in the years to come 3D-bioprinting will begin to meet the growing demand for cartilage tissue, and printed versions of complex organs such as kidneys and livers are expected to appear on the market by 2030.

3D Bioprinting Market



Source: TechNavio.

Vessel 3D Bioprinting Process



80%

of patients in need of kidney transplantation are still waiting for donor organs

1-2 years

expected waiting time for transplants

123thnd

people in the US are awaiting transplants

"Today, there are two major unsolved problems impeding the active development of 3D-printing: vascularization (the formation of tissue inside the blood vessel network) and innervation (supplying tissue with nerves). Solving these would be a major step towards achieving the ability to print complex organs", says Yusef Hesuan.

Scientists at Harvard University have obtained impressive results in this area. In 2013, a team under the guidance of Professor Jennifer Lewis managed to create a biological tissue with a branched blood vessel network. For that purpose they used special "ink" consisting of various types of cells. The application of 3D printing may substantially accelerate the creation of artificial organs for testing drugs and possibly, in the long term, for transplantation to humans.

In 2013, the American company Organovo announced the printing of a sample of liver tissue more than 500 microns thick which retains the same type of metabolic activity as a natural one for at least 40 days. In mid-2014, the company said that liver tissue printed using their technology also has predictive potential. According to Yusef Hesuan, the use of 3D-bioprinting to obtain samples for the purpose of pre-clinical studies of pharmacological agents has great prospects. The creation of the liver construct by Organovo is the most prominent achievement in this area. Tests using liver tissue printed by Organovo revealed a negative effect of a medicine which had previously been studied in the laboratory and successfully passed a series of pre-clinical animal tests.

TREND: **BIONIC ORGANS**

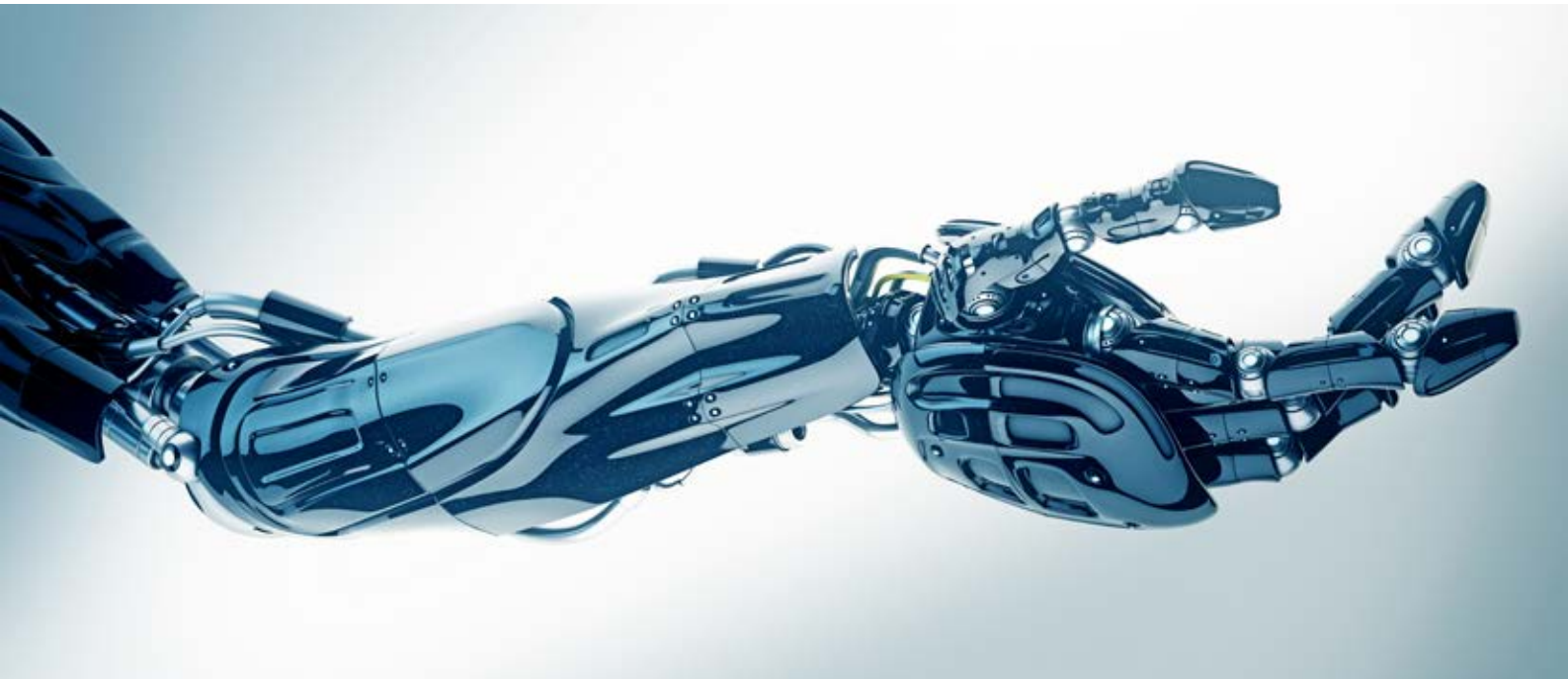
One of the trends in bionics — applied science consisting in the application of organizational principles, properties, functions and structures found in nature to the design of technical devices — is research associated with the development of bionic prosthetic devices and implants. Despite the imperfection and high prices of such technologies at the current stage of development, some devices have been already used for transplantation into humans.

The main focus at this stage is the improvement of already created bionic organs and the development of new ones; for instance, modern prosthetic devices controlled by neural signals enable their owners to perceive objects. Leg prostheses created in the Vanderbilt University are connected to nerve fibers in the leg, which enables them to be controlled by the "power of thought", while arm prostheses can now be controlled through the implantation of tiny electrodes into the brain by neurobiologists at the University of Pittsburgh.

CASE

3D BIOPRINTING SOLUTIONS

3D Bioprinting Solutions is a Russian company which develops 3D bioprinting technology and is involved in the development of reproductive medicine technology in Russia. It formed the first laboratory in Russia for the 3D bioprinting of organs and tissues. "3D Bioprinting Solutions is one of 10 companies in the world and the only one in Russia involved in designing both a bioprinter and all bioprinting components: bioinks and biopaper", says Yusef Hesuan. The owners of Invitro have invested funds in the company, and in 2014 USD 3 million was reported to have been invested. The purpose of this innovative project is to solve the problem of the shortage of donor organs for transplants. A bioprinter was created at earlier stages, and "bioink", "biopaper" and elements of branched vessels were produced. The company remains hopeful of demonstrating the first 3D bioprinter in 2014. In the long term the biotechnological research laboratory plans to produce a kidney; according to experts, this objective can be achieved by 2030. The choice of this organ was not accidental, as according to the FSBI Shumakov Federal Research Center of Transplantology and Artificial Organs of the Ministry of Health of the Russian Federation, in 2012 24,000 people were dialysis-dependent. The cost of caring for such patients is at least minimum USD 1 million over 12 years.



In 2013, London's Science Museum unveiled a bionic human called Rex which is made entirely from bionic organs, with the exception of lungs, bladder, stomach and brain, since scientists haven't yet managed to create these organs artificially. Technology for improving memory and intelligence, which will probably be used by people in a few decades' time, is currently at the developmental stage.

Bionic organs can be used not only for prosthetics, but also for the treatment of diseases such as diabetes. Scientists of the Boston University created a pancreas with "smart" insulin pumps which is connected to a sensor measuring blood sugar level and determines the required amount of insulin to be delivered by the pumps. The pancreas can be controlled by a mobile application.

According to expert forecasts, the global market for artificial and bionic organs will have grown to USD 38.75 billion by 2020 with an annual average growth rate of 9.3%.¹⁹ The creation of artificial bionic organs will enable hundreds of patients' lives to be saved, and prosthetic devices capable of reacting to signals from

the central system will make it possible for people with severe injuries to resume a normal life.

CASE

BIONIC EYE

In February 2013, Wentai Liu, Professor in Bioengineering (UCLA), created the first bionic eye for blind people, the Argus II Retinal Prosthesis System, which was successfully used twice during operations on 16 and 22 January 2014 by surgeons at the University of Michigan. These prosthetic devices enable people to orientate themselves, read texts in large print and see the contours of objects and faces.²⁰

²⁰ <http://www.ixbt.com/news/hard/index.shtml?17/63/26>

¹⁹ <http://www.grandviewresearch.com/press-release/global-artificial-organ>

MOBILE MEDICINE

The mHealth market, consisting of wearable devices, mobile applications, data analysis tools, portable medical devices and telemedicine, is actively developing. According to analysts' forecasts, the turnover of the global mHealth market will increase fourfold by 2017 to up to USD 50 billion.

Apart from the fact that remote supervision devices facilitate diagnosis at home, without the need to visit a specialist in person, they also help to optimize the working process in clinics. For example, blood pressure monitors can automatically measure pressure level at time intervals set by the doctor and send data to the attending doctor via the internet. If the figures obtained exceed a permissible level, the doctor is informed immediately and can take emergency measures without losing time. It is ex-

pected that among mobile applications those that focus on health monitoring will be the most popular — by 2017 their share will be 65% (USD 9.8 billion). Among these, particular attention will be paid to technologies designed to help monitor the health of people who have chronic diseases or are recovering after illness. The share of such programs will account for 70% of the market (USD 6.8 billion) in 2017.

TREND:
USE OF PORTABLE
DEVICES

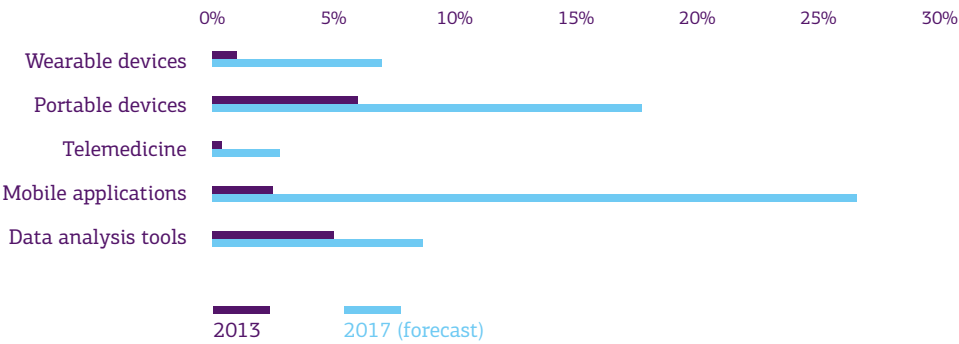
The development of the market is confirmed by data from the International Consumer Electronics Show (CES-2014), where the number of companies offering digital medical devices has risen by 40% compared with last year to 300 firms.²¹

Juniper Research predicts that the global market for portable devices will grow by more than 70% annually and amount to USD 7 billion by 2017.

According to Egor Rudy, the co-founder of the PROFIL.RU service, there will be active development in the area of portable diagnostic devices and methods providing detailed data, primarily because of people's increased awareness of the importance of looking after one's health and the need to monitor it on a day-to-day basis. Compared with fitness bracelets, which help to measure a limited range of basic parameters (pulse, respiration rhythm, etc.), the functional capability of modern portable medical devices is considerably wider. For example, one of the most awaited innovations of 2014 is the Scanadu Scout: simply placing a tiny sensor on various parts of the body enables a person to obtain almost all information about his body that is required

²¹ <http://yvek.ru/гаджеты/носимая-медицина/>

The Global mHealth Market, USD billion



Source: Juniper Research, Markets&Markets, Statista, research2guidance, Ovum, EY

for sports activities or looking after his health: pulse, temperature, oxygen level in the blood, pressure, breathing rate, ECG, and psychological stress level.

“Portable devices facilitate comprehensive monitoring of human health and faster patient-doctor feedback, accelerating the adoption of emergency measures when needed and, in the future, enabling the administration of medications to be managed with dosing devices built into organs”, – believes Alexander Galitsky, the founder of Almaz Capital Partners venture fund.

There is also expected to be great demand for diabetic devices. This trend can be observed in the development of noninvasive glucose meters. The first noninvasive glucose meters were rather large and weighed 4-5 kg, while today they are the size of an ordinary watch, and improvements are continuing to be made.

DMITRY YURCHENKO

General Director of the Knopka Zhizni Project

“We borrowed the idea of creating an emergency call system for the elderly and disabled from the United States. There, the emergency call button and the drop sensor (option) are embedded in a person’s mobile phone, bracelet or pendant. In Russia, there was no such solution before we came along, while in the USA it has existed for over 30 years.

The first thing we encountered in Russia is mental attitudes that are different from those in the West and Asia. In the West, older people often take care of themselves. They have a habit of getting insured, “laying straw” for their future. People are willing to pay for insurance products. In fact, our product is also a kind of insurance — the ability to make an emergency call in the event of an accident.

In Asian countries, on the contrary, people adopt a comfortable approach towards old age, and children take special care of the elderly. Services similar to the “life button” are easily promoted as “symbols of love and care”.

But Russia lies between these two attitudes. We primarily take care of children and ourselves, and the elderly are accorded a low level of priority. But the elderly themselves are fatalists — what will be, will be. In fact, we are fatalists at any age: if corporate voluntary health insurance is not provided, people will not buy it independently.

In Russia, many people like the service, but not many are willing to pay for it. It is too early yet to say that we have created a market. It will take five to ten years for people to acquire awareness of the need for such a service, and for a constant demand to emerge. Potentially, we might gain around 100,000 customers over the next three to four years. After 10 years, that figure could grow to 1 million people. In the United States, television advertising is broadcasted in prime time: “I have fallen and I cannot get up ...” It is hard to imagine similar advertising in Russia — the service is very expensive, and the market is not yet ripe.

As regards the scale of the problem, in Russia there are currently 18 million elderly people, and by 2020 there will be around 40 million (about 1/3 of the population), as those born during the “baby boom” reach retirement age. Currently, out of 18 million elderly people one-third require emergency assistance at least once a year, and 25% of them do not receive timely assistance — they cannot make a telephone call or call for help, as there is no one around.

During the first year, our project was funded by money from investors. Over time, state support became of key importance to us. We received grants from the Foundation for Assistance to Small Innovative Enterprises in the Field of Science and Technology (the Bortnik Fund), won tenders organized by the RVC, and received investments from the IIDF. Now, the main cash flow comes through public procurement. The state buys the device and the service and sells them as part of social welfare programs.”

CASE

GLUCOSE METER IN GOOGLE CONTACT LENSES

In 2014, Google, in cooperation with Novartis, announced contact lenses with incorporated glucose meters that can receive data on blood sugar level in real time.

"Smart contact lenses" consist of a wireless chip and a miniature sensor placed between two layers of the lens material that measures the glucose level in a tear. In order for the data to be transferred and processed the device is synchronized with a smartphone or tablet PC. Lenses can measure the level of glucose once per second. Now the company is working on the addition of a light-emitting diode capable of giving signals if the glucose level exceeds the permitted value. A prototype of such lenses was demonstrated in January 2014. Now the company is conducting negotiations aimed at getting the product released on the market in 2015.



Almost all portable electronic devices and portable diagnostic devices are used along with smartphone applications. By 2015 the number of users of diagnostic mobile applications is expected to reach 500 million, and this number will increase by 1.7 billion by 2018.

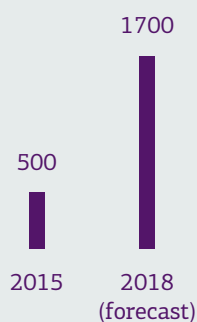
In May 2014, Samsung announced a cloud platform SAMI (Samsung Architecture Multimodal Interaction) and a wrist device, Simband, which monitors the physical condition of the owner. The bracelet transfers data to the cloud via sensors, where it is stored, processed and systematized. SAMI is capable of interacting not only with the Simband device: anybody who wants to develop applications and devices for the platform can do so.

Their major competitor is Apple, which in early June 2014 announced the release of HealthKit — a software package for the new iOS 8. This technology, similar to SAMI, enables health data to be measured and transferred to other applications and directly

to medical institutions. The daily collected information enables insurance companies to be warned of risks of imminent payments on insured events and helps doctors to evaluate a patient's health condition with more precision.

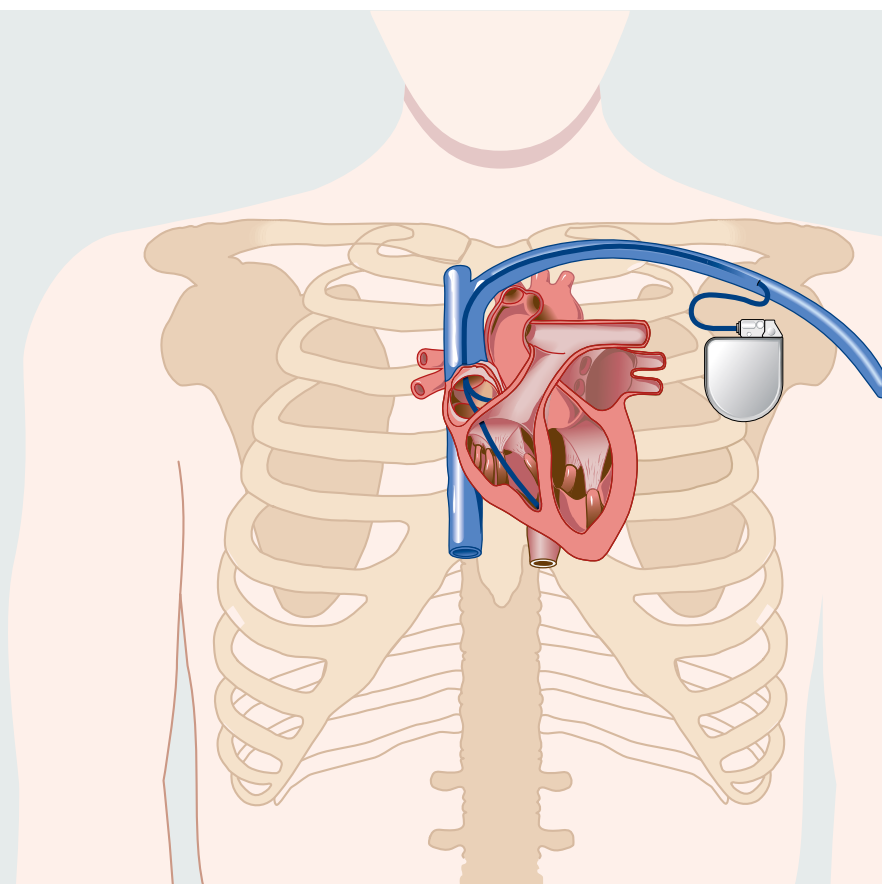
Increasing the amount of data collected from portable devices is a driving principle in the development of the analytical tools segment and corresponding processing technologies. The market for analytical data processing tools is actively developing and becoming more accessible. According to Ovum Agency, the market will grow from USD 5 billion in 2013 to USD 11 billion in 2018 with an average growth rate of 30%. One such tool is Big Data, an application which in some cases enables research time to be cut from one year to a few weeks and helps doctors to determine the risk of disease.²²

²² <http://www.computerra.ru/90582/vanderbilt-puredata/>



1.7 bn

smartphone users will be using mobile health apps for diagnostics by 2018 compared to 500 million in 2015



Another tool that enables the processing of a huge amount of data and the diagnosis of illnesses is the supercomputer Watson. IBM began preparing the computer for use in medicine in 2011: the machine has "studied" more than 3 million pages of medical books and the medical records of 1.5 million patients.²³ Today Watson is already used for practical consultations; the accuracy of its diagnosis of cancerous diseases and selection of the optimum method of treatment is 90%.²⁴ With the aid of the computer medical companies such as WellPoint Inc.²⁵ can process data quickly and suggest optimum solutions based on the patient's genome.

TREND:

DEVELOPMENT OF NONINVASIVE INTERFACES IN MEDICINE

Noninvasive and minimally invasive methods of treatment and diagnosis have become more and more popular in recent

times. In addition to glucose meters, new portable devices for home noninvasive diagnosis are being developed and commercialized. For example, in 2014 a noninvasive hemodynamic monitoring system was created (control of stroke volume and cardiac output), which produces data similar to the data obtainable with the aid of invasive catheters, using just a finger cuff and a standard cardiac sensor. This technology makes it possible not only to measure absolute values of the cardiac function, but also to monitor changes in those values in real time.²⁶

²³ <http://habrahabr.ru/post/166467/>

²⁴ <http://www.forbes.com/sites/bruceupbin/2013/02/08/ibms-watson-gets-its-first-piece-of-business-in-healthcare/>

²⁵ http://www.wellpoint.com/PW_D014812.html

²⁶ <http://mhealthrussian.wordpress.com/2014/07/21/clearsight/>

The introduction of noninvasive methods of early diagnosis and treatment of diseases has made it possible for patients to use interfaces at home and report necessary information to the doctor on a regular basis prior to an appointment, which helps save the doctor's time and means that the patient doesn't have to visit the clinic so often.

In addition to noninvasive diagnosis methods, minimally invasive methods are used during treatment or surgeries. For example, the Russian company Smart Innovations (Tomsk) is developing a new-generation noninvasive insulin pump. The system will measure and control sugar content in the blood without any punctures and calculate the amount

of insulin needed to prevent a future increase in the sugar level. These data will be transferred to a microcontroller which controls the speed of delivery of insulin through the skin into the blood. Insulin will be transferred to the blood via a plaster saturated with a special substance to enlarge the skin pores. Investments in this project amounted to RUB 11 million, and commercialization is scheduled for 2015.

The importance of noninvasive or minimally invasive methods of treatment is linked to the fact that many operations involve a high degree of surgical risk, and this means that many patients have to decline such operations. In such cases innovative minimally invasive procedures

make operations for high-risk patients possible. For example, the Micra Transcatheter Pacing System is one tenth of the size of an ordinary pacemaker and does not require any surgical incisions of the chest, but only involves making a pocket under the skin and inserting it in a femoral vein. This product is now undergoing a large-scale clinical trial with the first results expected by the end of 2014.²⁷

²⁷ <http://newsroom.medtronic.com/phoenix.zhtml?c=251324&p=irol-newsarticle&id=1883208>

VLADIMIR KOVALSKY

General Director of
MEDESK

"Patients and health care institutions need quick access to vast amounts of information that has to be quickly transferred between them. Soon, there will be a completely new generation of integrated health records, which will include data collected by patients themselves as well as those obtained by physicians in clinics and laboratories. There is a need for an ecosystem enabling easy interaction between patients and doctors".

UNIFIED INFORMATION SYSTEMS IN HEALTH CARE

The creation of an effective system of health care is not possible without a unified information space. Many countries have begun implementing programs aimed at the creation of a unified information space: NHS Connecting for Health in Great Britain has had USD 25 billion invested in it up to 2014, while the governments of Germany and the USA also plan to invest scores of billions in electronic medicine over the next ten years.²⁸

"However, no country has so far been able to achieve full implementation of EMR (Electronic Medical Records) — a system for the automation of multiple types of medical establishments," says Egor Rudy. "One of the reasons for this is

the strict governmental regulation of medicine. Liberalization of the law in Russia would boost innovation in this area, facilitating the faster introduction of EMR and the development of telemedicine".

The Ministry of Health Care and Social Development of the Russian Federation has developed a conceptual framework for the development of the information system in health care over the period up to 2020 in which two main lines of development may be discerned: the formation of a unified reference information base and maintenance of individual pa-

²⁸ <http://urotoday.ru/issue/4-2012/article/opyt-primeneniya-sovremennykh-informatsionnykh-tehnologii-v-rabote-ambulatorno>

614

healthcare facilities
in Moscow implemented
UMAIS

66 mln

Appointments made
via UMAIS by
July, 2014

7.3 thnd

Moscow healthcare
facilities are using
electronic medical records.

tient records.²⁹ The first element involves the creation and implementation of an automated electronic medical card system for maintaining patient health records, making appointment with a doctor online, and the creation of a unified information space for doctors. The key purpose of the second element is the maintenance of day-to-day records of medical care.

The Unified Medical Information Analysis System (UMIAS) is implemented at 614 health care facilities in Moscow³⁰, and as of July 2014 more than 24 million patients have made a doctor appointment online³¹. In 2013, the Ministry of Health Care approved the standard form of a unified electronic medical card within the framework of this system, and as of today more than 7,300 healthcare organizations use individual record-keeping and electronic medical cards³². By autumn 2014 they will have been introduced in all outpatient departments in Moscow.³³

TREND: TELEMEDICINE DEVELOPMENT

The main advantages of telemedicine lie in the increased accessibility of high-quality medical services to residents of remote territories, time saving and cost optimization for the organization of health care system. Telemedicine is widely used in Western countries. Outpatient departments are widely equipped with means of visual communication, audio systems and other necessary equipment. Physicians are able to collect data on patients' condition in real time and monitor patients around the clock. There are services that enable qualified home visit services to be obtained via Internet. The market for such services will reach USD 2.8 billion by 2017, and the volume of the European market for telemedicine video technologies will amount to USD 414.4 million by 2020 (USD 151.2 million in 2013).³⁴

In spite of the great popularity of telemedicine and the understanding of its significance, Russia has only just begun to enter this market. In 2014 the member states of the Eurasian Economic Community signed the Agreement on Cooperation in the Field of the Creation and Development of Compatible National Telemedical Systems that allowed patients and attending medical doctors to receive video instructions from a remote medical center.³⁵

²⁹ <http://www.gosbook.ru/node/15491>

³⁰ <http://www.rg.ru/2014/07/16/karta-site-anons.html>

³¹ http://www.medvestnik.ru/news/6_mln_moskvichey_hotya_by_raz_zapisyvalis_k_vrachu_cherez_emias/

³² <http://www.rg.ru/2014/04/09/medkar-ti-site-anons.html>

³³ http://mospravda.ru/health/article/k_oseni_2014_goda_vo_vseh_poliklinikah_moskvi_bydyt_vvedeni_elektronnie_medkarti/

³⁴ Frost&Sullivan

³⁵ <http://www.rg.ru/2014/02/06/telemedicina-site-anons.html>

Which Forms of Remote Consultation With a Doctor do Patients Prefer?

19%

of patients prefer a video consultation with a doctor

20%

of patients prefer to communicate with a doctor via sms

21%

of patients prefer to communicate with a doctor by email

23%

of patients would rather call a doctor by telephone

20%

would like to use mobile applications to obtain a doctor's advice

Source: Cisco Systems.

In the nearest 2-3 years it is also planned to create a system of military medicine in Russia that will make it possible for doctors who are far apart or located in remote regions of the country to exchange experience.³⁶

The development of this area is restricted by the reluctance of people to share their personal data and the low level of the use of IT-technologies by doctors.³⁷ Among successful Russian projects in this field it is worth mentioning the Button of Life project, which has received investments amounting to RUB 45 million. This is an emergency call system

that enables disabled and elderly people to contact specialists and receive help by pressing the SOS button on a specialized device.³⁸

Significant prospects for innovations in the area of the provision medical services are also noted by the co-founder of the PROFIL.RU service, Egor Rudi: "For example, the "InfoDoctor" portal, which provides such services as free medical consultations, selection of a doctor and booking into a clinic, is every bit as good as its foreign equivalents."

EXPRESS DIAGNOSTICS, LABORATORY AUTOMATION PLATFORMS

The development of laboratory technologies helps to achieve significantly improved research accuracy and broaden the range of analysis methods used. The capacity of the global market for information systems was up to USD 1.38 billion in 2013, and will be up to USD 2.16 billion in 2019 (CAGR 7.7% per year).³⁹

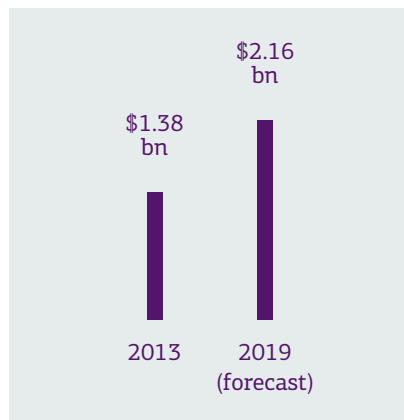
³⁶ <http://actualnews.org/politika/rossiya/16959-novost-poslednego-chasa-rossii-21-iyulya-v-rossii-poyavitsya-telemedicina.html>

³⁷ <http://mhealthrussian.wordpress.com/2014/07/26/telemed-2/>

³⁸ http://i.rbc.ru/anons/item/fond_razvitiya_internetinitsiativ_investiroval

³⁹ http://www.cnews.ru/reviews/new/publichealth2014/articles/kak_rabotaet_sovremennaya_laboratoriya_1/

World Market of Laboratory Information Systems



One of the key trends in the development of laboratory medicine is the automation of laboratory processes. A variety of laboratory methodologies provides a wide range of possibilities for carrying out investigations. The automation of laboratory investigations makes it possible to exclude the influence of human factors on the performance of tests, thereby avoiding errors and increasing the accuracy of the result obtained. Standardization also cuts the amount of time spent on investigation and allows a lesser quantity of material to be used.

Modern laboratory automation platforms permit the use of multiple test methods with minimal sample use, and provide for high investigation accuracy and automated quality control. Thus, the activities of the governments of developed countries, primarily the USA, are directed at building completely automated laboratory information systems (LIS) at health-

care facilities. Medical laboratories have been split off as independent businesses, and this has become a pronounced trend of the last few years that has enabled costs to be reduced and profitability to be increased, as well as reducing the level of dependence on the availability of relevant specialists in healthcare facilities. Thus, the medical laboratory is developing into a modern hi-tech enterprise with minimal use of manual labor.⁴⁰

Another trend in the development of the LIS-market is integration with mobile systems due to the growth of the mobile medicine market. The development of mHealth means that some laboratory analyses can be carried out by the patient himself through a smartphone. A set of assays carried out on an ongoing basis (remote tests with the help of smartphones supported by laboratory results) and data processing increase the precision of diagnostics.

The development of the remote assay segment is a result of progressing technologies in the field of sensor diagnostics that makes it possible for assays to be carried out at home, producing results on an express basis.

Semiotic (a portfolio company of RVC Biofund) attracted RUB 84 million investments to supply in 2015 a batch of chips that enable up to 100 diseases to be diagnosed through one test, including oncological, infectious and autoimmune diseases.

The European Center of Innovation Development, a resident of the Biomed Cluster of the Skolkovo Center, is developing a line of biosensors for multi-parameter individual express-immuno-diagnostics that consists of an electronic biochip (the matrices of 256 measuring cells), a mobile measuring device and software. As regards interfaces enabling the instant diagnosis of disease, mention should be made of a joint product of GT and DARPA. The companies are working on the creation of an interface that can change the color of paper upon contact with a nasal packing according to whatever disease might be identified, and is capable of diagnosing a range of diseases in less than one hour.⁴¹

3D MODELING IN MEDICINE

The application of computer technologies in medicine is a trend that has been developing over the last few decades. One of the focuses of the application of 3D graphics in medicine is the creation of 3D models of organs and joints.

3D modeling is used as the most important stage of organ bioprinting, since printing is carried out on the basis of the model provided. The 3D pattern must exactly reproduce the vascular network and organic structure of an organ.

⁴⁰ http://www.cnews.ru/reviews/new/publichealth2014/articles/kak_rabotaet_sovremennaya_laboratoriya_1/

⁴¹ <http://www.qmed.com/news/diagnostics-demand-device-could-be-game-changer>

One recent development is the commercialization of 3D modeling services in orthopedics for the creation of scale models of skeletons and organs. These models are necessary for diagnostics and the discussion of methods of treating complicated traumas and diseases and manufacturing implants. The 3D visual tools allow the selection of appropriate instruments for an operation, preliminary design and shaping of implants and demonstration of an injury to a patient.⁴² The ability to demonstrate a surgical operation to a patient is another area of medicine where 3D graphic technologies may be employed.⁴³

3D modeling is extensively used in orthopedics, maxillofacial and anaplastic surgery. Diagnosis of diseases and injuries of the musculoskeletal apparatus is based on spiral computed tomography enabling 3D reconstruction of the examined object.⁴⁴ The doctor's ability to see patient information (tomography, 3D data of X-ray machines, ultrasonography, etc.) allows significant improvements in the quality of work and the planning of surgical interventions.

3D models make it possible to simulate characteristics that cannot be assessed through other approaches. Medical professionals use current imitation and simulation technologies for the creation of models of complex human organs, including the heart and the brain. 3D models make it possible to simulate, forecast and understand the activities of complex systems in the organism and evaluate the effects of new medicines on them.⁴⁵

For instance, scientists at various research institutions in the USA and China have developed methods of creating 3D tumors with the characteristics of real malignancies with 90% living cells after 3D printing. The model thus produced may be used to study the mechanisms by which cells spread, reactions to drugs and other molecular characteristics.

They have developed a universal methodology for creating tumor models of any type that will lead to increased knowledge in the field of oncology and expand the possibilities of therapy. There are plans to model a tumor using the cells of a specific person, which would make it possible to forecast the progress of the disease and select optimum approaches for treatment.⁴⁶

The scientists have also succeeded in creating a highly detailed model of the heart, providing an understanding of the mechanics of a particular patient's heart in order to assess the safety and efficiency of treatment methods.⁴⁷

3D technologies are also used for the development of simulators for doctors, enabling them to practice particular skills and feel mechanical action on tissues and organs.

⁴² <http://www.dvfu.ru/-/2012-01-13-v-meditsinu-prishli.htm>

⁴³ http://krasgmu.ru/sys/files/ebooks/el_medinfo/800.html

⁴⁴ http://bone-surgery.ru/view/virtualnoe_modelirovanie_v_travmatologii_na_osnove_dannyh_kompyuternoj_tomo/

⁴⁵ <http://compassmag.3ds.com/ru/4/INDUSTRIYA/IMITACIYA-CHELOVEKA>

⁴⁶ <http://www.abc-gid.ru/news/show/4105/>

⁴⁷ <http://compassmag.3ds.com/ru/4/INDUSTRIYA/IMITACIYA-CHELOVEKA>

INFORMATION TECHNOLOGIES

Developments in information technologies lead to changes in all areas of life and increase the comfort level for every individual. Everyday activities — from education and health care to financial services — are becoming shifting to a digitized format, with improvements in quality, convenience and availability. An important role in this process is played by the development of high-speed data networks and the increase in smartphone penetration (according to forecasts, the penetration rate will exceed 50% by 2019⁴⁸), which facilitates digitization and gives users increased mobility. In addition to smartphones, new types of portable mobile devices are becoming widely available: from “smart” watches and bracelets to virtual reality devices. These open up new possibilities — from monitoring health and accessing content without the need for frequent access to one’s smartphone to major changes in the communications and media industry.

The increasing number of devices used by humans that generate a lot of information, the growing volume of data transmitted and the increased opportunities in the field of data processing and recognition increase the relevance of these tasks. Another consequence of the advent of large data volumes is the challenge of personal data protection both through the creation of special software and hardware solutions and through legislative initiatives.

In line with the development of information technologies, industrial production is also changing, including mass customization of products and further robotization of work processes. The application of low-

cost 3D-printing enables the creation of unique objects: from components of space engines, batteries, and computer chips to beauty accessories, gifts, and even food. This opens up new opportunities for running small and medium-sized businesses, as well as driving the spread of 3D-printers in the mass segment. Robotization is ongoing in a wide range of fields in agriculture and industry. The development of robotics extends the range of application of robots, enabling them to replace people in dangerous operations and at highly toxic production sites and assist the elderly and disabled in their everyday lives.

The development of information technologies in Russia is proceeding in line with global trends. The trend of the transfer of activities onto digital platforms and greater mobility of services provided is relevant in Russia due to the increased penetration of cellular services (growth exceeded 170% in 2013) and the growing proportion of smartphone subscribers (it amounted to 32% in 2013 and is expected to reach 94% in 2019⁴⁹). The country is witnessing the active development of latest-generation data networks, built on LTE technology, coupled with the growing popularity of portable devices.

⁴⁸ Smartphone Connections Forecast: 2014–19, Ovum

⁴⁹ Smartphone Connections Forecast: 2014–19, Ovum

MIKHAIL ROMANOV

EY CIS,
Telecommunications,
Media and Technology
leader

"The need to find new sources of growth and ways of optimizing of companies' activities is what drives the development of new technologies. The development and deployment of breakthrough innovations transforms business principles, creates new markets and changes consumer habits.

The rapid displacement of leading corporations is especially characteristic of the information technology market.

Today's corporate champions — Apple, Facebook, Google, Cisco, and Amazon — have displaced giant companies which, 10 years ago, were at the top of the list of greatest IT companies. Some companies which were in the top ten 20 years ago have now virtually ceased to exist as independent corporations. Well-known software developers — Microsoft, IBM, Intel — have retained their leadership for decades. In 2012-2014, the software sector accounts for more than half of mergers and acquisitions in the IT industry. Every year, the software market grows by an average of 5%. By 2013 it amounted to USD 369 billion. We consider it to be quite an achievement that Russian companies from the software sector, such as ABBYY, Kaspersky, Acronis and Parallels, are worthy competitors on the global market".

In many spheres of human life — education, financial services, and processing of large amounts of data — world-famous brands are entering the Russian market. However, alongside this process Russian companies are developing, too. The most successful Russian projects focus on software development (compared, for example, with initiatives for the development and promotion of new devices), which may be explained by historical strength in the field of mathematics, which determines the success of knowledge applications. Thus, successful Russian projects in the field of secure communications, online educational services and computer vision are likely to develop in the future.

3D-printing technology is also gaining popularity in Russia, and it is not only the increasing use of 3D-printers. Russian companies are appearing which develop and produce their own 3D-printing devices, including 3D-bioprinting. Robotization and automation of various activities are not yet sufficiently developed in Russia (particularly due to the availability of labour resources), but they have extensive prospects in agriculture, industry and highly toxic production operations for improving efficiency and reducing costs.

The state support of Russian software developers will also boost the development of IT in Russia. The main goal of this support is to increase the level of independency from foreign software products. The list of remedies designed by Ministry of Communication and Mass Media of Russian Federation according to the order of the President includes the creation of special fund for IT development and tax exemptions.

In order to modernize the economy and bring high-tech products and technolo-

gies to the market, it is necessary to create an infrastructure which supports innovation. One of the tools to achieve this goal is the creation of technology parks (technoparks) — organizations that provide resident companies with an equipped industrial, research, information and infrastructural base. According to the HSE and High Technology Technoparks Association NP, in 2014 there are around 80-90 industrial parks in Russia, either in operation or at various stages of construction and design. About half of this total specializes in the IT sector.

Technoparks are usually set up on the basis of universities, research institutes or industrial companies, and as from 2006 Russia has been implementing the governmental program for creation and development of technology parks in the area of high technology, which is coordinated by the Ministry of Communications and Mass Communications. According to the Ministry's data, federal budget investments in the infrastructure of technoparks by the end of 2013 amounted to RUB 11.95 billion. In addition, 18,000 jobs were created, and revenue of resident companies exceeded RUB 31 billion.

The program provides for 13 parks to be set up in 10 regions: the Republic of Tatarstan, the Tyumen, Kemerovo and Novosibirsk Regions and the Republic of Mordovia, as well as in the Samara, Moscow, Penza, Tambov, and Kaluga Regions. The most successful parks are in the Novosibirsk Campus⁵⁰, which is home to 289 companies generating RUB 13.5 billion of revenue and creating 7,700 jobs, and in Kazan (139 companies generating RUB 6.4 billion of revenue and 3,400 jobs⁵¹).

⁵⁰ <http://www.academpark.com/>

⁵¹ <http://itpark-kazan.ru/>

According to Alexander Turkot, Managing Partner at Maxfield Capital, only a small number of Russian technology projects currently have competitive advantages over foreign companies. For regional companies it is quite difficult to get access to venture capital. Like venture funds, it is not always possible for them to access the information about regional projects. Maxfield Capital uses the available channels, such as the IIDF, the RVC, Skolkovo, and nominations and tenders, but this is not enough. Among the fund's portfolio companies there are projects not only from Moscow, but also, for example, from Saint-Petersburg and Novosibirsk. Alexander also notes that in view of the current trend of import substitution it is important to create a system in which large Russian companies are interested in developing and purchasing innovative enterprises, with options for a venture investor to exit from portfolio companies, replacing foreign corporations within the system.

DMITRY CHIKHACHEV

Managing Partner at Runa Capital

Are there any promising technology start-ups in the Russian market capable of competing with global companies in the future?

There are many technology companies, which have been created in Russia recently and are already successfully competing on the global market. In particular, some of them are included in the investment portfolio of Runa Capital. For example, NGINX — the developer of a web server for high-load websites (NGINX technology is now used by more than 146 million Internet sites); Ecwid — the developer of the e-commerce platform, which is one of the key partners of Facebook and PayPal in the world; and Infratel — the developer of unique communication software products which are successfully used in the United States, Europe, and Asia. Strong Russian start-ups have a high potential in the global market.

How do you assess the role of the regions in the development of innovative products?

The emergence of successful innovative companies requires three basic components: money, specialists, and technologies. The contribution of each region is proportional to the degree of development of these three components. It is clear that Moscow and Saint Petersburg are historically the major scientific and educational centres of the country. The contribution of other regions is not so great, but it is certainly present. The international company Ecwid from Uly-

anovsk and the BARS Group from Kazan are worthy examples.

What might serve as a catalyst for the development of innovation in Russia?

We should speak about state policy and growth points, not about catalysts. There is no magic here. One should think systematically and in terms of the long term. As I said before, the key components of innovation are personnel and technology. If there is good personnel and advanced technologies, the capital will come itself. In terms of education, I am relying on the government program to increase the international competitiveness of the leading universities in Russia (TOP-100) and the reforms that have begun in Russian science (reform of the Russian Academy of Sciences). In particular, the leading universities may become centres of growth. Together with Sergey Belousov and other graduates of MIPT, we founded Phystech-Union in order to contribute to the development and modernization of the university. Together, we supervise a number of educational and business projects.

What changes are required to make Russian technology companies competitive in the global market?

In my opinion, no changes are required. Many Russian technology companies, such as Parallels, Acronis, Acumatica, Kaspersky, Yandex, ABBYY, Acumatica and others are successfully competing on in the international market. The main thing is to avoid legislative changes. If these companies suddenly ceased to be considered Russian, then we would have nothing to be proud of.

ALEXANDER VASILIEV

CEO, Apps4All

"Mobility is a very broad concept. We face it in all spheres of human activity. And each of the current trends has partly to do with the sphere of mobile technologies.

An example is advertising technologies. Currently, mobile media are the fastest growing segment of digital media. People's attention is increasingly focused on mobile devices. Every day a person spends almost 100% of the time with his or her phone, in contrast to the time he or she spends on traditional media such as television, print media, and radio. The advertising market could not help but take notice of this fact.

If we talk about the global market, we see that mobile advertising in the United States and the United Kingdom in terms of funds raised from advertisers is comparable with traditional media. Unfortunately, globalization trends come to Russia with a certain delay (usually within two or three years). But more and more people are moving from regular phones and feature phones to smartphones that have full Internet access. We can therefore say with confidence that we expect significant growth in the mobile advertising market in Russia in the next two or three years."

DEVELOPMENT OF THE WEARABLE DEVICE SECTOR

Wearable devices are becoming more and more popular due to their increasing affordability and the broadening range of functions they perform. In addition to the already traditional smart watches and fitness bracelets, virtual-reality and augmented-reality glasses are becoming widespread. Forbes declared 2014 to be the year of wearable technology, and Bloomberg has predicted that over 100 million wearable devices will be sold globally this year.

Wearable devices can provide real-time information to their owners and be used for communication and information storage. They are extremely popular in businesses and in the defense industry, as well as for personal use.

The use of wearable devices in business makes it possible to increase the efficiency and productivity of labor. For example, wearable devices are used by warehouse employees to simplify searching for goods and reading their bar codes, facilitating inventory-taking processes and supply chain management.

Smart glasses provide employees with access to information necessary for their work using voice and gestures and simplify the exchange of photographic and video information with geographically remote colleagues. They can be useful for equipment repair and maintenance

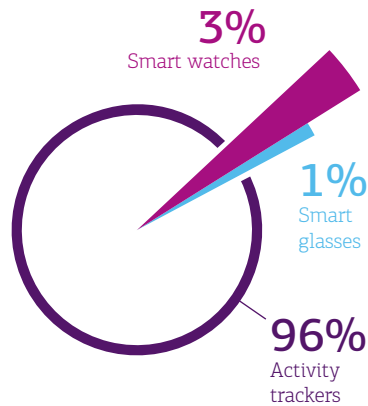
and for promptly notifying employees of the tasks assigned to them. In the defense industry, wearable devices can be used to improve situational awareness and communications between military personnel.

Wearable devices for personal use have quite a broad range of functions. A smart watch, when used in combination with a smartphone, offers its user the option of answering messages and calls, using social networks, and receiving notifications about planned events. Some models of watches are designed to integrate with an automobile's systems in order to provide information about it: average speed, fuel consumption and required maintenance.

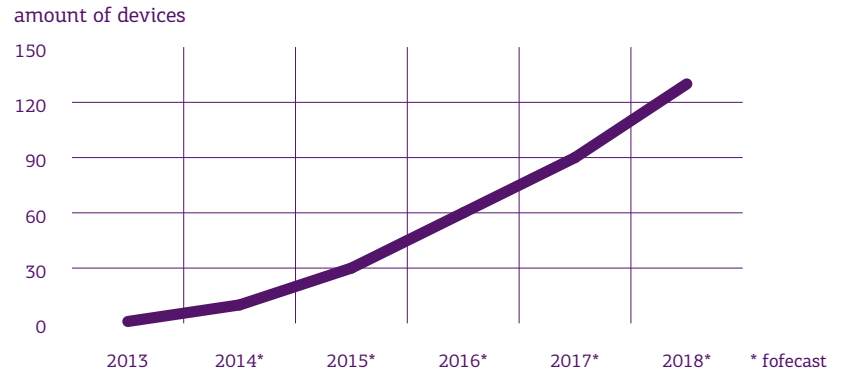
It is expected that the global market of smart wearable devices will expand rapidly, primarily on account of devices designated for use in the fitness industry and health care. A significant share of the wearable devices market will be occupied by smart bracelets and watches, the latter of which have great potential. However, these devices are difficult to call watches anymore, because apart from displaying time they can do almost everything a modern computer does.⁵² Sales growth is driven by the launch of new wearable devices by Samsung, Google, Qualcomm, Apple, and others.

⁵² <https://edugalaxy.intel.ru/index.php?automodule=blog&blogid=9&showentry=6438>

Sales of Wearable Devices in 2013 (by device type)



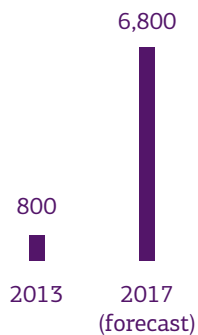
Sales of Wearable Devices, 2013-2018



Source: Cisco Systems, IHS, ABI Research, Juniper Research.

Sales volume will grow from 15 million units in 2013 to 70 million in 2017, with an average annual growth rate of 47%; it is expected that wearable devices designated for fitness and sports will account for 80% of the market in 2017. Over 60% of the sales volume will be provided by developed countries: the USA and Western European countries.

The Global Wearable Devices Market, 2013-2017



Source: Juniper Research.

STEVE PAPERMASTER

Appconomy CEO

"Mobile commerce is the tip of the spear for mobile's disruptive impact globally — beyond social and communications uses. E Commerce on the web, and notable success stories such as Alibaba and Amazon.com are widely known. And yet the e Commerce market share is still less than 10%. Mobile will drive 90% of the rest of commerce — in shops, malls and large and small businesses — through mobile payments and integrated social commerce. All forms of banking, payments, shopping and commerce will be transformed within a few years. Smart phones, wearables, sensors and pervasive internet access will fuel this boom globally — with China and Asia among the top innovators".

CASE STUDIES

THE BEST-KNOWN PRODUCTS ON THE SMART WATCH MARKET

Samsung: The South Korean company announced the launch of its Galaxy Gear smart watch in September 2013; it is compatible with some Android apps and can work in conjunction with Galaxy Note devices.

Qualcomm: In September 2013, the company introduced the Toq smart watch, a notable feature of which is the use of a Mirasol display, which makes it possible to display high-quality color images with greater energy efficiency than LED displays.

Sony: The Japanese company has expanded its line of wearable devices by releasing the SmartWatch on 2 June 2013; this is a successor to the LiveView devices launched back in 2010. The company is staking on the device's versatility; it is compatible with any smartphone utilizing Android 4.x, and the manufacturer is promoting the creation of apps for the device by third-party developers.

Nissan: In September 2013, Nissan launched its own brand of Nismo watches, capable of monitoring heart rate, body temperature and other driver biometrics, as well as data which assist in driving the vehicle, such as average speed and fuel consumption.

Apple: The company intends to launch its own version of the smart watch, the iWatch, in Q4 2014.

Pebble: Pebble Technology's smart watch offers a simple, energy-efficient solution for displaying notifications from a smartphone. In 2012 the project accumulated over USD 10,000,000 on the Kickstarter crowdfunding platform, where the starting amount was USD 100,000. Unlike their counterparts, Pebble watches utilize a monochromatic display based on Memory LCD technology, with reduced power consumption enabling the watch to run for up to seven days without recharging.

The widespread use of wearable devices is restricted by the following technological factors:

- The difficulty of ensuring the confidentiality and security of data being transmitted;
- An insufficiently developed ecosystem of apps for wearable devices;
- Batteries of acceptable size cannot ensure long-term autonomous operation of devices with high processor throughput, display quality and communication module parameters.

The further development of wearable device technologies will be aimed at eliminating these restrictions.

PENETRATION OF VIRTUAL-REALITY AND AUGMENTED-REALITY DEVICES IN THE MASS MARKET

Virtual-reality devices, which enable their users to immerse themselves in artificially created worlds, as well as augmented-reality devices, which introduce additional, artificial elements to the perception of the real world, are being launched on the mass market, changing people's day-to-day lives and creating new possibilities in the media space and the entertainment industry.

The creation of such devices has become possible due to the rapid development of mobile technologies, which has led to reduced cost of high-definition displays, decreased price and reduced dimensions of sensors and detectors, and improved throughput of processors for processing of high-resolution images with high refresh frequency, all of which are necessary for creating the effect of immersion in a virtual world.

The idea of augmented reality was proposed as early as the 1990's; it involves supplementing the real world with computer-generated information, making it possible to simplify and enrich human perception of the surrounding world.

Implementation of augmented reality requires the use of devices to analyze the real world (cameras, positioning and spatial orientation sensors), a computational processor for processing data, and a device for presenting information to the user. Currently widespread smartphones and tablets possess all these necessary components.

They are used successfully, for example, for marketing purposes to integrate print and video versions of promotional products. Special images are placed in printed editions which, when scanned by a smartphone or tablet, activate video or other content which is then shown to the user.

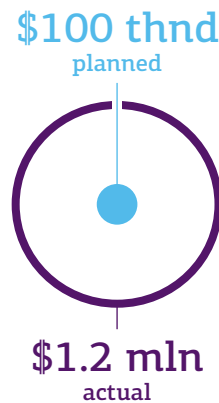
Unlike smartphones and tablets, which require at least one hand to use, new augmented-reality devices — glasses — do not have this disadvantage restricting their possible uses. The best-known manufacturers on the market are Google, Vuzix, Optinvent, Meta-View, and Recon Instruments.

Despite the advantages of augmented-reality glasses over smartphones and tablets, the first versions of these inventions can only show additional information to the user in real time. However, the device is incapable of assessing the surrounding world to an extent sufficient for superimposing artificial objects over

it. For example, Google Glass cannot help the user "try on" a piece of jewelry from a catalog. Such capabilities will become available if depth-measuring sensors are integrated into the glasses.

The Tango Project⁵³ for the creation of such a device was presented by Google Corporation in early 2014. However, for now a smartphone with a specialized Myriad 1 processor and sensors which scan the environment at a frequency of 250,000 measurements per second are used to build a 3D model of the surrounding world.

Results of Crowdfunding for Structure Sensor



Similar solutions are used in Microsoft Kinect, as well as in a device being developed as part of the Structure Sensor project⁵⁴, which raised over USD 1,000,000 through crowdfunding in late 2013. A similar device for obtaining a depth map and software for recognition of human gestures and movements is being developed by the Russian company 3DiVi⁵⁵ (Chelyabinsk Oblast)

CASE

USE OF GOOGLE GLASS AND SONY SMART- WATCH BY VIRGIN ATLANTIC AIRLINES

The British airline Virgin Atlantic began an experiment in early 2014 for improving its personalized service. Upper Class Wing service personnel were provided with Google Glass spectacles and Sony SmartWatch 2 watches with special apps installed which are integrated with the airline's systems, making it possible for them to identify passengers and check them in for their flights, promptly obtain updated information about flights and give it to passengers, offer information on expected weather conditions and activities of interest at the destination, and translate information from a foreign language.⁵⁶

⁵⁶ <http://www.virgin-atlantic.com/gb/en/the-virgin-experience/upperclass/upper-class-wing/google-glass.html>

⁵³ <https://www.google.com/atap/projecttango/>

⁵⁴ <https://www.kickstarter.com/projects/occipital/structure-sensor-capture-the-world-in-3d/posts>

⁵⁵ <http://www.3divi.com/rus/>

CASE

OCULUS RIFT — A VIRTUAL REALITY DEVICE

Devices for creating virtual reality are being successfully used in architecture, industrial design and engineering; however, individual virtual reality devices are only starting to emerge. The first and best-known example aspiring to enter the mass market is the Oculus Rift virtual reality headset. The keen interest of enthusiasts in such devices is confirmed by the success of its crowdfunding. Oculus VR raised over USD 90,000,000 for the implementation of the project, of which about USD 2,400,000 was raised on the Kickstarter crowdfunding platform⁵⁷. Over 9,000 users took part in the funding, and the initial required amount of USD 250,000 was raised within four hours. In 2014, Sony offered a prototype of its version of virtual-reality glasses, Project Morpheus, which speaks of the increasing interest of large companies in the new trend.

The current version of the prototype has a high-resolution 7" display and a pair of lenses making it possible to obtain a stereoscopic effect with a 90-degree horizontal and 110-degree vertical field of vision. To monitor head movements, a tracker consisting of a three-axis gyroscope, accelerometers and a magnetometer is used, as well as an external infrared camera. The market launch of the new version (Oculus VR) is expected in 2015.

Initially, Oculus Rift was created as a computer gaming device, and such well-known companies as Id Software, Valve Corporation and Epic Games have already announced support for it. However, the potential range of possible applications of the device is a lot wider.

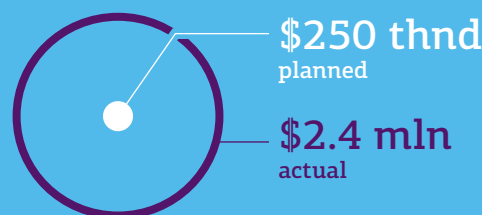
Oculus Rift can be used for educational purposes and for conducting specialized training. Virtual-reality devices not only make it possible to visit another continent during class time, but also to travel to a different era, to the time of the dinosaurs or to the Renaissance. For example, a team from Harvard has developed an Oculus Rift-compatible application for a virtual visit to the pyramids of Giza⁵⁸, and the release of a similar application for Ancient Rome is expected.

Personal virtual reality devices could become indispensable for training members of hazardous professions — firefighters, rescue workers, and military personnel — without needlessly subjecting the trainees to undue risk. For example, American astronauts already use virtual reality devices in order to simulate their actions aboard the International Space Station⁵⁹.

Thanks to the development of data-transfer and online image-processing technologies, in due time it will become possible to create unpiloted aircrafts which provide 360-degree visibility and are remotely operated by a pilot.

The application of virtual reality devices could also substantially alter conventional forms of communication. After the acquisition of Oculus VR by Facebook in March 2014, the social network's creator declared that the device could become a "new communication platform" that would enable sharing not only of photographs and messages but also "entire experiences and adventures".⁶⁰

Results of Crowdfunding for Oculus Rift



⁵⁷ <https://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game/posts>

⁵⁸ <http://giza3d.3ds.com/en-stories.html>

⁵⁹ <http://www.nasa.gov/audience/foreducators/spacesuits/careercorner/david-homan.html>

⁶⁰ <http://www.forbes.com/sites/erikkain/2014/03/25/microsoft-should-have-acquired-oculus-rift-not-facebook/>



Distinctive features of the gesture recognition technology Nuidroid presented by Russian programmers are its optimization for the ARM-architecture (used in a wide range of consumer electronics, from cell phones to calculators) and full compatibility with the Android platform. This means that 3DiVi's technology will enable Kinect-style applications and games to be created on various Android-powered devices: game consoles, Smart TVs and tablet computers. Another area in the development of augmented reality devices may be improving the method of presenting information to the user. To view information generated by the glasses, their owner needs to shift his or her gaze away from real-world objects and focus on the image created by the projector, the location of which is greatly restricted by the glasses' capabilities.

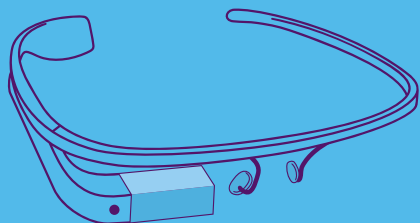
iOptik lenses, presented by Innovega at the CES 2014 exhibition, make it possible to see remote real-world objects and images

from the projecting glasses which come with the lenses equally easily, while maximally expanding the field of vision⁶¹. The lenses act as displays and possess two types of filters: the central filter, responsible for processing images sent from mini-projectors, and peripheral or external filters, which process information from the surrounding world. The consolidated image is generated directly in the retina. The manufacturer expects to obtain a permit to manufacture the lenses from the US Department of Health and Human Services by 2015 and then launch the product on the mass market.

⁶¹ <http://www.cnet.com/news/augmented-reality-contact-lenses-to-be-human-ready-at-ces/>

CASE

GOOGLE GLASS — AN AUGMENTED REALITY DEVICE



Google Glass glasses are currently the most popular product on the market of such wearable devices. Testing of the device prototype began in 2012, and the first mass-produced version became available to order in 2014. The commercial version has the computational capabilities of a 3-year-old smartphone, a camera capable of recording high-resolution video, and a mini-projector located in the right earpiece of the glasses which can display an image comparable to a 25-inch screen located at a distance of 2.4 m. The device is controlled using a set of voice commands and a sensor panel on the right earpiece. The technical characteristics of the device allow it to work for up to 8 hours.

Positive feedback about the use of the device in health care has been received from employees of the American College of Surgeons. The first surgery performed using the glasses took place in June 2013, during the product testing stage.⁶²

In doctors' day-to-day work, the capabilities of the device can be used as a means of displaying supplementary information about a patient in real time, communicating with colleagues and receiving remote recommendations, and implementing a "checklist" to prevent erroneous surgeries, and also as a tool for recording teaching videos from a first-person point of view.

Using Google Glass eyeglasses, surgeons gain the ability to view x-rays or CAT scans and other test results and monitor the patient's vital signs using voice prompts, all without leaving the operating table or taking their attention from the patient. An example of integrating medical equipment and Google Glass was presented in late 2013 by Philips⁶³. The convenience of using a projected image in the work of a plastic surgeon was confirmed by the first surgery for correction of a nose deformity using Google Glass, which took place in December 2013 at the Chicago Medical Center.

Currently, a number of developers are working on applications that would make it possible to use Google Glass to complete a pre-surgery "checklist" for preventing physician errors. The device will make it possible to perform these actions by means of voice prompts.

The high-resolution video camera with which Google Glass eyeglasses are equipped enables real-time broadcasting of what the medical worker sees. Even though Skype and video conferences offer similar functions, Google's device makes it possible to see the image from a first-person point of view and is the most interactive tool. Such capabilities will, for example, permit doctors located in remote areas to receive real-time consultations from a wide range of experts when acting in non-standard situations.

The option of recording the surgeon's actions from a first-person point of view is especially important when conducting training sessions, since it allows the students not only to see all of the doctor's actions in real time, but also to interact with him by asking questions and receiving comments during the surgery. Moreover, use of the device makes it possible to observe the doctor's actions without occupying space in the operating room.

⁶² <http://bulletin.facs.org/2014/07/surgeons-see-future-applications-for-google-glass/>

⁶³ <http://www.healthcare.philips.com/main/about/future-of-healthcare/>

TECHNOLOGICAL INNOVATIONS IN THE FINANCIAL SECTOR

Technological progress in the financial sector, particularly the widespread introduction of mobile technologies, is rapidly altering the industry's landscape, enabling small start-up companies to hold a significant share of the market and outpace existing players. The remedies aimed to solve the "digital divide" problem in Russia will stimulate the growth of telecommunication service penetration and promote the mobile financial services. Finally, it will result in engagement of more domestic software developers into this market.

TREND:

DEVELOPMENT OF MOBILE ACQUIRING SERVICES USING MPOS SOLUTIONS

An mPOS terminal is a device connected to a mobile device (smartphone or tablet) and enabling the use of bank cards for payment. Currently, mPOS terminals are widespread in North America, Europe, and several Southeast Asian countries. Such devices are most popular with small businesses — companies involved in the sale of goods and services for small amounts (up to USD 50-100). Some large retailers use mPOS terminals to simplify customer service (in addition to existing solutions).

The use of such solutions improves the convenience and quality of customer service and in the long run increases sales; therefore, it is expected that tablets with a connected mPOS terminal will eventually replace cash registers.⁶⁴ An mPOS service is a simple and convenient solution for entrepreneurs as well; to use it, one needs to register the organization with the service, receive the device and configure it for use with a tablet or smartphone. Furthermore, it is possible to use the company's existing current account, as well as mobile equipment already available to the employees (couriers, agents and salesroom employees).

mPOS acquiring is one of the most rapidly expanding areas on the market of technological innovations in the financial sector. The largest number of small new companies works in this segment; however, the American service Square remains the most popular in the world.

The appearance of new companies and the expansion of market competition is leading to the reduction of acquiring fees; the European service SumUp lowered its price from 2.75 % to 1.95 % in Austria and the Netherlands, 1.75 % in France, 1.5 % in Spain, and 0.95 % in Germany. Another European company, iZettle, is also lowering its rates from 2.75 % to 1.5 % in Great Britain, while offering a new, improved version of the mobile terminal.

The services are expanding the capabilities of their products: they are offering the option of accepting cards from new payment systems (the partnership between American Express and SumUp) and adding support of cards equipped with chips to the devices' capabilities.

The Russian mPOS-acquiring market has great potential; the country is at present characterized by a low level of penetration of offline acquiring, a large and still growing volume of issued bank cards, and an extensive level of cellular communications development. In 2013, over 10 startups offering mPOS acquiring services were operating in Russia, the first and largest of which is LifePay. In the first six months, the service attracted over 6,000 customers using 15,000 readers, by means of which over USD 1,000,000 in transactions were made in 2013.

mPOS acquiring is also developing in the area of expanding the functions of the terminal's software, which will make it possible not only to accept bank cards for payment, but also to interact with CRM and company loyalty systems in order to improve customer service and ERP systems for inventory and stock control.

⁶⁴ http://www.cnews.ru/reviews/new/telekom_2013/articles/rynok_elektronnyh_platezhej_budushchee_zampos/

CASE

WALLMOB

This startup from Denmark⁶⁵ offers small and medium-size companies a point-of-sale solution based on an iPad app, and it is also involved in developing specialized solutions for large companies such as L'Oreal and Armani.

The tablet can either be installed at a cash register or a customer service desk or be used by a company employee in the salesroom, offering complete access to information on the goods and their availability in stock, and also enabling payments using the mobile terminal for bank card payment. The Wallmob app also supports integration with other customer systems, making it possible, for example, to customize service using information accumulated on each client. In 2013 the service raised seed funding worth USD 1.2 million.

⁶⁵ <http://techcrunch.com/2013/08/19/with-1-2m-in-seed-funding-danish-mobile-point-of-sale-startup-wallmob-sees-big-potential-in-new-stand/>

CASE

LIFEPAD

The Russian project LifePAD, which involves the free distribution of Android tablets, has been actively developing since 2013. Apps for managing finances, personal time and shopping are installed on the tablet. The device is aimed at helping entrepreneurs to become more mobile and efficient and helping private persons to use the options the device offers in their daily lives. An important step in the development of the solution will be acquiring the capability to use a digital signature on the pre-installed SIM card.⁶⁶

The total volume of investments in the project amounted to USD 7,000,000 and involves different methods of cooperation with partners: project partners can pay for their apps to be installed on the tablet, or partners can share revenues received from installation of the app on the tablet.

⁶⁶ http://bg.ru/city/moskvichi_smogut_podpisyvat_dokumenty_s_pomoschju_mobilnogo_telefona-16445/

TREND:

EXPANSION OF THE USE OF TABLETS FOR MOBILE BANKING SERVICES

According to a forecast from Juniper Research, by 2017 the number of active users of mobile banking on tablets will reach 200 million, amounting to 19% of all users (in 2013 this figure was at 9%). New users will mostly transition from desktop personal computers and laptops. In connection with this, mobile banking applications are becoming more widespread.

TREND:

DEVELOPMENT OF MOBILE FINANCIAL SERVICES

In 2013 experts noted a new wave of interest in a wide range of mobile services in the financial sector. One of the drivers of increased interest in the technology is the growing number of smartphone users — over 30% of all mobile telephones at the end of 2013.⁶⁷

⁶⁷ <http://techcrunch.com/gallery/mary-meeker-internet-trends/slide/4/>

VLADISLAV SOLODKIY

Managing Partner
of Life.SREDA Venture Fund

"The development of distribution aimed at the scaling of market players was one of the key topics on the mPOS market in the first half of 2014. Companies took various steps to achieve these goals, such as the creation of unique partnerships or upgrading of existing platforms to integrate with outside vendors (through SDK or API). Of equal importance is the search for alternative sources of income for market players. It is quite obvious that such business cannot be developed relying solely on income from transactions. However, the customer base obtained through development of the acquiring business is the most valuable asset of the companies concerned, which can be used in the future for the upsale of any financial services.

Square, an mPOS global market leader, continues to be a key trendsetter and newsmaker in the industry. This year, Square management negotiated the sale of the service with such giants as PayPal and Apple that have stronger financial resources and an affiliate network and reach out to potential business users of the payment service. Whether or not this is true, the fact that the company suffered significant losses in 2013 and spends money raised too quickly leads critics to believe that selling may still be an option. Square has been the target of criticism since the company's inception. Many people doubt the actual value of the company and criticize it for inability to earn what it needs through its main product. However, one should consider the example

of the Whatsapp sale, where the company was sold for USD 19 billion without having earned a cent. How many years did it take Amazon to make any profit? It may be worth evaluating the company in the longer term. There is no doubt that one of the company's goals was to establish a large customer base that would become a basis for earnings in the future. New services launched by the company in recent years only support this hypothesis.

Meanwhile, Square's competitors in Europe are continuing to grow, attracting more investment. The Swedish mPOS startup iZettle has announced the next round of funding. The main investors were Zouk Capital, Dawn Capital and Intel Capital. The investment raised amounted to EUR 40 million (USD 55.5 million). Jacob de Geer, iZettle CEO told reporters that the money would be spent on business development and the possible acquisition of other companies with promising technologies in the field of online payments, loyalty programs and CRM, as well as on expanding the company's presence in Latin America and Europe.

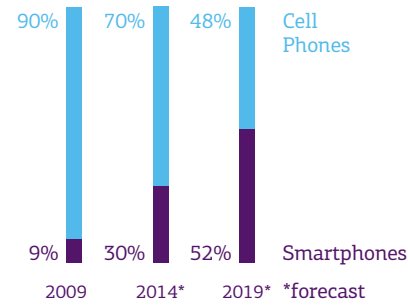
iZettle has already raised a total of USD 108.9 million. Among its investors are such companies as American Express, MasterCard and Banco Santander.

Another major player on the European market, SumUp, has developed and launched its own Chip&Pin reader. As a rule, most companies in the market use white-label solutions and do not develop proprietary hardware solutions. PayPal, iZettle, Payleven, and Worldpay use devices made by Miura Systems. SumUp decided to take a different path and became the first European service provider to create its own reader, ex-

plaining this step by the fact that the existing solutions do not meet their "strict requirements". "No vendor could have supplied us with a Chip&Pin device to meet out strict criteria for reliability, design and security, along with a user experience that is so intuitive that even merchants who have never accepted card payments before can start selling immediately without having to read a manual", says Daniel Klein, the company CEO. It took 18 months to develop the device, and will now be sold for USD 135 in practically all markets where the company operates. This year, SumUp also closed another round of investment with the participation of Groupon, BBVA Group, our fund Life.SREDA, and a number of its current investors. The size of the transaction has not been disclosed, but it is a two-digit EUR million figure. The money will be spent on building a full cycle of the payment solution, including the development of its own payment gateway and improvement of mobile point of sale terminals and software. Investment will also be used to promote the devices on international markets.

LifePay, a leading player in mPOS acquiring in Russia, showed impressive growth in 2014: over half a year the service attracted more than 14,000 new clients — owners of small and medium-sized businesses. Its monthly transaction growth rate is more than 20,000. The company has distributed more than 28,000 mPOS-terminals in total. Every 90 seconds non-cash payments in Russia are made through a LifePay terminal."

Global Smartphone Penetration



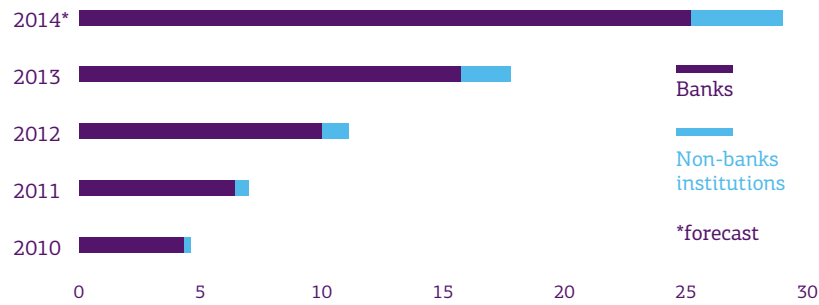
Source: Ovum.

At present, the proportion of users of “mobile money” does not exceed 7% of the number of mobile phone users world-wide, but experts predict a rise in the years to come, and assess the potential number of users at 450 million people in 2017⁶⁸.

As in previous years, most mobile financial services are provided by traditional banks. However, user demand for simpler and more convenient interfaces, higher speed and quality and transparency of services provide a promising market for rapidly growing innovative companies.

“In the next 10 years, the role of banks will not change, but the range of services from which they will earn will expand significantly,” thinks Alexander Galitsky, the founder of Almaz Capital Partners venture fund. “The relationships of that banks and payment systems have with major mobile platforms are likely to change. This may eventually lead to the transformation of Visa and Mastercard, for example, into VisaSmartphone and

Number of Mobile Payments Made by Clients of Non-Bank Institutions (2010-2014)



Source: World Payments Report 2012, RBS/Capgemini, 2013.

MasterSmartphone, which will change their operating mechanism.”

There are already a lot of financial services, both bank-related and independent, that provide convenient financial management services regardless of the user’s location. Such services include person-to-person (P2P) money transfers without opening an account, where the user’s identifier can be his e-mail address, cell phone number or a social network account.

The most famous non-banking institutions which enable one to use an electronic wallet to make purchases and transfers are such companies as PayPal and Fidor Bank, as well as Russia’s Yandex.Money, Qiwi, WebMoney, and Money@Mail.ru. Most electronic wallets, besides payment services, provide services for cash flow management and personal financial planning.

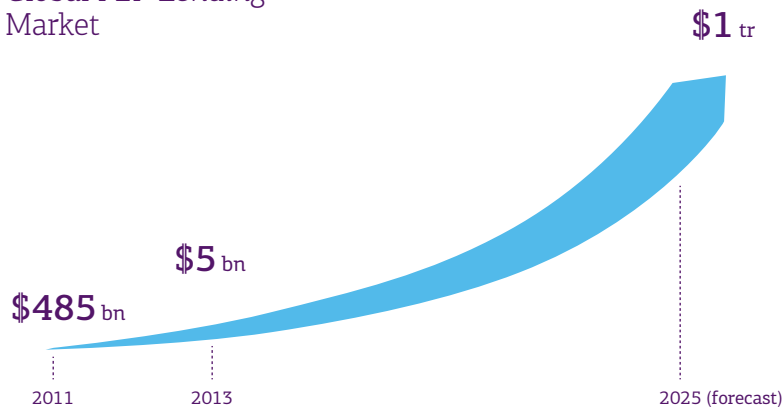
Banks are also developing capabilities for mobile money management. Russia’s Instabank and Rocketbank, for example,

give users of their mobile apps the option of telling their friends about purchases in social networks, as well as chipping in for joint gifts or splitting a restaurant or cafe bill.

Access to an enormous volume of data about the user — geographic location, social network account, volume and location of transactions made — permit providers of mobile financial services to more completely integrate with other services, both financial and non-financial.

⁶⁸ EY research; “Gartner Says Worldwide Mobile Payment Transaction Value to Surpass \$235 Billion in 2013,” Gartner, 4 June 2013; “The Mobile Economy 2013,” GSMA/A.T. Kearney, 2013

⁶⁹ “Gartner Says Worldwide Mobile Payment Transaction Value to Surpass \$235 Billion in 2013,” Gartner

Global P2P Lending
Market**TREND:****DEVELOPMENT OF THE
P2P LENDING MARKET**

P2P lending (peer-to-peer lending) means the issuing and receiving of monetary loans by physical persons directly, without the involvement of intermediaries (banks and credit institutions). The growth of Internet penetration has led to the appearance of online platforms facilitating the search and interaction between the lender and the borrower. As compared to traditional financial institutions, a lot of processes on such platforms are automated, making it possible to reduce costs and consequently offer a lower interest rate to borrowers and greater revenue than in banks to the lenders.

To make a decision on issuing a loan, users can utilize the borrower's credit rating assigned by the platform. To assess client reliability, companies use Big Data, analyzing, in addition to the information provided by the borrower, his credit histo-

ry, characteristics of his Internet behavior, data on activities and information in social networks.

Based on data for 2013, the global P2P lending market is estimated at USD 5 billion, and the average annual growth rate in 2010-2013 was 128% (the market volume increased from USD 485 million to USD 5 billion). Foundation Capital predicts that by 2025 USD 1 trillion will be lent through the P2P platform every year.

The Russian P2P market commenced its development in 2010; however, in the past few years its growth has slowed from 42% in 2012 to 3% in 2013⁷¹. The largest market players are WebMoney Transfer, Vdolg.ru, Credberry, LoanBerry and BezBanka. One of the characteristic features of the Russian lending market is the insufficient development of the practice of borrowers forming a credit history, which results in complications in assessing a user's creditworthiness.

⁷¹ data by Json&Partners

CASE**STARBUCKS
MOBILE APP**

The mobile app of the Starbucks⁷⁰ coffeehouse chain already has over 12 million users in the USA and Canada who make about 6 million payments per week, which is over 15 % of the transactions in all of the chain's coffeehouses, and the company is continuing to expand the capabilities of the mobile platform. According to the Chairman and CEO of the chain, Mr. Howard Schultz, thanks to integration of the mobile app with the loyalty program and the payment platform Starbucks is able to offer its customers a completely new level of service, while shifting to mobile solutions helps attract the young generation of customers. For example, coffeehouse customers can create new dishes, place pre-orders and pay for their purchases from a mobile phone.

⁷⁰ <http://www.nfcworld.com/2014/07/28/330631/starbucks-now-processes-six-million-mobile-payments-week/>

CASE

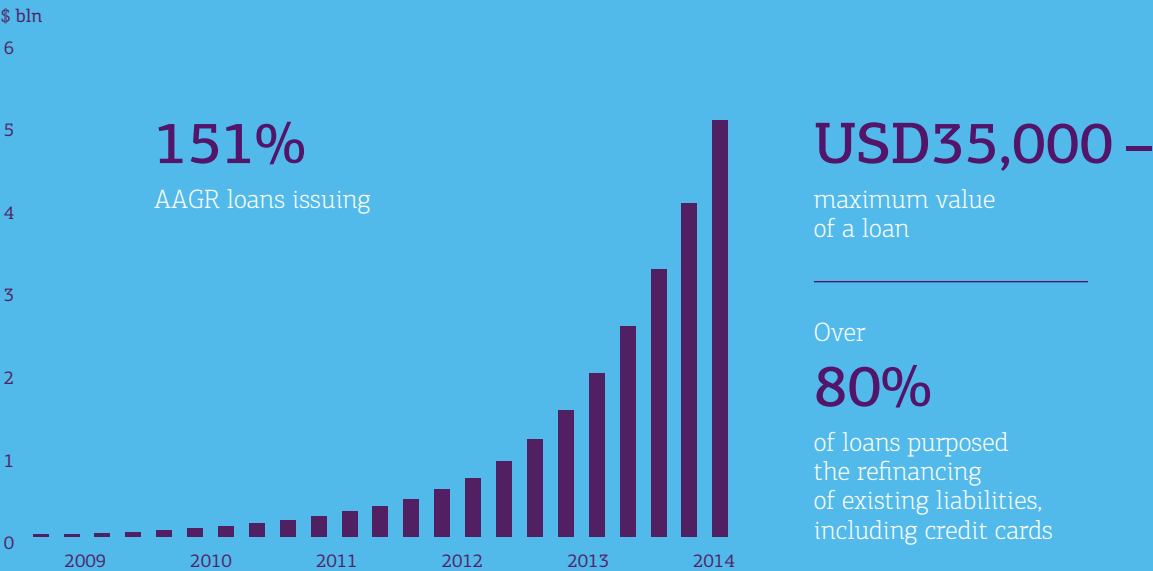
LENDING CLUB P2P LENDING SERVICE

Lending Club is the world's largest P2P lending service, founded in 2007; as of mid-2014 the total amount of loans issued had reached USD 5 billion, the number of borrowers exceeded 80,000 and the number of lenders was over 45,000.⁷² The company's board of directors includes the former CEO of Morgan Stanley, and at the end of 2013 the service was valued at USD 2.3 billion. In 2014, as part of preparations for its IPO, Lending Club hopes to be valued at USD 4-5 billion.

Loans of up to USD 35,000 for any purpose are issued through Lending Club; the average interest rate for a three-year loan is 12% (from 6.78% for the most reliable clients to 29.99% for high-risk clients); most loans, over 80% of them, are taken for refinancing existing loans and repaying credit card debt.

One of the main factors ensuring the service's success is a high-quality borrower scoring system, making it possible to select applications from reliable clients; on average, borrowers have 16 years of credit history and an annual income of USD 73,000, so Lending Club works with the most prosperous 10% of US citizens. Thanks to high yields and relatively low risk, the service has started attracting not only individuals but also investment, pension and hedge funds as creditors. In 2014, the service started offering loans to small businesses, and it has been planning international expansion.

A total of USD 5 billion had been lent by mid-2014, of which the largest amount, approximately 1 billion, was lent in Q2 of 2014



Source: <https://www.lendingclub.com/info/statistics.action>.

⁷² <https://www.lendingclub.com/info/statistics.action>

PERSONAL DATA PROTECTION

TREND:

INCREASED DEMAND FOR HARDWARE AND SOFTWARE SOLUTIONS FOR PROTECTING PERSONAL USER DATA

When various companies — from communication providers and mobile app developers to power generating companies — are collecting, transmitting and analyzing an immense volume of user data, the issue of personal data protection is becoming especially urgent.

Users view the collection and use of personal data with caution and suspicion: up to 68 % of respondents in a study performed by Ovum in late 2012 among residents of 11 countries (including Russia)⁷³ expressed a desire to stop the collection of their personal data on social networks and by search engines and other services. Furthermore, 50% of those surveyed are sure that Internet companies use collected personal data dishonestly, and 36% have doubts about the honesty of data use.

68%

Respondents wishes to
stop the collection of
their personal data via
social networks and oth-
er Internet resources

86%

Respondents are not
sure about the integrity
of their personal data
use by Internet
companies

SERGEY ZOLOTAREV

Big Data Line Director, EMC,
Russia and CIS

"In Russia, banks were the first companies to begin using Big Data in their operations. Two or three years ago the trend spread to telecom operators as well, but the technology is not yet widespread and has so far been used in test mode. In the United States and Western Europe, Big Data is actively used in retail trade, while in Russia we have failed to use this experience effectively and adapt it to the needs of our companies.

In the United States and Western Europe, the "user experience" sphere is widespread, where marketing agencies focus on studying the Internet audience: they collect customer data, analyse them and compile data profiles for business customers. One of the most prominent representatives of this industry, the company comScore, has recently entered the Russian market.

The expansion of the scope of application of Big Data technology through the accumulation of extensive experience is among the major trends. Originally, Big Data was used primarily in research, then in the area of customer marketing by banks and telecommunications companies, and later in retail trade. Today, the processing of large amounts of data for further use is becoming increasingly popular in geological exploration and opinion surveys."

⁷³ OVUM, Consumer Insights Snapshot: Personal Data, 2013.

CASE

BLACKPHONE BY SILENT
CIRCLE, ENSURING SECURE
COMMUNICATIONS

In 2013, Silent Circle, a company specializing in solutions in the area of secure communications, managed to raise over USD 30 million worth of investments for the creation of a telephone which would ensure confidentiality of communications.⁷⁴ Blackphone, which is being developed together with the Spanish start-up Geeksphone on the PrivatOS platform (a customized Android system), will ensure secure calls, message transmission, access to cloud services, Internet search and a Wi-Fi anonymizer. Based on the number of preliminary orders, which started to be taken in February 2014, demand for the device, which costs USD 629, has exceeded the manufacturer's expectations.

⁷⁴ <http://www.techcrunch.com/2014/05/21/silent-circle-funding/>

More and more users are expressing their wish to control the nature of personal data being collected and the manner of their use by companies. Such companies as Yahoo, Twitter and Pinterest are already supporting the Do Not Track standard⁷⁵, enabling Internet users to opt out of automatic collection of information about their visits to web pages.

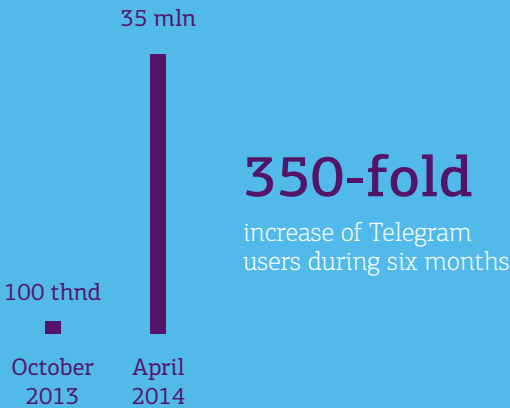
In such circumstances, the development of software and hardware solutions aimed at protecting personal data and providing users with greater control over their personal data could become a more viable strategy than those involving the collection and processing of personal data. For example, growing demand can be observed in the market for services providing secure communications; the secure voice calling apps RedPhone and Silent Phone and the secure message exchange apps ChatSecure and TextSecure have been downloaded over 100,000 times each on Google Play alone.

⁷⁵ <http://www.donottrack.us/>

CASE

TELEGRAM MESSENGER
SECURE COMMUNICATIONS
SERVICE

Mr. Pavel Durov, the founder of the VKontakte social network, along with his brother, Nikolai, developed a messenger for smartphones that enables the exchange of text messages and media files. The app's main feature is that it ensures the confidentiality of information transferred through the use of the MT-Proto correspondence encoding protocol created by the developers.



From October 2013 through April 2014 the number of the app's users grew from 100,000 to 35,000,000. After reports of Facebook's acquisition of the messenger WhatsApp, the Telegram app was downloaded over 5 million times in one day.

INFORMATION TECHNOLOGIES IN EDUCATION

TREND:

INCREASED ACCESSIBILITY OF HIGH-QUALITY EDUCATION THROUGH THE DEVELOPMENT OF ONLINE DISTANCE LEARNING SERVICES

One of the most actively developing forms of distance learning is online courses with massive interactive participation and open access (Massive Open Online Courses, or MOOC). Unlike video recordings of lectures and other learning materials, MOOCs offer students the option of interacting with each other and with the instructor and also of performing real-time assignments. MOOCs can usually be taken free of charge, and upon finishing one can receive a certificate of completion for a small fee paid to the online platform.

Currently, the following educational platforms enjoy the greatest popularity: edX, founded by Harvard University and the Massachusetts Institute of Technology; Udacity, created under the auspices of Stanford University; and Coursera, created by Professors Andrew Ng and Daphne Koller from Stanford University. They offer free online courses on a wide range of subjects, from scientific disciplines to art history.

The most famous non-profit organization in the sphere of online education is Khan Academy, founded in 2006. Unlike edX, Coursera and Udacity, which prepare detailed video courses in conjunction with well-known global universities, Khan Academy specializes in creating and providing access to a database of short video lectures, mostly aimed at secondary-school students, to all who desire it. The project is funded by donations, most of which are given by Google and the Bill and Melinda Gates Foundation.

Online learning models also offer possibilities for monetization. For example, online learning services can issue paid certificates of successful completion for courses, develop courses for prospective employers, and also provide paid access to the database of students who have completed the necessary set of courses.⁷⁶

VITALY BARDALIM

Mersibo Project Manager

“Online education is undoubtedly a global trend which has not passed Russia by. Unlike many fads, which spread quickly and then fade away, Russian online education is here to stay, especially given the size of our country. There will, of course, be aspects of development that are particular to Russia, but this is perfectly normal. For example, I do not see any problems in the area of corporate and business training, which is growing very rapidly since students, employers and providers of educational services all have an interest in it. Despite the fact that many methods and training materials come to us from abroad, they can be quickly adapted to local conditions. Various types of supplementary private education such as cooking or foreign language courses have excellent prospects, and in this area there are great opportunities for small and medium businesses. We should like to make separate mention of online learning for children. In my opinion, this is at an early stage of development, but it has huge potential. Indeed, unlike some adults, children are happy from the outset to use such a model of learning. Computers and gadgets are part of their everyday living environment, which makes online learning natural and appropriate for them.”

⁷⁶ <http://rusbase.vc/school/platit-za-onlajn-obrazovanie/>

MOOCs are gaining popularity; in early 2014, users of edX and Udacity numbered about 1.6 million each, while users of Coursera numbered 6.3 million.⁷⁷ The Khan Academy web site is visited by 80 million users annually.⁷⁸

Despite the advantages of distance learning, currently this form of education is not widespread among institutions of higher education. One of the reasons is the low effectiveness of this approach to education, since success largely depends on students' internal motivation, and they often lack diligence.⁷⁹ For example, according to data from edX, out of 800,000 people registered at the portal for the first year of study, almost 300,000 people never even looked at the contents of the instruction materials, and 470,000 looked at less than half of them.⁸⁰ Moreover, the share of students who complete an online course on average amounts to 4-7 % of those who sign up for it.⁸¹

53%

of respondents consider that gamification will be widespread in ordinary life by 2020, from education to health

One method of improving the effectiveness of online learning is gamification of the educational process. Based on the results of a poll conducted by the Pew Research Center, 53% of respondents agree with the statement that by 2020 the use of gamification will be widespread in daily life, from education to health care.

Integration of gamification in the learning process will make it possible to increase students' involvement in the educational process, promote faster assimilation of material, and improve motivation for independent study by offering rewards.

One of the best-known Russian educational projects containing gamification elements is LinguaLeo, an online resource for studying English⁸². Game mechanisms are also used by resources such as Codeacademy and Netologiya. New projects, such as SmartFox, a project for preparation for the Uniform State Examination in mathematics that was one of the first to receive funding from the Internet Initiatives Development Foundation, are also being developed in this field.

Game mechanisms being used include:

- Creation of educational courses in a game format offering virtual rewards;
- Using a system of ratings and achievements for completion of work;
- Open profiles of other students to promote competition;
- Gradual presentation of information (expansion and provision of access to content) and addition of complexity to assignments to monitor progress.

In addition to gamification, Maxim Spiridonov points to the cross-platform capabilities of educational applications, the reduced length and increased number of lessons as another trend in the education market: "I can take one lesson at home and do a test, take another lesson on a smartphone for five to seven minutes on my way to work, finishing it with a test, and then, on returning home, watch a video tutorial on my smart TV."

⁷⁷ <http://www.computerra.ru/92998/mooc-kak-budushhee-obrazovatel'nogo-protssessa-za-i-protiv/>

⁷⁸ <http://kommersant.ru/doc/2411173>

⁷⁹ <http://www.onlinelearningsurvey.com/reports/changingcourse.pdf>

⁸⁰ <http://www.computerra.ru/92998/mooc-kak-budushhee-obrazovatel'nogo-protssessa-za-i-protiv/>

⁸¹ <http://www.nytimes.com/2013/12/11/us/after-setbacks-online-courses-are-rethought.html?src=me&ref=general>

⁸² <http://lingualeo.com/ru/>

The segment of online learning is under active development in Russia, and in 2013 educational technologies and training services became one of the five most rapidly expanding sectors of the Internet market.⁸³ In 2011, over two thousand electronic educational resources were developed, and currently 76 % of schools are connected to the Dnevnik.ru educational network (electronic grade books, magazines, libraries and educational media content). According to Maxim Spiridonov, the further secondary education segment is the most profitable in Russia. "This is due to the fact that the market is already in place, with a turnover of around about USD 2 billion a year. It is a market in which there is already a habit of paying for services, as every other parent hires a tutor for his or her child," says the General Director of the Netology service."

A mandatory prerequisite for mass online training is the availability of sufficient learning materials in a digital format. In 2012, Connexions launched the OpenStax College project for the creation of high-quality freely distributed textbooks for students, available in both printed and digital form. During the year textbooks on physics, sociology and biology were issued, and they were accepted for use at over 400 educational establishments, downloaded 400,000 times and helped students to save USD 5.5 million. There are plans to issue a total of 25 such textbooks by 2018.⁸⁴

The digitalization of education is taking place in Russia, and one sign of this is the use of electronic textbooks. As from

1 January 2015, in Russia it will be possible to publish only textbooks which have an electronic version.⁸⁵ Electronic textbooks are already being actively used in South Korea, Great Britain and the USA.

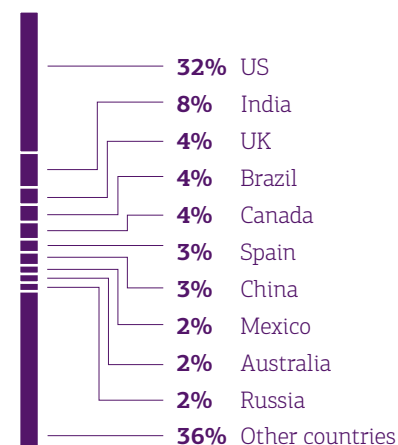
The development of MOOCs in Russia is especially relevant, since over one half of those wishing to study at Moscow's higher education establishments cannot afford it, often as a result of the geographical remoteness of their place of residence from Moscow.⁸⁶

"Remote e-learning allows students to study and do research with their chosen teachers, regardless of distance," says Alexander Galitsky, founder of Almaz Capital Partners venture fund. "At the same time, universities are more likely to credit their students for courses taken at other universities. For example, if I study at MIT, and I want to take a physics course at Harvard, because it is delivered by Mikhail Lukin⁸⁷, I can do this with no problem, and this course will be credited at MIT."

In October 2013, the global educational platform Coursera was for the first time in history joined by Russian institutions: MIPT, SPBU, and HSE. Over six months of cooperation, the Higher School of Economics launched 12 educational courses, for which over 100,000 people signed up. The courses can be taken free of charge, and the cost of a certificate authenticated by the institution is about USD 50. However, according to Maxim Spiridonov, the prospects for Western educational platforms on the Russian market are low, since they are geared to a different mentality and do not take

into account the specific ways in which education is approached in Russia.

Geographical Structure of Coursera's Users



Source: <http://thenextweb.com/insider/2013/10/24/coursera-partners-13-institutions-pass-100-total-sees-5-million-students-500-courses/>
<http://cdn1.tnwn.com/wp-content/blogs.dir/1/files/2013/10/Coursera-Infographic.jpg>

⁸³ <http://rusbase.vc/news/EdTech-trends/>

⁸⁴ <http://www.forbes.com/sites/skollworldforum/2014/02/13/the-future-of-online-education/>

⁸⁵ <http://rusbase.vc/news/EdTech-trends/>

⁸⁶ <http://presscenter.rbc.ru/pressconf/2014/03/24/1556/>

⁸⁷ Professor of physics, Harvard University, the chair of the International Advisory Board of the Russian Quantum Center.

The development of Russia's own educational online services comes up against issues that are specific to Russia. "One of the considerations in the development of Russian online education is the lack of the habit of studying outside school and university," notes Maxim Spiridonov. In addition, most Russian services provide only paid access to content from the outset, which greatly limits the scale of the audience and opportunities for project promotion. According to Maxim Spiridonov, the relative unpopularity of online educational platforms is also explained by the fact that Russians doubt the effectiveness of online learning.

Maxim plans to solve this problem within the framework of project Netology project by engaging highly qualified teachers from leading universities for courses and using their feedback.

Another factor is a shortage of high-quality content in Russian and difficulties in the monetization of services caused by the absence of effective demand and the availability of free counterparts. The best-known free, publicly available projects in this sphere are Universarium, Interneturok.ru (the Russian version of Khan Academy) and Eduson, which are completely free of charge.⁸⁸

UNIVERSARIUM

The platform was launched with the support of Agency of strategic initiatives and RIA Novosti. Russian universities such as Lomonosov Moscow State University, Moscow Institute of Physics and Technology and Plekhanov Russian University of Economics participated in development of training courses.

- Over **245 thnd** users
- **37** courses (available and in development)
- **10** partner universities

EDUSON

This service focuses on online business education. Eduson's mission is to make a high-quality education available for the professionals. The project was initially orientated on BRIC countries.

- Over **48 mln** users
- **190** courses available

UNIWEB

Uniweb offers online educations in partnership with top Russian universities. The Key partner is Russian Presidential Academy of National Economy and Public Administration. Lomonosov Moscow State University, MGIMO University and Russian International Olympic University also participated in development of learning courses.

- Over **5 thnd** users
- **35** courses available
- **10** partner universities

NETOLOGY

The online platform for basic and advanced training of Internet specialists. The instructors are practicing industry professionals.

- Over **112 thnd** users
- **58** courses available

A prominent place among paid online learning platforms in Russia belongs to Uniweb, the first project that has been able to conclude distance-learning contracts with universities. For higher education institutions, cooperation with the portal is free of charge, and now agreements are in place with nine institutions, including MGIMO, MSU, RANEPa and MSSSES.⁸⁹ The startup is aimed at business education and improvement of professional skills; however, there are plans to launch Bachelor's and Master's Programs in the future.

⁸⁸ <http://www.vedomosti.ru/career/news/24218821/obrazovyyajtes-sami?full#cut>

⁸⁹ <http://www.rbcdaily.ru/media/562949988663542>

DEVELOPMENT OF THE ROBOTICS INDUSTRY: NEW CAPABILITIES FOR UNIVERSAL APPLICATION

Achievements in the field of robotics have given rise to opportunities for using robots not only in industrial production, but also in a wide range of sectors, from agriculture to oil production.

"Reductions in the cost and improvements in the quality of sensors, along with the expansion of the affordable functionality of robots, will lead to large-scale robotization of our everyday lives: from the "smart" home to the driverless vehicle," says Alexander Galitsky, the co-founder of the Almaz Capital Partners venture fund.

The implementation of foreign robotized industrial solutions might be extremely

expensive. The problem of Russian robotics industry is its fragmentation: individual firms and enthusiasts are engaged in their own projects developing the solutions in mechanics, electronics and programming. The industry players hardly exchange their ideas and participate in joint projects so finally it causes the problems in realization. Nevertheless, the upcoming projects in robotics allow to expect the future industry development including the creation of professional society and renewal of scientific and technical basis ⁹⁰.

⁹⁰ <http://habrahabr.ru/sandbox/79741/>

YURI BUROV

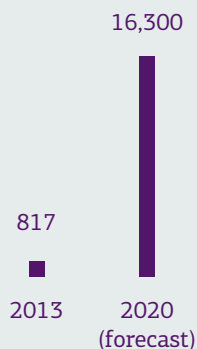
General Director
of Cubic Robotics

"Today, robotics and autonomous systems in Russia and abroad are one of the promising areas for investment. Investors and independent analysts alike are saying this. Even most conservative estimates would put size of the global market at USD 4.5 trillion.

It follows that more and more robotic projects will appear on the market every day. In my view, such projects will mostly be narrowly focused – in the sense that there will be no super robot which can do everything. The creation of such a robot requires time and resources, and the cost could be very high. Such robots will appear in laboratories, but not yet in mass production.

However, the market will see (and is already seeing) relatively low-cost robots that can perform one or two tasks, but will do it much better than people. It is important to realize that the market is created not only by technologies, but also through the generation of new finished products. It is products that develop the industry, bringing technologies from offices and laboratories into real life."

Agricultural Robots Market,
2013-2020



16.3
billion USD

will be agricultural robots
market by 2020, CAGR 50

Source: WinterGreen Research



TREND: INCREASED AVAILABILITY OF AGRICULTURAL ROBOTS

The main application of flying drones (miniature aircraft or quadcopters) is making high-quality photographs of the Earth's surface at an affordable price. Such devices are equipped with a GPS module, cameras for taking images and other sensors. All stages of the flight, from takeoff to landing, are carried out on autopilot; the software also generates the optimum route and adjusts the camera to take the most suitable images for further processing.

Compared to satellite images and images taken from a regular airplane, pictures produced by drones are a lot cheaper and of higher quality (more detail and less dependence on cloud cover due to the lower flight altitude).

The cost of such devices starts from just USD 1,000, which opens possibilities for their usage on the mass market. This has become possible thanks to the rapid development of technologies: various types of sensors (accelerometers, gyroscopes, and pressure and magnetic field sensors), GPS modules, high-performance processors and communication modules. The technical specifications of all these components are improving, while prices are falling.

Aerial photographs made by agricultural drones can facilitate the discovery of problems resulting from poor irrigation, soil quality, and pest infestations that are difficult to detect using other methods. Moreover, the cameras of modern drones can simultaneously take pictures in the infrared and visible ranges, the

combination of which makes it possible to detect sick plants among healthy ones.

TREND: ROBOTIC AUTOMATION OF HUMAN ACTIVITIES

In 2013 the European Commission, along with ten commercial institutions led by Shell, launched the PETROBOT project for creating a robot to replace humans in the complex and costly process of maintaining reservoirs used in the oil, gas and chemical industries. The European Union's investments in the project will total up to EUR 6.2 million over three years.⁹¹

Until very recently, robots used at production facilities only had one manipulator ("hand"), and if the production process involved an action that could only be performed using two "hands", a second one-handed robot had to be installed. More and more companies have been offering two-handed robots in the past few years: Seiko Epson, Nachi, ABB, and Kawada. The use of such robots will facilitate the joint performance of work by both robots and humans.⁹² "In medicine, robots and semi-robots are already performing operations to such a high standard that recovery after surgery takes not weeks, but a few days. Further development of robotics will enhance the effectiveness of treatment and reduce

⁹¹ http://europa.eu/rapid/press-release_IP-13-810_en.htm

⁹² <http://spectrum.ieee.org/automaton/robotics/industrial-robots/four-technology-trends-from-the-international-robot-exhibition-2013>

costs, for example by carrying out remote operations,” says Alexander Galitsky.

Robots capable of moving through irregular terrain, as humans can, will be able to replace humans in dangerous rescue operations and at toxic production facilities, and also provide day-to-day assistance to the elderly and disabled. “Robotics will change the labour market,” believes Alexander Galitsky. “Some professions will disappear, as the relevant activities will be automated”.

For robots to be used in day-to-day life and in an environment customary for humans, the robots need to learn how to move in such conditions. Walking, while intuitive for people, is a complicated process, and it is only recently that progress has been made in robots' mastering of this method of movement.

The humanoid robot Atlas created by Boston Dynamics confidently walks over uneven terrain and can even run on an even surface. This has become possible thanks to a qualitative breakthrough in improving the robot's software.

Its predecessors, Honda's robot ASIMO and QRIO created by Sony, were able to walk, but they did not manage their balance well enough, which restricted options for their use. Atlas, however, has a more advanced ability to maintain equilibrium in any situation. Equipped with two video systems — a laser distance meter and stereoscopic cameras — the robot can both run on a treadmill and walk over a pile of debris. Also, Atlas keeps its balance after being pushed, changing the position of its hydraulically controlled body in space and transferring its weight to one “leg”.

Despite the fact that Atlas is as yet unable to perform day-to-day tasks at home or in the office due to its complete dependence on an external power source, even now it is able to work in places too dangerous for humans, for example, at nuclear power stations and highly toxic production facilities, performing such tasks as opening doors, closing valves, using power tools, etc.

VALERIA KOMISSAROVA

Business Development Director,
Grishin Robotics

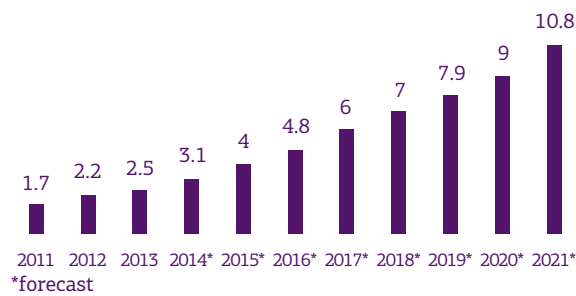
“The emergence and spread of consumer robotics is one of the main trends in the global technology market. We regard consumer robotics as the next great technological wave on a par with the advent of personal computers and the Internet and the penetration of smartphones. Robotics is finally becoming mass-consumed. Some time ago, computing devices were large, expensive and inaccessible; then PCs became powerful and available to everyone. Now the same thing is happening to robotics.

One of the drivers of the development of robotics is the fall in the price of components, largely thanks to the smartphone revolution. Mass production has made components cheaper and better-quality. The entry threshold has decreased, and dozens of start-ups are able to use sensors, which has led to increased innovation in this field and the development of the industry.

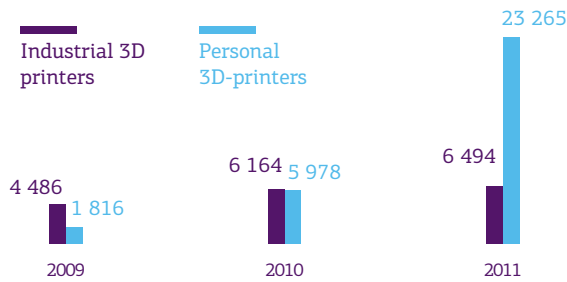
The democratization of 3D-printing is a factor in the growth of the consumer robotics industry. The threshold for entry to the robotics market is falling owing to the simplification of prototyping, which facilitates a faster rate of innovation and the development of the “economical start-up” concept, the essence of which is to reduce to the maximum extent the gap between an idea and a product that can be shown to the consumer. For example, the company makes a half-ready prototype, puts it to the market, gets feedback, and after a few improvement iterations presents the finished product that meets the demands of the consumer.

The latest trend is production growth in developing countries. It is becoming possible to produce small and medium-sized batches of goods without any urgent need to launch mass production in China. This has been made possible by the development of new production methods, 3D-printing and the appearance of local production facilities.”

The Global 3D-Printing Market,
2011-2021



Sales of 3D Printers,
2009-2011



3D PRINTING

3D printers are additive manufacturing devices which create tridimensional objects of practically any complexity layer by layer based on a digital computer model.

The development of 3D printing and the resulting drop in prices on 3D printers offer new possibilities for their industrial use in manufacturing, designing and creating prototypes of products in all areas of life: for the manufacture of private goods, in the automotive industry, in the aerospace and defense industries, in health care and in electronics manufacturing.

The advantages of 3D printing and the increased affordability of the printers are promoting the rapid development of the market and enabling private parties and small businesses to utilize them.

"In the corporate segment, 3D-printing technology will enable problems to be solved faster and more cheaply than now," Nikolay Bobrov, CEO of Picaso 3D, the Russian manufacturer of 3D-printers, says with confidence.

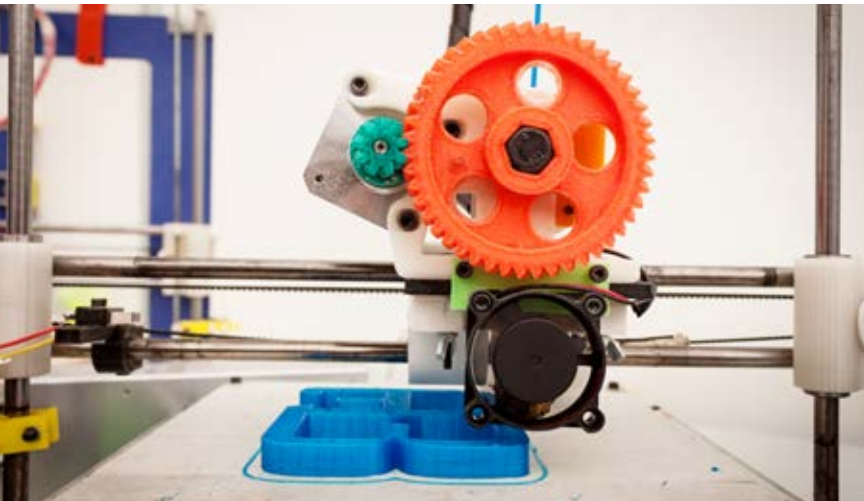
These days a 3D printer can be purchased for less than USD 1,000. Inexpensive printers are in particular demand with scientific institutions and enthusiasts who prefer to make things with their own hands. The availability of new 3D printing services is also promoting increased popularity and the level at which the technology is used. For example, 3D printing cloud services, Cubify and Sculpteo, make it possible to create or upload an al-

ready existing model of a 3D object free of charge, and then order a printed model with delivery.

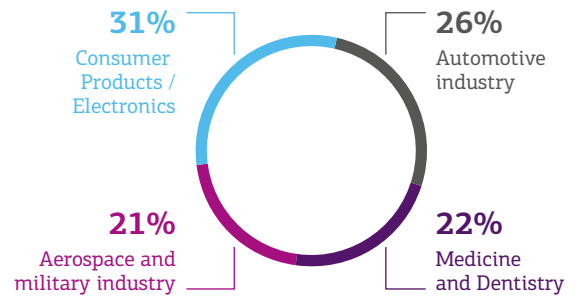
Currently, the main driver of the 3D printing market is the use of printed objects in the automotive industry. Momentum is being gained in segments for the manufacture of medical devices and designer and jewelry items. In the health care sector, 3D printing is used to create hearing aids and orthopedic and dental implants. In the mass sector, according to Nikolay Bobrov of Picaso 3D, 3D-printing will be most actively used for the manufacture of spare parts (for household appliances, cars, and so on), and for printing items designed to meet the needs of the family: assembly kits, toys and souvenirs. The German concern Siemens has announced its use of 3D printing for the production of spare parts for gas turbines, which, according to the company, will make it possible to reduce downtime due to repair work (in certain cases from 44 to four weeks) and lower costs. Siemens has also become the first company to use 3D printing for mass production of metal products. A number of large companies, such as EADS and General Electric, have spoken of implementing the technology in industrial production.

In August 2013, the American National Aeronautics and Space Administration (NASA) successfully tested the most complex rocket engine part ever created on a 3D printer — a nozzle which injects fuel into the engine using 40 distribution heads⁹³. The new

⁹³ <http://www.nasa.gov/press/2013/august/nasa-tests-limits-of-3-d-printing-with-powerful-rocket-engine-check/>



The Main Industries of 3D Printers Applications



Source: Wohlers Associates <http://makezine.com/2013/08/16/maker-pro-newsletter-24/>

technology made it possible to reduce production costs by over 70 % and the production time from one year to four months.

3D printing offers businesses a number of advantages, including reduction of production costs, rapid implementation of innovations, shortening of the supply chain, mass customization and the ability to launch new products on the market quickly. At present, however, there are certain impediments to the further spread and mass use of 3D printing. The most significant of these are the limited range and high cost of materials used, the high cost and complexity of modeling software and the lack of industrial standards in the sector.

TREND:

IMPROVEMENT OF PRINTING ACCURACY AND USE OF VARIOUS MATERIALS FOR PRINTING

Currently existing personal 3D printers can only use various plastics for printing, while the most advanced industrial devices have expanded the range of applicable materials to include certain metal alloys. One of the most promising areas for the development of 3D printing is the broadening of the range of materials used.

Accomplishing this task will make it possible not only to create objects with a set structure, but also complex objects

with set mechanical, electroconductive and optical characteristics which are capable of performing complex functions.

To achieve this objective, both the development of processing methods for existing materials and the creation of new ones are needed, as well as improvement of mechanical systems. Noticeable progress has been made in this field by teams from Princeton University, who were able to print an artificial ear from biomaterials and electronics, and also by representatives of Cambridge University who used retina cells to create eye tissues.

3D printing technologies are gaining popularity in Russia, where not only are objects being created with 3D printers, but there are also companies that manufacture their own devices. For example, work on the project for production of 3D printing devices commenced in 2011, and the Picaso 3D Builder became the first device to be mass produced in 2013 at the price of about RUB 85,000. The third generation of the device, called Picaso Designer, is currently available⁹⁴. Maket-City⁹⁵, a company from Kursk, offers the Lumen 3D printer, the construction of which is characterized by open development, making it possible to set a low price for the device, starting from RUB 39,000.

⁹⁴ <http://3dtoday.ru/3d-printers/picaso-3d/picaso-3d-builder/#description>

⁹⁵ <http://cnc.maket-city.ru/>

“The quality of Russian 3D printers today is on a par with well-known American counterparts,” says Nikolay Bobrov of Picaso 3D. “However, Russian companies can provide better quality in meeting the needs of the client: this includes technical support, maintenance and supervision of the use of a device, solving basic problems and troubleshooting within five hours.”

3D printing technology offers great potential for innovative development, and it could lead to changes in many industries. The governments of many countries are taking steps to stimulate investments in the development of this sector.

CASE

PUBLIC AND BUSINESS INITIATIVES FOR PROMOTION OF THE 3D PRINTING SECTOR

Russia: State investment funds are making investments in companies working on the development of 3D printing technologies. Another way of stimulating the development of the 3D-printing market in Russia is through government initiatives aimed at import substitution. “We expect sales of Russian equipment and services to grow in the B2G segment (schools, universities and state-owned companies),” says Nikolay Bobrov. “Another positive trend in terms of the development of the market is the growth of state investment in the upgrading and replacement of equipment in universities and laboratories.”

USA: In 2012, the American National Additive Manufacturing Innovation Institute (NAMII), founded by a consortium of business firms, research institutes and non-profit organizations, received federal funding in the amount of USD 30 million, and another USD 40 million was later contributed by the group's members. The institute's operations are aimed at accelerating the implementation of additive manufacturing. On 9 May 2013, the USA announced the expansion of its network of innovative research and development centers and public-private partnership, and also announced the allocation of an additional USD 200 million for the development of 3D printing.

China: The government plans to invest USD 245 million in the development of 3D printing over the course of seven years. The Asian Manufacturers Association plans to build ten 3D printing centers throughout China.

EU: Investing in the development of promising technological 3D printing solutions is to be one of the main methods for increasing the share of industrial production in the GDP from 16% in 2013 to 20% by 2020.

Great Britain: The government provides grants of up to USD 10 million for research and development of 3D printing technologies; in 2015 the creation of an Additive Technologies Center is planned, and the government has allocated £15.3 million (about USD 25 million) for its construction.

Canada: The Federal Economic Development Agency of Canada is investing USD 19 million in companies working on the development of 3D printing technologies.

Australia: State agencies are promoting the development of the 3D printing industry by organizing thematic conferences and seminars and by investing in research.

South Africa: The AeroSwift project developed by Airbus, in conjunction with the South-African Council for Scientific and Industrial Research (CSIR) and the South-African aircraft manufacturer Aerosud, launched in 2012, is aimed at developing ways of using additive printing from titanium-based materials to produce aircraft parts.

CLEAN TECHNOLOGIES AND ALTERNATIVE ENERGY SOURCES

Achieving the goal of reducing greenhouse emissions and the destructive impact of mankind on the Earth's climate while the rate of consumption of the planet's energy resources continues to grow requires, on the one hand, an increased use of clean energy sources, and on the other, optimization of current energy resources.

Even now, about 19% of all power consumed comes from renewable sources. In the past few years, the cost of generating power by means of wind turbines and solar batteries has fallen significantly, and more and more companies are looking at renewable sources as the most reliable and profitable. "In Europe, solar and wind energy sources are considered as not the alternative, but the main sources: in some buildings, up to 30% of the energy balance is provided by wind turbines," – Oleg Dmitriev, the founder of Vert Rotors company, which is engaged in the development of wave generators, says.

In order to continue the replacement of hydrocarbon-based fuels, ways have to be found of improving the efficiency of the transformation and storage of energy from renewable sources. Further advances in the technology of solar photocell production will help reduce the cost of power generation; new methods of energy storage and weather forecasts will help to increase the share of alternative energy sources in the total generation volume.

Reduction of power consumption is achieved through the use of intelligent systems capable of minimizing power consumption by households and businesses without human intervention and also of redistributing it so as to lower consumption during peak hours.

Apart from the growth of power consumption, increases in population augment the problem of the lack of clean drinking water, which is especially urgent in certain regions. Improvements in water treatment and desalination methods and the use of new materials for these purposes will make it possible to improve the effectiveness of the process and lower power costs, which will in turn expand the possibilities for their application.

SERGEY SUNCHUGASHEV

General Director
of EcoCat LLC

"Innovations in the manufacturing sector of the Russian economy emanate mainly from the Russian Academy of Sciences (RAS). Work done by scientists has resulted in inventions that have great value for businesses throughout the country. The duplication of innovative solutions generated by RAS institutions is many times less likely than the duplication of new solutions in the field of the Internet and IT. The RAS works in conjunction with industrial institutions and global business leaders, using the results of inventive activity to design innovative end products which are used by enterprises. For instance, EcoCat's main line of business involves deploying the results of intellectual activities of the Institute of Catalysis of the Siberian Branch of the Russian Academy of Sciences in the sphere of catalytic heating.

In order to establish a strong position in the global technology market the Russian Federation needs to give priority to the development of exactly such development centres, which currently account for significantly less investment than IT projects".

ETAY
ZETELNY

EY Israel, CleanTech
Advisory and Global Incentives
Groups Leader.

"Cleantech is maturing and scaling up globally. Today, renewable energy is the fastest growing energy source. Over the last 15 years the cost of onshore wind has fallen by 50%, and over the last 5 years solar prices have decreased by 80% and LED lighting prices by 85%, while energy storage has got 50% cheaper. Despite the reduction in subsidies, the total installed capacity is on the rise. During 2013 China invested 61B USD in renewable energy, USA 49B USD, and Japan increased its investment by 55% to a total of 36B USD. Annual new generation capacity worldwide increased by 83 GW.

One of the most interesting mega-trends in cleantech is the empowerment of customers. Energy transformation, the rapid growth of the "Internet of things" and the shift to mobile technology and applications are all transferring power to customers. New cleanweb technologies, the distribution of power generation, smart grids and smart homes, improvements in energy efficiency management tools and future trends such as electrification of transportation and energy storage are changing customers' experience and affecting the traditional utility business. New players such as Google, Apple, AT&T and new business models of energy optimization will keep the demand for cleantech solutions growing".

FURTHER DEVELOPMENT
OF ALTERNATIVE ENERGY
SOURCES

TREND:

DEVELOPMENT OF FORECASTING SYSTEMS

Given the lack of development in means of preserving energy, the main shortcoming of alternative energy sources, such as wind and solar energy, is the severe fluctuation in the level of the generation depending on weather conditions. The increased share of alternative sources in the total volume of the energy generated by energy companies gives rise to a need for energy back-up, i.e. the creation of other sources that are able to compensate for shortages of energy supply at particular times. Conventional power plants operating on hydrocarbon fuels are usually used for this purpose. This is an expensive solution, and the larger the volume of reserve energy needed, the greater the cost. Increasing the accuracy of forecasting may help to reduce the volumes required, thus reducing dependence on conventional fuels.

Global Installed Wind Generating Capacity, GW



4 bn USD
the potential economy due
to the improvement
of forecasting

The exact forecasting of weather conditions is especially needed in implementing ideas relating to the scheduling of energy consumption and conservation. Rechargeable batteries of electric cars have sufficient capacity to supply the electricity needs of a dwelling for several days. The use of the following arrangement for reducing the use of hydrocarbon energy sources is becoming possible with the growth in the take-up of electric cars, which may accumulate energy received from a solar array in the day-time, use it to supply power to rooms and premises in the evening, when demand is at its highest, and then recharge at night and in the morning using energy received from wind turbine generators. The National Renewable Energy Laboratory in the USA, in partnership with energy companies, manufacturers of transport vehicles and charging plants, is developing a plan aimed at the integration of electric cars.⁹⁶

TREND:

REDUCTION IN THE COST AND INCREASE IN THE EFFICIENCY OF SOLAR CELL ARRAYS

The share of renewable energy sources in the total volume of electric power produced in the world is continuing to rise. The greatest growth among alternative sources in relative terms in 2013 occurred in the solar power sector, which increased 28% during the course of the year. In absolute terms it was second only to hydropower: the increases amounted to 39 and 40 GW respectively.⁹⁷

⁹⁶ http://www.nrel.gov/vehiclesandfuels/project_ev_grid_integration.html

⁹⁷ Renewables 2014 Global Status Report, Table R1. <http://www.ren21.net/ren21activities/globalstatusreport.aspx>

CASE

WEATHER FORECASTING INSTRUMENTS OF THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH FOR XCEL ENERGY

A number of years ago, Xcel Energy, an energy company providing energy services to 3.3 million electricity consumers, used wind energy forecasts based on data from two meteorological stations located at wind farms. The differences between the forecast and actual figures were 20% on average, and, in some cases, the forecast was not justified at all. This meant that the full volumetric capacities of wind turbines had to be backed up.

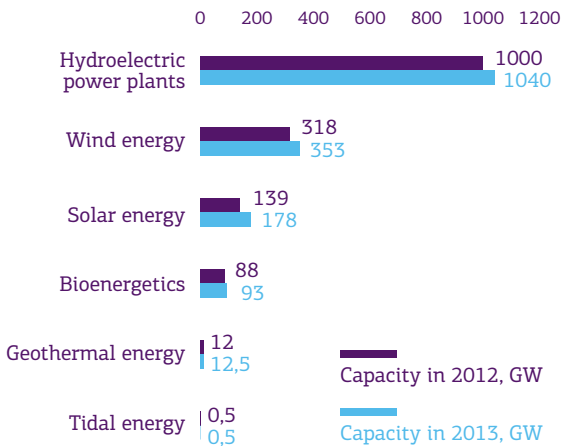
The monitoring solution of the National Center for Atmospheric Research (NCAR) collects information from a large number of wind generators, and then uses these data to form a forecast that is combined with forecasts from five other independent sources. Then, the most probable forecast for each wind farm is determined with the use of historic data on weather conditions. Based on the forecast produced, the volume of capacity expected to be generated by a wind farm at fifteen-minute intervals is calculated for the next seven days.

The forecast obtained through the new system is significantly more accurate than the previous system, allowing the company to suspend the operation of a number of conventional-fuel-based stations. The forecasting system is used in six U.S. states, including Colorado, Minnesota, New-Mexico, Texas and Wisconsin, covering more than 3,000 turbines, and its application has enabled Xcel Energy to increase the share of wind energy in the generated volume to 30% and to save up to USD 6 million per year.⁹⁸ On one weekend in 2013 more than 60% of electricity in Colorado was sourced from wind farms, which is a record figure.

The next stage of the development of the NCAR forecasting system will be the preparation of forecasts for the generation of solar energy, using data from satellites, thermovisors and pollution monitors and from publicly owned solar arrays.

⁹⁸ <http://www2.ucar.edu/atmosnews/news/5771/ncar-wind-forecasts-save-millions-dollars-xcel-energy>

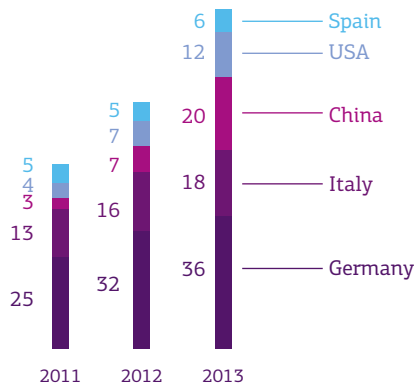
Total Capacity of Alternative Electric Energy Sources in the World in 2012 and 2013, GW



The main generating capacities of solar power engineering are still centered in Europe (Germany, Italy, Spain and France), as well as Japan, the USA and China. In this respect, in 2013, China was in second place after Germany in terms of the capacity of its solar power plants, which increased almost threefold to 19.9 GW (compared with the 35.9 GW capacities of Germany's solar plants).

The popularity of solar power engineering may be explained by the continued reduction in the manufacturing cost of photocells (generally based on polycrystalline silicon), improvements in manufacturing methods and economies of scale. In 2013, large Chinese manufacturers achieved a solar electricity cost of 0.5 US cents per 1 W. There is a continuing trend in favor of the relocation of photocell manufacturing from Europe, the USA and Japan to developing markets: in 2013, over 87% of production was manufactured in Asia, including 67% in China.⁹⁹

Solar Electricity Generation in the 5 Biggest Countries, GW



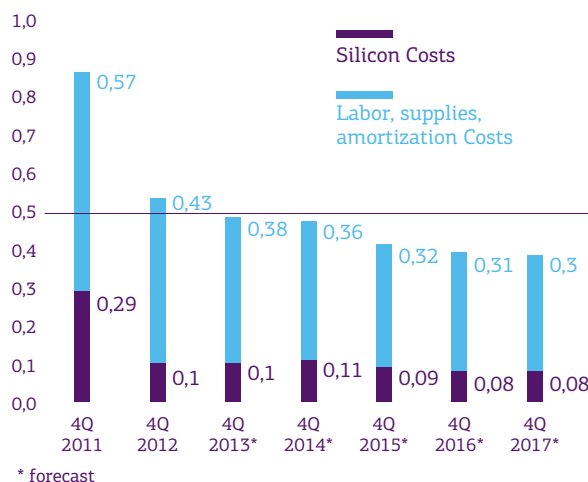
The cost of installed solar energy systems has also decreased, though not as fast: in the US, the cost of a roof-mounted solar cell array has fallen by 37%, with approximately 80% of this reduction attributable to the cost of photocells.

Solutions with innovative materials are also being developed alongside improvements in existing photocell production technologies. Thus, new photocells based on calcium titanate may reduce the cost of production of a solar cell array by more than 4 times.

The rapid improvement in solar power engineering technologies is explained in particular by intensive investments in this area: in 2013, USD 113 billion was invested in this trend, which is more than a half of the entire volume of investments in alternative energy sources.¹⁰⁰

⁹⁹ Renewables 2014 Global Status Report, SOLAR PV INDUSTRY. <http://www.ren21.net/ren21activities/globalstatusreport.aspx>
¹⁰⁰ Renewables 2014 Global Status Report, Table R11. <http://www.ren21.net/ren21activities/globalstatusreport.aspx>

The Costs of Photovoltaic System Production by the Most Efficient Manufacturer in China, dollars/W



Source: Global PV Competitive Intelligence Tracker.

In Russia, the total capacity of solar generation in 2012 was no more than 5-6 MW, accounting for 0.003% of the total established capacity of electric power plants (223 GW).¹⁰¹ This state of affairs may be explained by the lack of stimuli for the use of alternative energy sources, as Russia is not dependent on foreign energy resources, being, on the contrary, a major exporter of those resources.

Additionally, the larger part of the Russian Federation is characterized by a low insolation level of no more than 3-3.5 kWh/m² per day. A maximum solar radiation level of no more than 5 kWh/m² per day is found only in certain regions of Eastern Siberia and the Russian Far East, which are notable for their underpopulation and low economic indicators.

The regions of the Southern and Northern Caucasus and the Central Federal District, in which economic potential combines with solar insolation, are the most favorable for the construction of solar power plants. The first solar power plant was built in Russia in November 2010 at Krapivenskie Dvory in the Belgorod Oblast, with a designed capacity of 133,400 kW*h per year.

¹⁰¹ http://minenergo.gov.ru/activity/powerindustry/powersector/structure/manufacture_principal_views/

CASE

IMPROVEMENT OF THE CHARACTERISTICS OF AMORPHOUS HYDROGENATED SILICON

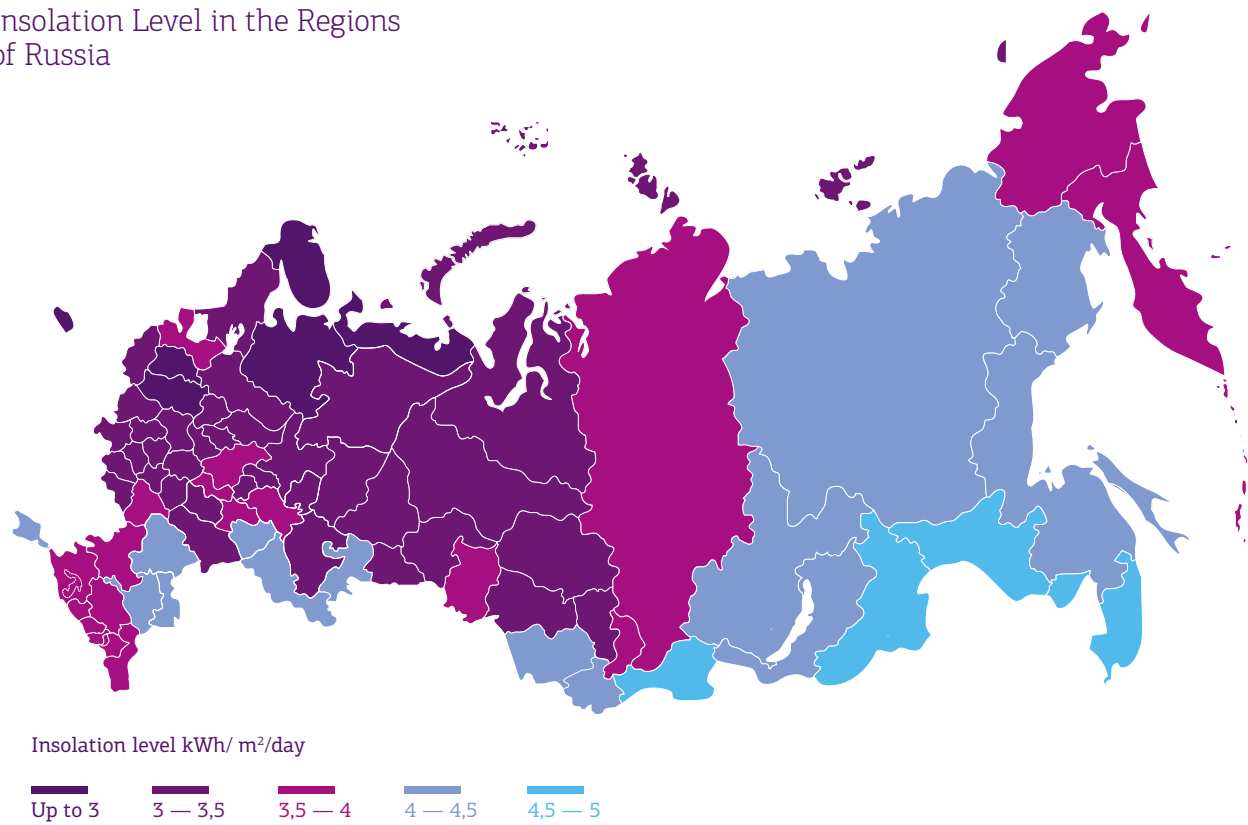
The main shortcoming of amorphous hydrogenated silicon, which is used in the production of thin film modules, is the deterioration of its optical and photoelectric characteristics when exposed to sunlight, resulting in decreased efficiency of solar cells. In order to rectify this fault, silicon nanocrystals are added to amorphous silicon, but increasing the volumetric proportion of nanocrystals above a certain level causes the photoelectric properties of the amorphous silicon to deteriorate, which is why it is important to determine the optimum level of additions.¹⁰²

Workers at the Physics Faculty of Moscow State University and the Ioffe Physical-Technical Institute have determined optimum levels of added silicon crystals for the purpose of eliminating degradation and preserving the properties of amorphous silicon, as well as offering means of obtaining a material that is compatible with existing industrial technologies.

The technological parameters of the formation of the material were developed at the Ioffe Physical-Technical Institute. The results of the project had a practical application: the technology developed for the production of modified amorphous silicon may be used at the Havel factory for the manufacture of thin film solar modules, as it is completely compatible with company's technological processes

¹⁰² http://www.strf.ru/material.aspx?CatalogId=222&d_no=52427

Insolation Level in the Regions
of Russia



The cost of electricity generated by the Krapivenskaya electric power plant is RUB 9 per kW*h. Although the cost of electricity at the nearby Kursk Nuclear Power Plant is lower, amounting to RUB 2.3–4 per 1 kW*h, it is much more profitable to build a new solar power plant than to build new power lines and distribution stations¹⁰³. In addition, the cost of the production of electricity generation is expected to reduce as the volume generated increases.

Russia also has plants for the production of photovoltaic modules. For instance, the solar cell arrays based on polycrystalline silicon that were used in the con-

struction of the Krapivenskaya electric power plant were produced at the Ryzan Metal Ceramics Instrumentation Plant (RZMKP).

Developments in the manufacture of second-generation photoelectric transducers based on light films are an upcoming trend. The technology of manufacturing thin film modules is less energy-intensive and enables the production of flexible, inexpensive modules with a large surface area, though at the cost of reducing their efficiency. In 2014, Hevel began manufacturing thin film modules using the Oerlikon Solar production line in Novocheboksarsk. The project

resulted in the creation of a fully integrated enterprise with a capacity of 130 MW per year¹⁰⁴.

It is anticipated that products made by this enterprise will be supplied to countries of Southern Europe (Italy, Spain and Greece) and Germany, while up to 15% of the modules will eventually be sold in the Russian market.

¹⁰³<http://www.kommersant.ru/doc/1536273>

¹⁰⁴<http://www.rusnano.com/projects/portfolio/hevel>

CASE

USE OF PEROVSKITE FOR THE MANUFACTURE OF PHOTOCELLS

Perovskite (calcium titanate), which was discovered in the Urals in 1839, may serve as a material for the creation of cheaper and more efficient photocells than those currently on the market. The United States Department of Energy estimates that the cost of electricity generated by the most widespread silicon-based photocells amounts to 0.75 US dollar per 1 W, while generation by fossil fuels amounts to 0.50 US dollar per 1 W. The use of perovskite would enable the production of photocells generating electricity at a cost of 0.10-0.20 US dollar per 1 W.¹⁰⁵

Perovskite, first used in photocells in 2009, showed a low efficiency in converting solar energy into electricity — approximately 3.5%. Additionally, the use of liquid electrolyte resulted in rapid dissolution of the mineral, making it unsuitable for mass use. Through the development of technologies over the next few years and the replacement of liquid electrolyte with solid materials, Michael Gretsel, the creator of the cells of the same name, achieved 15% solar energy conversion into electricity in perovskite-based photocells. This indicator in polymer solar cells or standard Gretsel cells represents a lower level of solar energy conversion into electricity than in photocells based on crystalline silicon. Nevertheless, the major advantage of a material such as perovskite is its low cost.

Perovskite-based materials do not require power-intensive and complicated manufacturing processes; unlike in the case of crystalline silicon, neither a vacuum chamber

nor high temperatures are required, nor does the material have to be at a super-high level of purity. In addition, the low thickness of perovskite cells (1 micron, compared with 180 microns for silicon-based cells) means that the consumption of material is also reduced, as is the weight of the final structure. At the same time, perovskite can be applied to various surfaces, such as windows and walls.

Henry Snaith of Oxford University has organized the Oxford Photovoltaics start-up for the commercialization of the technology. By July 2013, the company had attracted £4.4 million in investments, and employed 14 people.¹⁰⁶ As noted above, the manufacturing processes for perovskite-based solar cells manufacturing are quite simple: it may take the form of spraying liquid material over a surface or sedimentation from the gaseous state. On the other hand, experience shows that establishing a large manufacturing enterprise would take more than 10 years, and the price of silicon-based solar cells might reach USD 0.25 per 1 W within that time, which would level down the advantages of perovskite¹⁰⁷.

One possible alternative application for the material might be to boost the efficiency of conventional solar cells by applying a film made of perovskite material to the surface of the photocells. This would increase the price of the product by no more than by 20%. In the long run, it would enable the achievement of a reduction in the cost of electricity generation.

¹⁰⁵ <http://www.technologyreview.com/news/517811/a-material-that-could-make-solar-power-dirt-cheap/>

¹⁰⁶ <https://www.innovateuk.org/-/the-future-of-solar-power-is-oxford-photovoltaics>

¹⁰⁷ <http://scitechdaily.com/oxford-researchers-creating-simpler-cheaper-solar-cells/>

INTELLIGENT SYSTEMS FOR CONTROLLING POWER CONSUMPTION

TREND:

INCREASED PRESENCE OF SYSTEMS FOR CONTROLLING POWER CONSUMPTION

Global power consumption is expected to show a 56%¹⁰⁸ increase by 2040. Though the share of alternative energy sources is increasing, hydrocarbon fuels will cover up to 80% of energy production, causing an inevitable increase in the level of polluting emissions into the air.

About 40% of all energy consumed is used jointly by households and commercial buildings for the purposes of heating, cooling and lighting¹⁰⁹. According to experts, about 39% of this energy is used unnecessarily or lost¹¹⁰. Intelligent systems used to control power consumption in buildings may provide power savings of up to 30% on current consumption levels¹¹¹. As a rule, such systems for increasing the efficiency of resource consumption form part of automated building management systems comprised in the concept of a smart home.

Smart homes are capable of recording and monitoring the consumption of resources (power, gas and water) by managing the system of lighting, heating, ventilation and electrical appliances. For these purposes, data is collected from sensors located inside the building and use is made of information on current weather conditions and forecasts, the

time of the day and other factors.

The idea is gaining popularity as it becomes more and more affordable through the use of integrated systems combining sensors, electrical appliances and power generators; such systems are also facilitated by the growing penetration of smartphones used to manage them. It is expected that, by 2020, the smart homes market will have a turnover of USD 52 billion, meaning an annual growth level of 18%.¹¹²

Sensors and detectors are also becoming more affordable. Today one can buy a smart programmable thermostat for just USD 150-USD 200. The most popular of these devices is the Nest Labs thermostat equipped with a humidity detector, luminance sensor and motion detector. What is special about the Nest Labs product is that it can be taught. The thermostat enables you to set the desirable temperature via the Internet. It also accumulates information on the users' preferences and either cools or heats the house before the residents are back. The device is also equipped with a motion detector enabling it to identify when no one is present in the room and to decrease the power consumption. In

February 2014, Nest Labs Company was purchased by Google for USD 3.2 billion, which will enable it to keep developing its products and to conquer international markets using the experience gained by the world's largest search engine.

Intelligent energy management system technologies represent a promising area for the Russian market. However, the deployment of such systems is a high-tech undertaking and requires significant investment. At present, investments made by domestic energy companies are geared towards addressing urgent issues, such as the upgrading of basic equipment.

It would be premature to expect the rapid widespread deployment of "smart" network technology in the Russian energy sector, but today, pilot projects are being implemented in this area, one of them in the North-West Federal District. This region was selected owing to the existence of unresolved problems there, and in particular the need to increase the transmission capacity of transmission lines, create redundant power systems and improve the reliability and quality of the power supply to consumers in St Petersburg. Elements of "smart" networks are implemented not only in the region's primary grid but also in distribution networks. This involves both the installation of smart meters for consumers and the implementation of software solutions for the processing of measurement signals and automated management of consumption and emergency modes.

¹⁰⁸ <http://www.eia.gov/todayinenergy/detail.cfm?id=12251>

¹⁰⁹ <http://www.eia.gov/tools/faqs/faq.cfm?id=447&t=1>

¹¹⁰ <http://www.bems.trendcontrols.com/en/>

¹¹¹ http://www.knx-gebaeudesysteme.de/sto_g/English/GENERAL_DOCUMENTATION/2CDC500060M0201_HB_EnergyEfficiency_EN.pdf

¹¹² <http://www.prweb.com/releases/smart-homes-market-2020/analysis-and-forecasts/prweb11302579.htm>

CASE

SMART DEVICES USED TO ADJUST POWER CONSUMPTION PATTERNS ACCORDING TO THE TIME OF THE DAY

You can save power costs by adjusting consumption in the course of the day and consuming less during the high-peak morning and evening hours and more during low-peak hours at night. To do this you need tools to monitor and manage power consumption and options for the application of lower tariffs during off-peak hours.

Intelligent power accounting is possible through 'smart meters' and is an integral part of smart power networks. An average consumer takes the readings of their power meter once a month at most. Smart meters, on the other hand, are capable of transmitting readings to the power provider much more often.

Beside, such smart meters are able to meter the consumption rates of particular electrical appliances and inform the user accordingly, thus enabling the user to analyze and control the power consumption for those appliances. The 'smart meters' used under the "10,000 Smart Meters" program by E.ON made it possible for households to reduce consumption rates by 10% over 18 months¹¹³. "In the UK, interaction between the user and the energy supplier is fully automated, so that even meter readings are recorded automatically", – Oleg Dmitriev says.

As mediators between electricity producers and consumers, smart meters receive updates on tariffs from the powergenerating companies. Such meters are able to advise users on the best times for using power-intensive devices, or even to control power consumption without the user's involvement, e.g., by switching on a washing machine during the night hours when the lowest power tariffs are applicable.

Miele, the German manufacturer of domestic appliances, makes its products (such as washing machines, dishwashers, clothes dryers etc.) compatible with 'smart electricity networks', i.e., such devices can be switched on by signals received from the Meile@home gateway. Such devices also have options for exchanging data with other available smart systems; for example, a device can switch on appliances under its control once it gets confirmation that enough power is being generated by solar batteries installed on the roof.

Adjusting the power consumption schedule can save costs only if load-rate tariffs are available. Wholesale prices for electricity are subject to the flow of demand and vary significantly in the course of a day and week. Retail prices are generally set at a fixed rate. In 2012-2014, the power generating company providing power to Sacramento, CA, carried out a pilot project introducing load-rate tariffs¹¹⁴ that were varied according to the flow of demand. The purpose of the project was to ensure correspondence between wholesale and retail tariffs. As a result of the pilot project, power consumption during peak hours fell by 26%, and only 10% of consumers opted out of the dynamic tariff plan. By 2018, the company plans to apply load-rate pricing to all consumers with a view to eventually reduce peak-hour power tariffs.

¹¹³ Greentech 3.0 made in Germany

¹¹⁴ <http://www.utilitydive.com/news/dynamic-pricing-pilots-5-utilities-programs-technology-and-results/152381/>

VYACHESLAV DZYUBENKO

Technology&Manufacturing
Director, RM Nanotech

"Our country has significant potential for research and development in the field of membranes and membrane equipment. The history of the development of membrane technology in Russia is inextricably connected with the establishment and development of Membranes Interbranch Scientific and Technical Complex (ISTC) more than 40 years ago. It was on the basis of ISTC that the Vladipor Scientific and Technical Center was established in 1998. The Vladipor Scientific and Technical Center is the initiator of the Russian Membranes Project for the execution of which RM Nanotech was founded in 2010.

RM Nanotech exports more than 50% of its products and is highly competitive with European manufacturers in terms of the quality of water purification membranes.

The main competitors of RM Nanotech on the global market are the USA membrane manufacturers which either produce entirely new membranes or upgrade existing models every three years. In order to remain competitive, RM Nanotech continues to invest to R&D, including the development of new membrane forms tailored to specific applications, thanks to the project initiator and shareholder Vladipor, a science and technology center that has transferred its membrane studies and technological advances, and in view of the high demand for better quality water".

INNOVATIVE TECHNOLOGIES FOR WATER TREATMENT AND DESALINATION

TREND:

INCREASING ENERGY PERFORMANCE OF WATER TREATMENT AND DESALINATION TECHNOLOGIES

The problem of the shortage of safe drinking water is already a pressing issue and is set to become more and more acute as the world population grows. Existing technologies for water purification and desalination are very power-intensive, making them too expensive to be applied on a large scale. The general trend is toward the use of innovative materials and improved technologies in order to increase performance.

Improvement of purification technology can provide reduced power consumption and increased portability of systems by using new materials and applying innovative technologies. These new materials include membranes based on extra-long carbon nanotubes as well as biomimetic membranes based on the same principles as aquaporins. Aquaporin is a Danish company engaged in the commercialization of aquaporins (proteins discovered in 2003); it announced that its products will be available for commercial use with effect from 2014.

CASE

WATER PURIFICATION MEMBRANES BASED ON EXTRA-LONG CARBON NANOTUBES

In 2013, researchers at the Singapore University of Technology and Design announced that they were developing membranes based on extra-long carbon nanotubes capable of absorbing salts, organic impurities and pollutants from various solutions¹¹⁵. The material presented has an unprecedentedly high salt adsorption capacity that is 100 times greater than the capacity of similar filters using activated carbon.

Researchers say that their method provides 70% purified water output, which is comparable with the performance rate of a major industrial-scale reverse osmosis system requiring much higher pressure. This technology allows the portable high-performance water purification systems to be created and presented to the market.

¹¹⁵<http://www.nature.com/ncomms/2013/130813/ncomms3220/full/ncomms3220.html>

DEVELOPING ENERGY STORAGE TECHNOLOGIES

TREND:

ENERGY STORAGE TECHNOLOGIES APPEAR AS THE SHARE OF ALTERNATIVE POWER SOURCES INCREASES

With improvements in alternative sources of power and the continued growth in their share of total energy generated, the problem of energy storage is becoming increasingly topical. However, new solutions to address this problem are not being developed at a fast enough rate.

Accumulator batteries used by a wide variety of devices (from home appliances to electric cars) are the most popular solution for conserving energy. Projects aimed at expanding the use of accumulator batteries are in evidence all over the world.

Germany, the world leader in the use of alternative power sources, is promoting development in this area by subsidizing new solutions to conserve alternative energy (mainly acid and lithium-ion batteries). The project was launched in 2010 and by 2013 it had been allocated EUR 32 million in the form of preferential-term loans and EUR 5 million in the form of grants.¹¹⁶

In 2013, the state of California enacted a decree obliging power companies to provide for the storage of at least 1,325 MW by 2020 (storage technologies may include accumulator batteries without limitation).

However, experts believe that accumulator batteries will provide adequate energy storage only in the short-term future, and will fall short of covering consumer demands in the long term; besides, since accumulators do not have proper energy-saving properties it is essential for other methods to be developed, including chemical (e.g., hydrogen-based) methods and compressed air energy storage.¹¹⁷

CASE

USING COMPRESSED AIR TO STORE ENERGY

The basic principle consists of using alternative sources of power to compress and cool gas stored in gas chambers (for which purpose underground caves are used) at a pressure of 60-70 standard atmospheres. When the stored energy is needed, the air is released from storage and heated, activating a gas turbine that generates power. This method is not new. It was patented in 1948 and is used by Huntorf (Germany) and McIntosh (USA) power plants. The drawback it has is the low thermal efficiency (40-50%), which is due to the fact that much energy is lost at the stage of compressing the gas and this energy has to be compensated to the compressed air in order for it to be used in the turbine. The air is heated using traditional hydrocarbon fuel.

The ADELE Project carried out by General Electric, the German companies RWE and Züblin and the German Aerospace Centre is aimed at increasing the efficiency level of this method to 70% through the use of an adiabatic process (which means that heat does not enter or leave the system). It is supposed that heat generated in the course of compressing the air will be accumulated and then returned to the air once it is released. A demonstration plant based on this principle with a capacity of 1 GWh and an output of 200 MW is expected to be ready by 2016.

¹¹⁶ <http://reneweconomy.com.au/2013/germany-finances-major-push-into-home-battery-storage-for-solar-58041>

¹¹⁷ <http://www.greentechmedia.com/articles/read/the-long-term-storage-challenge-batteries-not-included>

CASE

USING HYDROGEN FOR ENERGY STORAGE

Using hydrogen for energy storage involves using excess solar or wind energy to electrolyze water (split it into oxygen and hydrogen). The hydrogen may then be accumulated and used separately (e.g., in power cells) or as part of a process to obtain methane (e.g., through a Sabatier reaction). The advantage of this solution is the option to use the existing gas distribution network.

The process of electrolyzing water requires new facilities. It should be noted that, unlike storage plants, such facilities are quite compact, do not involve much capital investment and may be installed almost anywhere. The hydrogen generated may be used not only to generate power but also for production and transportation purposes.

Though the hydrogen energy storage solution is easy to implement, its performance index is low, i.e. ~ 60% of the initially generated power is lost. In view of this fact, work needs to be done to improve the efficiency of this technology.

In November 2013, a German company named Thuga supplied¹¹⁸ hydrogen that it generated by electrolysis to the gas distribution network. After 2014 it is expected to take two years to carry out pilot testing of a 315 kWh unit producing 60 cubic meters of hydrogen per hour. The fuel used is hydrogen-enriched natural gas, which has a 50% lower nitrogen oxide emission rate than standard natural gas. After 2016, it is planned to improve the engineering process to achieve full conversion of hydrogen into natural gas for supply to the gas distribution network.

In France, the GRHYD project scheduled for 2013-2020 is being carried out jointly by GDF Suez S.A. and AREVA. This project also involves obtaining hydrogen using excess solar or wind energy and then supplying it to the gas distribution network for space and water heating or using it as fuel.¹¹⁹ A similar project for using hydrogen to store energy was launched in 2013 in the Apulia region (Italy) and in Canada.

¹¹⁸ <http://energytransition.de/2013/12/p2g-gets-going/>

¹¹⁹ <http://www.gdfsuez.com/en/gdf-suez-at-the-center-of-the-national-debate-on-energy-transition/power-to-gas-an-innovative-solution/the-grhyd-demonstration-project/>

ELECTRIC CARS

TREND:

EMERGING ELECTRIC CAR MARKET

By 2014, sales of electric cars are expected to increase by 86%, amounting to 346,000 per year.¹²⁰ The major electric car markets will still remain the USA, Europe (the Netherlands, Denmark, and Norway) and Japan. In Norway, around 20% of all cars sold are electric vehicles, while in the UK electric cars will account for 2-3 % of the market by 2020.¹²¹

Competition is becoming more and more intense both in terms of the luxury cars market, in which players such as Audi (e-tron), BMW (i8, i3), Cadillac (ELR), Mercedes (B-Class Electric Drive), Saab and Volvo are competing with Tesla Motors, as well as in the area of low-cost cars (Nissan, Kia, and Volkswagen are expected to offer their own models).

The ever increasing popularity of electric cars is driven both by government incentives and by the enhanced performance and reduced prices of electric cars.

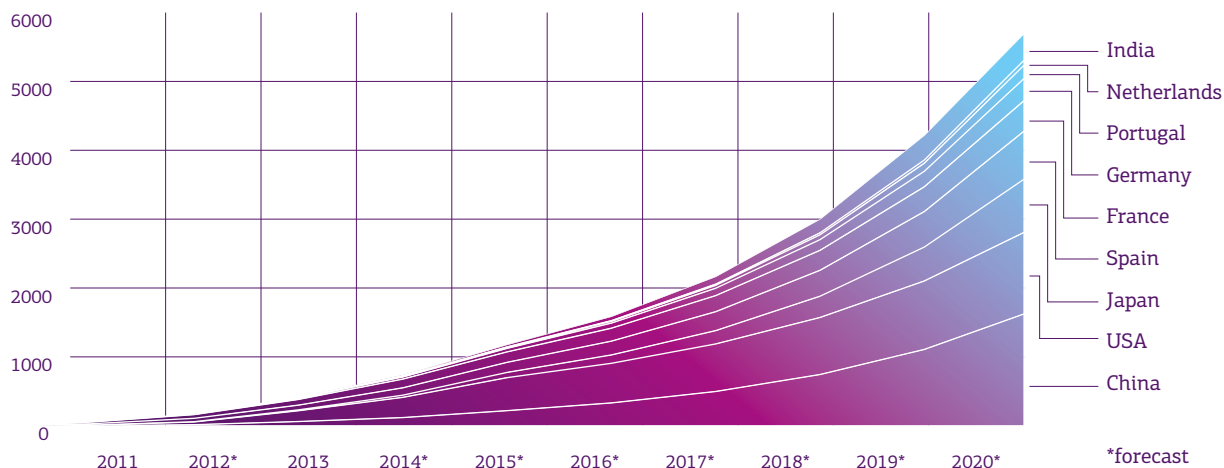
The Zero Emission Vehicle (ZEV)¹²² Project carried out by the authorities of California (USA) is aimed at decreasing automotive pollutants and sets minimum targets for the percentage of electric cars within the overall volume of car

¹²⁰ <http://www.navigantresearch.com/research/electric-vehicles-10-predictions-for-2014>

¹²¹ <http://www.theguardian.com/environment/2014/may/03/uk-electric-car-sales-speed-up>

¹²² http://www.arb.ca.gov/msprog/zevprog/zevregs/1962.2_Clean.pdf

Electric Vehicle Sales by Country, thousand vehicles



Source: http://www.iea.org/publications/globalevoutlook_2013.pdf.

sales. The targets are 2% by 2018 and 10% by 2022. It should be noted that instead of manufacturing electric cars itself, a company may purchase so-called ZEV credits from other manufacturers that have enough of them, such as Tesla Motors. The system will eventually lead to an increase in sales of electric cars. So far, seven other states have partially joined the California project, and more states are expected to join.

At the beginning of 2014 the UK prolonged by two years its program offering GBP 5,000 grants to those who purchase electric cars. In addition, GBP 100 million was allocated for scientific research in this area, GBP 50 million for the green car program and GBP 5 million was for the program of electric cars for civil servants.

In Russia, however, the electric car market is only just getting started. At present, apart from certain models manufactured in China, the country officially imports only the Mitsubishi i-MiEV model. In 2013, just 100 of these cars were sold (in total, about 200 electric cars have been sold since the market launch). To put this in context, in the same year, 2.78 million¹²³ internal combustion engine cars were sold. In 2013, 97,000¹²⁴ electric cars were sold in the USA (accounting for 0.6% of total motor car sales); in the same year, 30,000¹²⁵ electric cars were sold in Japan and 23,000 in the Netherlands.

By the end of 2013, Russia decided to cancel its 19% import duty on electric cars. Renault announced that it is ready to import its electric cars to Russia; however, most manufacturers have adopted a wait-and-see approach.

Russian manufacturers are also developing electric cars of their own (such as the Lada Ellada by AvtoVAZ, based on the Lada Kalina model). The batteries that the Ellada is equipped with enables the user to drive 140 km, and it takes 8 hours to charge the battery using your home socket. The Stavropol Krai authorities have launched a pilot program that involves purchasing 100 electric cars to be used as taxis at the Caucasian spa resorts. The first five electric cars under this project were supplied in January 2013, and 30 more electric cars were delivered to dealers for test drives.

¹²³ <http://www.aebrus.ru/en/press-releases/sales-of-cars-and-light-commercial-vehicles.php>

¹²⁴ <http://www.hybridcars.com/december-2013-dashboard/>

¹²⁵ <http://evobsession.com/japan-electrified-vehicle-sales-2013-report/>

Technical Characteristics of the Most Popular Electric Cars

Electric car models	Average Price, USD	Drive Range, km	Charging time (min/hours)
Tesla Model S	69 900	335	40 min
BMW i3	41 350	129-161	30 min
Chevrolet Volt Plug-in-Hybrid	39 145	61	4 hours
Nissan Leaf	28 800	121	4 hours
Toyota Prius Plug-in-Hybrid	32 000	17	1,5 hours
Ford Focus Electric	39 200	122	4 hours
Honda Fit EV	36 625	132	3 hours
Smart ForTwo Electric	28 800	109	6 hours
Chevrolet Spark EV	27 495	132	7 hours

Source: <http://www.statista.com/chart/1787/electric-and-hybrid-vehicles-by-the-numbers>.

The factors deterring Russians from purchasing electric cars include their high price and the lack of charging infrastructure. On average, electric cars cost twice as much as similar internal combustion engine cars. After the import duty was cancelled, the price of an officially imported Mitsubishi I-MiEV car decreased from RUB 1.8 million to RUB 999,000, and a Lada El-lada may be purchased for RUB 1.25 million or more (whereas Lada Kalina may be purchased for just RUB 400,000). The absence of charging infrastructure is the other reason preventing electric cars from entering the market. Basically, your electric car may be charged at home, but it will take 6 to 8 hours. As of now, Russia has approximately 200 fast-charging points (enabling your car battery to be charged to 80% of capacity with-in just 15-20 minutes), 50 of them in Moscow. By way of comparison, Europe has around 15,000¹²⁶ fast-charging points, and the USA around 8,000.¹²⁷

The situation in this segment could be changed through government incentives to help the industry, e.g. by applying similar measures to those used in Europe and the USA, such as permitting electric cars to drive in bus lanes or offering owners of electric cars free parking.

TREND:
DEVELOPMENT OF RENT-AN-ELECTRIC-CAR SERVICES

Rent-a-car services for cheap trips within the city are becoming more and more popular. Experts¹²⁸ say that in the USA such services will use more than 22,000 cars by 2014, while in Europe, by 2020, the overall vehicle fleet will reach the level of 240,000 cars (for reference: in 2011 these services had a fleet of 21,000 cars) and the number of people using them will increase during the same period from 700,000 to 15 million people.

One of the reasons for the increased popularity of rent-a-car services is that they use electric cars that are more compact in size than traditional cars, making them more convenient when it comes to parking. Even basic-configuration electric cars include GPS navigators, and they are less expensive to maintain than cars based on the internal combustion engine.

¹²⁶ <https://www.plugsurfing.com/en/charging-station-list>
¹²⁷ http://www.afdc.energy.gov/fuels/electricity_locations.html
¹²⁸ Navigant Research's

AutoLib rent-a-car service offers only Bollore BlueCar electric cars, and the company has displayed sustained growth since its incorporation in the late 2011. By the end of 2014, it plans to expand its network in and around Paris to 3,000 electric cars. The company also plans to expand into other French cities (such as Lyon and Bordeaux) and to enter the USA market (Indianapolis, Indiana). Major manufacturers such as BMW or Daimler are also developing this type of service using electric cars. In view of the foregoing, we can expect electric cars to be further promoted.¹²⁹

TREND:

ENHANCED BATTERY PERFORMANCE AND CREATION OF WIRELESS CHARGERS FOR ELECTRIC CARS

Despite the impressive progress made by the technology, battery capacity (limiting driving distance) remains a constraining factor for the popularity of electric cars. As of now, there is only one model (namely, the Tesla Model S) that has a driving distance exceeding 400 km without recharging; however, its minimum price is USD 71,000. More affordable electric cars have a driving distance below 160 km.

Tesla Motors has announced its commitment to increase battery capacity without increasing the price. By 2017 the company expects to present its Tesla Model 3, providing a driving distance of 320 km

without recharge; it will have a starting price of USD 35,000. Experts estimate the price of the Tesla Model S battery at USD 15,000, and the manufacturer expects to reduce this by 30% by using batteries of its own, manufactured by the plant that it runs jointly with Panasonic. LG Chem also announced that, by 2017, it expects to present a car battery providing a driving distance of 320 km; the price of the battery is expected to vary between USD 30,000 and USD 35,000.¹³⁰

Another possible solution to deal with the low capacity of electric car batteries is for wireless chargers to be installed along highways and roads. The first commercial samples are expected to be presented in 2014. The know-how used to create such devices involves the wireless transfer of electric power through electromagnetic induction (meaning that electric power would be transformed into an electromagnetic field with the aid of a special device to be incorporated in the road bed, and electric power would then be absorbed by a special receiving device attached to the bottom of the car).

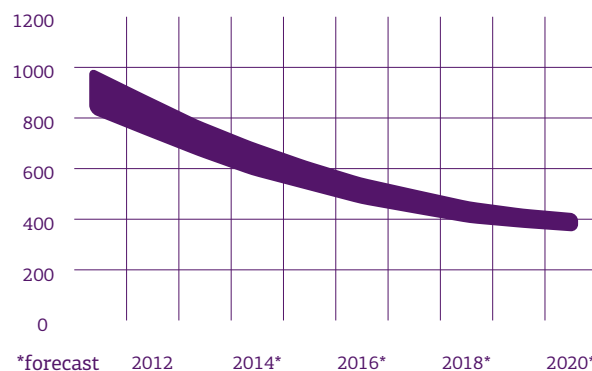
This technology would make it possible for an electric car to be charged during short stops, removing the need to increase battery capacity for city electric cars. The Society of Automotive Engineers is expected to develop standards for the frequency and capacity of electric cars, which represents an important new step in the development of this technology. The standardized parameters would make it possible for wireless chargers to be used by cars manufactured by different companies, thus facilitating the take-up of electric

¹²⁹ <https://us.drive-now.com/>

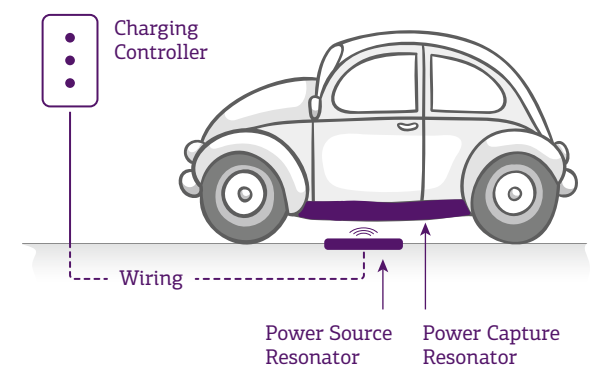
¹³⁰ <http://online.wsj.com/articles/>

lg-chem-working-on-battery-to-rival-teslas-range-1407776312

Estimated Cost of Electric Vehicle Batteries
up to 2020, Dollars/kWh



Pattern of Operation of Wireless EV
Charging System



cars on the Russian market.

Tests carried out by Qualcomm and Bosch on their Halo WEVC and Plugless Power batteries respectively have proved to be a success. Plugless Power batteries are already available for sale in the USA; this model is compatible with the Nissan LEAF and the Chevrolet Volt, which are already available on the market.

Another promising area of development in wireless power transfer consists in chargers being incorporated into the road bed, providing in-traffic recharging for electric vehicles. Such chargers, based on the same technology as fixed wireless chargers, would be useful for electric public transport vehicles operating on circular routes. This new technology would make it possible to reduce the capacity (and weight) of batteries, thus making the vehicles cheaper and reducing power consumption.

CASE

SOUTH KOREA LAUNCHES DYNAMIC WIRELESS CHARGER FOR ELECTRIC BUSES

In neighborhoods of Gumi City, South Korea, vehicles using dynamic wireless chargers have been tested under real operating conditions since 2013. Under the OLEV (Online Electric Vehicle) Project there are two buses serving the city and using the shaped magnetic field in resonance technology for recharging. This technology was developed at KAIST, the leading Korean public research university. It involves the use of underground cables that are positioned at a shallow depth beneath the asphalt and generate a magnetic field; the buses are equipped with devices to convert the magnetic field into a direct current that is stored in a low-capacity accumulator.¹³¹

Testing of this technology within the territory of the South Korea Institute began back in 2009. At that time the receiver had to be no higher than 12 cm above the road bed and the technology efficiency was rated at 60 %. Now, the receivers are located 20 cm above the road bed and the efficiency of the wireless charging technology used by the Gumi city bus has reached the level of 85 %.

According to engineers, all the electromagnetic field parameters are within normal limits and the technology is not harmful for pedestrians or passengers of electric buses.

In Gumi city the electric bus route is 24 km long. To ensure that the bus travels the whole distance, only 10-15% of the road bed needs to be equipped with charging wires. The bus's battery begins charging almost instantly once the bus reaches the cabled area. It should also be mentioned that only 5 meters of cable is activated to release energy, not the whole cable segment.

Wireless chargers used in the OLEV Project have enabled a threefold decrease in the capacity and weight of accumulators. However, the receivers installed on the bottom of the buses weigh 180 kg and are compatible with high-capacity devices, meaning that the receivers can only be used by large public transport vehicles.

As of now, the price of electric buses under the OLEV Project amounts to USD 630,000, which is much higher than the price of standard buses. However, such buses are much cheaper to operate and maintain, owing to the absence of numerous moving parts and complicated wiring schemes. Also, the charging infrastructure is available to all the vehicles following the same route, which also contributes to cost reduction.

By 2015, it is planned to operate 10 buses under the OLEV Project. Further plans exist to make such roads available to mass-produced electric cars.

¹³¹ <http://chargedevs.com/features/olev-technologies-dynamic-wireless-inductive-system-charges-vehicles-while-in-motion/>

TRANSPORT AND INFRASTRUCTURE

Rapid technological development forms the basis for advanced transportation and infrastructure projects. The developments in infrastructure and transport is tightly linked to the deployment of innovations that change the principles of human interaction with familiar objects. Today, the Internet and information technologies contribute to the emergence of new ways of moving in an urban environment, which compete with traditional carrier services. New ways of processing large amounts of data help to predict the situation on the roads more accurately than ever before. Thanks to intelligent decision support systems, cars driven by electronics, which 20 years ago were the stuff of science fiction, are now becoming a reality. Infrastructure megaprojects increase the speed of vehicles movement and improve the quality of life in metropolitan areas.

Development of the transport network in Russia — the largest country in the world in terms of geographical area — is crucial for economic growth. Currently, the inadequate level of development is partly due to the fact that significant amounts are spent on the maintaining existing infrastructure facilities, which reduces the amount of available funding for industry innovation. Most of Russia's industrial infrastructure facilities have been operating since Soviet times, and, for many sectors, the capacity retirement rate has reached a critical level: in the transport sector, depreciation of fixed assets stands at 55-70%.

The task of infrastructure development has certainly come to the fore in Russia's economic policies, as is evidenced by the large plans for the construction of high-

speed railways. In some sectors, Russian companies are achieving global-level results. For instance, at the intersection of information technology and the transport industry domestic IT companies such as Yandex create products that rival and even outstrip the achievements of Western competitors.

The federal pilot project "Innovative Road" is aimed at the testing new technologies during the construction of three types of roads: federal (the Republic of Tatarstan), regional (the Ryazan Region) and municipal (in Moscow). The project should result in improved standards of construction and reconstruction for Russian roads for the large-scale application of innovative technologies. Three areas of innovative solutions may be singled out:

Increased durability and lifetime of the road surface through the addition of colloid nanodisperse polymer components to roadbed materials, use of the road grid and reinforcement of composite materials and improving the quality of road markings through the use of thermoplastic elastomer.

Increasing energy efficiency, through the use of LED lighting systems powered not from mains supply, but from their own, solar rechargeable batteries, as well as intelligent lighting control systems.

Development of an intelligent transport system which provides for data exchange between vehicles and infrastructure (road signs, traffic lights and video cameras) and automatic traffic control in order to avoid congestion.

ANTON CHIRKUNOV

Founder of the Wheely Service

What trends do you see in the development of urban transport infrastructure?

"More and more city residents are giving up private cars in favour of public transport. The main reasons are simple: parking problems and the high cost of car maintenance. It is much easier to take your phone, double-tap the screen and 10 to 15 minutes later get into a good car with a professional driver, which is not inferior to your private car in terms of quality and comfort. We try to follow the latest trends and offer people a quick and affordable way to get around the city with familiar comfort."

How does the transport infrastructure in London differ from that of Moscow, and do these differences affect the business dramatically?

"In London, public transport is much better developed. People actively use the subway, and in the city center there are more cars, taxis and buses than private cars. We try to offer something that is useful and advantageous in this environment — our services in London are cheaper than city cabs, and we use eco-friendly hybrid Prius cars, thus minimizing pollution. If we talk about the differences in doing business, everything is more or less the same, but tax rates and legal regulation in the UK are stricter than in Russia."

ALTERNATIVE TRANSPORT FOR THE URBAN ENVIRONMENT

TREND: RIDESHARING

The year 2013 became one of the most successful for services employing the sharing economy concept based on the principle of sharing surplus resources, turning the consumer into a producer. Such services involve making resources (e.g. cars or bicycles) available for joint use by multiple people.

The joint use of cars (ridesharing) means that any car owner can use an online service to find themselves fellow travelers without causing significant deviations from their route. Both the driver and the passengers save in this case because they share their expenses. The concept has become very popular, and companies doing business in this segment have raised hundreds of millions of dollars from major venture funds.

Offering their customers low-cost travel, ridesharing services compete directly with the licensed taxi service providers, much to the discontent of taxi drivers. In 2013, more than 15,000 taxi drivers went on protest marches in many European countries and in the USA, calling for the operation of ridesharing services

to be limited in their countries. There are loopholes in the laws that make the legitimacy of the business models used a complex issue. There are also unresolved taxation issues.

Though some difficulties still exist, estimates based on 2014 data show that the major ridesharing services (Uber and Lyft) will attain record performance levels in terms of passenger traffic and investments raised, and will approach international markets.

These services became a success by reason of the following factors: smart-phones being used on a global scale, user communities being formed around such services, exchange of information and integration of traditional transportation systems.

Apart from the US companies Uber and Lyft trying to expand their worldwide presence, Russia has its own national ridesharing services. One of the first companies to operate in this field was called "Davai So Mnoy" ("Come Join Me"). It appeared in 2010, positioning itself as an easy way to find fellow travelers, though it did not gain much popularity. To some extent this is due to the cautiousness with which Russians tend to

3.5 According to Forbes estimates, in 2013
the shared resources market amounted to
billion USD
and the annual growth rate is 25%.



regard someone they do not know. On the other hand, having and maintaining a private car is not as expensive as in Europe. At the same time, a similar project named “Podorozhniki” (“Fellow Travelers”) started operating in Russia and Ukraine. This service was based on the concepts of the ridesharing platforms that were well known by the time, such as BlaBlaCar, Carpooling.com, Lyft and Ridejoy. By 2012, the “Podorozhniki” service already had a mobile application of its own and by the end of 2014 it reached the target of 40,000 users.

Early in 2014 the “Podorozhniki” service was acquired by the French service BlaBlaCar. By that time, BlaBlaCar was operating in 12 European countries, providing services to 8 million customers, and shortly before the acquisition it had raised investments of USD 100 million to expand its business. During the first three months of operation following the merger the company attracted more than 250,000 new users, which represented the most successful service startup in a new market. The service is aimed at international trips planned at the last minute (several hours to several days before departure) when other transport tickets are not available.

SHAHAR WAISER

Founder of GetTaxi

“Today, one of the key trends in big cities around the world is a change in the consumer model. There is a shift of emphasis from ownership of goods to lease or joint consumption. Society is approaching a tipping point in its development in terms of the acquisition and use of valuable assets, such as private cars, motorcycles, car parks and even homes. This trend is driven by the spread of mobile devices, making people better connected, and the growth of consumer confidence, which is partly attributable to the use of social networking. All this will result in fewer cars on our roads and more efficient utilization. The end result will be greener cities that are pleasant to live in.”

INCREASING THE SPEED OF PUBLIC TRANSPORT

The improvement of passenger service and increase of competitiveness of public transport are challenges that are central to the development strategies of many countries. For passengers, speed of transport is one of the key parameters in the selection of a mode of transport, making improvements in speed a priority target of public passenger transport development programs worldwide.

Large territory and high level of urbanization in Russia make the increase of speed of public transportation crucial task, both for urban and intercity transportation. The leading role of railway transport in intercity transportation causes the necessity of development of high-speed railways.

The following areas of development may be singled out in terms of increasing the speed of public transport.

- High-speed railway lines, such as the magnetic levitation trains (maglev)
- Development of personal high-speed automatic transport.

TREND: HIGH-SPEED RAILWAY LINES

One of the quickest ways to travel short and medium distances (up to 1,000 km) is by high-speed railway, with a speed of around 200-250 km/h. Some modern trains currently in use can reach speeds of up to 350-400 km/h. Although trains are slower than aircraft, time is saved by not having to travel to the airport, check in and wait for departure.

The development of high-speed lines (HSLs) can be undertaken on the basis of existing public lines, as is done in Germany, Italy and Russia, or by creating a new, separate infrastructure, as is typical for Japan, Spain and France. However, launching high-speed trains on existing public lines entails making major changes to passenger and freight transport routes, leading experts to assert that the construction of separate HSLs is unavoidable despite the high capital costs involved in such projects.

Russian Federation

Area:

17
mln sq km

Extension form
West to East:

10
thnd km

Extension form
North to South:

4
thnd km

Inhabited
Localities

133
thnd

25%
of population resides
in 15 largest cities with
population over 1 mln

37%
of population resides
in 63 largest cities with
population over 300 thnd

CASE

COMPETITION BETWEEN UBER AND LYFT RIDESHARING SERVICES

Uber and Lyft are the largest and the most widely-known ridesharing companies in the world, capable of changing the shape of the whole transportation industry while competing hard with each other.

Both companies use similar business models: the use of mobile applications to mediate between passengers and the non-professional drivers. For Uber, ridesharing is the only line of business (before it launched ridesharing it offered classic luxury taxi services). However, in 2012 a decision was taken to use the same brand to provide cheaper services. This is how the most successful ridesharing startup appeared.

Uber was the first company of its kind, which enabled it to become the leader in the field. In terms of company value Uber exceeds Lyft almost thirtyfold, and in terms of the number of employees it is 5 times larger.

However, a number of investors invested USD 250 million in Lyft during the last round of financing; these investors believe that Lyft has a real chance to compete with the leader. They believe that this start-up has managed to create a better service for the mass-market customer while Uber has retained its image as a luxury service provider. Lyft positions its services not only as an option for moving around the city, but also as a way to get to know new people and find friends. Consequently, there is a community of like-minded people formed around it, which creates an advantage in a market that is still in its infancy.

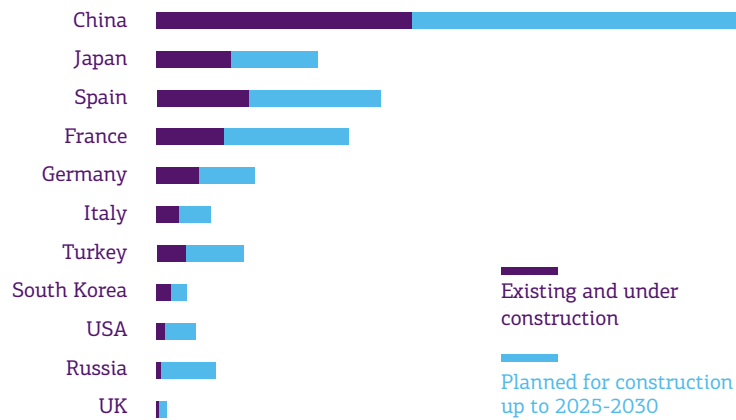
Competition encourages these companies to offer more services. In August 2013, for instance, both companies announced a new service offering customers who follow similar routes the opportunity to share their taxi expenses, thus paying less for their regular trips.

The cost of the Russian project to construct high-speed lines is estimated at RUB 3.2 trillion, and the first HSL from Moscow to Kazan is expected to be launched in 2018. At present, Moscow, St. Petersburg, and Nizhny Novgorod are linked by Sapsan trains running at speeds of up to 200 km/h. St Petersburg is linked to Helsinki by the Allegro train, which also accelerates to 200 km/h. For comparison, the average speed of long-distance trains operated by JSC Russian Railways is about 60 km/h.

The leader in the development of high-speed connections is China, where the length of high-speed railway track is more than 6,000 km. It is followed by Japan (2,600 km), Spain (2,100 km), and France (2,000 km). At present, Russia has around 180 km of high-speed trackage, but plans to increase this to 2,274 km by 2030.

One possible area of development of high-speed railways with a view to achieving greater speeds is the use of magnetic levitation trains, or maglevs, which hover above the track and move with the aid of an electromagnetic field. Since there is no physical contact between train and track, the only factor limiting the speed of such trains is drag. This is why the achievable speeds are theoretically comparable with those of aircraft. In fact, the speed record reached by the Japanese train MLX01 is 581 km/h.

The Development of High-Speed Railways Around the World



Source: International Union of Railways

Compared with conventional trains, maglevs require much greater capital expenditure on infrastructure, although operating expenses are much lower owing to the lack of exposure to wear and tear through friction. Because of the enormous cost of building the infrastructure and the long payback period, maglevs are not yet widespread: there are two projects in operation, and two more under construction.

JSC Russian Railways declared the intention to develop Russian maglev train in 2011. In 2014 during the St. Petersburg International Economic forum it was announced that Russian Railways and Rosatom State Atomic Energy Corporation started the joint project on developing such train. D.V.Efremov Institute of Electrophysical Apparatus will lead the research and design process. According to Sergey Kirienko, the head of Rosatom, the project can lead to the creation of new segment in Russian high-tech industry with the potential to compete with foreign manufacturers.

TREND:
**PERSONAL RAPID
AUTOMATIC TRANSPORT**

In addition to the development of familiar types of urban transport, new types are becoming common, including Personal Rapid Transit (PRT). This is a form of public transport whereby small groups of passengers (from two to six people) are carried in automatically-operated (driverless) pods on dedicated tracks.

The main advantages of PRT over other forms of public transport are cost efficiency and energy efficiency per passenger, as well as low operating costs. Passengers, meanwhile, receive a level of comfort that is comparable with private transport, combined with low waiting times and high safety standards. In addition, the passenger specifies the destination (similar to booking a taxi), which eliminates the need for changes or intermediate stops. The positioning of stops

on side tracks means that there is no need to decelerate and hinder the movement of vehicles behind. This means that speeds of 40 km/h are possible regardless of traffic load.

PRTs are operating in West Virginia in the United States and in Abu Dhabi in the United Arab Emirates, and there are plans to launch them in Dubai in the UAE within the next few years¹³². According to the US Department of Transportation, after 110 million passenger miles there has not been a single emergency situation involving transport based on an automated AGT system.

The advantages of personal rapid transport are encouraging further development in this area and improvements in the technology. For instance, a new project that is currently being developed is the high-speed SkyTran, which involves the creation of PRT systems with trains suspended on a magnetic cushion. The maximum vehicle speed will be 240 km/h. The project involves the construction of a special monorail just a few meters above the ground on which the pods will travel. The pods can be summoned using an application on a smartphone. In June 2014, SkyTran company signed a contract with Israel Aerospace Industries (IAI) for the construction of a pilot system in Tel Aviv by 2016. The project has also attracted the attention of transport companies from India, France and the USA¹³³. In the future it is planned to equip SkyTran with solar panels that will make the system independent of mains power¹³⁴.

¹³² <http://gulfnews.com/news/gulf/uae/high-tech-podcars-to-take-to-dubai-streets-in-a-few-years-1.1328418>

¹³³ <http://www.skytran.us/skytran/>

¹³⁴ <http://techvesti.ru/node/7521>

BIG DATA AND MODERN WAYS TO FIGHT CONGESTION

Traffic jams often stretching out over many dozens of kilometers and costing drivers many hours are a problem in many developed and developing countries. The negative impact of jams on the quality of life and on the urban economy can hardly be overestimated.

According to data from the Texas Transportation Institute research center, in 2013 total losses from jams on US roads exceeded USD 210 billion, or USD 1.000 per passenger. The results of another study show that US drivers who have to use one of the 10 most crowded high-ways in the country every day waste an average of about 140 hours a year, which is comparable with a full working month. Beside this, long-term exposure to exhaust gases has an adverse impact on the body, significantly increasing the risk of cancer and heart disease and,

scientists believe, facilitating the destruction of brain and synapse cells, which are responsible for memory. Recent surveys of public opinion in Hong Kong have shown that traffic jams and

overcrowded public transport are the main causes of stress and have a negative impact on health and working capacity.

CASE

ULTRA PERSONAL AUTOMATED TRANSPORT PROJECT AT HEATHROW AIRPORT

In 2011, a project for the creation of a personal high-speed transport system, called ULTra, was launched at London's Heathrow Airport. Wheeled pods driven by electric motors travel along dedicated lines 4 km long, which have a conventional road surface and are fenced only with concrete barriers.

The route connects Airport Terminal No. 5 with car parks. In 2011 it replaced the bus service that previously ran between these points. The vehicle's batteries are charged while it is parked at the station. The main advantage of this type of transport is rapid availability: the average waiting time is 10 seconds. According to the operator, the energy efficiency of ULTra pods is 50% higher than that of conventional buses. The total cost of constructing the line was 30 million pounds, which is significantly less than the cost of creating similar bus and rail routes.

Price of Traffic Congestion in USD in 2013:

Total costs:

121
billion USD
per year

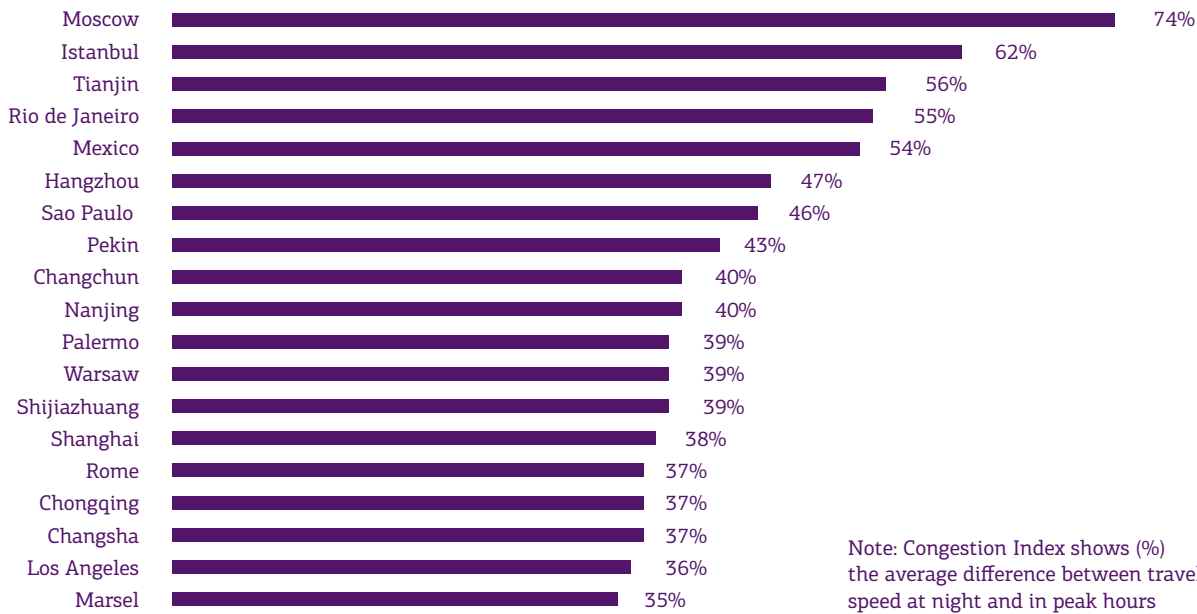
Wasted fuel:

11
billion liters

Additional CO²
emission:

25
billion kg

The World's Most Traffic-Congested Cities, 2013-2014



It is clear that Moscow has an acute congestion problem: for the third year running the capital has topped the world congestion ranking prepared by Tomtom, the Dutch manufacturer of satellite navigation devices, based on the data from the GPS devices of its users.

The research is conducted in over 160 large cities in North America, Europe, Australia, New Zealand, and South Africa. The database contains 6 trillion measurements, with 5 billion measurements added every day.

There are three possible ways to solve the problem:

1. Construction of new roads and parking areas
2. Development of the public transport system
3. Implementation of intelligent traffic flow monitoring and control systems.

The third option is the newest area of development, but it is becoming increasingly popular all over the world. This approach encourages the creation of solutions for tackling congestion among non-governmental companies. The main weapon is the use of the Big Data concept, i.e. a set of methods and technologies for collecting and processing large quantities of road data for the purpose of improving the transport system. Perhaps it will be in Russia that the best solutions to the problem will appear, given the expertise it has at its disposal and the urgency of the issue.

CASE

TOKYO, CONGESTION, BIG DATA, AND THE ZENRYOKU ANNAI! APPLICATION

The first taxi in Tokyo appeared as early as in the beginning of the 20th century, and today there are around a quarter of a million cars operating in Japan's capital. For the Nomura Research Institute, the largest consulting company in the country, all these vehicles are a source of information on how to solve the traffic problem in one of the most heavily populated cities in the world.

NRI employees use three primary data sources to analyze traffic jams:

1. Its own sensors on transport infrastructure throughout the country
2. Location-based sensors from 12,000 taxi cabs in the capital region, and
3. Photos and information from satellites.

All of these generate around 360 million observations every minute. Until recently, the Institute used to process this information using ordinary relational databases; analysis of collected data took about 20 minutes, which did not allow real-time prediction of the road traffic situation.

The use of in-memory computing technology, which involved processed data being saved to random access memory, allowed the company to analyze all observations on their servers within less than a second. The in-

creased data processing speed allowed the creation of the mobile application Zenryoku Annai! to track the road situation in the city in real time and build optimum routes that take into account current traffic conditions and predictions based on collected historical data.

The results achieved by the Institute are very relevant for Japan. Japanese public institutions and companies are often searching for ways to use road traffic data to improve the quality of life of the country's population. For example, Toyota, the largest supplier of taxi cars in the country, has recently announced plans to use road traffic information received from the company's 700,000 vehicles to provide various services to local authorities and enterprises.

Another example is the announcement made by the Japanese Government of its intention to use data from navigation devices to receive prompt information about the state of roads after various natural disasters. We know that on the day after the 2011 earthquake the Government did not have enough information on the state of about a quarter of all roads in the country, which increased the time needed to restore normal traffic conditions. In addition, the availability of rapid and accurate means of analyzing location-based data will enable problems to be resolved faster.

CASE

RUSSIAN ROAD TRAFFIC MONITORING SERVICE — YANDEX.TRAFFIC

Yandex.Traffic is a Yandex service that provides information on the traffic situation on the streets of the largest Russian cities, and is available both on the web and in the Yandex.Maps app. Yandex.Traffic automatically collects the necessary information from app users, analyzes it and displays it on the map.

When in use by drivers, the apps transmit a car's geographical coordinates and driving speed to the company's servers. Based on these data an algorithm is used to create a single route, which forms a "track" in combination with driving speed data at each point on the route. "Tracks" are provided not only by private drivers, but also by cars of Yandex partners — companies with large fleets of cars that regularly drive through the city. Finally, having collected together numerous tracks, the program analyzes them and applies "green", "yellow" and "red" scores to the relevant road sections.

The company is continuously improving the algorithms and principles underlying the data analysis and expanding the functionality of the service, which helps it remain on a par with other similar systems worldwide. At the beginning of 2013, for instance, the company introduced a feature enabling short-term traffic prediction, in order to be warned of traffic jams expected in 15, 30, 45 and 60 minutes. The data analysis technologies and algorithms used for this purpose are not disclosed, but, compared with the use of real-time congestion data, the forecast allows for a more precise prediction of traffic volume, as it also takes account of patterns of changes and historical data.

Eventually, the quality of the prediction is expected to be significantly enhanced by including a number of external factors in the analysis. For instance, the prediction model already includes reference to the time of the day, and there are plans to add variables that would reflect precipitation intensity and other weather conditions. Employees of the company say that, if they manage to find a reliable and prompt source of information on road accidents, this factor will be also included in the model in order to estimate the possible duration of traffic jams on various road sections.



VEHICLE EFFICIENCY ENHANCEMENT

Kinetic energy storage and recycling (regeneration) systems based on the fly-wheel or compressed air principle have been known since the middle of the XX century, but thanks to the development of technologies to make the mechanisms more compact, light, reliable and capacitive, such devices are already appearing in the private motor vehicle segment. Their application enhances the energy efficiency and environmental friendliness of existing cars with internal combustion engines.

Systems that enable kinetic energy released during the braking of a vehicle to be converted into flywheel rotational energy for use when needed (KERS, Kinetic Energy Recovery System) were first used in Formula 1 racing cars and other racing cars to increase traction power. The temporary storage of energy is achieved using rotors made of high-strength composites, which are constructed of interlaced threads of carbon fiber rotating on magnetic bearings inside the vacuum chamber.

Developments in manufacturing technologies over the last few years have enabled the system to be used in private cars as well. Unlike in racing cars, in this case the flywheel is used to reduce fuel consumption.

The system is especially effective for vehicles where frequent stops, such as city transport vehicles. In July 2014 the London public transport operator, Go-Ahead, announced the purchase and installation of five hundred Gyrodrive systems, which work similarly to KERS for two years¹³⁵. Engineers estimate that the use of this system will provide a 20% fuel saving; moreover, it can be installed on a bus in a matter of days, and is no bigger than a car wheel.¹³⁶

Vehicles with compressed air propulsion systems are propelled by air-powered motors using compressed air stored in cylinders. As these motors do not use fuel material, they enable the level of polluting emissions to be reduced where they are used, and have a simpler design and smaller weight and dimensions. The filling of cylinders with compressed air requires the consumption of electricity.

CASE

PEUGEOT-CITROEN HYBRID AIR

For instance, representatives of Peugeot-Citroen state that their "Hybrid Air" hybrid car will save up to 45% of hydrocarbon fuel, giving a fuel consumption level of 2 l/100 km. The saving derives from the fact that the energy released in the process of braking is not dispersed as heat, but is stored as compressed air in a cylinder, and is then used when needed. Mass production of the model is to begin in 2016.¹³⁷

¹³⁷ <http://www.psa-peugeot-citroen.com/en/automotive-innovation/innovation-by-psa/hybrid-air-engine-full-hybrid-gasoline>

CASE

REGENERATIVE BRAKING

In 2013, Volvo announced a flywheel-based system for its S60 Sedan¹³⁸. Volvo representatives claim a potential fuel saving of up to 25% against a similar motor without the system, with a simultaneous power increase of 80 h.p. The flywheel weighs 6 kg, is no more than 20 cm in length, and its rotor is capable of rotating at a maximum speed of 60,000 rpm. The testing of samples in Great Britain was successfully completed in March 2014, and the company is working on integrating the device into the model for serial production.

¹³⁸ <https://www.media.volvocars.com/uk/en-gb/media/pressreleases/141626/volvo-car-group-and-flybrid-conduct-uk-testing-of-flywheel-kers-technology>

The use of air-powered motors is complicated by the need to heat and cool down air during its operation, creating a need for additional air filling stations. Furthermore, tests show that compressed air cylinders have a poor energy density, which makes it difficult to create vehicles with an air-powered motor

alone. When used together with an internal combustion engine, however, air-driven motors significantly enhance a car's energy efficiency.

¹³⁵ <http://www.busandcoach.com/newspage.aspx?id=8574&categoryid=0>

¹³⁶ <http://www.wired.com/2014/07/f1-kers-london-buses/>

VITALY PONOMAREV

Founder of WayRay

"The market for vehicle infotainment systems is currently at the formative stage. IT companies and electronics manufacturers, including Apple and Google, are now getting actively involved. Consortiums of companies are being established in order to create uniform standards for such solutions. According to forecasts, the market will grow to USD 160 billion by 2020.

WayRay develops and deploys intelligent systems for vehicles. One of the products being prepared for sale is a device that projects an augmented reality image onto the vehicle windshield.

As of the beginning of this year, WayRay's headquarters are in Switzerland, which makes it easier for us to access target markets in Europe, the USA and Asia. But the centre of research activities is still in Russia, and we do not plan to move it. The new structure is more attractive to foreign investors. In view of the tense political situation, foreign venture capital funds are not ready to invest in Russian companies. We plan to attract USD 30 million in the next round, and good relationships with the Government of Switzerland and internationally positioning of our company will contribute to this."

INTELLIGENT DECISION-MAKING SYSTEMS FOR DRIVING

The first examples of driverless cars date all the way back to the 1920s: the Linri-can Wonder of 1925 was driven by small electric motors that controlled the car's driving systems and were connected to the radio receiver, the signal to which was sent from a car driving in direct proximity.

The goal of creating of an automatically-controlled (autonomous) vehicle has moved on since then. The significant advances witnessed over the last ten years have been made possible by rapid developments in computer vision technologies, improvements in various sensors, such as radars, lidars (devices receiving information on remote objects with the help of optic systems) and position and acceleration sensors, and the enhanced computing capacity of mobile computers, which are capable of processing a huge volume of incoming data.

Developments in the field of driverless vehicles generally began in research institutes and laboratories (of Munich University, Oxford, Stanford, University of Parma, Carnegie Mellon University) in conjunction with car manufacturers (BMW, Mercedes-Benz, General Motors, Nissan, Toyota, Audi, Volvo). Their cooperation resulted in prototypes capable of travelling on a pre-determined route without human participation.

Intelligent systems currently used in the mass market do not allow for full substitution of a driver, but automate certain driver actions. For instance, adaptive cruise control alters the speed of a vehicle in order to maintain a safe distance in traffic flow, while lane support systems help the driver to keep in lane, inform him of any deviation from the selected

8th

leading cause of death
globally: road accidents

2x

increase in delay hours due
to congestion by 2050

95%

or road accidents caused
due to human error

6.3^{bn}

urban dwellers accounting for
70% of population by 2050

750 Mb/sec
data gathered by fully
functioning AV

% of global vehicle sales attributed to AVs

2015 — 4%, 2030 — 41%, 2035 — 75%

Estimated price consumers will pay for AV technologies:

2025 \$7,000 — \$10,000, 2030 — \$5,000, 2035 — \$3,000

path and even make corrective interference with steering.

AvtoVAZ, the largest Russian automobile company, announced its model Lada Granta equipped with cruise control system in 2014, but the adaptive cruise control is an appliance the manufacturer is still to develop and implement. It might be the perspective market segment, taking into account the annual production volumes of AvtoVAZ (500 thnd cars).

Large car manufacturers, including BMW, Mercedes-Benz, General Motors and Nissan, as well as Google, have presented modified versions of production models that can be automatically driven in certain conditions (usually while driving on a highway). These cars are able to change lane on their own, overtake and perform emergency braking at 100 km/h. They use various sensors to collect information on the location of surrounding objects and their driving speed — stereoscopic cameras, radars, laser scanners, infrared

cameras and ultrasonic sensors — and integrated computing methods to choose the optimum driving path.

The potential applications of driverless cars are obviously enormous: their use will make driving safer and more efficient. Since computers react to situational changes more rapidly than humans, never get distracted or tired and are capable of watching hundreds of objects at the same time, it will reduce the amount of accidents and increase driving speed. Automatic control systems will help people to use time spent at the wheel for other things; the systems will park the car on their own while the owner does their own thing.

However, models with these capabilities are a long way from commercialization, and manufacturers expect them to appear on the market no sooner five years from now, while the full substitution of humans in driving a car in any conditions will take much longer.

There are several reasons for this, the most significant of which are technological factors. The sensors and computing systems used in the prototypes are too expensive for the mass market: for instance, the cost of a lidar of the type mounted on the roof of the Google Car (a modified Lexus RF450h), which creates a 3D image of the surrounding space to an accuracy of 2 cm, is around USD 70,000. Furthermore, unfavorable weather conditions change the perception of the surrounding environment by sensors: snow on the roads and splashes from cars distort the lidar signal, while fog and snow limit radar visibility.

The most difficult problem, which is crucial for the substitution of humans in driving a car, is the imperfection of the automatic decision-making system, which is currently unable to evaluate quickly and accurately enough all the possible outcomes of non-standard situations that frequently occur in road traffic, such as rapid changes of lane by neighboring cars and oncoming traffic.

In addition, the use of driverless cars on roads would require changes to be made to the provisions of key international treaties, such as the Vienna and Geneva Conventions on Road Traffic, which establish that a driver must remain fully in control of his car while driving. At present, the use of driverless vehicles is expressly permitted in only four US states and in certain European countries (Germany, the Netherlands and Spain).

Nevertheless, IHS, a consulting company in the field of industry and technology, predicts that 54 million driverless cars will be in operation by 2035. Annual sales of the vehicles will amount

to 11.8 million cars, half of which will not have any manual control devices. By 2050, driverless cars will completely replace ordinary cars.

CASE

GOOGLE CAR

Work on a car that can drive without human participation is being carried out in the Google X laboratory of prospective technologies. The project involves modified production models of the Toyota Prius and the Lexus RX540h. In addition, in May 2014 the company demonstrated a new prototype of a two-seated car of its own design, which has no pedals, steering wheel or other control systems, since they are not needed.

The first tests of Google Cars occurred in 2010. Then, driverless systems coped with driving along a highway: single-lane driving, braking and speeding up to avoid road accidents, and changing lane. A car driving at 100 km/h recognizes vehicles driving next to it on time and responds adequately. The next stage in the development of the technology involved driving on city streets in regular traffic, where it is necessary to take into account hundreds of objects within a small area, and to drive according to particular rules. Thus, the Google Car control systems can take account of road signs, traffic lights, the behavior of pedestrians and other cars, and even cyclist maneuvers.

Controlling the car without the involvement of a driver is made possible by an automatic system that includes a wide range of sensors and indicators to receive information about the surrounding space, and specialized software that processes incoming data and controls the car. In the most difficult situations the system still informs the driver of the need to take control, but as the technology develops, the need for this becomes increasingly rare. In 2014, the company announced that Google Cars had travelled 1.1 million km with minimal human participation.

Navigation equipment mounted on the Google Car includes: a laser electronic distance meter on the roof of the car, four radars on the front and rear bumpers, a high-resolution camera on the windshield and another inside the car, and a GPS indicator. A central part of this system is the 64-ray laser electronic distance meter "Velodyne", which makes 1.5 million measurements per second, allowing a 3D model of the surrounding space to be created with an accuracy of up to 2 cm. In total, the equipment mounted on the Google Car gathers about 1 GB of data each second. The 3D map of the surrounding space that is created built with the aid of the sensors is compared with a high-precision record of the area in the database, and the result enables the special software to drive the car while avoiding obstacles and complying with traffic rules.

In order to obtain a detailed map and data on the surrounding environment and terrain features, Google engineers have to drive the planned route first, and add detailed information to the cartographic data. In addition, Google Car systems cannot currently differentiate between a pedestrian standing on the roadside or, for example, a traffic controller, from a lamp post, or a stone lying on the road from a crumpled newspaper (Google Car will try to travel around the "obstacle" in both cases). Holes and sanitary sewage manholes not marked by road signs also cause complications.

In spite of the continuing difficulties in the development of driverless cars, Google expects them to be used in the future for automated services, e.g. taxi services. In August 2013, the search giant invested USD 250 million in Uber, the taxi services company, which in turn plans to buy 2500 driverless cars.



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