

*The scientific methods experience of  
basic space research contribution  
for  
the use of micro-satellite platforms  
for the warning and the liquidations  
of the hazard situations*

*L.M.Zelenyi, S.I.Klimov, O.I.Korablev, V.G.Rodin  
Space Research Institute of RAS, Moscow, Russia*

## The tendency of a microsatellite use

*In the last decade because of the reduction of financing the entire space industry, presence of the conversion launch systems, qualitatively new achievements of microelectronics and micromechanics, accessibility of the elements of the space systems much attention began to be given to the use of small spacecraft:*

*- micro-satellite - MS (100 - 10 kg)*

*- nano-satellite - NS (10 - 1 kg)*

## The tendency of a microsatellite use

*The analysis of the launch of small SC (mass to 300 kg), carry out in the period from 1986 through 2000, shows that this segment of space activity intensively commercialization.*

The tendency of a microsatellite use

*Table 1. Statistics of the launch of low-orbital small SC (mass to 300 kg)*

	<b>1986-1999</b>	<b>1986-1999</b>	<b>1986-1999</b>
<b>Military</b>	82%	68%	21%
<b>Civil</b>	17%	27%	41%
<b>Commercial</b>	1%	5%	38%
<b>Total SC:</b>	<b>129</b>	<b>132</b>	<b>123</b>

## The tendency of a microsatellite use

*The comparison of the periods of 1986-1990 and 1996-2000 demonstrates the clearly expressed tendency:*

*a considerable increase in the portion of the launch of civil (2,5 times) and especially commercial (from 1 to 38 %) SC occurred due to the sharp (four times) reduction of the share of the launch SC of military designation.*

*The distribution of the number small SC on the weight groups shows that almost 50% of them are SC with mass to 50 kg, moreover in Russia are achieved so many the launch of such SC as in the remaining countries, about 100 during the period of 1985-2000.*

## The tendency of a microsatellite use

*From January 2005 on the present time in orbit works  
Russian micro-satellite "University" (mass - 31,5 kg).*

## The tendency of basic space research

*At present in space physics and astrophysics is accumulated the significant observant material, obtained by SC. Great successes are achieved in the theoretical and experimental studies of near-earth space, atmosphere and lithosphere of the Earth. There are serious studies of laboratory and computer simulation.*

*Examination from the united positions of entire complex of preparation and conducting of basic space research leads to the need of the association of the efforts of scientists, who carry out the study of each of the directions enumerated above. In this case it is necessary to carry out an integral approach to the solution of the problems presented by the way:*

## The tendency of basic space research

*the development of the new methods of experimental studies of the Earth and near-earth outer space with the use of achievements of physical instrument manufacture, microelectronics and micromechanics for their realization on the micro-satellite platforms (MP);*



## The tendency of basic space research

*the development of the methods of introducing the contemporary technological-design solutions in the process of creating of constructions and systems MP;*

## The tendency of basic space research

*theoretical analysis method of control onboard system  
micro- and nano- space platform for purposes guarantee  
high demand on their orientation and stabilization, presented  
from experiment;*

## The tendency of basic space research

*conducting the laboratory and numerical simulation of control processes by onboard systems of microplatform for the purpose of the determination of the critical elements of models.*

## The tendency of basic space research

*Promising trends in development of experimental physics require of ever more precise and more highly informative scientific instruments. Moreover, situation is complicated by a constant reduction of financing scientific studies, even in the developed countries.*

*This specifies the need for development and creating the new generation of scientific instruments with the light weight and the required power, the high level of the metrological parameters.*

## The tendency of basic space research

*Since 2004 in the Space Research Institute of RAS is conducted the work on the theme*

*"Creation of the onboard platform of the micro-satellite of applied and scientific designation on the basis of contemporary technologies and developments",*

*included in*

*The Program of basic research of Presidium RAS*

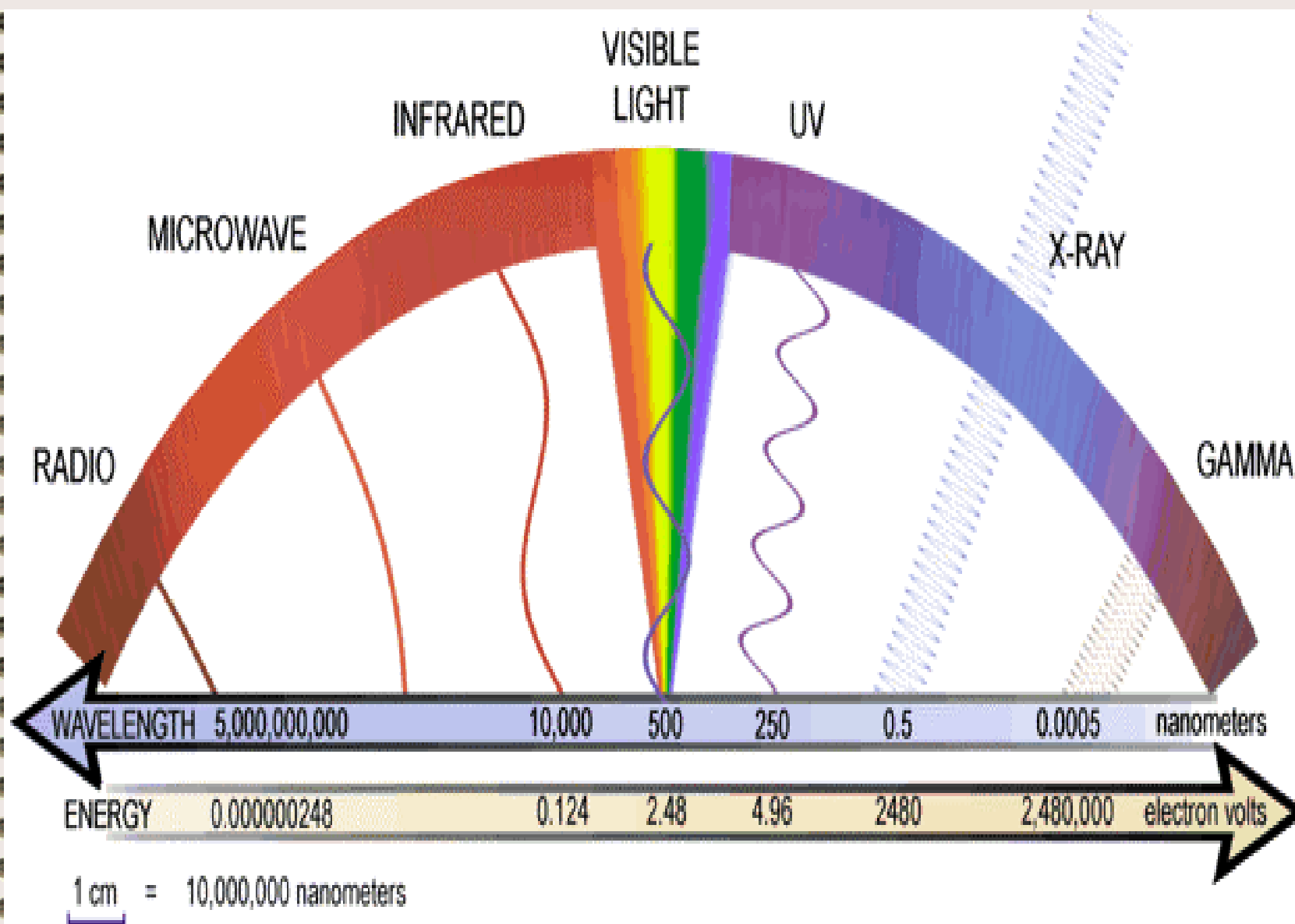
*“Changes in the environment and climate: natural catastrophes ”.*

## The tendency of basic space research

*At present micro-satellite sufficiently widely are used in the practice, including for warning and liquidation of extraordinary situations. In this case in practice is used the relatively narrow range of the electromagnetic radiations of the visible region - visible light (Fig. 1).*

*Using a large experience of basic space research, SRI RAS in last 2 years studies the scientific programs with the use of micro-satellite, oriented to the study of infrared, ultraviolet - UV and X -ray ranges not only for basic space research, but also oriented to the tasks the study of some aspects of hazard situations.*

# The tendency of basic space research



## *Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*Atmospheric carbonic acid, as basic greenhouse gas, plays the most important role in the climate of the Earth, absorbing the thermal radiation of the earth's surface, and preventing its emission into the space. Circulation CO<sub>2</sub> and generally carbon in the atmosphere, the ocean and the biosphere to the high degree is checked by natural factors, but it is known in also the time that 30% an increase of the concentration of this gas in the atmosphere occurred in the last 100 years (Cicerone et al, 2001).*

*The possible climatic consequences of this process are intensively studied by the leading scientific centers of entire peace and serve as the object of serious political discussions.*



*Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*In particular, there are serious indications of the powerful drain CO<sub>2</sub> in the northern hemisphere, but it is not possible to divide the contributions of North American and Asian continents and oceans.*

*Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*At the present moment in the world there are no satellites, which make it possible to solve this problem both globally, and it is regional (Dufour and Breon, 2000).*

*Measurements with high spectral resolution in the broad spectral band in combination with the theoretical examination of the processes of the transfer of harmful substances will make it possible to make a serious contribution to the solution of this problem.*

## *Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*Comparatively recently appeared the new and extremely interesting data about the distribution in the atmosphere of the Earth of the greenhouse gases, connected with the processes in the Earth's atmosphere and on the Earth's surface. It was shown that methane CH<sub>4</sub> is one of the most important greenhouse gases of the Earth's atmosphere, in the essential measure which determines radiation balance and the climate of planet.*

*The effectiveness of absorption by methane of the thermal radiation of the earth's surface is 60 times higher than in CO<sub>2</sub>. Ejections CH<sub>4</sub> into the atmosphere, according to the estimations of the reaching at present 500 megatons per year, and observing increase in its atmospheric content, can lead to a considerable increase in its temperature in the next decades.*

*Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*In the process of works according to the Program of basic research of the Presidium RAS "Changes in the environment and climate: natural catastrophes" we showed that measurements of reflected and scattered solar radiation in the UV- the neighbor IR ranges give the possibility of the remote sensing of basic greenhouse gases, such as CO<sub>2</sub> and CH<sub>4</sub>, and also numerous atmospheric admixtures. In the case of catastrophic phenomena this method makes it possible to judge the course of the process, proceeding in the center of event, from the sufficiently large distances.*

## *Monitoring greenhouse gases (CO<sub>2</sub>) and catastrophic phenomena on the surface, in atmosphere and ionosphere of the Earth.*

*Are most promising the spectroscopic observations in the neighbor IR range, which make it possible to conduct the precise measurements of the complete content CO<sub>2</sub> in the atmosphere with satisfaction of two conditions: high spectral resolution, which makes it possible to distinguish the separate unsaturated spectral lines in the weak strips CO<sub>2</sub> and a good knowledge of the optical path, which passes entire thickness of the atmosphere. Small overall sizes and mass of equipment play important role.*

*The preparation of the compact spectrometer of high resolution for the Project Venus Express (Korablev et al, 2202, 2004, Nevejans et al, submitted) makes it possible to propose for the micro-satellite "Chibis" the practically finished development of spectrometer with resolving power of  $\lambda/\Delta\lambda \approx 20000$  in the range 1.58 mkm. In the instrument the diffraction grating of the echelle grating, which works in the high orders of diffraction, is used.*

## *Study of the new physical mechanisms of the electrical discharges in the atmosphere*

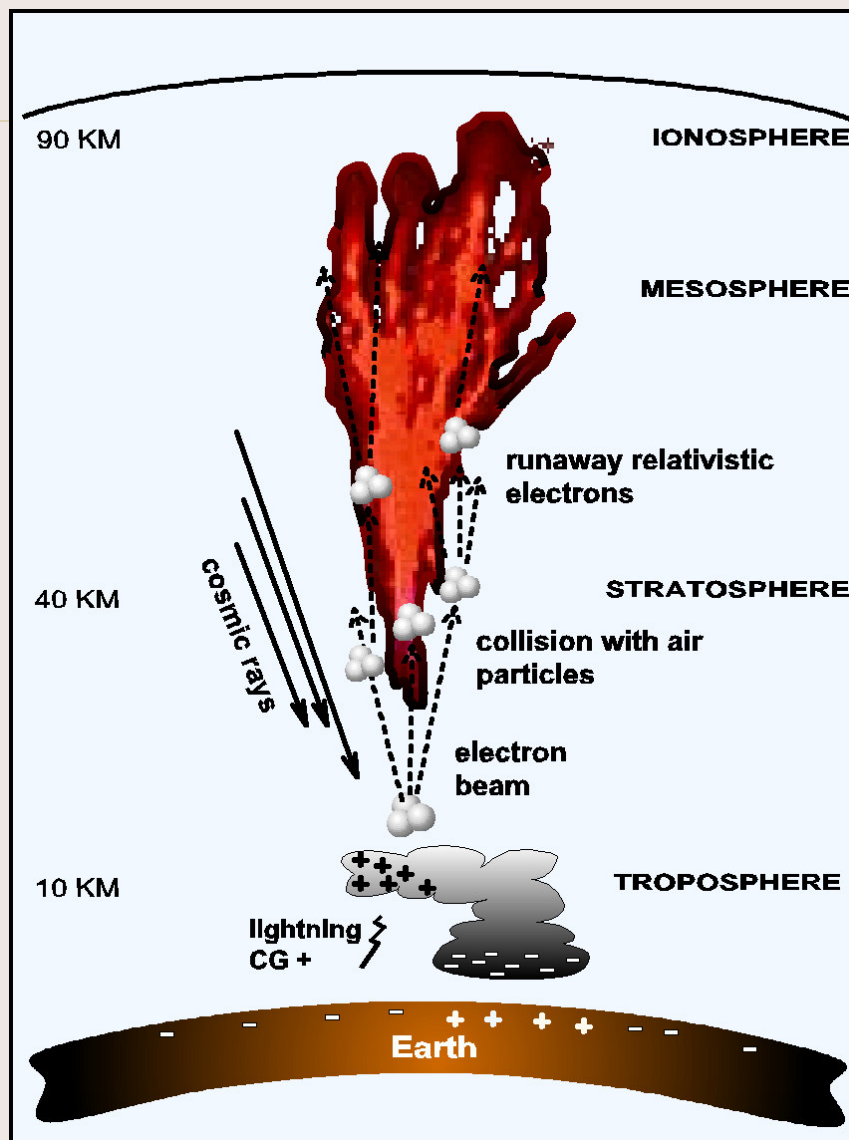
*A number of the physical phenomena in the atmosphere, which fundamentally changed our idea about the lightning discharges, is discovered in recent years.*

*1. In the observations from automatic spacecraft COMPTON and RHESSI are discovered the exceptionally powerful pulses of the gamma emission, which go from the Earth. Energy of pulses reaches tens of kJ, i.e., to  $10^{17}$ - $10^{18}$  of radiation quanta with the energy 100 keV and above [Fishman G.J. et al, Science, 1994; Smith D.M. Et Al, Science, 2005]. At present these phenomena in detail are investigated. It is experimentally proven that these pulses it is generated during 2-3 ms before the basic lightning discharge. COMPTON and RHESSI they were not intended specially for thunderstorm studies. Therefore, the measurements carried out on them do not bear complex nature and do not possess a sufficient time resolution.*

## *Study of the new physical mechanisms of the electrical discharges in the atmosphere*

*2. Is discovered the generation of the short ( $\sim 1$  s) single radio bursts, which lead to the emission of the radio-frequency pulses of the superhigh power (to 100 GW and above) [ Smith D.A. et al, Radio Sci., 2004; Jacobson A.R., JGR, 2003; Dwyer J.R. Et Al, GRL, 2005; Chubenko et al, Phys. Lett., 2003]. Pulses are generated in the thunderstorm clouds at the large heights of 13-20 km such pulses create the radio emission in the very wide frequency band, observed at the distances to several thousand kilometers.*

# *Study of the new physical mechanisms of the electrical discharges in the atmosphere*





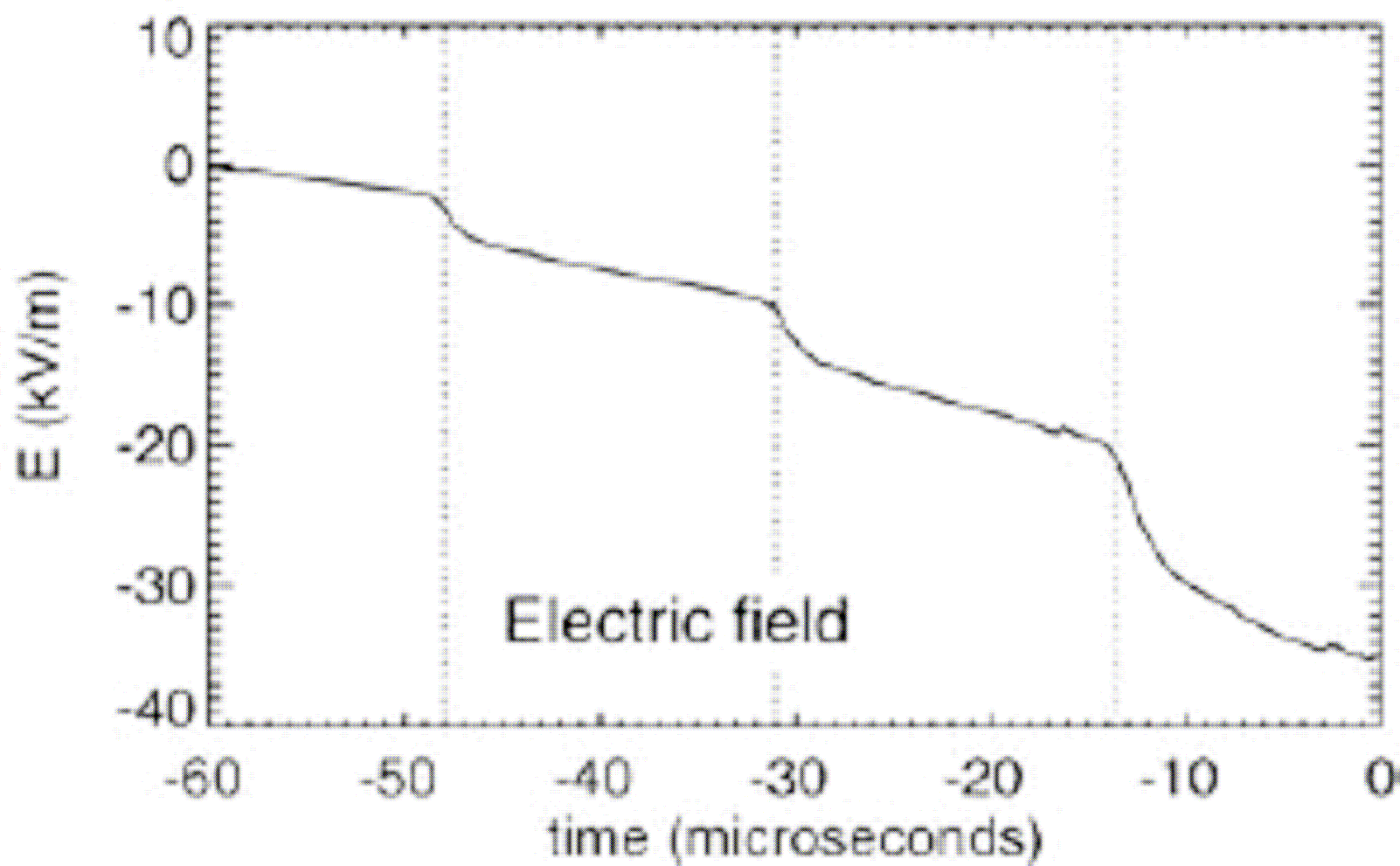
## *Study of the new physical mechanisms of the electrical discharges in the atmosphere*

*3. In the ground observations are discovered the flashes of the gamma emission, associated with the jumps of electric field, characteristic for the propagation of the stepped leader of lightning [Gurevich A.V., et al, Phys. Lett., 1992]. Gamma emission covers the area of 0.3-0.5 square kilometers, and possibly also more.*

## *Study of the new physical mechanisms of the electrical discharges in the atmosphere*

*At the basis of the observed phenomena lies the theoretically forecast in the FIANE new physical phenomenon, which was called breakdown on the running away electrons [Gurevich A.V., K.P. Zybin, UFN 2001]. The electrons of relativistic energies play the determining role in this process. The avalanche of the running away electrons being born in the course of the development of breakdown serves as the source of gamma emission.*

# *Study of the new physical mechanisms of the electrical discharges in the atmosphere*



## *Study of the new physical mechanisms of the electrical discharges in the atmosphere*

*The practical importance of the proposed studies is determined by the following circumstances.*

*1. Super-power gamma emission at the heights of 10-20 km is of significant interest from the point of view of safety of both the passengers and the aircraft of civil and military aviation.*

*2. Large areas, covered with intensive gamma emission on the Earth, can prove to be important both from the point of view of ecology and from the point of view of safety of people.*

*3. Super-power single radio-frequency pulses have powerful emission in practice in entire working range of the radio waves (to 3 GHz and above). They can serve as convenient natural radiation source for creating the global monitoring of radio communication.*

## *Micro-satellite platform "Chibis".*

*The development of the complex of scientific instruments proposed within the framework of project practically does not have an analog. For the first time is developed the complex of measuring equipment, oriented to the study of the lightning discharges, which entire overlapping practically spectrum of electromagnetic radiations and precisely under this task is created the design of small spacecraft, its systems of the collection of information and service systems.*

## *Micro-satellite platform "Chibis".*

*In particular, SRI RAS in the cooperation with the Russian partners from the space industry was developed and with the support of the RSC "ENERGIA" was injected into orbit during March 2002 the micro-satellite "Kolibri-2000" [Klimov, S.I., 2003].*

*The injection of the micro-satellite "Kolibri -2000" (Fig. 4) into orbit, close to the orbit of the ISS, is realized on 20 March, 2002, by separation from ship the "Progress M1-7", redocked before this from ISS.*

*Study program by "Kolibri-2000" included the following tasks: monitoring strong technogenic by action in the ionosphere; a study of ionospheric disturbances with the development of the magnetic storms in the terrestrial magnetosphere [Klimov, S.I., 2005].*

<http://www.energia.ru/english/energia/sci-education/microsat/microsat-02.html>



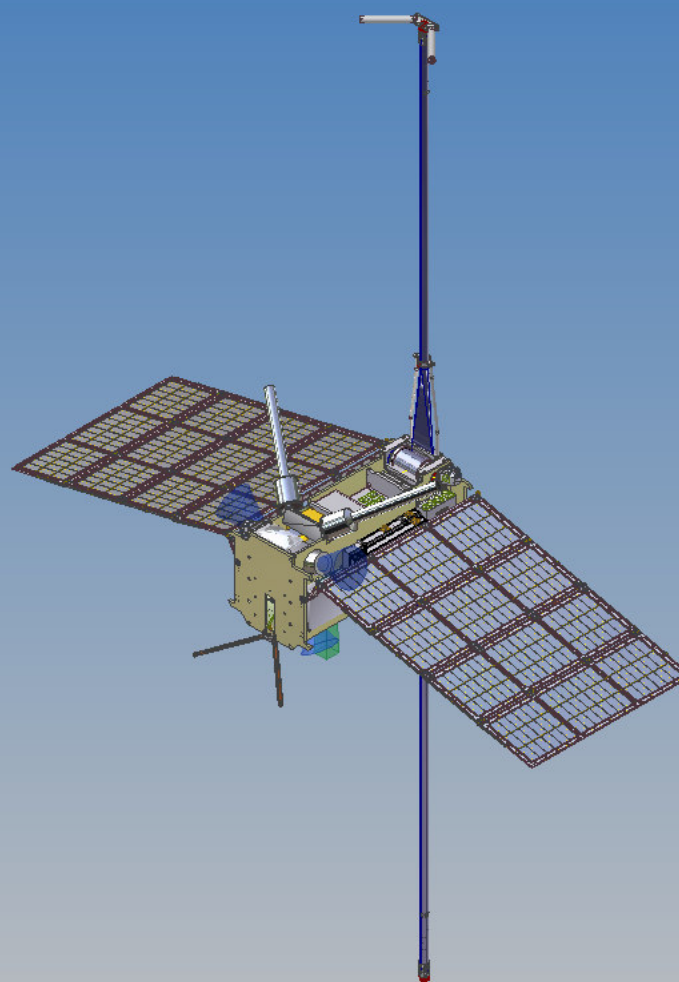
“Kolibri-2000”  
Total mass-20.5 kg

## *Micro-satellite platform "Chibis".*

*For the realization of the above-indicated projects, drawing on experience of development and use of a micro-satellite "Kolibri-2000", is carry out the development of micro-satellite "Chibis".*



## *Micro-satellite platform "Chibis".*



## *Micro-satellite platform "Chibis".*

### • *Main technical characteristics of the micro-satellite "Chibis".*

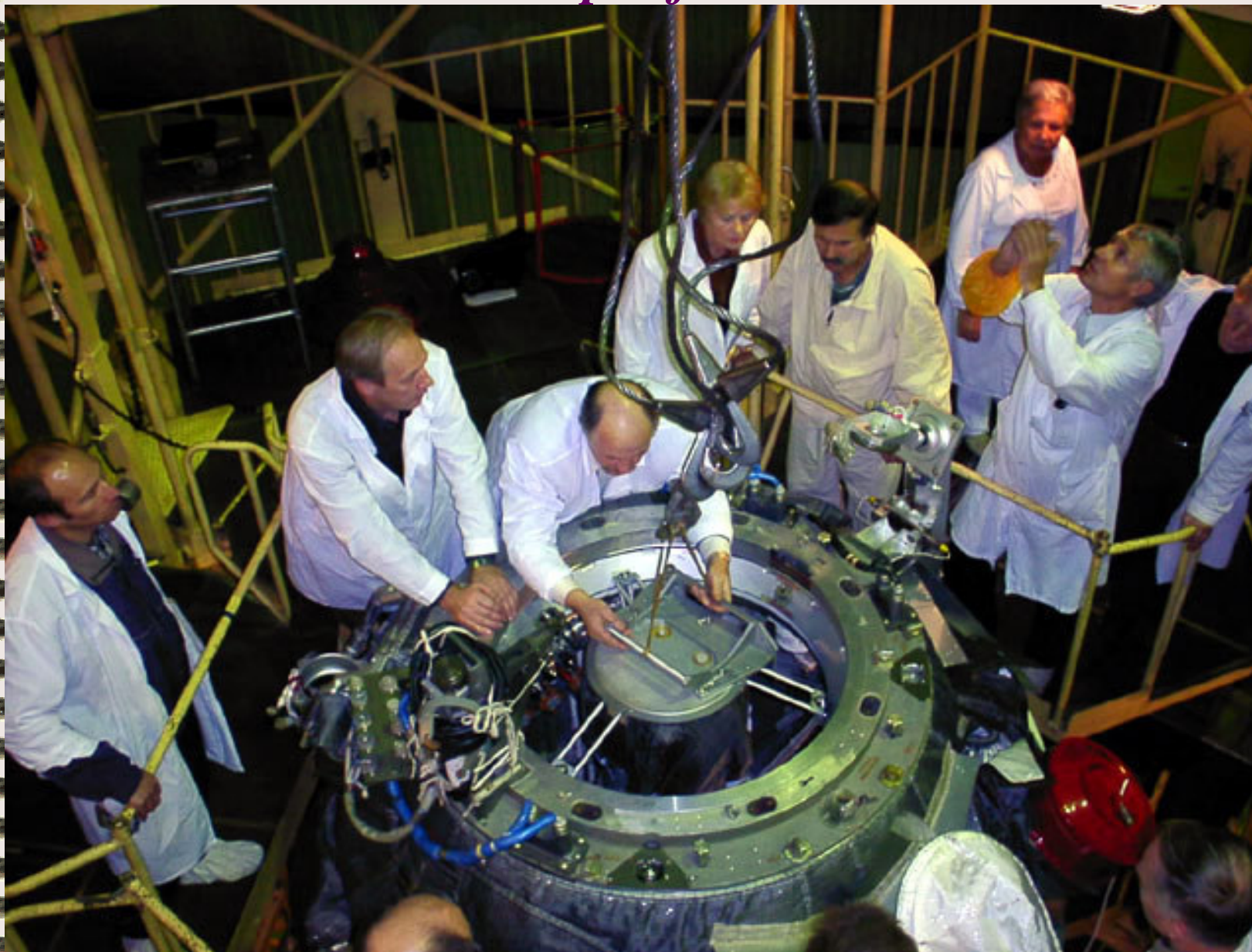
- **Mass** - 40 kg.
- **Scientific instruments** - 12.5 kg.
- **Service system** - 18.2 kg.
- **Construction and temperature control system** - 9.3 kg.
- **Orbit** - circular with the height ~ of 480 km.
- **Orientation systems:**
  - - types: the electromechanical (electroflywheels) magnetodynamic (electromagnets) gravitational (boom);
  - - accuracy of the determination of orientation from the sensors (starry, solar) and systems GPS - GLONASS to 2- angl. deg.
  - - accuracy of guidance +/- 3 - 15 angl. deg.
- **Data-transmission system:**
  - S/C-Earth - 128 kbit/s
  - the capacity of onboard storage - 8 Mbytes
  - the volume of the adopted from the board information - ~ 50 Mbayt/day
- **The radio frequency of command and telemetering links** 145 and 435 MHz.
- **The system of onboard power supply** 50 W:

## *Micro-satellite platform "Chibis".*

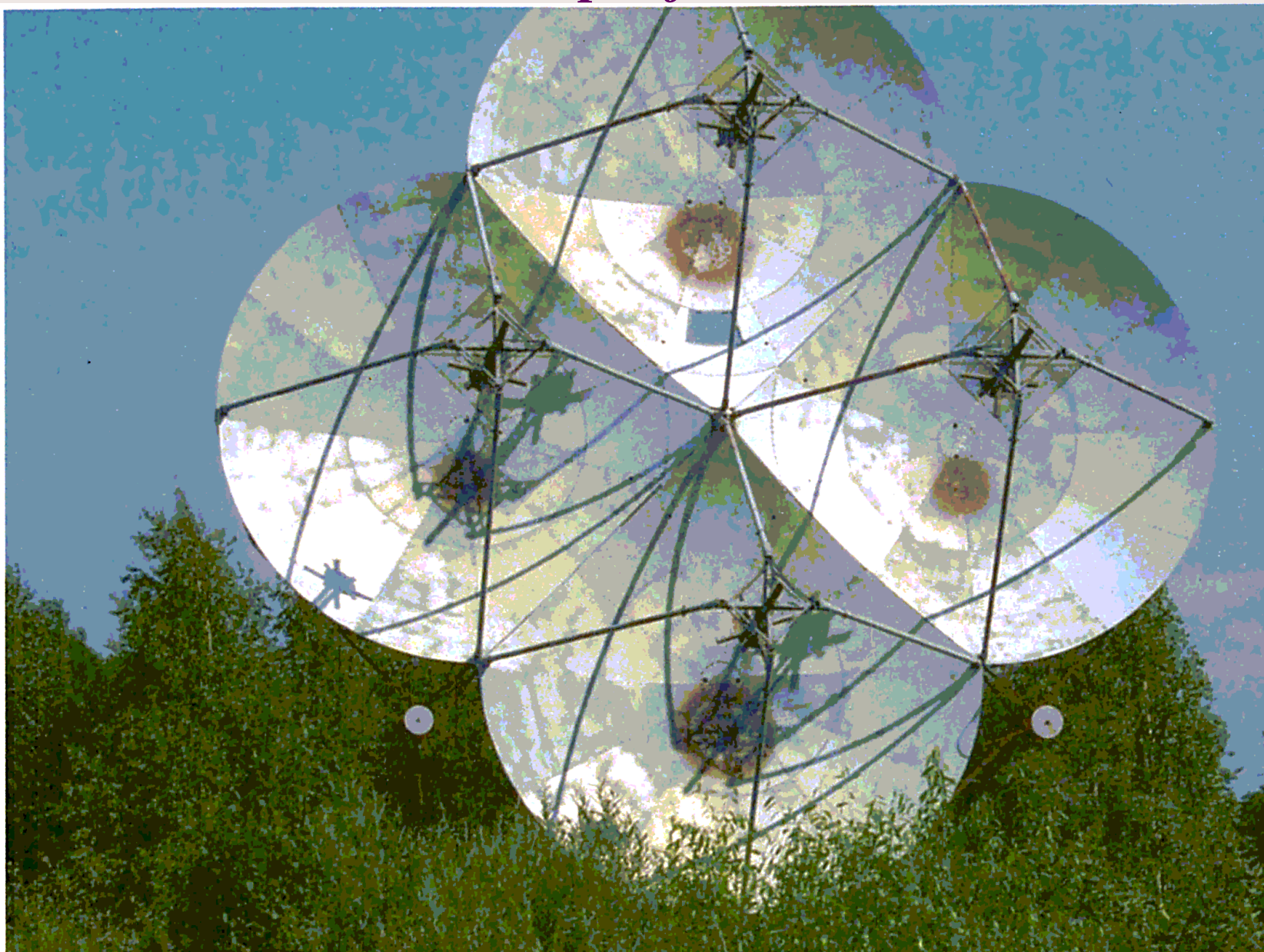
**Micro-satellite "Chibis" will be delivered onboard the ISS by cargo ship "Progress" analogous with the "Kolibri".**

**After separation from the ISS the orbit of the "Progress" will be raised to an altitude ~ of 500 km and the "Chibis" will be separated and it will begin to function in the working orbit.**

*Micro-satellite platform "Chibis".*



*Micro-satellite platform "Chibis".*



## *Micro-satellite platform "Chibis".*



A graphic of a spiral-bound notebook is positioned on the left side of the page. The spiral binding is silver and runs vertically down the page. The notebook's cover is brown, and the pages are a light beige color. The notebook is open, showing several pages.

# CONCLUSION

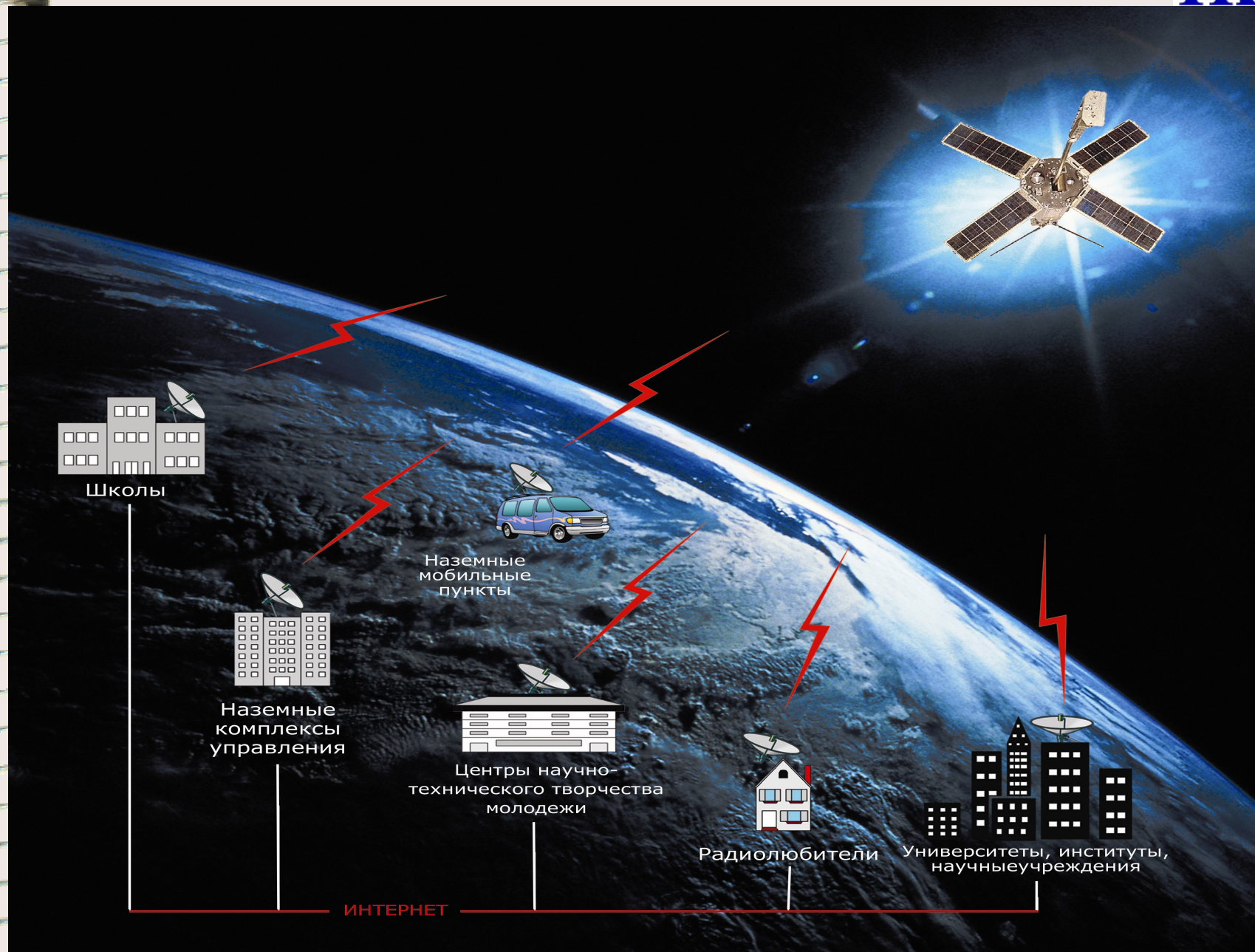
*In 2006 in SRI RAS is finished the phase "A".*

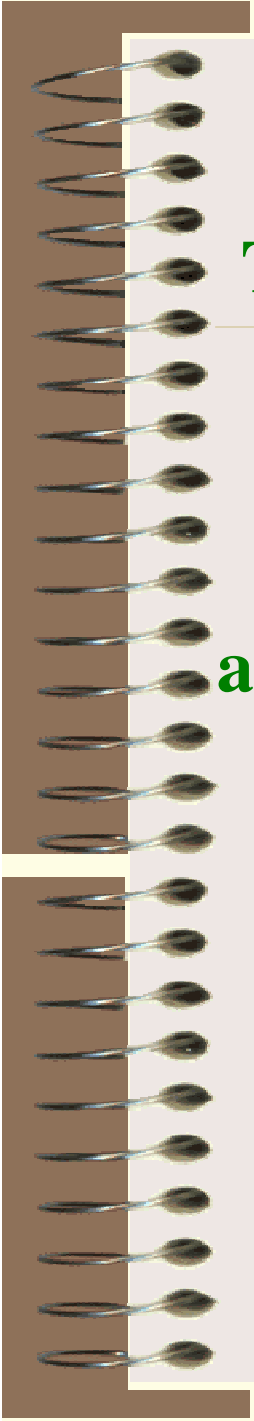
**Is developed the model composition of  
the complex of scientific instruments,  
support systems, construction of  
microsatellite "Chibis".**



**The results of space studies are used in many applications, including the education. Work with the schools is a natural method to inform the general public about the role of space studies for humanity.**

**For this we is utilized radio amateur's communication channels for the transmission of scientific information from the micros-satellite directly to the schools.**



A decorative graphic on the left side of the slide depicts the spiral binding of a notebook. It features a brown cover and a silver metal spiral that winds through a series of holes along the left edge of the page.

**This work is executed with the partial support of  
the RFBR grants 06-02-08076 and 06-02-08244**

**and also within the framework of collaboration on  
basic space research between**

**Russian Academy of Sciences and**

**Bulgarian Academy of Sciences**

**for “BalkanSat” project.**



The Scientific & Technical Subcommittee of the COPUOS, 44<sup>th</sup> session, Vienna 12 - 23 February 2007

A vertical spiral binding on the left side of the page, with a brown cover and silver wire.

***Thanks for the attention***

***Distinguished Chairman***

***and the respected Delegates***