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Proposals for the Creation of a Satellite System for Data Collection and Transmission Based on Domestic Spacecraft

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Abstract. The paper shows the necessity for tracking the location and state of both stationary and moving objects. The solution of this problem is possible by creating a domestic satellite system for data collection and transmission that provides automated collection of information on the state and coordinates of various objects serviced within this system regardless of their location on the globe. The choice of the optimal option for building a satellite data collection and transmission system is justified. The article presents data on the existing scientific and technical groundwork of Joint Stock Company "Russian Space Systems" for creating a satellite data collection and transmission system. The main functions and principles of creation and tasks solved by the system for data collection, processing, and transmission are shown. The main design and technical solutions, composition, features of operation, and the main characteristics of such a system and its components are given. A procedure for creating and deploying such a system is proposed.

Keywords: onboard radio complex, data collection and transmission system, data collection platform, information relay, hydrometeorological data, visibility range, information receiving and processing station

Topicality of creating a satellite data collection and transmission system

The need for constant control of the location and state of different, both mobile and stationary, objects is currently an urgent task.

For solving this problem, it is expedient to ensure the creation of a stable and secure information-telecommunication infrastructure for the transmission, processing and storage of required data volumes that can be accessed by all potential users. At the same time, the task of ensuring information security during data transmission, processing and storage must be tackled with the implementation of domestic developments.

In this regard, the task arises of introducing new reliable technical means, which would allow automated collection of status information from stationary and mobile objects, as well as the transfer of information to objects. Technically, this task can be tackled with the use of satellite means [1]. At present, however, none of the domestic satellite systems are used to solve this problem.

The creation of such a space system will provide automated collection of information about the state and coordinates of different objects serviced by the system regardless of their location on the globe, i.e. in global mode. In this case, the system will automatically calculate the coordinates of the location of objects and send them to corresponding user control centers [2]. The information can also be requested from the control center if it is possible to transmit the required information to the object.

The data collection and transmission satellite system (DCTSS) will not only allow solving control and management tasks, but will also increase the likelihood of maintaining the desired state and security of objects controlled.

Justification of the choice of the optimal option for building a data collection and transmission satellite system

The structure of the satellite system is determined by the type of orbit (elliptical, GEO – geostationary, MEO – medium Earth Orbit, LEO – low Earth Orbit), its altitude, the total number of spacecraft (SC) in the constellation and their mutual positioning, the number of orbital planes and the angular distance between them, the orbital inclination to the equatorial plane, and others.

Currently, there is a rather large quantity of domestic [3–5] and foreign [6, 7] satellite systems (regional and global) based on the use of low, medium, geostationary and elliptical orbits, such as:

– geostationary systems: Raduga-1M, Yamal, Express, Luch, Inmarsat, MobileSat (Australia), AMCS (USA), MSAT (Canada), AceS, Thuraya;

– systems in elliptical orbits: satellites of the Molniya series, Ellipsat;

– MEO systems: New ICO, Odyssey; and

– LEO systems: Parus, Gonets, Globalstar, Iridium, Orbkomm, Argos.

Geostationary (GEO) systems are characterized by a radio visibility zone, which provides the possibility of controlling and monitoring objects on a vast territory with one SC.

The large number of satellite systems based on the use of geostationary SC is associated with their obvious advantages:

– almost total coverage (90%) of the Earth's surface with the implementation of only 3–5 satellites for global systems, and zonal coverage with use of 1–2 satellites for regional ones;

– mature technology for manufacturing, launching, orientation and keeping the SC in geostationary orbit;

– possibility of using rather simple non-tracking antennas;

– relative simplicity of building an operations control and state monitoring system for a SC constellation;

– possibility of using a minimum number of expensive ground-based stations (as many as one for each sub-satellite zone) as part of the ground-based segment of the satellite communication system (SCS), which ensure interfacing of different types of subscriber terminals (STs) with ground communication networks;

– immobility of the Earth-surface coverage zones formed by the beams of satellite antennas ensures a lower probability of the need of ST transition from one zone to another in the process of conversation and, as a result, the automation of this process does not require considerable expenditures of system resources (signaling and control channels).

Due to the passage of the orbit above the equator and the small elevation angle of ground stations, geostationary SC do not provide communication for the polar regions of the Earth.

Spacecraft in elliptical orbits can be employed for communication in the circumpolar and polar regions.

Low-Earth orbit (LEO) Earth artificial satellites (EASs) are at low altitudes and provide such a signal level at the input of receiving devices of terminal stations that allows information to be received by an omnidirectional antenna in motion, not only during stops. In its turn, the transmitters of the terminal with omnidirectional antennas provide a signal onboard LEO EAS that is sufficient for relay. Thus, reliable operation of low-power mobile and portable stations with omnidirectional antennas is ensured in systems based on LEO EAS.

The space segment of LEO systems is usually made up of dozens of SC evenly distributed across the surface of the Earth in such a way that at least 1–2 space repeaters are within the line-of-sight of any terminal station; and 3–5 repeaters are in polar regions ensuring the required reliability of communication within the limits of the entire surface of the Earth. The redundancy of interconnected satellites in the space segment also conditions the high survivability of low-orbit systems because of created bypass and backup communication links.

The feasibility of using LEO satellite systems is currently conditioned by:

– limitations in the creation of GEO systems in terms of station points and parameters of relay channels associated with the congestion of the geostationary orbit with a large number of SC;

– possibility of using the Doppler effect for positioning controlled objects;

– possibility of subscriber operation using omnidirectional antennas associated with the practical application of low frequencies in downlinks (SC to Earth);

– high system reliability determined by the level of redundancy, at which the failure of one SC leads only to a decrease in system operability;

– independence of communication link efficiency from the relief and other characteristics of the terrain where the controlled object is located; and

– relatively low costs of providing personal communication.

Thus, the performed analysis demonstrates that the choice of the optimal option for building a data collection and transmission satellite system based on domestic SC should be determined by the following set of criteria and conditions [8]: cost, compliance with the objectives and required characteristics, the possibility of creation and deployment within financial and political constraints. The implementation of this approach is possible provided that the existing reserve for the creation and usage of domestic satellite systems and their components is applied together with the characteristics and advantages of different space segments of the system being created in the process of their joint operation.

In this regard, the main properties of such a system should be defined as the availability of a space constellation of already created or only being created SC capable of forming a two-tier space segment with a realized capability of inter-satellite relay mode [9], which ensures global and efficient information delivery, as well as the availability of SC equipment with an onboard radio-engineering complex capable of operating with one type of user equipment. Apart from this, an important characteristic for ensuring the efficiency of the system being created in its global application is the use of the Doppler effect for independent positioning of different objects.

Expertise, scientific and technical reserve of JSC “Russian Space Systems” in the creation of the *Kurs* data collection and transmission satellite system

The *Kurs* system [10], which was potentially capable of solving problems faced by a data collection and transmission system, was developed by RNII KP in 1985–1990. In order to assess the accuracy and efficiency of measuring coordinates of objects with the implementation of the *Kurs* system, FSUE RNII KP conducted a series of demonstration experiments and tests confirming the utilization efficiency for controlling the location of mobile objects and cargo, as well as validated the technical solutions for creating separate elements of the ground-based infrastructure of the *Kurs* system.

Based on the positive results of flight tests (FTs) of the *Nadezhda* system, upon recommendation of the State Commission, the *Kurs* system [2] was accepted into trial operation by the decision of Roscosmos in 1997 comprising the following:

– a SC (*Kosmos-2135*);

– a local user terminal (LUT) (an information receiving and processing station) providing operation in *Kurs* mode (Teplyy Stan) at a frequency of 1643 MHz in the SC–LUT radio link;

– a regional center (RC) at Teplyy Stan responsible for receiving data obtained from the LUT and their transmission to the international mission control center (Moscow) and users;

– the *Maran* radio beacons emitting a radio signal in the link of the subscriber terminal – SC (ST –SC) at a frequency of 406 MHz.

In 2008, during the preparation period for the launch of the *Sterkh* SC within the framework of the research and development project *Nadezhda-M* at FSUE RNII KP, a bench was created for testing the mathematical support and software (MSS) of a prototype of an information collection and processing center of the *Kurs-M* subsystem [11].

However, the currently existent ground infrastructure of the *Nadezhda* system has lost the ability to operate in *Kurs* mode because of a number of factors:

– long absence in orbit of a SC with an onboard radio complex (ORC) operating in *Kurs* mode;

– lack of a system operator capable of ensuring the operation, the required system modernization and provision of monitoring services;

– lack of an information receiving and processing station (LUT) ensuring the operation with the *Kurs* ORC at a frequency of 1700 MHz, as well as consumer equipment operating at a frequency of 402 MHz (the *Kurs* system was set at the frequency of 402 MHz in the ST–SC link and at 1700 MHz in the SC–LUT link in 2003 in agreement with Roshydromet).

The fact that currently there are domestic hydrometeorological LEO and GEO AESs in orbit and future launches of highly elliptical SC are planned makes it possible to use the capabilities of the onboard equipment installed on these SC for acquiring, processing and retransmitting signals from PSD-402 data collection platforms. This ensures the transmission of monitoring data for mobile and stationary objects.

Thus, domestic hydrometeorological SC presently in orbit and those planned for launch will, basically, form a two-tier space segment of a system that is capable of monitoring mobile and stationary objects on a global scale by transmitting and processing data concerning their state and location. Such a DCTSS system provides data retransmission from ground platforms through LEO SC at a frequency of 465 MHz to geostationary KA and then to ground LUTs.

To realize the potential capabilities of the DCTSS, it is necessary to create a ground infrastructure and a single controlling body for the system.

Main functions and principles of creation and tasks of a data collection, processing and transmission system

The DCTSS being created should perform the following functions [11]:

– automated collection of data on the state and location of stationary and mobile land and sea objects, including objects carrying hazardous and valuable cargo;

– collection of meteorological, oceanographic and other information in the interests of different sectors of the national economy and for the hydrometeorological support of ships;

– collection of environmental and natural resource information; and

– transmission of obtained information about the state and location of controlled objects to users, including time-sensitive information in emergency situations (earthquakes, floods, ecological and industrial disasters).

The evaluation of mutual radio visibility zones [9] of the GEO SC *Elektro-L* and the LEO SC *Meteor-MP* (Fig. 1) demonstrates the possibility of using inter-satellite relay mode to improve the efficiency of information delivery from data collection platforms in the DCTSS being created.

At the same time, the hardware of the modernized onboard radio complex of the DCTSS LEO SC [9] should ensure the performance of the following functions:

– acquisition, processing, storage and transmission to the transport data frame formed in the onboard information system (OIS) of data from ground data collection platforms for their further transmission to the main meteorological centers; and

– retransmission of data from ground-based data collection platforms located in the polar regions of the Earth through LEO SC with a frequency translation from 402 MHz to 465 MHz and then to ground LUTs via geostationary SC.

The creation of such a DCTSS based on domestic low-orbit and geostationary SC calls for a solution to the problem of building and deploying the infrastructure of information services concerning the state and location of mobile and stationary objects, hazardous and valuable cargo to subscribers located anywhere in the world, as well as the problem of providing organizational and regulatory conditions for the new domestic segment of consumer services.

The implementation of the capabilities of the domestic orbital constellation made up of SC with installed onboard equipment for receiving, processing and retransmitting signals from the collection platforms at a frequency of 402 MHz requires the creation of new elements of the ground infrastructure of the data collection, processing and transmission satellite system based on domestic SC, as well as the solution of a series of organizational, technical, financial and economic problems.

Basic design and technical solutions

System composition

The DCTSS determines the location of mobile objects and ensures the acquisition and transmission of a limited volume of data (500–5000 bits) from stationary and mobile objects via AES to the ground-based data acquisition and processing center. The system consists of three parts:

- space segment
- ground segment
- ground-based user facilities.

The space segment includes onboard radio complexes (ORCs) installed on domestic AESs launched into low orbit (*Meteor-MP* satellite) and geostationary orbit (*Elektro-L* satellite).

The new-generation low-orbit hydrometeorological satellite *Meteor-MP* is used as the base SC of the system.

The ground segment of the DCTSS consists of:

– a data reception and processing center (DRPC), the creation of which is possible at JSC "Russian Space Systems";

– regional stations for receiving and processing data from a low-orbit LEOLUT and geostationary GEOLUT of the DCTSS space segment located on the territory of the Russian Federation;

– regional user centers (RCs) of the system, if necessary, combined with a LUT; and

– communication links between LUTs, DRPCs, RCs and users.

LEOLUTs and GEOLUTs must be part of the DRPC hosted by JSC "Russian Space Systems".

Ground-based user facilities providing the required type of services of data transmission in various operating conditions and access to system resources include:

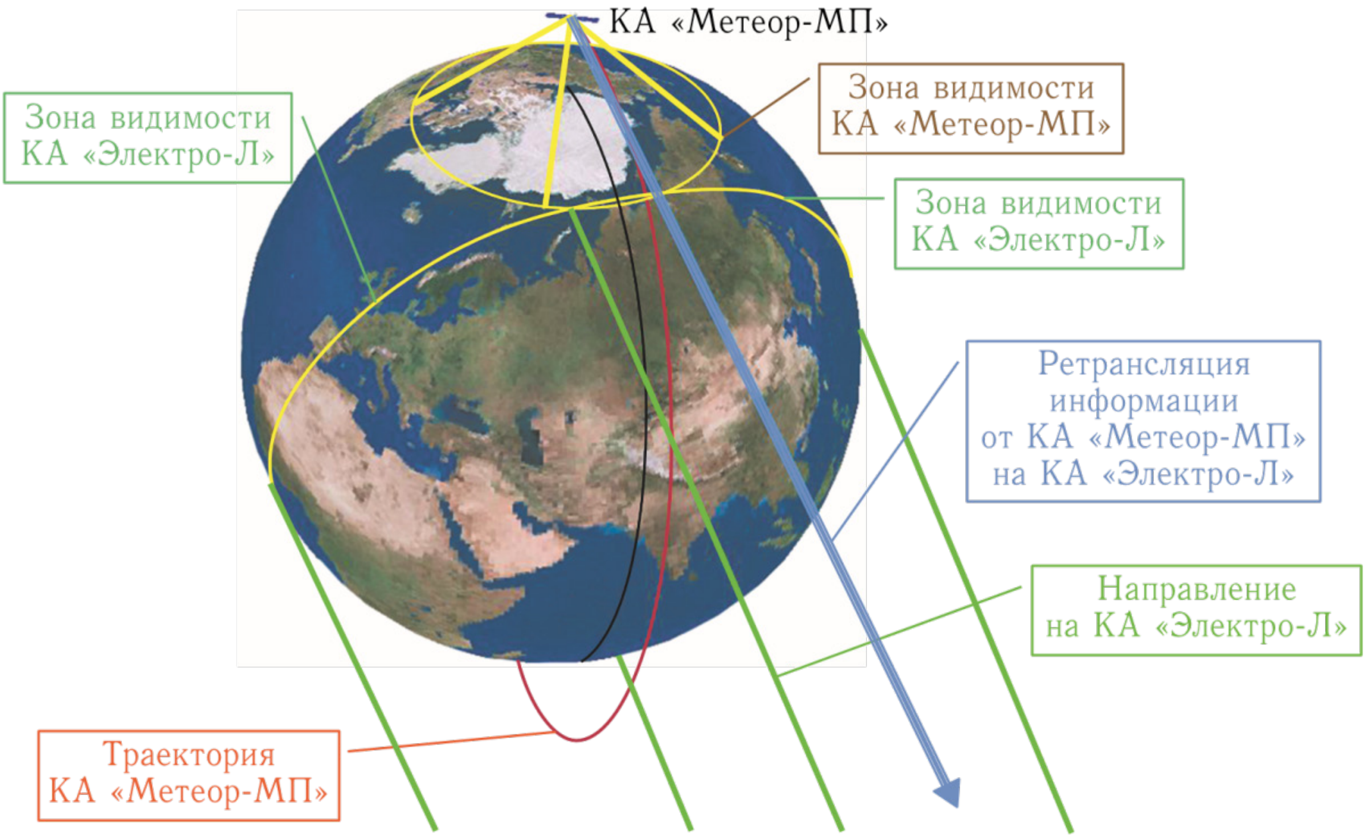

Fig. 1. Visibility zones of the *Elektro-L* and *Meteor-MP* SC

– user equipment operating in personal mode;

– communication subsystems and the global communication network of the Internet, which are part of the DCTSS functionally.

Special features of DCTSS operation

The DCTSS operates as follows:

– the transmitters of subscriber terminals (STs) periodically (once a minute) send a message in automatic mode, which is received by satellites with an ORC operating at a frequency of 402 MHz;

– in the ORC, these messages are converted in accordance with the operation cyclogram and then transmitted to ground stations for data reception and processing;

– ground stations perform the extraction of the digital stream transmitted from the ORC memory, determine ST location, generate and transmit an exchange data array with DRPC (the ORC of the geostationary space segment of the DCTSS retransmits the ST messages, which were received at a frequency of 465 MHz);

– the information received from the ground stations about the location and state of controlled objects is transmitted to the DRPC, where it is received, processed and provided to users, as well as stored in databases for further analysis.

– The data obtained by the system can be presented by displaying the location on an electronic map, by keeping tabular records of the state, by statistics of the behavior of controlled objects (track covered, route, etc.).

The subsystem for analysis and visualization of information in DRPC ensures the issuance of signals and reference information in the event of any incidents, as well as the operation of the decision support system.

Main characteristics of DCTSS, characteristics of telematic services rendered by the system

The principal characteristics of DCTSS [11] for two–four LEO AESs and one GEO AES are given in the Table.

Number of serviced objects by the transceiving equipment of a single LEO SC [9]:

– per revolution – 2000;

– operating simultaneously within radio visibility zone – 150;

– for DCTSS based on GEO SC – 300 radio beacons in the visibility zone (operating simultaneously).

Table. DCTSS characteristics

Technical characteristics	DCTSS-LEO  Meteor-MP	DCTSS-GEO  Elektro-L
Orbit parameters altitude, km/ inclination, ° station point, E.	650/98 –	36000 76
LUT location	Moscow, Novosibirsk, Murmansk, Yuzhno-Sakhalinsk, Petropavlovsk-Kamchatsky, Krasnoyarsk	Moscow
System performance	150 radio beacons in the visibility zone, 2000 per revolution (with three channels in receiver-processor)	300 radio beacons in the visibility zone (operating simultaneously)
Standby time, min maximum average	130/60 for 2 LEO AESs 80/40 for 4 LEO AESs	1
Message volume per communication session, bit	500–2000	500–5000

Communication session delay time: maximum/average — 130/60 min (for 2 AESs), 80/40 min (for 4 LEO AESs).

Number of communication sessions from one ST per day (for one LEO AES):

> 15 for > 80°lat.; > 7 for > 50°lat.; > 4 for > 20°.

Probability of data reception and positioning in one communication session for an elevation angle >7° — 0.98.

Accuracy of determining the coordinates of a ST installed on a mobile object with the implementation of GLONASS/GPS equipment — no worse than 0.1 km.

ST nominal carrier frequency – 402 MHz. Nominal carrier frequency of the AES ORC–LUT – 1696.4 MHz.

The system ensures the transmission of data during the time spent in the visibility zone from subscriber terminals in the format of short packets obtained by collecting messages about the location and sensor information with a volume indicated by the technical specifications for user systems.

Data transmission rate via the AES–LUT link – 9600 bit/s.

The volume of a message per one communication session is 500 – 2000 bits.

The DCTSS provides protection against unauthorized access to satellite links by implementing specialized means of subscriber authentication.

The system renders the following telematic services to users:

– determination of location of mobile objects;

– automated collection of data from sensors monitoring the state of any objects, including unattended ones, collection of location data;

– transmission of emergency messages.

The ground-based facilities of the system provide interaction with the public network: telephone (TLP) and telegraph (TLG), the Internet and other terrestrial networks.

Characteristics of DCTSS constituent parts. Onboard radio complex (ORC)

Onboard radio complexes are a set of special receiving and transmitting equipment installed on an AES, which interacts with the equipment of subscriber terminals located at user objects and ground stations.

The onboard radio complex of the DCTSS mounted on a hydrometeorological LEO SC ensures the interaction between consumer equipment and ground data receiving and processing stations and, in doing so, it performs the following functions:

– reception, detection and extraction of the digital message from the signal transmitted from subscriber terminals (STs);

– measurement of the Doppler frequency shift of the signal from the ST with reference of the start of measurement to the onboard time;

– storage of data concerning the received message, Doppler value of the frequency and measurement time for its transmission to a LUT in the LUT–AES visibility zone;

– generation of a modulating signal in digital form, containing messages received from the ST, the value of the Doppler frequency and the time of measurement; and

– transmission of data received in real-time and data previously stored in RAM from the AT to the LUT in continuous operation mode.

The onboard antennas of the LEO SC are oriented towards the center of the Earth with an accuracy of ±8° in the geometric visibility zone of the set potential ST–AES and AES–LUT.

The ORC installed on a hydrometeorological GEO SC ensures operation in the mode of retransmission of data received from the ST.

The following special features characterize the DCTSS onboard radio complexes.

The ORC equipment mounted on a LEO SC and simultaneously functioning in COSPAS and DCTSS modes ensures (in DCTSS mode) the reception of data from the ST (in the range from 401.91 to 401.99 MHz), their preprocessing and storage for transmission to OIS and the subsequent information transmission in digital form to a ground LUT in the total data flow from the SC.

In addition, the upgraded equipment must be responsible for coding, generating and the subsequent retransmission of information at a frequency of 465 MHz to the onboard complex (6th channel) of the GEO SC.

The data transmission rate from ST (402 MHz) to LUT is 9600 bits/s. The ORC equipment ensures the reception of bursts from 150 STs (402 MHz) operating simultaneously and uniformly distributed in the SC radio visibility zone. The capacity of the ORC RAM is no less than 10 Mbit, which is enough to store 20 000 ST bursts (402 MHz).

The sixth channel of the second trunk of the ORC of the GEO SC provides the re-retransmission of data (incoming from LEO SC ORC) from data collection platforms at a rate of 1.0–1.2 kbit/s. A signal with a frequency of 465 MHz is fed into the input of the lownoise amplifier (LNA). After amplification, the signal enters the data retransmission channel of the DAP, where the signal is heterodyned in the 465 MHz band. The signal is modulated, filtered, converted to the carrier frequency of 1696.4 MHz, fed into the input of the power amplifier (PA) and then goes to the antenna for its subsequent transmission to GEOLUT.

The seventh channel of the second trunk GEO SC ORC is responsible for interacting with ST (402 MHz) and the transmission of data to LUT (1697 MHz). The ORC provides the retransmission of information from ST in the quantity of up to 300 frequency division multiplexing channels with a transmission rate of up to 300 bit/s and a volume of transmitted information of not more than 5200 bits from each ST without storage and RAM processing. It is possible to use STs with a rate of 400, 1200 bit/s.

Data receiving and processing station

1. The data receiving and processing station supporting operation with the ORC of the LEO SC (LEOLUT) is one of the main elements of the ground segment of the system. It is intended for solving the following tasks:

– tracking the AES according to the program;

– acquisition, demodulation and detection of received signal;

– extraction of the digital stream transmitted from the ORC memory device containing burst information, the Doppler value of the frequency and the time of detection of the signal from the subscriber terminals by the ORC;

– determination of coordinates of objects equipped with STs;

– data storage in a PC;

– autonomous determination of AES trajectory data by reference radio beacons or by measurements of the Doppler frequency shift in the AES–LUT link (ephemeris data are calculated on a PC or come from the ballistic center (BC) of the system); and

– transmission of data received during the communication session to the DRPC of the system and users.

The LUT processes all of the data received during the session and ensures their sorting. After sorting, the LUT determines the location of the radio beacon if at least four correct burst were received. If an insufficient number of bursts was received, the data from the ST is transmitted without determining the coordinates.

A LUT should include main and auxiliary equipment.

Main equipment:

– antenna system

– receiver

– a device for interfacing with a PC

– a PC-based computing complex with mathematical support and software

– reception system for precision time signals

– a communication link interface device.

Auxiliary equipment:

– onboard radio complex simulator

– reference radio beacon

– a set of measuring instruments

– a set of spare parts.

The LUT includes automatic testing of the functioning of the entire complex and of individual instruments.

The set of LUT equipment operates as follows. According to calculated ephemeris data (calculated or received from the BC), the PC estimates the visibility zones of each AES and, before each communication session, forms an antenna-pointing program for tracking AES movement with the help of the antenna system.

The AES signal received by the antenna is fed into the receiving device, where signal detection, extraction and preprocessing take place.

Preprocessed digital signals are sent for final processing in the PC, which decodes incoming data, stores them for the purpose of reprocessing, determines the coordinates of controlled objects, forms the streams of output data and sends them to the interface device with the communication link that transmits the information to DRPC.

2. Stations for receiving and processing information of the GEO system (GEOLUT) are designed to solve the following tasks:

– continuous round-the-clock reception of the signal carrying information from the ST, which is retransmitted by the ORC of the GEO SC at a frequency of 1697 MHz in the band of 80 MHz;

– detection, extraction and output into the communication link of messages from the ST for delivery to the DRPC hardware-software system;

– measurement of the frequency of signals from the ST for their identification;

– simultaneous reception of signals from at least 20 STs in the radio visibility zone of the GEO SC.

The composition of means included in the GEOLUT is similar to that of the LEOLUT.

Data receiving and processing centers

1. The data receiving and processing center is responsible for fulfilling the following tasks:

– database storage

– analysis of the state and operability of the DCTSS system as a whole

– reception of trajectory data from AES mission control center

– coordination of the operation of all LUTs forming part of the system

– collection of data from all LUTs functioning as part of the system, data analysis and processing

– generation of output messages; the sorting and transmission of messages received from objects to the corresponding consumer

– prompt resolution of system reconfiguration issues in the event of a malfunction of any element of the system

– registration of subscribers, ensuring their input into the system and maintenance of a database of ground-based system means

– automatic accounting (billing) of user traffic.

In accordance with the problems posed, the DRPC includes:

– hardware and software

– LEOLUT and GEOLUT

– specialized software

– device for interfacing with communication links

– communication channels (TLP, TLG, the Internet) are included functionally.

2. The regional user center (if necessary, combined with LUT) should ensure:

– the organization of the reception and collection of information in the region, its sorting and transmission to the appropriate consumer of messages received from their objects

– simultaneous interaction with all SC in the radio visibility zone of the combined RC with the LEOLUT

– determination of the possibility of servicing individual groups of terminals, of organizing communication sessions for batch servicing of terminals.

– interaction with technical means of other systems, including for the purpose of reducing the time of information delivery

– interaction of DCTSS subscribers with other ground networks via information gateways;

– the maintenance of databases of users assigned to the RC with information about their current location, service mode and declared traffic.

In accordance with the tasks to be solved, the RC includes:

– a software and hardware complex

– specialized software

– a device for interfacing with communication channels

– communication channels (TLF, TLG, the Internet are included functionally)

– LEOLUT (if necessary).

Subscriber terminals

Subscriber terminals are intended for the transmission of information on the state and location of controlled objects via the DCTSS ORC.

Different kinds of subscriber terminals are used in the DCTSS. The terminals are installed on mobile or stationary objects and emit a modulated radio signal, which is used to determine the coordinates and which carries the necessary information for the user about the state of the object. GLONASS/GPS navigation equipment is installed on the ST for high-accuracy positioning.

The following types of STs should be developed to meet the demands of subscribers of DCTSS services [11]:

– autonomous terminal + GLONASS/GPS receiver (for high-precision determination of object coordinates) — ST-1;

– autonomous terminal + unattended data collection controller (for determining the parameters of the state of stationary objects, with the possibility of positioning with an accuracy no worse than 3 km) — ST-2;

– autonomous terminal + unattended controller + GLONASS/GPS receiver (for high-precision determination of coordinates and parameters of the state of the object) — ST-3.

A special feature of the DCTSS is the possibility of creating universal subscriber terminals for operating both through low-orbit and geostationary satellites.

The configuration of terminals, software and design are developed with the use of the basic modification according to the technical specifications of the component, agreed upon with the Customer (user) of the system.

Proposals for the arrangement of ground-based segment elements of the DCTSS system across the territory of the Russian Federation

It is advisable to locate the Data receiving and processing center in Moscow at JSC "Russian Space Systems". The DRPC comprises one LEOLUT and one GEOLUT.

To implement the capabilities of the DCTSS under development, it is necessary to deploy a network of regional LUTs on the territory of the Russian Federation: in Yuzhno-Sakhalinsk, Novosibirsk and Murmansk (one LEOLUT in each city). This is conditioned by the characteristics of the LEOLUT radio visibility zones [10, 11] demonstrated in Fig. 2. The radio visibility zone for operation with GEOLUT is given in Fig. 3.

In order to increase the reliability of system operation, it is expedient to place an additional LEOLUT in Petropavlovsk-Kamchatsky and Norilsk in the future (at the second stage of system deployment).

Function-wise, the LUTs should be subordinate to the main center, thus, ensuring the solution of regional monitoring tasks and the transmission of received data to DRPC. Such an arrangement of system facilities makes it possible to perform monitoring functions throughout the territory of the Russian Federation and its economic area.

The transmission of information to the potential users of DCTSS is carried out by means of a web interface via the Internet (TCP/IP protocol).

The transmission of messages to remote users is also possible (to web servers) via GSM networks in GPRS format.

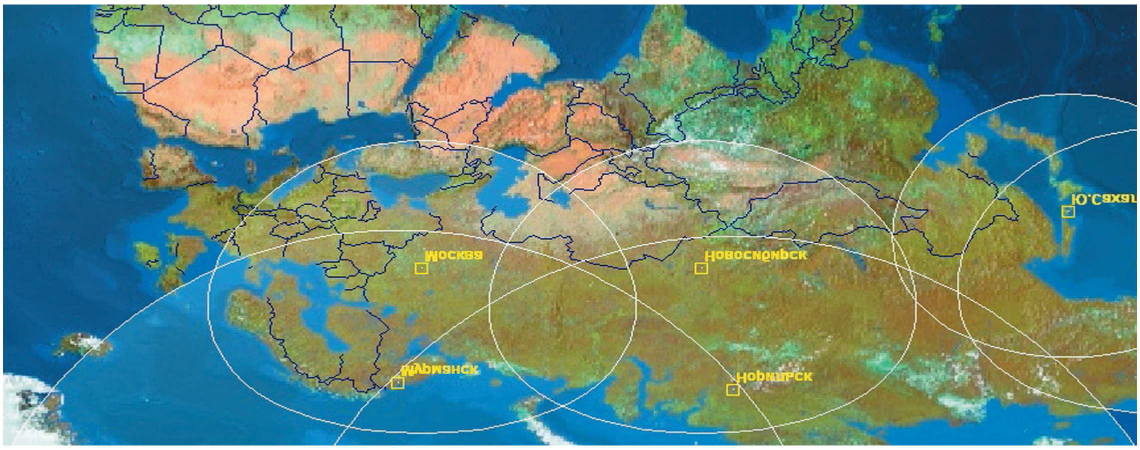

Fig. 2. Radio visibility zone for low-orbit SC (angle > 10°).

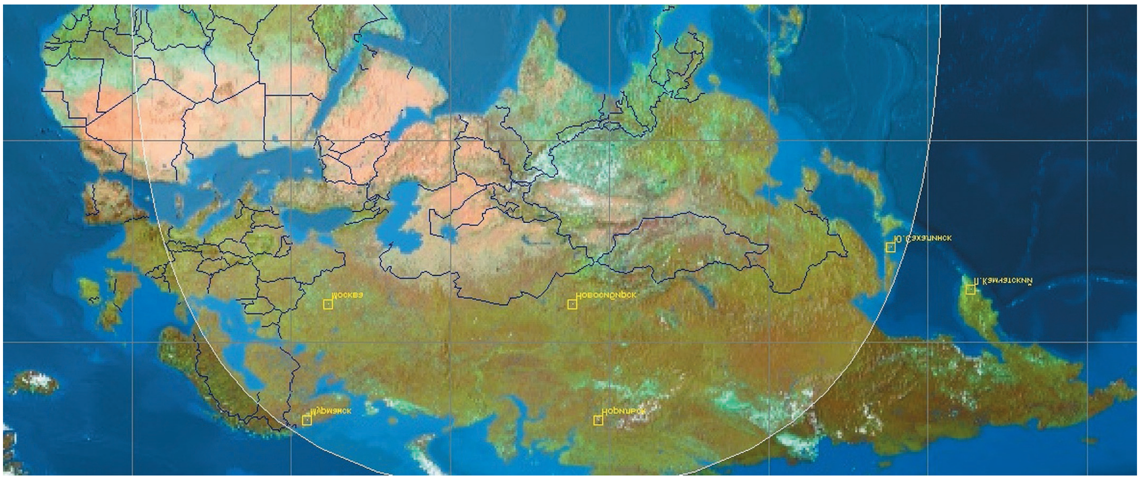

Fig. 3. Radio visibility zone during GEO SC operation.

Upon request from consumers of system services, a network of regional user data receiving and processing centers in the regions of the Russian Federation can be created.

The procedure for DCTSS creation and deployment

Roscosmos (Customer) together with JSC "Russian Space Systems" (Contractor) in coordination with Roshydromet, Rosrybalovstvo, the EMERCOM of Russia and other involved federal executive authorities are responsible for organizing and conducting works aimed at DCTSS deployment.

The package of works ensuring the creation and efficient use of DCTSS includes:

– the creation of a data receiving and processing center (JSC "Russian Space Systems"), the formation of a regulatory framework and organizational structure for the creation of a main data receiving and processing center and a system operator on its basis;

– the development and manufacturing of LEO and GEO LUTs for receiving and processing data from the ORC that are installed both on low-orbit and geostationary SC;

– the creation of regional user data receiving and processing centers;

– production of prototypes and serial batches of subscriber terminals;

– comprehensive testing and commissioning (deployment) of the system;

– completion of a set of organizational works to create a controlling body – a system operator, and to ensure the promotion of operator services for monitoring the state of stationary and mobile objects, hazardous and valuable cargo on the market.

A network of user centers for receiving and processing information located in the regions of the Russian Federation can be created at the request of system users.

Concurrently with the execution of the mentioned works with the aim of creating and deploying a DCTSS and providing services for monitoring mobile and stationary objects, a number of technical and financial issues has to be resolved:

– the creation of a legal framework (system statement, regulatory documents for providing monitoring services to consumers, a basic tariff agreement and etc.);

– the formation of a centralized structure based at JSC "Russian Space Systems", which operates the system in the interests of consumers of monitoring services, and the creation of a single controlling body –DCTSS operator. At the same time, the system operator ensures:

– provision of the whole range of DCTSS telematic services

– certification of technical means

– sale and lease of subscriber equipment, software and user elements of the DCTSS ground segment

– warranty service and service support of ground equipment.

At the stage of technical documentation development, the issues of combining the monitoring functions of different ministries and departments within the framework of a single state monitoring system should be worked out.

Since the technical means of centers are unified, they can duplicate the capabilities of each other if necessary, thus, ensuring the reliability and high quality of monitoring services.

It is obvious that with such an approach the system can easily be built up by creating similar centers on the territories of foreign countries, which will ensure constant uniform loading of the space segment.

Conclusion

Building a domestic data collection and transmission system together with the creation and deployment of the necessary infrastructure will ensure the implementation of system capabilities to solve the following urgent tasks:

– creation of an efficient monitoring system based on domestic satellite facilities to provide subscribers with information services on the state and location of mobile and stationary objects located anywhere in the world;

– creation and introduction of promising scientific and technical developments (including a set of technical means intended for monitoring, information technologies for processing data) into current and future monitoring systems;

– ensuring information security in the interests of national security when monitoring objects;

– creation of a system operator, as well as the use of system capabilities for functional interaction with foreign systems to pursue a proactive policy in the market of operator services, which will boost the economic efficiency of the created DCTSS and contribute to the development of international relations.

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