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DETERMINATION OF THE OBSERVATION CONDITIONS
OF CELESTIAL BODIES WITH THE AID OF THE
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DETERMINATION OF THE OBSERVATION CONDITIONS
OF CELESTIAL BODIES WITH THE AID OF THE DISPO
SYSTEM

R.K. Kazakov and A.V. Krivov

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Nebesnykh Tel s Pomoshch'yu sistemy DISPO", Academy
of Sciences USSR, Institute of Applied Mathematics,
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A N N O T A T I O N

The interactive system for determining the observation conditions of celestial bodies is described in the present work. A system of programs has been created containing a part of the DISPO (Display Interactive System of Orbit Planning) of the IPM (Institute of Applied Mathematics) of the AN (Academy of Sciences) of the USSR.

The system is designed for computation in the man-machine dialog mode of the position and movement of celestial bodies relative to the NIPs (Observation Measuring Points) located on the surface or close to the Earth's surface. The program facilities of the system make it possible to effect the output of resulting quantities in both tabular and graphic form on a display screen with the use of the facilities of interactive machine graphics. Capability is provided to automate operations for the creation of film-illustrative material based on the graphic facilities of the system.

The system was used for calculating the observation characteristics of Halley's comet during its approach to Earth in 1985-86.

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DETERMINATION OF THE OBSERVATION CONDITIONS OF CELESTIAL BODIES WITH THE AID OF THE DISPO SYSTEM

R. K. Kazakov and A.V. Krivov

INTRODUCTION

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The determination of the visibility conditions of celestial bodies from a ground, air or orbital observation point is a necessary link in the problems of planning and organizing astronomical observations and space experiments. Here we are concerned, in particular, with problems in the creation of ephemeris support of the programs of observation of natural bodies in the solar system. These problems arouse special interest in connection with the creation and functioning of artificial bodies, space vehicles of different types, AES (Artificial Earth Satellites) and their systems.

In many cases of this type (the formulation of retrieval ephemerides), ephemeris information of high precision is frequently not required. Therefore for small intervals in the prognosis of observation conditions, it is possible to confine oneself to approximations of the real motion by some simple model frequently even a Keplerian (unperturbed) orbit is sufficient, and the use of "spacing" of Keplerian curves or an Eulerian orbit [1] provides the necessary precision in the overwhelming majority of cases. In this work Keplerian or Eulerian elements (if necessary, periodically corrected) will be the input information about the object of observation.

* Numbers in margin indicate foreign pagination

The use of simple models of the movement of the Earth and the observed celestial bodies makes it possible to create a program system which would provide the calculation of ephemerides by fast-operating algorithms, would present to the user important conveniences for the input and correction of data and would have a developed set of capabilities for the presentation of resulting information in digital and graphical form, with recording on various media, etc.

An attempt to satisfy all these requirements was the "visibility" program system, created in the IPM (Institute of Applied Mathematics) of the AN, USSR based on the SDS-910 computer and comprising a part of the DISPO system [2,3,4] which has already been successfully used for many years. The given system, just like the other DISPO programs is interactive, i.e., it operates in the man-machine dialog mode. The selection of the computer for system implementation is dictated by the presence in the SDS-910 of a developed set of hardware and software facilities of interactive communication. Among the hardware dialog facilities one must include the "Graphic display - light pen" system; among the software - the set of subprograms supporting the interactive process by means of the set of "light buttons" and the LINK device [5]. The components of the system of programs and subprograms are written in the Fortran-II language for the SDS-910 computer [6].

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The system being examined makes it possible, in interactive form to enter and correct the input data, carry out for a sequence of time moments the calculation of series of topcentric characteristics of the observability of the object--the horizontal and equatorial coordinates, range, range rate, as well as a series of auxiliary quantities, and to achieve the output of results in digital form or graphic form, with a distribution of information to an a wide ATsPU (printing device), a DS (display screen), graph-plotter, and MT (magnetic tape). Special modes of operation of the system for obtaining film-illustrative material are based on the calculated ephemerides.

Despite the fact that a specific program to implement the system is accomplished within the framework of the DISFO system of the IPM AN, USSR, the general design principles of the system of programs for the calculation of ephemeris information, developed in the present work, can be recommended to a wide circle of persons interested in the building of similar systems based on different hardware and software support.

The authors take this opportunity to express their deep gratitude to K.L. Volkova, L.T. Gromova and L.A. Myryshkina for the great help in creating the "Visibility" system, installing and surveying film-illustrative material on observations of Halley's comet.

§I. The Algorithm for Calculating the Visibility Conditions of Celestial Bodies

I.I. The selection of a model of motion and reducing calculations

The algorithm for calculating ephemeris information about an object is broken down into two stages. In the first stage the position vectors and the velocity of the object relative to the center of mass of the central body are calculated. The second stage consists of the conversion of these quantities to a coordinate system: geocentric (if the central body is not the Earth) and topocentric. Then the desired topocentric quantities, comprising the ephemeris, are calculated. The following are adjusted to the point of the NIPs (observation-measuring points) by these quantities:

Elevation	$\tilde{\delta}$	Declination	δ	Range	D
Azimuth	A_0	Right ascension	d	Range rate	\dot{D}

This set of quantities is, evidently, sufficiently complete, since it responds to the interests of a wide circle of users of ephemeris information. The azimuth coordinates directly reflect the

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accessibility of the object to observations and can be used as a rough guide to users applying a device on an azimuth installation; the equatorial coordinates are of interest in the organization of observations by means of classical astronomical instruments; the range is important in the observations of small bodies of the solar system and, in addition, can be useful in the case of laser or radar range finder measurements; the value of range rate is necessary in the use of narrow-band receivers for the calculation of the Doppler frequency shift.

At the same time the elevation of the Sun is calculated with these values. This makes it possible to determine whether the current instant of time is related to the dark or to the light time of the day.

To effect a specific implementation of the two stages of the algorithm described for the calculation of low precision ephemerides (of the research type, at the planning stage of a flight to celestial bodies) it is necessary to assume a model of the motion, which can be rather crude, but must be fast-operating and economic in the computation sense. For this, it is necessary to discard the method of approximation of the actual complex motion of the celestial body occurring under the action of all possible perturbing factors; to select those factors whose calculation is necessary for the attainment of the required precision, and neglect the rest. We shall consider both stages of the algorithm from this point of view.

The set of parameters specifying the orbit of the body and the current instant of time are the input quantities for the first stage. Whether or not parameters are in fact included in this set depends on the method of approximating a perturbing motion. Different versions having different precision and difficulty are possible. We shall point out the main ones:

1. The maximum possible calculation of perturbations. For example, the totality of the values of the osculating elements at the current instant of time is taken (for this a preliminary integration of the equations of perturbed motion is of course required) as a set of parameters. In this case with the passage from one instant to another, the values of all the parameters are changed. This leads to a large volume of input information. /6

2. A partial calculation of the perturbation by means of an approximation of the actual motion of a "spliced" Keplerian orbit. For example, the Keplerian elements, which are periodically adjusted, are taken as the parameters in this case. Thus, in the passage from one instant to another, the parameters are not changed each time.

3. The approximation of an Eulerian orbit. Eulerian elements are taken as the parameters.

4. The approximation of the perturbed motion of an unperturbed orbit. In this case the set of parameters is an aggregate of six Keplerian elements. It remains constant in the scanning of the current instants.

The class of celestial bodies for which it is possible to abandon the complete calculation of the perturbations (Method 1) is defined by the required precision and time interval in which this precision has to be guaranteed. For the investigation of comets, the requirements for precision are not great. Such a class of objects will be sufficiently extensive. More than this, in most cases not even the use of a "splicing" of Keplerian orbits or a Eulerian orbit (Methods 2 and 3) is required, but it is sufficient to use the rather rough, but economical in the computation plan, Method 4 the approximation of the motion of an unperturbed orbit. The exceptions comprise only the remaining situations: close approaches of comets to large planets, the initial and final portions of the trajectory of a space device and a few others.

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In Table I are shown δ - declination and D - the range of Halley's comet for the Ashkhabad NIP, calculated by two methods based on the complete calculation of the perturbations and by means of an approximation of the unperturbed orbit, i.e., corresponding to Methods 1 and 4. The data according to the use of Method 1, taken from [7] are obtained on the basis of the numerical integration of the equations of motion with regard for the perturbations of 8 large planets. In the calculation by Method 4, the set of values of the osculating elements at the instant the comet will pass perihelion on 9 February 1986 is taken as the fixed Keplerian elements.

It is seen that errors in an angular quantity (declination) do not exceed 22' in the neighborhood of the pericenter, and decrease rapidly at a distance from it (for several months before it and during several months after it, the deviation is already less than 1'). The range error for every interval considered does not exceed 2 million kilometers, i.e., it comes to about 0.4%. These values for ephemerides of the research type are fully acceptable.

TABLE I

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Date	δ - Declination		D - Range, millions of km	
	Method 1	Method 4	Method 1	Method 4
05.01.1985	12° 5.4'	12° 5.9'	646.1	645.2
06.03.	13 46.9	13 47.4	686.7	685.7
05.05.	16 18.6	16 19.3	732.3	731.8
02.09.	19 21.6	19 23.5	441.3	439.8
01.11.	21 46.7	21 52.0	161.1	169.4
31.12.1985	- 2 14.1	- 2 28.0	170.4	170.9
01.03.1986	-16 12.4	-16 34.0	189.8	188.8
30.04.	-19 16.9	-19 07.0	115.2	117.0
29.06.1986	- 4 59.7	- 4 59.8	400.9	402.8

The second stage of the algorithm is the transformation of the vectors of position and velocity to the desired ephemeris information. In this stage it is possible to neglect certain reduction calculations included in the classical astronomical system. We know it is possible not to consider those factors whose neglect

leads to errors amounting to several minutes of arc for angular quantities. Thus, corrections for nutation and aberration are not introduced. Refraction is also not considered since in the zone of accessibility of astronomical and navigational devices (Elevation 8) it does not introduce errors greater than 3'. The calculation of precession is also not made, since, as a rule, the orbit elements of a celestial body, which are entered as input data can be supplied at a time close to the observation instants, so that precession will essentially already be accounted for in the orbit elements. However, for example, the flattening of the Earth should be taken into account since the reduction, subjected to it, of the astronomical latitude of the point to the geodesic, and consequently of the correction to the angular ephemeris quantities, can reach an unacceptably large value in 12'. We would also risk an error of the order of 10' if we were to neglect the altitude of the NIP about sea level.

1.2. A specific implementation of the algorithm in the "Visibility" system.

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We shall consider in more detail a specific implementation in the "Visibility" system of the two algorithm stages described.

The first phase is program-effected in such a manner that the most convenient for the user are the Keplerian and piecewise-Keplerian approximation of motion, i.e., Methods 2 and 4. The use of Method 1 is also possible, however, as was noted above. This is connected with a sharp increase in difficulty, since the user must enter long series of values of the osculating elements. (For each instant these values will be his own). Method 3 has not been implemented in an operating version of the system. However, in case of need it is possible to modify in an appropriate fashion a number of the system modules so that this method could also be used. (For this it is necessary to introduce insignificant changes into certain program modules). The Eulerian model will not be considered further.

No matter which of the described models the user selects, in each current instant the 6 Keplerian elements and the adjusted mass of the central body, as well as the value of this instant, serve as the initial parameters defining the instantaneous orbit of the body. For brevity, we shall designate the set of these quantities by $\{\overline{r}, t\}$. Then the first stage should be considered as the transformation of the vector $\{\overline{r}, t\}$ into the vector $\{\overline{r}, \overline{v}, t\}$, i.e., into Cartesian coordinates and velocity components. This transformation is one of the main operations of DISPO, and is accomplished by access to the standard subprogram $\overline{3AK}$ [2,3,4].

In this case, if the object was designated by heliocentric ecliptical elements, and, consequently, the calculated coordinates and velocity components are referred to the heliocentric ecliptical system, the latter will then be transformed after the calculation of the Earth's heliocentric radius-vector (according to the elements of the Earth orbit available in the system) into geocentric ecliptical, and, finally by a rotation of the coordinate system about an angle $\epsilon = 23^{\circ}27'$ into geocentric equatorial coordinates. If, however, the object is designated by geocentric equatorial elements, then after the use of the operation $\overline{3AK}$ no additional transformations are required.

The second stage of the algorithm is the transformation of the vector $\{\overline{r}, \overline{v}, t\}$ into the set of ephemeris quantities listed in Para I.I. It is implemented in the form of a special subprogram. We shall /9 consider this stage in more detail;

We shall assume the following quantities are known:

- $x, y, z, \dot{x}, \dot{y}, \dot{z}$ - The coordinates and velocity components of the object in the absolute geocentric coordinate system;

- t - The current instant of Greenwich mean time;
- φ, λ, h - Astronomical latitude, longitude (considered positive eastward from Greenwich) and height of the NIP above sea level.

It is necessary to calculate the above-listed quantities $\gamma, A_0, \delta, \alpha, D, \dot{D}$. We shall convert from astronomical latitude and NIP elevation to two equivalent quantities - the distance from the center of the Earth to the NIP Point R and the geocentric latitude ϕ [8].

$$R = R_3 (1 - \alpha_0 \sin^2 \varphi) + h$$

$$\phi = \varphi - \alpha_0 (1 - h/R) \sin 2\varphi,$$

where R_3 - is the equatorial radius of the Earth (6378160 M);
 α_0 - is the flattening of the terrestrial ellipsoid (0.0033529).

We now make a transformation to the Greenwich coordinate system (a geocentric cartesian system whose abscissa axis passes through the point $\varphi=0, \lambda=0$, Z-axis - through the North Pole, and ordinate axis expands the triad to the right):

$$x_1 = x \cos \psi + y \sin \psi$$

$$y_1 = -x \sin \psi + y \cos \psi$$

$$z_1 = z$$

here ψ is the sidereal time at the Greenwich meridian, corresponding to the instant t of Greenwich mean time. In the given algorithm, it is assumed

$$\dot{\psi} = \psi_0 + \Omega (t - t_0),$$

where $\psi_0 = 6^h 42^m 07^s$; $t_0 = 1977$, January 1,

h	m	s
0	00	00

,

and the number of sidereal periods in some mean periods $\Omega = 1.0027379$. It is natural that for a certain class of objects (low MES) the precision of the last formula may be insufficient, and at least a periodic adjustment of the null-point (ψ_0, t_0) will be required. But for the

overwhelming majority of cases, this formula may be used without reservations.

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In the same system, Greenwich, the NIP coordinates will be:

$$\begin{cases} A = R \cos \varphi \cos \lambda \\ B = R \cos \varphi \sin \lambda \\ C = R \sin \varphi \end{cases}$$

We get the relative coordinates of the object (i.e., Greenwich topocentric coordinates):

$$\begin{cases} \alpha = x_1 - A \\ \beta = y_1 - B \\ \gamma = z_1 - C \end{cases}$$

and the range is $D = \sqrt{\alpha^2 + \beta^2 + \gamma^2}$

Now the declination and right ascension of the object are determined from the formulas:

$$\sin \delta = \gamma / D, \quad \delta \in [-90^\circ, 90^\circ]$$

$$\begin{cases} \cos \alpha = (\alpha \cos \psi - \beta \sin \psi) / \sqrt{\alpha^2 + \beta^2} \\ \sin \alpha = (\alpha \sin \psi + \beta \cos \psi) / \sqrt{\alpha^2 + \beta^2}, \end{cases} \quad \alpha \in [0, 360^\circ]$$

Next we shall calculate the horizontal topocentric coordinates of the object. For this we shall form the matrix of transition from the Greenwich topocentric to the horizontal topocentric coordinate system:

$$\| \delta_{ij} \| = \begin{pmatrix} -\cos \lambda \sin \varphi & -\sin \varphi \sin \lambda & \cos \varphi \\ \cos \varphi \cos \lambda & \cos \varphi \sin \lambda & \sin \varphi \\ -\sin \lambda & \cos \lambda & 0 \end{pmatrix}$$

The cosine of the Zenith distance, i.e., the sine of the elevation, is equal to the scalar product of the topocentric radius-vector $\{\alpha, \beta, \gamma\}$, normalized to unity, and the directional unit vector to the Zenith at the point of the NIP (second row of the matrix:

$$\sin \gamma = (\alpha \delta_{21} + \beta \delta_{22} + \gamma \delta_{23}) / D$$

Then calculating the scalar products of the same radius-vector by the remaining rows of the matrix

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$$\xi = \alpha \delta_{11} + \beta \delta_{12} + \gamma \delta_{13}, \quad \eta = \alpha \delta_{31} + \beta \delta_{32} + \gamma \delta_{33},$$

we find the azimuth from the formulas

$$\sin A_0 = \eta / \sqrt{\xi^2 + \eta^2}, \quad \cos A_0 = \xi / \sqrt{\xi^2 + \eta^2}$$

Finally, we shall determine the radial velocity of the object. The velocity components on the Greenwich geocentric axes will be

$$\begin{cases} \ell = \dot{x} \cos \psi + \dot{y} \sin \psi + \Omega_0 \cdot B \\ m = -\dot{x} \sin \psi + \dot{y} \cos \psi - \Omega_0 \cdot A \\ n = \dot{z} \end{cases}$$

Here the last addends of the first two formulas reflect the rotation of the Earth with a velocity of $\Omega_0 = 1/13713.44$ radians/second.

The desired radial velocity equals

$$\dot{D} = (a\ell + bm + cn)/D.$$

§ 2. The Structure of the System and its communication with other program facilities of DISPO

The visibility system consists of two relatively independent program units where the coordination of the operation and the information interchange between them is effected by means of the LINK device available in the DISPO system. These parts, called henceforth the first and second LINK-blocks, or simply "Links" are individually written onto MT (magnetic tape). The need for such segmentation is caused by the large volume of memory which is required for the arrangement of the compiled operating programs of the system (about 45,000 cells of the SDS-910), which exceeds the volume of the machine's operating memory. However, the volume of each of the LINK-blocks does not surpass the capacity of an OZU (operating storage unit) of the SDS-910, and they are called up from the MT to the OZU alternately, according to need.

From the point of view of Fortran, each of the LINK-blocks represents an aggregate of a basic (control) program, a set of sub-programs which is a property of "visibility", as well as those

subprograms which play in DISPO a role of standard, but are necessary to the system during its functioning.

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The decomposition of the system into two LINK-blocks, in addition to the requirements of the machine implementation (limited by volume), is carried out also with regard for logical considerations. The first LINK-block centralizes in itself the facilities which in the interactive mode permit the introduction of the input information necessary for the operation of the system; the second LINK-block has two main functions - it performs directly the computational algorithm considered in §I, and accomplishes the output of results in the necessary form. Naturally, each of the links performs other functions also -- communication with other units of DISPO, the transfer of control to another link, the control of the sequence of execution constituting the given link of the module, access to the file of the constant of an information field, documentation, etc.

The operation of the system is initiated by an instruction to the "Visibility" light button situated on the upper button level of DISPO and is started in the first link; subsequently the transfer of control from one LINK-block to another is carried out by the program facilities of the LINK-block themselves, i.e., automatically and the information interchange between them is effected by means of the designated COMMON-cells of the information field, accessible by both links of the system and by other program units of DISPO which makes it possible in case of need to transmit the latest information generated in the operation of the system.

A more detailed program implementation of "visibility" is performed in accordance with the conception of modular programming. The main programs of both LINK-blocks are built of relatively independent parts - modules. They are not program separated units (independent programs or subprograms of FORTRAN), but distinctly separated in the logical sense (each of them has a rigidly defined function - for example, the input of some data group), and in the structural (any module is bipolar, with one input point and one output point). From the point of view of FORTRAN, each module is represented by a group of 30 - 250 operators. Such a distribution

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by magnitude was the price which had to be paid for the clear observance of the reason for the logical and structural separability (especially the latter).

The structure described (LINK-block and modular) provides the logical simplicity of the system, facilitates familiarization and operation with it. In addition, it significantly simplifies the insertion of changes and modifications, which enables us to consider "Visibility" an open system.

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The diagram of system interconnection with other program facilities of DISPO, reflecting both information interchange and links for the transfer of control, is depicted in Figure 1.

§3. The Interactive Operation with Respect to the Input of Initial Data

The structure and operating principles of the first LINK-block of the system will be described in this paragraph.

As was noted in Paragraph 2, the main function of this link is the bringing in of the necessary input information to the appropriate COMMON-cells of the DISPO information field. After completion of the input, operations control will be transferred to the second LINK-block, which retrieves this data, carries out its required transformation into the required ephemeris information and accomplishes its output in some form.

The link makes available to the user two main capabilities of data input. First, information can be entered from without, from various devices of the machine - from PC (punched cards), TT (teletype) and also from the DS by means of the light pen. Second, the link has its own small information field which besides an array of constants, contains data on a limited quantity of observation points (their coordinates), on certain more interesting objects of observation (the initial version contains orbital elements of Halley's comet), as well as a series of values of time parameters (their

meaning will be explained below), adopted as standard, Thus the user working with the first LINK-block can initiate a transfer of data from this internal list to the common information field of DISPO by a simple instruction to a button by means of the light pen which, of course, shortens the time needed for the input of initial data. Since the data which the user wishes to enter rarely coincides completely with the standard, one most often successfully uses combined input when part of the information is entered from without, and part -- by the "rapid" method, from the internal list.

The operation of the link is constructed on the basis of the questionnaire method of data entry. It is implemented on 9 pushbutton levels (Figures 2,3). Each of them has several functions. A series of light buttons (lists of standard objects, points, etc.) services the above-described method of entering data from the internal list. Other buttons are used for "external" input: They make it possible to select the desired set of quantities for the designation of any characteristic (for example, the object may be designated by both heliocentric ecliptic, and geocentric equatorial elements); to determine the external device from which data will be entered; to inform the system of the ending of the entry of the next data group, etc. Finally, there are special buttons which make it possible to control the sequence of data entry and artificially pass either to the second LINK-block or "upward" to the upper pushbutton level of DISPO. /17

As a whole, the interactive operation for information entry can be presented in the following manner. Operating with the light buttons with the aid of the light pen, the user enters in any sequence, by any of the methods described, in the most convenient and natural form, all the needed quantities. It is possible to use an incomplete entry, i.e., performing the processing of some variant of the initial data, to change quantities only partially and restart the machine for calculation. This makes it possible to "scan"

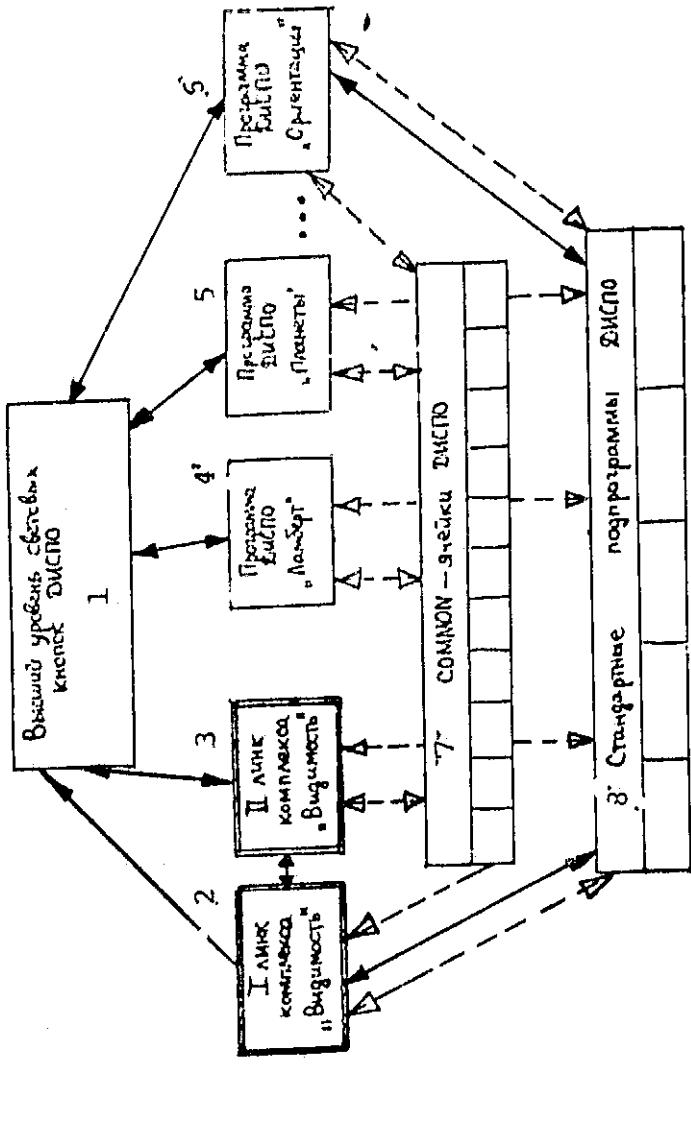


Рис. 1. Взаимосвязь комплекса с другими программными средствами ДИСПО

Figure 1. The interconnection of the system with other program facilities of DISPO.

- Key:
- 1--Higher level of DISPO light buttons; 2--I LINK of the "Visibility" system;
 - 3-- II LINK of the "Visibility" system; 4-- DISPO Program "LAMBERT";
 - 5--DISPO Program "PLANET"; 6--DISPO Program "ORIENTATION"; 7-- DISPO Common-cells;
 - 8--DISPO Standard subprograms; 9-- - - - Transfer of information; ———→ Transfer of control.

<p>OBJECT</p> <p>Elements Halley Heliocentric ecliptic Geocentric equatorial Up Down</p>	<p>ENTRY OF ELEMENTS</p> <p>DS PC TT</p> <p>Up Down</p>	
<p>3.P TAU AI Year Hour Month Minute Day Second</p> <p>E OM OMEGA</p> <p>Up Down</p>	<p>POINT</p> <p>1 Coordinate Map</p> <p>Up Down</p>	<p>1 Moscow - Presnaza Pulkovo Goloseyevo Simeiz Dushanbe IRKUTSK Greenwich</p>
<p>ENTRY OF POINT</p> <p>DS PC TT</p> <p>UP Down KV</p>	<p>LATITUDE LONGITUDE HEIGHT</p> <p>O " H M S KM</p> <p>Up Down</p>	
<p>ENTRY OF DATES AND STEPS</p> <p>DS PC TT</p> <p>Up Down</p>	<p>START DATE END DATE</p> <p>Year Hour Year Hour Day Minute Month Minute Month Second Day Second</p> <p>Step 1 Step 2 Hour Hour NCL * KV * Up Down</p>	

Figure 2.

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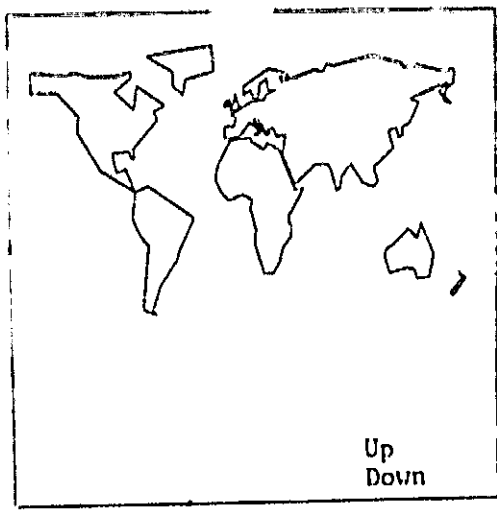


Figure 3. Representation of the world map for the entry of geographic coordinates.

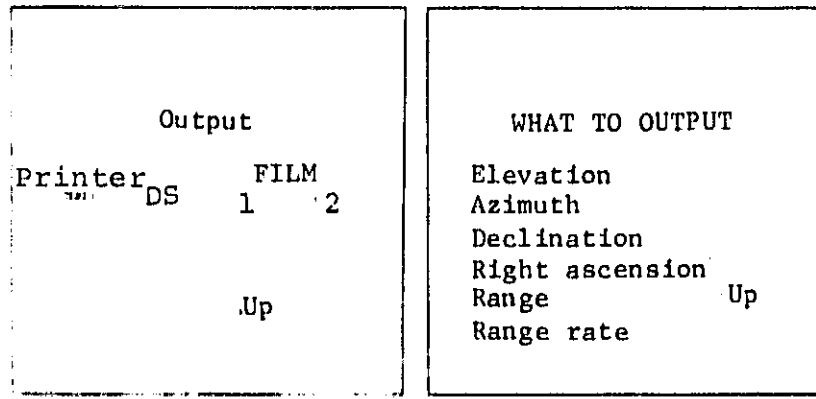


Figure 4. The levels of light buttons for information output.

- 1. Fullmotion Film
- 2. Continuous Motion Film

quickly the different variants - to vary the objects of observation, NIP's, time characteristics, etc.

We shall now consider the construction of the first LINK-block and its capabilities in more detail, at the module level. For the calculation of ephemeris information, three groups of numerical data are necessary: data on the object of observation, on the observation point and a number of parameters defining the sequence of instants at which the calculation of ephemeris data is carried out. According to this, the link is built up from three modules, each of which enters its own group of parameters.

The "object entry" module: During "internal" entry by means of the "Halley" button it is possible to transmit the elements of Halley's comet to the information field. During of "external" entry, there is the ability to enter orbital elements -- from PC, TT or ED. If the given celestial body revolves about the Sun, it is given ecliptic elements; if, however, the orbit is geocentric, then it is necessary to use equatorial elements.

The "point entry" module: There are the following capabilities of NIP designations: the "internal entry of the coordinates of one of seven points: Moscow- Presnya, Pulkavo, Calosevo, Simeiz, Dushanbe, Irkutsk, Greenwich; - the "External" entry - explicit entry of latitude, longitude and height from PC, TT or ED; -- calling to the ED of the world map representation and the indication by the pen on any location of it, as a result of which the automatic calculation of geographic coordinates corresponding to the indicated point and the transmission of them to the information field take place. /18

The "dates and steps" entry module: The parameters "start date", "end date", "Step 1" and "Step 2" make it possible to prescribe an aggregate of time instants for which the calculation of the characteristics of object visibility will be carried out. This set of instants in the system considered has a rigidly prescribed structure of the following form. It consists of a set of sequences of instants, up to 49 instants in each sequence, where the origins of the sequences are uniformly distributed along the time axis from "start date" to "end

date" with a step equal to "Step 1". Moreover, each sequence covers a time interval equal to "Step 2".

The structure described is flexible enough and especially convenient for making film-illustrative materials, since it permits to a known degree the automation of the process of creating film sections.

The indicated time parameters, like the preceding two groups of data, can be entered by both the "internal" and "external" methods. Additional facilities are provided for the use of "incomplete entry".

All of the entered data is documented by each of the opening modules for TT and printer. At the conclusion of input and documentation, the modules carry out a transformation of the data to a form necessary for the computing process, and in this form place them in the DISPO information field.

§4. Forms of Presentation of Output Ephemeris Information

The work of the second LINK-block is begun in the module "indications of the output quantity and output form". By means of the two push-button levels, the user is queried as to which of the ephemeris quantities are of interest to him in which form to output them (tabular or graphic) and which require action (for example, writing the graphs obtained) on [12]. The code number of the operation mode selected by the user for output and information on the quantities subject to output are transmitted to special cells whence they will then be retrieved and used by the next module of the second link - the module "calculations and output" (the push-button levels are depicted in Figure 4).

/19

The quantities listed above -- elevation, azimuth, declination, right ascension, range, range rate of the object and the elevation of the Sun, constituting the principal ephemeris information -- are calculated in turn for each of the sequences of instants described

in §3, and are packed into arrays, localized in the given link. This information will be transformed and output in numerical or graphic form. However, as follows from §I, during calculation other information is also generated. Certain of these intermediate quantities, for example, heliocentric and geocentric cartesian coordinates and velocity components of the object and the Earth, are available to other DISPO programs, since they are transmitted to the COMMON-cells of the information field. In addition this auxiliary information may also be necessary to the user; he can take out such quantities for printing, by operating the binary keys on the machine console.

We shall consider in more detail the system's operating modes with respect to the output of the main ephemeris information. There are three modes, conventionally called "DS", "Full Motion Picture" "Continuous Motion Picture". In all cases, the ephemerides are represented on the DS in the form of graphs giving a time function of one of the quantities $\gamma, A_0, \delta, \alpha, D$. . As only one of these modes is ordered, the buttons light up quickly, indicating on which one it is possible to select the relevant output quantity. Each graph corresponds to one of the sequences of instants.

In addition, to the points of the curve giving the time function of the selected quantity, "shade" is inscribed on the graph. The fact is that the elevation of the Sun γ_0 is determined simultaneously with the calculation of the visibility of the comet. In this case, the elements of the Sun (with regard for sign) will be the input into the visibility calculation block. The elevation of the Sun is required for a more descriptive representation of comet visibility on the graphs. If $\gamma_0 \geq 0$, , than a vertical band is traced on the graph, "shade" appears, corresponding to the dark time of the day. If $\gamma_0 > 0$, , then the vertical band is not inscribed. Consequently this instant is related to the daylight hours.

Under the time axis from the left and right, the dates are illuminated (day, month, year, hours, minutes, seconds). The marking of the ordinate axis for elevation and azimuth is fixed: -90° , 90° , 0° , 360° (degrees). For the quantities δ , α , D , \bar{D} , the program finds the lowest and highest values of a quantity in a given interval and automatically selects the scale along the ordinate axis (Figure 5,6). In this case the appropriate documentation is available by printing on teletype. /20

Simultaneously with the graph, a set of light buttons is illuminated on the DS to support the interactive mode of operation in the calculation and the graphic output of the ephemerides. The buttons give to the user the ability to intervene at the right time in the computation process and in the image visualization process, to exit promptly from the given module for the purpose of data correction, to change the computation sequence, to perform an output of the image at any stage of its construction to the graph plotter, recording it on MT, etc. The button "ATsPU" makes it possible to output all the ephemeris information in digital form (Table 2-10).

Everything said above pertained in equal measure to all three modes. We shall consider the differences among them. In the ED mode, the graph is constructed on the ED and at the completion of construction is illuminated as long as the user does not indicate otherwise on the light button. In particular, for the program to pass to the construction of the next graph (for the next sequence of instants), an indication on a special button is required. In the "full motion picture" at the completion of construction of the next graph, the image is automatically written on to MT, and a transfer to the new calculations is immediately affected and then to the construction of a new graph and so on. The operation of the system also proceeds in a similar manner in the "continuous motion picture" mode, but in this case the writing on MT of not only each graph, but all stages of construction of

each graph, takes place (in the construction of a graph on the DS, the axes, the numbering of the axes, the legend explaining for which of the quantities the graph is being constructed appear sequentially; then the points of the curve - one, two, ...49 appear in turn on this background).

From what has been said, it is clear that the modes "Full Motion Picture" and Continuous Motion Picture are oriented toward the creation of film-illustrative materials, which reflect the dynamics of change in the ephemeric quantities in graphic form. For practical operation in taking the appropriate film sections, there are in DISPO special program facilities. The sequence of images recorded by the "visibility" system is visualized on the DS by means of a special monitor program, is edited and photographed on a movie film by a movie camera synchronized with the DS [9]. Immediately after connection to DISPO, the "visibility" system was used for operations of this nature in the planning of film sections dedicated to the impending appearance of Halley's comet in 1985-1986. The results of the calculations carried out in this case, obtained by means of the visibility system, are covered in the following paragraph. /23

§5. The Results of the Calculations of Visibility Conditions for Halley's Comet in 1985-86.

The visibility conditions for Halley's comet in 1985-86 were calculated by means of the system described. The calculations are carried out for a number of NIP's located both in the northern and southern hemispheres. Moreover, the input parameters, especially "dates" and "steps" described in §3 were widely varied.

The resulting information was output in graphical and digital form. In the case of graphic output, the sequences of images, illuminated on the DS, were written onto pc which made it

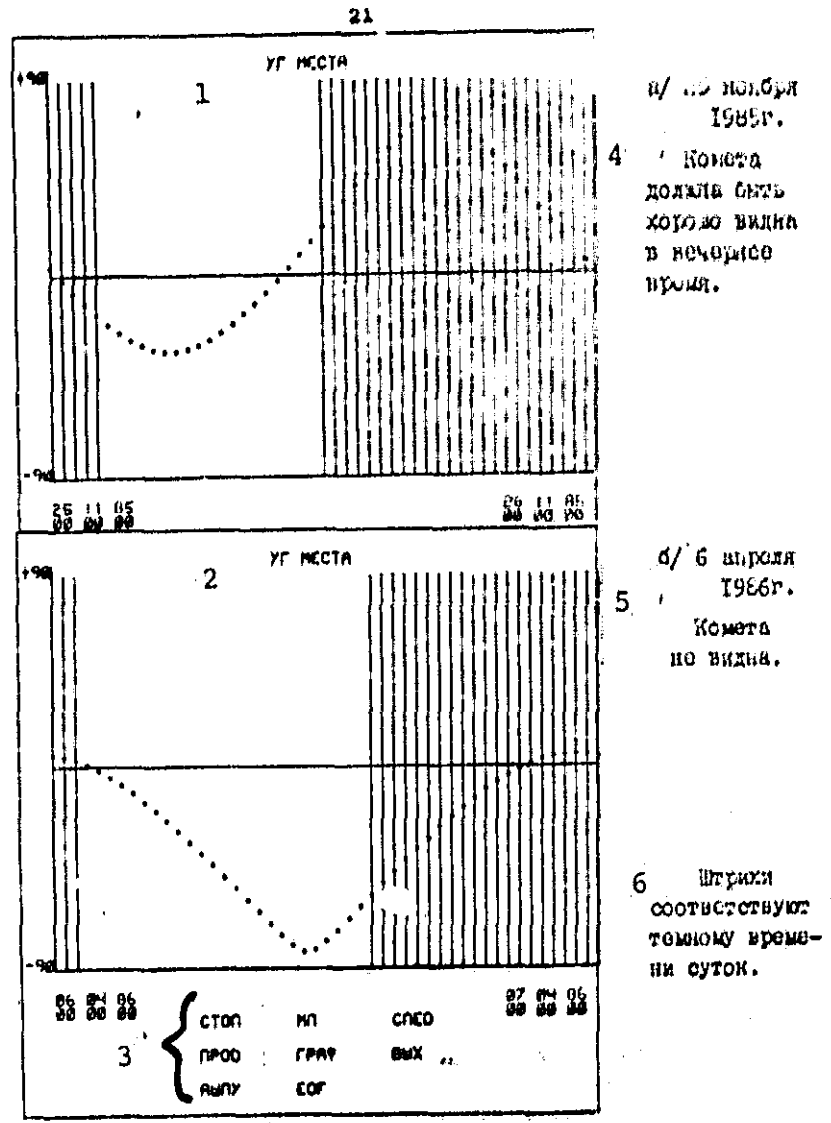
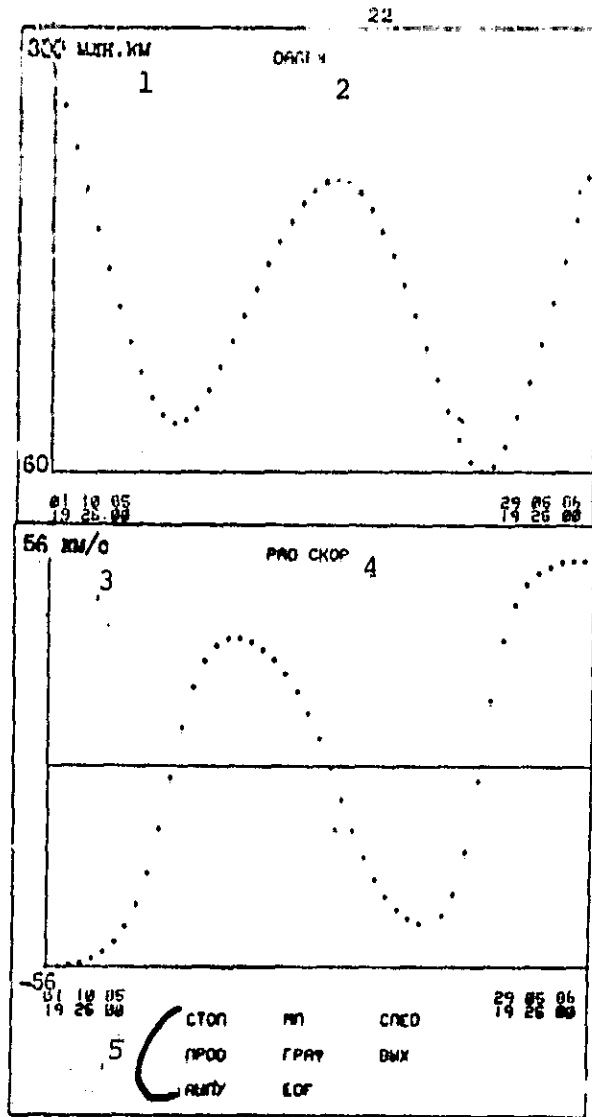


Figure 5. Dushambe Observation Point.

Key: 1--Elevation; 2-- Elevation; 3-- Stop MT SLED (next)
PROD GRAPH Output
PrinterEOF

4-- 25 November 1985 Comet must be easily seen during evening hours; 5--6 April 1986. Comet not visible; 6--Strokes correspond to dark time of day.



(a) Range. 1st minimum
11/27/85. Second minimum,
4/10/86.

(b) Range rate

Figure 6. Dushanbe Observation Point.

The change in range and range rate in the period
from 1 October 1985 up to 29 May 1986.

Key: 1-- Millions of kilometers; 2--range; 3--kilometers/second;
4-- Range rate; 5--As in Fig. 5

possible to obtain FILM sections demonstrating the dynamics of the observability characteristics of Halley's comet in 1985-86. In the present work, several graphs are depicted illustrating the daily variation of the comet's elevation (Figure 5a,b): During the 24 hours of 25 November 1985 (about the first closest approach to Earth) and during the 24 hours of 6 April 1986 (for 4 days up to the second closest approach to the Earth) under observation from the Dushanbe NIP; as well as graphs showing the dynamics of change in range and range rate in the period from October 1985 to May 1986 (see Figure 6a,b). The distinctive features of the impending appearance of the comet are seen on the graphs. The points of the closest approaches to Earth (27 November 1985, 93 million kilometers and 10 April 1986, 62 million kilometers) are singled out. It is evident that observation conditions in the northern hemisphere will be much worse than for southern NIP's and, in particular, that after passage of perihelion the comet will execute a steep "dive" downward, when its declination will reach -47° , as a result of which in the period of morning visibility it will be completely unavailable to observations from the northern NIP's.

As a result of the issuing of information in digital form, tables are obtained which give the elevation, azimuth, declination, right ascension, range, range rate of the comet for a number of domestic and foreign observatories and stations (Tables 2-10).

Since it is obvious that equatorial coordinates, range and range rate change little from point to point (within the limits of the computing precision provided by the system), it is possible for these characteristics not to make a distinction between geo-/24centric and topocentric quantities. However, as for elevation and azimuth, it is necessary to calculate them for each point individually. But it is clear also that in the calculation of elevation and azimuth of a comet (in contrast to an AES, for example) for a general characteristic of the observability conditions, it is sufficient to take several points covering a large arc of latitude as the longitude may not be varied (the results of calculations performed for NIP's with identical latitude and different longitudes will

be almost identical with a precision before the shift along the time axis at a magnitude equal to the difference in longitudes since the equatorial coordinates of a comet change slowly). Starting from these considerations we cite data for only three points with widely varying latitudes: Pulkovo ($\varphi = +59^{\circ}46'18''.5$, $h = 75\text{m}$, $\lambda = +2^{\circ}01'18''.57$), Dushanbe ($\varphi = +38^{\circ}33'39''.9$, $\lambda = 4^{\circ}35'07''.47$, $h = 820\text{m}$) and Perth (Australia) ($\varphi = -31^{\circ}57'10''$, $\lambda = 7^{\circ}42'14''.4$, $h = 0$).

Tables 2-4 cover the period from October 1985 to May 1986 with a step of 5 days. The times indicated in the first column of a table is with respect to Greenwich and correspond to the local mean midnight of the observation points. In the last column are shown the symbolic designations: 0 - light, 1 - dark part of the day. Tables 5 and 6 give more detailed information with 30 minute steps about comet visibility from Dushanbe during one 24-hour period on two dates: 25.11.85 and 6.4.86. The time is reckoned from Greenwich midnight.

The analysis of the results obtained makes it possible, in particular, to give the general nature of the comet's visibility conditions from any NIP. We shall consider Dushanbe as an example. At the beginning of October 1985 Halley's comet, already quite bright (about stellar magnitude 8) will be accessible to observations mornings, culminating high above the horizon (elevation 71°) approximately an hour before sunrise. At the end of October the visibility conditions are improved: The comet becomes visible almost all night, culminating at the height of 72° 3-4 hours before it sets. In the second half of November, the comet is accessible all night - at the time of sunset its angular height is $20-22^{\circ}$, culmination occurs around midnight (elevation 69°). The period of visibility is gradually displaced to the first half of the night; in mid-December the comet will culminate immediately after sunset at a height of 52° . By the middle of January, the observation conditions will worsen significantly. The comet will be visible evenings for a short time (not more than 2 hours) low above the horizon (not higher than 20°).

Then the comet will disappear in the Sun's rays, but after

/25

passage of perihelion the second period of visibility will approach. During the second half of February and in March 1986, the comet will be visible mornings shortly before sunrise not high above the horizon (10-15°, but at the beginning of April - not higher than 8°). The total stellar magnitude will reach 4m. In May, the visibility conditions will improve again. However, the comet will quickly lose brightness and become less accessible for observations.

The cited tables also show how unfavorable conditions build up for northern points. Thus, for the Pulkovo NIP the comet will be accessible only to the end of December 1985, at the same time its elevation above the horizon will be 20-30°. However, at this time the comet will still be far from perihelion and its total stellar magnitude will not exceed 7-8m.

NIP's of the southern hemisphere will turn out to be in favorable conditions. In the case of Perth, it is evident that, for example, on 26 March 1986 the comet will culminate close to the zenith. It can be assumed that the geographic distribution of southern hemisphere points will not impose any limitations on the observability of Halley's comet. For such points only, the brilliance of the comet and the penetrating strength of the instruments being used determine the limits of the comet's accessibility period. The asymmetry described between northern and southern NIP's becomes still more acute if we consider that the southern observatories and stations are found usually in much better astroclimatic conditions.

In Tables 7-10 are shown the observation characteristics of Halley's comet from the Dushanbe (a southern point in the Northern Hemisphere) and Perth (Australia, Southern Hemisphere) NIP's with a step per 1 24-hour period) in a protracted interval of time in the region of the first and second approach of the comet to Earth.

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TIME	ELEVATION	AZIMUTH	DECLINATION	W. ASCENSION	RANGE	RANGE RATE	O-DAY	L-NIGHT
1945.10.1.21.54.41.1	211126.13	941243.59	200471.00	61106.05	.299802058E	09	-.96071647E	0P
1945.10.4.21.54.41.1	207453.29	905242.00	201608.40	60873.48	.275456148E	09	-.840800980E	0P
1945.10.7.21.54.41.1	211923.73	955467.57	201005.69	60433.28	.251580113E	09	-.857442953E	0P
1945.10.10.21.54.41.1	304424.93	1013519.33	204644.67	55432.43	.287728450E	09	-.850107023E	0P
1945.10.13.21.54.41.1	304424.93	1040216.49	210417.37	85017.72	.204294098E	09	-.850787909E	0P
1945.10.16.21.54.41.1	782954.93	1154140.13	212826.88	50871.09	.141531038E	09	-.818353809E	0P
1945.10.19.21.54.41.1	240144.34	1251215.46	215137.55	52213.45	.159787418E	09	-.849746131E	0P
1945.10.22.21.54.41.1	463752.73	1773748.15	221130.23	45947.84	.139556881E	09	-.844604653E	0P
1945.10.25.21.54.41.1	503230.05	1543065.43	221753.62	48886.39	.121500730E	09	-.844213681E	0P
1945.10.28.21.54.41.1	523257.00	1745965.55	210052.91	74011.45	.106409254E	09	-.834338900E	0P
1945.11.01.21.54.41.1	401141.14	2074465.49	201135.20	75472.34	.948337580E	04	-.179223175E	0P
1945.11.04.21.54.41.1	401141.14	2074465.49	172355.44	19015.32	.921118961E	04	-.301892511E	0P
1945.11.07.21.54.41.1	292244.64	2447423.14	123487.56	10311.76	.938210550E	04	-.109817617E	0P
1945.11.10.21.54.41.1	173451.10	2540814.11	92814.74	10124.70	.100978769E	09	-.219605856E	0P
1945.11.13.21.54.41.1	72316.86	2485400.30	65119.43	273723.19	.118075650E	09	-.292809827E	0P
1945.11.16.21.54.41.1	-11041.19	2775905.04	25722.57	230832.40	.125418628E	09	-.334148208E	0P
1945.11.19.21.54.41.1	-31637.46	2455453.17	218.94	24431.77	.140419401E	09	-.352289776E	0P
1945.11.22.21.54.41.1	-11041.19	2928226.73	-10281.33	222723.8E	.155432318E	09	-.353925940E	0P
1945.11.25.21.54.41.1	-191104.97	3002930.45	-2942.24	221528.13	.170446341E	09	-.343327800E	0P
1945.11.28.21.54.41.1	-237921.54	3073434.48	-33064.57	220408.34	.184391666E	09	-.322720610E	0P
1945.12.01.21.54.41.1	-271417.74	3144308.05	-47684.14	215405.86	.198262413E	09	-.293254066E	0P
1945.12.04.21.54.41.1	-307115.41	3207450.82	-63147.71	214454.18	.210071183E	09	-.254574165E	0P
1945.12.07.21.54.41.1	-323336.77	3295211.26	-82644.75	213405.70	.220007478E	09	-.205849036E	0P
1945.12.10.21.54.41.1	-335151.74	3375929.24	-92110.45	212720.31	.227413717E	09	-.144929088E	0P
1945.12.13.21.54.41.1	-345424.79	3461342.11	-10029.12	211825.47	.232387631E	09	-.042267185E	0P
1945.12.16.21.54.41.1	-353533.41	3533955.81	-92524.75	210817.49	.239836248E	09	-.092567166E	0P
1945.12.19.21.54.41.1	-400537.74	45112.18	-103648.09	210002.94	.231611728E	09	-.091456124E	0P
1945.12.22.21.54.41.1	-412646.44	142007.78	-115447.59	205051.08	.228039819E	09	-.180526007E	0P
1945.12.25.21.54.41.1	-41325.74	23518.98	-131517.22	204154.12	.216194840E	09	-.255853741E	0P
1945.12.28.21.54.41.1	-412516.24	72111.10	-145100.83	203144.53	.203792110E	09	-.317680254E	0P
1945.12.31.21.54.41.1	-400328.51	423.475	-163211.17	202441.69	.189031293E	09	-.365734760E	0P
1946.01.03.21.54.41.1	-395554.97	515457.41	-182700.64	201340.10	.172172478E	09	-.401315079E	0P
1946.01.06.21.54.41.1	-372937.25	412220.98	-204216.86	200222.24	.164445627E	09	-.425113961E	0P
1946.01.09.21.54.41.1	-372937.25	722212.25	-232821.07	195256.55	.136021048E	09	-.438129658E	0P
1946.01.12.21.54.41.1	-344644.37	822414.95	-270037.83	193934.89	.117484689E	09	-.436539700E	0P
1946.01.15.21.54.41.1	-344644.37	953372.64	-313959.13	191031.99	.927582100E	04	-.413804741E	0P
1946.01.18.21.54.41.1	-312216.31	1115626.47	-374248.47	182424.71	.820490920E	04	-.354731190E	0P
1946.01.21.21.54.41.1	-272516.10	1285429.14	-442132.25	171446402	.601601422E	04	-.233611862E	0P
1946.01.24.21.54.41.1	-203123.64	1573429.14	-471417.21	151704100	.401599426E	04	-.354737633E	0P
1946.01.27.21.54.41.1	-113444.85	1873210.62	-44616.70	131806110	.666325761E	04	-.186751207E	0P
1946.01.30.21.54.41.1	-30217.33	2073018.07	-323632.74	120305003	.744262253E	04	-.352365039E	0P
1946.02.02.21.54.41.1	-12424.24	2173912.48	-244251.25	112148494	.959180885E	04	-.450424241E	0P
1946.02.05.21.54.41.1	426.05	2270134.39	-191142.90	105203.25	.116612699E	09	-.507625061E	0P
1946.02.08.21.54.41.1	1296.72	245026.24	-151422.13	104344.19	.139117493E	09	-.537166729E	0P
1946.02.11.21.54.41.1	-2617.67	245026.24	-122456.47	103457.72	.162164129E	09	-.655412502E	0P
1946.02.14.21.54.41.1	-12518.17	2511710.49	-132141.04	122925.48	.146826560E	09	-.565500070E	0P
1946.02.17.21.54.41.1	-30324.74	2573813.22	-84031.80	102612.10	.211333783E	09	-.576423382E	0P
1946.02.20.21.54.41.1	-44400.11	2624842.21	-74019.47	102427.64	.235832443E	09	-.571442744E	0P
1946.02.23.21.54.41.1	-64056.70	2579710.62	-65110.16	102319.60	.260364507E	09	-.465021029E	0P

Table 2

Pulkovo

October 1985
May 1986

Local midnight

Step = 5 days

ORIGINAL PAGE IS
OF POOR QUALITY

TIME	ELEVATION	AZIMUTH	DECLINATION	R ASSASSION	RANGE	RANGE RATE	DAY	1-HIGH
1985-10-1-19:25	181618.84	743117.48	200418.50	4 4.5V	+300318576E	09	..54211849E	02
1985-10-6-19:25	272911.87	813213.95	201557.92	6 7.167	+276171479E	09	..562017164E	02
1985-10-11-19:25	272913.76	844535.75	202947.95	6 7.158	+252092250E	09	..558647830E	02
1985-10-16-19:25	321313.39	841820.95	204622.99	5 8.850	+228222794E	09	..551401471E	02
1985-10-21-19:25	281112.03	922209.48	214552.31	5 8.850	+204787778E	09	..532074794E	02
1985-10-26-19:25	442935.69	971300.05	212756.42	5 8.850	+182007201E	09	..519789928E	02
1985-10-31-19:25	813844.13	1030154.17	211111.03	4 2.237	+160077115E	09	..490798607E	02
1985-11-5-19:25	593542.31	1135043.85	221113.14	3 0.017	+139968932E	09	..444501246E	02
1985-11-10-19:25	676674.05	1227261.70	221820.33	4 2.237	+121914175E	09	..386166570E	02
1985-11-15-19:25	731119.17	123231.91	215204.10	4 2.237	+107081048E	09	..296670800E	02
1985-11-20-19:25	473119.57	2203103.43	204281.39	2 5768.84	+961493682E	04	..175883416E	02
1985-11-25-19:25	531524.01	3450107.12	173424.74	2 0029.70	+921139958E	04	..326074034E	02
1985-11-30-19:25	368242.67	757242.28	134020.87	1 0419.24	+937225538E	04	..107664484E	02
1985-12-5-19:25	210474.65	168281.65	93781.05	1 602.51	+100770744E	09	..218711450E	02
1985-12-10-19:25	71300.44	2713435.92	5 521.66	2 7807.36	+111804025E	09	..274971437E	02
1985-12-15-19:25	34542.87	2481308.61	3 041.70	2 3904.41	+138313164E	09	..148190170E	02
1985-12-20-19:25	-131614.90	340700.59	4 401.40	1 764.37	+140027044E	09	..391303370E	02
1985-12-25-19:25	-61246.37	2664034.98	-1049.40	2 2241.23	+153104977E	09	..315442030E	02
1985-12-30-19:25	-743255.97	3915127.23	-29503.31	2 21054.02	+172314900E	09	..344714058E	02
1986-1-4-19:25	-345507.16	2971957.90	-3142.40	2 20421.04	+184624110E	09	..324276561E	02
1986-1-9-19:25	-64104.03	7532356.65	+4380.39	2 15418.60	+197994299E	09	..294991432E	02
1986-1-14-19:25	-15546.92	3101436.25	-5036.70	2 14505.45	+245574509E	09	..266185947E	02
1986-1-19-19:25	-50395.12	3182234.12	-68431.70	2 13616.85	+219819424E	09	..207585028E	02
1986-1-24-19:25	-544714.87	3278727.91	-71985.00	2 12631.56	+227480604E	09	..147785943E	02
1986-1-29-19:25	-38156.72	1392322.35	-81908.35	2 11837.00	+232203432E	09	..761160070E	01
1986-2-3-19:25	-403939.05	3521404.47	-92356.03	2 10729.48	+232863430E	09	..601361424E	01
1986-2-8-19:25	-415006.60	737.45.19	-103911.85	2 10014.78	+231707213E	09	..436673350E	00
1986-2-13-19:25	-413738.81	225123.55	-119301.75	2 08104.70	+225806477E	09	..179032416E	02
1986-2-18-19:25	-400605.01	171110.87	-131722.96	2 06207.39	+216430722E	09	..254770664E	02
1986-2-23-19:25	-503236.42	495417.43	-144856.18	2 04329.54	+204085464E	09	..217042130E	02
1986-2-28-19:25	-413526.56	605811.87	-162452.12	2 02492.43	+189368013E	09	..365513478E	02
1986-3-3-19:25	-30227.43	704202.00	-182420.29	2 00543.56	+172847718E	09	..431459937E	02
1986-3-10-19:25	-60713.30	794642.09	-20790.22	2 00543.56	+155036825E	09	..426402400E	02
1986-3-15-19:25	-11854.68	817615.01	-23242.59	1 98314.99	+136423693E	09	..38790529E	02
1986-3-20-19:25	-195511.72	975219.24	-265525.80	1 96623.94	+117849550E	09	..437817157E	02
1986-3-25-19:25	-294300.24	1042320.91	-313307.09	1 91114.72	+991379458E	04	..415671650E	02
1986-3-30-19:25	-215495.80	1211618.93	-373413.12	1 82952.156	+823943657E	04	..357574284E	02
1986-4-4-19:25	-120518.12	1375201.37	-441355.15	1 71649.42	+622741470E	04	..237890072E	02
1986-4-9-19:25	-2440.75	1545113.35	-471544.43	1 51951.75	+431919317E	04	..407368251E	01
1986-4-14-19:25	92646.24	1820335.68	-45713.55	1 32012.61	+663601083E	04	..182464371E	02
1986-4-19-19:25	142757.15	2029453.24	-324755.11	1 20415.56	+781012627E	04	..250123068E	02
1986-4-24-19:25	151687.70	2190039.43	-245722.59	1 12222.20	+955028576E	04	..497033000E	02
1986-4-29-19:25	174809.27	2305235.92	-191742.41	1 05226.31	+118146973E	09	..505725593E	02
1986-5-4-19:25	111605.38	2394730.32	-151435.93	1 04402.31	+138621009E	09	..537758264E	02
1986-5-9-19:25	81946.25	2464502.11	-122801.10	1 03506.48	+142193112E	09	..556300562E	02
1986-5-14-19:25	45228.91	2522744.37	-102354.84	1 02973.81	+188286418E	09	..566464420E	02
1986-5-19-19:25	13751.55	2971734.69	-85211.23	1 02615.11	+210729361E	09	..571627718E	02
1986-5-24-19:25	-14631.70	2613146.64	-74333.78	1 02429.00	+235307276E	09	..572734900E	02
1986-5-29-19:25	-51148.24	245101.82	-69205.61	1 02349.70	+259865260E	09	..572474078E	02

Table 3

Dushanbe

October 1985

May 1986

Local midnight

Step = 5 days

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

TIME	ELEVATION	AZIMUTH	DECLINATION	R ASSENSION	RANGE	RANGE RATE	Q JIV	2-NIGHT
1985-10-1-16-17-46	882136.20	890052.40	200406.77	41111.55	300948718C	09	36236581	C 08
1985-10-4-16-17-46	88264.48	859308.54	201538.92	40442.62	276401554E	09	262339124E	0P
1985-10-11-16-17-46	41674.80	423518.64	202929.52	40447.09	262718797E	09	269102244E	02
1985-10-18-16-17-46	80226.21	584113.01	204601.13	55859.36	223852378E	09	251919124E	02
1985-10-21-16-17-46	133314.76	540456.85	210524.66	55043.77	205379341C	09	239447328E	02
1985-10-26-16-17-46	182620.97	682933.10	212730.26	83910.04	142590940E	09	290595400E	02
1985-10-31-16-17-46	233214.77	412421.23	215044.43	82307.78	160789149E	09	22045505E	02
1985-11-5-16-17-46	283444.51	320352.34	221058.40	50055.01	140474045E	09	22743355E	02
1985-11-10-16-17-46	330773.61	194504.53	221823.73	43038.93	122350743E	09	238192157E	02
1985-11-15-16-17-46	360517.33	31111.70	213336.95	35012.44	107417964E	09	229275734E	02
1985-11-20-16-17-46	384105.16	342404.87	202780.93	25224.44	265522829E	09	179314454E	02
1985-11-25-16-17-46	303407.40	3213700.01	174009.30	20200.54	221842300E	09	262744257E	01
1985-11-30-16-17-46	313426.35	3071314.27	134704.07	10541.97	234082078E	04	104439025E	01
1985-12-5-16-17-46	111400.62	2845959.78	93946.27	1714.27	100532291E	09	216767054E	0P
1985-12-10-16-17-46	11618.20	2775503.14	60064.40	233857.28	111444897E	09	271713821E	02
1985-12-15-16-17-46	72744.46	2685734.58	30454.92	230942.84	124941852E	09	334379422E	02
1985-12-20-16-17-46	450855.21	2411617.66	4810.86	884724.67	133704482E	09	35327249E	02
1985-12-25-16-17-46	214953.28	2541514.97	5813.28	223007.15	154912151E	09	35578613E	0P
1985-12-30-16-17-46	274116.12	2472828.05	22455.44	22413.57	169948439E	09	245572501E	02
1986-1-4-16-17-46	225413.15	2403439.98	33253.96	220438.62	18430466E	09	325147015E	02
1986-1-9-16-17-46	373149.22	2331935.98	43231.92	216432.90	197664314E	09	285471853E	02
1986-1-14-16-17-46	412926.67	2252310.55	52704.93	214519.49	209531885E	09	125475010E	02
1986-1-19-16-17-46	44304.34	2164031.03	62302.28	21340.47	219586726E	09	209118438E	02
1986-1-24-16-17-46	470507.76	2070029.86	71820.53	212745.30	227314740E	09	149285613E	0P
1986-1-29-16-17-46	482417.27	1963224.08	81728.60	211861.07	232203822E	09	781822543E	01
1986-2-3-16-17-46	463111.62	1894007.11	92203.71	210943.85	233401135E	09	378280323E	00
1986-2-8-16-17-46	422203.27	1790326.41	103309.17	210029.20	231602979E	09	214005111E	01
1986-2-13-16-17-46	456135.93	1690935.82	115049.01	209118.86	226004554E	09	174966647E	02
1986-2-18-16-17-46	414050.76	1562840.96	131459.36	208223.10	214719399E	09	253058108E	02
1986-2-23-16-17-46	473140.05	1490525.32	144619.77	208342.32	204437642E	09	316729067E	02
1986-2-28-16-17-46	324209.23	1429109.64	162457.98	208906.43	145774187E	09	266578392E	02
1986-3-5-16-17-46	271427.74	1373558.58	182100.05	201606.98	172293805E	09	40061867E	02
1986-3-10-16-17-46	210365.18	1331047.90	203504.81	200600.80	155510073E	09	428721707E	02
1986-3-15-16-17-46	139714.63	1292300.70	231922.26	195337.13	13791962E	09	4303482E	02
1986-3-20-16-17-46	53041.93	1242759.81	264700.23	194654.27	1118435107E	09	43232443	02
1986-3-25-16-17-46	50002.41	1241141.21	312439.18	191203.49	995963092E	08	416783116E	02
1986-3-30-16-17-46	184552.23	1225729.50	372316.56	183110.14	827826118E	08	359592.21E	02
1986-4-4-16-17-46	371767.85	1234926.68	440417.85	171917.49	62629145E	08	222762E	01
1986-4-9-16-17-46	603351.25	1310236.65	471654.67	152167.73	53233823E	08	46212839E	01
1986-4-14-16-17-46	794010.01	127380.39	431009.51	132240.64	61807024E	08	47218002E	01
1986-4-19-16-17-46	475932.24	2600315.67	330135.17	126542.80	77707063E	08	346858.4E	0P
1986-4-24-16-17-46	425832.42	2644544.01	250738.70	112310.80	494927803E	08	46974804E	0P
1986-4-29-16-17-46	41284.13	2713444.34	192454.31	10854.91	115599847E	09	4147777E	02
1986-5-4-16-17-46	321557.41	2713146.31	152330.46	10443.86	13402650E	09	5373077E	02
1986-5-9-16-17-46	244623.44	2702145.46	123131.32	103517.42	14153433E	09	546224.0E	02
1986-5-14-16-17-46	12127.20	2635753.41	102403.09	102940.51	18582764E	09	5667704.1E	02
1986-5-19-16-17-46	124100.82	2671550.62	85407.89	102418.94	210482962E	09	5718041E	02
1986-5-24-16-17-46	7318.75	2652208.25	71500.18	102430.80	234666814E	09	5730540E	02
1986-5-29-16-17-46	24824.06	2633645.01	66309.34	102350.06	25922407E	09	5712704E	02

Table 4

Perth

October 1985

May 1986

Local midnight

Step = 5 days

TIME	ELEVATION	AZIMUTH	DECLINATION	R.A. HENSATION	RANGE	RANGE RATE	DAY	NIGHT
1984 2:15 0 0 0	14179.37	942119.19	12122.40	204855.87	222868791C	09 +200905361C	02	1
1984 2:16 0 0 0	13204.77	952719.87	122111.59	204704.23	222061558C	09 +716396912C	02	1
1984 2:17 0 0 0	12241.08	962726.79	122606.96	204591.29	220191836C	09 +73140812C	02	1
1984 2:18 0 0 0	112810.77	972738.06	12317.67	204335.05	218160154C	09 +25482271C	02	1
1984 2:19 0 0 0	103213.77	982751.32	12375.32	204191.61	216005440C	09 +239335417C	02	1
1984 2:20 0 0 0	93729.48	992764.29	12434.06	204005.63	213733028C	09 +227229377C	02	1
1984 2:21 0 0 0	84251.00	1005527.70	12484.88	203870.32	211317114C	09 +214058884C	02	1
1984 2:22 0 0 0	74751.84	1020115.76	12535.10	203748.58	208852783C	09 +202820236C	02	1
1984 2:23 0 0 0	65249.18	1035712.98	12585.12	203639.19	206284923C	09 +191001377C	02	1
1984 2:24 0 0 0	55738.01	1051324.61	12635.29	203540.11	203858408C	09 +178114363C	02	1
1984 2:25 0 0 0	46218.56	1067955.66	12685.52	203451.77	201574042C	09 +165171714C	02	1
1984 2:26 0 0 0	36690.28	1085604.98	12735.92	203373.32	200344419	09 +152473795C	02	1
1984 2:27 0 0 0	27153.97	1104271.78	12786.48	203305.99	199274701C	09 +140334452C	02	1
1984 2:28 0 0 0	17619.65	1123957.23	12837.21	203248.77	198347272C	09 +128794402C	02	1
1984 2:29 0 0 0	8178.44	1144652.42	12888.11	203191.66	197541220	09 +117944467C	02	1
1984 2:30 0 0 0	-12804.13	1166357.48	12939.18	203144.78	196844220	09 +107894467C	02	1
1984 2:31 0 0 0	-22321.09	1189072.53	12990.43	203108.14	196247220	09 +98544467C	02	1
1984 2:32 0 0 0	-31838.14	1212797.58	13041.85	203081.76	195749220	09 +90044467C	02	1
1984 2:33 0 0 0	-41355.36	1237522.63	13093.45	203065.64	195351220	09 +82444467C	02	1
1984 2:34 0 0 0	-50872.72	1263247.68	13146.23	203059.76	195053220	09 +75844467C	02	1
1984 2:35 0 0 0	-60390.19	1289972.73	13200.19	203054.14	194855220	09 +70244467C	02	1
1984 2:36 0 0 0	-69907.65	1317697.78	13254.23	203048.78	194707220	09 +65644467C	02	1
1984 2:37 0 0 0	-79425.11	1346422.83	13309.35	203043.68	194609220	09 +62044467C	02	1
1984 2:38 0 0 0	-88942.57	1376147.88	13364.55	203038.84	194531220	09 +59444467C	02	1
1984 2:39 0 0 0	-98460.03	1407872.93	13420.83	203034.26	194473220	09 +57844467C	02	1
1984 2:40 0 0 0	-107977.49	1441597.98	13478.29	203029.94	194435220	09 +57244467C	02	1
1984 2:41 0 0 0	-117494.95	1477322.03	13536.83	203025.88	194407220	09 +57644467C	02	1
1984 2:42 0 0 0	-127012.41	1515047.08	13596.45	203022.08	194389220	09 +58044467C	02	1
1984 2:43 0 0 0	-136529.87	1554772.13	13657.15	203018.54	194381220	09 +58444467C	02	1
1984 2:44 0 0 0	-146047.33	1596497.18	13718.87	203015.26	194383220	09 +58844467C	02	1
1984 2:45 0 0 0	-155564.79	1641222.23	13781.65	203012.24	194395220	09 +59244467C	02	1
1984 2:46 0 0 0	-165082.25	1688947.28	13845.50	203009.48	194417220	09 +59644467C	02	1
1984 2:47 0 0 0	-174599.71	1739672.33	13910.52	203006.98	194449220	09 +60044467C	02	1
1984 2:48 0 0 0	-184117.17	1793397.38	13976.73	203004.64	194491220	09 +60444467C	02	1
1984 2:49 0 0 0	-193634.63	1850122.43	14044.15	203002.46	194543220	09 +60844467C	02	1
1984 2:50 0 0 0	-203152.09	1910847.48	14112.83	203000.44	194605220	09 +61244467C	02	1
1984 2:51 0 0 0	-212669.55	1975572.53	14182.87	203000.00	194677220	09 +61644467C	02	1
1984 2:52 0 0 0	-222187.01	2044297.58	14254.27	203000.24	194759220	09 +62044467C	02	1
1984 2:53 0 0 0	-231704.47	2117022.63	14326.93	203000.74	194851220	09 +62444467C	02	1
1984 2:54 0 0 0	-241221.93	2193747.68	14400.95	203001.50	194953220	09 +62844467C	02	1
1984 2:55 0 0 0	-250739.39	2274472.73	14477.43	203002.52	195065220	09 +63244467C	02	1
1984 2:56 0 0 0	-260256.85	2359197.78	14556.37	203003.80	195187220	09 +63644467C	02	1
1984 2:57 0 0 0	-269774.31	2447922.83	14637.77	203005.34	195319220	09 +64044467C	02	1
1984 2:58 0 0 0	-279291.77	2540647.88	14721.63	203007.14	195461220	09 +64444467C	02	1
1984 2:59 0 0 0	-288809.23	2637372.93	14807.95	203009.18	195613220	09 +64844467C	02	1
1984 2:59 0 0 0	-298326.69	2738097.98	14896.73	203011.46	195775220	09 +65244467C	02	1
1984 2:59 0 0 0	-307844.15	2842822.03	14988.07	203013.98	195947220	09 +65644467C	02	1
1984 2:59 0 0 0	-317361.61	2951547.08	15081.97	203016.74	196129220	09 +66044467C	02	1
1984 2:59 0 0 0	-326879.07	3064272.13	15177.43	203019.74	196321220	09 +66444467C	02	1
1984 2:59 0 0 0	-336396.53	3181997.18	15274.55	203022.98	196523220	09 +66844467C	02	1
1984 2:59 0 0 0	-345914.00	3304722.23	15373.33	203026.46	196735220	09 +67244467C	02	1
1984 2:59 0 0 0	-355431.46	3432447.28	15473.77	203030.18	196957220	09 +67644467C	02	1
1984 2:59 0 0 0	-364948.93	3565172.33	15575.87	203034.14	197189220	09 +68044467C	02	1
1984 2:59 0 0 0	-374466.39	3702897.38	15679.63	203038.34	197431220	09 +68444467C	02	1
1984 2:59 0 0 0	-383983.85	3845622.43	15785.05	203042.78	197683220	09 +68844467C	02	1
1984 2:59 0 0 0	-393501.31	3993347.48	15892.13	203047.46	197945220	09 +69244467C	02	1
1984 2:59 0 0 0	-403018.77	4146072.53	16000.87	203052.38	198217220	09 +69644467C	02	1
1984 2:59 0 0 0	-412536.23	4304797.58	16111.37	203057.54	198509220	09 +70044467C	02	1
1984 2:59 0 0 0	-422053.69	4469522.63	16223.69	203062.94	198821220	09 +70444467C	02	1
1984 2:59 0 0 0	-431571.15	4640247.68	16337.73	203068.58	199153220	09 +70844467C	02	1
1984 2:59 0 0 0	-441088.61	4817972.73	16453.53	203074.46	199505220	09 +71244467C	02	1
1984 2:59 0 0 0	-450606.07	5002697.78	16571.09	203080.58	199877220	09 +71644467C	02	1
1984 2:59 0 0 0	-460123.53	5194422.83	16690.33	203086.94	200269220	09 +72044467C	02	1
1984 2:59 0 0 0	-469640.99	5393147.88	16811.25	203093.54	200681220	09 +72444467C	02	1
1984 2:59 0 0 0	-479158.45	5598872.93	16933.87	203100.38	201113220	09 +72844467C	02	1
1984 2:59 0 0 0	-488675.91	5811597.98	17058.21	203107.46	201565220	09 +73244467C	02	1
1984 2:59 0 0 0	-498193.37	6031322.03	17184.27	203114.78	202037220	09 +73644467C	02	1
1984 2:59 0 0 0	-507710.83	6258047.08	17311.97	203122.34	202529220	09 +74044467C	02	1
1984 2:59 0 0 0	-517228.29	6491772.13	17441.41	203130.14	203041220	09 +74444467C	02	1
1984 2:59 0 0 0	-526745.75	6732497.18	17572.61	203138.18	203573220	09 +74844467C	02	1
1984 2:59 0 0 0	-536263.21	6980222.23	17705.67	203146.46	204125220	09 +75244467C	02	1
1984 2:59 0 0 0	-545780.67	7234947.28	17840.51	203155.08	204697220	09 +75644467C	02	1
1984 2:59 0 0 0	-555298.13	7496672.33	17977.13	203163.94	205289220	09 +76044467C	02	1
1984 2:59 0 0 0	-564815.59	7765397.38	18115.45	203173.04	205901220	09 +76444467C	02	1
1984 2:59 0 0 0	-574333.05	8042122.43	18255.47	203182.38	206533220	09 +76844467C	02	1
1984 2:59 0 0 0	-583850.51	8326847.48	18397.13	203191.96	207185220	09 +77244467C	02	1
1984 2:59 0 0 0	-593367.97	8619572.53	18540.45	203201.78	207857220	09 +77644467C	02	1
1984 2:59 0 0 0	-602885.43	8920297.58	18685.43	203211.84	208549220	09 +78044467C	02	1
1984 2:59 0 0 0	-612402.89	9229022.63	18832.07	203222.14	209261220	09 +78444467C	02	1
1984 2:59 0 0 0	-621920.35	9545747.68	18980.27	203232.68	210003220	09 +78844467C	02	1
1984 2:59 0 0 0	-631437.81	9870472.73	19130.03	203243.38	210775220	09 +79244467C	02	1
1984 2:59 0 0 0	-640955.27	1030322.78	19281.35	203254.24	211577220	09 +79644467C	02	1
1984 2:59 0 0 0	-650472.73	1081272.83	19434.27	203265.26	212409220	09 +80044467C	02	1
1984 2:59 0 0 0	-659990.19	1139322.88	19588.71	203276.44	213271220	09 +80444467C	02	1
1984 2:59 0 0 0	-669507.65	1203472.93	19744.77	203287.78	214163220	09 +80844467C	02	1
1984 2:59 0 0 0	-679025.11	1273722.98	19902.45	203299.28	215085220	09 +81244467C	02	1
1984 2:59 0 0 0	-688542.57	1350172.03	20061.77	203310.94	216037220	09 +81644467C	02	1
1984 2:59 0 0 0	-698060.03	1432822.08	20222.67	203322.76	217019220	09 +82044467C	02	1
1984 2:59 0 0 0	-707577.49	1521672.13	20385.15	203334.74	218031220	09 +82444467C	02	1
1984 2:59 0 0 0	-717094.95	1616722.18	20549.23	203346.88	219073220	09 +82844467C	02	1
1984 2:59 0 0 0	-726612.41	1719072.23	20714.83	203359.18	220145220	09 +83244467C	02	1
1984 2:59 0 0 0	-736129.87	1827722.28	20881.95	203371.64	221247220	09 +83644467C	02	1
1984 2:59 0 0 0	-745647.33	1942772.33	21050.63	203384.26	222379220	09 +84044467C	02	1
1984 2:59 0 0 0	-755164.79	2064222.38	21221.97	203397.04	223541220	09 +84444467C	02	1
1984 2:59 0 0 0	-764682.25	2192172.43	21395.97	203410.08	224733220	09 +84844467C	02	1
1984 2:59 0 0 0	-774199.71	2326622.48	21572.63	203423.38	225955220	09 +85244467C	02	1
1984 2:59 0 0 0	-783717.17	2467572.53	21752.03	203436.94	227207220	09 +85644467C	02	1
1984 2:59 0 0 0	-793234.63	2615022.58	21934.17	203450.76	228489220	09 +86044467C	02	1
1984 2:								

TIME	ELEVATION	AZIMUTH	DECLINATION	R ASSENSION	RANGE	RANGE RATE	D-DAY	I-NIGHT
1965. 1:15:21.0	0.0	15211.44	101163.24	+12369.21	806221.47	+22333344E	09	+1160077.5E
1965. 2:16:21.0	0.0	31844.21	-1370.8429	-184322.14	805451.66	+22473210E	09	+124866.6E
1965. 3:17:21.0	0.0	48284.67	107157.18	-171311.14	804344.32	+225119134E	09	+12487785E
1965. 4:18:21.0	0.0	65724.56	106155.16	-131236.69	803202.47	+22647362E	09	+12487785E
1965. 5:19:21.0	0.0	71294.16	101331.26	-13039.31	802011.73	+22789949E	09	+12487785E
1965. 6:20:21.0	0.0	83311.14	110652.10	-13499.74	800334.47	+22921782E	09	+12487785E
1965. 7:21:21.0	0.0	93224.16	120315.76	-14268.34	798643.33	+23051674E	09	+12487785E
1965. 8:22:21.0	0.0	11134.80	160130.48	-147104.66	796360.12	+23186377E	09	+12487785E
1965. 9:23:21.0	0.0	13720.22	194730.48	-149006.10	794373.01	+23317376E	09	+12487785E
1965. 10:24:21.0	0.0	135501.61	199230.48	-149987.74	792145.09	+23444948E	09	+12487785E
1965. 11:25:21.0	0.0	15189.67	194426.31	-157913.11	789571.10	+23569710E	09	+12487785E
1965. 12:26:21.0	0.0	16373.37	194040.66	-159200.05	787811.34	+23691073E	09	+12487785E
1966. 1:27:21.0	0.0	19284.47	191200.67	-161001.79	786303.51	+23805476E	09	+12487785E
1966. 2:28:21.0	0.0	194017.27	197266.79	-163110.74	784944.12	+23914302E	09	+12487785E
1966. 3:29:21.0	0.0	202803.16	197428.41	-165251.72	783700.57	+24018617E	09	+12487785E
1966. 4:30:21.0	0.0	220612.33	197046.11	-171906.65	782114.62	+24118404E	09	+12487785E
1966. 5:31:21.0	0.0	227421.23	194749.67	-173759.44	780286.74	+24214343E	09	+12487785E
1966. 6:32:21.0	0.0	232244.29	182441.13	-180331.71	778236.38	+24306817E	09	+12487785E
1966. 7:33:21.0	0.0	267004.74	161231.74	-185118.82	776044.57	+24396347E	09	+12487785E
1966. 8:34:21.0	0.0	274235.87	153235.47	-191044.44	774734.47	+24483492E	09	+12487785E
1966. 9:35:21.0	0.0	273000.41	148000.41	-197071.13	773287.10	+24568647E	09	+12487785E
1966. 10:36:21.0	0.0	273872.02	144110.02	-199327.67	771714.51	+24651422E	09	+12487785E
1966. 11:37:21.0	0.0	274423.29	141420.29	-200000.15	770044.30	+24732332E	09	+12487785E
1966. 12:38:21.0	0.0	275210.60	138629.60	-201171.36	768231.24	+24811897E	09	+12487785E
1967. 1:39:21.0	0.0	276229.19	134231.17	-202446.51	766284.77	+24890642E	09	+12487785E
1967. 2:40:21.0	0.0	277421.57	130130.11	-203826.14	764220.16	+24968974E	09	+12487785E
1967. 3:41:21.0	0.0	278824.25	125445.51	-205319.14	761967.62	+25047296E	09	+12487785E
1967. 4:42:21.0	0.0	280444.24	120119.18	-206944.24	759544.52	+25126103E	09	+12487785E
1967. 5:43:21.0	0.0	282273.43	114219.27	-208720.87	756973.67	+25205910E	09	+12487785E
1967. 6:44:21.0	0.0	284294.56	107712.76	-210659.37	754284.98	+25287229E	09	+12487785E
1967. 7:45:21.0	0.0	286507.24	100723.14	-212769.92	751498.52	+25370572E	09	+12487785E
1967. 8:46:21.0	0.0	288824.47	92739.67	-215059.31	748644.24	+25456451E	09	+12487785E
1967. 9:47:21.0	0.0	291244.24	84235.04	-217529.29	745644.24	+25544374E	09	+12487785E
1967. 10:48:21.0	0.0	293763.99	747229.79	-220183.99	742544.24	+25634852E	09	+12487785E
1967. 11:49:21.0	0.0	296383.47	637153.47	-222923.11	739344.24	+25727374E	09	+12487785E
1967. 12:50:21.0	0.0	299102.82	51515.74	-225746.27	736044.24	+25822342E	09	+12487785E
1968. 1:51:21.0	0.0	301921.95	384231.95	-228653.93	732644.24	+25919367E	09	+12487785E
1968. 2:52:21.0	0.0	304840.95	244231.95	-231646.07	729144.24	+26018952E	09	+12487785E
1968. 3:53:21.0	0.0	307859.82	100231.95	-234722.68	725544.24	+26121607E	09	+12487785E
1968. 4:54:21.0	0.0	310978.57	-138231.95	-237883.76	721844.24	+26227832E	09	+12487785E
1968. 5:55:21.0	0.0	314197.24	-278231.95	-241129.31	718044.24	+26337147E	09	+12487785E
1968. 6:56:21.0	0.0	317515.84	-418231.95	-244459.34	714144.24	+26449062E	09	+12487785E
1968. 7:57:21.0	0.0	320934.47	-558231.95	-247873.85	710144.24	+26563087E	09	+12487785E
1968. 8:58:21.0	0.0	324453.14	-698231.95	-251373.81	706044.24	+26679732E	09	+12487785E
1968. 9:59:21.0	0.0	328071.81	-838231.95	-254958.19	701844.24	+26799597E	09	+12487785E
1968. 10:00:21.0	0.0	331790.48	-978231.95	-258618.06	697544.24	+26922182E	09	+12487785E
1968. 11:01:21.0	0.0	335609.15	-1118231.95	-262353.44	693144.24	+27047997E	09	+12487785E
1968. 12:02:21.0	0.0	339427.82	-1258231.95	-266164.33	688644.24	+27176542E	09	+12487785E
1969. 1:03:21.0	0.0	343246.49	-1408231.95	-270050.74	684044.24	+27307417E	09	+12487785E
1969. 2:04:21.0	0.0	347065.16	-1568231.95	-273912.68	679344.24	+27440232E	09	+12487785E
1969. 3:05:21.0	0.0	350883.83	-1738231.95	-277840.15	674544.24	+27574587E	09	+12487785E
1969. 4:06:21.0	0.0	354702.50	-1918231.95	-281833.15	669644.24	+27710092E	09	+12487785E
1969. 5:07:21.0	0.0	358521.17	-2108231.95	-285891.68	664644.24	+27846247E	09	+12487785E
1969. 6:08:21.0	0.0	362339.84	-2308231.95	-290015.76	659544.24	+27983552E	09	+12487785E
1969. 7:09:21.0	0.0	366158.51	-2518231.95	-294195.39	654344.24	+28121507E	09	+12487785E
1969. 8:10:21.0	0.0	369977.18	-2738231.95	-298430.56	649044.24	+28260612E	09	+12487785E
1969. 9:11:21.0	0.0	373795.85	-2968231.95	-302721.27	643644.24	+28400367E	09	+12487785E
1969. 10:12:21.0	0.0	377614.52	-3208231.95	-307067.52	638144.24	+28540272E	09	+12487785E
1969. 11:13:21.0	0.0	381433.19	-3468231.95	-311469.31	632544.24	+28680827E	09	+12487785E
1969. 12:14:21.0	0.0	385251.86	-3748231.95	-315926.64	626844.24	+28822532E	09	+12487785E

Table 10

Perth

Comet visibility during 3 months

15 February 1986

23 May 1986

Step = 1 day

Time corresponds to local mean midnight

TIME	ELEVATION	AZIMUTH	DECLINATION	R ASSENSION	RANGE	RANGE RATE	D-DAY	I-NIGHT
1969. 1:15:21.0	0.0	781158.97	2043216.44	+452446.52	165919.05	+67352370E	04	+199233946E
1969. 2:16:21.0	0.0	782843.67	2174040.20	+461309.19	143310.71	+687907113E	04	+162079078E
1969. 3:17:21.0	0.0	641351.24	2239135.58	+465740.35	142717.90	+69553488E	04	+121944683E
1969. 4:18:21.0	0.0	617375.84	2207057.06	+471707.31	154065.38	+69671784E	04	+792816497E
1969. 5:19:21.0	0.0	464736.11	2310528.20	+47126.38	151406.31	+69149207E	04	+347193661E
1969. 6:20:21.0	0.0	614217.27	2322508.73	+464904.24	143201.77	+69044181E	04	+10961770E
1969. 7:21:21.0	0.0	684737.79	2349528.30	+460104.84	142632.17	+683214200E	04	+568780150E
1969. 8:22:21.0	0.0	147471.42	2160510.76	+449280.70	140214.78	+689894523E	04	+102814293E
1969. 9:23:21.0	0.0	165122.81	2160544.11	+432748.54	133936.68	+680415170E	04	+144104059E
1969. 10:24:21.0	0.0	320345.74	2373144.05	+415004.20	131852.84	+686625057E	04	+187897804E
1969. 11:25:21.0	0.0	464737.92	2370414.57	+400348.30	130007.04	+68232210E	04	+27080694E
1969. 12:26:21.0	0.0	230150.00	2381136.06	-381230.24	124223.10	+703269144E	04	+62346396E
1969. 1:27:21.0	0.0	145026.92	2341327.04	-352023.30	122424.04	+727206877E	04	+296341210E
1969. 2:28:21.0	0.0	145241.31	2382100.34	-32459.04	121514.23	+738175187E	04	+826837143E
1969. 3:29:21.0	0.0	110859.98	2381733.19	-324029.10	120331.10	+783009310E	04	+35272284E
1969. 4:30:21.0	0.0	73851.57	2380921.14	-309405.85	115708.19	+814361952E	04	+378119047E
1969. 5:31:21.0	0.0	92144.24	2375726.66	-281649.35	114355.70	+844770087E	04	+399812281E
1969. 6:32:21.0	0.0	11701.77	2374174.40	-264253.64	112544.79	+89281208E	04	+19214648E
1969. 7:33:21.0	0.0	11469.40	2372254.63	-241432.82	109277.67	+91950489E	04	+13451348E
1969. 8:34:21.0	0.0	14634.34	2370292.47	-223146.41	112157.52	+95740884E	04	+451785317E
1969. 9:35:21.0	0.0	65138.12	2363919.82	-223428.41	111608.46	+99246395E	04	+65427837E
1969. 10:36:21.0	0.0	91431.73	2361130.81	-222209.34	111058.42	+103742224E	04	+177571714E
1969. 11:37:21.0	0.0	112932.46	2359330.43	-214451.32	110414.06	+107883399E	04	+28380123E
1969. 12:38:21.0	0.0	133451.30	2351901.92	-201804.82	110200.60	+112123121E	04	+98036879E
1969. 1:39:21.0	0.0	153737.44	2344357.04	-191342.82	109511.85	+116437051E	04	+16447484E
1969. 2:40:21.0	0.0	173052.96	2341024.34	-181916.46	108945.02	+120821849E	04	+14430699E
1969. 3:41:21.0	0.0	191843.62	2333144.44	-172831.47	108437.72	+125269751E	04	+21220205E
1969. 4:42:21.0	0.0	210105.47	2325252.17	-164511.47	107947.87	+12974786E	04	+52373635E
1969. 5:43:21.0	0.0	228426.92	2317301.47	-156370.74	107413.69	+134330442E	04	+67887612E
1969. 6:44:21.0	0.0	246748.47	2309350.81	-148390.66	106953.51	+138931745E	04	+83762078E
1969. 7:45:21.0	0.0	265069.92	2301400.11	-140570.66	106444.05	+143573909E	04	+10241434E
1969. 8:46:21.0	0.0	283391.47	2293449.71	-132710.44	105950.19	+148232718E	04	+12195075E
1969. 9:47:21.0	0.0	291712.92	2285498.82	-125000.15	105464.54	+152964424E	04	+14722910E
1969. 10:48:21.0	0.0	299934.47	2277548.79	-117390.02	104984.47	+157705258E	04	+1728432E
1969. 11:49:21.0	0.0	308155.84	2269598.38	-11004.01	104501.04	+1		