

Risk assessment of projects implementing technology 4.0 industry in the oil and gas business

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Abstract — The article presents the results of the development of individual technology 4.0 industry in the energy business study. It was noted that the development of robotization technologies is one of the priority innovative technologies, including the use of unmanned aerial systems, the Smart Well and Smart Refinery technologies. The article also presents a model for assessing and managing the risks of introducing new technologies, as a result of which it is possible to build a risk management system. As a result of all the developments, the authors proposed the results of testing the model using the example of the introduction of robotization technologies in an oil company.

Keywords — industry 4.0, robotics, risk assessment, risk assessment methodology, risk management, project effectiveness assessment.

I. INTRODUCTION

The review of the development of this market in various industries is indicative for forming an idea of the prospects for the use of robotics. According to World Robotics 2015, the number of industrial robots sold is increasing, which indicates an increasing need for robots and their wider application (Eable 1: for comparison, data on service robotics are given).

TABLE 1. KEY PERFORMANCE INDICATORS FOR INDUSTRIAL AND SERVICE ROBOTICS MARKETS

Indicator	2013	2014	2015
The number of industrial robots sold, thousand units	179	221	254
The number of service robots sold, thousand units	21	24	41
World market of industrial robotics, billion dollars	29	32	37
World market of service robotics, billion dollars	3.57	3.77	4.60

Figure 1 shows data on global shipments of industrial robots.

Thousand, PCs.

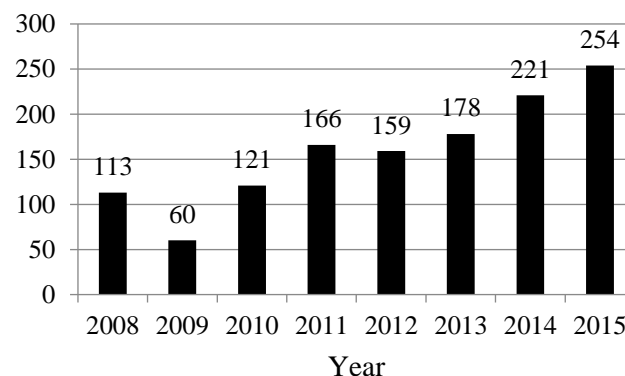


Fig. 1. Worldwide shipments of industrial robots

In the whole world and throughout industry, the robotics market has a high growth rate. Since 2010, after recovering from the global economic crisis in 2008, sales of industrial robots have increased by 48% [1]. The world density of use of robotics is at the level of 66 installed robots per 10,000 workers in the manufacturing industry (Figure 2). The first place in this indicator is occupied by the Republic of Korea (in 2014, 478 units of industrial robotics per 10,000 employees, and in 2015 - 531 units). Second place is Singapore (396 units), which burst into the top five countries in terms of robot density for the year. Then Japan comes: 305 units. The fourth place is Germany, in which in recent years the density of use of robots has a positive trend (301 units, in 2014 - 292 units). China, with its fast-growing economy, has reached 36 units, which indicates the high potential for the use of robots in this country. The data are shown in Figure 3 more clearly.

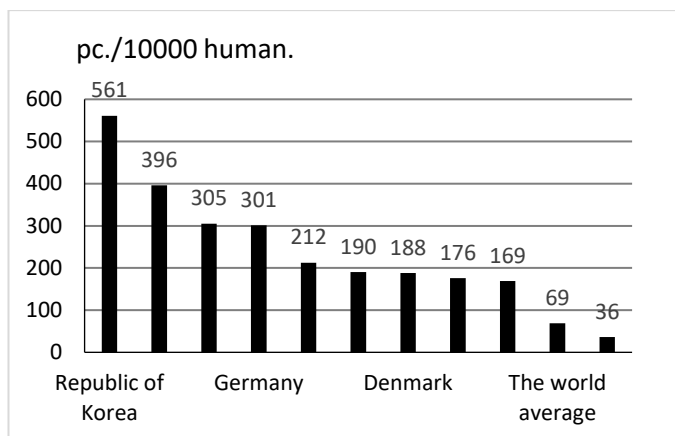


Fig. 2. Robot density in leading countries in 2015

In Russia, the density of industrial robotics in 2013 amounted to 2 units of robotics per 10,000 workers. Sales of robots in the Russian Federation from 2010 to 2013 had a steady growth, but in 2014 fell by 13% to 533 robots due to a dramatic change in the exchange rate (Figure 3).

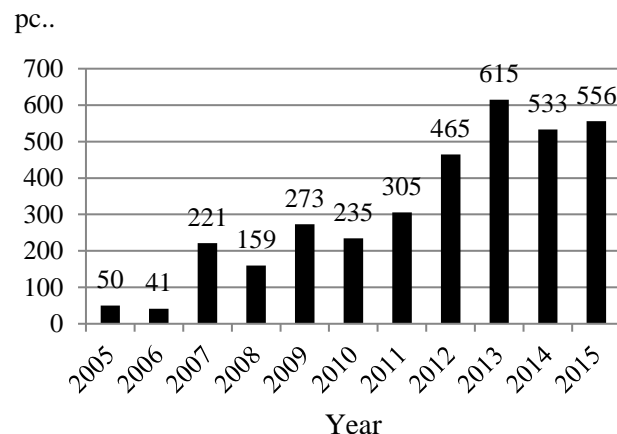


Fig. 3. Dynamics of sales of industrial robots in the Russian Federation

The main areas of application of robotics in Russia are as follows: loading and unloading, welding, painting, automotive and metalworking (Figure 4).

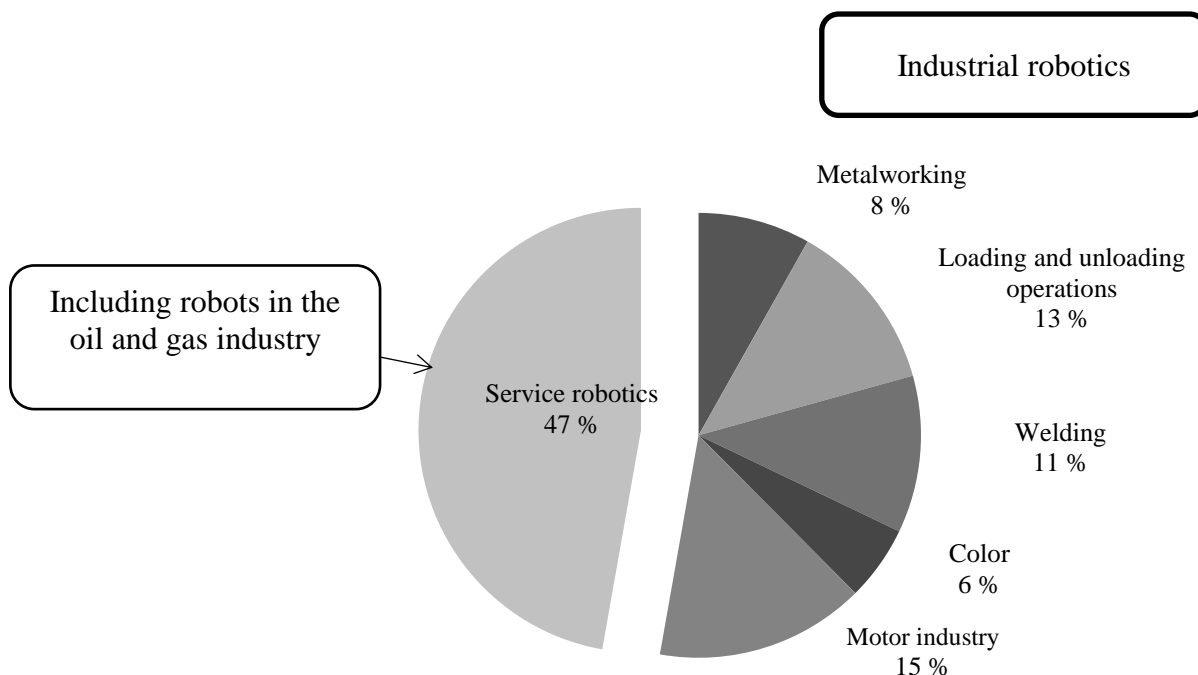


Fig. 4. Directions for the use of robots in the Russian Federation in 2015

The level of use of industrial robots in Russia is much lower than in other countries, which poses a significant threat, but at the same time it is an opportunity for modernization and robotization of production in order to increase its efficiency and competitiveness. [1]

Against the analysis background of global trends in the development of robotic devices, it can be concluded that automation is the dominant means of achieving success in the context of the globalization of international economic relations, although it is not the only way to win in the competition. Automation creates fundamental opportunities for improving production conditions and increasing labor productivity, increasing product quality, reducing the need for labor and systematically increasing profits, which allows

changing the development trend, maintaining developed markets and conquering new ones. [2]

Oil and gas production has different requirements for the design and capabilities of robots. In addition to resistance to adverse weather conditions, the robot must be explosion-proof. Robots for offshore platforms must withstand extreme temperatures, strong winds, exposure to salt water and even snow and glaciation. Ground robots must withstand sandstorms, direct sunlight, rain and high humidity, extreme temperatures and exposure to harmful gases such as H₂S. Such specific requirements are usually not imposed on robots in normal production. [3]

In the oil and gas industry, there are two broad areas for the use of robots: areas requiring robots of completely new

designs, and areas where existing industrial robots can be used. Further development of subsea oil and gas fields relies mainly on remotely controlled mechanisms. These mechanisms are used for production, inspection and interaction with the organization of processes. Such applications are unique to the oil and gas industry and require robots with a completely new design. [3]

Other applications show direct analogies to production processes where robots are already used to perform monotonous work, and where increased automation has convincingly proven its advantages. However, the nature of these operations in the oil and gas industry differs from conventional production processes. It is assumed that in the oil and gas industry robots will be used to carry out surveys and maintain the technological infrastructure. [3]

Now the robotics market is talking about the creation of future robotic operators of oil and gas fields, the Swiss company ABB, the largest manufacturer of robotics in the world, is striving for this goal. Another company, Robotic Drilling Systems (RDS, Norway), borrowed NASA's space products, which formed the basis of the Curiosity rover, which, when viewed from the point of view of an oilman, has excellent qualities of technology for exploration and mineral recognition. At the moment, RDS offers oil companies a robotic system that includes a robot at the drilling site, a robotic "assistant driller", a lift and a robotic pipe manipulator.

For companies in the oil and gas sector, ABB Robotics offers the following solutions: Robotization of the processes of welding, cutting and machining of metal structures (for example, pipes, vents, turbine blades); the use of robots in the manufacture of oil and gas equipment; palletizing, packaging and bottling of final refined products.

Palletizing robotization is an alternative to manual control of the stacking process: reduced assembly time for pallets; increased conveyor throughput; maintaining product quality, reducing the "battle" reduction of personal injury; compliance with the requirements for the organization of workplaces for safety and sanitary standards; reduced employment in difficult and hazardous areas; reduction in labor costs.

The in-line diagnostics of oil and gas pipelines using special robots is widely known, since one of the necessary conditions for ensuring the operational reliability of trunk pipelines is to diagnose them using a complex of in-line inspection shells: profiler shells and flaw detector shells. Such devices relate to mobile robots moving in the flow of a transported product under the action of excessive pressure created by a liquid or gas inside a pipeline [4]. Such robots are already used by large Russian companies, for example, AK Transneft, PJSC, LUKOIL, PJSC and many others.

The services of unmanned aerial vehicles (UAVs) are used by oil companies to monitor production facilities and pipelines. Specifically, UAVs serve as a substitute for walking rounds and small aircraft, and also allow shooting at low altitude from the ground with high image quality and taking panoramic pictures. In addition, the use of UAVs is much more economical. Various equipment is installed on the "drones" - for video shooting, digital photography and thermal

imaging - the latter allows you to see hydrocarbon spills in the infrared range even at night and underground at a depth of up to 1 m. The combination of different monitoring methods makes it possible to comprehensively assess the condition of the object, and modern technologies make it possible to accurately determine the coordinates of the area where a particular image was taken. In practice, UAVs are used to assess the condition of pipelines, inspect near-pipe spaces, timely detect spills and unauthorized selection of oil from pipelines. They also allow to control the implementation of planned work at the facilities, and in case of emergency to coordinate work to eliminate them; identify unauthorized persons who entered the territory of the protected object. UAV aerial photography is used not only to detect problems that have already occurred, but also as a preventive measure. One of the promising ways to use unmanned technology in the oil and gas industry is the use of aircraft in engineering and geodetic surveys. [5]

The creation of a multi-purpose integrated airborne geophysical information-measuring system based on UAVs is of great interest to companies involved in the study of the geological structure of the Earth and mining, ecology, and solving special problems (especially in hard-to-reach regions: Arctic and subarctic regions, impassable forest zones, desert, equatorial forests, troubled geopolitical zones).

The use of UAVs in airborne geophysics provides the following advantages compared to manned carriers: reduction in the cost of work; the possibility of using a new, previously not practically not used, high-altitude range of geophysical surveys: from units to hundreds of meters; the ability to quickly conduct multi-altitude surveys on a given route; obtaining more detailed and high-quality information necessary to highlight low-contrast anomalies; lack of need for special runways; UAV maintenance does not require highly qualified flight and technical personnel; the possibility of equipping field detachments and expeditions with this system, which will dramatically increase the volume and quality of research work. [6]

The so-called ROV robots (Remote Operated Vehicles - autonomous underwater vehicles) are used to assemble and maintain equipment on the shelf, research the bottom and other underwater tasks. The use of robotics in the oil and gas industry is possible at various stages, including those dangerous to humans.

ROV robots are used when drilling wells, in geological and geophysical inspections, when inspecting gas pipelines and industrial communications, identifying breakdowns and malfunctions. Robotics plays a particularly important role in the extraction of large items and mine clearance operations. ROV robots are easily synchronized with each other, easily adapted to a specific task and can work in a variety of environmental conditions. [7]

Thus, an object analysis of the use of robotics in the oil and gas industry showed the widespread availability of robotic developments. The results of object analysis are shown in Figure 5. There are already robotic developments on the market that are applicable in oil and gas production, including those related to the main production, presented by foreign

companies. The use of UAVs for air monitoring of pipelines, robots for in-line diagnostics and robots for underwater operation is widespread in the industry. In general, Russia has a low degree of robotization. This may become a threat in the future, as foreign ones can reach a new level of industrial production due to innovative robotic technologies. As part of this study, a separate object of the oil and gas industry was considered, namely, pipelines and the introduction of unmanned aircraft systems on them in order to increase the efficiency of oil companies.

In general, for the robotic market in the oil and gas industry in the long term (6-20 years), the following general trends and development vectors can be distinguished:

- the use of airborne geophysical research technology using unmanned aerial vehicles; in the field of mining, the use of robotic field development technologies [8];
- maintaining the oil price at the current level (about \$ 50 per barrel) will provoke NC to look for ways to increase operating efficiency by reducing production costs;
- the need for import substitution will require investment in domestic engineering;
- in the areas of unmanned technologies, foreign equipment and services will remain expensive, which represents a great advantage for Russian manufacturers of robotics and equipment in the oil and gas sector;
- equipment imports from China will increase, which will create some difficulties for domestic players in this market;
- an increase in the oil recovery coefficient will play an increasingly important role; this increase will be achieved, including through increased automation and robotization.

The use of robotics will be closely intertwined with a change in the profile of oil production in Russia (Figure 6):

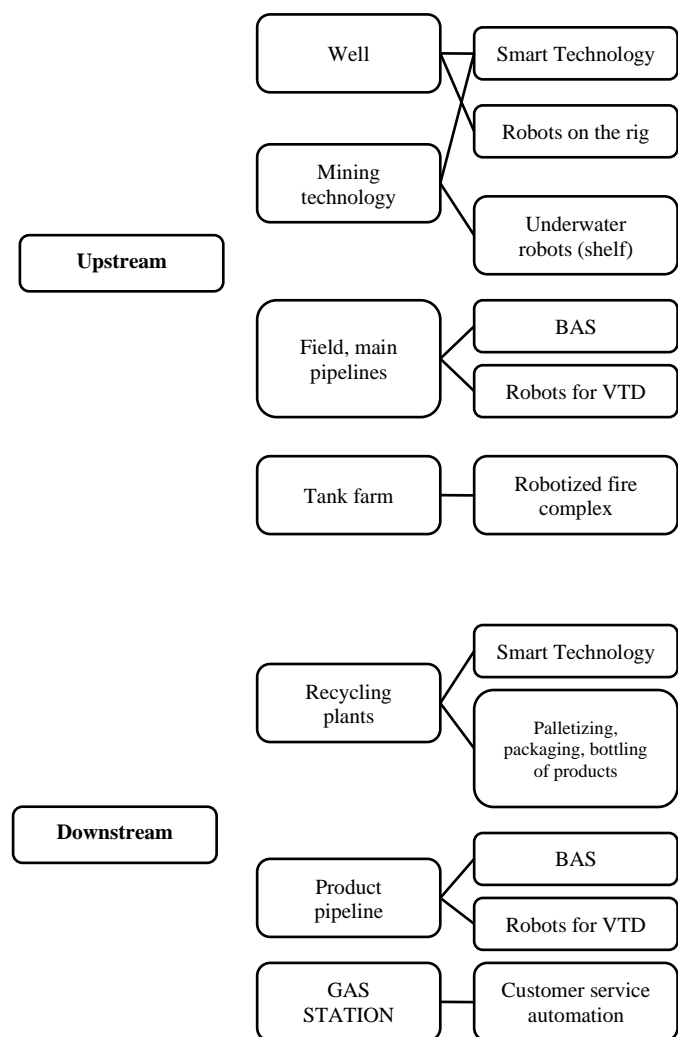


Fig. 5. Object analysis of the use of robotics in oil and gas industry

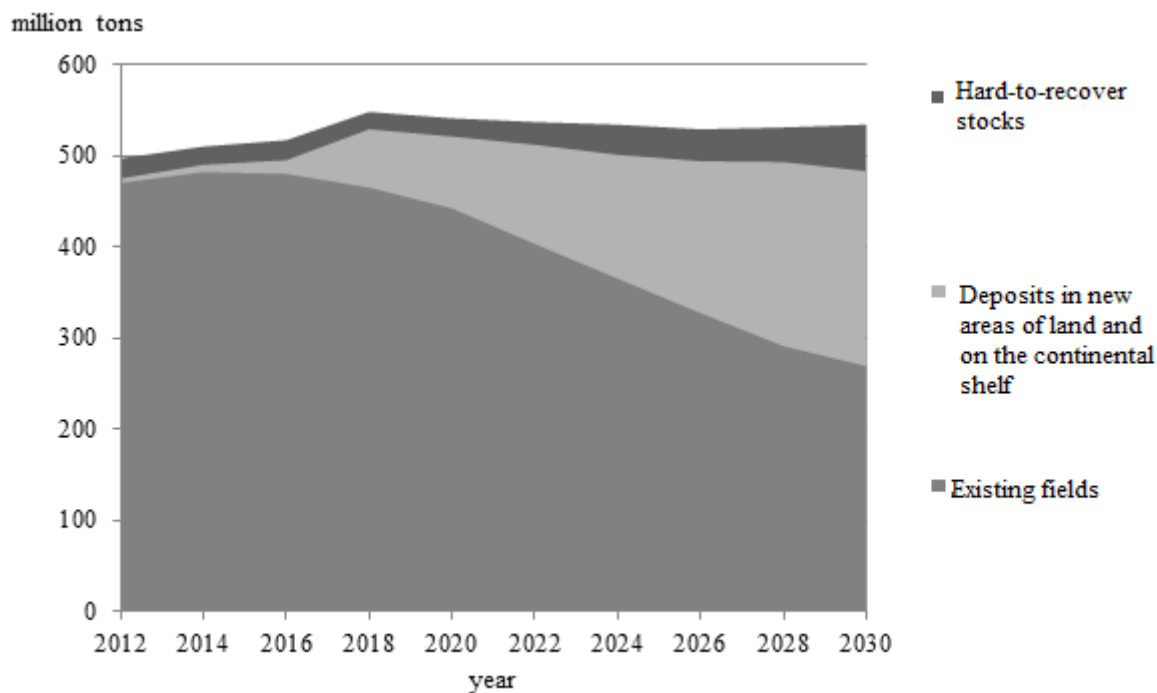


Fig. 6. Oil production profile in Russia until 2030 (source: company data, Energy Center of the Moscow School of Management SKOLKOVO)

State regulation measures plan to create conditions for the introduction of innovations, including robotic technologies aimed at maximizing the use of the potential of exploited fields. It is expected that administrative barriers will be reduced and economic incentives will increase. In a geological study of the undeveloped areas of the country and the continental shelf, it is planned to introduce measures to stimulate private investment in order to stimulate own import-substituting technologies. In the technologies of prospecting and exploration of minerals in the deep-sea regions of the oceans there will be a need for robotics, as in the means of sampling and drilling for solid minerals. [8]

II. RESEARCH METHODOLOGY

The research was based on theoretical and methodological provisions contained in the works of domestic and foreign authors in the field of introducing innovative technologies of industry 4.0., Methods of accounting, assessment and risk management, taking into account the specifics of the new industry .0.

To justify the author's development, it is necessary to highlight in the course of the study the problems to consider in detail:

1. Risks of import dependence on foreign suppliers of robotics. The global market for industrial robots was formed several decades ago and is protected from new entrants by high barriers to entry. An analysis of foreign experience has shown that countries that go through the stage of large-scale industrialization and the creation of the automotive industry may have chances to develop national manufacturers of industrial robots. Without fundamental changes in the domestic economy, the likelihood of successful development

of Russian manufacturers of industrial robots is small. The main reasons for this are the following circumstances: the development experience and the scale of production of industrial manipulators in Russia are not comparable with world leaders in this field; the level of competition in the world market of industrial robots is extremely high, their production is profitable only with a significant scale of production (tens of thousands of pieces per year).

2. Risks of low domestic demand in Russia

3. Risks of low opportunities to enter foreign markets. An important role in creating added value in robotics and the related segment of automation systems is played by engineering companies that implement robots in the production process. While their number in Russia is small, and experience is often insufficient for the implementation of complex projects. Nevertheless, as industry demand for robotics grows, there will be an increase in the number and advanced training of Russian integrators.

4. The threat of low competitiveness of robotics production in Russia: high costs of organizing production; the level of tax burden, the cost of electricity, components and the inaccessibility of long-term financing, as well as low price. Additional factors that have a negative impact on the development of robot manufacturers in Russia are the customs policy, remoteness from the main sales markets and the inaccessibility of individual components.

A comprehensive study of the enterprise's risk profile (Figure 7) will provide the necessary information to develop preventive measures to minimize or prevent risk.

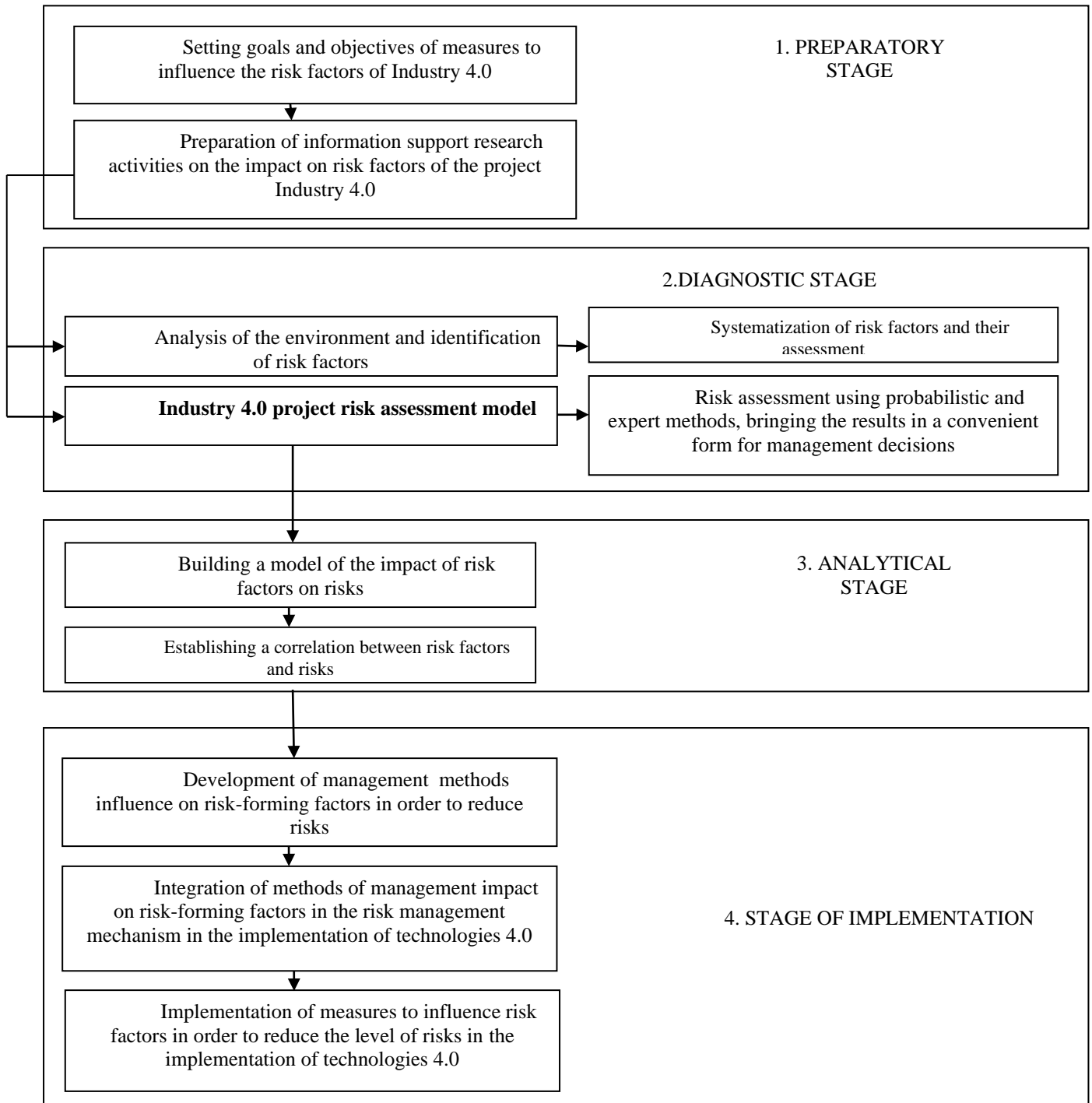


Fig. 7. Risk management algorithm for introducing Industry 4.0 technologies

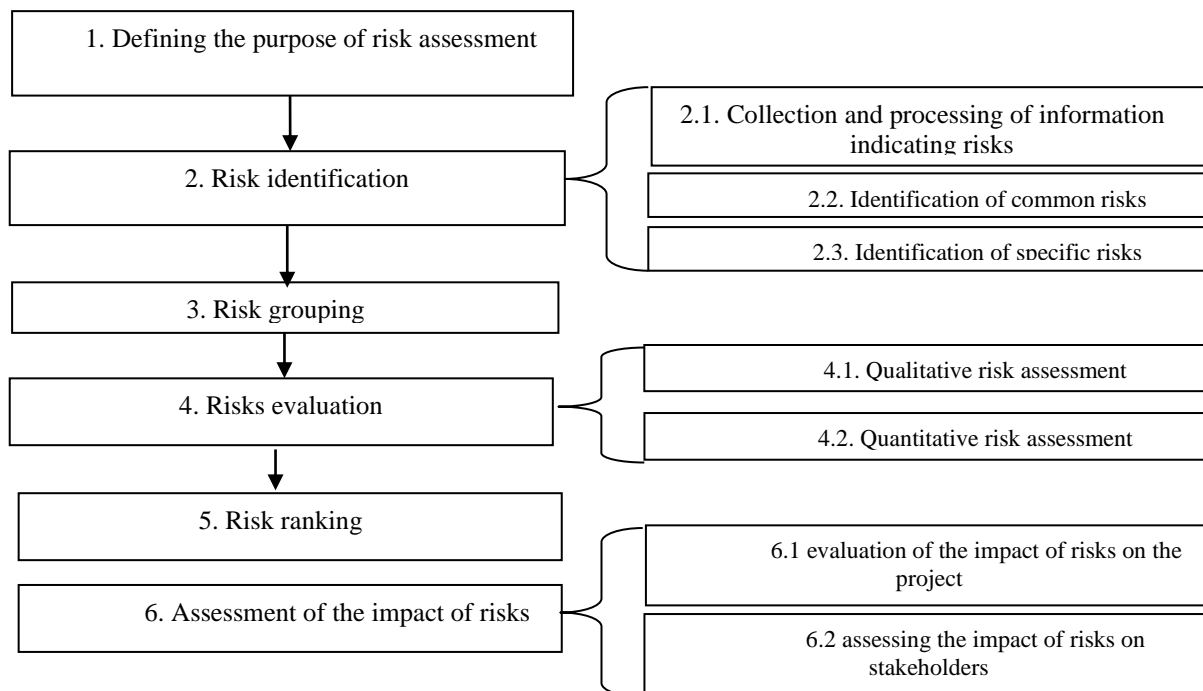


Fig. 8. Industry 4.0 Project Risk Assessment Model

The main problem of the assessing economic efficiency reliability of a project is risk accounting.

In addition to the main risks inherent in many innovative technologies, Industry 4.0 technologies have a number of challenges:

1. A limited number of large companies can take advantage of Industry 4.0.
2. The threat of cyber attacks due to the complexity of creating secure networks. With the growth of Industry 4.0, production processes can be terrorized remotely by manipulating the production protocol or simply paralyzing the process.
3. By 2035, about 50% of the world's jobs will be fully automated, which could lead to global unemployment.

The use of a risk assessment model and an industry 4.0 technology implementation risk management algorithm will improve the quality of managerial decision-making related to the sound implementation of technological solutions.

III. RESULTS OF THE RESEARCH

Testing was carried out on the example of the market for unmanned aerial vehicles in the oil and gas industry. According to the Federal State Statistics Service for 2015, the length of gas pipelines amounted to 177.7 thousand km, oil pipelines - 54.8 thousand km, oil product pipelines - 19.3 thousand km. Details of the length of pipelines are presented in Table 2. The length of field pipelines for 2015 is about 350 thousand km.

TABLE II - THE LENGTH OF THE RUSSIAN OIL PIPELINES 2013-2030. (YEARS MARKED * ARE FORECAST)

Indicator	The length of trunk pipelines, thousand km	The volume of the length of field pipelines, thousand km	The total length of pipelines, thousand km
2017	254.3	350	604.3
2018 *	255.4	351.5	607
2019 *	256.6	353.1	609.7
2020 *	257.7	354.6	612.4
2021 *	258.9	356.2	615.1
2022 *	260	357.8	617.8
2023 *	261.2	359.3	620.5
2024 *	262.3	360.9	623.2
2025 *	263.5	362.5	626
2026 *	264.6	364.1	628.7
2027 *	265.8	365.7	631.5
2028 *	267	367.3	634.3
2029 *	268.1	368.9	637.1
2030 *	269.3	370.6	639.9

Estimated forecasting of the volume of the market for monitoring oil pipelines in Russia is presented in Figure 9.

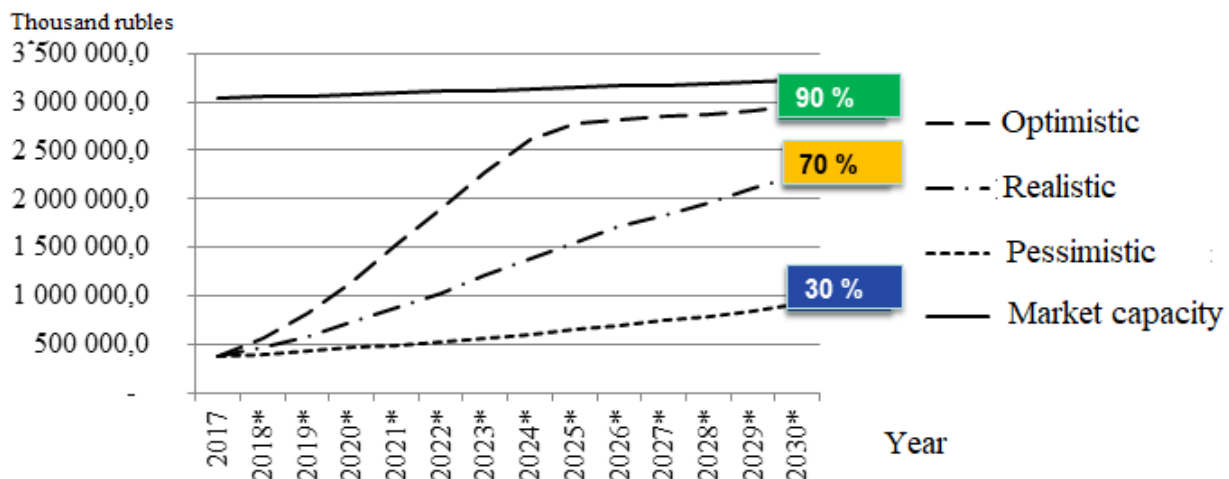


Fig. 9. Forecast of orders and volumes of the UAS market for services in oil and gas industry for 2017-2030 (years marked * are forecast)

The base year on which the forecast is based is 2017. Market growth rates are based on the growth rate of pipelines, based on growth rates set by the IFR and other sources predicting the market size of industrial unmanned aerial vehicles. When making the forecast, the reduction in prices for UAVs and for services for monitoring production facilities was also taken into account.

A realistic option for the development of the market is such a scenario, when large companies in the oil industry begin to use UAVs for the air monitoring of their trunk and production pipelines. We are talking about such companies as NK Rosneft, PJSC, Transneft, PJSC, Gazprom, PJSC since they have large or monopolizing market shares. These companies can become catalysts for the "robotization" of oil and gas industry. At the moment, some subsidiaries of these holdings have begun the test use of UAVs to control their production facilities. With a successful assessment of such application results, the degree of use of "drones" will increase sharply in the near future.

Thus, the market capacity will expand rapidly in the next five years. Companies will replace walking rounds, small aircraft, with cheaper unmanned systems, which offer a wider research functionality.

The market is potentially so large that while domestic companies practically do not compete with each other: each has found its own niche and works with varying degrees of success. This situation will probably continue in the medium term.

In accordance with the compiled scenarios for the development of the unmanned aerial vehicle market in the State Tax Administration, the accumulated economic effects for the period 2017-2030 were calculated.

In 2017, the savings from using UAVs instead of helicopters will amount to 5.29 million rubles. The length of production facilities subject to air monitoring in the reporting year is 417.5 km. The length of all pipelines of the oil and gas complex in Russia for 2017, based on statistical data, is 604,306.6 km. Based on these and other data, predicted economic effects were calculated according to market development scenarios, as well as taking into account risks

specific to industry 4.0, presented in Figure 17. They are presented in Table 3.

TABLE III. CALCULATION OF THE ACCUMULATED ECONOMIC EFFICIENCY ACCORDING TO THE DEVELOPMENT SCENARIOS OF THE UNMANNED AERIAL VEHICLES MARKET IN THE NATIONAL CIVIL REGISTRY FOR 2017-2030.

Year	Optimistic scenario	Realistic scenario	Pessimistic scenario
2017	950.1	950.1	950.1
2018	1418.9	1182.4	1012.2
2019	2048.2	1471.4	1078.1
2020	2854.8	1831.1	1148.5
2021	3780	2187.6	1223.5
2022	4704.3	2548.3	1303.4
2023	5573.6	2968.4	1388.5
2024	6381.6	3398.7	1479.2
2025	6736.8	3789.9	1575.8
2026	6813.4	4150.6	1678.7
2027	6890.0	4421.7	1788.3
2028	6890.0	4710.5	1905.1
2029	6966.5	5018.1	2029.6
2030	7043.1	5345.8	2162.1
Accumulated economic efficiency million rubles	62008.2	43974.6	20723.1

Thus, the accumulated economic efficiency from the use of unmanned aerial vehicles in order to monitor trunk and field pipelines at domestic enterprises by 2030, according to forecasts, is up to 62 billion rubles according to the optimistic scenario.

IV. DISCUSSION OF RESULTS

The authors developed a model for assessing the risks of industry projects 4.0., Which is based on six interrelated stages: determination of the purpose of risk assessment, risk identification, risk grouping, risk assessment, risk ranking and

assessment of the impact of risks on existing production. The model, unlike the previous ones, takes into account the risks that manifest themselves when introducing new technologies of industry 4.0. Also in the framework of the model, in this study, a pool of problems is identified and streamlined, the solution of which is in the competence of the oil and gas company itself. A set of proposals for improving the current regulatory framework governing activities in the oil and gas market is presented, which involve the development of new regulatory and technical documentation and the introduction of amendments to the existing one. A set of proposals for improvement affects the financial, tax, administrative and legislative aspects of state policy. Summing up, we would like to note that the main feature of oil and gas treatment facilities in foreign fields is their organic connection with the entire complex of the oil field. In almost all developed countries, joint processing of oil and gas is used, which can significantly reduce the territory of facilities by reducing and combining many general-purpose nodes and reduce investment and energy costs by 25-30 per cent, compared to the option of separate preparation of oil and gas for technological and organizationally autonomous facilities. In the USA, Canada, France and other countries, laws have been passed prohibiting the extraction and preparation of oil without the utilization of associated petroleum gas. Thus, it is necessary to use the author's proposals to improve the regulatory framework governing activities in the oil and gas market.

In addition, an analysis of existing methods showed that in order to achieve the required indicator of 100% oil and gas utilization, it is necessary to change the priorities of the efforts of oil companies and federal and regional authorities. The stumbling block should be not various sanctions (up to the revocation of licenses for the right to use subsoil), but a change in the economic efficiency of oil and gas useful projects. The result should be the profitability of processing all currently unclaimed resources, in particular oil and gas of small and medium remote oil fields.

V. CONCLUSION

The analysis of the current state of the robotics market in the framework of the new industry 4.0 at the international and national level, which identified the main positive aspects and implementation risks, including at the enterprises of the oil and gas industry. It is noted that the most significant factors ensuring the implementation of industry 4.0 technologies. in Russia are: low level of labor productivity, manufacturability of production processes in the oil and gas industry, as well as oil and gas transportation. A methodological approach to accounting, assessment and risk management in the implementation of new industry 4.0 technologies has been developed. in existing industries.

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