Chapter 23

Digital Earth in Russia

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Abstract A brief overview of the history of Digital Earth in Russia, its current status and prospects for further development are proposed and discussed in this chapter. The anticipation of the concept of Digital Earth in Russian culture is demonstrated and explained. Conclusions about the specificity of the development of the concept of Digital Earth in Russia due to its geographical, historical and cultural characteristics are drawn, and development factors are revealed. The vital need for the concept in ensuring the effective governance and sustainable development of the country is emphasized. Theoretical and applied results achieved by the Russian Digital Earth community are presented. Special attention is paid to the outreach of the Digital Earth vision to state governance, business, society and education. The key importance of international cooperation for the successful implementation of Digital Earth in Russia is explained.

Keywords Digital Earth · Russia · Precursor · Sustainable development · Neogeography · Effective governance

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23.1 Introduction

As a new geospatial principle and interdisciplinary research area, Digital Earth addresses the most fundamental problems of concern to all mankind—ensuring precise decision making, sustainable development, and efficient use of limited resources. These problems are particularly evident in large and diverse countries such as Russia. Two main factors determine the strong interest in the concept of Digital Earth in Russia. The first factor is the vastness. From a geospatial point of view, Russia is a big landmass with extremely unevenly distributed population, resources, and infrastructure. For more than four hundred years, Russia has been the biggest undivided country in the world, and national stability and sustainable development highly depend on the quality of governance. Therefore, sustainable managing of vast and diverse territories with the help of increasingly complicated hierarchical governing structures was recognized as a vital problem many centuries ago. Sustainable development of Russia depends highly on consistent and comprehensive geospatial data with a wide range of scales and the flawless integration of geospatial data of different scales and different origins into a single heterogeneous dataset. As a geospatial approach with radically new properties, Digital Earth is very attractive and promising, especially for Russia.

The second vital factor that creates a strong interest in the concept of Digital Earth in Russia is the predominance of space exploration in the national mentality. Russia has the longest history of space exploration in the world. Applied space research, especially the idea of holistic, non-mediated, direct representation of our planet using remote sensing data instead of maps has become very popular and commonplace for at least two generations of Russians since the beginning of the space age in the second half of the 1950s. Wide usage of satellite remote sensing for decision making, management and governance of all kinds and levels was very popular in the beginning of the twenty-first century, and thus Digital Earth as new scientific, technological and social initiative was met with great enthusiasm—Russian society was mentally prepared for a new scientific revolution.

In 2005, the Google Earth online service was started, following the geoportal Google Maps. This event marked the beginning of a great geospatial revolution in Russia. As a bright embodiment of the Digital Earth concept, Google Earth was almost instantly recognized in Russia, and new geospatial approach was widely appreciated with remarkable speed. New, highly demanded, colored high-resolution satellite images were recognized by Russian users as an invaluable resource for decision making. However, the implementation of Digital Earth in Russia was a rather long and controversial process. Understanding Digital Earth and the rapid expansion of detailed satellite data triggered a long process of adaptation of national legislation and management practices to the new technological reality. In the second half of the 2010s, the process of adopting Digital Earth reached its culmination: in 2017, the Russian government proclaimed Digital Earth as a new ideology of national space remote sensing. In addition, a critical review of national goals and space assets was initiated. The digital economy has been recognized as a new and

ultimate goal for Russia's technological development. Under these circumstances, Digital Earth was gradually anticipated as a pivotal element of national command and control infrastructure due to its organic compatibility with digital economy. Currently, the synergy of both "digital" concepts is becoming an important factor in the development of national industry, national technologies and the nation itself.

23.2 Prehistory and Precursors of Digital Earth in Russia

The importance of Digital Earth for Russia and its visible scientific significance raised the question of its prerequisites in national history. There are indications that the essence of Digital Earth, as a new geospatial approach that was visibly different from other geospatial approaches, was anticipated in Russia many years and even centuries before the current geospatial revolution, and the concept of a universal, direct representation of Earth has repeatedly manifested in Russian culture.

23.2.1 Cultural Precursors of Digital Earth in Russia

The official history of Digital Earth started in the eve of the 20th century, when Vice President of the USA Al Gore introduced and described a new, promising type of geospatial information systems—so-called "Digital Earth"—in his book "Earth in the balance" (Gore 1992) and in a famous speech given at the California Science Center in Los Angeles on January 31, 1998 (Gore 1998). Digital Earth was described as a comprehensive, three-dimensional and multi-scaled model of Earth that could be used as an ultimate collector of spatially localized information. However, this core idea of Digital Earth was anticipated many times in different countries, including Russia. One of the most unbelievably accurate descriptions of an informational system that envisioned the future Digital Earth was made by the great Russian and Soviet writer Mikhail Bulgakov (1891–1940). In his mystical novel "Master and Margarita" (Bulgakov 1967), written between 1928 and 1940, he described a so-called 'Globe of Woland'—a magic globe that demonstrated and emphasized the ability to visualize all events in any place of the Earth immediately, interactively, completely and in full detail. The main features of the 'Globe of Woland' described in detail in the novel accurately and comprehensively anticipated the basic features of the Digital Earth approach—a three-dimensional, scale-independent, dynamic model of Earth. Moreover, Bulgakov envisioned avoiding mapping signs to improve the quality of perception, consciously anticipated and described in detail the basic principles of the future Digital Earth with unbelievable accuracy nearly 60 years before Digital Earth was manifested and interdisciplinary research was initiated.

Bulgakov's 'Globe of Woland' also had a predecessor. There is opinion (Sokolov 1988) that the idea of the magic Globe was borrowed from the novel 'War and Peace' (Tolstoy 1869) written by Russian writer Leo Tolstoy (1828–1910). The novel

depicted an ‘alive and vibration globe without any dimensions’ (in original Russian text) that the hero saw in a dream. This kind of impossible object could be regarded as a metaphorical description of the idea of scale-independency. Notably, in the English translation of the novel, this paradoxical property of the Globe was reduced to a more imaginable form—an ‘alive and vibration globe without fixed dimensions.’

Therefore, we assume that a representation of our planet as a scale-independent and projection-independent, sign-less, space-temporal replica of real Earth was anticipated, understood and popularized in Russia long before the establishment of Digital Earth as a scientific paradigm, technological and social initiative.

23.2.2 Technological Prerequisites of Digital Earth in Russia

With the beginning of the Space Era a new, holistic vision of our planet as a live Globe became widespread globally. The first image of Earth from outer space was produced in 1947 with the help of the US-launched German missile V-2 (NASA 2017). The first satellite was successfully launched from the Russian space center (cosmodrome) Baikonur in 1957. The American satellites Explorer-6, in 1959, and TIROS, in 1960, provided the first photographic and television images of Earth, respectively. In 1959, the Soviet automatic station Luna-3 captured the first image of the far side of the Moon. In 1961, Soviet cosmonaut Yuri Gagarin made the first manned space flight (Afanasiev et al. 2005; Baturin et al. 2008). During his day-long orbital mission flight (August 6–7, 1961), the second cosmonaut, Gherman Titov, took the first photographic images and movies of Earth from space manually.

A new vision of Earth became very popular, especially in Russia as it was an initial leader of the space race. The numerous benefits and hidden potential of remote sensing were quickly understood. This trend was amplified by the new concept of state governing with the help of digital computer networks, proposed during the same time by famous Soviet cybernetic and mathematician, academician Victor Glushkov (1923–1982), the chief designer of the first Soviet small (‘personal’ of some kind) computer for engineering purposes ‘Mir-1’ (1966). He proposed and popularized the idea of a so-called ‘OGAS’ (Universal State Automated System, or All-State Automated System)—a net-centric, internet-like architecture intended for collecting, storing and processing information on the state level to improve decision making. The project was proposed in the 1950s, became very popular in the 1960s–1970s, and gradually died out after the death of V. Glushkov in 1982 and as the country entered a deep crisis in the end of the 1980s. OGAS was not centered on geospatial data, but the clear necessity of spatial and temporal localizations of data in a universal, scale-independent framework induced interest in new approaches to handling geospatial data. The widely appreciated and supported concept of OGAS contributed to the future explosive growth of common interest in the Digital Earth concept in Russia (Fig. 23.1).

The fragmentation of the Soviet Union into 15 independent countries in 1991 and the severe, prolonged economic and political crisis significantly limited the scientific

Fig. 23.1 Cultural and technological precursors of Digital Earth in Russia

potential of Russia and demands for innovations in the 1990s, and led to the shutdown of many promising projects. In the eve of the new millennium, the manifesting of Digital Earth in 1998 by Vice President of the USA Al Gore attracted the attention of the Russian scientific community. A real breakthrough came in the middle of the 2000s, following the start of the Google Earth online service in 2005, establishment of the International Society of Digital Earth (ISDE) in 2006, and proposition of the neogeography concept the same year.

23.3 Introducing Digital Earth in Russia

One of the first forerunners of Digital Earth in Russia was the virtual globe ArcGlobe—a software module and 3D viewing environment for the popular software ArcGIS (ESRI). ArcGlobe was introduced in the beginning of the 2000s and became popular as an effective new approach for integration of geospatial 3D data into the virtual globe. For the first time, ArcGlobe allowed for a user to immerse data into a rich geospatial context formed by global mosaic satellite images, and interact with it. However, the low spatial resolution of contextual geospatial data provided on DVD in the absence of online services and standalone applications as well as the relatively high cost prevented the wide usage of this interesting product. However, ArcGlobe ignited discussion about the future directions of GIS development and generated expectations for the emergence of a new type of geospatial product in the near future. The first products that incorporated the same approach to varying extents (e.g., NASA WorldWind, Microsoft Encarta, etc.) were introduced around same time, but

were not widespread. For example, there are no mentions of NASA WorldWind in the articles registered in the Russian national scientific electronic library until 2005. The next big step toward understanding and assessing the new paradigm in Russia was made by Google.

The start of the Google Earth online service in the first half of 2005 provided an inspiring and thought-provoking effect and triggered the process of adopting the Digital Earth paradigm in Russia. Due to relatively good broadband access across the country and free access to Google Earth in its basic configuration, the high reliability, very rich contextual data and pressing demand for correct and unmediated geospatial data in the country resulted in amazingly rapid proliferation of the use of Google Earth in Russia. In 2007, the first open Russian model of a Russian city for Google Earth became accessible through the web site (Wolodtschenko et al. 2015). The model was based on a previous GIS-based model (Fig. 23.2a, b).

The model of Protvino was followed by others. They were increasingly used for urban and regional planning, education, and monitoring of social processes in urban environments (Fig. 23.3a, b).

Fig. 23.2 a, b Left to right: evolution of the 3D model of the city of Protvino (Moscow region, Russia) during the adoption of the Digital Earth concept. **a** GIS-based 3D model of Protvino created in 2004, **b** realistic dawn view of Protvino generated using a photorealistic 3D model of Protvino based on the Digital Earth paradigm (2014)

Fig. 23.3 a, b (From left to right) Visualizations of statistical and social data on urban (a) and regional (b) levels in the Digital Earth environment in Russia in 2005–2014

In 2008, the first software tools for Google Earth developed in Russia were proposed (Blogru.geoblogspot.com 2008). The scientific novelty of Google Earth and its advantages were obvious, leading to discussion about the nature of new approaches for working with geospatial data. In Russia, this discussion was induced by a comparative analysis of 'Geography' and 'Neogeography', initiated by A. Turner in his book 'Introduction into Neogeography' (Turner 2006). In Russia, neogeography was recognized and studied as a new scientific paradigm and quantum leap in cartography. Therefore, it was eventually identified with Digital Earth as an advanced geospatial approach, with Google Earth as its embodiment. Digital Earth was regarded as a significant innovation and promising achievement in a variety of geospatial products that emerged, especially after 2005. This vision stimulated the search for scientific, not solely technological, foundations of a new approach. In 2008, the first Russian intentional definition of neogeography, later adopted for the Digital Earth, was proposed (Eremchenko 2008). The fundamental interconnection between Digital Earth and the concept of situational awareness has also been identified and studied (Boyarchuk et al. 2010). The philosophical effects of the new geospatial paradigm were discussed in a comprehensive analysis based on the 'Noosphere' concept (Lepsky 2013). In 2008, a range of conferences dedicated to new approaches in cartography began to be held in Russia annually, and a growing number of scientific articles have been published each year.

In 2012, the book 'Virtual Geographic Environments' (Lin and Butty 2009) with the chapter 'Concept of "Digital Earth"' was published in Russia. The first scientific article with the term 'Digital Earth' (in Russian) in its title registered in the Russian official scientific database E-Library was published in 2013 (Lisitsky 2013). In 2015, a common vision of Digital Earth and neogeography was proposed (Eremchenko et al. 2015). In 2016, the first scientific event was held in Russia (Novosibirsk), organized by the ISDE as part of the annual Interexpo GEO-Siberia 2016 international conference (ISDE 2016).

The number of Digital Earth-related articles (Fig. 23.4) has grown annually. The growing interest in Digital Earth stimulated its transfer to different areas. The Digital Earth concept began to be perceived by a wide audience, especially among government officials. To some extent, 2017 was the watershed year.

At the 10th International Symposium on Digital Earth held in Sydney, Australia, in 2017, the Russian "Neogeography Group" was recognized as one of the founders of the Digital Silk Road Alliance (DSRA). The DSRA will build a cooperative network and a geospatial 'think tank' for the Silk Road countries and support the advancement of geo-spatial information and sustainable development through international cooperation within the Digital Earth paradigm (ISDE 2017).

Fig. 23.4 Number of scientific papers and books about Digital Earth (in Russian), indexed in the Russian national scientific citation index E-Library from 1998 to 2017. Note that the term ‘Digital Earth’ was also widely used in hardware engineering to describe the ground potential of digital equipment

23.4 Establishing the Digital Earth Russia Community

The understanding, development and adoption of the Digital Earth vision in Russia were organized in an interdisciplinary manner from the beginning. A significant part of the efforts of the Russian Digital Earth community was dedicated to outreach and the projection of the Digital Earth vision into different disciplines, industries, and social groups to address vital problems of society. Conferences and meetings were organized in different Russian cities (Fig. 23.5) for different groups of participants.

Discussion of the Digital Earth concept occurred during the annual Neogeography conferences held in Moscow in 2008–2011, as well as at a long list of conferences organized and supported by famous Russian scientist and expert in scientific visualization, visual analytics, situational awareness and neogeography, Prof. Stanislav Klimenko (1941–2018). In 2009, 2014 and 2016, the Digital Earth Vision was presented and discussed at the Annual International Conferences “Information and Mathematical Technologies in Science and Governance” held in Irkutsk and Baikal (Siberia). In 2014, the Russian Digital Earth community helped organize a special session on the semiotics aspects of geospatial visualization, “Neogeo-Semiotic Synthesis”, at the 12th World Congress of Semiotics in Sofia, Bulgaria (Semio2014.org 2014). Since 2016, the Digital Earth concept has been presented during the annual InterCarto/InterGIS conferences organized in different locations in Russia and abroad. From 2017, activity in the Russian Digital Earth community began to increase. For example, in 2017, the Digital Earth Vision was presented by

Fig. 23.5 Spatial distribution of Russian Digital Earth centers and the locations of the most significant scientific Digital Earth conferences and other events in Russia since 2008

Russian supporters at more than half a dozen scientific conferences in different fields: philosophy, visual analytics, governance, innovative economics, the Silk Road and Belt Initiative, geography and GIS, monitoring and security, scientific visualization and big data, aerospace and remote sensing, and cartography.

At some conferences, the Digital Earth sessions have become traditional (Neogeography.ru 2017, 2018). The Russian Digital Earth community has also focused on outreach as a vital way to proliferate Digital Earth expertise and provide a synergy effect in the scope of Silk Road infrastructure projects and a Digital Turn in the economy (Eremchenko et al. 2017).

The positive dynamics and fast recognition of the Russian Digital Earth community attracted the attention of colleagues abroad. At the 7th Digital Earth Summit held in Al-Jadida, Morocco in 2018, the council of the ISDE decided to organize the next (2020) 8th Digital Earth Summit in Russia. It will be held in Obninsk—a well-known scientific and university center with a history of being affordable. The selection of the relatively small (approximately one hundred thousand inhabitants) university town Obninsk with very diverse industry and science as the host of a Digital Earth Summit emphasizes the interdisciplinary and outreach goals of this forum and demonstrates the significance of Digital Earth in the Silk Road and Belt project because Obninsk is a Russian hub of the Silk Road.

Establishing a national corpus of relevant scientific journals is also a key factor for the successful development of disciplines, especially interdisciplinary ones. Scientific articles about different aspects of Digital Earth are published in various journals. In addition, the proceedings of the annual GraphiCon and InterCarto/InterGIS conferences, the annual almanac Geocontext, and other sources of information are relevant. To share the Digital Earth vision, internet portals, social networks, and media are

actively used. Many reviews, news, and outreach-oriented discussion materials are published on the internet portal NeoGeography.ru. Notably, Digital Earth in Russia was developed mainly within the Russian linguistic context and terminology, therefore the constant coordination of discourse and results and harmonization of research with the international community is a significant issue.

Also in 2018, preparation for a Russian chapter of the ISDE was initiated (DERussia.ru 2018).

23.5 Exploration of Digital Earth in Russia

A key factor of success in technological development is a clear understanding of the nature of Digital Earth as a scientific paradigm and new approach for processing geospatial information. Since the introduction of the Google Earth geoservice in 2005, the discussion about Digital Earth in the Russian scientific community has focused on fundamental issues, primarily on the problem of developing a scientific definition of Digital Earth. Special attention was also paid to its paradoxical properties, primarily semiotic ones.

The following are the main directions of research of the Digital Earth phenomenon in Russia (Eremchenko 2017):

- development of an intensional definition of Digital Earth;
- proposal of a typology of geospatial visualization methods;
- discussion of the semiotic implications of Digital Earth, including introduction of the ‘zero sign’ concept;
- proposing and discussing the concept of georhetorics; and
- studying the concept of Digital Earth in the context of situational awareness, the digital economy, visual analytics, and smart city concepts.

Digital Earth is also used in Russia to observe social processes in the urban environment with unprecedented spatial and temporal resolutions.

23.6 Digital Earth: Russian Government Initiatives

In May 2017, less than two months after the 10th International Symposium on Digital Earth was held in Australia and two weeks after announcement of the Digital Earth Australia project, a similar Digital Earth-based concept of new space remote sensing policy was officially adopted by the Russian government (Kremlin.ru 2017). At the presidential meeting on developing the space sector held on May 22, 2017, the concept of Digital Earth was proposed and approved as a core idea of new national policy in space. The Russian Space Agency provided information about the “Digital Earth” project focused on stimulating development of the Russian economy in accordance with new “digital” trends and an innovative “digital economy”. Digital Earth

in Russia should become a central element of a highly effective national command and control system to ensure sustainable development in Russia. The main declared goals of the “Digital Earth” project are the creation and regular updating of a seamless raster coverage for the entire globe with 1 m accuracy (or better) and formation of a family of new geospatial services focused on the urgent demands of business, government, and society. Commercialization manifested as a fundamental approach to satellite remote sensing. One specificity of the Russian policy in the field of remote sensing is the desire to ensure independence and autonomy in space. In accordance with this policy, the country is developing all the elements of the infrastructure of the future Digital Earth.

Development of Digital Earth in Russia and its infrastructural elements was supported by regulatory documents such as “The concept of development of the Russian space system of remote sensing of the Earth for the period up to 2025”, resolution of the Government of the Russian Federation No. 326 on 28 May, 2007, “On the procedure for obtaining, using and providing geospatial information”, Bases of the state policy of the Russian Federation in the field of space activity for the period till 2030 and further prospect, approved by the President of the Russian Federation on April 19, 2013 № IIP-906, the state program of the Russian Federation “Space activities of Russia for 2013–2020” approved by the government of the Russian Federation on April 15, 2014 № 306, and others.

23.7 Infrastructure of Digital Earth in Russia

The concept of Digital Earth naturally integrates achievements in the fields of space exploration, advanced technologies, promising areas of fundamental scientific research, establishment of an appropriate infrastructure backbone, and social, industrial and governmental demands. The need to revise the existing principles of obtaining, accumulation, processing and use of geospatial data in accordance with the internal logic of scientific and technological development was realized in Russia in the first decade of the twenty-first century.

In Russia, this state-of-the-art system consists of number of components and national assets such as a remote sensing satellite constellation, global navigational satellite system (GLONASS) and a unique project of a common geographically distributed information system of remote sensing (ETRIS DZZ).

23.7.1 Remote Sensing Constellation

Satellite remote sensing capabilities are fundamental to a Digital Earth-based information system. Russia has long and bright history of remote sensing, though the present constellation and its potential are rather modest. At the beginning of 2019, it consisted of the high-resolution (better than 1 m) satellites of the “Resurs” family

and moderate resolution (2.5 m) satellites of the “Kanopus-B” family, the meteorological satellites “Meteor-M” and “Electro-L”, as well as hydro-meteorological and experimental satellites. Increasing the number of satellites and the capacity of the national constellation of remote sensing satellites is considered a major national task. A plan to increase the number of national remote sensing satellites from 8 (2017) to 20 by 2025 was revealed (Roscosmos.ru 2017). Highly reliable “Kanopus-B” satellites work in the common constellation with the identical Belorussian satellite BKA. As of May 2019, there were 7 satellites in the common “Kanopus-B” constellation (6 Russian satellites and 1 Belorussian satellite).

23.7.2 National Global Navigation Satellite System

Global Navigational Satellite System (GLONASS) is a key national space resource. A core element of GLONASS is a space segment that consists of 24 satellites that are evenly distributed on 3 orbital planes (8 satellites in each plane). Like GPS, GLONASS provided two free worldwide navigational signals (L1 and L2). Development of GLONASS was initiated in 1976. The deployment of the first experimental satellites of the “Uragan” family began in 1982. The system began limited operation in 1993, deployment of the full GLONASS constellation (24 satellites) was successfully completed in 1995, and full-scale operation of the system began. However, the system degraded due to a lack of resources and incoherent national space policy.

Rehabilitation of GLONASS was stimulated by a federal special purpose program initiated in 2002. Through this program, the orbital segment of the system was eventually recovered, and in 2009 GLONASS was redeployed and returned to full-scale operation as a second global navigational satellite system for the world. Now, the orbital segment of the system is based on “Glonass-M” satellites. GLONASS development is regulated by RF Government Ordinance No. 189 “Supporting, developing and using of GLONASS for 2012–2020” dated March 3, 2012. Development of a new “Glonass-K2” satellite with improved specifications, deployment of navigational satellites with new types of orbits, and creation of a wide-area augmentation system are planned.

In conjunction with another navigational systems like GPS, BeiDou and GALILEO, GLONASS is actively used for creating new digital infrastructure in Russia. One prominent example is the ERA-GLONASS system intended to generate rapid information about car incidents. Since January 1, 2017, all new cars in Russia and other countries of the Eurasian Custom Union must be equipped with ERA-GLONASS car modules. A similar system, eCall, was developed in the EU and will be technologically compatible with ERA-GLONASS.

23.7.3 The International Global Aerospace System (IGMAS)

Historically, the first predecessor of the modern Digital Earth Russia system can be considered, was the IGMAS (International Global Aerospace System) project proposed in 2009 (Menshikov 2009). IGMAS was proposed as a “special space system”, or system-of-systems, comprising space, aerial and ground segments and intended for “real-time monitoring of asteroid and comet hazard... continuous incoming of real-time forecast monitoring information on the occurrence of natural and manmade disasters on a global scale, as well as timely detection of asteroid and comet hazard and availability of such information to a wide range of consumers” (Kuzmenko et al. 2010). The IGMAS project remained unrealized but contributed to the idea of creating a unified global information system that met Digital Earth requirements.

23.7.4 The ETRIS-DZZ System

The “Digital Earth Russia” project that has been developed by the Russian Space Agency since 2017 includes a new state-of-the-art ground segment system as a key element—a ‘common geographically distributed information system of remote sensing’ (ETRIS DZZ). The new system, developed by the “Russian Space Systems” holding, was successfully tested and recommended for operation in 2016 (RussianSpaceSystems.ru 2016). ETRIS DZZ consists of 13 centers distributed throughout Russia and abroad, including in the Arctic and Antarctic. Compared with the existing single-point reception, the deployment of a system with a multi-point reception organization will significantly improve the efficiency of the use of existing and planned Russian remote sensing satellites due to the timely discharge of accumulated information from satellite memory on most orbital turns.

23.7.5 The SPHERE Project

The ambitious SPHERE project was announced by the president of Russia on June 7, 2018. The project envisages the deployment of an extensive (approximately 640 satellites) LEO constellation aimed at solving three main tasks: communication and internet access, remote sensing, navigation and geopositioning. There are three stages of deployment of the system: 2022, 2024, and 2028 (Kremlin.ru 2018). The specifications of the future SPHERE system and information about the satellites is not accessible yet.

23.7.6 *Services and Applications*

Remarkable visualization of Earth with the help of state-of-the-art computer systems is a prominent aspect of the Digital Earth paradigm. Historically, the Russian scientific community has focused on the study of Digital Earth as a scientific paradigm based on existing practical realizations (NASA WorldWind; Google Earth, ERDAS Titan, etc.). In addition, the range of palliative, 2D geoportals such as Google Maps was developed in Russia—[Maps.Yandex.ru](https://maps.yandex.ru), [Kosmosnimki.ru](https://kosmosnimki.ru), etc. However, the limited capabilities of map-based geoportals are obvious and the demand for a real Digital Earth-like solution persists.

In 2010, the ‘Geoportal of Roscosmos’ (<https://gptl.ru>) was presented; it was promoted as an innovative, updated daily global coverage made using satellite images. Low-resolution images are free of charge and accessible for any user, higher-resolution images can be purchased. The cost of developing the ‘Geoportal of Roscosmos’ was estimated at approximately \$300,000. Nevertheless, the need to create a fully featured Digital Earth was obvious due to the practical needs of the vast country.

The first national geospatial product that met the requirements of the Digital Earth paradigm was the NeoGlobus software, developed in VNIIEM Corporation, a leading aerospace enterprise specializes in producing satellites, including the remote sensing satellite families “Meteor” and “Kanopus-B”. In 2010, NeoGlobus was presented at the seventh international industrial forum “GeoForm+2010” as an ‘innovative environment for integration of geospatial data’ based on a global seamless mosaic of satellite images (VNIIEM 2010). NeoGlobus was proposed and implemented as an environment for long-term planning and tasking for Russian remote sensing satellites of the “Kanopus-B” family, and therefore its market niche was limited.

23.8 Digital Earth Russia: Private Business Initiatives

Russian private business was also involved in Digital Earth R&D. One of the most successful Russian Digital Earth services that was implemented at the same time and is increasingly being used in various fields is Sputnik GIS, developed by Russian privately owned company Geoscan Group.

A predecessor of the Sputnik GIS project was started in June 2009 as a 3D globe based on NASA WorldWind SDK, intended for spatial data visualization. Later, Sputnik GIS developed by Geoscan emerged. The history of development is interesting because it is well-suited for the specific demands of the national Russian market.

Sputnik GIS is based on the Digital Earth paradigm but has a substantially and gradually expanded functionality compared with most widespread solutions such as Google Earth. From the beginning, Sputnik GIS was oriented for use by emergency services for UAV monitoring. The first versions had few features:

- Visualizing UAV flight trajectories;
- Visualizing SRTM as a 3D surface on the globe; and

- Visualizing UAV-borne data (orthophotos).

The next step in the evolution of Sputnik was creating a Ground Control Station (GCS, Geoscan Planer) for the Geoscan UAV. The Geoscan GCS used a fully 3D environment and had the ability to plan flight with respect to the local terrain, modelled using the SRTM or other sources.

The third big step in Sputnik GIS evolution was releasing support for the Agisoft PhotoScan *.tls format. This feature made Sputnik GIS a unique software solution for 3D modelling, visualization and analysis of cities. Along with *.tls format support, basic measurements tools such as ruler, corner ruler and area were released. At the same time, Geoscan finished the project of creating a Tomsk city 3D model (Fig. 23.6). It was a rather ambitious project, because Tomsk is a big Siberian city with a population of more than half a million. In addition, Tomsk is well-known for its very rich and unique urban heritage, especially wooden architecture, which is very difficult to model in 3D. Nevertheless, the project was completed in a short term with exceptional, unprecedented quality. Since 2014, the Tomsk city administration has used Sputnik GIS intensively and successfully. Later, similar models were created for other big Russian cities: Khabarovsk, Vladivostok, Kazan, Tula, Veliky Novgorod (Sputnik.Geoscan.aero 2018). Moreover, the practical possibility of creating high-precision photo-visual 3D models of cities and entire regions has been demonstrated. For example, a 3D model of the Tula region in central Russia (an area of more than 25 thousand square kilometers, with a population of approximately 1.5 million inhabitants) was successfully created.

Geoscan also developed and released new versions of Sputnik GIS with a number of features including change detection, volume calculation, section generation,

Fig. 23.6 View of a photorealistic detail of a 3D model of the city of Tomsk, created and visualized in Sputnik GIS

Fig. 23.7 Precise 3D model of historical Sofia Cathedral in Novgorod, Russia, created and visualized in Sputnik WEB GIS

contour generation, slope maps, creation and visualization of the NDVI, thermal maps and more. With the idea of involving UAV technologies in different industries, Geoscan developed the Sputnik GIS product family:

- Sputnik GIS—for surveyors and urban planners;
- Sputnik Agro—for agricultural companies and individual farmers;
- Sputnik PTL—for energy companies; and
- Sputnik WEB—a web implementation of Sputnik GIS with cloud photogrammetry features (Fig. 23.7).

Sputnik GIS has a long (nearly 10 years) history of development and is a mature, versatile, functional, multipurpose Russian Digital Earth service, oriented toward the specific needs of national and international (Arza-García et al. 2019) customers and developed dynamically. Due to the user-oriented approach, significant upgrading capabilities and full integration with state-of-the-art UAVs, Sputnik GIS became an effective replacement for Google Earth as a nationwide Digital Earth platform.

23.9 Conclusions

The Digital Earth paradigm has been actively investigated in Russia since 2005 and was anticipated many decades before. This anticipation originated from the vital necessity of a global, scale-independent, three-dimensional, unified, unmediated representation of geospatial context. Digital Earth is natural geospatial approach for all cultures and nations, especially for Russia.

Russian studies of Digital Earth were mainly focused on its fundamental issues. A range of applications and online services, inspired by Google Earth, was created in Russia and actively used, especially in state governance and emergency services. The culminating point of the process of adopting the Digital Earth Vision was its manifestation as a core ideology of national space remote sensing in 2017. The process of harmonizing national activities with the International Society for Digital Earth through the establishment of the Russian Chapter of the ISDE has been finalized.

Some fundamental issues and effects of the Digital Earth paradigm, unveiled by the Russian Digital Earth community, are fruitful and could impact a wide range of disciplines. The process of harmonizing geospatial data within the new framework of the ‘Silk Road and Belt’ and technological development of new generation of geospatial services should also be fruitful. The future of Digital Earth in Russia looks promising, bright and full of scientific and technological achievements.

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