

Robert A. Heinlein Flight into the Future  
Project Contest

FINAL PROJECTS' PRESENTATION

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# Proceedings



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# **STARS AND CROSSES OF SPACE**

**Motto «Happiness – In Overcoming»**

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In offered work the following problems are solved:

- «Tests» of space diskolyot of vertical take-off and landing (DVTOL) , made by analogy with atmospheric DVTOL were carried out;
- The convertible disk wing is patented;
- The patent is offered, on the basis of which DVTOL is designed and its model remotely controlled is created;
- The way of removing and extension of blades is offered and implemented;
- The new rotor hub is designed;
- The theory of removing and extension of blades is implemented;
- The theory of control of DVTOL taking into account gyroscopic effect is constructed;
- The monitoring balancing of rotated disk wing is designed;
- The swash plate and control unit of flapping, controlling servo tabs of blades are offered and have passed tests;
- The compressed blade is offered;
- The way of landing of stages is offered.

# **NEURAL CONTROL SYSTEM FOR ASPECT ANGLE OF SPACECRAFT**

**Motto «The Future Calls for New Solutions»**

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A spacecraft (SC) includes elastic damper nonlinear oscillators (antennas, solar batteries, extension beams and the like). In process of flight the SC is subjected to various kinds of disturbances (gravitational, electromagnetic, aerodynamic, solar pressure, gassing ones, etc.), which causes deviation of the satellite aspect angle from the course set. To compensate the deviation, the control system gives a command to the final control elements to create a certain steering moment. Traditionally, a mathematic model of the satellite angular movement is used for calculation of the control moment. The model consists of a system of nonlinear second-order differential equations. However, such a model cannot describe the object with required accuracy, because it may be subjected to the following restrictions:

- with the regard for all the oscillators, the model becomes extremely complex;
- the model parameters obtained in land modeling differ from those actually observed in process of flight;
- the mass and geometrical characteristics of the object may change in time.

One of the actively developed approaches in the control theory today is the so-called “non-classic approach”, which involves application of artificial neural networks (ANN) to the problem of controlling complex dynamic processes. In this approach the object is treated not as an absolute known “point” in the space of features, but only as certain information about this “point”. The control in this case is reduced to formal processing of this information. The analytical functional dependences of the parameters are replaced with a-priori or a-posteriori knowledge or with the results of learning by examples.

Neural networks have already been applied to the problems of nonlinear control, but it’s been just recently that they were offered for controlling spaceships (SS). Artificial neural networks may be used as adaptive controllers in a situation when there exist one-for-one but unknown relations between the system position and the necessary controlling efforts.

An adaptive control system can be learned by the data of the satellite model, as well as by the satellite functioning in flight, instead of using the classical control laws. Moreover, a well-adjusted system can be used for the subsequent satellite programs, with no need of altering the basic system structure. The repeated use of the system allows to considerably reduce the system development costs.

# **CONCEPT FOR THE USE OF INTERACTION WITH THE EARTH AND OTHER PLANETS MAGNETIC FIELD TO IMPROVE ORBITAL ROCKET AND SPACE SYSTEMS EFFICIENCY**

**Motto «The Heinlein's Star Points Us the Way»**

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Current space programs have a lot to do with the ideas of Robert Heinlein, particularly in the field of his futuristic foresight in space exploration perspectives. In Russia, the researches on issues of manned expedition to Mars that started many years ago are still under way. What could we do but remember the «Stranger in a Strange Land» by R. Heinlein? These researches are the most efficiently implemented in the Keldysh Institute, RSC Energia and recently founded Aerospace Systems Company.

The President of the United States has recently announced a new cycle of integrated research foreseeing a manned mission to Mars in the near future. Research teams of the European Space Agency are also working on this topic.

Generally, the technical outline of the elements of space systems being designed for interplanetary missions envisages the use of rocket engines that have a large range of power capabilities based on the fuel resource carried onboard.

In recent years, a range of projects have been implemented that selected such a flight trajectory which allowed to use the influence of the Earth, Moon and other planets gravitation fields. The advantage provided by this approach is the ability to provide the boost of a spacecraft (SC) at some stages of the trajectory without spending the onboard propellant.

The work proposed for the competition reviews the possibility to use the interaction between an SC and the planets' magnetic fields, first of all, with that of the Earth, to control the motion without spending the onboard propellant resource at the phases of trajectory lying in the magnetic fields. At that, there are two separate options of interaction with a magnetic field:

- Interaction that almost does not require any external power source but the magnetic field;
- Interaction requiring an external power source, for example, the energy of solar radiation, but does not use the onboard propellant.

A brilliant example of using a combined interaction between the Earth's gravitation and magnetic fields is a device for deorbiting disposable SC that have served their time developed by R.Hite and R.Forward. The main elements of this device are a flexible line 5 to 20 km long, an electron "indraft" (suction) collector from the ionized environment at one end of the line and an end cap for electron emission into environment at the opposite. This device does not require external power, but it is only able to deorbit an SC, not to transfer an SC into a higher orbit.

In 2002, experts of Yuzhnoye State Design Office began their research on the use of effects of interaction with the Earth magnetic field. In this paper submitted for the competition's review it is

proposed to use an external power source, for instance, solar radiation, which transforms the energy of solar rays in electricity through photocell panels.

The paper contains a scheme of an Active Spacecraft (SC-A) having three rods that, interacting with the Earth's magnetic field, is capable of increasing the movement velocity at the account of external energy without spending the onboard propellant. It also presents the differences between the SC-A and the spacecraft able to deceleration and deorbiting (SC-D).

There is an experiment proposed concerning the simultaneous injection of three types of SC in orbit.

First goes the SC-A, then the «neutral» SC (SC-N), and the SC-D brings up the rear. The SC-N placed in the middle serves as a standard sample which is identical to the other two spacecraft as to their ballistic performance, but does not have any sources of energy in the orbit.

By means of remote sensing, for example, from the Earth, it is possible to evaluate the efficiency of deceleration depending on the increase of the distance between the SC-N and SC-D. The SC-A carries a source of energy able to overcome the inductive current appearing when moving in the Earth's magnetic field. In such a case, the SC-A will get an acceleration having the value that will also be registered using the distance between the SC-A and SC-N.

Apart from the commercial benefits, the proposed project in case of its implementation will contribute significantly in the resolution of global problems, such as:

- A real ability of “taking down” from high orbits the SC that have served their time;
- An increase in the probability of deflection of trajectories of asteroids that threaten the Earth through impacting them by orbital modules;
- Increases in the durability of “patrol” SC being part of the global natural disaster caution systems.

# **UNIVERSAL TECHNOLOGY OF BOOSTERS REENTRY AND LV OPERATION TECHNOLOGY**

**Motto «Creative»**

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Now, all over the world, the enterprises-manufacturers of the launch services conduct an active search of the launch cost decreasing ways as instrument for increasing their competitiveness.

The most obvious and conventional direction of works on the launch services price reduction is creation of completely or partially of reusable launch vehicles (LV). However, first of all, due to the technical problems, now there are no projects of such LV, acceptable from an economic point of view.

The received families will be free from the above problems for the traditional projects of the reusable LV development due to the new conceptual, technical, operational and organizational solutions, developed by authors of the project (there are patents of Russian Federation for private persons and "know-how" and applications for patents in Europe and USA are sent).

These decisions use will allow to lower the specific cost of the payload injection into orbit for the transformed families due to the above they can dominate over the world commercial launches market for a long time (10 and more years).

The LV development is based on a new concept, which consists in the optimal distribution of the general task for the reusable booster reentry between the means, allocated on the booster (LV segment with mass of not more than 12.5% from the booster "dry" mass) and means, allocated on outside of booster (external segment).

The LV main solution is a mid-air recovery (MAR) of the parachuted used booster by helicopter Mi-26. The use of the mid-air recovery by helicopter is caused by the large international and Russian experience (more than 2 mln. of operations), high practical reliability and by new engineering solutions in this area, allowed to capture the objects with the large mass up to values, close to the maximum carrying capacity of helicopter Mi-26 (more than 20 tons).

# TO THE STARS USING MICROWAVES

**Motto «Microwaves»**

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Nuclear thermal rockets long ago bypassed the 50 year-old specific impulse performance limitation of conventional rockets by using heat-exchangers instead of chemical combustion to heat the propellant. Unfortunately the nuclear reactors on which these rockets are based have thus far proven a little too heavy (and controversial) for space launch.



The microwave thermal rocket is a recent adaptation of the nuclear thermal propulsion principle to use a ground-based microwave energy source rather than an on-board nuclear reactor. Using an array of high power microwave sources directed at the rocket underside, propellant is heated within hundreds of small channels running through a microwave absorbent coating. By dispensing with the uranium fuel, neutron shielding, reflectors and moderators of a nuclear reactor, a microwave thermal thruster can achieve the same thrust and specific impulse as its nuclear counterpart but weigh much less.

Microwave thermal launch is now possible due to the recent advent of high power microwave sources in the millimeter wavelength range for which microwave launch is economically feasible. A little-known prototype array constructed at San Juan Capistrano during the 1980s paved the way for the larger millimeter array needed for microwave thermal launch. If successfully reduced to practice, the microwave thermal rocket will lower the cost of access to space by an order of magnitude and make launches an hourly event, initially for microsatellite-class payloads.

# **APPLICATION OF AN ELECTRICAL ROCKET PROPULSION SYSTEM ON THE BASIS OF STATIONARY PLASMA ENGINES FOR CORRECTION OF LOW-ALTITUDE ORBITS OF SATELLITE SYSTEMS OF REMOTE SOUNDING OF THE EARTH**

**Motto «Prospect»**

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In the project the feasibility of an electrical rocket propulsion system for correction of low-altitude orbits of satellites of remote sounding of the Earth, entering in system of global supervision is considered.

The economic target of the project consists in increase in a volume of the high-quality and operative information delivered to the consumer due to prolongation of term of active functioning space vehicles and optimization of structure of space system of supervision.

The substantiation of structure and parameters of the satellite system solving a problem of global supervision of a surface of the Earth with set parameters of efficiency (periodicity, efficiency of delivery of the information, the sanction to districts) is given. It is shown, that application of low nearby-circular orbits of the identical form allows to meet all set requirements.

Influence of the upper atmosphere of the Earth on change of an orbit is investigated. This phenomenon is looked through in braking the satellite and its displacement along a line of the vehicle. As a result, the configuration of system collapses, and demanded parameters of efficiency leave the set range of values.

It is offered to solve a problem of correction of satellite orbits by means of an electrical rocket propulsion system (ERPS) on the basis of the domestic electrical rocket engines (ERE) relating a class of fixed plasma engines.

The arrangement of sites of actuation ERE on an orbit, proceeding from reasons of an optimality of correction under the charge of a propulsive mass (xenon) is chosen. Thus it is considered, that for activity ERE significant electrical power which is necessary for removing from solar batteries is required. It is offered to use sites of an orbit on which there is a redundant electrical power, according to cyclogrammes of actuation-deenergizing of onboard hardware. Thus characteristics of a mode of correction slightly differ from optimum, however, it is possible to satisfy to the basic technical limitation on a disposed reserve of electrical power and to consider all features of system of a power supply of space vehicle of remote sounding of the Earth.

Standard cyclogrammes of orbit correction for various conditions of an atmosphere are calculated. A condition of an atmosphere are characterized by various levels of density and force of an aerodynamic drag.

Guaranteeing estimations of a required level of thrust ERE and the charge of a propulsive mass for correction of various types of orbits on the set interval of time exceeding 1-3 years are received. The basic design parameters of additional system of orbit correction on the basis of ERE are

chosen: number of engines (the basic and reserve), a total volume and weight of a xenon, a volume and quantity of tanks, parameters of system of storage and submission of a propulsive mass, etc. thus the weight of a space vehicle will save a preset value determined by characteristics of the launcher and an orbit of the ascent. Accordingly, the weight of fuel of the basic approach-correcting propulsion system, using Liquid-fuel jet engine, is decreased.

The project of modernization of existing space vehicles of a class "Resource" by installation on them of an additional approach-correcting electrical rocket propulsion system on the basis of the stationary plasma engine is developed.

The project is executed with use of a package of solid-state modelling "Solid Works". It is developed mathematical and the software for realization of design and ballistic calculations.

The economic analysis of the project is executed. It is shown, that economic efficiency of modernization is justified from the point of view of increase in a volume of the delivered information, at operation lifes of space vehicle over a year.

Realization of the given innovative project is possible within the nearest 1-2 years as by modernization of existing space vehicles of a class "Resource", and by creation of space vehicles with small weight and overall dimensions on a platform initially envisioning application of fixed plasma engines of a domestic production.

# **THE CHEAPEST WAY TO TRAVEL INTO SPACE**

**Motto «Medea»**

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Some methods of decreasing of spaceflight's (mainly for suborbital and orbital flights) cost are presented in this work. The main attention is paid to use of solid-fueled rockets that are apparently the best suitable devices for mass tourist space travel. The work tries to show that accuracy generally necessary in modern spaceflight is not very important in tourist spaceflight as tourist market has got its own demands that will be quite different from the scientific or commercial spaceflight.

The modern rockets use two approaches to get the orbit: staging and using liquid fuels. Because of both reasons modern spaceflights (orbital) are very expensive. To decrease their cost, we need to discard at least one of them.

The suborbital flight is one of the easiest one ever planned by humankind. The only thing that is required is altitude, we do not need accuracy in altitude, and neither in following the vertical direction-deviation from it by several degrees would be acceptable. The highly developed technologies are necessary for new kind of task, such as lunar or especially Martian spaceflight, they would be extremely expensive but absolutely necessary. As for mass tourist spaceflight, nobody needs some certain altitude and such requirements. Several minutes spent in weightlessness, the view of the Earth from the space that makes unforgettable impression would satisfy all clients. The one-stage, solid-fueled rocket would be the most suitable device for such spaceflight.

And in spite of solid-fueled rockets' some disadvantages they really would be the safest and cheapest way to travel into space.

# **A STUDY OF ECONOMIC EFFICIENCY A. SHTERNFELD PARABOLIC TRANSITION METHOD FOR RECOVERY OF GEOSTATIONARY BOOSTERS**

**Motto «House Clean – Space Clean»**

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In view of rapid pace of space activity we observe a steady growth of the amount of used space objects in near-earth orbits and so the secondary collisions of objects between themselves are of serious hazard to space flights. The most objects are in the area of geostationary orbits where in 1999 there were around 600 space vehicles and approximately 200 boosters.

Statement of a problem assumes designing of environmentally-clean boosters which will not contaminate the operational orbits.

In solving the problem we specify:

- the reentry concepts for boosters and the retrieval system optimal parameters;
- the degree of economic efficiency of recoverable boosters;
- the characteristic variation of boosters when recovery systems were introduced in their composition.

The following conclusion had been made:

1. By means of A. Shternfeld parabolic transition it is possible to reduce velocity expenses in half for unit recovery;
2. As the altitude of apocenter increases, so does the time of operation executions which will be about 30 days at velocity expenses 1,36 km/s;
3. A domain of rational solutions is the earth orbit area with the apocenter altitude about 400 000 km. By velocity expenses 1,53 km/s the time of operation execution will be 180 hours.
4. The use of reusable booster units in geostationary orbits is economically profitable, cutting in half the expenses. It should be compulsory with regard to the requirements of ecological purity of geostationary orbits.

# **THE CLOSED BIOLOGICAL SYSTEM PLACED IN AN ORBIT OR AT THE LIBRATION POINT ON A LONG-TERM SPACE VEHICLE AND A DIRECTION OF ITS USE, INCLUDING COMMERCIAL**

**Motto «ATTOEDEN»**

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The offers submitted in work concern to area of use space spaces, in particular to space biology, researches of an opportunity of long-term existence in the closed biological systems (areas) in is artificial the created conditions of a space.

The offered decision of creation of the independent closed biological systems placed on a space vehicle is based on necessity of use of achievements on studying ability to live of organisms in the closed biological systems and developments of this direction in conditions of space, and also comprehension public increases of a priority of development on expansion of a noosphere.

The closed biological systems can be used: in the scientific purposes (modelling of biospheric attitude on the Earth, research of interaction of organisms in conditions of a space and set of other tasks); in commercial objectives (development of space tourism at use closed biological system as object of visiting); in the applied purposes (maintenance of technologies piloted flights, including increase of safety).

Decisions offered in work are developed at a level of research of concept (CBS) on SV (space vehicle) in space with the purpose of the description of prospective results and effect and definition of shape of the design decision.

Main principle of creation of the closed biological system formation of biological forms of a life on the basis of maintenance of cyclicity of an exchange of gas, water, substances, energy so that property of self-organizing was provided, self-control of biological community.

CBS it is based on a three-phase basis firm, liquid and gaseous with adjusted structurally and biologically circulation substances.

Space vehicle carrier CBS after a conclusion in a space focus on the Sun and result in the movements, providing cyclicity of processes in CBS. Due to receipt of a solar energy create necessary cycles, for example daily, seasonal, annual.

Space vehicle equip with a technological platform for start of ability to live in CBS after positioning in a space and supports and managements of processes in CBS.

CBS develop in view of aesthetic requirements and in a variant of visiting equip with devices of mooring for maintenance of ability to live with compartments of life-support and supervision for CBS, devices of an entrance of the person in CBS.

# **MICROSATELLITE PLATFORM FOR RENT: PENETRATING THE UNIVERSITY MARKETS**

**Motto «Space Practice»**

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The main aim of the present project is rendering of services directed to improvement of the quality of education in the High school, by the example of a part of the general curriculum – a course of laboratory works.

The performance of laboratory works on research of fundamental laws realized on elements to space-rocket techniques, in particular, on space vehicles and rockets - carriers (physical modeling) - in addition to ground computer modeling (mathematical) of the same laws - is a perspective and effective direction for increase of an engineering education fundamentalization level, and also working through the perspective educational technologies.

The present course of laboratory works is based on computer and physical modeling of fundamental laws of physics and is intended for a wide range of general-profession and special disciplines of higher educational institutions. Novelty of the project is in its opportunity of application of the given educational technology not only in traditional space-rocket specialties, but also in the broad audience of specialties not connected with the space-rocket branch, demanding fundamental knowledge of physics. Realization of laboratory works is provided on a personal computer, as on experimental plant for carrying out physical experiences (mathematical modeling), with attraction of results of telemetric instrumentation from the space vehicles situated in the orbit (physical modeling). The devices installed on space vehicles, realize a wide range of fundamental laws of physics, which are modeled on computers on the ground. The comparison of results of computer modeling and results of functioning of devices in space will demand from the student deeper penetration into essence of a studied problem, will promote mastering of physical material and develop physical and mathematical intuition.

The offered project concerns to sphere of modern educational technologies in the field of natural-science disciplines, in particular, physics, and provides development of a laboratory practical work on the basis of use of small scientifically educational Space vehicles (SV) functioning in an orbit. It is focused on students, masters of the elite (complicated) form of preparation, post-graduate students, experts, including foreign, at improvement of professional skill in the field of space-rocket techniques.

The market of educational services in the world now is most dynamically developing. One of his most claimed forms is the system of remote education providing interaction of the teacher and the trainee with the help of modern information technologies.

Now within the frames of remote education the significant number of teaching materials on electronic data carriers which they are not recurrence known and the classical textbooks well enough approved in student teaching, grants and methodical instructions is developed, and represent the further development of educational technologies in view of a modern level of a computerization.

Recently, in connection with progress in computer technologies, works in which approaches to teaching physics with use of personal computers are reconsidered have appeared and their use as experimental installation for carrying out of physical experiences is offered.

# The Heinlein Prize Trust



**PRESS RELEASE--for immediate release**  
JANUARY 27, 2005

## **THE HEINLEIN PRIZE TRUST ANNOUNCES THE "ROBERT A. HEINLEIN FLIGHT INTO THE FUTURE PROJECT CONTEST"**

The Trustees of the Robert A. and Virginia Heinlein Prize Trust are pleased to announce the Robert A. Heinlein Flight into the Future Project Contest.

The "Robert A. Heinlein Flight into the Future Project Contest" is a competition to encourage young international students and researchers in the field of space exploration. The competition will identify, support, and promote innovative projects by these researchers. Winning researchers will receive a cash award, a prize diploma, and international recognition of their work.

Created to honor the memory of renowned American author Robert A. Heinlein, the contest was established to forward the shared dream of a future of humankind expanding ever outward into space. The "Robert A. Heinlein Flight into the Future Project Contest" is being conducted by the Heinlein Prize Trust ([www.heinleinprize.com](http://www.heinleinprize.com)) and assisted by the Russian Aviation and Space Scientific Innovation Educational Complex (RASSIEC). Further information can be found at: [www.heinleincontest.info](http://www.heinleincontest.info).

The competition is open to citizens from European, African, and Middle Eastern nations. Also eligible to enter are students and post-graduate students, regardless of nationality, attending any European, African, or Middle Eastern school. All contest entrants must be less than 30 years old on July 7, 2005. Entries may be submitted by individual authors, or by teams of no more than three authors. Academic advisors may be associated with the development of the contest works.

Contest entries should include scientific, technical, and economic substantiation (business plan) of the proposed project. Entries must describe the peaceful use, and practical applications of the work in the field of space exploration. Entries will be judged by an international team of experts. The entered works will be judged on a basis of the novelty and originality of the proposal, the economic and social benefits, the technological substantiation and profundness of research, and the veracity and investment attractiveness of project.

Entries must be sent by May 14, 2005. Authors of the top ten entries will receive invitations giving them an opportunity to meet directly with the judging committee to discuss and evaluate their projects. Presentation of the top entries will take place on July 6, 2005. Awards will be presented on July 7, 2005, the anniversary of the birth of Robert A. Heinlein.

The first place award has been set at US\$3500. Two second place prize of \$1500, and three third place prizes of \$1000 each will also be awarded. Academic advisors of the winning teams will also receive a special award of \$1500, \$500, and \$300 respectively.

The awards for the "Robert A. Heinlein Flight into the Future Project Contest" will be presented at a yet-to-be-determined European center for space research and industry.

The competition is part of the Heinlein Prize, a substantial cash award created to encourage commercial activity in space. The Heinlein Prize is focused on practical, private commercial advancements that produce substantive results in the area of space enterprise. Future Heinlein Prize Trust winners may, or may not, be dealing directly with space flight advances.

The Heinlein Prize and the "Robert A. Heinlein Flight into the Future Project Contest" honor the memory of Robert A. Heinlein, best-selling American author regarded as one of the founders of modern science fiction, and of his wife Virginia. Both Robert and Virginia Heinlein were strong advocates of human advancement into space through commercial endeavors. The purpose of the Heinlein Prize is to encourage and reward progress in commercial space activities that advances their dream of humanity's future in space.

The Mission Statement of the Heinlein Prize Trust says:

"The legacy of Robert and Virginia Heinlein is the shared dream of a future of humankind expanding ever outward into space—to the Moon, to the planets, out and onward to the stars.

"Space is not to be the realm of the select few. The dream, and the future, belong to us all, of every race and every nation. It is in a child in school today who understands the positive vision of the future of Robert Heinlein. It is the dream of all who see a future bright with possibilities.

"The day will come when we will mine the asteroids and walk the sands of Mars. We'll live and work in space for the benefit of all humanity. We'll have horizons so vast that no one who dreams and strives need be left behind. All of these things we can do, and we shall.

"This bright future will be created by those of you, today, who strive to create advances in commercial space activities."

### **CONTACT INFORMATION:**

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