SOLAR POWER ENGINEERING
(Subproject of the «Environment» Project)

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Introduction. This integrated project in the field of space solar power engineering pursues the following objectives:

— further development of the theory of processes of solar energy conversion into electric energy and its transmission to remote users in the space environment;

— creation of adequate mathematical models and study of the dynamics of advanced technological structures in solar power engineering as specific mechanical systems.

«Cable-Tether System» Experiment
STUDY OF THE BASIC VARIABLES OF A CABLE-TETHER SYSTEM INTENDED AS AN ELECTROMECHANICAL LINKAGE BETWEEN SPACE VECHICLES

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One of the trends in space power engineering is isolation of power modules of a space vehicle as a self-contained power space vehicle. Power transmission from such a «power space vehicle to the space vehicles-«users» could be carried out by cables or with wireless technology. The latter method repre-

sents the more advanced technology. However, the efficiency of power transmission, which can be achieved with the wireless technology, is low. The mentioned wire technology of power transmission can be realized by means of a cable-tether linkage. On the other hand, implementation of this cable-tether linkage requires solving the problems of space electrical engineering and control of such a mechanical tether configuration as «power space vehicle — cable-tether system — space vehicle-user». The electromechanical coupling can be also used for transfer of pull impulses to compensate for the aerodynamic effect or for transporting the space vehicles to other orbits. The proposed space experiments are aimed at solving some of the above problems.

A. The basic variables of a cable-tether system. Functioning of the «power space vehicle — cable-tether system — space vehicle-user» system requires dynamic isolation of the space vehicles. A constraining tether will transfer not only the legitimate forces but also forces upsetting the stabilization of a vehicle. The dynamics of the tether proper will also have an essential influence. Analysis of the dynamic problems of such a system shows the necessity to develop special fastening unit for the areas of the cable-tether attachment to the space vehicles. On the one hand, this unit will provide the vibrational isolation of the space vehicle, and, on the other hand, it will ensure the accuracy of orientation of the space vehicle and the system as a whole. Other problems of functioning of the «power space vehicle — cable-tether system — space vehicle-user» system are degradation of the mechanical and electrical properties of the cable-tether during its operation and interaction of the extended cable-tether with the environment.

The following experimental procedure is envisaged. At the beginning of the experiment, the unit with the folded cable-tether is moved by the cosmonauts to the exit port. Then, the unit is installed on a platform outside the URM by the mechanical manipulator. After this, the cable-tether is extended for 20 m from its folded condition by a special deployable mechanism. The stretching force and the voltage of about 25 kV are applied to the cable-tether. Mechanical vibrations are periodically excited at one end of the cable-tether by a drive-vibrator. After 3 to 5 years of service, the cable-tether system is delivered to the Earth for further study.

The following basic variables of the cable-tether system will be measured during this experiment: resistance of insulation, surface temperature of the cable-tether, voltage, and current. It is also planned to determine the equilibrium configurations of the tether at small loads and its dynamic parameters, the level of vibrations damping when passing through the tether and the unit of fastening to the URM and station, the cable-tether rigidity from vibration characteristics, and the serviceability of the stabilization system.

B. Dynamics of the «power space vehicle — cable-tether system — space vehicle-user» system. The space-tethered system (STS) of «power space vehicle — cable-tether system — space vehicle-user» includes the cable-tether as the principal and novel system element. From this point of view, study of the dynamics of the current-conducting tether at small loads, of its equilibrium configurations and interaction with the environment is of great importance. It appears to be expedient to carry out this study in two stages. The first stage will consist of an experiment on the dynamics of the tether deployment and initial retrofitting of the deployment system. A small self-contained STS with the mass of about 5 Kg and with tether length of about 100 m will be deployed. The tether tension and stabilization of motion of such a system will be implemented by imparting to the system a torque about the center of masses. This experiment would enable a large-scale experiment with the model of a space vehicle-user to be performed. The second stage will consist of an experiment on deployment of an STS mock-up to testify the stability of its radial configuration and stabilization of its motion.

The following experimental procedure will be used. Spring pushers with two spherical bodies are installed on the external side of the URM. The deployment system is located inside one of these bodies. The spherical bodies are separated from the URM after the spring pushers come into action. The difference between the two stages of the experiment is as follows. The mock-up of the space vehicle will be one of these bodies and the tethered system will be deployed only with this one body. A special device will be used to separate the mock-up of the space vehicle from the URM. This device will be designed along similar lines as the device for separation of the sub-satellite from the space vehicle, developed in the Yangel SDO «Pivdenne» under the «Warning» space project. Special sensors will follow the process of deployment of the tethered system and will transmit these data aboard the URM. Upon completing these experiments,

the equipment will be separated from the URM and will move separately until entering the atmosphere.

The tasks defined in this experiment undoubtedly have a scientific novelty. Their solution is of great importance for development of promising space tethered systems, orbital space stations, creation of the «space vehicle — tether — sub-satellite (micro-satellite)» system, development of space electrical engineering and power engineering, as well as of orientation and stabilization systems.

«Concentrator» Experiment

PROCESSES OF SOLAR ENERGY CONVERSION INTO ELECTRIC ENERGY IN THE ADVANCED MULTIPLAYER PHOTO CELLS IN A COMPLEX WITH SOLAR RADIATION CONCENTRATORS

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The use of advanced solid-body photo-voltaic (PV) converters and PV converters with solar energy concentrators allows reducing the solar arrays cost, increasing their resistance to performance degradation under the impact of the space environment factors, and improving their efficiency. Development of efficient PV converters is hindered by insufficient knowledge of physical phenomena of solar energy conversion under the space environment conditions. Application of concentrators is limited by the need to maintain the required thermal mode of PV converters exposed to concentrated radiation. This implies the urgency of studying new physical phenomena in solid-body PV converters and of solving the problem of heat removal.

The purpose of the experiment is to study the physical phenomena that occur in the solar array structures under the complex influence of space factors and to determine the maximum permissible degree of solar radiation concentration for PV converters of different structure and with different methods of heat removal.

The results of the experiment will allow verification of the calculated data and design solutions aimed at decreasing the degradation, as well as selection of coatings and materials both for PV converters and concentration systems, and for heat removal systems. Novel technologies will be developed to improve the solar arrays both for space and ground applications.