Improving production efficiency through the implementation of digital projects in the agricultural sector

A.D. Burimsky, *V.A.* Nikolenko and *V.V.* Gerasidi*

F.F. Ushakov State Maritime University

Abstract. The article deals with the digitalisation of agriculture in Russia and abroad. The article considers the projects on implementation of digital technologies in agriculture. In Russia, the digitalisation of agriculture has been actively developing in recent years. There are many projects to improve the efficiency of agricultural production, covering crop monitoring, machinery management, animal welfare control and product quality tracking. Abroad, the digitalisation of agriculture is also at the forefront. The US and France are adopting advanced technologies such as artificial intelligence, the internet of things and blockchain to increase production efficiency, reduce costs and improve product quality. The article reveals that Russia is well positioned in the world in the digitalisation of agriculture, owing to its developed infrastructure, skilled workforce and more affordable digital solutions compared to foreign ones.

1 Introduction

In recent years, Russia has witnessed a rapid spread of digital, information and telecommunication resources, which actively affects processes in various areas of society. Software products of this kind have a significant impact on the activities of government agencies, helping to optimise work and providing access to necessary information. Therefore, digital technologies are becoming an integral part of many spheres of public life. [1–4].

In an effort to narrow the gap in labour productivity, yields and other aspects compared to countries with developed agriculture, Russia is paying increasing attention to the creation of state support measures aimed at stimulating the development of digital technologies in the agro-industrial complex. This strategic decision, aimed at improving the efficiency and competitiveness of domestic agriculture, opens up new prospects for innovation and modern approaches in the agricultural sector. Among the examples we can find such companies as Cognitive pilot, Agrosignal, Skyscout and Agronaut with their products [5–8].

2 The main part

Examples of digital projects for agriculture in Russia are as follows.

1. "Cognitive Agro Pilot" is a revolutionary system for autonomous control of agricultural machinery, representing the world's first industrial complex based on advanced artificial intelligence and computer vision technologies. By integrating advanced algorithms and technologies, the system becomes the real brain of the machine, analysing images from the video camera and making instant decisions [9].

The system operates with a modified convolutional deep learning neural network that analyses the video stream, identifies object types and positions, builds an optimal trajectory and transmits commands for manoeuvres. The ground-breaking technology delivers a level of precision unmatched before: tillage deviations are reduced from more than 30 cm to an astonishing 1–2 cm at high speeds (more than 10 km/h) [10–13].

Autonomous guidance systems become particularly valuable in environments where traditional methods encounter difficulties, such as night time, rain or fog. To minimise positioning errors, the autopilot system takes into account not only data from satellites but also correction signals from the nearest reference stations.

Each square centimetre of the surface is cultivated only once per operation, ensuring efficiency and precision in the use of fertilisers and crop protection products. The advantage of unmanned driving in agricultural fields, based on artificial intelligence, is also the absence of legal restrictions, which allows this technology to be used freely in agriculture.

* Corresponding author: gerasidi@rambler.ru

Table 1. Advantages of COGNITIVE AGROPILOT over competitors.

Comparison parameters	Cognitive Agro Pilot	Systems with technical vision	Parallel driving systems
Motion and sweeping control by vision and GPS	Yes	GPS-only operation	GPS-only operation
Suitable for any mill	Yes	Only one vendor	Yes
Digital hydraulic complete block	Yes	Just the car with the preparation	Electric paddles
Independence from navigation when working by sight	Yes	You have to carry a base station	No
Row guidance with any cutterbar	Yes	GPS only	Only a special reaper
Edge/roll movements	Yes	Just in a straight line, on the GPS	Just in a straight line, on the GPS
Speed control on different harvesters	Yes	Only one vendor	Just the car with the preparation
Automatic cleaning on uneven edges (complex edge geometry)	Yes	No	No
Sending telemetry to the most common ERP systems on the market	Yes	Proprietary only	Proprietary only
Identification of artificial and natural obstacles	Yes	Yes	No

2. "Agrosignal" system is a tool designed to provide agrarians with prompt and informed decision-making, providing full control and transparency over all production processes. The principle of the functioning of this system is the continuous recording and analysis of data from a multitude of sensors installed on the objects that require constant monitoring. In real time, the farm manager has access to summary indicators that allow him to analyse the current situation, to plan and control work processes. This allows him to quickly adjust work progress and assign tasks to employees, ensuring effective management of all aspects of production. Key functions include "Work and agro-operations accounting", "Machinery monitoring", "Agronomist assistant", "Reporting and analytics", "Cadastral accounting" [14–16].

Let us look at each function separately.

(a) "Accounting for works and agro-operations" involves operational planning and schedule management: the ability to automate all accounting processes related to area processing, creating shift schedules, developing individual and group plans, as well as generating reports on machinery operation, resource allocation, cargo movement and supply measures. Generation of trip tickets in 1C programme is the automatic uploading of data on works performed and efficiency of mechanics when integrated with the 1C system.

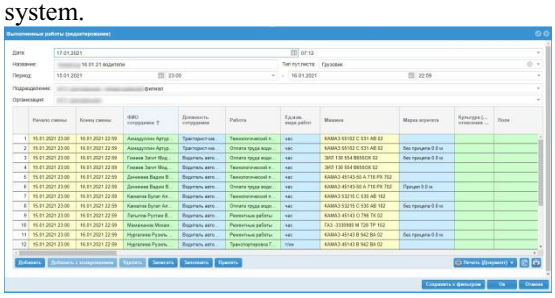

Fig. 1. Work accounting table in the application interface of the AgroSignal system.

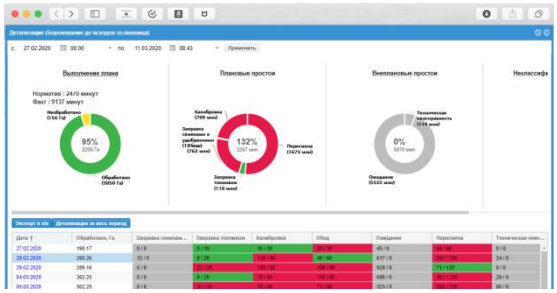

Fig. 2. Interface for analysing company control and downtime.

b) "Monitoring Techniques" are real-time monitoring of movements and work efficiency; it is the ability to detect unauthorised unloading and leaks of fuel and lubricants, deviations from established routes and violations of technological standards. Notifications and instant alerts (via email or SMS) are automatically triggered when deviations from set parameters are detected. Detailed information on the progress of major field operations is presented in the form of intuitive dashboards covering the entire production campaign period, as well as information for each day [17].

The AgroSignal system analyses data from various devices installed on vehicles, including primary (GPS trackers, engine sensors, speed sensors, fuel level sensors, drain analysers, etc.) and secondary (fuel level or auger unloading sensors, receiver key reader or mechanic shift keys, etc.) devices. The platform collects data on the location, movement and speed of machinery from devices, providing the ability to monitor information in real time and set up instant notifications.

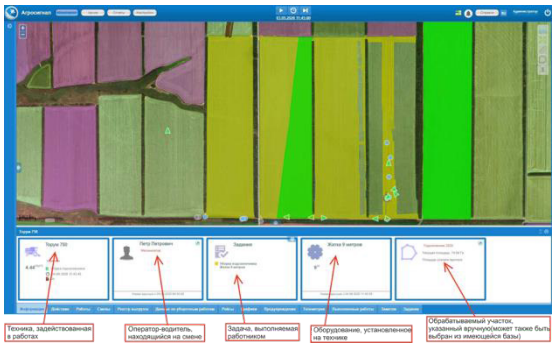

Fig. 3. The main interface of the "Monitoring for Techniques".

c) "Assistant Agronomist" is the Agronomy Unit that monitors field conditions and plant health, allowing you to take the necessary action quickly. It includes four key functions: calculation of the vegetation index (NDVI) for each field and its individual plots, spot surveys, differentiated fertiliser and protection applications with rates for each individual zone, and weather monitoring with the ability to set custom thresholds and keep digital records.

Fig. 4. Vegetation index display interface (NDVI).

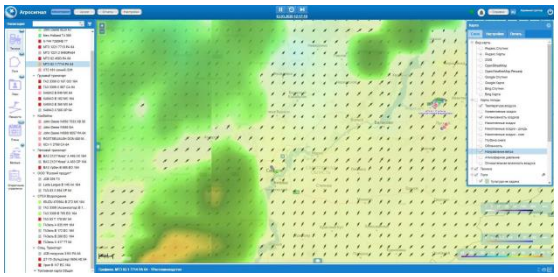

Fig. 5. Interface for displaying meteorological indicators.

d) "Reporting and analytics" is the system that displays in real time the dynamics of key indicators of agro-operations, providing information in a simple and understandable form. Working with data and analysing information are made easy and convenient due to a variety of reporting forms and filters, as well as the ability to customise them according to the needs of a particular enterprise or user [18].

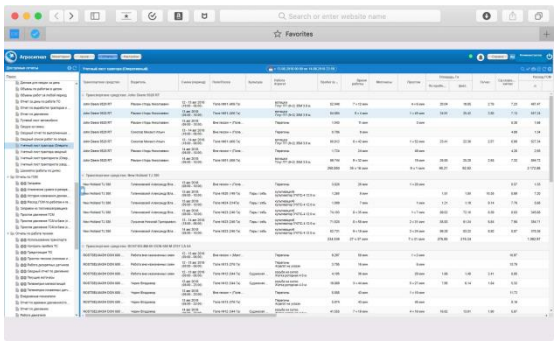

Fig. 6. Report database interface.

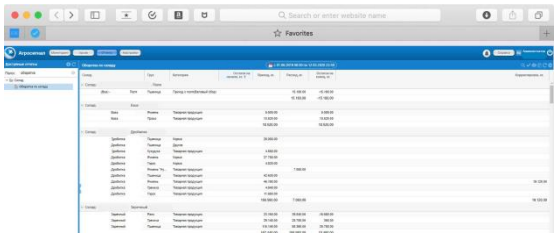

Fig. 7. Report database interface using keyword search.

e) "Cadastral registration" is optimisation of land resources use: functionality for entering and storing all legal information on cadastral plots, comparison of data on legal and actual areas, and automatic identification of overlapping plots.

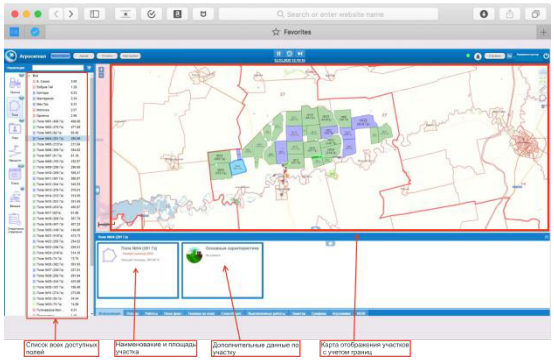

Fig. 8. Interface of "Cadastral registration"

In Russia, apart from Agrosignal, there are many similar systems, such as Skyscout and Agronout, whose basic functions are the same, the difference being mainly in the appearance of the interface, the used operating systems and the programming languages [19].

Examples of digital projects in agriculture abroad are the following.

Since Russia is a competitor to a large number of countries, in order to maintain proper development, we are obliged to follow the innovations of rival countries, among which we note the projects of the United States and France.

Smart Dairy Farm project in France was launched in 2015 by Dairyland Power Cooperative, which is a supplier of electricity to agricultural enterprises in the United States. The project aims to introduce artificial intelligence and Internet of Things technologies in the dairy industry. The project has installed sensors and cameras on farms that collect data on the animal condition, milk quality and other metrics. This data is

then used to optimise farm management, to increase productivity and reduce costs [20].

The possible benefits from the implementation of the Smart Dairy Farm project are:

- increased productivity. Using data collected from sensors and cameras allows farmers to optimise farm management, which can lead to increased productivity;
- cost reduction. The use of data collected by sensors and cameras allows farmers to reduce costs for feed, fertiliser, pesticides and other inputs;
- product quality improvement. Using the data collected by sensors and cameras allows farmers to improve product quality, e.g. increase the fat content of milk.

Fig. 9. Structural diagram of the Smart Dairy Farm project

Smart Dairy involves flexible control, touch screen milking parlour control, flexible access control, comprehensive equipment monitoring, complete parlour management, safe and accurate data management, on-site or remote data access and review, a data duplication system for complete data security, reliable, a long-term monitoring system, StepMetrix / StepGuardian, in and out of parlour feeding [21].

Agricultural Blockchain project in the United States aims to bring blockchain technology to US agriculture. The project has developed a platform that allows farmers to track the origin and quality of agricultural products.

Possible benefits from the implementation of the Agricultural Blockchain project are:

-increased transparency. Blockchain enables transparency at all stages of agricultural production, which can increase consumer confidence;

-improved traceability. Blockchain makes it possible to track the movement of agricultural products from producer to consumer, which can help combat fraud;

-improving efficiency. Blockchain can help farmers optimise production and management processes, which can lead to increased efficiency.

On the basis of the projects studied, we can draw up Table 2, in which we make a brief comparison of the directions in which digitalisation is heading.

Table 2. Comparison of Russian, US and French projects.

Country	Sector of agriculture	Functions of digital projects	Projects
Russia	Fields	Crop and crop monitoring, irrigation management, weather forecasting	Agrosignal, Skyscout, Agronout
U.S.A.	Fields	Crop and yield monitoring, irrigation management,	Agricultural Blockchain
France	Cattle	Monitoring livestock health, tracking livestock movements, feeding and caring for livestock	Smart Dairy Farm

3 Economic calculation of projects

In order to understand the situation of agricultural digitalisation projects in our country compared to rival countries, we will make an economic calculation of the installation and operation of the Russian project "Agrosignal" and the American project "Agricultural Blockchain".

1) Calculation of installation and operation of the Russian project "Agrosignal" make up the cost of Agrosignal services depending on several factors. These are a type of agricultural enterprise (for large enterprises, the cost of services will be higher than that for small enterprises), a required scope of services (the more services required by the enterprise, the higher the cost will be); a degree of complexity of the project (more complex projects will cost more) [22].

The one-time cost of implementing Agrosignal services ranges from 100 to 500 thousand rubles.

Monthly subscription cost for Agrosignal services ranges from 10 to 50 thousand rubles.

Agrosignal offers discounts for large enterprises and companies that participate in government programmes for the digitalisation of agriculture.

Here are some examples of Agrosignal's cost of services. For a large dairy farm, the cost of implementing the agricultural machinery monitoring service will be about 300 thousand roubles. The cost of subscription to the service will be about 30 thousand roubles per month.

For an average grain farm, the cost of implementing a crop and yield monitoring service will be about 200 thousand roubles. The cost of subscription to the service will be about 20 thousand roubles per month.

For a small vegetable growing farm, the cost of implementing the transport work accounting service will be about 100 thousand roubles. The cost of subscription

to the service will be about 10 thousand roubles per month.

2) Calculation of the installation and operation of the US Agricultural Blockchain project. The cost of Agricultural Blockchain services depends on several factors, including a size of the farmland (large farmland will cost more than small farmland will), a type of crop (different crops require different software), and a level of automation required (the higher the level of automation, the higher the cost).

The one-off cost of implementing blockchain software in agriculture is between €50,000 and €100,000 per site.

The monthly cost of software subscription is between 5 and 10 thousand euros per site. The cost of support services ranges from 1 to 2 thousand euros per hour.

Here are some examples of Agricultural Blockchain project service fees. For a 100-hectare site, the implementation cost will be around 1 million euros. The monthly cost will be about 15 thousand euros.

For a 50-hectare site, the implementation cost of the project will be about 500 thousand euros. The monthly cost will be about 7.5 thousand euros [23].

For a 25-hectare site, the implementation cost of the project will be about 250 thousand euros. The monthly cost will be about 3.75 thousand euros.

Table 3. Comparison of the cost of services of agricultural digitalisation projects

Parameter	Agrosignal project	Agricultural Blockchain Project
Size of agricultural land	From 1 hectare	From 1 hectare
Type of crop	Doesn't matter	Relevant
Required level of automation	Doesn't matter	Relevant
One-off implementation cost	From 100 to 500 thousand roubles	From 50 to 100 thousand euros
Monthly subscription fee	From 10 to 50 thousand roubles	From 5 to 10 thousand euros

4 Conclusion

The above analysis has shown that the digital technologies considered in this paper allow improving production efficiency through the implementation of digital projects of the agricultural industry.

Russia is devoting a fair amount of resources to the digitalisation of agriculture and this is going quite well, as can be seen from the analysis of the competition in the domestic market for this niche. According to the performed calculation, one can see that Russian systems are many times cheaper, although they provide similar functions in most cases. On the basis of this, we can say that Russia has a fairly good position in the world in the digitalisation of agriculture, and in the future it may well take the place of the leader of the countries whose digital systems are used in more cases.

References

1. GOST R 59920-2021 *Artificial intelligence (AI) systems in agriculture. Requirements for ensuring operational safety characteristics of systems for automated control of agricultural machinery movement*
2. L.G. Akhmatova, Digitalisation of Russian agribusiness: opportunities for the implementation of IoT projects, Economics of Agriculture of Russia **5**, 2–10 (2019)
3. S.N. Volkov, Digital transformation of agriculture: challenges and prospects, AIC: Economics, Management **6**, 2–12 (2022).
4. O.Z. Zagazezheva, Digitalisation of agriculture: the current level of digitalisation in the Russian Federation and prospects for further development, Economics of Agriculture in Russia **3**, 2–12 (2023)
5. M. Weinzapfel, *Digital Agriculture: A Guide to the Future of Farming* (2022)
6. M. Lynas, *The Future of Food: How Technology Will Revolutionize the Way We Produce, Eat, and Think About Food* (2021)
7. D. Zilberman, S.M. Irwin, *The Digital Transformation of Agriculture: A Global Perspective* (2020)
8. S.M. Irwin, D. Zilberman, S.R. Pandit, *Digitalization in Agriculture: A Review of the Literature* (2021)
9. M.C. Canavari, F.C.A. Garcia, A.M.C.A. Coelho, *The Impact of Digitalization on Agricultural Productivity: A Meta-Analysis* (2022)
10. E.M.A. van der Velde, M.J.C.M. van Ittersum, M.A. van den Berg, *The Role of Digitalization in Sustainable Agriculture* (2023)
11. M.Z. Yamilev, A.M. Masagutov, A.K. Nikolaev, V.V. Pshenin, N.A. Zaripova, K.I. Plotnikova, Modified equations for hydraulic calculation of thermally insulated oil pipelines for the case of a power-law fluid, Sci. and Technol.: Oil and Oil Prod. Pipeline Transport. **11(4)**, 388–395 (2021), DOI: 10.28999/2541-9595-2021-11-4-388-395
12. V. Pshenin, A. Liagova, A. Razin, A. Skorobogatov, M. Komarovsky, Robot Crawler for Surveying

Pipelines and Metal Structures of Complex Spatial Configuration, Infrastruct. **7(6)** (2022), DOI: 10.3390/infrastructures7060075

13. G.Y. Korobov, A.A. Vorontsov, Study of conditions for gas hydrate and asphaltene-resin-paraffin deposits formation in mechanized oil production, Bull. of the Tomsk Polytech. Univ. Geo Assets Eng. **334(10)**, 61–75 (2023), Retrieved from: https://doi.org/10.18799/24131830/2023/10/4181
14. E.A. Zverev, V.Yu. Skeeba, N.V. Martyushev, P.Yu. Skeeba, Integrated quality ensuring technique of plasma wear resistant coatings, Key Eng. Mater. **736**, 132–137 (2017), DOI: 10.4028/www.scientific.net/KEM.736.132
15. N.V. Martyushev, Alignment of the microstructure of castings from the heterophase lead bronzes, Adv. Mater. Res. **880**, 163–167 (2014), DOI: 10.4028/www.scientific.net/AMR.880.163
16. L.M. Tatarintsev, O.E. Merzlyakov, T.E. Karbozov, F.K. Koshzhanova, Agroecological typology of agricultural land use in the arid steppe of the Altai Territory**.** Sustainable developm. of mountain territ. **14(3)**, 440–452 (2022), DOI: 10.21177/1998-4502-2022-14-3-440-452
17. A.A. Korshak, N.A. Vykhodtseva, M.T. Gaysin, A.A. Korshak, V.V. Pshenin, Influence of operating factors on the performance of oil vapor recovery adsorption plants, Sci. and Technol.: Oil and Oil Prod. Pipeline Transport. **9(5)**, 550–557 (2019), DOI: 10.28999/2541-9595-2019-9-5-550-557
18. N.V. Ksenz, I.V. Yudaev, M.A. Taranov, I.G. Sidorcov, A.M. Semenikhin, V.A Chernovolov, Determination of the Efficiency of the Operation Mode of Nonflowing Installation for Electroactivation of Water and Aqueous Solutions, Int. J. of Autom. Technol. **13(4)**, 539-–544 (2019), DOI: 10.20965/ijat.2019.p0539
19. M.E. Isametova, R. Nussipali, N.V. Martyushev, B.V. Malozyomov, E.A. Efremenkov, A. Isametov, Mathematical Modeling of the Reliability of Polymer Composite Materials, Mathem. **10**, 3978 (2022), DOI: 10.3390/math10213978
20. B.V. Malozyomov, N.V. Martyushev, S.N. Sorokova, E.A. Efremenkov, M. Qi, Mathematical Modeling of Mechanical Forces and Power Balance in Electromechanical Energy Converter, Mathem. **11**, 2394 (2023), DOI: 10.3390/math11102394
21. N.V. Martyushev, B.V. Malozyomov, O.A. Filina, S.N. Sorokova, E.A. Efremenkov, D.V. Valuev, M. Qi, Stochastic Models and Processing Probabilistic Data for Solving the Problem of Improving the Electric Freight Transport Reliability, Mathem. **11**, 4836 (2023), DOI: 10.3390/math11234836
22. A.E. Balanovskiy, M.G. Shtaiger, V.V. Kondratyev, A.I. Karlina, Determination of rail steel structural elements via the method of atomic force microscopy, CIS Iron and Steel Rev. **23**, 86–91 (2022)
23. G. Zakirova, V. Pshenin, R. Tashbulatov, L. Rozanova, Modern Bitumen Oil Mixture Models in Ashalchinsky Field with Low-Viscosity Solvent at Various Temperatures and Solvent Concentrations, Energies **16(1)** (2023), DOI: 10.3390/en16010395