

Soviet and Japanese Aerospace Literature

Throughout 1991 the *AIAA Journal* will carry selected abstracts on leading research topics from the Soviet aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Spacecraft Navigation and Control from the USSR and Japan.

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Soviet Aerospace Literature This month: *Spacecraft Navigation and Control*

A90-42923 State estimation of self-contained strapdown inertial navigation systems (Ob otsenke sostoiianiia avtonomnykh besplatformennykh inertsiial'nykh navigatsionnykh sistem). S. V. SOKOLOV and I. N. MARINENKO, *Priboostroenie* (ISSN 0021-3454), Vol. 33, March 1990, pp. 44–49.

A stochastic model for a strapdown inertial navigation system is developed. An approach based on the general theory of nonlinear stochastic filtering is used for the state-vector estimation of a self-contained strapdown system without the use of signals from external measuring instruments.

A90-41963 Channel-type hydraulic nutation dampers (Kanalovye zhidkostnye dempfery nutatsionnykh kolebani). A. IU. KOGAN, *Kosmicheskoe 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.

A90-41962 Optimal algorithms for state limitations of a spacecraft with relay controllers (Optimal'nye algoritmy ogranichenii sostoiianiia kosmicheskogo apparata s releinymi ispolnitel'nymi organami). N. E. ZUBOV, *Kosmicheskoe Issledovaniia* (ISSN 0023-4206), Vol. 28, May–June 1990, pp. 336–345. 5 Refs.

A new version of a relay controller based on an algorithm with a predictive model is developed which serves as the basis of state limitation automata for a spacecraft. Particular attention is given to state limitation for a linear stationary spacecraft and to state limitation for a linear nonstationary spacecraft and a nonlinear spacecraft.

A90-41961 Attitude control system of a flexible spacecraft with a dynamic filter (Sistema orientatsii deformiruемого kosmicheskogo apparata s dinamicheskim fil'trom). G. IA. LEDENEV, *Kosmicheskoe 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.

A90-39537 Transmission of parallel radiation beams through weakly scattering screens (in space navigation) (Prokhozhenie parallel'nykh puchkov izlucheniia cherez slaborasseivaushchie ekrany). I. A. GROMYKO and V. E. PUSTOVAROV, *Radiofizika* (ISSN 0021-3462), Vol. 33, March 1990, pp. 385, 386.

The metrological problem of the development of optical radiation attenuators based on weakly scattering screens is investigated analytically. A full solution to the equation of the ray arrival angle dispersion indicates the presence of a near stationary zone when using parallel energy beams of any initial cross section. At present, the use of weakly scattering screens makes it possible to solve two important metrological problems: development of sky simulators of the dynamic type and optical radiation attenuators allowing the scanning of an energy beam across a screen.

A90-37795 Effect of the method of sensor block reorientation on the estimation accuracy of INS instrumental errors (Vliianie sposoba pereorientatsii bloka chuvstvitel'nykh elementov na tochnost' otsenivaniia instrumental'nykh pogreshnostei INS). V. A. TIKHONOV, *Priboostroenie* (ISSN 0021-3454), Vol. 33, Jan. 1990, pp. 70–75.

The estimation accuracy of the instrumental errors of inertial navigation systems during ground calibration in the case of the continuous rotation of the sensor block is compared with that in the case of reorientation of the sensor block to fixed positions relative to the geographical navigation coordinate system. An analysis of the results obtained indicates that, for the same estimation time, the estimation accuracy of the instrumental errors of a block of accelerometers is the same in both cases. For the model of the errors of a block of gyroscopes, the higher estimation accuracy is obtained in the case of the uniform rotation of the sensor block.

A90-34601 Accuracy of absolute and relative determinations of the coordinates of geodesic points on the basis of navigation-satellite observations (O tochnosti absoliutnogo i otnositel'nogo opredeleniia koordinat punktov po nabludeniiam navigatsionnykh sputnikov). V. V. BOIKOV, *Geodeziia i Aerofotos'emka* (ISSN 0536-101X), No. 5, 1989, pp. 72–77. 5 Refs.

The paper examines the accuracy of absolute and relative determinations of the coordinates of geodesic points using observations of satellites of a Navstar-type system with the aid of a navigation receiver operating in the pseudo-range measurement mode. Formulas for assessing the accuracy of absolute and relative positions are obtained.

A90-37794 Functioning algorithms, precision synthesis, and identification of a strapdown inertial navigation system (Algoritmy funktsionirovaniia, tochnostnyi sintez i identifikatsiia besplatformennoi inertsiial'noi navigatsionnoi sistemy). A. G. SHCHIPITSYN and A. F. GUBNITSKII, *Priborostroenie* (ISSN 0021-3454), Vol. 33, Jan. 1990, pp. 63-69. 10 Refs.

Mathematical models are developed which describe the functioning and accuracy of a strapdown inertial navigation system whose inertial data block can vary the system orientation relative to an object. Methods for increasing the accuracy of the system and for identifying errors are presented. A block diagram of the general system operation algorithm is presented.

A90-36137 A representation of the principal equation of inertial navigation using gradiometry (Ob odnom sposobe predstavleniia osnovnogo uravneniia inertsiial'noi navigatsii pri ispol'zovanii gradiometrichekikh izmerenii). M. G. VASIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), Mar.-Apr. 1990, pp. 9-18. 10 Refs.

A new representation of the main equation of inertial navigation is obtained using measurements of the tensor of second geopotential derivatives. A qualitative analysis of the dynamic properties of the inertial systems considered is presented. Based on estimates of the observability measure, simple correction algorithms are synthesized, and the accuracy of these algorithms is evaluated. Practical recommendations are given concerning the use of the algorithms proposed here for determining the instrument and methodical gradiometer errors.

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.

A90-32516 An efficient algorithm for the computation of the earth's gravitational potential and its first-order derivatives for solving satellite problems (Effektivnyi algoritim vychisleniia gravitatsionnogo potentsiala zemli i ego pervykh proizvodnykh dlia resheniia sputnikovykh zadach). M. V. BELIKOV and K. A. TAIBATOROV, *Kinematika i Fizika Nebesnykh Tel* (ISSN 0233-7665), Vol. 6, Mar.-Apr. 1990, pp. 24-32. 15 Refs.

An efficient algorithm has been developed for computing the earth's gravitational potential and its first order derivatives, which can be used in the construction of any satellite orbit, including polar orbits. The simple normalizing factors for the associated Legendre functions and the stable recursive relations of the algorithm result in a quadruple reduction in calculation time compared with Cunningham's algorithm. The proposed method permits the practical utilization of geopotential models of high degrees and orders when constructing satellite orbits with decimeter accuracy on computers of moderate efficiency.

A90-29197 Effect of damping on the gravitational orientation regime of a rotating satellite (Vlianie dempfirovaniia na rezhim gravitatsionnoi orientatsii vrashchaiushchegosia sputnika). V. I. VETLOV, V. V. SAZONOV, and V. A. SARYCHEV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), Jan.-Feb. 1990, pp. 3-11. 7 Refs.

A two-parameter integral surface of the equations of motion is constructed which describes quasi-stationary rotations of a satellite that coincide with the conical precession of a symmetric rigid body in a gravitational field when epsilon equals zero (epsilon is a small parameter describing the nongravitational external moment applied to the satellite, effect of the damper, and the deviation of the body from the dynamically symmetric position). The motions close to such quasi-stationary rotations have been used for the uniaxial gravitational orientation of the Salyut-6 and Salyut-7 space complexes. The effect of the damper type on the deceleration of the quasi-stationary rotations is examined.

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 solnechnykh 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.

A90-29064 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.

A90-29061 Maneuverability of large orbital stations (Manevrenost' 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.

A90-37752 Relativistic perturbations in the motion of geodetic satellites (O relativistskikh vozmushcheniakh v dvizhenii geodezicheskikh ISZ). I. U. V. PLAKHOV, *Geodeziia i Aerofotozemka* (ISSN 0536-101X), No. 6, 1989, pp. 65-71. 6 Refs.

The problem of the effect of relativistic perturbations on the motion of geodetic satellites is investigated with reference to the Etalon satellite. It is shown that, given the present precision of laser observations of satellites (0.1-0.2 m in range), it becomes necessary to take into account relativistic perturbations in the Schwarzschild approximation in the numerical integration of the equations of satellite motion over a period of a few days.

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 (Vlianie gisterezisnogo sterzhnia, ustanovlennogo vdol' osi naibol'shego momenta inertsi sputnika, na ego dvizhenie v rezhime gravitatsionnoi orientatsii). V. A. SARYCHEV, V. I. PEN'KOV, M. I. 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.

A90-17270 A means of constructing the control range for a control moment gyroscope system (Ob odnom sposobe postroeniia oblasti upravlaemosti girostilovoi 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 gyroscopes—two-DOF power gyroscopes with servo drives along the axes of precession—is considered. One of the gyroscopes is redundant. The control range is constructed by successive addition of the ranges for one gyrodyne, then for two, and so on.

A90-17241 Narrow-band VLBI for deep space navigation. II—Orbital vehicles; Coordinate measurements of the Astron satellite (Dlinnobazovaia uzkoplosnaia radiointerferometriia dlia kosmicheskoi navigatsii. II—Orbital'nye apparaty; Izmereniia koordinat ISZ 'Astron'). V. A. ALEKSEEV, V. I. ALTUNIN, A. A. ANTIPENKO, E. D. GATELIUK, I. U. 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.

A89-38186 Economical method of orientation of large orbital stations. V. A. SARYCHEV and I. U. A. SADOV, *Proceedings of the 16th International Symposium on Space Technology and Science*, Sapporo, Japan, May 22-27, 1988, Vol. 1 (A89-3803116-12). Tokyo, AGNE Publishing, Inc., 1988, pp. 1193-1198.

The evolution of a large space station orbits discussed, using the Salyut-Soyuz orbital complex as an example. Calculations are conducted to describe the effects of the nonpotential aerodynamic torque on the orientation of the system. Also, the rotation of a satellite with a magnetic damper is studied numerically. The evolution of resonance effects are examined, emphasizing peculiarities in the station's orbit caused by secondary resonance effects.

A90-21805 A stability-loss mechanism for gravity-gradient satellite attitude control (Ob odnom mekhanizme poteri ustoiichivosti rezhima gravitatsionnoi orientatsii sputnika). V. V. SAZONOV, *Kosmicheskii 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.

A90-17231 Synthesis of control signals using a predictive model in a spacecraft control system with relay controllers (Sintez upravliaiushchikh signalov s pomoshch'iu prognoziruushchei modeli v sisteme upravleniia KA s releinyimi ispolnitel'nymi organami). N. E. ZUBOV, *Kosmicheskii issledovaniia* (ISSN 0023-4206), Vol. 27, Sept.-Oct. 1989, pp. 682-690. 5 Refs.

The paper examines the synthesis of optimal control for a spacecraft represented as a nonlinear plant. A modified relay-control algorithm with a predictive model is proposed. This algorithm is applied to a problem of rendezvous control.

A90-17226 Stabilization of a satellite with flexible rods. I (O stabilizatsii sputnika s gibkimi sterzhniami. I). S. I. ZLOCHEVSKII and E. P. KUBYSHKIN, *Kosmicheskii 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.

A90-10958 Adjustment of continuous triangulation networks, taking satellite observation data into account (Ob uravniavanii sploshnykh setei triangulatsii s uchetom dannykh sputnikovyykh nabludenii). KHOANG NGOK KHA, *Geodeziia i Aerofotos'emka* (ISSN 0536-101X), No. 6, 1988, pp. 55-64. 8 Refs.

Effective algorithms for the processing of ground-based and satellite measurements in connection with the adjustment of triangulation networks are discussed. Particular emphasis is placed on adjustment algorithms that account for Doppler data via a recursive formula. Cases of adjustment using Doppler translocation data are examined.

A89-52887 Investigation of the orbital gyrocompassing problem by methods of the theory of linear observation systems (Issledovanie zadachi orbital'nogo girokompasirovaniia metodami teorii lineinykh sistem nabludenii). S. N. EGOROV, A. F. DIUMIN, and D. M. SURINSKII, *Kosmicheskii issledovaniia* (ISSN 0023-4206), Vol. 27, July-Aug. 1989, pp. 502-508. 11 Refs.

It is demonstrated that the orbital gyrocompassing problem can be solved by the use of various types of observing instruments. Existing types of orbital gyrocompasses are investigated on the basis of a general approach. The possibility of improving the precision of orbital gyrocompassing using various types of instrument sets for evaluating and compensating the effects of errors of local-vertical plotters and gyro drifts is substantiated in principle.

A89-48074 Narrow-band very long baseline interferometry for space navigation. I Interplanetary probes: Measurements of the coordinates of the Vega probe (Dlinnobazovaia uzakopolosnaia radiointerferometriia dlia kosmicheskoi navigatsii. I—Mezhplanetnye apparaty: Izmereniia koordinat AMS 'Vega'). V. A. ALEKSEEV, V. I. ALTUNIN, A. A. ANTIPENKO, A. V. BIRIUKOV, E. D. GATELIUK et al., *Kosmicheskii issledovaniia* (ISSN 0023-4206), Vol. 27, May-June 1989, pp. 447-453. 10 Refs.

Narrow-band signals were received from the Vega spacecraft at a wavelength of 32 cm during experiments conducted in 1985-1986; the interferometer baseline was about 1200 km. The aim of the experiments was to determine the equatorial celestial coordinates of spacecraft in a system associated with an extragalactic radio source. The method is described, and experimental results are presented. Sufficiently high precision of coordinate measurement was obtained.

A89-50863 Synthesis of the dynamic control of spacecraft orientation (Sintez podvizhnogo upravleniia orientatsiei kosmicheskikh apparatov). A. P. ALPATOV and A. V. PIROZHENKO, *Kosmicheskii nauka i Tekhnika* (ISSN 0321-4508), No. 3, 1988, pp. 71-75. 5 Refs.

The synthesis of algorithms for the dynamic control of the angular position of a spacecraft under different conditions of its motion is examined analytically. In particular, two approaches are discussed. The first approach involves the synthesis of a controller providing the required quality on the basis of a linear model (for small deviations). The second approach involves the synthesis of quasi-optimal control of spacecraft orientation using a nonlinear system of equations.

A89-52886 Existence and stability of the periodic pendulumlike motions of a satellite (O sushchestvovanii i ustoiichivosti periodicheskikh maiatnikovyykh dvizhenii sputnika). N. I. CHURKINA, *Kosmicheskii issledovaniia* (ISSN 0023-4206), Vol. 27, July-Aug. 1989, pp. 497-501. 9 Refs.

The problem of the motion of a satellite with respect to the mass center of the system is examined which reduces to the study of the motion of a mathematical pendulum under the effect of a small periodic perturbation of general form. Conditions for the existence and stability of periodic Poincare solutions are obtained in a rigorous nonlinear formulation.

A89-50865 Calculation of the apparent velocity (O vychislenii kazhushcheisia skorosti). A. I. TKACHENKO, *Kosmicheskii nauka i Tekhnika* (ISSN 0321-4508), No. 3, 1988, pp. 82-89. 7 Refs.

The paper is concerned with the problem of calculating the apparent velocity of a moving object from measurements of its apparent acceleration in projections onto the axes of a connected trihedral. Two types of formulas for calculating this quantity are proposed, and data are presented which make it possible to improve the accuracy of calculations or to reduce the computational effort. The possibility of reducing errors associated with the quantization of the apparent acceleration data is examined.

A89-49179 Universal finite algorithm for differential-range finding navigation systems (Universal'nyi konechnyi algoritim dlia raznostnodal'nomernoi navigatsionnoi sistemy). O. O. BARABANOV and L. P. BARABANOVA, *Priboroostroenie* (ISSN 0021-3454), Vol. 32, May 1989, pp. 42-45.

An algorithm to increase logical and digital reliability is presented for a wide class of navigation systems with variable geometry. The algorithm is oriented toward structural programming and requires a reduced number of arithmetical operations.

A89-49178 Algorithms for controlling additional rotation of the block of sensing elements of inertial navigation systems (Algoritmy upravleniia dopolnitel'nym vrashcheniem bloka chuvstvitel'nykh elementov inertsial'noi navigatsionnoi sistemy). I. U. G. EGOROV, *Priboroostroenie* (ISSN 0021-3454), Vol. 32, May 1989, pp. 39-42.

Algorithms have been obtained for controlling additional rotation of the sensing-elements block during the identification of inertial navigation system errors. The algorithms are optimal according to the criterion of minimum control error at the end of the discreteness period.

A89-48064 The geometry of the locally optimal control of the terminal accuracy of the reorientation of a spin-stabilized symmetrical spacecraft (Geometriia lokal'no-optimal'nogo upravleniia terminal'noi tochnost'iu pereorientatsii simmetrichnogo KA, stabilizirovannogo vrashcheniem). A. N. SIROTIN, *Kosmicheskii issledovaniia* (ISSN 0023-4206), Vol. 27, May-June 1989, pp. 375-384. 5 Refs.

The optimal control of the terminal accuracy of the reorientation of the sensitivity axis and the associated set of coordinates of a spherically symmetrical spin-stabilized spacecraft is studied. Local necessary conditions determining the structure of the optimal control are obtained using a special type of control variation.

A89-47881 Joint adjustment of Doppler and ground geodetic networks using a recursive formula (O sovmenstnom uravniavanii doplerovskoi i nazemnoi geodezicheskikh setei s primeneniem rekurentnoi formuly). NGOK KHA KHOANG, *Geodeziia i Aerofotos'emka* (ISSN 0536-101X), No. 5, 1988, pp. 75-85. 6 Refs.

A joint adjustment method is proposed which is based on a geodetic-network linking algorithm using a recursive formula of matrix inversion. This approach is characterized by separate data processing in the ground and Doppler networks. A numerical example illustrating the proposed adjustment method is presented.

A89-35506 Optimization of the arbitrarily redundant structure of a strapdown inertial navigation system (Optimizatsiia proizvol'no-izbytochnoi struktury besplatformennoi inertsial'noi navigatsionnoi sistemy). I. U. A. KARPACHEV and I. U. M. KUZ'MENKO, *Mekhanika Giroskovicheskikh Sistem* (ISSN 0203-3771), No. 7, 1988, pp. 25-31.

In the arbitrarily redundant structure of a strapdown inertial navigation system, the sensitivity axes of single-coordinate meters are optimized in such a way as to minimize the rms error and computational effort in determining the kinematic parameters of the rotational and translational motions of the orthogonal computational basis of the navigation system in conjunction with a rigid body. The optimization is carried out with allowance for the errors of the measuring instruments and instrumental errors in the referencing of the instrument mounting planes to the computational basis of the system.

A89-34138 Electrochemical rocket powerplants in spacecraft control systems (Elektrokhimicheskie raketnye dvigatel'nye ustanovki v sistemakh upravleniia KA). I. U. P. RYLOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1988, pp. 50-54. 7 Refs.

The physical processes occurring in the electrochemical rocket powerplants of spacecraft control systems consisting of low-thrust (0.01-10 N) engines are examined. Some specific design features of these engines that are associated with their applications in flight control, orientation, and stabilization systems are discussed, and methods for calculating such engines are presented.

A89-48063 The problem of constructing three-dimensional gyrodyne systems (Problema postroeniia prostranstvennykh girodinnykh sistem). E. N. TOKAR', *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, May-June 1989, pp. 368-374. 8 Refs.

Four problems associated with the construction of three-dimensional and multiple three-dimensional gyrodyne systems are formulated. It is shown that the solution to these problems is reduced to the search for infinite series of polyhedrons satisfying certain extreme requirements.

A89-40572 Construction of an algorithm for taking into account atmospheric drag when investigating the motion of an artificial earth satellite (Postroenie algoritma ucheta soprotivleniia atmosfery v dvizhenii iskusstvennogo sputnika zemli). E. P. STREZHENKOVA and V. A. TAMAROV, *Astronomicheskii Zhurnal* (ISSN 0004-6299), Vol. 66, Mar.-Apr. 1989, pp. 404-411. 12 Refs.

An analytical theory for taking into account perturbations due to atmospheric drag in investigations of satellite motion is developed. The theory is based on an asymmetric variant of the Euler intermediate orbit. The expansion of components of perturbing acceleration due to the drag of a satellite in a stationary rotating atmosphere is presented.

A89-37360 A decomposition method applied in the problem of near-planetary astronavigation using pseudostars (Metod dekompozitsii v zadache priplanetnoi astronavigatsii s ispol'zovaniem psevdozvezd). V. F. PETRISHCHEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, Mar.-Apr. 1989, pp. 221-227.

The paper examines the problem of measurement-space decomposition in the problem of near-planetary astronavigation including the zenith distances of two stars and the angular diameter of the planet. Particular attention is given to the decomposition of the state space into a four-dimensional space of in-plane motion parameters and a two-dimensional subspace of out-of-plane motion parameters. From measurements of the zenith distances of two sighted stars, there is a transition to the zenith distances of two pseudostars, the direction to the first of which coincides with the current transversal, while the direction to the second coincides with a binormal to the plane of the a priori orbit. The in-plane parameters are determined from measurements of the zenith distance of the first pseudostar and the angular diameter of the planet, while the out-of-plane parameters are determined from measurements of the zenith distance of the second pseudostar.

A89-18436 Dynamics of a spacecraft with direct active control of the gravity gradient stabilizer (Dinamika kosmicheskogo apparata s priamym aktivnym upravleniem gravitatsionnym stabilizatorom). E. M. POTAPENKO, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 26, Sept.-Oct. 1988, pp. 699-708. 8 Refs.

Equations of spacecraft motion are obtained with allowance for an arbitrary but finite number of tons of elastic oscillations of a controlled gravity gradient stabilizer. A dynamic controller is used to optimize the spacecraft attitude control and stabilization system with allowance for the first tone of the elastic oscillations.

A89-42470 Determination of the precision of the orientation and stabilization system of the direct telecommunication satellite Ekran from flight test results and possible ways of its improvement (Opredelenie tochnosti sistemy orientatsii i stabilizatsii sputnika neposredstvennogo televeshchaniia 'Ekran' po rezul'tatam letnykh ispytaniy i vozmozhnye puti ee povysheniia). S. N. KALINOVICH, L. A. MIROSHNICHENKO, G. M. MARKELOV, and V. A. RAEVSKII, V. A. *Pioneers of space and the present age* (A89-42451 18-99). Moscow, Izdatel'stvo Nauka, 1988, pp. 138-145.

An analytical procedure for estimating the precision of the orientation and stabilization system of the Ekran telecommunication satellite on the basis of flight test data is presented, and recommendations are given as to how to improve the precision of the system. These include: (1) consideration of the constant component of the methodological error when installing the local vertical plotter on the ground; (2) introduction of constant corrections into the bank control circuit; and (3) improving the precision of orientation with respect to yaw by reducing the pumping angle of the gyro flywheel axis once the methodological error has been compensated.

A89-35552 A gradiometric inertial navigation system. II (Gradiometricheskaiia inertsial'naia navigatsionnaia sistema. II). I. A. KOROTAEV and V. I. KLIUEV, *Priroostroenie* (ISSN 0021-3454), Vol. 32, Feb. 1989, pp. 26-31.

Different representations of the error equations for a three-component gradiometric inertial navigation system are obtained. Analytical solutions to these equations are obtained, and the effect of instrument errors on the accuracy of the system is evaluated.

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, *Priroostroenie* (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.

A89-13241 Mathematical modeling of an inertial navigation system in an anomalous gravitational field (Matematicheskoe modelirovanie raboty inertsial'noi navigatsionnoi sistemy v anomal'nom gravitatsionnom pole). I. K. ZHBANOV, D. M. KLIMOV, and M. A. URIUPIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), July-Aug. 1988, pp. 13-16. 6 Refs.

The operation of an ideal nonautonomous undamped inertial navigation system in a gravitational field is investigated by the method of direct mathematical modeling. A method for improving navigational precision is proposed which employs a bank of gradiometers for monitoring the current values of the matrix of second derivatives of the anomalous geopotential. The effect of gradiometer errors on the precision of navigation is discussed.

Japanese Aerospace Literature This month: *Spacecraft Navigation and Control*

A90-39331 Adaptive control of large space structures. YUZO SHIMADA, *Chinese Society of Astronautics Journal* (ISSN 1000-1328), No. 1, 1990, pp. 45-53. 5 Refs.

This paper deals with the application of a model reference adaptive control theory to the attitude control of large space structures that don't satisfy the conditions of sensor/actuator collocation. The signals from several different positions on the flexible appendages are combined into outputs so that the number of outputs and inputs is the same. As an example, a spacecraft that has flexible solar paddles and a momentum wheel within the rigid central body is studied. Computer simulation results are presented for a situation where the flexural rigidity of the flexible appendages are assumed to vary widely from nominal values.

A90-30544 Observation of the Z mode with DE 1 and its analysis by three-dimensional ray tracing. KOZO HASHIMOTO and WYNNE CALVERT, *Journal of Geophysical Research* (ISSN 0148-0227), Vol. 95, April 1, 1990, pp. 3933-3942. 27 Refs. (NAG5-310; NAGW-1206).

Certain Z-mode wave emissions in the earth's magnetosphere have been identified using the wave spectra and polarization measurements of the DE 1 satellite. Although such emissions accompany the aurora, and thus presumably originate from the evening-sector auroral zone, they are found to occur over much wider ranges of latitude and longitude. Since the predicted cyclotron maser emission at the cyclotron frequency could not have produced waves which travel such great distances, as shown by three-dimensional ray tracing, it is proposed instead that these emissions must originate from lower altitudes within the auroral zone and probably from near the plasma frequency inside the auroral plasma cavity.

A90-13493 Manipulator control algorithm to minimize the effect of arm movement on the spacecraft attitude and translational motion. Y. OHKAMI, O. OKAMOTO, I. YAMAGUCHI, and T. KIDA, IAF 40th International Astronautical Congress, Malaga, Spain, Oct. 7-13, 1989. 7 p. (IAF Paper 89-377).

This paper presents a new algorithm for manipulator control to minimize the effect of the arm motion on the spacecraft attitude and translational motion. The method is based on the unified matrix approach, and also on the introduction of a 'virtual' hinge that restricts the spacecraft motion to a desired motion. This algorithm can be applied not only to digital simulation of the system in order to evaluate the controller performance or actuator gains but also to generation of the real time control law. Some numerical results are shown for illustration as applied to the spacecraft consisting of a main body and 4 arm manipulator.

A90-11725 Real-time relative motion monitoring for co-located geostationary satellites. SEIICHIROU KAWASE, *Communications Research Laboratory Journal* (ISSN 0914-9260), Vol. 36, July 1989, pp. 125-135. 5 Refs.

For the tracking of the relative orbital motion of two satellites closely placed and operated in the geostationary orbit, the concept of differential angle observation from a ground station is presented. A linearized Kalman filter is employed for the estimation of three-dimensional relative position and velocity, with the solar radiation pressure perturbation being analytically taken into account. A tracking simulation using pseudo-differential angle data indicates that an accuracy of a few hundreds of meters can be expected in the estimation of the relative position of the satellites.