Soviet and Japanese Aerospace Literature

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Soviet Aerospace Literature
This month: *Spacecraft Guidance/Control*

A91-41209   Optimal two-impulse perturbed transfer trajectory between coplanar near-circular orbits (Optimal'naia dvukhimpul'snaia vozmushchennaia traektoriia perekhoda mezhdu komplanarnymi okolokrugovymi orbitami). V. S. NOVOSELOV, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Jan. 1991, pp. 84–88. 6 Refs.

An optimal two-impulse transfer between small-eccentricity orbits is derived analytically with allowance for first-order perturbations due to the nonsphericity of the gravitational field. If an arbitrary phase of motion occurs at least in one of the boundary orbits, the perturbation leads to a shift in the start position in the zero approximation.

A91-39135   A method for operational control of satellite motion during its descent into the atmosphere (Sposob operativnogo kontrolia dvizheniia aerokosmicheskogo apparata pri spuske v atmosfere). D. IU. MOSTOVOI and IU. G. SIKHARULIDZE, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Mar.–Apr. 1991, pp. 238–246. 9 Refs.

A method is proposed for on-ground trajectory control of a reusable spacecraft (such as the Soviet shuttle Buran or the U.S. Space Shuttle) during its descent into the atmosphere. Both the standard-program and the return-to-launch-site cases are considered. The guaranteed and the probable boundaries of the admissible-region maneuver are presented. Using results of mathematical simulations, a data base of boundary constraints is developed for use in the satellite-motion control.

A91-23781   Evolution of certain types of earth-satellite orbits (Ob evoliutsii nekotorykh tipov orbit ISZ). M. A. VASHKOV'IAK and M. L. LIDOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Nov.–Dec. 1990, pp. 803–807. 7 Refs.

Orbits are considered which have a perigee close to the earth and an apogee distance of several hundred thousand kilometers. The variation of orbital elements over a period of several years is evaluated. The present study is of interest in connection with the search for orbits that are most suitable for a space-based VLBI system.

A90-48315   Method-related errors in the prediction of spacecraft trajectory parameters (Metodicheskie oshibki prognoza parametrov traektorii KA). V. V. VASIL'EV and V. B. NIKOLAEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July–Aug. 1990, pp. 619–621. 5 Refs.

Method-related errors in the prediction of trajectory parameters are considered for spacecraft flight altitudes of 1000 and 20,000 km. A method for reducing such errors is proposed.

A91-39134   Generalized characteristics of gyro-force control systems (Obobshchennye kharakteristiki girosilovykh sistem upravleniia). V. N. VASIL'EV, D. M. VEINBERG, and S. I. ZLOCHEVSKII, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Mar.–Apr. 1991, pp. 231–237. 8 Refs.

This paper proposes a set of generalized characteristics that can be used for the assessment of the control ability of a gyrosystem and for a comparative analysis of different gyrosystems. These characteristics include the regions of change of the kinetic-moment vector and the control vector, the standard moment characteristics, and the kinetic-moment isochronous surfaces.

A91-39133   Optimal spatial turn of a spacecraft with a changing mass geometry (Optimal'nyi prostranstvennyi razvorot kosmicheskogo apparata s peremennoi geometriei mass). V. I. GULIAEV, V. L. KOSHKIN, and I. V. SAVILOVA, *Kosmichekie Issledovaniia* (ISSN 0023-4206), Vol. 29, Mar.–Apr. 1991, pp. 221–230. 13 Refs.

This paper examines the problem of optimal control of a satellite motions relative to its mass center. The control is accomplished by using small reactive moments and by changing the length of rigid gravitational rods with masses attached on their ends. Time-optimal computer programs for controlling spatial turns are developed for various constraints on the control moments.

A91-39132   Mathematical modeling of the attitude maintenance of the Mir orbital station by means of gyrodynes (Matematicheskoe modelirovanie protsessov podderzhaniia orientatsii orbital'noi stantsii 'Mir' s pomoshch'iu girodinov). V. A. SARYCHEV, M. IU. BELIAEV, S. G. ZYKOV, V. V. SAZONOV, and V. P. TESLENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Mar.–Apr. 1991, pp. 212–220.

Mathematical models are developed for simulating the process of attitude stabilization of the Mir space station in either the inertial or the orbital coordinate systems, by means of gyrodynes. These models, developed for calculating the optimal times for activating the station's microjets, are used for planning scientific on-board experiments.

A89-30079   Gradiometric inertial navigation system. I (Gradiometricheskaia inertsial'naia navigatsionnaia sistema. I). IU. A. KOROTAEV, *Priborostroenie* (ISSN 0021-3454), Vol. 32, Jan. 1989, pp. 45–49.

Equations are obtained which describe conditions for the perfect operation of a gradiometric inertial navigation system. The information structure of the gradiometric measurements is identified. Versions of the algorithmic and instrumental implementations of the system are proposed.

A91-24678   Glonass satellite navigation system, navigational aspects. G. MOSKVIN and V. SOROCHINSKII, *Proceedings of the NAV 89—Satellite navigation Conference,* London, England, Oct. 17–19, 1989 (A91-24676 09-17). London, Royal Institute of Navigation, 1989, 4 pp.

A brief overview of the Soviet Glonass satellite navigation system is presented. Consideration is given to the spacecraft configuration (24 satellites in 19,100-km circular orbits of period 11 h 15 min), the ground segment, the signal structure, the pseudo-range-finding navigation technique, shipborne equipment, performance parameters, and the possibility of building user equipment capable of using both Glonass and Navstar GPS for navigation. Diagrams showing the initial and fully operational satellite configurations and the signal structure are provided.

A91-23789   Experimental investigation of a toroidal liquid damper (Eksperimental'noe issledovanie toroidal'nogo zhidkostnogo dempfera). S. G. GUL'TIAEV, M. L. PIVOVAROV, and N. A. EISMONT, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Nov.–Dec. 1990, pp. 874–878. 12 Refs.

The paper presents results of an experimental study of the about-the-vertical oscillations of a rigid body suspended by an elastic string carrying a damper in the form of a toroidal tube completely filled with a low-viscosity liquid. A theoretical model is proposed whose predictions are shown to agree well with the observed oscillation damping. The results are of interest in connection with damping of spacecraft oscillations.

A91-23786   Analytical algorithms for solving the inverse navigation problem in a system of satellites (Analiticheskie algoritmy resheniia obratnoi navigatsionnoi zadachi v sisteme sputnikov). R. I. BRASLAVETS, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Nov.–Dec. 1990, pp. 846–853.

The paper presents algorithms for solving the inverse navigation problem on board an observer spacecraft according to simultaneous measurements of the location of several satellites forming a navigation field in which conditions for the unambiguous determination of the observer position vector are attainable. Several versions of the algorithms are discussed, and methodological recommendations on the development of computational navigation algorithms are presented.

A91-23785   Calculation of spacecraft sensor pointing accuracy according to autonomous measurements of the angular attitude of the target (K raschetu tochnosti navedeniia apparatury KA po avtonomnym izmereniiam uglovogo polozheniia ob'ekta issledovaniia). A. A. CHERNOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Nov.–Dec. 1990, pp. 837–845. 6 Refs.

An approach to estimating sensor pointing acuruacy is proposed where only the angle-measurement channel is used in the spacecraft information and measurement system. The pointing system utilizes the combined control mode with disturbance compensation. Errors of the filters which evaluate the angular attitude of the target in the body axis coordinate system, discrepancies in the implementation of the combined control mode, and errors of the baseline coordinate system are assumed to be prescribed. The signal hysteresis is also considered.

A91-21944   Asymptotic stabilization of the relative equilibrium positions of a satellite-gyrostat (Ob asimptoticheskoi stabiliziruemosti polozhenii otnositel'nogo ravnovesiia sputnika-girostata). V. A. ATANASOV, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 54, Sept.–Oct. 1990, pp. 861–863. Research sponsored by the B'lgarska Akademiia na Naukite. 5 Refs.

The possibility of the asymptotic stabilization of the equilibrium orientations of a satellite-gyrostat by means of control moments applied to the rotors is investigated analytically using a theorem proved in an earlier study (Atanasov and Lilov, 1988). The possibility of asymptotic stabilization is established for two classes of positions with respect to the relative gyrostat equilibrium.

A91-17033   A numerical and experimental approach for the analysis of the dynamic accuracy of the stabilization of flexible spacecraft under the effect of internal disturbances (Raschetno-eksperimental'nyi sposob analiza dinamicheskoi tochnosti stabilizatsii gibkikh KA pri deistvii vnutrennikh istochnikov vozmushcheniia). N. N. SHEREMET'EVSKII, E. E. MALAKHOVSKII, E. L. POZNIAK, and A. A. EVMENOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Sept.–Oct. 1990, pp. 706–714. 16 Refs.

The simulation of the motion of an uncontrolled geostationary satellite with flexible solar arrays in the case of disturbances from drive devices is examined. The approach used is based on finite-element modal analysis of the spacecraft structure and experimental data on the forces and moments from actual drive devices.

A90-32655   Motion stability of maneuvering elastic spacecraft (Ustoichivost' dvizheniia manevriruiushchikh uprugikh KA). E. M. POTAPENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Mar.–Apr. 1990, pp. 203–211. 9 Refs.

Simple methods for the motion stability analysis of elastic spacecraft carrying out large spatial maneuvers are developed without constraints on the number of elastic-vibration tones considered. Theorems are proved that reduce the nonlinear problem of the motion stability analysis to a stability analysis that does not take into account the elasticity of the spacecraft.

A91-17004   Effect of an onboard computer on the dynamics of a spacecraft controlled by two pairs of powered gyroscopes (Vliianie BTsVM na dinamiku nositelia, upravliaemogo dvumia sparkami silovykh giroskopov). N. I. KIRINA, *Dynamics of control systems* (A91-17001 05-70). Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, pp. 41–45. 5 Refs.

A particular problem of the stabilization of the principal central axes of a spacecraft in the direction of the axes of the orbital coordinate system is considered. The stabilization is effected via two powered-gyro complexes and an onboard computer in the control loop. Conditions on the signal quantization step which provide for the required spacecraft-stabilization accuracy are defined.

A91-16917   Slow-scan-operated CCD photodetector arrays for spacecraft attitude sensing. VLADIMIR I. BEREZIN, EDUARD A. IZUPAK, and ALEKSANDR G. KHVILIVITSKII, *Jena Review* (ISSN 0448-9497), Vol. 35, No. 3, 1990, pp. 119, 120.

A Peltier-cooled CCD image-sensor head with slow-scan operation (readout register frequency of 500 Hz) is described. The head utilizes a two-dimensional array of 520 x 580 buried-p-channel charge-coupled devices operating in a frame-transfer mode. In order to increase sensitivity, especially in the short-wavelength range, the matrix configuration includes 'windows' not covered by poli-Si electrodes. A CCD head developed on the basis of a photosensitive CCD array with virtual phase is also described. It contains two clock and one virtual electrodes, and about half of its photosensitive area is not covered by poli-Si electrodes, so that the quantum yield in the 0.4- to 0.7-micron range may amount to 40 to 50 percent.

A91-16916   The ASTRO-1M as part of the attitude control system of the unmanned SPEKTR satellite. ALEKSANDR V. RYBACHEV and ALEKSANDR I. ULIASHIN, *Jena Review* (ISSN 0448-9497), Vol. 35, No. 3, 1990, pp. 117, 118.

A star sensor employed in the attitude-control system of the unmanned SPEKTR satellite is described. The sensor (ASTRO-1M) consists of three optical blocks fixed rigidly to the spacecraft body, an electronic computer block, and a power supply block. It operates on the principle of geometric star selection: the relative coordinates of the brightness centers of all stars seen by each of the optical blocks are measured and compared with the data in a digital star catalog stored in the system. Two-dimensional CCD arrays employed as detectors are covered, as well as positioning of the optical blocks, their protection from elements, and a two-way exchange of data between ASTRO-1M and an onboard computer.

A90-48305   Experimental verification of a mathematical model of a spacecraft with in-tank dampers allowing for fluid vorticity (Eksperimental'naia proverka matematicheskoi modeli KA s vnutribakovymi dempfiruiushchimi ustroistvami, uchityvaiushchei zavikhrennost' zhidkosti). V. G. LEBEDEV, A. I. MYTAREV, B. I. RABINOVICH, and G. A. CHURILOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July–Aug. 1990, pp. 521–530. 9 Refs.

Consideration is given to mathematical models of varying degrees of sophistication describing the rotation of a spacecraft with in-tank dampers about a longitudinal axis of symmetry with allowance for fluid vorticity. An analysis of the results of a full-scale experiment confirms the validity of the mathematical models proposed here; applicability regions are defined for each of the models. The effect of vorticity on the dynamics and stability of the controlled motion of the spacecraft is analyzed.

A90-29064   Periodic oscillations of a satellite gyrostat with respect to the center of mass under the effect of magnetic and gravitational moments (Periodicheskie kolebaniia sputnika-girostata otnositel'no tsentra mass pod deistviem magnitnogo i gravitatsionnogo momentov). A. A. VORONIN and V. V. SAZONOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Jan.–Feb. 1990, pp. 22–34. 9 Refs.

An analysis is made of the rotational motion in circular orbit of a satellite gyrostat with a permanent magnet under the effect of gravitational and magnetic moments in the earth's magnetic field. This motion is described by a system of sixth-order ordinary differential equations with periodic coefficients. Analytical and numerical methods are used to obtain symmetric periodic solutions to this system which are close to periodic solutions of a corresponding second-order degenerate system. On near-polar orbits, the motions described by such solutions can be used to realize three-axis magnetic attitude control.

A90-21806   Effect of a hysteresis rod installed along the axis of the greatest moment of inertia of a satellite on its motion in the gravity-gradient attitude control regime (Vliianie gisterezisnogo sterzhnia, ustanovlennogo vdol' osi naibol'shego momenta inertsii sputnika, na ego dvizhenie v rezhime gravitatsionnoi orientatsii). V. A. SARYCHEV, V. I. PEN'KOV, M. IU. OVCHINNIKOV, and A. D. GERMAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Nov.–Dec. 1989, pp. 849–860. 6 Refs.

An analysis is made of the oscillatory motion of a gravity-gradient-controlled satellite equipped with hysteresis rods made of magnetically soft material. One of the rods, installed along the axis of the maximum moment of inertia, provides for damping of three-dimensional motions according to the Coulomb friction law. Time dependences of small oscillations are obtained in the form of finite relations, with the hysteresis loop approximated by a parallelogram.

A91-17005 **Algorithm for solving a route problem involving an encounter with a group of satellites (Algoritm resheniia odnoi marshrutnoi zadachi obleta gruppy ISZ).** IU. E. LEVICHEV and N. N. PERFEEVA, *Dynamics of control systems* (A91-17001 05-70). Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, pp. 49–53.

The paper examines the problem of planning a two-dimensional route for the encounter between a single controlled spacecraft and a group of N uncontrolled spacecraft. The objective is to construct a route where the controlled spacecraft would encounter each of the uncontrolled satellites just once and where the total energy consumption for the manevuver and the total time used for the encounter would not exceed prespecified values. The proposed algorithm is reduced to the consideration of a single whole-number parameter for the encounter with each of the satellites.

A90-48304 **Application of the recursive method of parabolic extremum approximation to the problem of optimum spacecraft behavior (Primenenie rekurrentnogo metoda parabolicheskoi approksimatsii ekstremalei v zadache optimal'nogo povedeniia KA).** A. L. VOROB'EV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July–Aug. 1990, pp. 513–520. 6 Refs.

A recursive extremum approximation method has been developed which describes the behavior of a dynamic system during a rapid transition from the initial phase state to a final state with allowance for the limits of the system motion characteristics. A solution to the problem of a rendezvous between a spacecraft and a satellite is obtained by modifying the one-dimensional Pontriagin regulator for use with a two-dimensional system.

A90-48302 **Plane librations of a satellite under the effect of gravity- and light-induced moments (Ploskie kolebaniia sputnika pod deistviem gravitatsionnogo i svetovogo momentov).** V. V. BELETSKII and E. L. STAROSTIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, July–Aug. 1990, pp. 496–505. 11 Refs.

The plane motion, relative to the center of mass, of an umbrella-like symmetric satellite in circular orbit is analyzed in the case where body librations are due to gravitational and solar radiation moments. The small librations of the satellite in the vicinity of the main resonance are analyzed asymptotically. An approximate amplitude-frequency characteristic of the induced oscillations is obtained. The parametric instability regions of the periodic librations of the satellite are determined numerically.

A90-41963 **Channel-type hydraulic nutation dampers (Kanalovye zhidkostnye dempfery nutatsionnykh kolebanii).** A. IU. KOGAN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, May–June 1990, pp. 346–351.

A method is proposed for calculating and optimizing the characteristics of a channel-type damper for attenuating elastic vibrations in precision passive systems of spacecraft attitude control. Formulas are given for the parameters of an equivalent pendulum-type damper.

A90-37104 **Oscillations of a tethered satellite of small mass due to aerodynamic drag.** E. M. SHAKHOV, International Symposium 16th Rarefied gas dynamics: Space-related studies, Pasadena, CA, July 10–16, 1988, Technical Papers (A90-37101 16-34). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, pp. 40-52.

This paper deals with the plane transverse oscillations due to aerodynamic drag of a tethered satellite of small mass at low orbit. The period of the oscillations is a single-valued function of the aerodynamic drag at the altitude of flight. In an atmosphere of nonuniform density the oscillations are asymmetric. Both the difference of half-periods and the amplitude difference in deviations up and down from a position of relative equilibrium are defined by the density gradient. Some possible ways of using the satellite-pendulum as a facility for experimental rarefied gasdynamics and aeronomy are discussed.

A90-32653 **Synthesis of a quasi-optimal spacecraft attitude control and stabilization system (Sintez kvazioptimal'noi sistemy pereorientatsii i stabilizatsii KA).** L. D. AKULENKO and L. K. LILOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Mar.–Apr. 1990, pp. 186–197. 11 Refs.

Approximate analytical solutions are obtained for the problem of synthesizing a quasi-optimal spacecraft attitude control and stabilization system. A mathematical model for a system of rigid bodies is used, including dynamic Euler equations for the carrying body and control-system equations and kinematic relationships for the quaternions or the rotation vector. Asymptotic methods of the theory of singularly perturbed systems and dynamic programming are used to construct the time-optimal synthesis of the attitude control as well as stabilization regimes that are optimal with respect to the standard integral quality functionals.

A90-29068 **An algorithm for calculating the parameters of multiple-circuit distant-aim maneuvers (Algoritm rascheta parametrov mnogov-itkovykh manevrov dal'nego navedeniia).** A. A. BARANOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Jan.–Feb. 1990, pp. 69–76.

An analysis is made of four-impulse distant-aim maneuvers assuring a soft rendezvous of the active spacecraft with the target, which are moving in close nearly circular orbits. A numerical-analytical approach is used to construct an algorithm for determining the parameters of optimal maneuvers in a class of solutions for which the signs of all the transversal impulses coincide. A geometrical interpretation of the process of searching for the solution is given.

A90-41961 **Attitude control system of a flexible spacecraft with a dynamic filter (Sistema orientatsii deformiruemogo kosmicheskogo apparata s dinamicheskim fil'trom).** G. IA. LEDENEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, May–June 1990, pp. 329–335. 7 Refs.

Sufficient stability conditions are obtained for the attitude control system of a flexible spacecraft with a dynamic filter under the effect of a slowly varying perturbation. This filter substantially attenuates the elastic-vibration signal and excludes the effect of the slowly varying perturbations on the orientation precision. Relationships are obtained which make it possible to choose parameters of the filter that assure the stability of the attitude control system.

A90-29061 **Maneuverability of large orbital stations (Manevren-nost' krupnykh orbital'nykh stantsii).** V. P. LEGOSTAEV and E. N. TOKAR', *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Jan.–Feb. 1990, pp. 3–10. 11 Refs.

The maneuverability of orbital stations in the earth's gravity field is examined for different types of station orientation, i.e., constant orientation with respect to the inertial coordinate system and constant orientation with respect to the orbital coordinate system. A calculation is made of the total kinetic moment of gyro systems providing different degrees of angular maneuverability to the station.

A90-21807 **Optimal program for the control of the angular position of a spacecraft with planar solar arrays (Optimal'naia programma upravleniia uglovym polozheniem KA s ploskimi paneliami solnech-nykh batarei).** A. M. IANSHIN and S. M. ZABLUDA, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Nov.–Dec. 1989, pp. 861–866.

The paper determines the optimal program for the angular-position control of a spacecraft with planar solar arrays, guaranteeing the minimum value of gravitational forces acting on the spacecraft with maximum illumination of the arrays. In the case of passive gravitational stabilization of the spacecraft, optimal angles of array installation are determined which guarantee maximum integral illumination of the arrays with constraints on the array control channels.

A90-21805 **A stability-loss mechanism for gravity-gradient satellite attitude control (Ob odnom mekhanizme poteri ustoichivosti rezhima gravitatsionnoi orientatsii sputnika).** V. V. SAZONOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Nov.–Dec. 1989, pp. 836–848. 11 Refs.

Bifurcation theory of limit-cycle generation is used to investigate the stability-loss mechanism for gravity-gradient satellite attitude control, leading to significant oscillations of the longitudinal axis of the satellite with respect to the local vertical. The existence of such oscillations is determined by the balance between the energy dissipation of onboard devices and energy transfer induced by the nonpotential character of the aerodynamic moment acting on the satellite. The results obtained can explain a case of spontaneous establishment of the gravity-gradient control regime on the Salyut-7 station.

A90-17270 **A means of constructing the control range for a control moment gyroscope system (Ob odnom sposobe postroeniia oblasti upravliaemosti girosilovoi sistemy orientatsii).** S. I. ZLOCHEVSKII, A. A. SOKOLOV, V. N. VASIL'EV, and D. M. VEINBERG, *Moskovskii Universitet, Vestnik, Seriia 1—Matematika, Mekhanika* (ISSN 0579-9368), Sept.–Oct. 1989, pp. 42–46.

A system consisting of four gyrodynes—two-DOF power gyroscopes with servo drives along the axes of precession—is considered. One of the gyrodynes is redundant. The control range is constructed by successive addition of the ranges for one gyrodyne, then for two, and so on.

A89-37358 **Control of spacecraft with relay-impulse and continu-ous-action controllers on the basis of an algorithm with a predictive model and its application to spacecraft rendezvous dynamics (Up-ravlenie ob'ektami s releino-impul'snymi i nepreryvnymi rulevymi organami na osnove algoritma s prognoziruiushchei model'iu i ego prilozhenie v dinamike sblizheniia KA).** N. E. ZUBOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Mar.–Apr. 1989, pp. 206–213. 5 Refs.

The paper examines the problem of spacecraft control with simulta-neously functioning relay-impulse and continuous-action controllers using a modified optimal control algorithm with a predictive model reproducing the motion of the vehicle in accelerated time. The proposed theory is applied to the control of spacecraft rendezvous in an orbital coordinate system.

A90-17241 **Narrow-band VLBI for deep space navigation. II—Or-bital vehicles; Coordinate measurements of the Astron satellite (Dlinnobazovaia uzkopolosnaia radiointerferometriia dlia kosmich-eskoi navigatsii. II—Orbital'nye apparaty; Izmereniia koordinat ISZ 'Astron').** V. A. ALEKSEEV, V. I. ALTUNIN, A. A. ANTIPENKO, E. D. GATELIUK, IU. N. GORSHENKOV et al., *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Sept.–Oct. 1989, pp. 765–771. 9 Refs.

The paper describes an April 1987 experiment involving the use of narrow-band VLBI for the operational measurement of the coordinates of vehicles in earth orbit. The experiment involved the detection of signals from a transmitter aboard the Astron satellite and from natural cosmic radio sources in the 32-cm band for an interferometer baseline of about 6100 km.

A90-29067   Enhancing the information content of satellite-borne observations of objects on the earth's surface (Povyshenie informativnosti nabliudenii nazemnykh ob'ektov s ISZ). M. IU. BELIAEV and D. N. RULEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 28, Jan.–Feb. 1990, pp. 56–68.

The paper determines the orbit parameters of a satellite in the case of which the information content of the observation of ground objects is maximal for minimal expenditures of fuel required for satellite maneuvers. The problem's solution is reduced to a linear-programming problem. The efficiency of the proposed approach is shown using numerical estimates for the Mir orbital station.

A90-17226   Stabilization of a satellite with flexible rods. I (O stabilizatsii sputnika s gibkimi sterzhniami. I). S. I. ZLOCHEVSKII and E. P. KUBYSHKIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Sept.–Oct. 1989, pp. 643–651. 6 Refs.

The problem of the stabilization of the angular position of a satellite with flexible rods is considered. A solution of the boundary value problem of the plane elastic vibrations of the flexible rods of a satellite obtained with the D-splitting method is used to construct the stability region on the parameter plane of the stabilization system with allowance for the entire frequency spectrum of the rods. It is shown that this region constitutes only a part of the stability region for a satellite with rigid rods.

A89-38429   Stability of the equilibrium states of a shielded earth satellite (Ob ustoichivosti polozhenii ravnovesiia ekranirovannogo sputnika zemli). L. I. KUZNETSOV and A. A. TIKHONOV, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Jan. 1989, pp. 66–71. 5 Refs.

The stability of the equilibrium states of an earth satellite with an electrostatic shield moving along a circular orbit in the geomagnetic field is analyzed in orbital coordinates. The necessary and sufficient stability conditions are obtained. The way in which the Lorentz forces affect the stability of the equilibrium states of the satellite is determined.

A89-32164   Investigation of the optimal two-parameter control of a spacecraft moving in an atmosphere (Issledovanie optimal'nogo dvukhparametricheskogo upravleniia pri dvizhenii KA v atmosfere). N. L. SOKOLOV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Jan.–Feb. 1989, pp. 64–70. 15 Refs.

The optimal control of a spacecraft in a planetary atmosphere is examined theoretically. The structure of two-parameter control is defined for problems with different optimized functionals and boundary conditions. In particular, expressions are presented which define the structure of the optimal control of attack and roll angles for two variational problems.

A90-17178   Positioning of a star camera with respect to the axes of the spacecraft (O razmeshchenii zvezdnoi fotokamery otnositel'no osei KLA). A. F. STETSENKO, *Geodeziia i Aerofotos'emka* (ISSN 0536-101X), No. 2, 1989, pp. 83–86.

The paper examines the accuracy of the determination of the orientation angles of a spacecraft according to star photographs in relation to the setting angles of the star camera with respect to the axes of the spacecraft. Graphs illustrating the dependence of the orientation accuracy on the setting angles for various conditions are presented.

A90-16523   Orientation of large orbital stations. V. A. SARYCHEV, M. IU. BELIAEV, V. V. SAZONOV, and T. N. TIAN, *Proceedings of the IUTAM/IFAC Symposium, Dynamics of controlled mechanical systems*, Zurich, Switzerland, May 30–June 3, 1988 (A90-1651604-31). Berlin and New York, Springer-Verlag, 1989, pp. 193–205. 7 Refs.

The single-axis gravitational orientation mode is considered for the Salyut 6 and 7 orbital stations. An integral statistical technique is described for determining the real rotational motion of the stations in this mode by the solar and magnetic sensor indications. The technique is illustrated by computations of residual microaccelerations aboard the station; their knowledge is important for an analysis of some technological experiments.

A89-32163   Mathematical substantiation of a theory of orbital correction using a solar sail (Matematicheskoe obosnovanie teorii orbital'noi korrektsii, vypolniaemoi s pomoshch'iu solnechnogo parusa). E. N. POLIAKHOVA and A. S. SHMYROV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Jan.–Feb. 1989, pp. 54–63. 8 Refs.

The paper examines the two-dimensional problem of the optimal correction of the geocentric elliptical orbit of a spacecraft using a solar sail. A combination of the averaging and small-parameter methods is used to obtain an approximately optimal solution. The problem is examined for arbitrary initial conditions in the sense of the orientation of the apsidal lines and the dimensions of the elliptical orbit with fixed constraints on the solar-sail thrust force.

A89-30078   Theory of semianalytical inertial damped structures invariant to external data errors (K teorii poluanaliticheskikh inertsial'nykh dempfirovannykh sistem, invariantnykh k pogreshnostiam vneshnei informatsii). R. M. KUKULIEV, *Priborostroenie* (ISSN 0021-3454), Vol. 32, Jan. 1989, pp. 40–45. 5 Refs.

An inertial navigation system is considered which uses external data signals for system damping. Theorems are proved concerning the impossibility of attaining absolute invariance of the error of gyroplatform deviation from the reference vertical to the external data errors.

Japanese Aerospace Literature
This month: *Supersonics*

A91-44657   Effects of chordwise displacement and nonrigid section deformation on unsteady aerodynamic response of subsonic and supersonic oscillating cascades. MASANOBU NAMBA and KAZUHIKO TOSHIMITSU, ASME Paper 90-GT-246 presented at the ASME 35th International Gas Turbine and Aeroengine Congress and Exposition, Brussels, Belgium, June 11–14, 1990. 9 pp. 5 Refs.

The double linearization theory is applied to lightly loaded two-dimensional subsonic and supersonic cascades undergoing oscillation with chordwise displacement or nonrigid section deformation. Numerical examples demonstrating parametric dependence of unsteady aerodynamic work on blades are presented. The chordwise displacement can be favorable or unfavorable for stabilizing the translational oscillation, depending upon the phase difference between the chordwise and normal components of the blade motion. For supersonic cascades the role of the effect of displacement of shock reflection points on unsteady aerodynamic response is significantly enhanced by the chordwise blade motion. The unsteady aerodynamic work for nonrigid section deformation is substantially influenced by steady loading.

A91-19289   Numerical prediction of two and three dimensional sonic gas transverse injections into supersonic flow. T. FUJIMORI, M. KAWAI, H. IKEDA, Y. ANDO, Y. OHMORI et al., AIAA Paper 91-0415 presented at the AIAA 29th Aerospace Sciences Meeting, Reno, NV, Jan. 7–10, 1991. 12 pp. 18 Refs.

Two- and three-dimensional sonic gas injections into supersonic flows are studied by two- and three-dimensional Navier-Stokes equation solvers, which have been developed by the authors recently. The results are compared with experimental data. For two-dimensional injection, close agreement of numerical results with experimental data are obtained. For three-dimensional cases, the qualitative agreements are obtained, but front separation area of the numerical results are larger than that of the experimental ones. To investigate mixing of injectant with primary flow in three-dimensional case, a transport equation of injectant is solved by a postprocessing method.

A91-44092   Supersonic air-intake study aiming at future airbreathing engine. K. SAKATA, S. HONAMI, and A. TANAKA, AIAA Paper 91-2012 presented at the AIAA, SAE, ASME, and ASEE 27th Joint Propulsion Conference, Sacramento, CA, June 24–26, 1991. 7 pp.

A development status evaluation is presented for Japanese efforts toward development of SST/HST airbreathing propulsion system air intakes featuring a minimum cruise Mach number of 3.0 and mixed compression operation within a two-dimensional ramp-type geometry framework. Experimental investigations have thus far encompassed a three-shock ramp system, multishock ramps with bleed systems, variable-geometry inlets, and inlets optimized for SST airframe integration. The avoidance of boundary-layer separation and the minimization of bleed airflow rates are identified as the most important steps toward achievement of performance goals.

A91-40585   Shock waves generated by an opposing jet. MICHIO NISHIDA, KOJI TESHIMA, KAZUYUKI UENO, and SHIGEKI TANAKA, *Proceedings of the 17th International Symposium on Shock Waves and Shock Tubes, Current topics in shock waves*, Bethlehem, PA, July 17–21, 1989 (A91-40576 17-34). New York, American Institute of Physics, 1990, pp. 114–119. 11 Refs.

The shock waves generated by a sonic nose jet exhausting counter to a supersonic free stream of a Mach number 3 were visualized by means of a laser induced fluorescence method. The experiments were conducted for various values of the ratio of opposing jet total pressure to free stream total pressure. The ratio of a jet exit diameter to a body diameter was taken to be 0.2 and 0.4. The results show that the shock waves generated by the opposing jet are significantly affected not only by the ratio of jet total pressure to free stream total pressure but also by the ratio of the jet exit diameter to the body diameter. It was also observed that at low pressure ratios, there exists unstable flow regime. Simple analysis is applied to the prediction of the position of a free stream shock and a Mach disk, and compared with the experimental result. The comparisons show good agreement.