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## Development focus of electronics industry in Russia: Shift from defense sector to market

Ekaterina V. Nezhnikova , Daniil A. Kopylov  

*RUDN University,  
6 Miklukho-Maklaya St, Moscow, 117198, Russian Federation*

 [danii-l@mail.ru](mailto:danii-l@mail.ru)

**Abstract.** The purpose of this research is to provide an analysis of the current status of the electronics industry in Russia and to suggest ways the government can invest in the industry to create a sustainable and competitive market. Research highlights the importance of the electronics industry in the global economy, and the need for Russia to invest in production and research to increase its domestic output. The study finds that the national strategy for the development of electronics in Russia needs to be more specific and rely on market trends. Research suggests that the government should provide clear funding for new and existing companies to build new facilities and improve research capabilities. Additionally, a feasibility evaluation model for project novelty in the electronics industry is proposed, which considers technology, facilities, funding, and compatibility. The paper emphasizes the significance of narrowing down general provisions of government documents to key development areas such as building factories or creating marketable products. It also recommends that during the recession of the technological cycle, Russia should make every effort to acquire mature equipment to overcome the shortage of semiconductors. The study finds that investing in mature equipment will ensure that the industry is sustainable over the long term. In conclusion, research recommends that Russia uses the current drop in demand for electronics manufacturing facilities to build a sustainable and competitive industry. By implementing these recommendations, Russia can improve both its domestic and international competitiveness in the electronics industry.

**Keywords:** electronics industry, sustainable development, sanctions, import substitution, digital economy

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## Направление развития электронной промышленности России: переход от обороны к рынку

Е.В. Нежникова , Д.А. Копылов  

*Российский университет дружбы народов,  
Российская Федерация, 117198, Москва, ул. Миклухо-Маклая, д. 6*

 danii-1@mail.ru

**Аннотация.** Цель данного исследования — проанализировать текущее состояние электронной промышленности в России и предложить правительству пути инвестирования в отрасль для создания устойчивого и конкурентоспособного рынка. Исследование подчеркивает важность электронной промышленности в мировой экономике и необходимость инвестирования России в производство и исследования для увеличения внутреннего выпуска продукции. Выявлено, что национальная стратегия развития электроники в России должна быть более специфичной и опираться на рыночные тенденции. В качестве рекомендаций авторы предлагают правительству предоставить четкое финансирование новым и существующим компаниям для строительства новых производственных объектов и повышения исследовательских возможностей. Дополнительно представлена модель оценки жизнеспособности проекта в электронной промышленности, которая учитывает технологию, объекты, финансирование и совместимость. В работе подчеркивается важность сокращения общих положений правительственных документов до ключевых направлений развития, таких как строительство фабрик или создание товаров сбыта. Также рекомендуется, чтобы в период экономического спада технологического цикла Россия приложила все усилия для приобретения зрелого оборудования, чтобы преодолеть нехватку полупроводников. Исследование показывает, что инвестирование в зрелое оборудование обеспечит устойчивость отрасли в долгосрочной перспективе. В заключение предлагается использовать текущее сокращение спроса на производственные объекты электроники для создания устойчивой и конкурентоспособной отрасли. Путем реализации данных рекомендаций Россия может улучшить как внутреннюю, так и международную конкурентоспособность в электронной промышленности.

**Ключевые слова:** электронная промышленность, устойчивое развитие, санкции, импортозамещение, цифровая экономика

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### Introduction

In Russia the main mechanisms to support the sustainable development of the electronics industry are defined in Strategy of Russia's electronics industry development up to 2030, which is intersectoral in its nature and includes not only manufacturers of electronic equipment, modules, components and embedded hardware, but also

developers and manufacturers of materials and tooling equipment for production of electronics. Basically, the industry produces components and narrow-focused ready-made products.

The Russian electronics industry accounts for less than 2 % of the gross National product (GNP), but the scientific, technical and industrial potential of the industry are factors in the development of related industries and indicators of the country's technological independence.

Strategy of Russia's electronics industry development up to 2030<sup>1</sup> defines the following markets of the future: neurotechnologies and artificial intelligence, devices based on quantum technologies, industrial Internet, robotics, virtual and augmented reality devices. It should be noted that as of 2023, in developed countries, only quantum technologies have not become a full-fledged market due to the specific way of implementing calculations and the lack of a sufficient number of development tools — the rest of the segments, which we in Russia consider the future, have already become the present.

The main question that Strategy of Russia's electronics industry development up to 2030 seeks to answer is why the country has to develop the domestic electronics industry. One of the goals is to accelerate the technological development of Russia, innovate the economy and the social sphere. The second goal is national security and import substitution. Both goals should be achieved, among other things, by using the global trend of increasing influence of the electronics industry on the growth of the gross domestic product.

Thus, Strategy of Russia's electronics industry development up to 2030 contains general provisions for the development of the electronics industry in the interests of the military-industrial complex, which runs the risk of becoming dependent on the industry itself. The main message of the Russian strategy is to develop the industry in a harmonious way, while obtaining benefits requires an imbalance in favor of the electronics industry and development and design tools. In the current version, the document consolidates the status quo, in which the needs of the defense industry are met, while other segments cannot develop (especially without funding).

## Goal

In our opinion, the key difference and value of the Strategy of Russia's electronics industry development up to 2030 is the expansion of cooperation, which includes the use of existing production, scientific and engineering resources, including partnerships with foreign organizations. The electronics industry in the digital economy is characterized by the interdependence of participants in the value chain.

There is no clear focus on investment in the stages of the Strategy 2030 and the planned results — the capital intensity of the industry is very high, the need for modern enterprises is also acute. The leading countries of contract manufacturing quite

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<sup>1</sup> Strategy of Russia's electronics industry development up to 2030. Retrieved February 1, 2023, from [government.ru/docs/38795](http://government.ru/docs/38795) (In Russ.).

simply solved the problem of personnel: for example, the PRC, in addition to financing education, offered salaries to specialists in the electronics industry higher than the world ones.

At the same time, the revenue and value added indicators do not reflect the consumption of the Russian market — literally all the key development milestones and which devices should be mastered by Russian manufacturers were listed in the technological part, although the time spent on mastering each technical process was omitted — Strategy of Russia's electronics industry development up to 2030 sets practically unattainable goals, omitting mechanisms other than protectionist measures, which is possible in a closed economy or with low requirements for digitalization.

### Materials and methods

After the tightening of sanctions against the Russian military-industrial complex and the electronics industry in 2022, development issues began to be discussed again at a high level, but the electronics industry was not recognized as an industry requiring technological leadership, not sovereignty. In the current environment, there are doubts about the ability to implement the 2030 Strategy without additional resources.

Knes (Knes, 2010), Ngoc & Binh (Ngoc & Binh, 2019), Raj-Reichert (Raj-Reichert, 2020), Hou (Hou, 2020), and Yaghmaie (Yaghmaie et al., 2020) have thoroughly observed the production of advanced equipment and hardware. Balkenende & Bakker (Balkenende & Bakker, 2015), Helo (Helo et al., 2009), and Yun & Lee (Yun & Lee, 2022) have stressed the issues of corporate governance and sustainability. Sodhi & Lee (Sodhi & Lee, 2007) have discussed intensive cooperation and flexibility in value chain management, while Zhou (2008), and Reshetnikova (Reshetnikova, 2020) have highlighted governance factors of high-tech development in China. Sellitto & Hermann (Sellitto & Hermann, 2019) have emphasized ecological innovation.

Compatibility issues in electronics economy are discussed by Baldwin (Baldwin, Clark, 2000), Hobday (Hobday, 1995) and Kawakami (Kawakami, 2011). Gereffi (Gereffi, 1994), Morrison et al. (Morrison, Pietrobelli, Rabellotti, 2008), Shin-Lung (Shin-Lung, 2003) and Sturgeon (Sturgeon, Kawakami, 2010) thoroughly observe business processes in modern capital-intensive industries all over the world. Brown and Linden (Brown, Linden, 2005) articulate the crucial elements of global semiconductor manufacturing. Danilov-Danilyan and Piskulova (Danilov-Danilyan, Piskulova, 2018), Golley (Golley, 1993) and Saha (Saha, 2016) emphasize that emerging countries have distinct issues when forming new ecosystems.

In Russian research, Kulikova (Kulikova, 2017) and Malinetskii (Malinetskii, 2020) articulate governance as the primary development factor of the national electronics industry. Teodorovich (Teodorovich et al., 2016) and Kryukov (Kryukov, 2018) show technological areas for improvement as well as best practices from market leaders, stressing the importance of human capital. Factors influencing China's position in the race to global leadership in artificial intelligence have been thoroughly observed Reshetnikova (Reshetnikova, 2021).

The methods of scientific research used primarily include induction, deduction, analysis, synthesis, and description with the latter three being crucial to assess Russia's strategy for development of electronics. The author introduces a point-based model for evaluating novelty in import substitution with regard to electronics industry in Russia. Materials from the Russian Strategy of electronics industry development up to 2030.

## Results and Discussion

The Russian experience of creating finished products includes many examples when a practically ready-made solution became obsolete during the transition to production. Elbrus processors, which have been developed by MCST since 2005. At the beginning of their development, they lagged behind by one or two generations in terms of applied technologies, having their own architecture, which made direct comparison of performance with world analogues impossible. At the same time, the scale of production did not expand, and the production profile changed from a processor for Russian computers to a development that is in demand in areas with increased requirements for information security.

Initially, the manufacturer was Mikron, but the new generations of Elbrus were produced by TSMC (since, 2014), since Mikron could not master the 65 nm process technology. After the imposition of sanctions against MCST, the company was deprived of communication with a contract manufacturer — although it is possible to replace and transfer to another plant, it is doubtful whether it is advisable to release a processor without established cooperation within the country or abroad.

In 2021, Sberbank issued a report in which it assessed the performance of purchased servers based on Elbrus processors (computers are available to a limited list of persons, the delivery time for a commercial batch exceeds a year) — the backlog in a number of test tasks compared to Intel processors was 23–26 times larger. In principle, the Elbrus central processor architecture is not suitable for servers and general-purpose computers, and the issue of incorrect positioning of products in the Russian electronics industry is not uncommon.

For the correct operation of such processors, their own software is required, which greatly increases the costs of switching to domestic products. For sustainable development, such issues need to be addressed on a market basis, since digitalization relies on the constant growth of the need for various kinds of computing. If one of the most famous processors produced in the country is used for other purposes, and the customer in the form of Sberbank does not know about its capabilities, this indicates a lack of awareness. Russia's electronics industry is a strategic one, but this is not the same as a secrecy regime.

When calculating the degree of Russian production in finished products, the percentage of localization is considered. For the electronics industry, where component density is high and components from foreign suppliers can be extremely cheap, localization will be reduced to trying to get around the import share.

As most producers of electronics rely on imported materials or devices, it is impossible to create an industry free from foreign components or influence. At the same time, it is important to outline criteria for prospective projects in electronics. We propose the following formula:

$$Feasibility = 0.5 * K_1 + 0.25 * K_2 + 0.1 * K_3 + 0.15 * K_4.$$

Feasibility is an index ranging from 0 to 3. This index describes the potential of any project or venture in electronics. Based on author-determined weights (perceived importance of factor), there are three outcomes: project should be rejected (result between 0 and 1), conditionally accepted (result between 1 and 2) or fully supported (result over 2) (Table 1).

Table 1

## Itemized system of novelty in electronics industry

Element	Tier	Points	Comments
Technology ( $K_1$ )	> 90 nm	0	This is an example from semiconductor industry. The more advanced node is proposed, the higher this venture scores
	90–45 nm	1	
	40–22 nm	2	
	14 nm or less	3	
Production facilities ( $K_2$ )	No facilities	0	Most projects focus on low-effort products with high rate and speed of return. This coefficient emphasizes importance of long-term investments
	Participation in a local production chain	1	
	Participation in a global production chain	2	
	Factory	3	
Funding requirements ( $K_3$ )	Requires funding from the government	0	Electronics industry is often supported by government or multinationals. This coefficient proposes more self-financing and sourcing from private sector rather than the state funds
	Requires funding from private sector	1	
	Requires partial funding	2	
	Does not require external funding	3	
Compatibility ( $K_4$ )	Requires foreign hardware and software	0	National electronics are always compatible with something. In order to synergize with import substitution in software, it is better to provide for better performance beforehand
	Can be used with national software	1	
	Can be used with national hardware	2	
	Can be used with both national software and hardware	3	

Source: compiled by authors.

Furthermore, to resolve the issue of local production, a mechanism for determining a priority supplier is used, but it is not considered that it does not have a market for a variety of Russian products — even the Strategy 2030 recognizes non-compliance with the requirements of civilian products. Instead of building production at a faster pace, deliveries of domestic computers will be made from

obsolete components or imported components. Both options are not suitable for sustainable development.

The use of open source operating systems allows all parties to inspect the code for vulnerabilities, but the main advantage for the Russian electronics industry is the transition to an independent product. Also, in the case of developing fully national components, in the case of closed operating systems, you need to contact the developer, with open operating systems, manufacturers themselves can add support — American companies add their code to Linux to support their components, but Russian companies can do this non-publicly, developing a branch the main core with its own modifications.

For many users of the Microsoft Office suite, the impossibility of running it on operating systems of the GNU / Linux family will be a discovery, and in most cases, their own versions of the programs are required.

A conditional Russian computer cannot be used for a wide range of tasks with a large discrepancy with the world component base. Technological sovereignty will require the development of programs at a faster pace — the process of switching to Russian electronics can only be complex: first, existing computers on GNU / Linux with new programs (which will require users to get used to), then new Russian computers.

Thus, the economic effect of the transition to domestic electronics will primarily be at the level of programs and operating systems — the state must take measures to support and regulate prices, since the commercial software market is oligopolistic in nature.

At the same time, the development of all technologies from scratch is impossible — the accumulated amount of knowledge in open access should be used, therefore the foundation of Russian software support should be open source software, which, if necessary, can be finalized in accordance with the goals of information protection.

Returning to Strategy of Russia's electronics industry development up to 2030, let's pay attention to the lack of a choice of specialization of finished products. A domestic computer is needed only when it is supposed to abandon foreign manufacturers. Since Russia will not catch up with world countries, there will be other options in practice.

Public computers and servers represent finished products that Russia has sought to produce. These devices perform a wide range of tasks, but development requires a lot of code. At the same time, the results of systems with Elbrus processors have become only an experiment. In Strategy of Russia's electronics industry development up to 2030, one of the points is the unification of production, but without specific requirements. It is public computers that are the challenge of unification. Their support requires the work of many developers, who often do not know the characteristics of the computer where the program will operate. Therefore, Russia can develop computers and servers for general use only with equal access to software and microcode with the whole world. The sanctions Russia is facing point to the impossibility of achieving technological sovereignty through computer components. Therefore, future import substitution requires fundamental software development — this is what Apple did, only

in 2020 introducing its own processors for computers, while maintaining compatibility with the previous architecture.

The next way where the world electronics is developing is high-performance computing. Lack of access to capacity and the ability to purchase components on the scale of new supercomputers Russia can only rely on software — distributed computing is at the intersection of electrical engineering and computer technology.

One way or another, low capacities and lack of technology do not deprive Russia of prospects in its own development. The Raspberry Pi example shows that a low-performance computer is suitable for many applications, and does not play the role of an educational toy.

For the development of the electronics industry along the path of embedded electronics, unification is indeed required — the state can determine the main component around which the application ecosystem will be built. Embedded appliances have become popular due to low power consumption, and this means dependence on foreign contract manufacturers until their own production appears. Russian design centers must choose a processor architecture or create a soybean, then find a manufacturer — in the current realities, only contract manufacturers in China are available.

Dependence on one country poses a serious threat to Russia's technological sovereignty, so the best way out is to organize joint production with subsequent localization, with the possible creation of a similar production in Russia. It should be noted that the dependent position of the Russian electronics industry in the domestic market from related industries currently prevents integration into accessible value chains.

At the same time, it will be necessary to search for small producers in the countries of South and Southeast Asia — the penetration of international technologies into their markets will lead to a transfer of technologies. Russia, even under sanctions pressure, can count on new technologies, but this requires cooperation with countries where production is only planned and where they also plan to achieve technological sovereignty, for example, in India.

In any case, dependence on the PRC as the leading chipmaker will grow as long as restrictions remain and there is no alternative manufacturing center. Therefore, the main failure of the Strategy 2030 will be an increase in dependence on China, if alternatives are not found in other countries within the next 3–4 years.

Thus, the biggest challenge for the Russian electronics industry is not backwardness, but a huge gap in accumulated technology and investment with China, which will constrain the development of Russian electronics to the same extent that the US seeks to limit China's access to new technologies.

Russia is a global supplier of neon for subsequent production in the electronics industry, and there is a duopoly in this market. Neon and other gases used in electronics should be used as donors for the Russian industry, and not exist separately.

The success of the policy is largely determined by economic benchmarks, which are separated from the technological stages. The creation of factories and the timing of the development of technologies are missing elements.



The lack of industry autonomy is combined with support for demand for its products. A situation arises when it is impossible to create a civilian product with the highest possible share of Russian electronics, and instead of a phased creation of the production of components, pull incentives are used. It is recommended to switch to direct stimulation and creation of production and slow down the pace of transition to domestic developments.

At the same time, the creation of ecosystems is required — growth in the field of software development is associated with the electronics industry (and is part of it according to Strategy of Russia's electronics industry development up to, 2030), requires less financial resources. The transition to technological sovereignty should take place in stages: first software and only then the creation of computers. Without a holistic approach, products will be a low-quality substitute that reduces labor productivity and the pace of digitalization.

One of the factors in the direction of the current development of the electronic industry in Russia at the moment remains the defense industry, which requires the localization of the component base. Russia's position as one of the leaders in the arms market and the army modernization program make it possible to fill the domestic electronics industry with orders.

Unfortunately, the reliance on the defense industry and the relatively small size of the Russian market lead to the fact that the demand for civilian products is traditionally met by foreign suppliers (according to some estimates, 90% of the consumption of electronic components in Russia comes from imports). As a result, the value added of the domestic industry in the final product is low.

An equally significant problem is the shortage of personnel in the Russian electronics industry — the level of remuneration in the industry does not correspond to the competencies of specialists who leave the school for training highly qualified engineers and prefer to change the industry or country of employment.

When developing mechanisms for development, it is necessary to maintain a balance between the interests of strategic industries that operate in their circuit, and the open market, represented by research centers, private and state-owned companies.

The experience of developed countries in combining defense industry orders from enterprises that also operate on the open market is determined by two factors: the demand for unified developments (which, from a security point of view, have the advantages and disadvantages of openness) and the ability to ensure uninterrupted supplies (sanctions pressure against Russia and China deprives countries of this factor). In other cases, enterprises in strategic industries rely on long-term relationships with companies that serve them.

Therefore, decisive changes in the development policy of the electronics industry will lead to a weakening of the stability of strategic industries. It is proposed to consolidate the division of the electronics industry into closed and open, and to concentrate development policy on the development of the open sector.

The spin-off of a new sub-sector as a whole represents the creation of an industry from scratch. Russian electronics must have its own unique role, but for this it is necessary to avoid the mistakes of the USSR and highlight the industry as a priority.

The error of Strategy of Russia's electronics industry development up to 2030 and current public policy in general is the assumption that progress in the electronics industry is linear. To get any return, the important indicators are the final product. In Russia, we are not talking about the process of supporting the electronics industry, but about achieving milestones in the form of a factory or the development of a processor with measurable characteristics. At the same time, the model and mechanisms used are consistent with sustainable development, but in a digital economy, sustainability is associated with future growth, and not obsolete production.

Therefore, it is proposed, within the framework of state policy, to move from target economic indicators to technological ones, which more fully reflects the needs of the digital economy. As a basis, the provisions of Strategy of Russia's electronics industry development up to 2030 on intellectual property embodied in production will be adopted. For example, for the production of processors, three areas can be distinguished: architecture, actual production, and software and hardware support — each is divided into smaller stages. Production requires: reagents, materials, equipment, software and hardware systems.

At every step there are alternative solutions: self-development and purchase. For contract manufacturing, specialization at one stage is important, because when combined with the production of materials and finished products, economic costs and renewal costs will be too high. This means that a contract manufacturer must specialize in its field and take into account that it is impossible to master all technologies. Next, you need to find out the cost of mastering production on your own and the cost of purchasing a turnkey plant. The 28 nm process technology was chosen precisely because of its prevalence, this is the most advanced technology that Russia can acquire bypassing export restrictions. Based on the comparison of cost and time spent, it is worth choosing the best option.

At the next stage of development, new partners from abroad should be attracted (to the already open parts of the electronics industry, where there is no predominance of strategic production), increasing the volume of cooperation with them.

Developing countries with their own developments and licenses that they did not renew (like Chinese processors based on AMD Zen) have an established production and some amount of intellectual property, but cannot significantly increase it. Russia may be of interest as a partner in research and as a customer of small volume products. Countries such as China, Vietnam and India should become strategic partners in the development of the electronics industry.

## Conclusion

Russia does not directly support new production by first creating incentives for the demand side. This situation leads to the search for technological loopholes to recognize the finished product as Russian. At this time, the industry does not receive new orders, and a consumer with a large digital budget will not turn to a non-competitive product. A vicious circle is created when the lack of Russian intermediate products (processors,

memory, etc.) makes it impossible to create a Russian computer, and without demand for a Russian computer, the vendor will not create demand for Russian processors.

In this case, there is no mechanism to support domestic producers — the state supports purchases, not industry. In this case, the requirements apply to a greater extent to the object of the procurement. The proposed refinement of the mechanism is a conditional roadmap for a completely Russian computer, where the maximum required percentage of localization is the share of a competitive product, and not just an analogue (which is possible in the case of strategic industries).

The main problem of all plans for the development of Russia remains domestic software. The dominance of the products of global software manufacturers in many countries has led to dependence on several companies. Historically, the user of technology interacts only with an interface designed specifically for him. Issues of functioning outside of normal interaction are considered the prerogative of specialists, although at the initial stage of the development of computer science, technical expertise was above average.

The stagnant nature of the country's electronics industry is due to disproportions in economic demand across sectors and the inconsistency of state sectoral policy with the goals of developing the digital economy. The dependence of electronics on the defense industry leads to the fact that the main added value is created by military and dual-use products, while the electronics industry is in an unstable position: strategic industries rely on mature and modern technologies, and promising developments do not live up to expectations. One of the reasons for this situation is the cheapness of outdated solutions. When developing new microelectronics for the defense industry, a significant amount of investment will be required, which will redistribute the cost of creating added value to the detriment of industry leaders. New technologies can only be created with a guarantee of future demand or capital investment — the defense industry does not guarantee demand, the state and private companies do not invest in the market, expecting low profitability.

Thus, serving the interests of strategic industries leads to aggravation of stagnation and restraint in the development of the electronics industry. Moreover, closed sectors of the economy do not seek to facilitate catch-up development and hinder the exchange of know-how and developments, or the expansion of cooperation.

The original approach of the authors of Strategy of Russia's electronics industry development up to 2030 is the abstract mastery of technology, while the most important transition around the world occurred during the transition to mass production, which was made possible through the division of labor and specialization.

At the same time the attitude towards the organization of production in the electronics industry has also changed — the participants in the production chains have moved from the constant production of a well-known nomenclature to the achievement of new milestones, or products.

The product approach has changed the attitude towards manufacturing, since a 40nm process chip manufacturing plant is not the equivalent of fully mastering the process, but at the same time, the cost of creating it, the payback is measurable and better suited to calculating the necessary funding.

The convention of obsolescence in the electronics industry, i.e. the existence of a demand for mature technologies when reaching new frontiers serves as a relative advantage for those who specialize in it. At the current level of development of electronics, Russia cannot claim leadership in mass production, but should strive to create its own niche — reliable and mature electronics. For this, new products are needed, which are not currently being created in a significant amount.

Achieving national goals for the development of a digital society depends on the electronics industry, but understanding why its sustainable development is necessary — the industry must answer questions about how it improves society and contributes to digital transformation.

At present, the Russian electronics industry is an almost imperceptible participant in the market for computing of varying complexity. The current solutions are foreign technologies with the addition of Russian intellectual property, and not vice versa.

To combine the product approach and improve goal setting, market participants support the development of their own technologies. In the US, technology giants Amazon, Alphabet, in China, Alibaba create their own processors and order contract manufacturing. In Russia, one of the largest players in the private user data processing market is Sberbank, Yandex and VK — they have sufficient intellectual resources to be partners of the state in the development of the electronics industry.

Finally, the desire for technological sovereignty and security must give way to reliance on open technologies, primarily in the field of software. Development on the basis of technologies available around the world will favorably affect the quality of the equipment produced and provide a benchmark for comparison in the form of similar products in other countries. Security issues will be resolved in the same way as ensuring compatibility — by making additions to the existing code (updates, patches).

Thus, the sustainable development of the Russian electronics industry is based on 4 proposed solutions:

- 1) withdrawal of the electronics industry from the defense industry;
- 2) identification of priority partners for development, and then — cooperation;
- 3) creating a roadmap with stages of technology development (each of them will achieve a new level of sustainability);
- 4) expanding the use of open source software.

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#### Bio notes / Сведения об авторах

*Ekaterina V. Nezhnikova*, Dr. Econ. Sci., Professor in Department of National Economy at the Faculty of Economics, RUDN University. ORCID: 0000-0002-5236-7950. E-mail: [katnej@mail.ru](mailto:katnej@mail.ru)

*Нежникова Екатерина Владимировна*, доктор экономических наук, профессор кафедры национальной экономики экономического факультета, Российский университет дружбы народов. ORCID: 0000-0002-5236-7950. E-mail: [katnej@mail.ru](mailto:katnej@mail.ru)

*Daniil A. Kopylov*, PhD student, Department of National Economics, RUDN University. ORCID: 0000-0003-1457-2803. E-mail: [danii-l@mail.ru](mailto:danii-l@mail.ru)

*Копылов Даниил Алексеевич*, аспирант кафедры национальной экономики, Российский университет дружбы народов. ORCID: 0000-0003-1457-2803. E-mail: [danii-l@mail.ru](mailto:danii-l@mail.ru)