Summaries of all articles

V.V. Vyshinskiy, S.S. Negodyayev

Introductory article

V.P. Legostaev, E.A. Mikrin, I.V. Orlovsky, Y.N. Borisenko, V.N. Platonov, S.N. Evdokimov

Development Control System of the Soyus crew and Progress transport vehicles: experience from the past, challenges for the future

The evolution questions of the Control System development for the Soyus crew and Progress transport vehicles are considered. At RSC Energia the 'Soyuz-TMA' and 'ProgressM-M' vehicles are being modified now. The main object of modernization is the onboard digital computer complex (ODCC) — the modern constantly working on an orbit CC101 replaced the out-of-date 'Argon-16'. CC101 works together with the matching units (BUS101-1 and BUS101-2). The flight tests for 'Progress M-M' vehicles confirmed the correctness of the chosen technologies during the control system modernization and the possibility of its use as the 'Soyuz-TMA' crew transport vehicles and other promising Russian vehicles.

Keywords: transport vehicle, Soyuz GN&C, Progress GN&C, Onboard Computer System, International Space Station.

N.N. Sevastiyanov, V.N. Branets, V.A. Panchenko, N.V. Kazinskiy, T.V. Kondranin, S.S. Negodyayev

Advanced approaches to Earth observation small satellite development

The worldwide tendencies of space industry stimulating the development of small spacecrafts are described. The issues of the development of small Satellites for Earth Remote Sensing, which allows one to meet the requirements on optical high-resolution satellites, are discussed. A brief analysis of foreign optical observation high-resolution systems used on small Satellites is made, and the recommendations on the main engineering solutions for the development of these systems are given. The general requirements for parameters for the altitude control system of Remote Sensing Satellites such as pointing accuracy, stabilization, etc. are given. The synthesis of the control system hardware composition is performed and examples of the up-to-date home-produced devices designed for survey support are given. The basic requirements for software and algorithmic products used for the altitude system operation are indicated.

Keywords: small spacecraft, Earth remote sensing, high resolution, attitude control system.

V.V. Vyshinskiy, A.L. Stasenko

Physical models, numerical and experimental investigation of the aspects of aviation ecology and flight safety

The overall structure of a winged flyer jet-vortex wake is surveyed, as well as a turbulent wake and vortices interaction, the results of numerical investigations, their interpretation and analytical interpolations and the effect of the external turbulence on the wake «lifetime». The main methods and the experimental results of an aircraft jet-vortex wake are briefly discussed. The classical models of spontaneous and heterogeneous condensation at different flight altitudes are presented (diffusion and free-molecular modes of a particulate growth and the interpolation between them). The droplet kinetics in a turbulent flow, methods for controlling the aircraft jet-vortex wake characteristics are envisaged (physical models, numerical investigations, recommendations for the optimal choice of regimes and the governing parameters). A numerous relevant bibliography is given.

Keywords: aircraft jet-vortex wake, atmospheric turbulence, droplet kinetics, heterogeneous flows, flight safety, aviation ecology.

Y.P. Ulybyshev

On topical problems of modern astrodynamics: a practical engineer's point of view

The modern astrodynamics problems and methods related with new practical objectives and possibilities of new applied mathematical methods (large-scale linear programming and computational geometry) are surveyed. Problems for near-Earth space are briefly discussed: launch trajectory optimization for a new manned spacecraft with regard to an abort system; formation flying; methods for spacecraft rendezvous and inspection; satellite constellation (SC) design for complex coverage; an orbital elements choice and optimization formation-keeping maneuvers for high-elliptical SC, optimization low-thrust transfer trajectories to a geostationary orbit. For deep space, the topical problems are: interplanetary superhighway, Earth–Moon cycler trajectories, the design of Moon missions based on the libration point L_1.

Keywords: astrodynamics, trajectory optimization, launch to orbit, rendezvous and orbital transfers, satellite constellations, interplanetary flight, linear programming, computational geometry, sets of pseudo-impulses.

Y.N. Besedina, S.I. Popel

Evolution of dust particles in Rossby vortices

The behavior of dust grains in Rossby vortices in Earth's atmosphere and a possibility of their vertical and horizontal transport are investigated. The soliton solutions of the Charny–Obukhov equation are considered in the form of the superposition of dipole and monopole vortices. The numerical experiments modeling the behavior of dust particles in Rossby vortex are carried out. Trajectories of dust grains are shown for different sizes of grains. It is shown that small particles (with sizes less than or of the order of ten micrometers) can exist in the vortex for two weeks or longer. This allows the particles to propagate together with the vortex for long distances exceeding 10 000 km.

Keywords: atmospheric nano- and microscale particles, synoptic-scale vortices, Rossby vortices, transport of dust particles.

V.N. Brazhko, A.V. Vaganov, G.N. Dudin, N.A. Kovaleva, I.I. Lipatov, A.S. Skuratov

Experimental investigation of delta-Wing aerodynamic heating peculiarities at large mach numbers

The experimental results of the heat transfer investigation of the windward delta-wing surface with deflected elevons are presented. The experiments are carried out at Mach numbers $M_\infty = 7.5$; 10.5 and wing angles of attack $\alpha = 0.5°$, 10°, 15°. The blunted leading edges sweep angle of the wing is $\chi = 75°$. Heat transfer measurements are made using thermal sensitive coatings. Two types of heat flux maximums on the wing surface out of leading edges and the wing top are revealed. The first is due to the boundary layer laminar-turbulent transition. The second one is caused by the influence of the wing top bluntness. The Mach number, Reynolds number and angle of attack influence on these maximums locations is investigated.

Keywords: hypersonic, experimental investigations, wind tunnel, blunted delta wing, windward, laminar-turbulent transition, heat flux.

A.V. Vaganov, S.M. Drozdov, G.N. Dudin, S.M. Zadonsky, V.I. Plyashechnik, M.A. Starodubtsev, S.V. Chernov, V.L. Yumashev

Numerical and experimental investigations of test model aerodynamics at high supersonic speeds

The numerical and experimental results of aerodynamics investigations of a test model are presented. The test model has the typical aerodynamics shape of a winged reentry vehicle of the «Space Shuttle» and «Buran» type and is designed for wind tunnels testing at a high angle of attack important for descent of a reentry vehicle. The experimental data can be used for the verification of the present and future numerical code and the estimation of uncertainties in the wind tunnel aerodynamics data. Numerical code ARGOLA (Euler calculations) and ANSYS CFX (Navier–Stokes calculations) are verified. There is good agreements between the experimental data and the numerical simulation.

Keywords: supersonic, hypersonic, wind tunnel, numerical simulation, winged reentry vehicle.

V.V. Vyshinskiy, G.G. Sudakov

Aircraft vortex wake and flight safety problems

The paper presents a mathematical model of the aircraft vortex wake for evaluating the safe separation and considers the wake generating and following aircraft types and weather conditions. Four major problems are solved by the model, viz. the wake generator aircraft, the interaction of the following aircraft with the vortex of the preceding aircraft, the description of the turbulent atmosphere, and the vortex destruction. The model is verified by the experimental results of the wind-tunnel and flight tests. The wake characteristics behind a concrete aircraft and safe separations in landing under various turbulent atmospheric conditions are calculated.

Keywords: aircraft vortex wake, flight safety, atmospheric turbulence, mathematical simulation, Reynolds' equations.

V.V. Zolotukhin, V.K. Isaev, B.H. Davidson

Some relevant problems of air traffic management

The paper provides an overview of advanced directions in scientific and technological research and development in air traffic management (ATM), which required the collective effort and considerable resources for its promotion. Special attention is given to the use of mathematical models for the planning, optimization and adjustment of flight, the prevention and elimination of conflict situations on the ground and in the air, including the system of wake vortex safety. The issues of the management coordination of incoming and outgoing air traffic, algorithms and systems for improving the structuring efficiency and the use of air and land space are also discussed.

Keywords: CNS/ATM in 4D-space, ADS-B, ICPM, Free Flight, airspace usage, vortex safety, CREDOS, EuroControl, multiagent systems, regular lattice, intelligent control, reachability sets, hybrid systems, ellipsoidal calculus, COIN, SGT.

O.Y. Izvekov

Pore pressure influence on the damage zone near a spherical cavity in rocks

This paper describes the physical background of brittle solids damage mechanics. A model for porous media continuum damage is discussed. The problem of evolution of the damage zone near a spherical cavity in rocks is posed.

Keywords: poromechanics, fracture mechanics, damage dissipation.

D.A. Kravchenko

Optimization of flapping wing motion for the thrust generation during aircraft flight at constant velocity

The problem of flapping wing motion optimization for the thrust generation during aircraft flight at constant velocity in a horizontal direction is studied. The optimization criterion is energy consumption minimization in the case of the fixed horizontal component of an aerodynamic force exerted on the wing in the presence of restrictions to the trajectory.

Keywords: flapping wing, optimal control, Pontryagin's maximum principle, energy consumption minimization.

M.M. Kuznetsov, Y.D. Kuleshova

On the reaction ability of molecules at the front of a strong shock wave

Some results of the analytical study of the effects of the translation nonequilibrium in hypersonic shock waves are given.

Keywords: hypersound, the molecule, polyatomic, reactivity, the relaxation, the shock wave, the front.

V.N. Lagutkin, Y.V. Slynko

Computer model for the calculation of spectral behavior of a high-temperature gas with particles

The computer model for calculating the spectral behavior of high-temperature gas streams with particles is designed. The model is based on the solution of a radiance transportation equation by an iterative method. All basic effects that determine the spectral behavior of high-temperature nonequilibrium streams of a gas–particle mixture under different conditions are taken into account. Comparison with other models is done. In order to validate the functionality of the proposed model the spectral behavior of gas-dynamic plumes is realized under different conditions. These results agree with the known regularities of the spectral behavior for different plume parameters.

Keywords: gas spectroscopy, dynamic gas objects, radiance transition, radiance diffusion.

Yu.E. Nesterikhin, V.K. Isaev, V.V. Lazarev, S.V. Sorokin

Research in the development of computer-aided weight control system

The new generation of computer-aided weight control system is developed to create equipment for controlling the product weight characteristics during the whole life-cycle. The results of the development of the program, conceptual and computational models are described. This paper generalizes the results of the preceding steps. The software architecture and the basic program components of the system are determined.

Keywords: system analysis and modeling, PDM/PLM/ERP/MRP, CALS technology, weight control, product life-cycle, network technology, object oriented analysis and design, Microsoft Sharepoint, Microsoft.NET.

E.E. Sivkova

Stabilizing the laminar methane-air flame by a nanosecond discharge

The effect of the nanosecond discharge plasma on the characteristics of the laminar methane-air flame is studied. The methane burning mechanism is selected. The effect of separate species produced by the plasma on the flame is studied. The influence of the nanosecond discharge on the preliminarily mixed laminar methane-air flame is considered. It is shown that the effect of the heat release in conversion reactions is produced by a greater influence on the speed of the flame rather than by chemical activating; at low initial temperatures ($T < 700$ K) the plasma influence is produced by the same effect on the flame speed as thermal heating.

Keywords: mechanism of burning of methane, laminar methane-air flame, nanosecond discharge plasma.

T.O. Tseytlina, V.V. Balashov, A.I. Dunaevsky, A.V. Smirnov

Forecasting the cost of a supersonic administrative airplane under development

The correlation between the cost and one or several (two, three) technical parameters of an airplane is typically used in aircraft industry for forecasting the cost of a supersonic administrative airplane at the preliminary design stage. This paper considers a wider range of technical parameters of an administrative airplane. Applying the methodology of factor analysis, these parameters are divided into three groups characterizing the payload, the power-to-weight ratio and the convenience of the administrative airplane. A factorial mapping is developed, which enables transition from the space of ten technical parameters to the space of three technical factors. Using neural network programming methods, a model for forecasting the cost of an administrative airplane is developed. Estimations were derived for the cost of a light supersonic administrative airplane with given technical characteristics, which is under development in TsAGI.

Keywords: administrative airplane, limit price, factor analysis, neural network programming.

L.N. Chaban, G.V. Vecheruk, T.S. Gavrilova

Investigation of possibilities of vegetation covers classification in hyperspectral images by remote sensing data processing packages.

The peculiarities of vegetation covers classification in hyperspectral images by the most known remote sensing data processing packages are analyzed. It is shown that the best results are provided by statistical classification with account taken of the dispersion of spectral features in each spectral band. To choose the appropriate patterns and classify a lot of imagery by these techniques one must select a subset of the most informative bands. Using examples of ground hyperspectral images, the possibilities and restrictions to the principal component analysis for solving this problem are considered, in particular, the technique of using band projections on the most informative components.

Keywords: thematic processing of remote sensing data, vegetation covers classification, hyperspectral images, classification techniques, principal component analysis.