UDC 33

System support of solutions in the field of technologies and software for simulation of space systems

Anatolii M. Rudkovskii

Economist,
Central Research Institute of Mechanical Engineering,
141070, 4, Pionerskaya st., Korolev, Russian Federation;
e-mail: xcvwerk@rambler.ru

Irina O. Rudkovskaya

Duty Officer,
Central Research Institute of Mechanical Engineering,
141070, 4, Pionerskaya st., Korolev, Russian Federation;
e-mail: boriraol88@yandex.ru

Azamat A. Koshimbaev

Commander logistics platoon,
142327, Military unit 03863, Chekhov-7, Russian Federation;
e-mail: azarar@rambler.ru

Abstract

At present, the relevance of operational decision support is increasing simultaneously with the increase in the level of their scientific validity, which leads to the need to develop and implement new methods using modern technology. In the conditions of formation and development of the digital economy of the Russian Federation, data in digital form is a key factor of production in all spheres of socio-economic activity, which increases the competitiveness of domestic technologies and products, ensures economic growth and national sovereignty. One of the directions of the currently implemented Program is the creation of an effective system of collection, processing, storage and provision of spatial data to consumers that meets the needs of the state, business and citizens. As a result of the analysis of the regulatory and technical documents identified a number of problems that prevent the effective use of UAVs for solving problems in the field of geodesy and cartography. The problems lie in the fact that the regulatory requirements relate to the conditions of use of film aerial camera materials, which are currently not used. In matters of modeling requirements are based on the creation of spatial models of the area mainly on cartographic materials. In this regard, the accuracy of the coordinate measurement and the detail of the displayed model elements depend on the scale of the original digital or analog topographic maps. The use of digital technologies requires a different approach in the formation of requirements for the source data to create digital terrain models.

For citation

Rudkovskii A.M., Rudkovskaya I.O., Koshimbaev A.A. (2019) System support of solutions in the field of technologies and software for simulation of space systems. *Ekonomika: vchera, segodnya, zavtra* [Economics: Yesterday, Today and Tomorrow], 9 (5A), pp. 380-387.

Keywords

Technologies, software, decision support, space systems, modeling.

Introduction

The target indicator of the AERONET action plan of the National technology initiative is to cover the territory of the Russian Federation with high-precision three-dimensional maps for the needs of maintaining and developing infrastructure, transport, mobile communications, precision agriculture, cadastre, etc., based on GLONASS technologies using unmanned aircraft systems (UAS) and the digital model of the Earth [Rudkovskii, 2019].

Main part

Geoindustry as a whole is a set of system-forming activities aimed at:

– for the development of normative documents, standards and technologies for the implementation of production cycles;
– creation, updating and support of the functionality of unified geospatial networks, systems and databases on the territory of the States;
– execution of geospatial (spatial) surveys and measurements, monitoring observations of changes in the position of the studied objects or their parts in space;
– production of geospatial (spatial) models and products on hard drives and in electronic form;
– the development, study, serial production and introduction into production of tool, hardware and software for collecting, storing, processing, delivery and visualization of geospatial (spatial) information, geospatial WEB services;
– integration of heterogeneous geospatial (spatial) data for their subsequent multifunctional application;
– professional training.

With the development of information technologies, there has been a transition of geospatial activity from the level of information functionality to the level of analytical functionality, which is based on the formation of spatial knowledge about the territory and the intellectualization of the preparation of innovative geospatial solutions for the rational use of all types of territorial resources [Barankov, 2019].

Geospatial approach is focused on the role of an integral tool for collecting elements of advanced scientific thinking into a single analytical system, aimed at considering the interaction of factors and objects at each point of the metric space, acquires the function of establishing dominant and auxiliary factors (with the possibility of distinguishing among the auxiliary factors such as can be neglected in the framework of the research task). This allows to plan, implement and control the optimal organization of the territory, to ensure inter-sectoral interaction, brings geospatial activity to a higher level of impact on the functioning of the socio-economic complex of territorial education of any level [Rostokinskii, Tolpekin, 2014].

Consider the basic definitions in the field of geospatial.

Geospatial – geographical shell of the Earth to be studied, displayed, modeled within a limited area, time period, object composition, list and degree of detail of its properties specified by the consumer of geoinformation. The criterion limiting the inclusion of spaces in the concept of "geographical" is the applicability for their study and modeling of coordinate systems: geographical and geodetic [Balukhto, Tverdokhlebova, 2019].

Geospatial is a set of geographical objects of natural and man-made nature, natural phenomena, man-made and natural processes and events located on the territory (above, under the territory) that have spatial properties of interest to us.

Geoinformational space is a set of information coordinated computer models of the studied geospatial. Geographical space is a set of geographical objects and phenomena with relations and connections between them. Spatial data, geographic data, GEODATA, geospatial data are digital data about features, including information about their location and properties, spatial and non-spatial attributes. A virtual model is a multidimensional model of real objects or processes, in many respects indistinguishable from them, but formed and interactively functioning in a software-controlled environment. A geospatial model contains models of objects and their relationships or, in established terminology, features. Thus, spatial objects are models of spatial objects [Malyuga, 2019].

Territory is a part of the earth's land surface with all its natural, economic objects, population and resources. The territory is characterized by its spatial position, size, structure, other geometric (morphometric) indicators and geographical (landscape) features.

The concepts of space and territory are interrelated, but not identical to each other. Without having the aim to identify all the features of them, confine ourselves to the fact that these concepts include topographic objects, processes and phenomena of nature.

Spatial information about territories is created and used in two main forms: discrete and analog. In discrete form – in the form of coordinates and heights of individual points of space – get the information methods of surveying. In recent years, the coordinates and heights of individual points of space are measured by satellite methods. Detailed study of geographical space is carried out using tools and methods of topography, photogrammetry and cartography [Malyuga, 2019].

Prior to the early 1980s, consumers received and used geodetic spatial information about the territories in the form of catalogs of coordinates and heights of points, and topographic and cartographic information in graphical form.

Scientific and technological progress of the last three decades and the use of computer technology have led to the creation, development and use of geographic information systems (GIS). The main function of GIS is spatial analysis of geospatial information. The analysis requires models of geospatial objects, so the second main function of geographic information systems is the modeling of geospatial objects.

Modeling of geospatial allows to optimize management decisions at the expense of more complete information support – providing data in a convenient for analysis, including automated, and perception form [Antonyan et al., 2014].

Sources of modeling geospace serve art materials, aerial photography data, satellite imagery, lidar data and field surveys.

At present, digital spatial data is an element of connection between different databases in the modeling of geographic information space of territories. A large part of spatial data is provided by means and methods of remote sensing of the Earth.

Currently, digital textured terrain models obtained as a result of photogrammetric processing of

aerospace survey materials are becoming more and more popular.

Specialists of the state Corporation Roscosmos (Russia) have developed a platform for creating Atlas VR geo-information services immersed in virtual reality. Within the framework of the platform, the terrain is recreated according to the surface scanning data in stereo mode and with a certain accuracy corresponds to the real appearance of the physical surface of the territory. Information about vegetation is formed by multispectral data obtained by remote sensing satellites. Atlas VR developers suggest that the platform can be used to accommodate projects of planned structures and structures. The ATLAS VR virtual space will allow not only to model objects, but also to create variable scenarios of events in the digital environment.

Group of companies GEOSCAN in the framework of the National technological initiative launched a public project to create three-dimensional models of regions of the country 3D Russia"", involving a continuous survey of the area with the help of UAVs. Within the framework of the project, interested enthusiasts can publish three-dimensional models of buildings, structures, monuments, natural objects created from the materials of ground survey or from a small height by Amateur UAVs. Models are created by means of the program Agisoft PhotoScan and placed on the geoportal Sputnik Web. Geoportal tools allow to solve measurement problems (measurements of length, height, area, volume, building profiles), to build maps of slopes and DEM in the form of TIN-models [Zanin, Klimenko, 2019].

Most of the created digital geospatial models are represented by vector and raster maps, digital elevation models, thematic geo-images, volumetric geo-images, map and feature services, and other static and dynamic models. Methods of creation, analysis, forecasting and representation of territories in the form of multidimensional geospatial models are increasingly being developed.

However, when studying geospatial data using its digital model, it should be remembered that any model always has differences from the simulated object. This is primarily due to the modeling process itself – the accuracy of the source data, processing algorithms, calculations and display. In addition, the resulting geospatial model will always correspond to the state of space that existed some time ago, at the time of receipt of the original data.

A model that is close to an ideal digital copy of the surrounding reality must meet the following criteria [Klyushnikov, 2019]:

– the model must be multidimensional and display the States and motion of matter in real space-time in four basic dimensions: three dimensions of space and time;
– the total number of measurements, including characteristic ones, in which the model is implemented, should strive for the maximum number of properties of phenomena existing in nature (the number of simulated classes and properties – to the existing in reality);
– the model must represent each elementary volume of space in each elementary period of time;
– spatial resolution of the model should seek to maximize;
– temporary solution is to strive for the highest possible;
– spatial coverage of the model should seek to maximize;
– coverage must strive for maximum;
– the accuracy of the model must tend towards full spatio-temporal identity;
– the validity of the model should aim at absolute.

Currently, the formation of a new regulatory environment is beginning to provide a favorable legal regime for the emergence and development of modern technologies, as well as for the implementation of economic activities related to their use.

We have analyzed the following existing regulatory and technical documents for geospatial modeling.

1) Federal law No. 431–FZ of 30.12.2015 "On geodesy, cartography and spatial data and on amendments to certain legislative acts of the Russian Federation".
2) instructions for photogrammetric work in the creation of digital topographic maps and plans (GKINP (GNTA))-02-036-02), approved by the Federal service of geodesy and cartography of Russia in 2002
3) guidance on the assessment of the quality of the source space imagery and derived products in digital and analogue form (GKYP (ONTA)-12-274-03) approved by the Federal service of geodesy and cartography of Russia in 2003
4) Manual on aerial photography for cartographic purposes (RAF-89), approved by the chief of the Military topographic Department of the General staff and the chief of The General staff of the Air Force in 1989
5) instructions for topographic surveys in scale 1 : 5 000, 1 : 2 000, 1 : 1 000, 1 : 500 (GCYP-02-033-82), with amendments approved, gugk maps, maps in 1982
6) GCYP-02-127-80. Guidelines for editing topographic large-scale maps and plans.
7) GCYP-CPL-02-118. Basic provisions for the creation of topographic plans of scales 1 : 5 000, 1 : 2 000, 1 : 1 000 and 1 : 500.
8) GCYP-09-32-80. The main provisions of the aerial survey performed for creation and updating of topographic maps and plans.
9) GOST R 52055-2003. GIS mapping. Spatial models of the area. General requirements.
10) GOST 28441-99. Cartography is digital. Terms and definitions.
11) GOST R 52438-2005. Geographic information system. Terms and definitions.
12) GOST R 52439-2005. Terrain models are digital. Catalog of objects of the area. Requirements for the composition.
13) GOST R 52440-2005. Terrain models are digital. General requirements.

The Federal law of 25.12.2015 № 431 "On geodesy, cartography and spatial data" defines the following concepts:

– spatial objects – natural objects, artificial and other objects (including buildings, structures), the location of which can be determined, as well as natural celestial bodies;
– spatial data;
– data about spatial objects including their shape, location.

According to GOST R 52438-2005 "Geographic information systems»:

– a spatial object (geo-object, geographic information object, geographic object) is a digital model of a material or abstract object of the real or virtual world with its identifier, coordinate and attribute data;
– spatial data (geoinformation data, geospatial data, geographic data, GEODATA) is data about spatial objects and their sets.

In accordance with GOST R 52055-2003 "Spatial terrain models" spatial terrain model is a visual and measurable three-dimensional image of the earth's surface on electronic means of information display, reproduced in accordance with the specified conditions of observation (review) on the basis of digital information about the area (electronic maps, digital terrain models) obtained from geographical maps, cadastral plans and space-aerophotographic materials, relief maps and video images.

Currently, cartographic methods to display areas being replaced by simulation of the geospace.

In this paper, under the model of geospatial we mean a set of information resources on the simulated

area, including:

– digital elevation model (DEM);
– digital terrain model (DMM);
– digital orthophoto;
– digital vector map (model);
– classifier of spatial objects and their properties;
– rules of digital description of spatial objects.

Conclusion

As a result of the analysis of the above regulatory and technical documents identified a number of problems that prevent the effective use of UAVs for solving problems in the field of geodesy and cartography. The problems lie in the fact that the regulatory requirements relate to the conditions of use of film aerial camera materials, which are currently practically not used.

In matters of modeling requirements are based on the creation of spatial models of the area mainly on cartographic materials. In this regard, the accuracy of the coordinate measurement and the detail of the displayed model elements depend on the scale of the original digital or analog topographic maps. The use of digital technologies requires a different approach in the formation of requirements for the source data to create digital terrain models.

Over the past two decades, there have been the following fundamental changes in the technique and technology of aerial photography production:

– switch from analog aerial photography to digital;
– use of unmanned aerial systems;
– air laser scanning;
– application of high-resolution space digital images;
– the use of high-precision on-Board systems determine the position and orientation;
– use of satellite methods of geodetic definitions;
– the application of the method of accurate positioning point (PPP – Precise Point Positioning);
– digital methods of photogrammetric processing;
– the use of GIS;
– GIS-spatial data analysis tools.

However, the current regulatory and technical documents do not reflect the requirements that consider the features of new technical means and technologies for data collection and processing.

References

1. Antonyan Yu.M. et al. (2014) *Ekstremizm i ego prichiny* [Extremism and its causes]. Moscow.
2. Balukhto A.N., Tverdokhlebova E.M. (2019) Analiticheskii obzor tekushchego sostoyaniya i perspektiv razvitiya v oblasti tekhnologii i programmnykh sredstv imitatsionnogo modelirovaniya kosmicheskikh sistem [Analytical review of the current state and development prospects in the field of technologies and software for simulation modeling of space systems]. *Kosmonavtika i raketostroenie* [Astronautics and Rocket Engineering], 2, pp. 118-133.
3. Barankov P.A. (2019) O kvaternionnom podkhode k modelirovaniyu obrabotki mezhsputnikovykh izmerenii v tselyakh modernizatsii otechestvennoi global'noi navigatsionnoi sputnikovoi sistemy [On the quaternion approach to modeling the processing of inter-satellite measurements in order to modernize the domestic global navigation satellite system]. *Kosmonavtika i raketostroenie* [Astronautics and Rocket Science], 2, pp. 5-20.
4. Klyushnikov V.Yu. (2019) Osnovnye problemy razvertyvaniya perspektivnykh krupnomasshtabnykh nizkoorbital'nykh kosmicheskikh sistem peredachi dannykh [The main problems of the deployment of promising large-scale low-orbit

space data transmission systems]. *Kosmonavtika i raketostroenie* [Astronautics and Rocket Science], 2, pp. 134-145.
5. Malyuga O.V. (2019) Vozmozhnosti i ogranicheniya ispol'zovaniya ekzoskeletov [Possibilities and limitations of the use of exoskeleton]. *Innovatsii i investitsii* [Innovations and investments], 2, pp. 340-342.
6. Malyuga O.V. (2019) Oblast' proizvodstva i razvitiya ekzoskeletov [The field of production and development of exoskeletons]. *Innovatsii i investitsii* [Innovation and investment], 3, pp. 316-318.
7. Rostokinskii A.V., Tolpekin K.A. (2014) Ocherednye «antiterroristicheskie» novelly ili vvedenie v «unikal'nuyu» chast' ugolovnogo kodeksa [Regular "anti-terrorism" stories or introduction to the "unique" part of the criminal code]. *Rossiiskii sledovatel'* [Russian investigator], 18, pp. 31-34.
8. Rudkovskii M.L. (2019) Mnogopotochnyi metod rascheta gravitatsionnogo potentsiala zemli i ego proizvodnykh [Multi-threaded method of calculating the gravitational potential of the earth and its derivatives]. *Kosmonavtika i raketostroenie* [Astronautics and Rocket Engineering], 2, pp. 21-29.
9. Zanin K.A., Klimenko N.N. (2019) Vybor parametrov orbital'nogo postroeniya kosmicheskikh sistem radiolokatsionnogo nablyudeniya [The choice of parameters for the orbital construction of space systems for radar observation]. *Kosmonavtika i raketostroenie* [Astronautics and Rocket Engineering], 2, pp. 30-41.

Системная поддержка решений в области технологий и программного обеспечения для моделирования космических систем

Рудковский Анатолий Михайлович

Экономист 1 категории,
Центральный научно-исследовательский институт машиностроения,
141070, Российская Федерация, Королев, ул. Пионерская, 4;
e-mail: xcvwerk@rambler.ru

Рудковская Ирина Олеговна

Дежурный по корпусу,
Центральный научно-исследовательский институт машиностроения,
141070, Российская Федерация, Королев, ул. Пионерская, 4;
e-mail: boriraol88@yandex.ru

Кошимбаев Азамат Акынович

Командир взвода технического обеспечения,
142327, Российская Федерация, В/ч 03863, ГЦ РКО, Чехов-7,
e-mail: azarar@rambler.ru

Аннотация

В условиях становления и развития цифровой экономики Российской Федерации данные в цифровой форме являются ключевым фактором производства во всех сферах социально-экономической деятельности, что повышает конкурентоспособность отечественных технологий и продукции, обеспечивает экономический рост и национальный суверенитет. Одним из направлений реализуемой в настоящее время Программы является создание эффективной системы сбора, обработки, хранения и предоставления пространственных данных. В результате анализа нормативно-технической документации выявлен ряд проблем, препятствующих эффективному использованию беспилотников для решения задач в области

геодезии и картографии. Проблемы заключаются в том, что нормативные требования касаются условий использования пленочных материалов для аэрофотокамер, которые в настоящее время не используются. В вопросах моделирования требования основаны на создании пространственных моделей местности преимущественно на картографических материалах. В связи с этим точность измерения координат и детализация отображаемых элементов модели зависят от масштаба исходных цифровых или аналоговых топографических карт. Использование цифровых технологий требует иного подхода при формировании требований к исходным данным для создания цифровых моделей местности.

Для цитирования в научных исследованиях

Рудковский А.М., Рудковская И.О., Кошимбаев А.А. System support of solutions in the field of technologies and software for simulation of space systems. // Экономика: вчера, сегодня, завтра. 2019. Том 9. № 5А. С. 380-387.

Ключевые слова

Технологии, программное обеспечение, поддержка принятия решений, космические системы, моделирование.

Библиография

1. Антонян Ю.М. и др. Экстремизм и его причины. М., 2014. 312 с.
2. Балухто А.Н., Твердохлебова Е.М. Аналитический обзор текущего состояния и перспектив развития в области технологий и программных средств имитационного моделирования космических систем // Космонавтика и ракетостроение. 2019. №2. С. 118-133.
3. Баранков П.А. О кватернионном подходе к моделированию обработки межспутниковых измерений в целях модернизации отечественной глобальной навигационной спутниковой системы // Космонавтика и ракетостроение. 2019. №2. С. 5-20.
4. Занин К.А., Клименко Н.Н. Выбор параметров орбитального построения космических систем радиолокационного наблюдения // Космонавтика и ракетостроение. 2019. №2. С. 30-41.
5. Клюшников В.Ю. Основные проблемы развёртывания перспективных крупномасштабных низкоорбитальных космических систем передачи данных // Космонавтика и ракетостроение. 2019. №2. С. 134-145.
6. Малюга О.В. Возможности и ограничения использования экзоскелетов // Инновации и инвестиции. 2019. №2. С. 340-342.
7. Малюга О.В. Область производства и развития экзоскелетов // Инновации и инвестиции. 2019. №3. С. 316-318.
8. Ростокинский А.В., Толпекин К.А. Очередные «антитеррористические» новеллы или введение в «уникальную» часть уголовного кодекса // Российский следователь. 2014. № 18. С. 31-34.
9. Рудковский М.Л. Многопоточный метод расчёта гравитационного потенциала земли и его производных // Космонавтика и ракетостроение. 2019. №2. С. 21-29.