Prospects for using remote sensing data in the armed forces, other troops and military formations of the Republic of Kazakhstan

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Abstract:

Introduction/aim: This article is written to acquaint readers with the development of a space system of Earth remote sensing in the Republic of Kazakhstan using remote sensing data to support the Armed Forces, other troops and military formations of the Republic of Kazakhstan. **Methods:** An analytical approach to the study of the development of space and information technologies has led to qualitative changes in the field of remote sensing of the Earth. Conclusions were also made based on the analysis of the historical aspects of the formation and development of space systems for remote sensing of the Earth. This article deals with significant improvements in the field of geoinformation support to the Armed Forces, other troops and military formations in the interests of the security of the Republic of Kazakhstan using high-resolution satellite images from domestic spacecraft to create digital state topographic maps of the entire scale series with simultaneous updating. **Results:** The article provides a brief overview of remote sensing systems using geoinformation technologies in foreign countries and in the Republic of Kazakhstan. **Conclusions:** A special unit "Photogrammetric center for remote sensing and UAV data processing" is capable of processing data of remote sensing and UAVS for the armed forces, other troops and military units of the Republic of Kazakhstan. Data processing technologies have little in common with traditional processing and representation of geographical data, and finally, geographical data serves only as a basis for solving a large number of applied problems.

Keywords: space remote sensing systems; aviation and space facilities; satellites; spatial resolution; radiometric resolution; spectral range

INTRODUCTION

The development of modern armies, as well as the development of modern society as a whole, is based on the introduction and development of information technologies. The most important component of most technologies is the means of processing digital information about the terrain in conjunction with a variety of data about the enemy and their troops.

Nowadays, owing to the benefits of digital image, sound and communication, topogeodesic software simply cannot stay away from technological progress.

It becomes obvious that geoinformation support is a topogeodesic support of the 21st century. It includes aerospace, optoelectronic exploration, satellite communications, and digital computer technology, as well as classical methods of geodesy, cartography, and photogrammetry. An analysis of the tasks solved by topographic services of associations of the Armed Forces, other troops and military formations of the Republic of Kazakhstan in the preparation and during operations and combat operations, as well as the means and methods of solving them, indicates that there is a serious lag in these issues behind the armies of developed countries.

With the development of science, knowledge about the Earth, natural resources, geology and geography, geoinformatics in many countries of the world was previously understood as "a specialized section of computer science dealing with geography" (Ivanov & Markus, 1999, pp. 36-37).

Effective work of modern GIS is difficult to imagine without satellite methods of studying the territories of our planet. Remote satellite sensing has found wide application in geoinformation technologies, both in connection with the rapid development and improvement of space technology, and with the curtailment of aviation and ground-based monitoring methods.

BACKGROUND OF REMOTE SENSING SYSTEMS

The history of remote sensing is inextricably linked to two scientific achievements: photography and aeronautics, as their combination marked the beginning of a new powerful means of exploring the Earth – the Aerial methods. The history of photography dates back to the emergence of the concept of camera obscura (lat. cameraobscura – "dark room"), mentioned in the works of Aristotle (336-323 BC) (Surdin & Kartashev, 1999), but may have deeper roots – back to 5th – 4th century BC according to some sources (Needham, 1962).

The explanation of the operation of the pinhole camera is attributed to Ibn al-haysam (Algazen) of Basra (1038 ad), who used special tents to observe eclipses of the Sun. Later, in 1267, Roger Bacon used these principles to create optical illusions with sunlight, and in the 90s of the 15 century, Leonardo da Vinci gave a detailed description of the pinhole camera and used it for sketches from nature.

The 17th century was marked by the discoveries of Angelo Sala related to the darkening of silver under the influence of sunlight (1614), experiments of Isaac Newton with a prism and the creation of the theory of light (1666), and the discovery of lenses by Johann Christoph Sturm (Khorram et al, 2016).

The end of the 18th and the beginning of the 19th century were the key periods in the formation of photography in the form in which it is known today. In 1777, Vilhelm Carl Scheele discovered that the exposed chromate of silver can be washed away with ammonia while leaving the dark recorded areas. In 1800, Frederick William Herschel measured the temperature of light and actually discovered the infrared region of the spectrum, and in 1802 Thomas Jung presented his work on the theory of light and colors, including it in the context of human vision. Finally, the studies of Joseph Nicephore Niepce and Louis Jacques Mande Daguerre (1827– 1839) led to the appearance of full-fledged photos.

Further work of the scientists of the 19th century was aimed at improving and reducing the cost of the image acquisition process, with the names of William Henry Fox Talbot, Niepce de Saint-Victor, and Frederick Scott Archer being associated with this time. Also during this period, the phenomenon of stereoscopy was discovered, and in 1855, Scottish physicist James Clerk Maxwell described the quantitative theory of colors which marked the beginning of color photography.

In contrast to the history of the development of photography, the sources on remote sensing practically do not consider the topic of improving the theory of aeronautics, and, as a rule, the key point for a further analysis is identified in 1858 – the flight of Gaspard Felix Tournachon.

However, besides paying tribute to these prerequisites, we should also emphasize the projects for the creation of aircraft by Leonardo da Vinci (1475), Francesco Lana de Terzi (1670), Bartolomeu Lawrence de Guzman (1709), as well as Mikhail Vasilyevich Lomonosov (1754). It is also worth mentioning that the research that formed the basis of aeronautics is that of Isaac Newton (1687), Daniel Bernoulli (1738), Jean leron d'alembert (1744) and Leonard Euler (1755), who were devoted to the motion of fluids and bodies in it.

Recognized pioneers of aeronautics are the brothers Joseph and Etienne Montgolfier, who, in 1783, in the French city of Annonay, first launched a balloon filled with hot air and thus proved a possibility of free flight. In September of the same year, an experiment was conducted with animals being carried in a ballon, and on November 21, the very first manned free flight took place, the pilots being Pilatre de Rosier and the Marquis d'Arlandes in the Montgolfier ballon.

On September 16, 1804, Joseph Louis Gay-Lussac, working together with Jean Baptiste Biot, made two balloon flights, during which he conducted studies of the Earth's magnetic field and atmospheric parameters. After these experiments, scientists began to show great interest in studying the atmosphere using aeronautics (Hallion, 2003).

HISTORICAL ASPECTS OF THE FORMATION AND DEVELOPMENT OF REMOTE SENSING OF THE EARTH

The 1st period of development of remote sensing: late 18th - early 20th century (The birth of aerial photography)

Before proceeding to describe the first successes in using aerial photography, it is necessary to note another event which occurred after the flight of Nadar and which had a significant impact on the formation of remote sensing. It is the research of E. Lossed, engineer major of the corps of engineers of the French army, who developed the ideas laid down by Johann Heinrich Lambert (1759) and Botan-Beaupray (1791) and in 1859 developed a way to "deploy" a photo taken from a balloon into a plan. He called this method metrophotography, and in 1867 the term acquired its current name "photogrammetry" (the so-called scientific and technical discipline that studies the theory and develops practical ways to determine the shape, size and position of objects from their photographic and other images).

In fact, with the help of Lossed's invention, one of major drawbacks of images of that time was overcome – the lack of perspective, which was the beginning of the development of aerial photo reconnaissance.

A panoramograph, a device designed by Richard Yulievich in 1898, can be considered as the next technical achievement which at that time was the most advanced multi-camera in the world designed for aerial photography.

Alternative ways to get aerial photos of that time included using kites, birds, and rockets. So already in 1882, English meteorologist E. D. Archibald obtained successful images using a kite. The name of Julius Gustav Neubronner is associated with achievements in pigeon photography (1903), and the first successful experiments in obtaining images using rockets belong to Alfred Nobel (1897).

The first experience of aerial reconnaissance in combat conditions dates from 1904 to 1905 (Russian-Japanese war). The experience is largely questionable, since the quality of images taken from unguided balloons left much to be desired, but then it became clear that aerial photography was the future - it only remained to find a suitable carrier.

It is important to remember that 1900 was the year of the Wright brothers' triumph, when their first airplane in the world took off. And three years later, it was time for the first controlled human flight on a heavier-than-air vehicle with an engine. Wilbur Wright is also considered to be the first person to take a photo from an airplane (1909).

The possibility of controlled flights opened up new horizons for remote sensing. By a decree of Emperor Nicholas II in 1910, the Russian air fleet was created, and a year later the first positive results were obtained (V. Gelgar's survey of fortifications on the Bosphorus).

Aerial photography developed especially during the First World War of 1914 – 1918; for example, many note its important role in the preparation of the Brusilovsky breakthrough. It should be noted that, in Russia, the Central Body Engaged in Aerial Photography then became the Aerial Photography Park, where V. I. Sreznevsky and V. F. Potte worked (the creator of the first semi-automatic camera for planned shooting, 1913). To manage the photometric units, a special Aerophotogrammetric Department was established, with a school for officers.

The importance of aerial reconnaissance was also understood in the West. During the First World War, all parties to the conflict used aerial photographs to get information about the enemy. There is evidence that at the end of the war, the entire front line was photographed at least twice a day (PAPA, 2007).

At the end of the described period in 1919, S. O. Hoffman made the first aerial images in the infrared range (Estes, 2005).

The 2nd period of development of remote sensing: 1920s - 1940s. (Use of aerial photography for civil purposes)

At the end of the First World War, aerial photography began to be used more and more for civil purposes, in national economies in particular. At the same time, industry institutions were formed along with aerial photography as a scientific discipline.

The year 1921 is important since that year the USGS began using aerial surveys for forestry inventory. The obtained materials were interpreted and a few were later initiated into account water resources and works on geographical and geobotanical research.

It is worth noting that, in this period, North American and European countries had different approaches to remote sensing. It is possible to say that the size of the country determined the main tasks facing aerial photography. For the unexplored territories of Canada and the United States, the speed of data acquisition was of primary importance, even taking into account the loss of information quality (small-scale aerial photography, multi-camera cameras, simplified methods of processing aerial images). European countries were characterized by an approach in which aerial photography was mainly aimed at refining the existing topographic maps, bringing them to the current state (large-scale photography).

The development of remote sensing leads to the emergence of the first specialized departments and industry institutes. The introduction of courses in photogrammetry dates back to 1920 (Nikolai Mikhailovich Aleksapolsky), and in 1925 the first Department of Photogrammetry was organized at the Moscow Boundary Institute (Tyuflin, 2011).

In 1929, the Research Institute of Aerial Photography (later the Central Research Institute of Geodesy, Aerial Photography and Cartography, Tsniigaik) was organized under the leadership of Alexander E. Fersman and the production of Soviet photogrammetric equipment was established (Vinogradov, 1941).

So, in the 30s of the twentieth century, the multi-objective aerial camera of F. V. Drobyshev (1932) and the first model of a topographic stereometer (1933) were created as well as the first wide-angle aerial lens "liar-5" by M. M. Rusinov (1933), which marked the beginning of a series of wide-angle and ultra-wide-angle lenses "Russar", and the slit aerial camera of V. S. Semenov (1936) (Tyuflin, 2011, p. 5).

Until 1936, aerial photography was used in the USSR not so much for continuous mapping of the country, but at the request of individual organizations. However, the formation of specialized state-owned enterprises created for aerial surveys in certain sectors of the economy (agricultural aerial survey, forest aviation trust, a network of aerial photo-geodesic trusts, etc.) enabled continuous coverage of territories paid for from the state budget. The result is an avalanche – like increase in the volume of aerial survey work over the period 1925 – 1938 when it increased almost 80 times (Vinogradov, 1941).

It is worth noting that at this time (1936) in the West, Captain Albert W. Stevens obtained the first images reflecting the actual curvature of the Earth and the boundary of the stratosphere. The survey was conducted from a height of 22 km.

In 1939, the Second World War broke out, in which aerial reconnaissance began to play a leading role, providing the armies of the warring parties with the necessary materials about the enemy.

The 3rd development period: late 1940s - 1980s (The development of methods for aerospace research)

This period is one of the most significant ones in the history of remote sensing. It is during these years that space sensing of the Earth began, programs of the most famous satellite groupings started, and the research base was actively developing.

Military industry remained the main engine of the progress of remote sensing in the 40s. In 1945, the first photograph of the Earth's surface was obtained from space. It was made using a camera mounted on a Fau2 ballistic missile (USA, White Sands test site) (Zamshin, 2014).

The beginning of the Cold war spurred the parties to create new ways to monitor a likely enemy. In 1954, flights of American Lockheed U-2 reconnaissance aircraft equipped with highly informative aerial cameras began.

It is worth noting that during the 50 – 60s, most of images were panchromatic (black and white) and their evaluation was carried out using visual methods. All the more important are the achievements of Colwell (1956), who already at this time proposed the use of color infrared technology (CIR) in photography to control the incidence of plants (in such photos, diseased vegetation looks more dim).

The foundations for image analysis by spectral characteristics were thus laid (Thenkabail, 2015).

In 1959, the first session of the US Congress presented a report describing the main features of the space system and options for satellites intended for remote sensing of the Earth (ERS) for both civil and military purposes. Since that time, remote monitoring of the Earth using space aircraft has developed.

In the same year, the Corona program (US military satellites) began, and in 1960, it provided the first successful photos from space (using cameras with film canisters that were dropped to the Earth in capsules, and then caught in the air by aircraft).

Focused civilian developments in Earth exploration began in 1959 with the launch of the Explorer VII satellites, designed to measure the amount of heat emitted and reflected by the Earth.

The TIROS 1 weather satellite (TV and Infrared observation satellite, USA) was launched in 1960 and transmitted back the first satellite image of the Earth's cloud cover. The transmission was carried out over a radio channel, i.e. almost in the same way as the transmission of information from modern satellites is carried out.

In March 1961, the Vostok spacecraft (Sputnik-9) was launched with the AFA-39 aerial camera installed; it was with its help that the first photos from space were taken in the Soviet Union.

On April 12, 1961, Yuri Gagarin became the first person to make a space flight. Shortly after Yuri Gagarin's flight in August 1961, Soviet cosmonaut G. S. Titov took the first "manual" photography of the Earth from space from the Vostok-2 spacecraft (Estes, 2005).

With a small lag behind the Soviet Union, there was the US Mercury manned flight program (1961-1963), as part of which images of the Earth were also obtained (Kapralov et al, 2005).

In 1962, the first Zenith remote sensing spacecraft (military intelligence, USSR) was launched successfully. Three types of equipment were installed on board: photographic, phototelevision, and radio equipment. In 1964, the United States launched the first Nimbus satellite (weather satellites). In the Soviet Union, the first operational meteorological satellite (meteor) was launched in June 1966.

The development of military vehicles continued. In 1964, the Zenit-2 complex (USSR) was adopted, and in 1965, thanks to the improvement of its optical system, the Zenit-4 complex of detailed photo observation was developed and adopted (Sukhorukov, 2011).

The United States continued its manned space flight programs with the launch of Gemini (1965-1966) which provided a systematic collection of remote sensing data throughout the project (Kapralov et al, 2005) while the next, Apollo, program was equipped with even more powerful remote sensing equipment. So Apollo 9, launched in 1968, captured the first multispectral images using its camera with four lenses taking photos that were later subject to digitization (Lavender & Lavender, 2015).

The year 1972 is an outstanding one in the history of remote sensing of the Earth: the National Aeronautics and Space Administration (NASA) launched Landsat 1, originally named the Earth Resource Observation Satellite. It was this satellite which initiated the first continuous archive of Earth observation data for scientific research, still being updated at the present time. Landsat 1 images (four spectral ranges and a pixel size of 80 m) opened up plenty of opportunity for scientists to study vast territories. These images were small-scale, which allowed the creation of appropriate maps in a short period of time and reflected extensive geographical information about the structure of the Earth.

The first special equipment for multi-zone shooting on a spacecraft of the Soviet Union was installed in 1973 (Soyuz-12). Soviet cosmonaut pilots V. G. Lazarev and O. G. Makarov performed a significant amount of filming in six and nine zones of the electromagnetic wave spectrum. This flight proved the effectiveness of multi-zone space sensing for mapping, geological research, studying vegetation, soils, shallow sea waters, and decoding natural formations based on their spectral reflectivity. As a result of decoding multi-zone images from Soyuz-12, experimental complex mapping was carried out for the first time, discovering oil and gas-bearing structures, previously unknown crystal faults, and desert territories with shallow fresh ground water (Zamshin, 2014, p. 68).

In the same year, a landmark event in remote sensing data processing technology took place - John Rouse used the normalized difference vegetation index (NDVI) in his work. Through a series of experiments, it was found that green vegetation has a high reflectivity in the near-infrared region of the spectrum and absorbs radiation well in the red range. At the same time, the reflectivity of soils and reservoirs in these ranges remains almost the same. A simple formula expressed in the operation of dividing channels made a breakthrough in determining the vegetation cover in satellite images (Kapralov et al, 2005).

The national oceanic and atmospheric administration of the United States launches the NOAA-4 (meteorological) satellite in 1974, particularly for carrying a very high-resolution radiometer (VHRR) on board. In addition, the information from this satellite was available to everyone if they had the opportunity to receive it. It is obvious, though, that ordinary users did not have the computer capacity to process data at that time (Thenkabail, 2015, p. 680).

The survey materials from space stations continued to produce tangible results. Salyut-3 (1974-1975) – in one of the regions of the country, 67 oil and gas structures were identified, including underwater ones, and a number of intersections of large faults promising for exploration of valuable minerals (Thenkabail, 2015). Salyut-4 (1974-1977) – multi-zone and multi-scale photography covered about 4.5 million square kilometers of the South of the country, and a number of regional photo maps were created covering the Northern Caspian region, Kyrgyzstan, Tajikistan, the Crimean Peninsula, and Kalmykia.

Launched in the United States, LAGEOS 1 (1976) was used by scientists to accurately track the movement of the Earth's surface, and the data obtained from it made a great contribution to understanding the processes of earthquakes and other geological activities.

Returning to the topic of meteorological satellites, we note the launch of TIROS-N (NOAA, USA) in 1978. The satellite contained an advanced very high-resolution radiometer (AVHRR), which, in addition to observing Earth's weather events, was also used to monitor the state of objects on the Earth's surface (Thenkabail, 2015, p. 681).

The year 1978 as a whole turned out to be very successful for launching space projects. This was confirmed by the NASAHCMM satellite, used to measure the Earth's temperature from space, helping in climate change research, then by the Seasat satellite intended (as its name probably implies) for monitoring the oceans, and, of course, by the Nimbus-7 satellite with a Full Ozone Layer mapping spectrometer (TOMS) on board, which helped confirm the existence of the Antarctic ozone hole. Moreover, the data from TOMS formed the scientific basis of the Montreal Protocol (1989) and other treaties banning production using ozone-depleting chemicals. The CCS scanner was also installed on the same Nexus -7, and the data from it is widely used to study the links between the biology of the oceans and the Earth's climate (Graham, 1999).

In the late 1980s, other countries also began to feel the need for their own remote sensing satellites, which eventually led to a rapid increase in data availability. In 1986, SPOT-1 was launched, the first of a series of French multispectral satellites developed by the National Center for Space Research (CNES) in collaboration with Belgium and Sweden. India launched its first satellite called IRS (1988). The 1990s saw the China /Brazil (CBERS) satellite as well as Japan’s one (ADEOS).

These events prompted further development of data processing methods, special software, and rapid discoveries in the world of computer technology allowed ordinary users to apply image processing methods.

The 4th period of development of remote sensing: the beginning of the 1990s up to the present time. (Remote sensing data as the main component of geographic information systems)

This period of development is characterized primarily by the fact that remote sensing has become an integral component of geographical information systems, the main supplier of spatial information for them.

The development of computer technologies in the 90s greatly simplified the digitization of remote sensing data, and the global development of GIS systems and personal receiving stations allowed any user to receive and process spatial data, which was a huge step in scientific and technological progress and the development of remote sensing in general.

Geographic information systems (GIS) allow converting images into electronic maps, with drawing on them not only geographical, but also statistical, thematic, and other information, as well as applying a variety of analytical operations. GIS can reveal hidden trends and relationships that are difficult or impossible to detect when processing satellite images "with the naked eye". Remote sensing and geographic information systems have formed a very effective method for conducting spatial analyses of the Earth's surface (Glushkov, 2012).

Under the leadership of R. Tomlinson, Canadian GIS (QGIS) was created to analyze data from the Canadian land inventory in the field of land using rationalization (Kapralov et al, 2005).

In the period of remote sensing development under consideration, the main breakthrough in GIS development occurred due to the saturation of the market with appropriate software, especially designed for personal computers, which dramatically increased the scope of GIS technologies and required significant sets of digital geodata. To understand what new geodata the scientific community had in the 90s, let us look at the launch history of this time.

Also, the 90s were marked by one interesting fact in the history of remote sensing development. In addition to sensing satellites, a whole group of spacecraft that were part of the Global navigation satellite system (GNSS) operated in space, including GPS (USA), GLONASS (Russia), Galileo (Europe), and Compass (China). Of course, the initial use of these satellites was associated with the positioning of objects on the Earth, but soon this attitude was revised and a new direction in remote sensing was born, known as GNSS reflectometry (GNSS-R). It is a well-known fact that due to atmospheric refraction, GPS signals travel through the Earth's atmosphere along a slightly curved path and with a small delay in speed, and at first this was considered a source of error, but thanks to the work of a number of scientists, it is now used to determine the level of the ocean surface, the speed and direction of wind above the ocean surface, soil moisture, or snow and ice thickness (Jin & Komjathy, 2010).

In addition to government programs, a private commercial remote sensing market is also emerging. Private companies launch their own satellites with the subsequent sale of images, and also provide licenses for the right to receive information from their space systems. The created market gave a huge boost to the appearance of a wide variety of satellite images offered. It became possible to order images for any territory of interest, almost any spatial resolution and in any required range (Glushkov, 2012).

The development of tools for remote sensing data processing also proceeded quite quickly: ERDAS Imagine (1992), ENVI (1994), MapInfo Professional (1995), ArcGIS (1999) – all these are well-known software products that are today the leaders of GIS software. Versions of products that had a graphical interface are listed, which greatly simplified the process of using them.

Software power of modern computers already allow for processing images, and cheaper remote sensing was facilitated by involving not only professionals but also ordinary users in the process of working with geodata.

There is a need for space survey materials with ultra-high spatial resolution, which was previously the prerogative of aerial photography. It is this segment that is beginning to be most actively developed by private companies. The United States, Israel, France, and India are beginning to build effective schemes of interaction between the state and the private sector in this area.

The developers of the first ultra-high-resolution satellites were exclusively American companies, but since 2006, launches of such devices have been carried out: Israel (Eros-B), Russia (Resurs-DC), Korea (COMP-2) and India (Cartosat-2). Nevertheless, the United States still retains its technological leadership, as evidenced by the launch of such devices as the IKONOS satellite (1999), geo-Oko-1 (2008), WorldView-1 satellite (2007) and WorldView-2 satellite (2009) with a resolution of 0.4–0.5 m.

An important feature of 2007-2010 is the increase in the number of launches of spacecraft with high-resolution radars. Radar images can be obtained regardless of weather conditions and light conditions in the target area and allow making requests for shooting within a few days. In addition, space–based radar images make it possible to create digital terrain models, and special interferometric imaging technologies make it possible to detect minor ground movements.

The existing radar space systems RADARSAT-1 (Canada), ERS-2, ENVISAT-1 (both ESA) and ALOS (Japan) provided an area resolution of no better than 8 m, which did not meet modern requirements, so the launch of the civilian satellite TerraSAR-X (Germany, 2007), which provided radar shooting with a resolution of 1 m, was a landmark event. At the same time, the Italian COSMO-Skymed satellite program was implemented (Lavrov, 2010).

CURRENT STATE OF REMOTE SENSING AND DEVELOPMENT PROSPECTS IN THE REPUBLIC OF KAZAKHSTAN

Today, more and more new satellites with modern sensor systems are being put into the orbit. The last of NASA's Landsat series satellites (number 8), was launched in early 2013 and today continues to provide a continuous archive of data from this mission. Other satellites, such as SMAP (USA) or FLEX (ECO), are very important for environmental monitoring.

SMAP was launched in early 2015 and carries SAR (synthetic aperture radar, L-band, 1.2 – 1.4 GHz) and a radiometer that measure soil moisture and monitor the continuous water cycle in nature. The antenna covers a 1000-kilometer range, providing global coverage of the Earth in just a few days.

FLEX is a derivative of ESA's eighth research mission and is intended to provide global fluorescent vegetation maps. The FLORIS (Fluorescence Imaging Spectrometer) is an on-board instrument that measures the emission of waves in the range of 500 to 800 nm with a bandwidth of 0.1 nm to 2 nm, which allows images to be obtained with a 150-kilometer range and a pixel size of 300 m. This information will allow a thorough study of the vegetation cover in dynamics. FLEX is scheduled to be launched in 2022.

Another American future mission suitable for processing Earth data is the large-scale hyperspectral GEO-CAPE (scheduled for launch in 2020). The GET-CAPE should become an improved MODIS receiver and provide continuous data acquisition for a variety of application areas, such as water resources, agriculture, disaster prevention, and environmental monitoring.

Another hyperspectral satellite, HyspIRI, is currently under development. HyspIRI will include two instruments: a spectrometer (in the spectrum from VIS to TIR) and a multispectral imaging unit (in the SWIR and TIR spectra); these data could be used in many areas, but primarily for monitoring the carbon cycle, ecosystems, and the Earth's surface.

To support today's much-needed high-resolution environmental monitoring, the European Union recently launched the Copernicus programme (formerly known as GMES). Copernicus is the European flagship of Earth exploration, adapted for environmental monitoring. Copernicus includes two types of missions: the Sentinel programme (Sentinel 1 - 6) and related space programmes. There are approximately 30 active or planned satellite space programmes operating under the auspices of ESA, EU member States such as EUMETSAT, and other global countries.

The launch of Sentinel-1A in 2014 provided new opportunities in the field of microwave radiation, offering global data for study with a repeated cycle of 12 days, which will be reduced to 6 days with the launch of the Sentinel-1B satellite. Thanks to the public data access policy, they are supposed to expand the scope of microwave methods. Subsequent SAR data for this area will be provided by the AMOS-2 satellite group (Japan, 2014), as well as two planned SAOCOM satellites (Argentina, launches 2016 and 2017) and the RADARSAT Constellation mission (Canada, 2018).

Since there is a demand for high-resolution data in the commercial market, new satellites are likely to be launched as private or national initiatives over the next decade to replace the current generation of TerraSAR-X and CosmoSkyMed sensors.

A pair of Sentinel-2 satellites (2015, 2016) will provide images with medium spatial resolution. Sentinel-2 guarantees continuous spot observation with the ability to improve spectral resolution and temporal illumination. The multispectral imaging unit (MSI) on Sentinel-2 covers the VIS, NIR, and SWIR spectral regions in 13 bands with a spatial resolution of 10 m × 10 m (point observation), 6 groups of 20 m × 20 m, and 3 groups of 60 m × 60 m. The increased width of the row, approximately 290 km, together with the presence of two satellites in orbit at the same time, will reduce the re-coverage of the territory to 2-3 days. This will make it possible to monitor rapid changes in the environment, such as crop maturation, especially during the agricultural season, and improve methods for detecting such changes.

The Sentinel-3 project was created for the purpose of monitoring the marine environment and was launched in 2016. This system carries both ocean monitoring tools and an OLCI scanner, which is the successor of MERIS, but with improved wavelength groups (21 compared to 15 on MERIS) and a spatial resolution of 300 m × 300 m.

The German En MAP (launched in 2018) will be a satellite with a spatial resolution similar to Landsat, but with an increased number of bands in the VIS and SWIR spectra (244), and a rotation time of less than 4 days (Thenkabail, 2015).

In addition to promising classical satellite programmes, it is time to use small spacecraft (MCAS). One of the most promising is "CubeSat" – nanosatellites of a certain design created at Stanford University. The size of the basic element of the satellite structure is 10x10x10 cm. The launch is performed using Poly-Picosatellite Orbital Deployer (P-POD). The standard allows combining two or more standard cubes as part of a single satellite (designated 2U, 3U, etc.). The development of modern high-tech industries has made it possible to create small-sized spacecraft at a relatively low cost of time and money. Despite the fact that they do not have the lifetime of larger satellites, they offer fantastic potential for testing new sensors or making specific short-term measurements, and are capable of solving serious scientific, technical, research, and industrial tasks. In fact, a new segment of the space industry is being formed. However, the biggest challenge to expanding the use of small spacecraft is the problem of putting them into orbit. Currently, ICAS are often put into orbit as a passing cargo (Prokopyev et al, 2014).

There are many promising ways to improve existing remote sensing mechanisms. In addition to the obvious, i.e. improving the technical stuffing of devices (robotization, design simplification, high-efficiency solar panels, etc.), new technologies for autonomous operation of spacecraft are being developed such as those for improving the launch formation (swarm), i.e., types of missions in which several vehicles fly at a short distance (up to several hundred meters) from each other. In contrast to the traditional orbital grouping of satellites, where the devices act independently, performing a common task, in the spacecraft formation flying they act together, distributing individual functions and elements of the task between individual devices. In fact, this is a creation of distributed satellite systems (Prokopyev et al, 2014).

In addition to satellites, other types of remote sensing devices are becoming more popular (for example, fixed–wing aircraft, helicopters and quadrocopters, unmanned aerial vehicles-drones), they are most often used for shooting at low altitudes and are test platforms for space instruments (Lavender & Lavender, 2015).

As mentioned earlier, remote sensing and data generated by it are now an integral part of geographic information systems. GIS have many classifications, but from the point of view of the prospects for use, we are only interested in the possibility of using this system on the Internet.

The migration of desktop software products to the network is a general trend in the software development market. For quite a long time, users can use Google Docs instead of MS Word, or Yandex mail instead of Outlook. Naturally, this approach requires a network connection, but it does not depend on platforms at all, and makes programs and data available from any computer and from any place.

The market for Web GIS systems is experiencing quite rapid development. There are many proprietary developments, for example, ArcGISServer, and no less freely distributed analogues (MapServer, GeoServer, etc.), the functionality of which improves from version to version, and almost always involves support for the WMS, WCS, and WFS standards.

Today, it is still more convenient to conduct primary data preparation in desktop GIS, thanks to the remote sensing information processing mechanisms developed over many years (image filters, classification plugins, etc.), but quite serious steps are already being taken to transfer this functionality to the network, i.e. full implementation of OGCWFS-T and WPS standards.

Based on the prerequisites for the transition of geoinformation systems that work with remote sensing data to the category of Internet services, the use of almost unlimited computer power, known as cloud computing, in the tasks of processing satellite images is becoming more and more obvious.

Until recently, only specialized scientific organizations had access to powerful supercomputers, which severely limited the ability of data processing (including remote sensing data) by ordinary users. Moreover, today even the expert community is not able to cope with the processing and decryption of constantly incoming information in a timely manner. For example, Digitalglobe's constellation of satellites – QuickBird, WorldView-1, and WorldView-2 – Collectively capture ultra-high-resolution images of about 1.5 million km per day (PAPA, 2007). However, thanks to the appearance of services such as, for example, Amazon Elastic Compute Cloud, it is now possible to use its capabilities to implement remote sensing tasks. Fast work with ultra – high-resolution data (several meters), spectral data with hundreds of channels, daily updated data, implementation of image processing algorithms in the cloud software environment, storage and archiving of very large volumes of data - all this is the future of remote sensing (Thenkabail, 2015).

Continuing the idea of a promising vector for the development of remote sensing, it is necessary to note the increasing role of crowdsourcing in the analysis of remote sensing data. When a large number of people use the Internet to access information received from satellites, there are amazing opportunities in using the capabilities of the human brain to solve spatial problems. Despite the ever-increasing performance of software systems for image analysis, nothing can replace the intuition and perception of the human brain. Cognitive tasks that are simple to us are very difficult for a machine.

There are several advantages of using crowdsourcing in remote sensing:

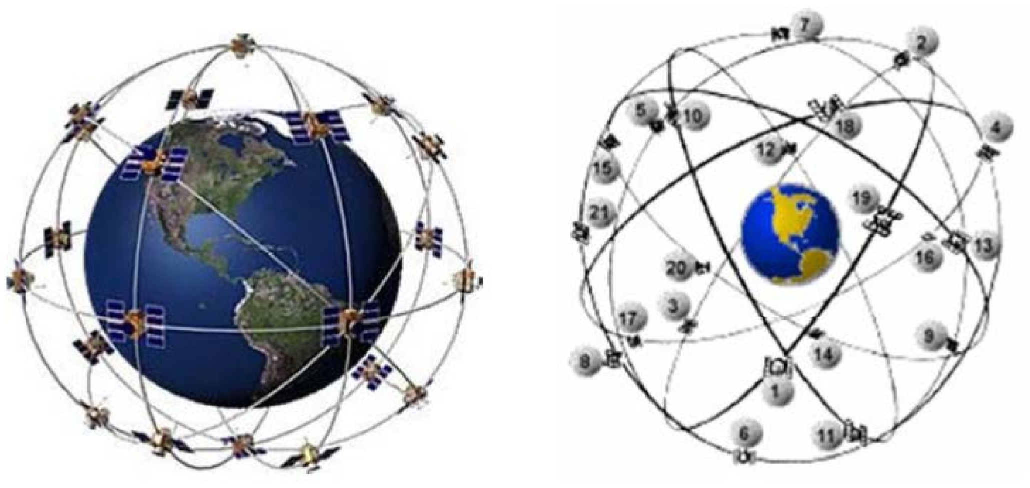
- quick analysis of images by hundreds and thousands of people. Even if they are not experts in a particular field, but the right task in this case can overcome this disadvantage.
- leveling the problem of a large amount of data. What an expert can analyze in a week, a large group of people will do in a day.
- full use of human cognitive capabilities, according to the classification of objects. No matter how advanced machine image recognition algorithms are, they cannot detect all possible variations of objects on the Earth.
- reliability of the information received. This is, of course, an effect that translates a quantitative assessment into a qualitative one, using confidence analysis algorithms. Everyone makes

mistakes, but if a lot of people come to an agreed opinion on a particular issue, the reliability of such information is considered significantly higher (DigitalGlobe, 2014).

The last thing worth noting is the increasing role of standardization in the provision of remote sensing data. Of course, remote sensing data itself is also standardized, especially in terms of names and metadata (Tyuflin, 2011), but the most important aspect is the transmission aspect, since operating with unified protocols allows the creation of spatial data infrastructures that provide information to any user on the Internet. This is about the growing support of leading manufacturers of remote sensing data and their derivatives for OGC standards (Open Geospatial Consortium – a non-core, international, voluntary organization for the development of standards in the field of geoinformation services). Map services and services on the Internet that support the WCS, WFS, and WMS standards make it possible to operate remote sensing data as if they are locally available, which opens up unlimited opportunities for comprehensive analysis of such data, highlighting the necessary information, and, ultimately, making the right management decisions.

The current level of scientific and technical development in the field of geodetic and cartographic activities, associated with the use of satellite geodetic methods, the widespread introduction of new technical means and technologies for creating digital cartographic products, and geoinformation systems, requires highly qualified specialists who can solve complex production and scientific problems in the field of geodesy and cartography.

The current stage of development of geodesy and cartography in Kazakhstan is characterized by reaching a fundamentally new level of production automation, which has caused fundamental changes in the applied technologies, technical means, devices and equipment. Namely, the implementation of cartographic and geodetic works is carried out using: satellite radio navigation technologies (GPS NAVSTAR (American) and GLONASS (Russian)) (Figure 1), satellite surveys, digital mapping methods, and GIS technologies.



a) b)

Figure 1.
Global satellite radio navigation systems: a – GLONASS, b – NAVSTAR
Рис. 1
Глобальные спутниковые радионавигационные системы: a – ГЛОНАСС, b – NAVSTAR
Слика 1
Глобални сателитски радио-навигациони системи: а) ГЛОНАСС, б) NAVSTAR

Currently, the greatest attention is paid to the introduction of remote sensing data and high-resolution satellite imagery materials from the domestic KazEOSat-1 spacecraft to create and simultaneously update digital state topographic maps of the entire scale range.

Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-1

The Law of the Republic of Kazakhstan No. 528-IV of January 6, 2012 "On Space Activities" stipulates that, by the decree of the Government of the Republic of Kazakhstan dated May 31, 2012, the joint-stock company "National Company Kazakhstan Gharysh Sapary" is the national operator of the space system for remote sensing of the Earth.

In 2014, Kazakhstan acquired its own space system for remote sensing of the Earth. Two vehicles were launched into orbit sequentially: high-resolution KazSat-1 and medium-resolution KazEOSat-2.

The KazEOSat-1 (Kazakhstan Earth Observation Satellite) is the first Kazakh satellite for remote sensing of the Earth, created by the order of the government.

On April 30, 2014, the KazEOSat-1 satellite was launched into orbit from the European Space Agency's Kourou spaceport in French Guiana. The device, which has an almost record spatial resolution of 1 meter per pixel for satellites of this level, was developed for our country by the French aerospace concern Airbus Defense and Space (PAPA, 2007), which was called EADS Astrium before the rebranding (Figure 2, Figure 3).

Figure 2.
Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-1
Рис. 2
Космический аппарат дистанционного зондирования KazEOSat-1 (Республика Казахстан)
Слика 2
Свемирска летелица KazEOSat-1 за даљинску детекцију (Република Казахстан)

As a payload, the satellite is equipped with a scanning device “NAOMI” (New Astro Sat Optical Modular Instrument), which enables taking photos with a resolution of up to 1 meter (in the panchromatic mode) and up to 4 meters (in the multispectral mode).

The survey capacity of the KazEOSat-1 spacecraft is 220,000 square kilometers per day.

The maximum length of the shooting lane is 2000 km (Table 1).

Figure 3.
KazEOSat-1 Satellite At the Kourou cosmodrome before launch (Photo by ESA-CNES-Arianespace Optique Video du CSG)
Рис. 3
Спутник KazEOSat-1 на космодроме Куру перед запуском (Фото ESA-CNES-ARIANESPACE Optique video du CSG)
Слика 3
Сателит KazEOSat-1 на космодрому Куру пред лансирање (Фотографија ESA-CNES-Arianespace Optique Video du CSG)

Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-2

Already in June 2014, the second medium-resolution remote sensing satellite KazEOSat-2 went into orbit. It was built by a subcontractor of Airbus Defence and Space – the British company Surrey Satellites Technology Ltd (Estes, 2005) (Figure 4).

The KazEOSat-2 (Kazakhstan Earth Observation Satellite) is the second Kazakh satellite for remote sensing of the Earth, created by the order of the government of the Republic of Kazakhstan on the basis of the SSTL – 150+ satellite platform by the British company SSTL. The SSTL is a subsidiary of Airbus, Figure 5.

The KazEOSat-2 medium-resolution remote sensing spacecraft was launched on June 20, 2014, from the Russian launch base Yasny (Orenburg region, Russia).

The KEIS (Kazakh Earth Imaging System) scanning device, also known as "JSS-56" (Jena-Optronik Spaceborne Scanner-56) or "MSI" (multispectralimager) is installed on board of the KazEOSat-2 satellite as a payload.

The survey capacity of the KazEOSat-2 spacecraft is 1,000,000 square kilometers per day (Table 2).

Under the contract with the French side, a fairly serious ground infrastructure was created in the capital of Kazakhstan to service satellites. It includes a spacecraft control system, a ground-based target system, and antenna systems, Figure 6.

Table 1. The characteristics of the imaging system KazEOsat-1
Таблица 1. Характеристики съемочной аппаратуры KazEOSat-1
Табела 1. Карактеристике система KazEOsat-1 за снимање сателита

The diameter of the aperture	640 mm		
Spectral channel	Panchromatic 0.45-0.75 μm	Multispectral Blue - 0.45-0.52 μm Green - 0.53-060 μm	Red - 0.62-0.69 μm infrared - 0.76-0.89 μm
Spatial resolution	1 m	4 m	
Capture band	12 bit		
Deviation from Nadir	20 km		
Radiometric resolution	+/- 35 degrees		
Tool weight	150 kg		
Possibility to get a stereo pair	Yes, from one turn		
Customer		JSC "NC "Kazakhstan Gharysh Sapary»	
Manufacturer		Airbus Defence and Space (EADS Astrium)	
Platform		Leostar-500-XO	
Orbit		Sun-synchronous, H=750 km, inclination 98.5 degrees	
Sizes		2.10 m x 3.70 m	
Power		1200 W	
Data rate		270 Mbit/s in the X-band	
Modulation of transmitted data		QPSK	
Weight		820 kg	
Estimated duration of stay in orbit		7 years	

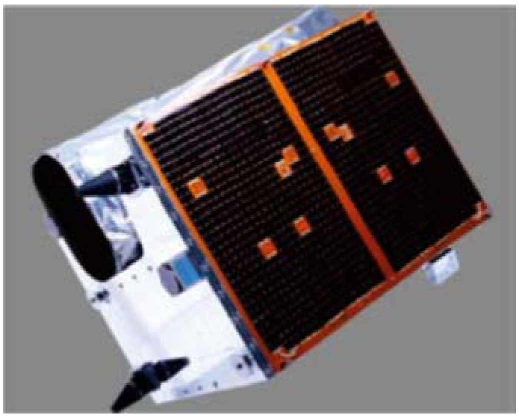


Figure 4.
Remote sensing spacecraft of the Republic of Kazakhstan - KazEOSat-2
Рис. 4
Космический аппарат дистанционного зондирования KazEOSat-2 (Республика Казахстан)
Слика 4
Свемирска летелица KazEOSat-2 за даљинску детекцију (Република Казахстан)

Figure 5.
Photo ESA-CNES-Arianespace Optique video du CSG
Рис. 5
Фото ESA-CNES-Arianespace Optique video du CSG
Слика 5
Фотографија ESA-CNES-Arianespace Optique video du CSG

The antenna systems are two autonomous systems for full control of telemetry, issuing commands to satellites and receiving information that they transmit to the Earth. The antenna of the Kazsat-1 satellite is mounted on the top of a three-story tower in a special spherical case built of radio-transparent material. It protects the device from atmospheric disturbances, precipitation, and sunlight. The dome of the KazEOsat-2 antenna system is made in the form of an icosahedron geometric shape. This shape improves the electromagnetic background in the antenna area, Figure 6.

Both satellites move in so-called sun-synchronous orbits. This is when the device flies from one pole of the planet to the other and is always on the illuminated side of the Earth. The radio visibility zone of the KazEOSat-1 satellite extends over a huge territory of the continent – from the Taimyr Peninsula and almost to Northern India. In total, the satellite makes 15 orbits per day, Figure 7.

Three day and three night sessions are held with it in the radio visibility zone. One communication session lasts 10-12 minutes. During this time, a package of program commands is transmitted to the satellite, and the information accumulated by the device is reset. The spatial resolution of the KazEOsat-1 satellite is one meter, and the survey is performed in panchromatic and multispectral modes.

The device simultaneously covers the territory of 20 by 20 km. The shooting period is 3-5 days. Capacity – 220,000 square kilometers per day.

The angle of inclination of KazEOsat-2's orbit is 98 degrees. And in 98 minutes, it makes a complete revolution around the Earth. It performs 14-15 revolutions per day. Of these, 5-6 times the satellite is in the radio visibility zone of the antenna.

Table 2. The characteristics of the imaging system KazEOsat-2
Таблица 2. Характеристики съемочной аппаратуры KazEOsat-2
Табела 2. Карактеристике система KazEOsat-2 за снимање сателита

The diameter of the aperture	145 mm	
Focal length	633 mm	
Spectral channel	blue - 0.45-0.52 µm green - 0.53-060 µm red - 0.62-0.69 µm	Extreme red - 0.69 – 0.73 µm infrared - 0.76-0.89 µm
Spatial resolution	6,5 m (in Nadir)	5 m (when creating an orthophoto)
Capture band	12 bit	
Deviation from Nadir	77 km	
Radiometric resolution	+/- 35 degrees	
Tool weight	150 kg	
Possibility to get a stereo pair	Yes, from one turn	
Customer	Kazakhstan Gharysh Sapary (KGS)	
Manufacturer	SSTL	
Platform	SSTL-150+	
Orbit	Sun-synchronous, H=630 km, inclination 98 degrees	
Sizes	700 mm x 800 mm x 900 mm	
Data rate	160 Mbit/s in the X-band	
Weight	180 kg	
Estimated duration of stay in orbit	7 years	

So-called flywheels are used to orientate KazEOSat-2 in space. This is a system of gyroscopes that record the position of the device relative to any static objects. And already for orbit correction, an ion engine running on xenon is used. The orbit is adjusted approximately once a month. There was already a case when the device evaded space debris. At an altitude of 600-800 kilometers, there is a lot of it.

The Kazsat-2 radio visibility Zone covers an area of 3 by 4 thousand square kilometers. Tracking the vehicle starts when it is only 5° above the horizon. The antenna orientation is performed by an automated system. The spatial resolution of Kazsat-2 is 6.5 meters per pixel. The shooting mode is multispectral. The stage size is 77 by 77 kilometers. The shooting period is 3-5 days. Productivity – one million square kilometers per day.

Images obtained from satellites are received at the Group for Photogrammetric Processing. The Department receives the original data. First, the primary processing is performed – unpacking and decoding.

The primary product gets the code L-1 A. Next, a geometric correction of the image is performed. It eliminates distortions caused by inaccuracy of geo-linking, curvature of the Earth, and terrain.

Distortion – optical distortions - is also eliminated. All software for this complex processing is developed by French manufacturers, Figure 8.


Figure 6.
Building of the National space center in Nur-Sultan, where the control and data processing systems KazEOSat-1 and KazEOSat-2 are located (Photo by Grigory Bedenko)
Рис. 6
Здание Национального космического центра в г. Нур-Султан, где находятся системы управления и обработки данных KazEOSat-1 и KazEOSat-2 (Фото Григория Беденко)
Слика 6
Зграда Националног центра за свемир у Нур Султану где су лоцирани системи за управљање и обраду података сателита KazEOSat-1 и KazEOSat-2 (Фотографија: Григориј Беденко)

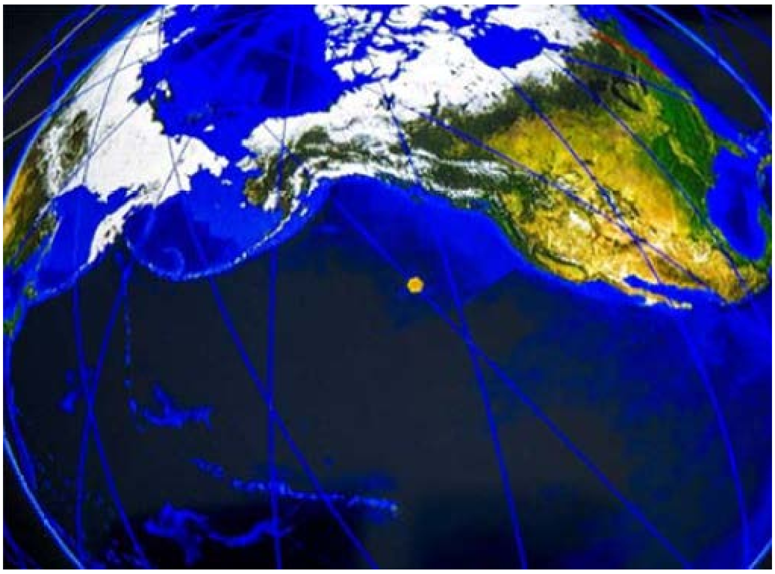


Figure 7.
KazEOSat-1 Ballistics calculated based on telemetry data (Photo by Grigory Bedenko)
Рис. 7
Баллистика KazEOSat-1, рассчитанная на основе данных телеметрии (Фото Григория Беденко)
Слика 7
Балистика израчуната на основу телеметријских података сателита KazEOSat-1 (Фотографија: Григориј Беденко)

As a result, specialists receive three types of products:

L-3 – orthorectified image. This is when the objects in the image are seen in the vertical plane. To do this, the corresponding orientation of each pixel is made;

L-4 – digital terrain or terrain model; and

L-5 – stitched mosaic.

Figure 8.
KazEOSat-2 satellite is controlled from here (Photo by Grigory Bedenko)
Рис. 8
Центр управления спутником KazEOSat-2 (Фото Григория Беденко)
Слика 8
Центар за управљање сателитом KazEOSat-2 (Фотографија: Григориј Беденко)

As a result, a single whole image is obtained, which has the widest range of applications, in particular, when monitoring territories or mapping.

The information is sent to the server and processed within two hours. After that, the data is written to special storage media for permanent storage. The server also has an array of RAM in which snapshots are stored up to a certain period. The server receives up to 12 terabytes of data per day. One medium is designed for 1.5 terabytes.

Remote sensing data obtained from the orbiting satellites is most reliable. In addition, this information is available on the whole territory of Kazakhstan. All hard-to-reach territories that are difficult to control are clearly seen from space.

A special role is assigned to satellite information in geographic information systems (GIS), where remote sensing of the Earth's surface from space is a regularly updated source of data necessary for the formation of natural resource inventories and other applications, covering a very wide range of scales (from 1:10000 to 1:1000000).

At the same time, remote sensing information enables to quickly assess reliability and, if necessary, update the graphic layers used (maps of the road network, communications, etc.), and can also be used as a raster "substrate" in a number of GIS applications, without which modern economic and military activities are unthinkable today.

USE OF REMOTE SENSING DATA IN THE ARMED FORCES, OTHER TROOPS AND MILITARY FORMATIONS OF THE REPUBLIC OF KAZAKHSTAN

Worldwide, the main consumers of remote sensing data (80%) are law enforcement agencies and government agencies. Kazakhstan is no exception. In Kazakhstan, 90% of consumers of the total volume of satellite data are government agencies. In particular, 72% of the total volume is presented to law enforcement agencies across the MD of RK.

To date, only Russia and Kazakhstan have their own satellite systems in space among the CIS countries.

The Resolution of the Government of the Republic of Kazakhstan dated May 31, 2012, No. 722, *On approval of the rules for planning space surveys, receiving, processing and distributing remote sensing data by the national operator of the space system for remote sensing of the Earth.*

General provisions

A division of the Ministry of Defense of the Republic of Kazakhstan is authorized to conduct control viewing procedures - remote sensing data and to plan space surveys together with the remote sensing system operator.

For the state bodies and the Armed Forces, other troops and military formations of the Republic of Kazakhstan, data obtained from the domestic remote sensing satellites are used to solve the following tasks:

- detection of forest fires, large emissions of pollutants into the natural environment;
- monitoring of man-made and natural emergencies, including natural hydrometeorological events;
- monitoring of agricultural activities and natural (including water and coastal) resources;
- land-use;
- operational observation of specified areas of the Earth's surface;
- monitoring the territory of possible hotbeds of hostilities and violations within the state; and
- production of derived materials for space surveys.

The Center for Mlitary Space Programs of the Defense Ministry produces a procedure of the control view - remote sensing data and, in conjunction with the operator COP ERS to plan satellite imagery and remote sensing data, provides the staffs and the management bodies of the Armed Forces, other troops and military formations. To fully solve all of the above tasks, it is necessary to create a unit capable of processing data in the DZ Forces, other troops and military formations of the Republic of Kazakhstan. The photogrammetric analysis of remote sensing and UAV data encompasses:

- photogrammetric thickening of the reference point network;
- the transformation or artifact repository space images (photos);
- decryption of satellite images (photos); and
- creating original updates (quickly corrected vector topographic and special maps of large scales and creating a 3-d terrain Model based on remote sensing and UAV data).

Training of specialists is possible at the National Defense University named after the First President of the Republic of Kazakhstan – Elbasy, together with the Center for Military Space Programs of the Ministry of Defense of the Republic of Kazakhstan.

Thus, in the future, the Republic of Kazakhstan needs to create a new generation of ultra-high-resolution mini-satellites such as fiber-optic gyrostabilization systems, spacecraft equipped with the most modern systems of unprecedented maneuverability, and train specialists for the "Photogrammetric data processing center for remote sensing and UAVS".

CONCLUSION

Analyses of modern military conflicts in the Persian Gulf and Yugoslavia shows that contactless methods of armed struggle are coming to the fore. The winner is the one who has highly accurate and up-to-date information about the enemy, ranging from a digital description of the terrain of its territory, the location of troops and vital objects to the climatic and weather conditions of the areas of combat operations.

Data from remote sensing of the Earth is part of the information required by the management bodies and headquarters of the Armed Forces, other troops and military units in the course of their activities. In addition to terrain data, there is a growing flow of operational-tactical, intelligence, meteorological and geophysical information used in the process of managing troops, which must be analyzed and taken into account when preparing and conducting operations.

Integration of geographic information systems with rapidly developing remote sensing systems will dramatically increase the capabilities of modern GIS, allowing real-time updating of spatial information, especially in the field of making important decisions.

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Primena podataka dobijenih daljinskom detekcijom u vojsci Republike Kazahstan

Sažetak:

Uvod/cilj: Cilj ovog rada jeste upoznavanje sa perspektivama budućeg razvoja svemirskih sistema daljinske detekcije Zemlje u Republici Kazahstan. Korišćeni su podaci daljinskog istraživanja u procesu organizovanja topografske i geodetske podrške Oružanim snagama, ostalim trupama i vojnim jedinicama Republike Kazahstan. **Metode:** U radu se razmatra niz krucijalnih pitanja u vezi s poboljšanjem stanja u oblasti geoinformacione podrške Oružanim snagama, ostalim trupama i vojnim jedinicama a odnose se na bezbednosne interese Republike Kazahstan. Korišćeni su satelitski snimci visoke rezolucije koji su snimljeni sa domaće svemirske letelice radi izrade i ažuriranja digitalnih državnih topografskih mapa za celokupan razmerni niz. **Rezultati:** Rad sadrži kratak pregled sistema daljinske detekcije Zemlje koji koriste kako strane geoinformacione tehnologije, tako i geoinformacione tehnologije Republike Kazahstan. **Zaključak:** Neophodno je formiranje posebnog odeljenja ("Centar za fotogrametrijsku obradu podataka prikupljenih uz pomoć daljinske detekcije sa bespilotnih letelica") koje bi se bavilo obradom prikupljenih podataka za potrebe Oružanih snaga, ostalih trupa i vojnih jedinica Republike Kazahstan, s obzirom na to da tehnologije obrade podataka nemaju mnogo zajedničkog sa konvencionalnom obradom i prezentacijom geografskih podataka. Pored toga, prikupljeni geografski podaci mogu da posluže kao osnov za rešavanje velikog broja aktuelnih problema.

Ključne reči: svemirski sistemi za daljinsko detektovanje; vazduhoplovna i svemirska sredstva; sateliti; prostorna rezolucija; radiometrička rezolucija; spektralni raspon

Применение данных дистанционного зондирования в вооруженных силах Республики Казахстан

Резюме:

Введение/цель: Данная статья написана с целью ознакомления читателей с перспективами развития космической системы дистанционного зондирования Земли в Республике Казахстан и использования данных ДЗЗ в процессе организации топогеодезического обеспечения Вооруженных Сил, других войск и воинских формирований Республики Казахстан. **Методы:** Применяя аналитический подход при исследовании причин, развитие космической и информационной технологий привели к качественным изменениям в отрасли дистанционного зондирования Земли. Выводы были сделаны и на основании анализа исторических аспектов становления и развития космической системы дистанционного зондирования Земли. В данной статье рассматриваются вопросы кардинального улучшения ситуации в области геоинформационного обеспечения Вооруженных Сил, других войск и воинских формирований в интересах безопасности Республики Казахстан с использованием материалов космической съемки высокого разрешения с отечественного космического аппарата для создания с одновременным обновлением цифровых государственных топографических карт всего масштабного ряда. **Результаты:** В статье приведен краткий обзор систем дистанционного зондирования Земли с использованием. геоинформационных технологий зарубежных государств и Республики Казахстан. **Выводы:** Создание специального подразделения «Фотограмметрического центра обработки данных ДЗЗ и БЛА» способных обрабатывать данные ДДЗ и БЛА для Вооруженных Сил, других войск и воинских формирований Республики Казахстан, так как технологии обработки данных имеют мало общего с традиционной обработкой и представлением географических данных, однако географические данные могут послужить базой для решения большого числа прикладных задач.

Ключевые слова: космические системы дистанционного зондирования, авиационные и космические средства, спутники, пространственное разрешение, радиометрическое разрешение, спектральный диапазон