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SHORT DESCRIPTION OF MATHEMATICAL SUPPORT PROGRAMS FOR SPACE EXPERIMENTS IN THE "INTERKOSMOS" PROGRAM

P. Ye. El'Yasberg

Translation of "Kratkoye opisaniye programm matematicheskogo obespecheniya kosmicheskikh eksperimentov v ramkakh programmy "Interkosmos". Academy of Sciences USSR, Institute of Space Research, Moscow, Report Pr-431, 1978, pp. 1-32.

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16. Abstract

A synopsis of programs of mathematical support designed at the Institute for Cosmic Research of the USSR Academy of Sciences for cosmic experiments being conducted in the "Interkosmos" Program is presented. A short description of the appropriate algorithm is given.

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P. Ye. El'Yasberg

INTRODUCTION

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Specific experience has been gained up to now in the processing and interpretation of telemetry data from satellites during the course of experiments in space in the "Intercosmos" Program. The algorithms and programs were developed at the Institute for Cosmic Research of the USSR Academy of Sciences and constitute the mathematical support for these experiments in its entirety. A short description of the programs and algorithms is given below in the following form:

Program name

1. Program type (applied, data processing, systems).
2. Language in which the program was written (FORTRAN, PL/1, etc.).
3. Algorithm content.
4. Program size. Execution time.
5. Program status (experimental use, series use).
6. Documentation (existence or lack of program and algorithm descriptions).
7. Programmer.

All programs and descriptions given below may be released to any participating organization in the "Intercosmos" Program in the order specified.

*Numbers in the margin indicate pagination of original foreign text.

1. PRELIMINARY INFORMATION PROCESSING PROGRAMS /6

1.1. Program for Processing the TR-2 Experiment Aboard the "Prognoz-6"

1.1.1. Program type: Information processing.

1.1.2. Language: PL/1 on a DOC/EC operating system.

1.1.3. Algorithm contents: Sequential scan of all [picture] frames during the communications session; selection of the number of telemetry channels for a given instrument; encryption of commutator segment numbers of the internal electronic commutator; decryption of the instrument operating mode; determination of instrument output parameters as functions of the numbers of commutator operating positions and telemetry channels. Initial data and the results of execution of the TR-2 program are recorded on magnetic tape. The structure of the data records on these tapes is determined by the standard format used in the preliminary and initial data processing system at the Institute for Cosmic Research of the USSR Academy of Sciences, IKI AN SSSR.

1.1.4. Program size: 600 statements. Execution time on the EC 1040 for contact each 4 days is 20 minutes.

1.1.5. Program status: series use.

1.1.6. Documentation: The program algorithm is not described. Program text, punchcards and instructions for use exist.

1.1.7. Programmers. Gavrilova, E.A.; Ershova, N. V.

1.2. Program for Processing Data on Charges and Masses of High Energy Particles from the I-1 Experiment Aboard the "Prognoz-5"

1.2.1. Program type: data processing.

1.2.2. Language: PL/1 on a DOC/EC operating system.

1.2.3. Algorithm contents: Sequential scan of all [photo] frames during one communications session; selection of the number of telemetry channels for a given instrument; decryption of the commutator segment numbers of the internal electronic commutator; decryption of instrument operating modes; determination of /7
instrument output parameters as functions of the numbers of telemetry channels and EhK positions.

The results of the preliminary processing of telemetry information recorded on magnetic tape are used as the initial data. The data recorded on output magnetic tape is the result of program execution. The data structure on the input

and output magnetic tapes is determined by the standard format for data records used in the preliminary and primary processing system at the IKI AN SSSR.

1.2.4. Program size is 500 statements. Execution time for contact each four days is 20 minutes on the EC 1040.

1.2.5. Program status: series use.

1.2.6. Documentation: The program algorithm is not described. Program text, punchcards and instructions for use exist.

1.2.7. Programmers: Gavrilova, E. A.; Ershova, N. V.

1.3. Program for Operations with Magnetic Tapes in FORTRAN (MTCFF).

1.3.1. Program type: Systems

1.3.2. Language: ASSEMBLER

1.3.3. Algorithm contents: With the aid of the MTCFF Program, any input-output operation on tape of interest to the programmer can be performed: record, reading blocks of any length in forward and reverse, various operations of handling tape, as the FORTRAN-IV language itself is limited in this use. The program can be used in programs written in other programming languages.

1.3.4. The program occupies a 224 byte machine memory. /8

1.3.5. Program status: series use.

1.3.6. Documentation: Preprint with statements of program provisions and directions for use.

1.3.7. Programmer: Gorokhov, V. N.

1.4. Program for the Organization of an Information-Reference Log (OJUR)

1.4.1. Program type: applied.

1.4.2. Language: PL/1, DOC EC.

1.4.3. Algorithm contents: The program provides for execution of the following functions:

-- storing information submitted by a problem program in a data storage bank;
-- outputting data on demand by the problem program;
-- organizing the data storage bank;
-- protecting the data bank from erroneous, repetitive or improper storage;
-- outputting information of the filling of data banks and on demands to produce new storage capacity.

The OJUR Program is the basic program for the OZhuR System, which includes problem and support programs.

Problem programs refer to the OJUR Program as a subroutine with a definite set of formal parameters.

1.4.4. OJUR Program size: 212 statements in PL/1.

1.4.5. Program status: series use.

1.4.6. Documentation: The program will be described in the collection of reports for the IV Conference on Information Processing.

1.4.7. Programmer: Pokras, V. M.

1.5. Program for Processing Scientific Telemetry Information from the AUOS Series Satellites. /9

1.5.1. Program type: Data processing.

1.5.2. Language: PL/1, DOC EC.

1.5.3. Algorithm contents: The program performs the following processing steps:

-- quality control in rewriting scientific information to EC computer magnetic tapes from telemetry tapes;
-- reduction of the standard telestructure;
-- division of information by modes (NP, VP) [expansion unknown];
-- processing onboard time channels;
-- referencing each telemetry frame to Moscow time and date;
-- processing magnetometer data and solar sensor data;
-- marking commutator segments of slow commutators.

The program consists of a main program, separate programs corresponding to specific processing stages, and a set of special programs, commonly used in all stages of processing.

1.5.4. AUOS Program size: 1,500 PL/1 statements.

1.5.5. Program status: series use.

1.5.6. Documentation: algorithm not described.

1.5.7. Programmer: Maslov, V. D.

1.6. Program for Preliminary Processing of Magnetometer and Solar Orientation Sensor Information (PGI).

1.6.1. Program type: Data processing.

1.6.2. Language: FORTRAN-IV, DOC EC.

1.6.3. Algorithm contents: The algorithm implements processing of initial magnetometer and solar orientation sensor information by rejecting fragmented measurements and increasing their information content. /10

The initial data is recorded on magnetic tape, prepared in a set form.

Processed, fragment-free data, "compressed" magnetometer and solar orientation sensor information recorded on magnetic tape is obtained as a result of program execution.

1.6.4. Program size: 820 statements. A 230 K operational memory is required.

1.6.5. Program status: series use.

1.6.6. Documentation: none.

1.6.7. Programmer: Il'icheva, V. D.

2. PROGRAMS FOR NAVIGATIONAL PLOTTING OF SCIENTIFIC TELEMETRY DATA. /11

2.1. Complex General Purpose Programs in the Problem of Two Bodies.

2.1.1. Program type: Applied.

2.1.2. Language: FORTRAN-IV, DOC EC.

2.1.3. Algorithm contents: Solution of the Keppler Problem using general purpose formulas; computation of any given sum of orbital elements in rectangular phase coordinates (and the solution of the inverse problem) or by any other given set of elements and matrices, derivatives of the initial values obtained; computation of first and second order isochronous derivatives of phase coordinates by their initial values and gravitational parameters.

2.1.4. Program size: 1,000 statements. Execution time: on the order of one second.

2.1.5. Program complex status: Experimental use.

2.1.6. Documentation: Preprint with a description of programs and algorithms.

2.1.7. Programmers: Bakhshyan, B. Ts.; Sukhanov, A. A.

2.2. Program for Computing Satellite [AES] Navigational Parameters (ORBIT).

2.2.1. Program type: Applied.

The program takes the form of a problem-oriented programming system, i.e., a complex of subroutines, consolidated by the control program, the adjustment of which in any operating mode is conducted with the aid of the control parameters [indices], which are elements of a specialized user language.

2.2.2. Language: FORTRAN-IV.

The program version with single precision is used on the BEhSM-6 /12 computer in an OS DISPAK system and the double precision version of an EC 1040 in a DOC M2.0. system. It can be used in other computing and operating systems.

2.2.3. Algorithm contents: The ORBIT program is designed for navigational plotting of results of the scientific experiments conducted using artificial earth satellites.

Program provisions:

The program computes AES motion parameters by means of numerical integration of a system of differential equation of AES motion for different assumptions with respect to the system of forces exerted. The classification of the exerted force model is made according to the scheme presented in Table 1, based on the use of indices having a one-to-one correspondence with various exerted force system variations.

The Adams method with an 8-term interpolation formula is used for integration and the Runge-Kutta method for dispersion. Provision is made for integration with a fixed step and with automatic step selection. The allowable error of integration can be assigned arbitrarily, depending upon the demands of the problem being solved.

TABLE 1 /13

SYSTEM OF FORCES TAKEN INTO ACCOUNT IN ARTIFICIAL EARTH SATELLITE EQUATIONS OF MOTION

## pp.	Coordinate system	Earth's gravitational field	Atmosphere	Gravitational perturbation	Light pressure
	1	2	3	4	5
0	Osculating elements	Central	Not used	Not used	Not used
1	Greenwich	Normal	Without using variations	Lunar	Without use of Earth's shadow
2	Absolute	Zonal harmonics	With long-term variations	Solar	Using Earth's shadow
3		Full anomalies	With long and short periodic variations	Lunar and solar	
4		Harmonics 10,20,30	CIPA-72		

A diverse form for assigning initial conditions is provided: In the form of oscillating orbital elements and in the form of coordinates and velocity vector components in either the absolute or Greenwich coordinate systems.

Provision has been made for printing out information on the oscillating orbit at each ascending node of the orbit or through a specified number of nodes during the integration process, for stopping the printout, and for stopping the output procedure on the orbital node.

The program enables the values of navigational parameters (NP) which characterize the AES position at any moment to be computed in the integration process and then prints out or reads them onto magnetic tape. /15

A list of computed parameters is given in Table 2. Provision is made for calculating any set of parameters in Table 2 and also for expanding the assortment of calculated parameters.

TABLE 2

LIST OF NAVIGATIONAL PARAMETERS CALCULATED IN THE PROGRAMMING SYSTEM

##	Designator	Name	Unit of measure
1,2,3	H, φ, λ	Altitude, latitude, longitude of AES	km, degrees
4,5,6	X, Y, Z	Rectangular coordinates	m
7,8,9	V, V_φ, V_λ	Velocity vector components	m/sec.
10	λ^*	Right ascension of AES	
11,12,13	$H_T, \varphi_T, \lambda_T$	Altitude, latitude, longitude of T-point: point of intersection with ends of lines connecting the AES with the sun	km, degrees
14,15	$T_\odot, Z_\odot$	Local time, zenith distance from the sun	hours
16,17	B, L	Geomagnetic parameters	Gauss, R of Earth
18,19,20	B_r, B_θ, B_φ	Vector components of B in the geographic coordinate system	Gauss
21,22,23	$H_c, \varphi_c, \lambda_c$	Altitude, latitude, longitude of the sun to the magnetically-joined point	km, degrees
24,25	$T_\odot, Z_\odot$	Local time, zenith distance of the sun to the magnetically-joined point	hours, degrees
26,27	Λ, Λ_0	Invariant geomagnetic latitude	degrees
28,29	φ_m, λ_m	Geomagnetic latitude, longitude	degrees
30	T_m	Geomagnetic time	hours
31	λ_a	Auroral longitude	hours
32	T_a	Auroral time	hours
33	v^2	Speed squared	m^2/sec^2
34,35,36	$R_e, \varphi_e, \lambda_e$	Modulus of radius vector, latitude, longitude of AES in solar ecliptic coordinate system	R of Earth, degrees
37,38,39	D, φ_p, λ_p	AES distance, angle of elevation, azimuth in the topocentric coordinate system	km, degrees

A sequence of moments in time for which the NPs must be calculated can be arranged in the form of a time interval and step. The step can be specified as a constant or as a function of time (or of several other parameters, for example, the altitude of the AES above the Earth's surface). The NPs can also be calculated in moments of time corresponding to the attainment of specified values or extreme values of any specified continuous function of AES motion parameters. Provision is made for assignment of moments in time in the form of a list.

These NPs can be recorded on magnetic tape (ML). Recording is accomplished with the aid of unformatted sequential access operators.

Service subroutines are at the user's disposal, which makes the readout of the information, the writing of short information into files recorded on ML (DIGEST) and of other information maintained in each individual file (PRMOD, PRREC) easier.

The integration can be terminated by loop number or by time.

2.2.4. The program consists of a main program and 110 subroutines. Program size: 5,000 statements. Required memory for the BEhSM-6 computer is 25 internal storage units (OZU). Required machine memory for the EC 1040 computer is 217 K bytes. Actual execution of the program can be shortened by decreasing versatility. Execution time is characterized as follows: one loop for "Intercosmos 7" on the K- /16
11100 with constant integration step is 30 seconds; with the printing of orbital information only, it is 3.5 seconds.

2.2.5. Program status: Series use.

2.2.6. Documentation: Preprint with program description and algorithm.

2.2.7. Programmer: Prokhorenko, V. I.

2.3. Program for Computing the Orbit of Artificial Satellites of Planets.

2.3.1. Program type: Applied.

2.3.2. Language: FORTRAN-IV, DOC EC.

2.3.3. Algorithm contents: The algorithm consists of the integration of differential equations of motion of a spacecraft, of the sun, and the perturbed motion of the satellite in a nonrotational reference system linking the center of

2.5. Program for Calculating the Orientation of an Unoriented AES (ATTIS).

2.5.1. Program type: Data processing.

2.5.2. Language: FORTRAN-IV, DOC EC.

2.5.3. Algorithm contents: The algorithm processes revised information from a magnetometer and a solar orientation sensor for determining the AES motion parameters about a center of mass. The motion is assumed to be unperturbed and /18
is described by the Euler-Poincot relation. The initial data is one magnetic tape, obtained after execution of the PCI program.

As a result of program execution, the parameters which characterize AES motion about a center of mass in the Euler-Poincot scheme are obtained. The parameters are output onto punchcards and onto a number sequence arithmetic unit (AUPU).

2.5.4. Program size: 610 statements. Required operational memory: 230 K.

2.5.5. Algorithm status: Series use.

2.5.6. Documentation: None.

2.5.7. Programmer: Sokolov, V. E.

2.6. Program to Compute Coefficients for Determining the Orientation of the "Prognoz" Satellites.

2.6.1. Program type: Data processing.

2.6.2. Language: FORTRAN-IV, DOC EC.

2.6.3. Algorithm content: The algorithm is used in the form of several subroutines and a main program. The algorithm content applies the least square method to the statistical processing of optical sensor measurements in order to determine the constants in the law of motion of a satellite relative to a center of mass. The harmonic approximation of the motion of a solid body of Euler-Poincot is taken as the law of motion.

The algorithm can be used for computing the orientation of satellites stabilized by rotation.

Initial data is presented as records on magnetic tape in standard format /19
used in the preliminary data processing system at the IKI AN SSSR. The results are output on magnetic tape as tables of coefficients which can be used later for calculating the required angles which characterize the satellite instrument axes in space.

2.6.4. Program size is 900 statements. The program permits processing of four daily contacts with the "Prognoz" satellite instruments for 30 minutes on the EC 1040.

2.6.5. Program status: Series use.

2.6.6. Documentation: The algorithm is described in a collection of articles.

2.6.7. Programmer: Ehismont, N. A.

3. STATISTICAL INFORMATION PROCESSING /20

3.1. System of Programs for Mathematical Processing of Photographic Images of the Earth Taken from Spacecraft ("SOFI").

3.1.1. Program type: Applied.

3.1.2. Language: FORTRAN-IV, DOC EC.

3.1.3. Algorithm content: The complex includes the following subroutines:

1) Change of formats: RETR11, RETR12, RETR21, RETR22, RETR1C, RETRC1 -- transfer of an image array with a 128 x 128 element dimension. For example: RETR12 is a transfer of an array from a LOGICAL x 1 into an INTEGER x 2 format.

   UP12, UP14, UP41 -- change of number record format. For example, UP14 is a translation of a number from a LOGICAL x 1 into an INTEGER x 2 format.

2) Threshold operations on images.
   DISKM2 -- replacement by zero of all image elements whose modulus exceeds a certain specified number.
   MIMA2 -- determination of the maximum and minimum image element and the coordinates of this element.

3) Image differentiation operation.
   PDS9 -- calculation in a nine-point scheme of a matrix of second derivatives by the space of the image:

$$\begin{vmatrix} \frac{\partial^2 f}{\partial x_1 \partial x_1} & \frac{\partial^2 f}{\partial x_1 \partial x_2} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2 \partial x_2} \end{vmatrix}$$

PDT8 -- calculation of the second derivative vector by space and time for images which change with time using an eight-point scheme: /21

$$\begin{pmatrix} \frac{\partial^2 f}{\partial x_1 \partial t} \\ \frac{\partial^2 f}{\partial x_2 \partial t} \end{pmatrix}$$

4) Averaging of image arrays.

AA average of two images.

AVER average by area.

AVEGA 2 average with normal distribution.

MEAN average by circumference. The program is used during image transfer from tape to tape.

5) Geometric operations.

DLINE separation of a line from the image array.

CLIMN separation of a column from the image array.

YEAX multiplication of the matrix by a vector.

INVERS inversion of the symmetrical real matrix.

6) Coordinate system change.

DTOPOL rewriting an image given in Descartes coordinate system into a polar coordinate system.

POLDOT rewriting an image given in a polar coordinate system into a Descartes system.

REVOL rotation of an image specified in a Descartes coordinate system.

POULR change from Descartes coordinate system into a polar system with exponential readings for the radius.

DECPOL change of a vector specified at each point of the image from a Descartes into a polar coordinate system.

7) Synthesis of test images. /22

SQRTI location of a square in image field.

IMK location of a cross in image field.

CRDSTK location of a square grid in image field.

8) Visualization on the Alphanumeric printer (ATsPU).

SLIDE halftone visualization of image lines recorded in an INTEGER x 2 form.

SEE halftone of the visualization of a 128 x 128 element array in LOGICAL x 1 format.

PDV2 preparation of the array for numeric-alpha visualization.

NSEE numeric-alpha element visualization. The natural order is coded in the series 0,1,2.... A,B,C....Z. The minus sign is represented by an overprint above the number or letter.

PNEO2 to print non-zero elements of the image array.

SLIDE 1 halftone visualization of image lines read in LOGICAL x 1 byte form.

9) Visualization on OPTRONIKS.

PCTML preparation of a image file tape initially recorded in COMPLEX (random dimension) for visualization on the OPTRONIKS. There is an output mode only on the ATsPU. Provides automatic brightness control.

RMDST reading of image with automatic aperture change into a file of a given COMPLEX dimension.

PCTURE preparation in a tape file image initially recorded in COMPLEX format 128 x 128 for visualization on OPTRONIKS (the image can be output only onto the ATsPU). Automatic brightness control. /23

INPMST reading of images in COMPLEX 128 x 128 array with automatic aperture change.

10) Algebraic operation on the image.

SUMMA2, SUMMA summation of all image array elements for various formats.

MEMPLN point summation or a product of two images (matrix), COMPLEX format.

AMULT point product of two images. Format— COMPLEX

MULT1) multiplication of all image array elements by
MULT2) number. Formatted in LOGICAL x 1 and INTEGER x 2.

TRNSP transposition of a rectangular matrix. Format: COMPLEX.

CONTG complex conjugate of a rectangular matrix. Format: COMPLEX.

LEGPLN taking the logarithm, taking the anti-logarithm, and complex conjugate of images. Format: COMPLEX.

LOMU1) taking the log with simultaneous multiplication of
LOMU2) the result of a specified number. Formats: LOGICAL x 1 and INTEGER x 2.

RA2 inversion of the 2 x 2 matrix. Format: REAL x 4.

INVERS inversion of the symmetric real matrix of arbitrary dimensions.

11) Fourier transformation /24

DQFT1, RQFT1 - forward and inverse fast discrete Fourier transformations of one-dimensional arrays. Format: COMPLEX.

SQFT2, RQFT2 - forward and inverse fast discrete Fourier transformations of two-dimensional arrays. Format: COMPLEX.

FTPLNE forward and inverse fast discrete Fourier transformations of a 128 x 128 COMPLEX array.

FURML forward and inverse fast discrete Fourier transformations of two dimensional COMPLEX arrays of $2^p x 2^p$ (p = 3,4.....) dimensions. Automatically selects the operating mode with an external memory depending upon the assigned operating range of the operational memory.

FFTRFT fast one-dimensional discrete Fourier transformations. Format: COMPLEX.

12) Generalized harmonic analysis of images.

FTFB fast Fourier-Bessell transformation.

FILT generation of a filter for Fourier-Bessell transformation.

BESO computation of Bessell zero-index functions with the aid of a series.

BESF computation of Bessell zero-index functions.

GAMMA1 computation of a gamma function of complex argument with the aid of Fourier transformations.

GAMMA computation of a gamma function of complex argument with the aid of series-products.

13) Computation of correlation functions.

CORF computation of correlation function of two images with the aid of fast Fourier transformations.

14) Computation of complex filters. /25

FLTRB generation of an exponential filter with a radial-symmetric characteristic.

FLTRC generation of a random radial-symmetric filter.

FLTRD generation of a trapezoidal filter.

FLTRE generation of a cross-shaped zero filter.

PSHSIN generation of a sinusoidal lattice.

FLTRA generation of a filter "hole."

15) Interpolation programs.

MODNEU selection of parameters of an arbitrary (generally speaking, nonlinear) function for the best description of the set of points. A modified Newton method is used for finding the multidimensional local minimum.

16) Auxiliary programs.

TIMER computation time in machine hours.

MEMREX creating copies of a complex 128 x 128 array in an external memory file, inverse swap. Upon demand, the subroutine rearranges the image quadrants for matching filters with Fourier transformation algorithms.

TOCOM transfer of images from the arbitrary array into a COMMON block.

OUTCOM transfer of images from COMMON block into a random array.

17) Main programs of the "SOFI" complex.

NEXTV objective subprogram of calls of absolute moduli from the "SOFI" library.

V 000 000 - absolute modulus for initiating execution of the complex ("task load").

V 000 0001 - absolute modulus for controlling the SOFI complex execution. /26

3.1.4. Total volume of the subprograms of the complex is 75 K bytes.

3.1.5. Program status: Experimental use.

3.1.6. Documentation: IKI preprints with a description of algorithm and programs.

3.1.7. Programmers: Zolotukhin, V. G.; Grushin, V. A.; Debabov, A. S.; Kolosov, B. I.; Tkhabisimov, K. K.; Usikov, D. A.

3.2. Program for Determining the Parameters of a Model when Processing Experiment Results (MODNEU).

3.2.1. Program type: Applied.

3.2.2. Language: FORTRAN-IV.

3.2.3. Algorithm content: The program allows:

a) selection of optimal parameter values for the theoretical model;

b) detection of mistakes of recovered parameters by errors in experimental data;

c) assessment of the adequacy of the model and of the experiment.

The algorithm is a modified Newton method. The program allows simultaneous processing of up to 400 experimental points and the location of up to 20 model parameters.

Parameter dependence -- any, including nonlinear.

The printing format and error diagnostics are used in assigning the initial data to the program.

3.2.4. Program size: 10 K bytes.

3.2.5. Program status: Experimental use.

3.2.6. Documentation: Preprint.

3.2.7. Programmer: Usikov, D. A.

3.3. Program for Determining the Field of Object Velocities in Photographs of a Scene Obtained at Two Adjacent Moments in Time (CLOUD). /27

3.3.1. Program type: Applied.

3.3.2. Language: FORTRAN IV, DOC EC.

3.3.3. Algorithm content: The program determines the field of velocities of objects in photographs obtained at two adjacent moments in time. For example, it uses shifts of cloud images in photographs of the Earth from geostationary satellites for determining velocity.

Depending upon the time interval separating the photographs, different algorithms and methods are used. For short intervals, there is an especially designed method for computing the velocity field; for long intervals, it is a correlational analysis of the basis of fast Fourier transformation algorithms.

The program processes photographs recorded on tape.

The program utilizes subroutines for image processing from the "SOFI" complex.

3.3.4. Program size: 20 K bytes.

3.3.5. Program status: Phase processing.

3.3.6. Documentation: None.

3.3.7. Programmer: Usikov, D. A.

3.4. Calculation of Light Penetration Through the Atmosphere of Planets in Heterogeneous Plane-parallel Geometry with Specific Scattering Indices.

3.4.1. Program type: Applied.

3.4.2. Language: FORTRAN-IV, DOC EC.

3.4.3. Algorithm content: Calculation is done by the Monte Carlo method in standard geometry of scattering media and processes. The program permits determination of light scattering from a thin light ray entering at a given angle /28

into the atmosphere as a function of surface coordinates.

The program also permits the determination of various atmosphere albedos and the transmission function (space-Earth, space-space, Earth-Earth, etc.).

Initial data: Cross-section of reactions of atmosphere and aerosol scattering and conditions depending upon the altitude and scattering index.

3.4.4. Program size: 10 K.

3.4.5. Program status: Experimental use.

3.4.6. Documentation: None.

3.4.7. Programmers: Zolotukhin, V. G.; Usikov, D. A.

3.5. Processing Data on Various Operating Modes for Spherical Ion Traps (ICZI, ICNP).

3.5.1. Program type: Data processing.

3.5.2. Language: FORTRAN-IV, DOC EC. Adaptation for other equipment having FORTRAN-IV.

3.5.3. Algorithm content: The program uses the expansion into linear and nonlinear parts of minimizing sum of squares.

The algorithm can be used for processing data obtained from traps with a decreasing potential.

Initial data is on magnetic tape, prepared in standard form.

Execution of the program results in determination of ion composition, concentration of appropriate ions, plasma temperature, and the potential of the satellite.

3.5.4. Program size: 50 statements. /29

3.5.5. Program status: Experimental use.

3.5.6. Documentation: Preprint with algorithm description.

3.5.7. Programmer: Tsoi, K. A.

4. SUPPLEMENTARY PROGRAMS /30

4.1. CHARGE Program for Loading Initial Data into the "OZhuR" Information-Reference System.

4.1.1. Program type: "Data processing."

4.1.2. Language: PL/1, version 2.0 in a DOC EC computer system.

4.1.3. Algorithm content: Initial loading of schedule identifiers into the "OZhuR" System, each of which defines the data received at the IKI AN SSSR on telemetry magnetic tape from several ground receiving stations during a communications session with specific spacecraft, loading data in reference to Moscow time of operating modes of spacecraft telemetry systems and information on the magnetic tape registration numbers, data inspection speed, deliveries. All or part of this information can be input both simultaneously with schedule identifiers ("LOAD" mode), as well as sequentially ("MODIFICATION" mode). The program also permits correcting of errors in all data except schedule identifiers while operating in the "MODIFICATION" mode. Data for program execution is prepared on punchcards. Special blanks are used during preparation. The procedure uses an external "OJUR" procedure to ensure access to the system data banks.

4.1.4. The program size is 72 statements.

4.1.5. The program is part of the "OZhuR" system and is in use along with scientific telemetry information processing programs.

4.1.6. Operational documentation exists.

4.1.7. Programmer: Evdokimov, V. P.

4.2. SHOW Program -- Reception of Information on Data Processing Phase Execution in a Preliminary and Initial Scientific Telemetry Information Processing System. /31

4.2.1. Program type: "Data processing."

4.2.2. Language: PL/1, version 2.0 in a DOC EC computer system.

4.2.3. Algorithm content: Sorting of "OZhUR" system data bank contents by spacecraft name for obtaining a schedule identifier list by increasing numbers of schedules and a list of data processing phases conducted for a given schedule. Initially, the sorting is determined by assignment of initial schedule number. During the sorting process, the quantity of schedule identifiers, the quantity of various communication schedule numbers and the maximum number of data processing phases is estimated. Besides this, a table containing the quantitative and percentage schedule content conducted for all previous data processing phases of the given

spacecraft is produced. Depending upon the operating mode, the list of identifiers and statistical data can be printed jointly or separately.

4.2.4. Program size: 115 statements.

4.2.5. The SHOW program is in use and is part of the "OZhUR" System.

4.2.6. Operational documentation exists.

4.2.7. Programmer: Evdokimov, V. P.

4.3. WEGOT Program -- Obtaining Information on Telemetry Magnetic Tapes Recorded in the "OZhUR" Information-Reference System.

4.3.1. Program type: "Data processing."

4.3.2. Language: PL/1, version 2.0 on a DOC EC computer system.

4.3.3. Algorithm content: Sorting the "OZhUR" system data bank contents /32 by assigned spacecraft name to obtain a list of communications schedules and corresponding telemetry magnetic tape numbers received at the IKI AN SSSR for a specified time period. The program simultaneously provided statistical data on the ground receiving station load during operation with a specific spacecraft. Sorting of supplementary indicators can be conducted in various operational modes: ground station number and the onboard telemetry system operating mode; the production of a list of schedules with station load data can be made simultaneously or separately.

4.3.4. The program size is 135 statements.

4.3.5. The program is in use and is part of the "OZhUR" System.

4.3.6. Utilization documentation exists.

4.3.7. Programmer: Evdokimov, V. P.