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VOLUME III
GEODYN
OPERATIONS DESCRIPTION

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INTRODUCTION

This manual describes in detail the operating and set-up procedures for the multi-satellite multi-arc GEODYN Orbit Determination Program. Additionally, all system output is described.

The GEODYN Program is the nucleus of the entire GEODYN System. It is a definitive orbit and geodetic parameter estimation program capable of simultaneously processing observations from multiple arcs of multiple satellites.

GEODYN has two modes of operation: the data reduction mode and the orbit generation mode.

In the data reductiom mode the following parameters can be estimated from satellite tracking data:

- Six orbital parameters representing the inertial position and velocity of the satellite at some given epoch,
- Physical constants related to the atmospheric drag and solar radiation forces affecting the motion of single satellites,
- Tracking station coordinates relative to the earth's center of mass,
- Tracking instrument errors, a zero-set bias, and a timing bias, and
- Geopotential gravity model coefficients.
- Surface density parameters.

In the data reduction mode the six orbital parameters are always estimated for each arc; if requested, the remaining parameters are estimated as options. If accurate values for the physical constants or geopotential coefficients are known a priori, these can be used in the system as fixed values.

In the orbit generation mode, the program will, given all of the orbit parameters a priori, compute satellite positions and velocities at times later than and/or prior to the epoch.

The GEODYN Program uses the terms inner and outer iterations. On inner iterations only individual arc parameters may be estimated. Individual arc parameters include the six orbital elements, drag, solar radiation, geopotential resonance coefficients, instrument biases and tracking station timing biases.

On outer iterations geodetic parameters are estimated using data from all arcs. Geodetic parameters include tracking station coordinates, geopotential gravity coefficients, and surface densities.

SECTION 1.0
GEODYN INPUT CARDS

Specific problems to be solved by the GEODYN program are defined by input cards, which are separated into two categories:

1. COMMON SET - These are input cards containing information that is common to all of the arcs being processed in the problem.

2. ARC SET - A collection of ARC SET cards is necessary to define each individual arc.

Thus the GEODYN input deck will consist of one collection of cards from COMMON SET and a collection of cards from ARC SET for each arc.

Each set contains mandatory and optional cards.

Mandatory Cards - These are input cards that must be present for each problem.

Optional Cards - These are input cards that are optionally used.

1.1 COMMON SET

COMMON SET defines that information which is common to all arcs and is necessary for the problem description.

Included in COMMON SET are four groups to be arranged in the following order:

1. Run description. (Mandatory)

2. Option cards which may be used to exercise GEODYN's capabilities to estimate tracking station positions, modify the earth force model, estimate geopotential coefficients, estimate surface densities, update the atmospheric density function, and modify the lunar and/or planetary solar gravity effects. (Optional)

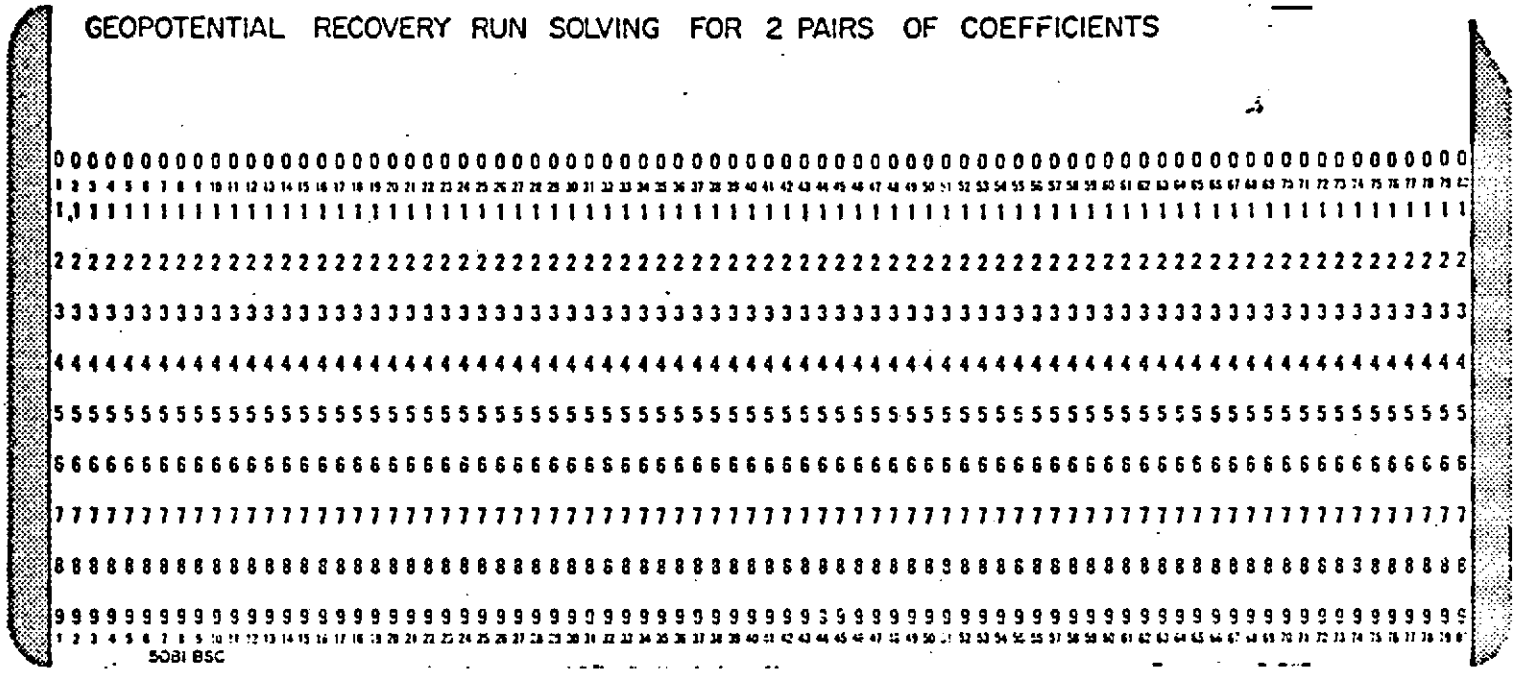
3. Station coordinate cards which may be used to alter GEODYN's built-in complement of tracking stations. (Optional)

4. COMMON SET termination card. (Mandatory)

The following pages describe these groups more thoroughly.

1.1.1 COMMON SET
GROUP 1 - RUN DESCRIPTION

TITLE CARDS



COLUMNS	FORMAT	DESCRIPTION
1-80	20A4	Run description to be printed on title page; use three title cards at the beginning of each run.

Three title cards are Mandatory.

1.1.2 COMMON SET
GROUP 2 - OPTION CARDS

Each Group 2 card is identified by the name beginning in column 1 and read under an A6 format. The name is followed by 9 fields:

Field Columns	Field Format
7, 8, 9, 10	4I1
11-25	D15.8
26-40	D15.8
41-55	D15.8
56-70	D15.8
71-80	D10.8

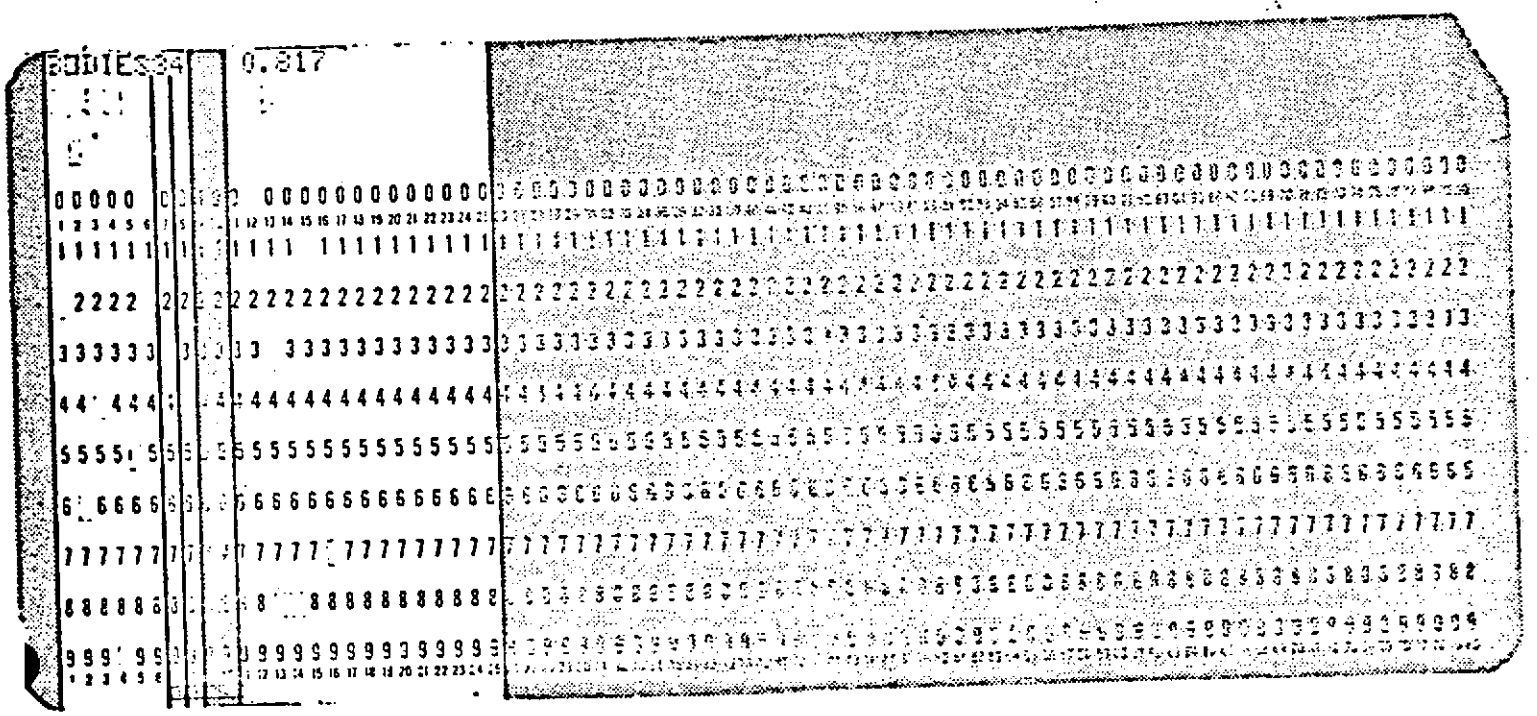
The Option Cards are:

BODIES	RSTART
CORREL	SEQDAT
EARTH	STAEST
EDIT	STEP
ELCUT	SURF
FLUX	TIDES
RECOEF(COEF)	TOLC
RESID	SURDEN
BPART	CENTER
J65	J650
J71	POLE

COMMON SET

GROUP 2 - OPTION CARDS

BODIES



NAME	COLUMNS	FORMAT	DESCRIPTION
BODIES	1-6	A6	Modifies non-earth gravity perturbations.
	7	I1	Indicates body for which gravity perturbation is to be modified: 1 - MOON 2 - SUN 3 - VENUS 4 - MARS

BODIES (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	7 (Cont.)		5 - JUPITER 6 - SATURN
	8	I1	Number * of perturbing bodies to be applied. (Maximum of 6) Default = 2. This number may be set on any one of the BODIES cards used.
	11-25	D15.8	Value of ratio of mass of body to mass of earth. If ratio is zero perturbing effect will be zero. Default mass ratios: M_1/M_e = 0.012299971710065O7 M_2/M_e = 332945.5619264376 M_3/M_e = 0.8150003229334958 M_4/M_e = 0.1074468525270073 M_5/M_e = 317.8809303 M_6/M_e = 95.14905175

IF CARD OMITTED: Lunar and solar gravitational perturbations will be applied using default mass ratios unless modified by BODIES card in ARC SET.

To omit a particular body for gravitational purposes a BODIES card representing that body must be included with the correspondin mass ratio set to zero.

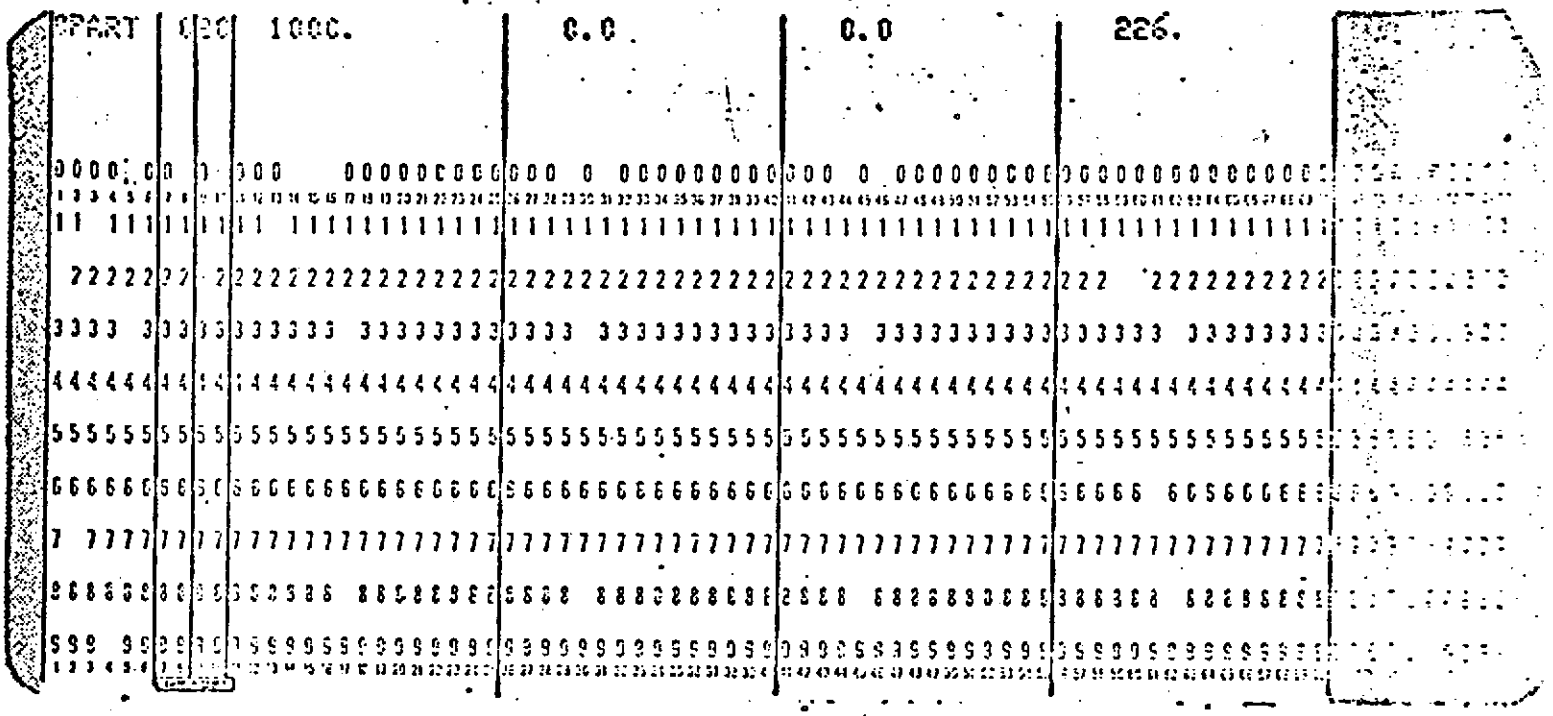
*For example, if the number of perturbing bodies is 4 then the effects of bodies 5 (Jupiter) and 6 (Saturn) will not be included

See also ARC Set - OPTION CARDS - BODIES

COMMON SET

GROUP 2 - OPTION CARDS

BPART



NAME	COLUMNS	FORMAT	DESCRIPTION
BPART	1-5	A5	Specifies that a) The B-Matrices created in this run will be formed in segments if necessary. b) That no outer iteration adjustment of common parameters will be performed if any of the arcs creates a B-Matrix.

NAME	COLUMNS	FORMAT	DESCRIPTION
	1-5 (cont.)		c) Solution for the arc parameters will be performed on the last iteration only if sufficient core is available.
	7-8	I2	Number of Segments to be utili: in formation of the B-Matrix. This is only an approximate number and may be modified by GEODYN. If values greater thar zero are placed in columns 11-2 26-40, or 41-55 then columns 7- will be ignored.
	9-10	I2	Number of measurements that wil be utilized in each operation on the normal equations. The time consumed for B-Matrix form tion by segments will be invers ly proportional to this value. The core required will be linea related to this value. Default 20.
	11-25	D15.8	Total amount of core allocated for the GEODYN execution in units of 1024 bytes.

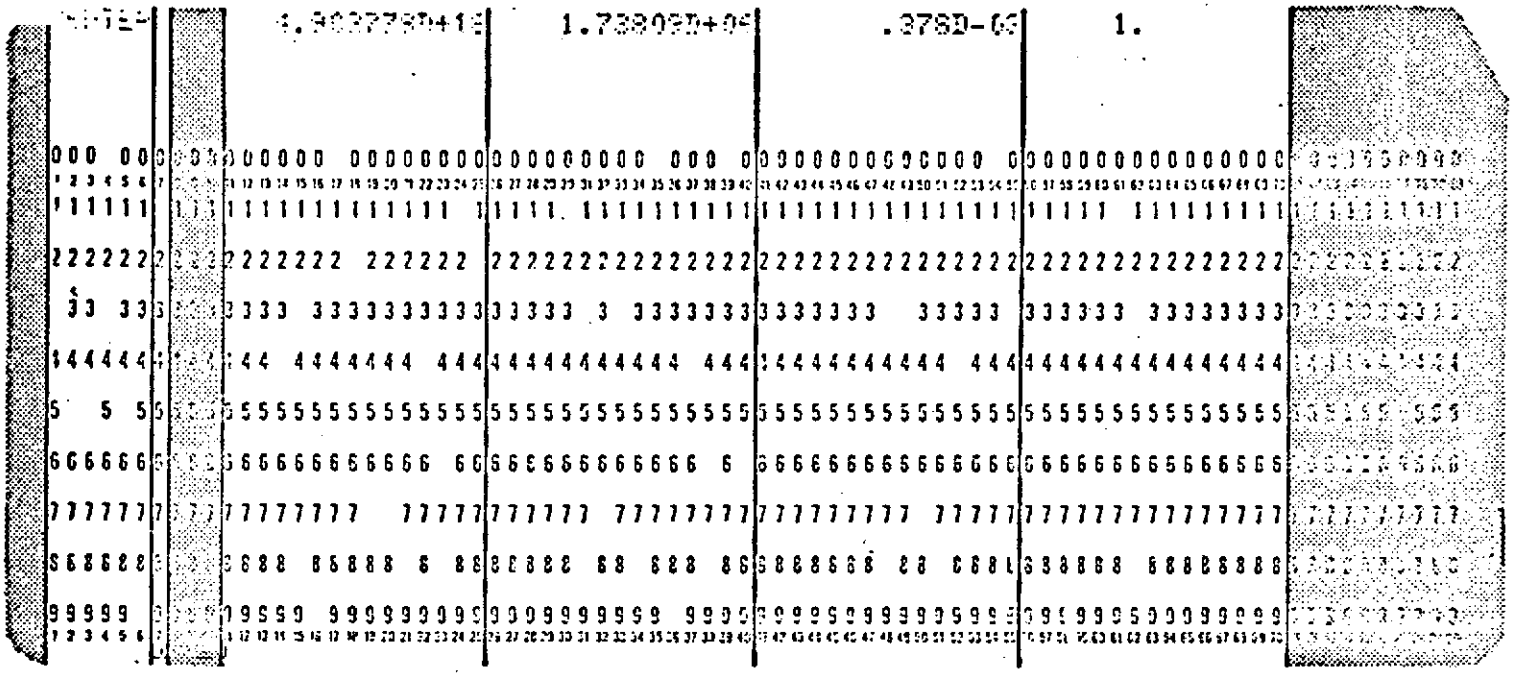
NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Total amount of core allocated for the GEODYN execution less that amount required for all I/O buffers. Units of 1024 byt If this value is greater than zero, columns 7-8 and 11-25 wil be ignored.
	41-55	D15.8	Total amount of core to be utilized for B-Matrix formation Units of 1024 bytes. If this value is greater than zero, columns 7-8, 11-25 and 26-40 wi be ignored.
	56-70	D15.8	Minimum B-Matrix Segment size in Double Words. The blocksize specified for unit 16 must be 8 times this value. B-Matrix segment sizes will be integral multiples of this number. Minimum value for this number is 226. Default value for this number is 226.

IF CARD OMITTED: B-Matrices will not be formed in segments.

Note: Increases in running time due to segmented formation of the B-Matrix are related to the parameters specified on this card as follows.

- directly proportional to the number of segments (which is proportional to the amount of core),
- inversely proportional to the blocksize for unit 16,
- inversely proportional to the value in columns 9-10.

COMMON SET
GROUP 2 - OPTION CARDS
CENTER



Name	Columns	Format	Description
CENTER	1-6	A6	Specifies change of central body in the forcing function.
	7	I1	Central body indicator = 1 Moon = 2 Sun = 3 Venus = 4 Mars = 5 Jupiter = 6 Saturn
	11-25	D15.8	GM_C - Universal gravitational constant times mass of the central body.

Name	Columns	Format	Description
	26-40	D15.8	A_c - Mean equatorial radius of the central body.
	41-55	D15.8	f_c - Flattening of the central body. Used only for surface density positioning.
	56-70	D15.8	Value greater than zero indicates trajectory output will be in mean of 1950 coordinates.

IF CARD OMITTED: Central body will be Earth.

Default values for Central Body Only.

				Potential Expansion	
Body	GM_c	A_c	f_c	Max Deg.	Max Ord.
MOON	4.902778D+12	1.73809D+06	.378D-03	4	4
SUN	1.327125D+20	6.96000D+08	.500D-04	4	4
VENUS	3.248602D+14	6.16881D+06	0.0	4	4
MARS	4.282843D+13	3.380422D+06	.105D-01	4	4
JUPITER	1.267077D+17	7.1371554D+07	.667D-01	4	4
SATURN	3.7926535D+16	6.0401128D+07	.105D-00	4	4

NOTES: This card should not be used if central body is Earth.

When this card is utilized the following inputs are referred to the central body:

- Columns 7-8, 9-10, 56-70, 71-80 on the EARTH card,
- RECOEF card information,
- SURF and SURDEN card information,

- Variance/covariance matrix of elements as specified on VARCOV card, and

- Epoch elements unless otherwise indicated on element cards.

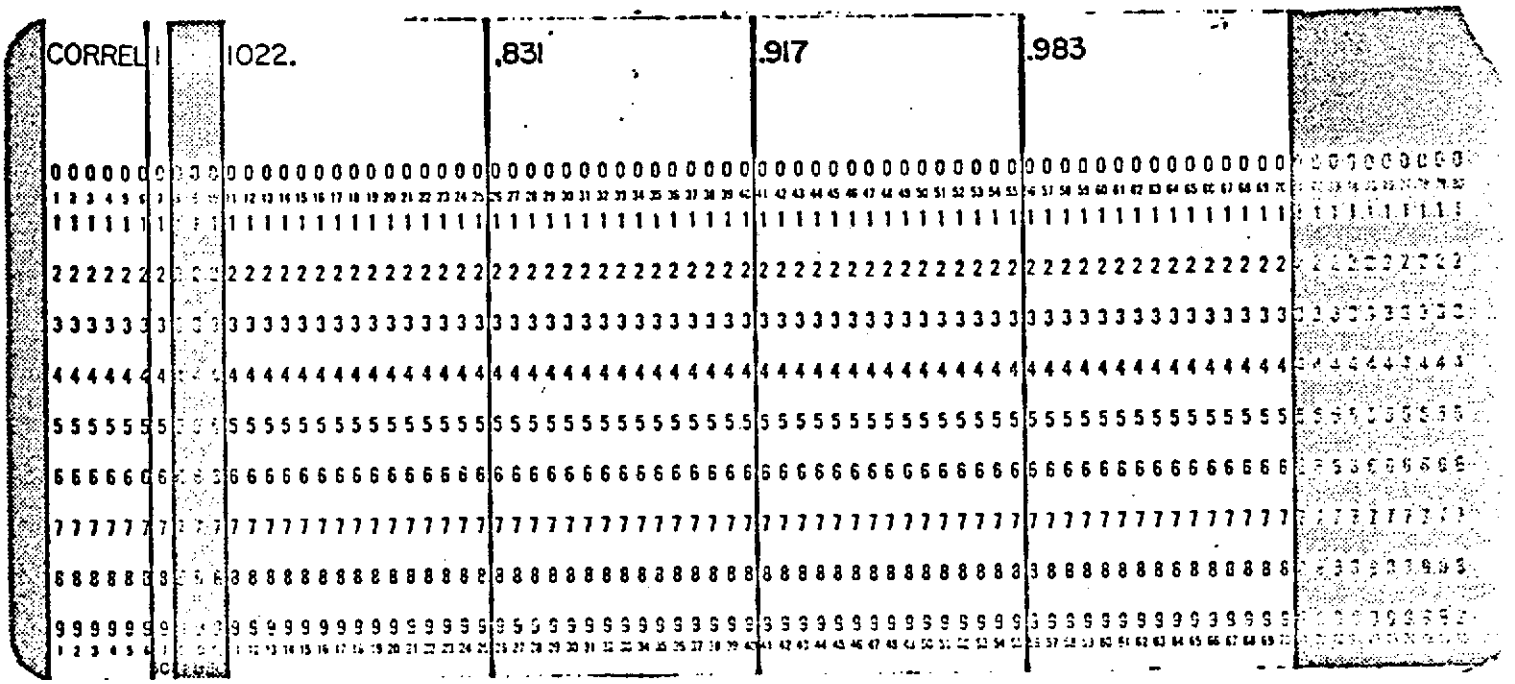
When the central body is not Earth, the drag and Earth tidal perturbations are automatically shut off.

See also Section 2.0, JCL for Unit 1 when CENTER card is used.

COMMON SET

GROUP 2 - OPTION CARDS

CORREL



NAME	COLUMNS	FORMAT	DESCRIPTION
CORREL	1-6	A6	Specifies the correlation coefficients between the coordinates of a station to be adjusted.
	7	I1	=1 - correlation coefficients input on earth-fixed X,Y,Z. = blank - correlation coefficients input on latitude, longitude, and height.
	11-25	D15.8	Station number.
	26-40	D15.8	Correlation coefficient between X and Y or latitude and longitude.
	41-55	D15.8	Correlation coefficient between X and Z or latitude and height.

NAME	COLUMNS	FORMAT	DESCRIPTION
	56-70	D15.8	Correlation coefficient between Y and Z or longitude and height.

IF CARD OMITTED: The coordinates of the station are assumed to be uncorrelated.

NOTES: The maximum number of master and unconstrained adjusted stations* (see STAEST card in this Section) is 381; one CORREL card may appear for each such adjusted station. If no CORREL card appears for such an adjusted station, uncertainties in the a priori station position will be assumed uncorrelated. Constrained adjusted stations which are not master stations are assumed to have the same correlations as the master station.

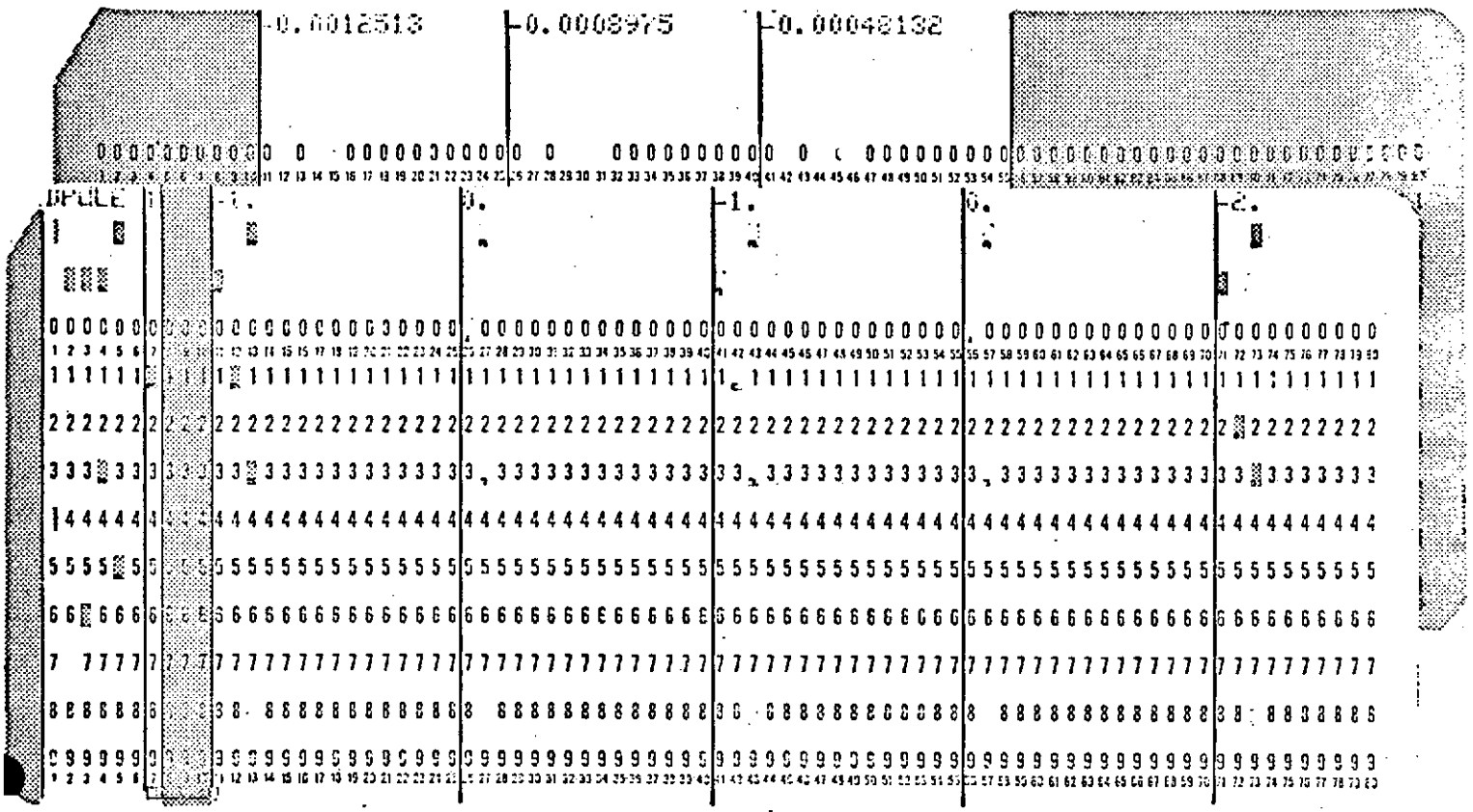
If a CORREL card appears for a station there must also be a STAEST card present for that station. If the station is a constrained station it must be a master station.

* The terms constrained, unconstrained and master stations refer only to adjusted stations (i.e., those for which STAEST cards are present). A group of constrained stations are stations which are adjusted such that the same station position corrections are to be applied to each station in the group. One station in each group is arbitrarily designated as a master station and all other stations in the group must refer to that master station. An unconstrained station is an adjusted station which is not a member of any group of constrained stations.

COMMON SET

GROUP 2 - OPTION CARDS

DPOLE



NAME	COLUMNS	FORMAT	DESCRIPTION
DPOLE	1-5	A5	Modifies the coefficients of the diurnal nutations of the pole*.
	7	I1	Specifies the disturbing body =1 moon =2 sun
	11-25	D15.8	Multiplier of the mean anomaly of the moon (ℓ).

*Note: The DPOLE option card may be used to expand or reduce the existing tables in BLOCK DATA.

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Multiplier of the mean anomaly of the sun (ℓ').
	41-55	D15.8	Multiplier of the mean angular distance of the moon from its ascending node (F).
	56-70	D15.8	Multiplier of the mean elongation of the moon from the sun (D).
	71-80	D10.8	Multiplier of the longitude of the mean ascending node of the moon's orbit (Ω).

SECOND CARD

COLUMNS	FORMAT	DESCRIPTION
1-10		Must be left blank.
11-25	D15.3	Coefficient for the rotation axis.
26-40	D15.3	Coefficient for angular momentum.
41-55	D15.3	Coefficient of Euler angle perturbations in longitude.

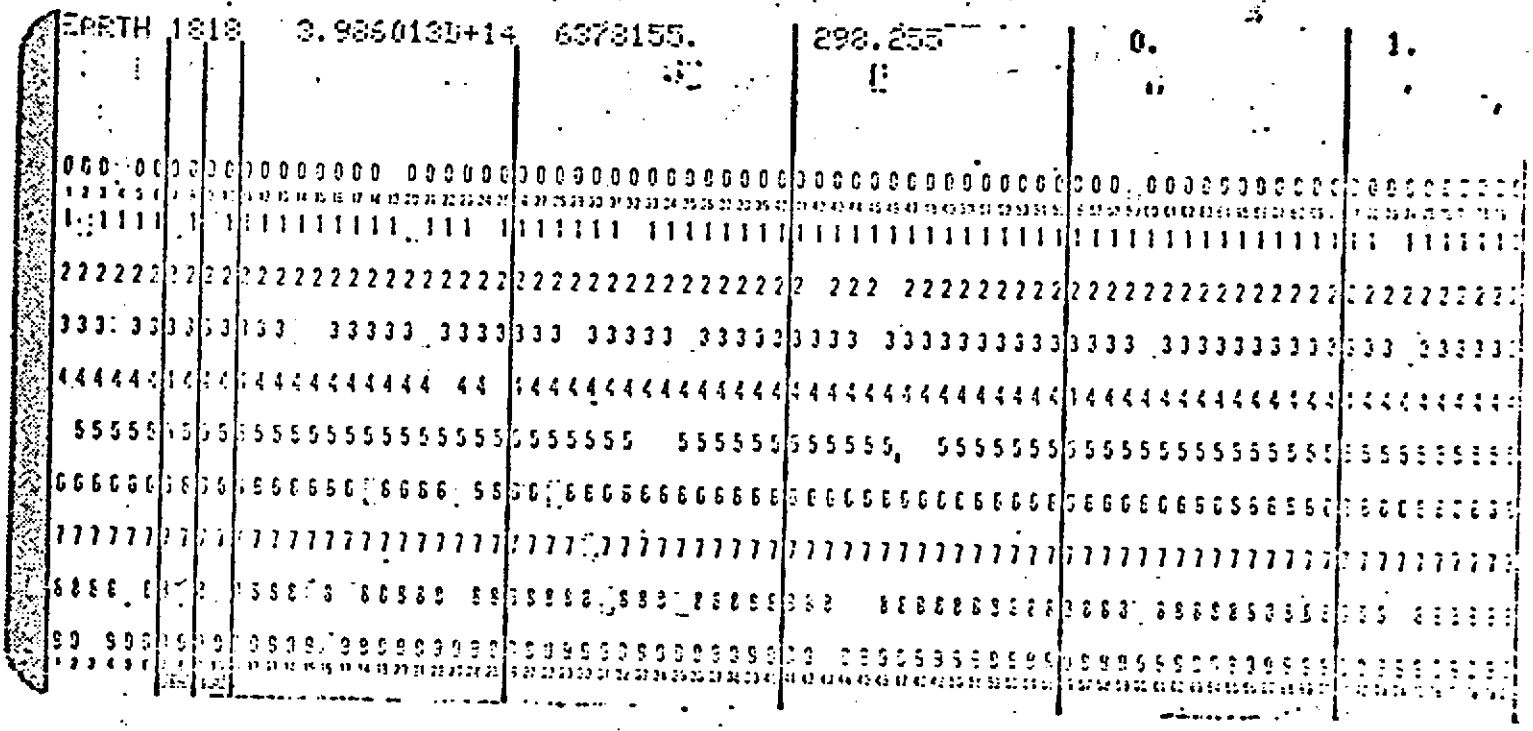
The second card must be present if the DPOLE option is used. If the second card is left blank, then there will be a zero contribution for the fundamental argument multipliers as specified on the DPOLE card.

Any number of DPOLE cards may be used.

COMMON SET

GROUP 2 - OPTION CARDS

EARTH



NAME	COLUMNS	FORMAT	DESCRIPTION
EARTH	1-5	A5	Modifies the geopotential and/or introduces new earth constants.
	7-8	I2	Maximum degree coefficient to be used in the geopotential model plus 1. Default = 23, Minimum = 4
	9-10	I2	Maximum order coefficient to be used in the geopotential

EARTH (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10 (Cont.)		model plus 1. Default = 23, Minimum = 2
	11-25	D15.8	GM - The gravitational constant times the mass of the earth.
	26-40	D15.8	a_e - Semi-major axis of the earth.
	41-55	D15.8	Inverse of the earth flattening. (1/f)
	56-70	D15.8	Odd value greater than zero - All geopotential coefficients set to zero except those which appear on RECOEF cards which follow this card.
			Value greater than 1.0 - Requests that geopotential coefficients printed in run heading be in normalized form rather than the default de-normalized form.
	71-80	D18.8	Fractional uncertainty in GM of the central body (see CENTER card). For value other than zero, GM of the central body will be adjusted.

The default values of the earth constants as used by GEODYN are:

GM = 3.986013D + 14 m^3/sec^2

a_e = 6378155. m.

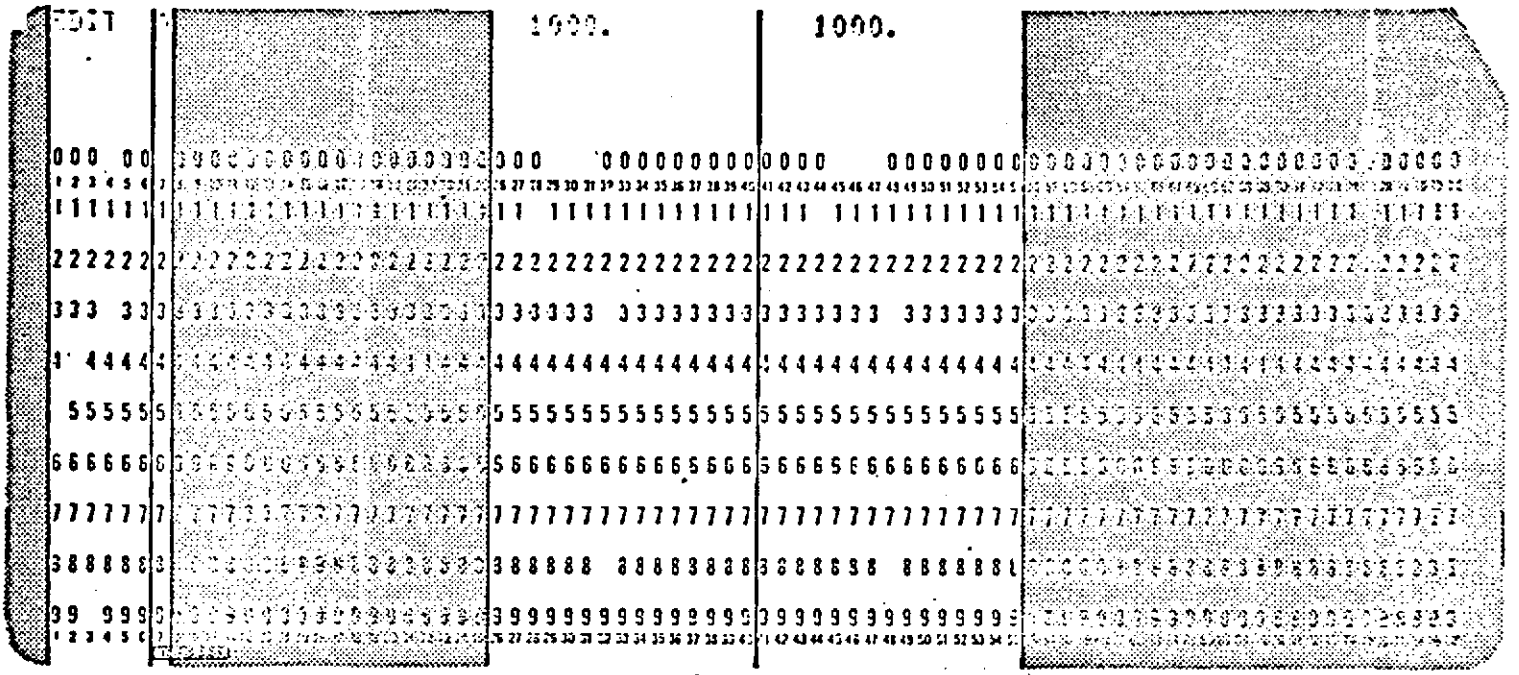
1/f= 298.255

IF CARD OMITTED: The stored SAO 1969 geopotential field containing terms up to degree and order 22 will be used with the default values of the Earth constants unless modified by RECOEF cards in COMMON SET or EARTH and RECOEF cards in ARC SET.

The set-up for two body Earth computation is explained in ARC SET, OPTION CARD -- EARTH.

See ARC SET, OPTION CARD -- EARTH for individual arc specification.

COMMON SET
GROUP 2 - OPTION CARDS
EDIT



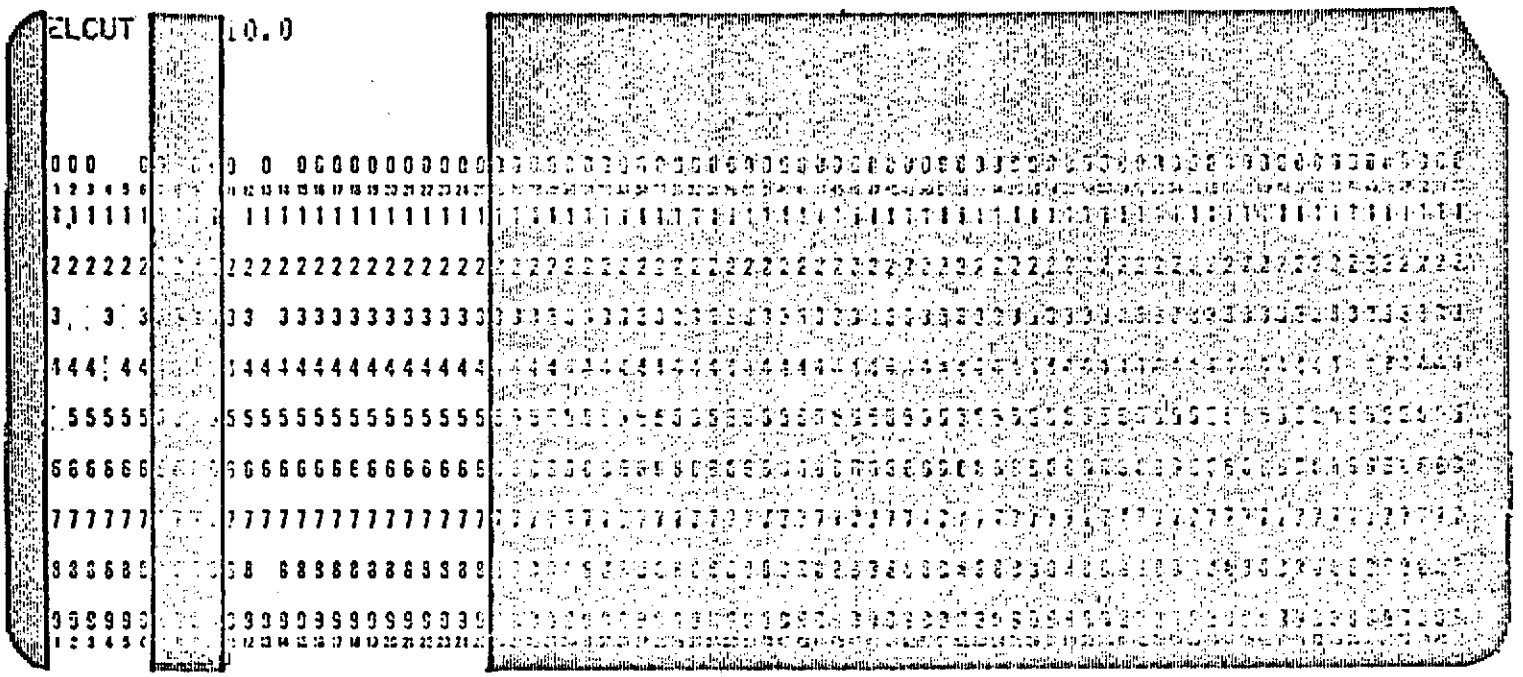
NAME	COLUMNS	FORMAT	DESCRIPTION
EDIT	1-4	A4	Used to change initial outer iteration RMS.
	7		Value greater than zero indicates that automatic editing of arcs will be performed.
	26-40	D15.8	Initial outer iteration RMS. Used for outer iteration convergence test. Default = 1000.
	4 55	D15.8	First iteration edit criterion for electronic bias passes. Default - use same editing as other data uses.

IF CARD OMITTED: Default RMS used, and no automatic editing will be performed.

COMMON SET

GROUP 2 - OPTION CARDS

ELCUT



NAME	COLUMNS	FORMAT	DESCRIPTION
ELCUT	1-5	A5	Specifies the elevation angle below which measurements will be deleted from the solution.
	11-25	D15.8	Elevation cut-off angle in degrees. Default = 0°

IF CARD OMITTED: All measurement with elevation angles less than 0° will be edited from the solution unless modified in ARC SET by ELCUT card.

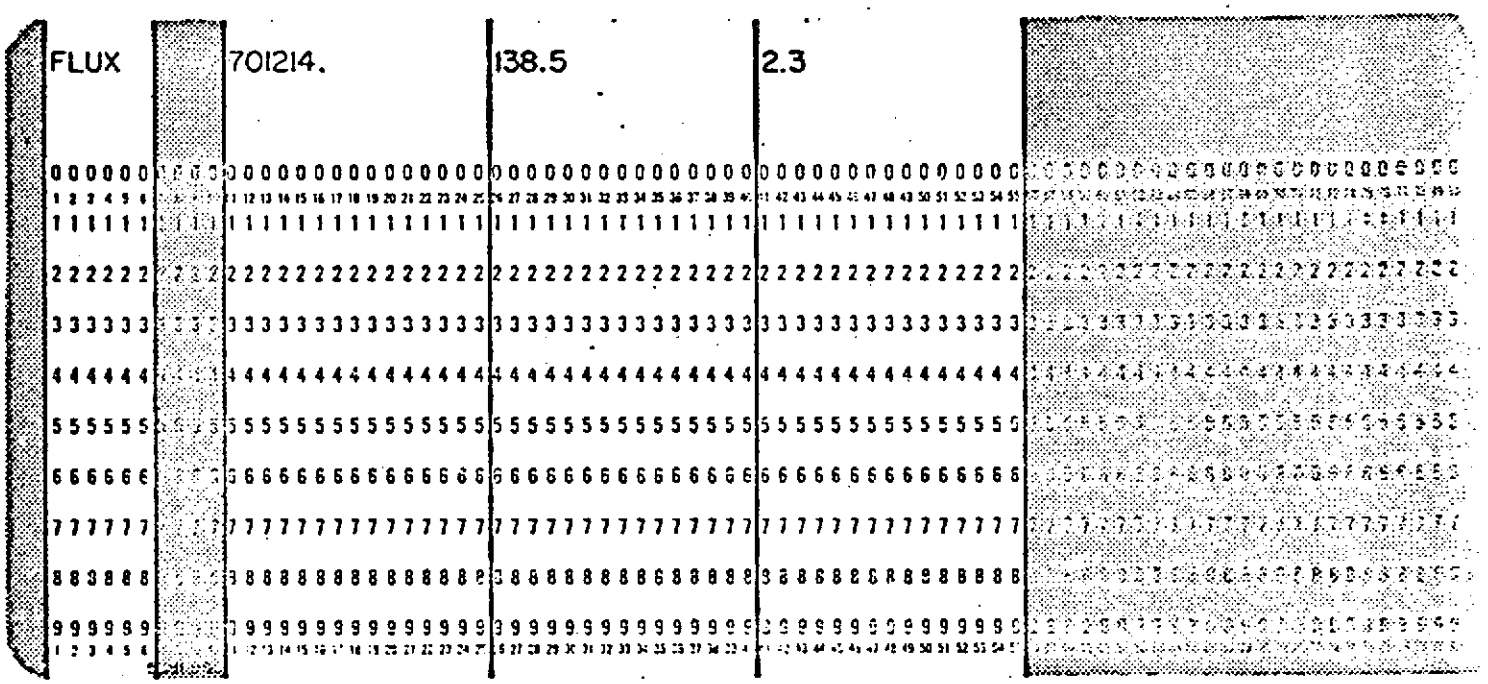
Elevation cut-off angle may be negative.

See also ARC SET, OPTION CARD - ELCUT.

COMMON SET

GROUP 2 - OPTION CARDS

FLUX



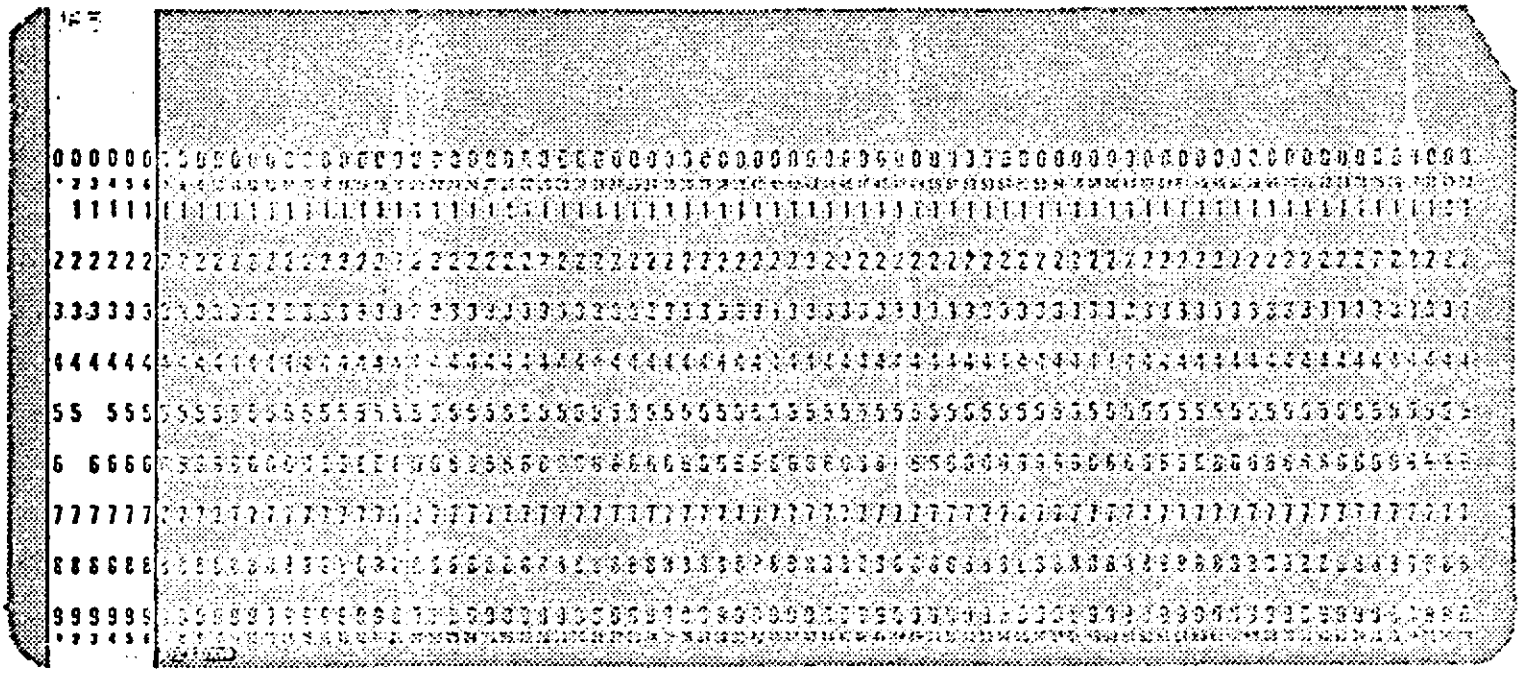
NAME	COLUMNS	FORMAT	DESCRIPTION
FLUX	1-4	A4	Adds and modifies solar and/or magnetic flux values in built-in tables.
	11-25	D15.8	Date of flux values (in YYMMDD).
	26-40	D15.8	Value of solar flux. If blank, value in table will not be altered. $F_{10.7}$

NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	Value of magnetic flux. If blank, value in table will not be altered. Input value is th daily sum of the eight three-hourly values k_p.

IF CARD OMITTED: Built-in tables are used.

Note: Flux values are daily values. All zero values between the end of the built-in tables and the data added via FLUX cards will be filled by straight line interpolation between known values. For dates beyond the table entries and data added by flux cards, the most recent values are used.

COMMON SET
GROUP 2 - OPTION CARDS
J65



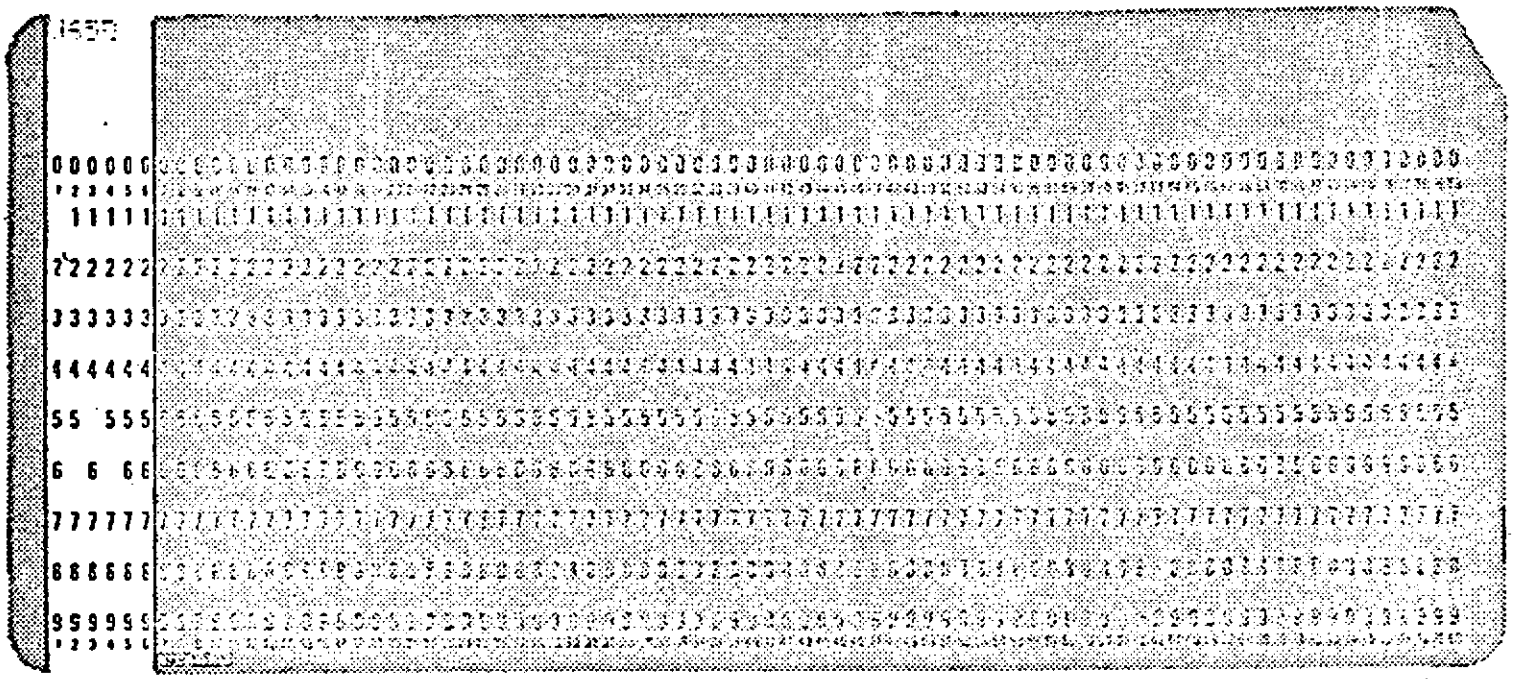
NAME	COLUMNS	FORMAT	DESCRIPTION
J65	1-3	A3	Changes the default atmospheric density model for all arcs to the Jacchia 1965a Static Density Model updated to 1968 (herein designated J65).

IF CARD OMITTED: Default will be J65 unless elsewhere modified to J650 or J71. See also Epoch Card and Option Cards J650 and J71.

COMMON SET

GROUP 2 - OPTION CARDS

J650



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NAME	COLUMNS	FORMAT	DESCRIPTION
J650	1-4	A4	Changes default atmospheric density model to Old J65 (herein designated J650). This model differs from J65 in several aspects [1]. It should be noted that these differences constitute errors in the J650 model. The J650 model is available in GEODYN only because this model has previously been the only model used by GEODYN.

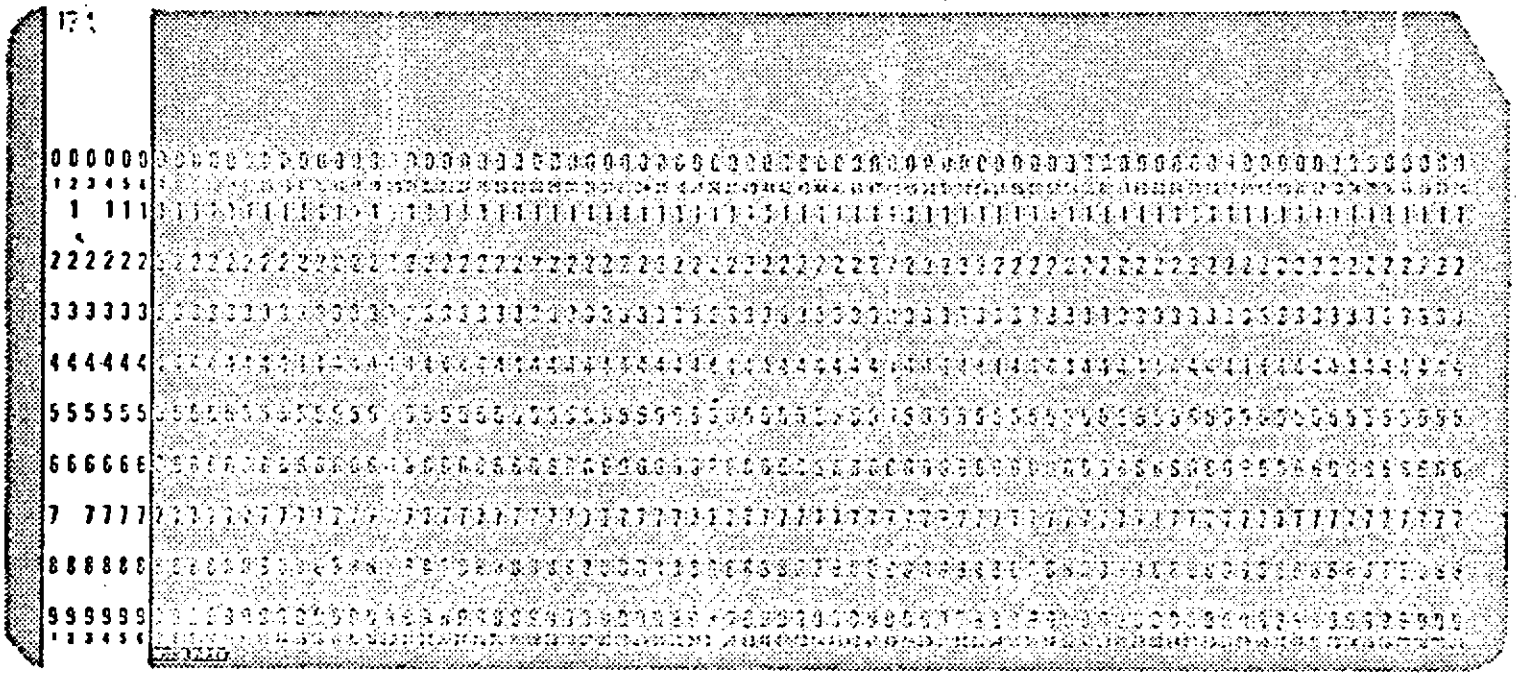
IF CARD OMITTED: Default will be J65 unless elsewhere modified to J650 or J71. See also Epoch Card and Option Cards J65 and J71.

[1] "Notes on the Application of 10.7 cm Solar Flux Data in the Jacchia Static Diffusion Models of the Upper Atmosphere and Related Topics," Wolf Research and Development Corporation, July 1973.

COMMON SET

GROUP 2 - OPTION CARDS

J71



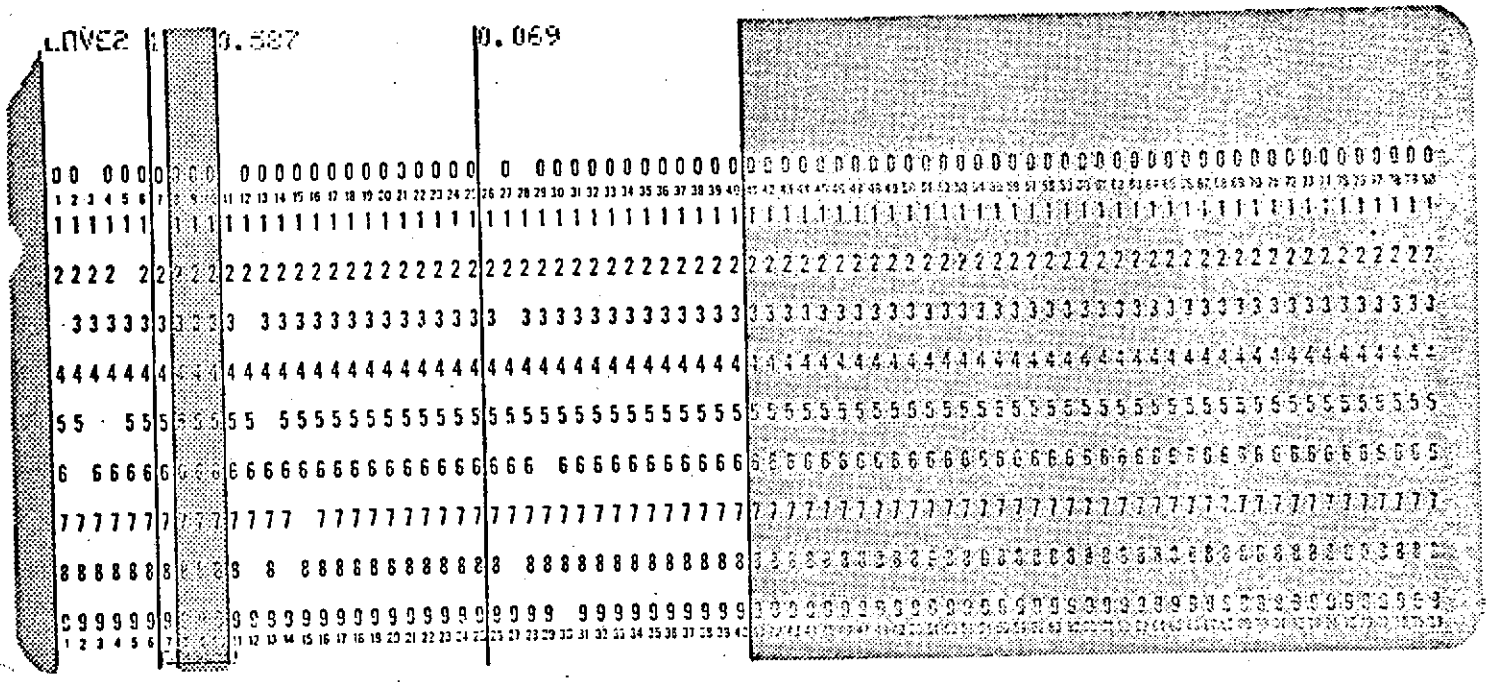
NAME	COLUMNS	FORMAT	DESCRIPTION
J71	1-3	A3	Changes default atmospheric density model for all arcs to the Jacchia 1971 Static Density Model (herein designated J71).

IF CARD OMITTED: Default will be J65 unless elsewhere modified to J650 or J71. See also Epoch Card and Option Cards J65 and J650.

COMMON SET

GROUP 2 - OPTION CARDS

LOVE2



NAME	COLUMNS	FORMAT	DESCRIPTION
LOVE2	1-5	A5	Requests that solid earth tide coefficients of the second and third kind be modified.
	7	I1	=0, this card pertains to both lunar and solar effects.
			=1, this card pertains to only lunar effects.
			=2, this card pertains to only solar effects.

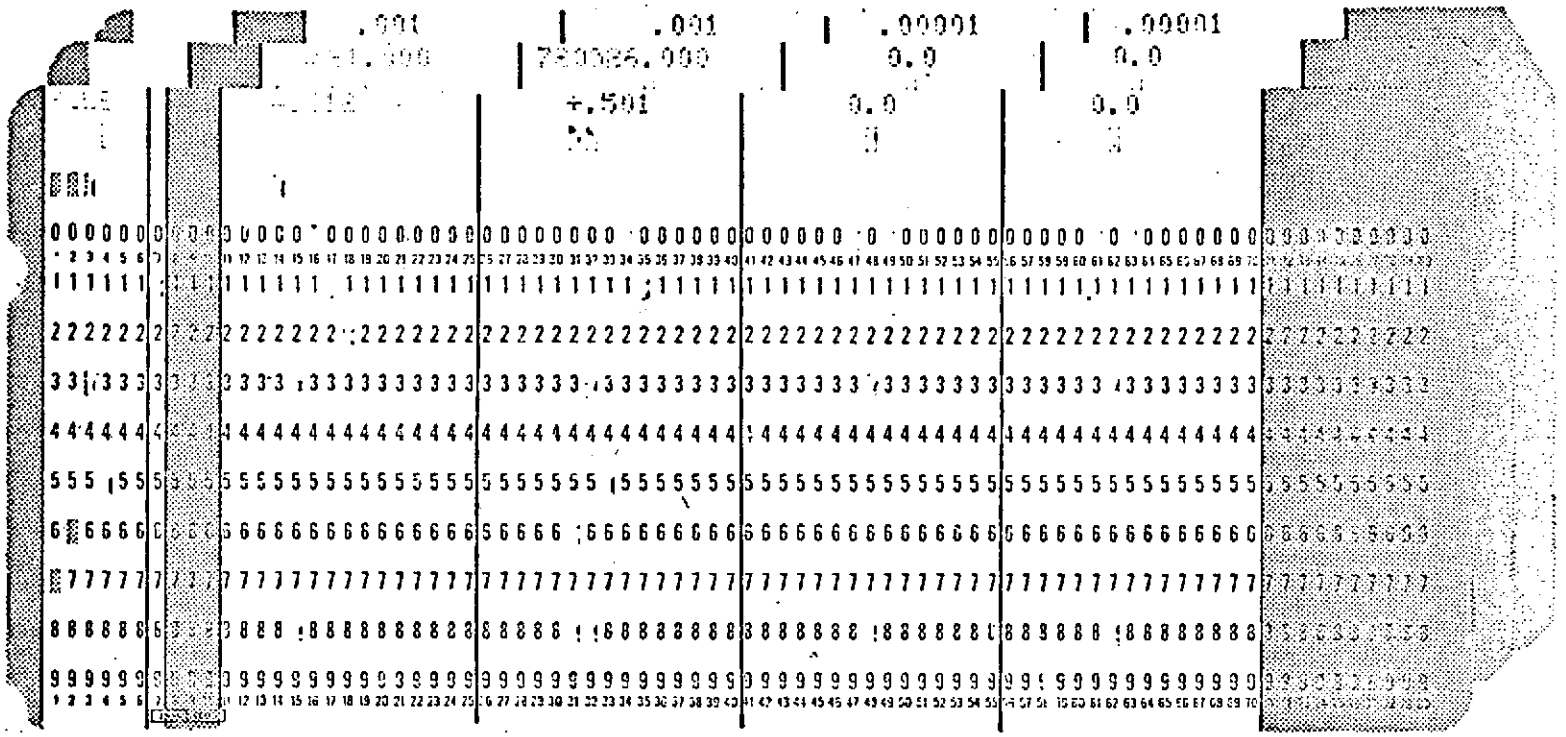
NAME	COLUMNS	FORMAT	DESCRIPTION
	11-25	D15.8	Love number of the second kind to account for radial displacement. h_2
	26-40	D15.8	Love number of the third kind to account for horizontal shearing. ℓ_2

IF CARD OMITTED:

Default values are as follows:

$h_2 = 0.600$ $\ell_2 = 0.075$

COMMON SET
GROUP 2 - OPTION CARDS
POLE



NAME	COLUMNS	FORMAT	DESCRIPTION
POLE	1-4	A4	Used to modify and/or request the adjustment of the true pole of the Earth.
	7	I1	=0 No adjustment to be made. >0 Adjustment requested. =2 Solution constrained to adjustments on the great circle passing through the pole as defined by the longitudes specified in columns 41-70 of the second card in this group.
	11-25	D15.8	X of the pole in seconds of arc.
	26-40	D15.8	Y of the pole in seconds of arc.

POLE (Cont.)

COLUMNS	FORMAT	DESCRIPTION
41-55	D15.8	$\dot{X}$ of the pole in seconds of arc per day.
56-70	D15.8	$\dot{Y}$ of the pole in seconds of arc per day.

SECOND CARD

1-6	A6	Blanks must be present.
11-25	D15.8	Start time for application of polar coordinates in form YYMMDD.DDD
26-40	D15.8	Stop time for application of polar coordinate in form YYMMDD.DDD
41-55	D15.8	A priori correlation coefficient between X an Y or (see First Card column 7) longitude of constraint for X and Y.
56-70	D15.8	A priori correlation coefficient between $\dot{X}$ an $\dot{Y}$ or (see First Card column 7) longitude of constraint for $\dot{X}$ and $\dot{Y}$.

THIRD CARD (read only if adjustment in requested; see First Card colum

1-6	A6	Blanks must be present. All other fields on this card must contain values greater than ze
11-25	D15.8	A priori uncertainty in X. Same units as X.
26-40	D15.8	A priori uncertainty in Y. Same units as Y.

COLUMNS	FORMAT	DESCRIPTION
41-55	D15.8	A priori uncertainty in $\dot{X}$. Same units as $\dot{X}$.
56-70	D15.8	A priori uncertainty in $\dot{Y}$. Same units as $\dot{Y}$.

IF CARD OMITTED: Default values of the pole will be used.

Maximum number of POLE cards 337.

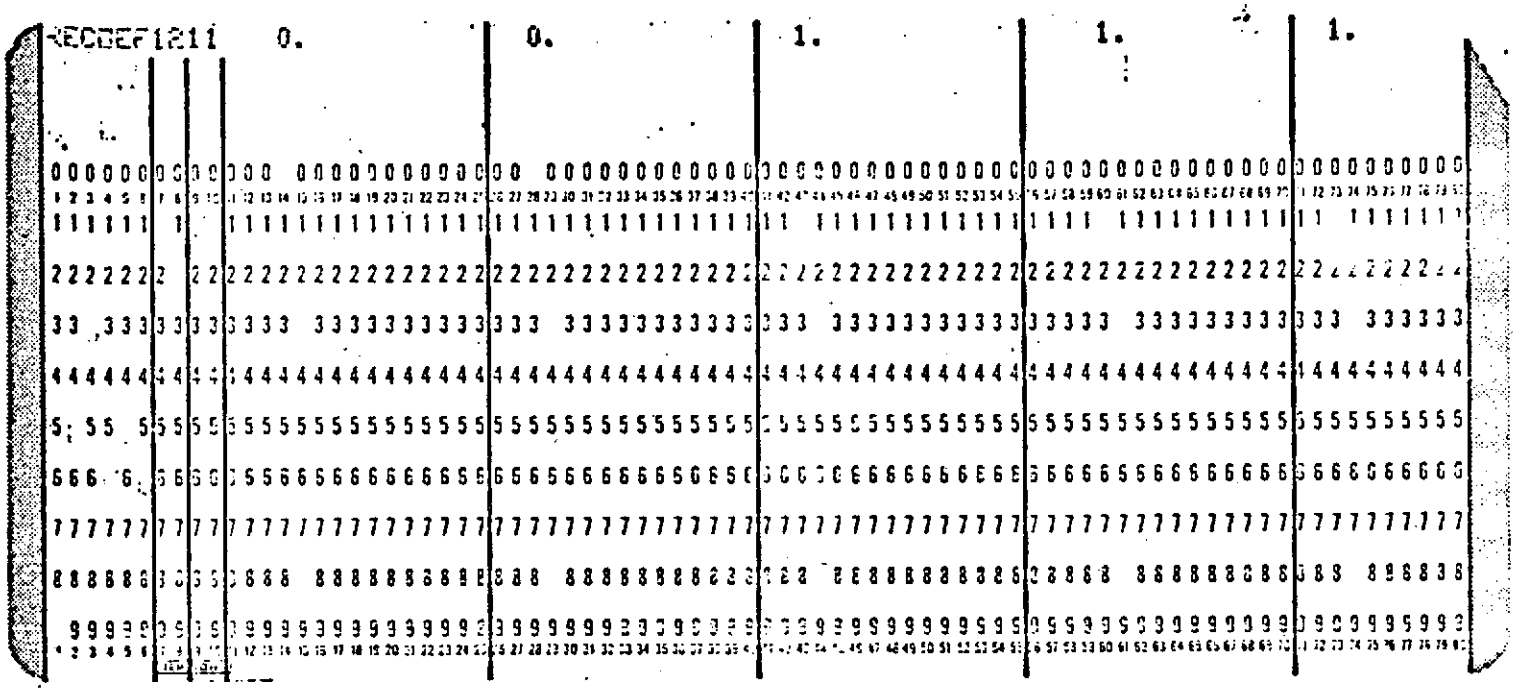
Coordinates of the POLE valid for midpoint of time span.

Overlapping time spans not allowed.

COMMON SET

GROUP 2 - OPTION CARDS

RECOEF (COEF)



NAME	COLUMNS	FORMAT	DESCRIPTION
RECOEF or COEF	1-6	A-6	Modifies and/or requests the estimation of coefficients in the geopotential model.
	7-8	I2	Degree of C and S coefficients. (n index)
	9-10	I2	Order of C and S coefficients. (m index)

NAME	COLUMNS	FORMAT	DESCRIPTION
	11-25	D15.8	A priori (or starting) value of C coefficient.
	26-40	D15.8	A priori (or starting) value of S coefficient.
	41-55	D15.8	Standard deviation of C coefficient. Coefficient will not be adjusted if value is zero. Value is fractional uncertainty if ≥1.OD-5 ($\sqrt{1.OD-5}$ for J2) and standard deviation equals fractional uncertainty times nominal* value of a priori coefficient. The fractional uncertainty is the standard deviation divided by the a priori value. Value is standard deviation if <1.OD-5 ($\sqrt{1.OD-5}$ for J2).
	56-70	D15.8	Standard deviation of S coefficient Coefficient will not be adjusted if value is zero. Value is fractional uncertainty if ≥1.OD-5 and standard deviation equals fractional uncertainty times nominal* value of a priori coefficient. Value is standard deviation if <1.OD-5.

RECOEF (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	71-80	D10.4	=0 Values on this card will be interpreted as being unnormalized.
			>0 Entries in columns 11-40 of this card will be ignored. A priori values of coefficients are obtained from current geopotential model including all modification prior to this card. Input standard deviations are un-normalized.
			<0 Values on this card will be interpreted as being normalized.

IF CARD OMITTED: The geopotential used will be the GEM 1 Model unless modified by EARTH card or modified in ARC SET by option cards, EARTH and RECOEF.

See also ARC SET, OPTION CARD - RECOEF.

The geopotential coefficient denormalization equation used is:

$$C_n^m = \overline{C_n^m} * D_n^m$$

$$S_n^m = \overline{S_n^m} * D_n^m$$

where

$$D_n^m = \sqrt{(4n + 2)\ \frac{(n - m)!}{(n + m)!}} \quad \text{for } m \neq o$$

$$D_n^m = \sqrt{2n + 1} \quad \text{for } m = o$$

and

C_n^m, S_n^m are un-normalized coefficients

$\overline{C_n^m}$, $\overline{S_n^m}$ are normalized coefficients

*Nominal values of geopotential coefficients are

$$|J_n^m| = \frac{(10^{-5})\ D_n^m}{n^2}$$

A Priori Value of Adjusted Coefficients

If it is desired that the starting values of geopotential coefficients be different than the a priori values for those coefficients then the RECOEF card should be used as follows:

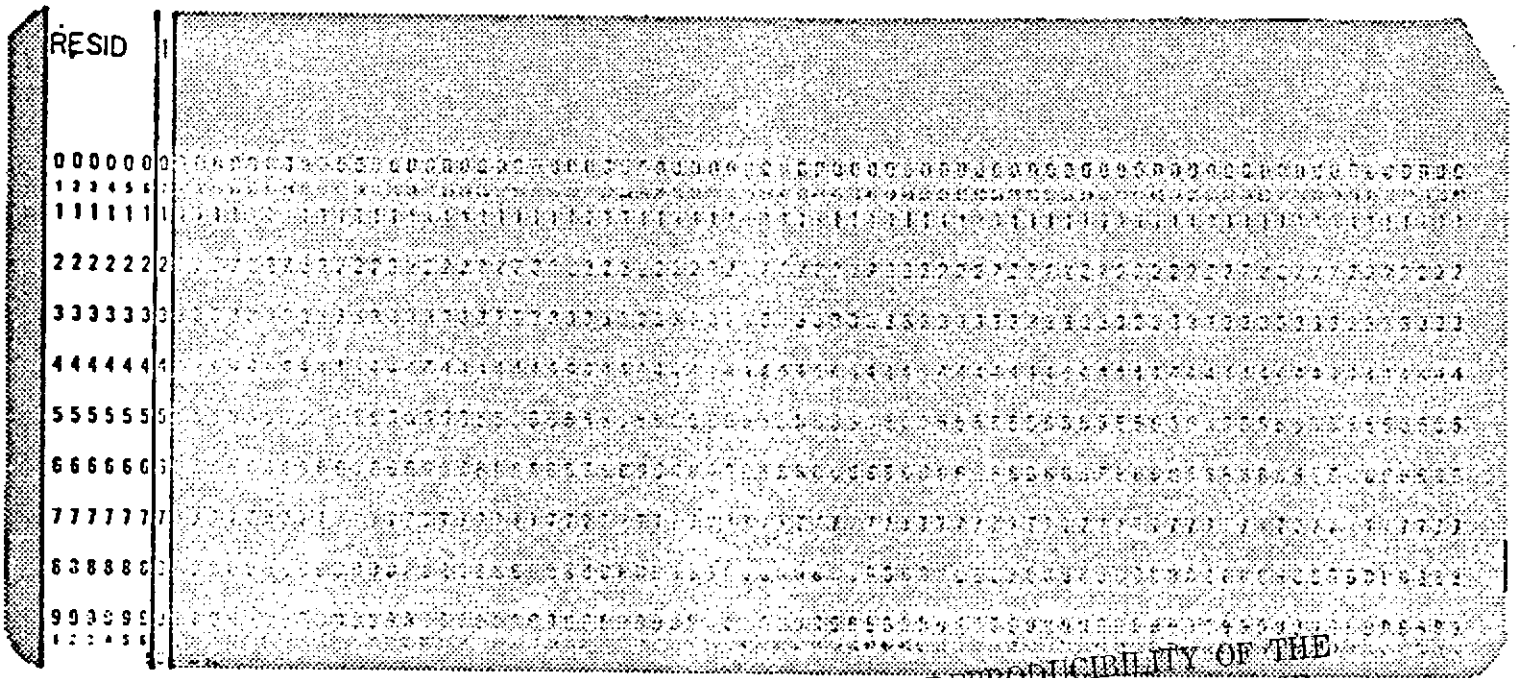
- RECOEF cards requesting the desired coefficient adjustments should be included in the setup deck. The a priori values will be indicated on these cards.

- For each coefficient pair for which the starting value is to be different than the a priori value, an additional RECOEF card should be in the setup deck. This RECOEF card will indicate the starting value and come later in the deck than the corresponding RECOEF card requesting adjustment.

COMMON SET

GROUP 2 - OPTION CARDS

RESID



NAME	COLUMNS	FORMAT	DESCRIPTION
RESID	1-5	A5	Controls residual printout for all arcs.
	7	I1	0 - Indicates no residuals are requested for any arc.
			1 - Indicates that residuals are requested on the first inner iteration of the first outer iteration for all arcs.

NAME	COLUMNS	FORMAT	DESCRIPTION cont.
	7 (Cont.)		2 - Indicates that residuals are requested on the last inner iteration of the last outer iteration for all arcs.
			3 - Indicates that residuals are requested on the first inner iteration of the first outer iteration and the last inner iteration of the last outer iteration for all arcs.
			4 - Indicates residuals are requested on all iterations for all arcs.

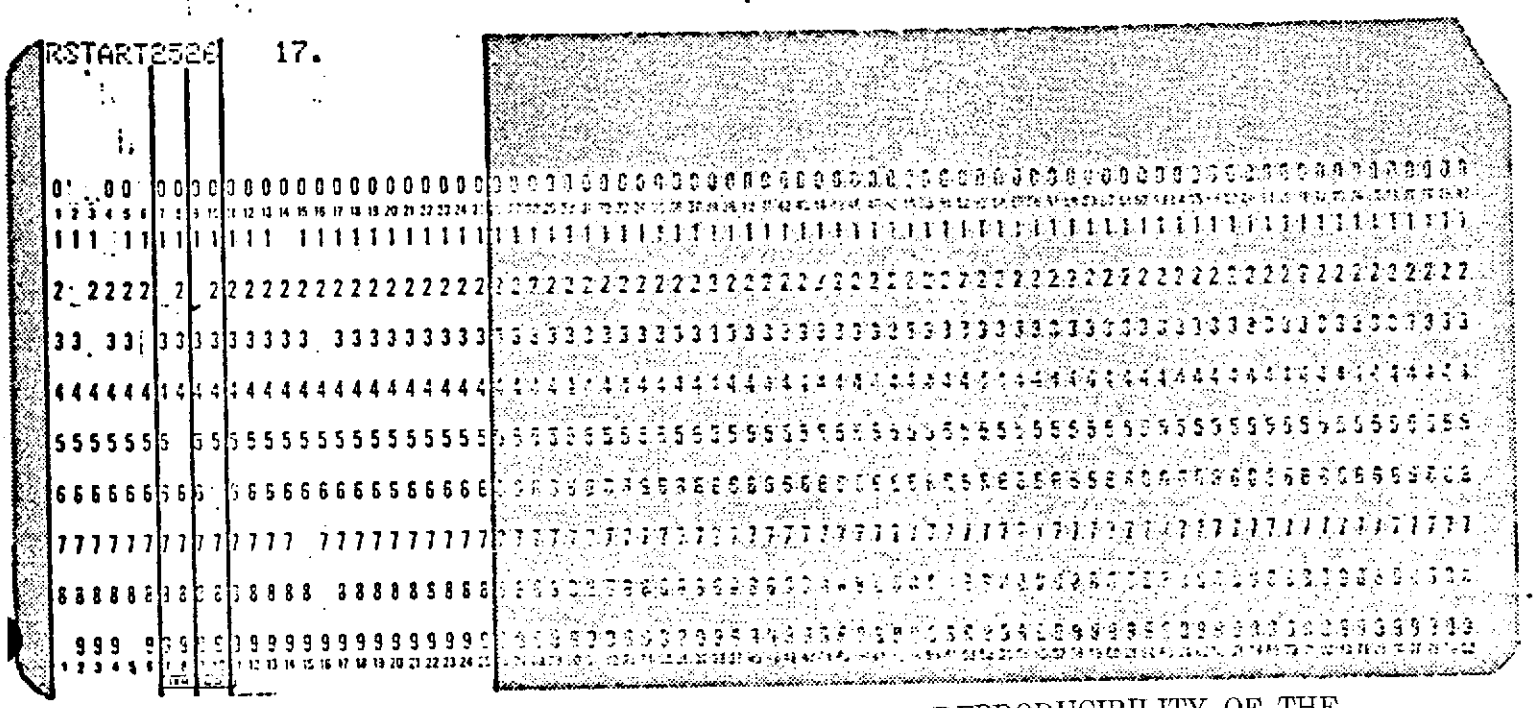
IF CARD OMITTED: Residuals are printed out for the first and last iterations of each arc unless modified in each arc by the RESID card in ARC SET.

See also ARC SET, OPTION CARD - RESID.

COMMON SET

GROUP 2 - OPTION CARDS

RSTART



REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

NAME	COLUMNS	FORMAT	DESCRIPTION
RSTART	1-6	A6	Requests the restart of a previous run and/or requests that a restart tape be written in this run.
	7-8	I2	Unit number of input restart tape. If zero or blank, job will start from the beginning.
	9-10	I2	Unit number of output restart tape. If zero or blank, no output restart tape will be written.

NAME	COLUMNS	FORMAT	DESCRIPTION
	11-25	D15.8	Number of arc in which termination occurred. If zero or blank, the job will start from the beginning.

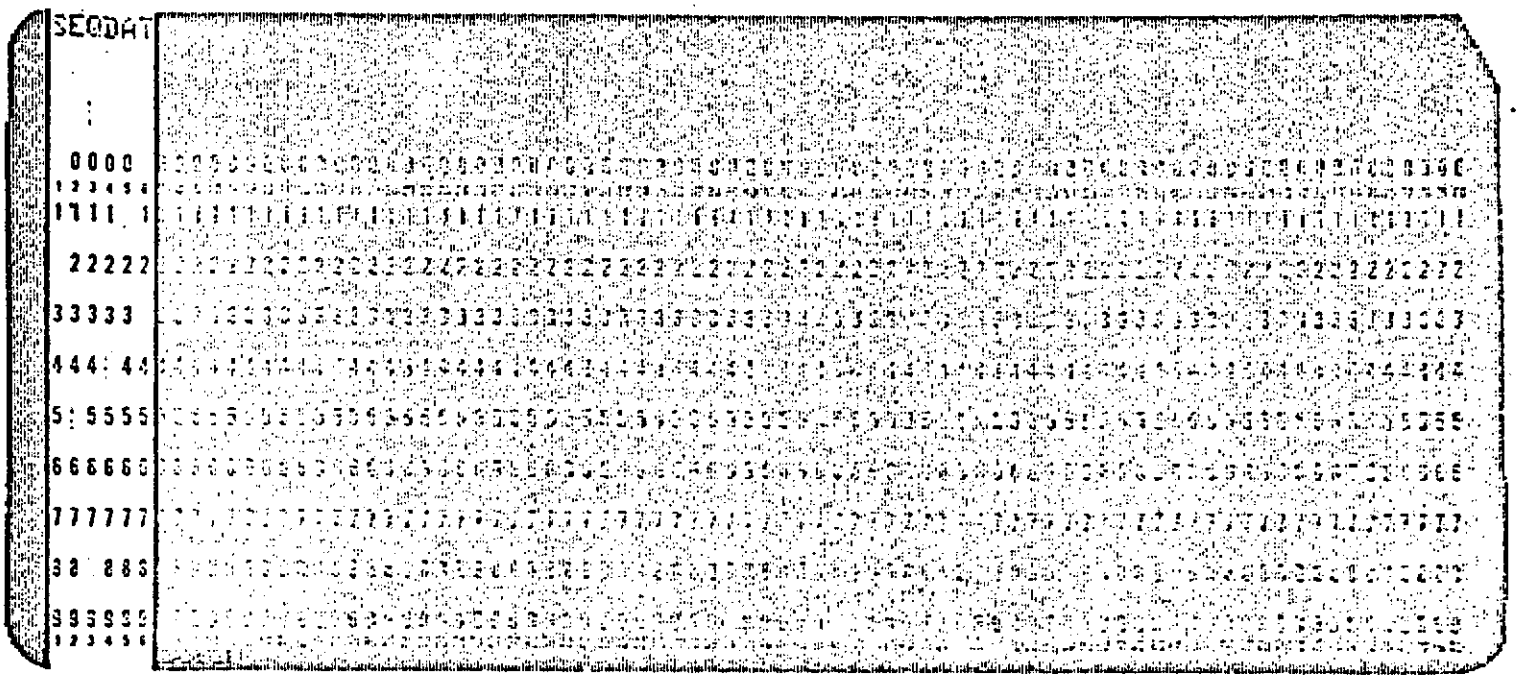
IF CARD OMITTED: The job will start from the beginning and no output restart tape will be written.

NOTE: Set up changes may not be made such that the size or configuration of the normal matrix is altered when restarting.

COMMON SET

GROUP 2 - OPTION CARDS

SEQDAT



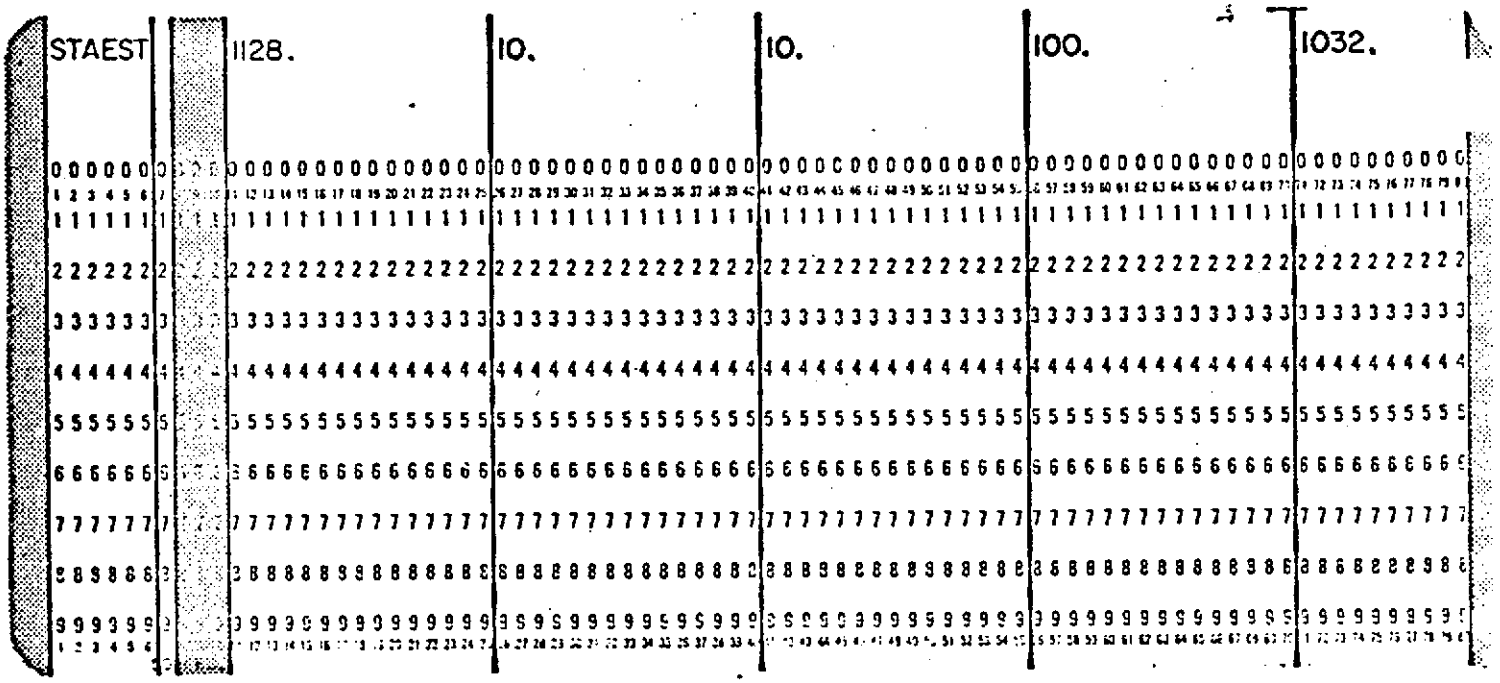
NAME	COLUMNS	FORMAT	DESCRIPTION
SEQDAT	1-6	A6	Assumes arcs are in chronological order.

IF CARD OMITTED: Makes no assumption as to order of arcs.

If SEQDAT is included in set up, arcs absolutely MUST be in chronological order.

This option is included to reduce running time by not rewinding the tape between arcs unless unit number changes. One data point will be lost between arcs when this option is used.

COMMON SET
GROUP 2 - OPTION CARDS
STAEST



NAME	COLUMNS	FORMAT	DESCRIPTION
STAEST	1-6	A6	Request estimation of a station position.
	7	I1	=1 - standard deviations input on station earth-fixed X,Y,Z. =blank - standard deviations input on station latitude, longitude and height.
	11-25	D15.8	Station number.
	26-40	D15.8	Standard deviation of X in meters or latitude in seconds of arc.

STAEST (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	Standard deviation of Y in meters or longitude in seconds of arc.
	56-70	D15.8	Standard deviation of Z in meters or height in meters.
	71-80	F10.4	Master station to which the adjustment of this station is to be constrained. If station is unconstrained or a master station leave blank.*

IF CARD OMITTED: Station positions will be held fixed.

NOTES: A STAEST card must be present for each station to be adjusted. If two or more stations are constrained one of these stations must be specified as the master station by leaving columns 71-80 blank.

A maximum of 381 unconstrained and master stations may be adjusted. The total number of adjusted stations including constrained stations may not exceed 381.

STAEST cards may not be present for stations that are not in the tracking complement.

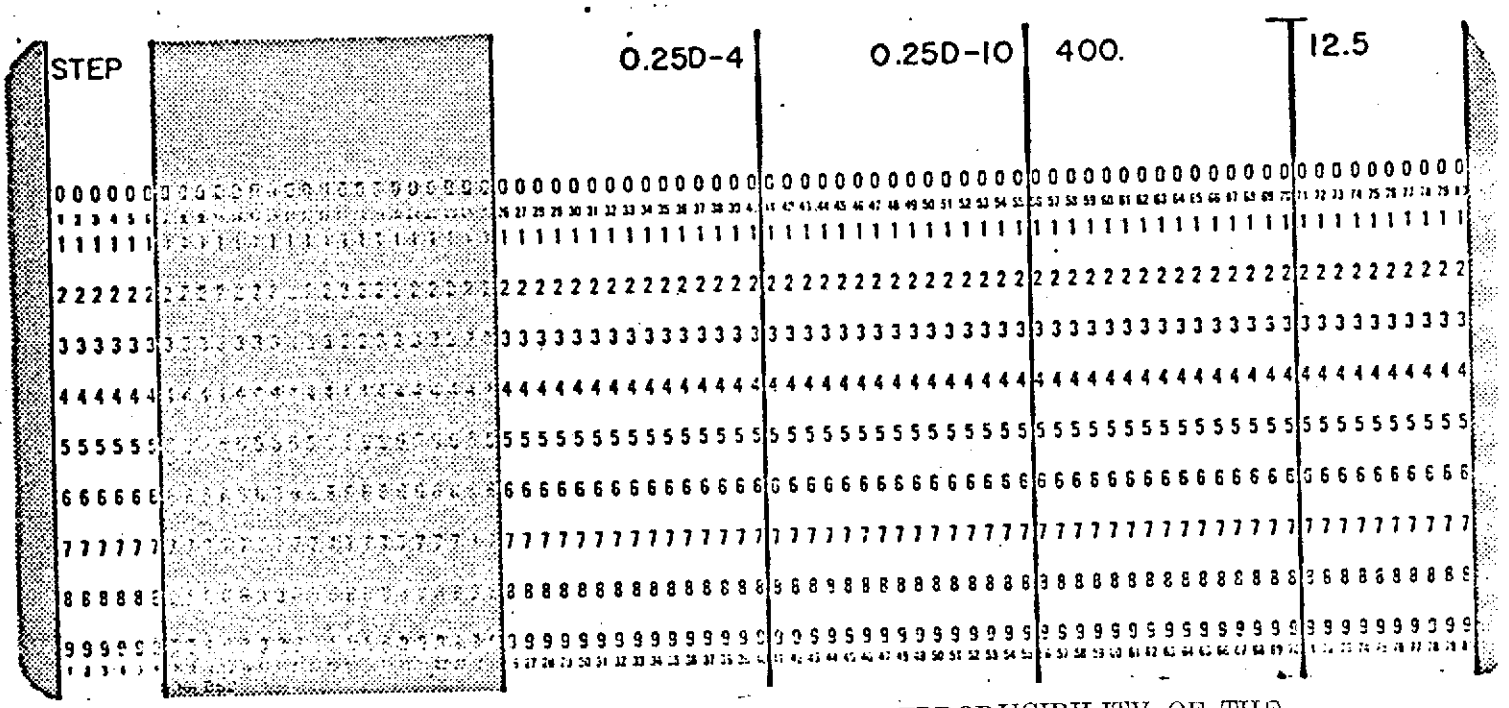
*See CORREL card in this section for definitions of constrained, unconstrained, and master stations.

See also STAPOS card.

COMMON SET

GROUP 2 - OPTION CARDS

STEP



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NAME	COLUMNS	FORMAT	DESCRIPTION
STEP	1-4	A4	Modifies variable step integrator error bounds and/or maximum and minimum step sizes.
	26-40	D15.8	Error tolerance for step size decrease. Default is 0.25D-4 m.
	41-55	D15.8	Error tolerance for step size increase. Default is 0.25D-10 m.
	1.1-26		

STEP (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	56-70	D15.8	Maximum step size in variable step mode. Default is 400 seconds.
	71-80	D10.5	Minimum step size in variable step mode. Default is 12.5 seconds.

IF CARD OMITTED: Default values given above are used unless modified by STEP card in ARC SET.

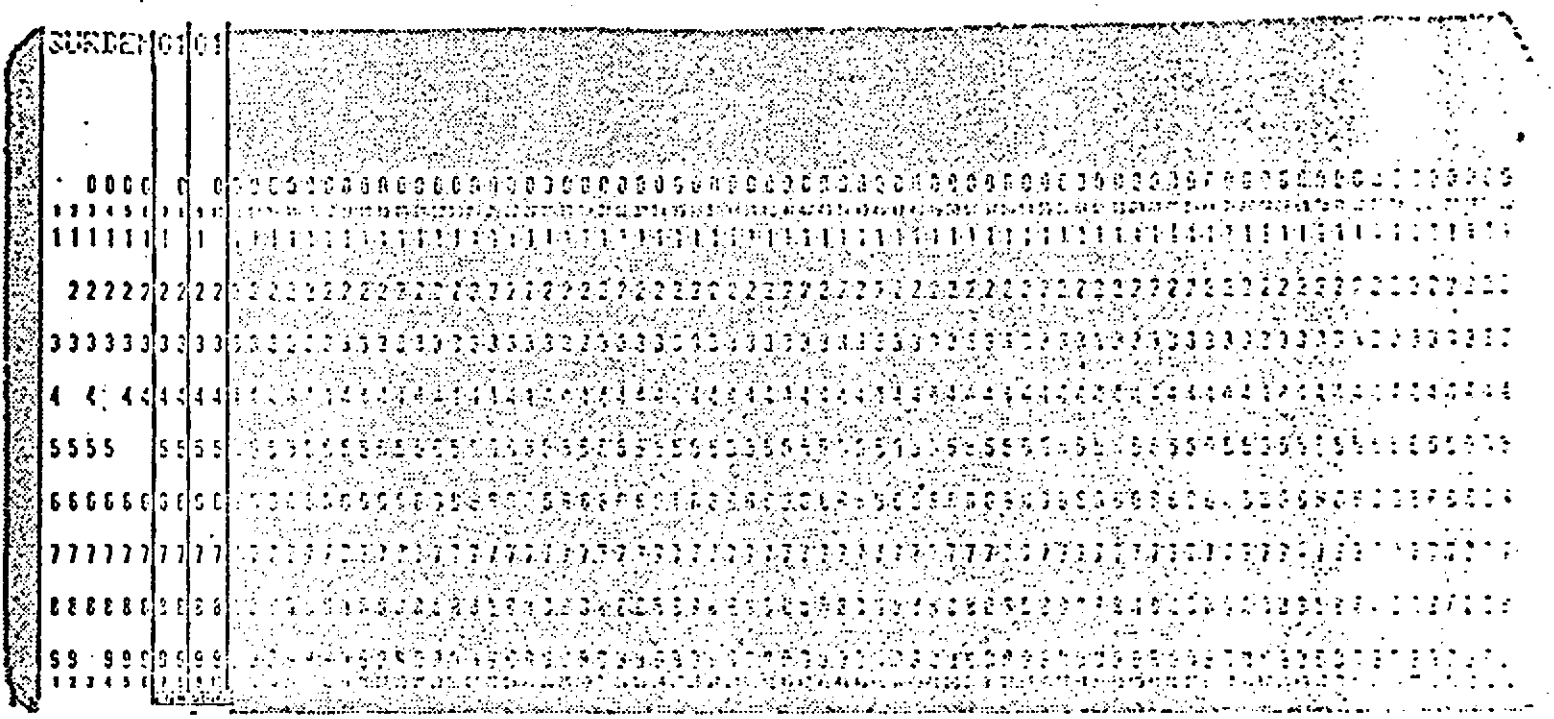
NOTE: Only those bounds for which non-zero values appear on the STEP card will be modified.

See also ARC SET, OPTION CARD - STEP.

COMMON SET

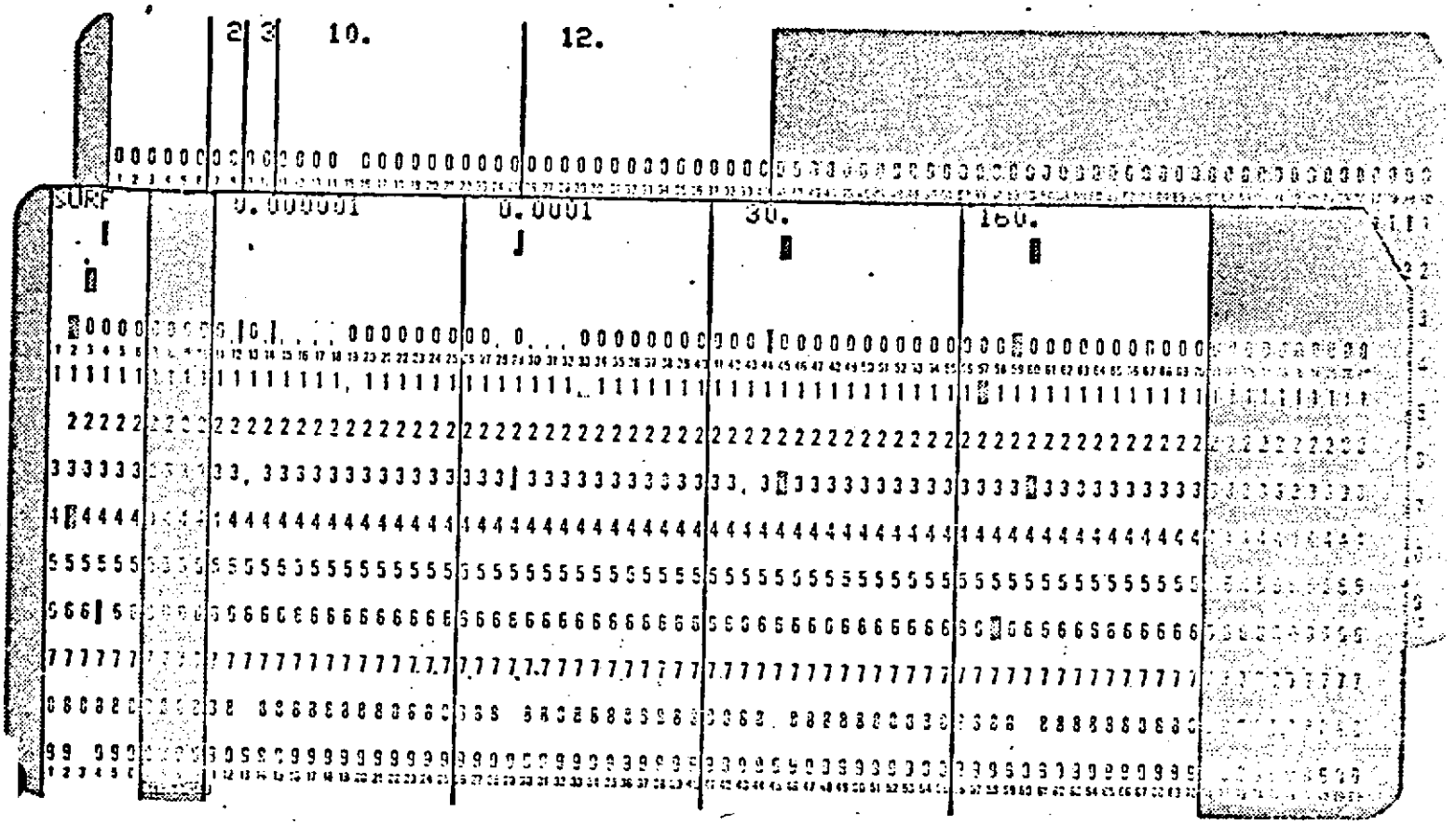
GROUP 2 - OPTION CARDS

SURDEN



NAME	COLUMNS	FORMAT	DESCRIPTION
SURDEN	1-6	A6	Specifies number of intervals in latitude and longitude used for surface area integration of surface densities. The trivial case degenerates to a Mascon.
	7-8	I2	Number of latitude intervals. Default = 1.
	9-10	I2	Number of longitude intervals. Default = 1.

IF CARD OMITTED: Default values used.



NAME	COLUMNS	FORMAT	DESCRIPTION
SURF	1-4	A4	Specifies application and/or estimation of surface densities.
	11-25	D15.8	A priori value of surface density in kg/m^2. Default = 0.
	26-40	D15.8	Value of surface density standard deviation in kg/m^2. >0 results in estimation of surface densities.

NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	Value of geocentric latitude at center of master block* in degrees.
	56-70	D15.8	Value of east longitude at center of master block* in degrees.

A second card must follow the SURF card in the input stream. The format of this card is:

NAME	COLUMNS	FORMAT	DESCRIPTION
	1-6	A6	These columns must be blank.
	7-8	I2	Number of latitude subdivisions in master block.* Default = 1
	9-10	I2	Number of longitude subdivisions in master block.* Default = 1
	11-25	D15.8	Size of each latitude subdivision in degrees.
	26-40	D15.8	Size of each longitude subdivision in degrees.

WARNING: Failure to provide the second card or to specify sizes of latitude and longitude subdivisions will result in program termination.

IF CARDS OMITTED: Surface densities will not be applied.

SURF (Cont.)

NOTES: Surface densities are an expression of deviations from the earth's gravitational potential as defined by the spherical harmonic expansion of the geopotential coefficients.

Surface densities are applied in GEODYN as uniform layers of mass covering areas of the Earth's surface. These areas are defined as the area of blocks bounded by lines of latitude and longitude.

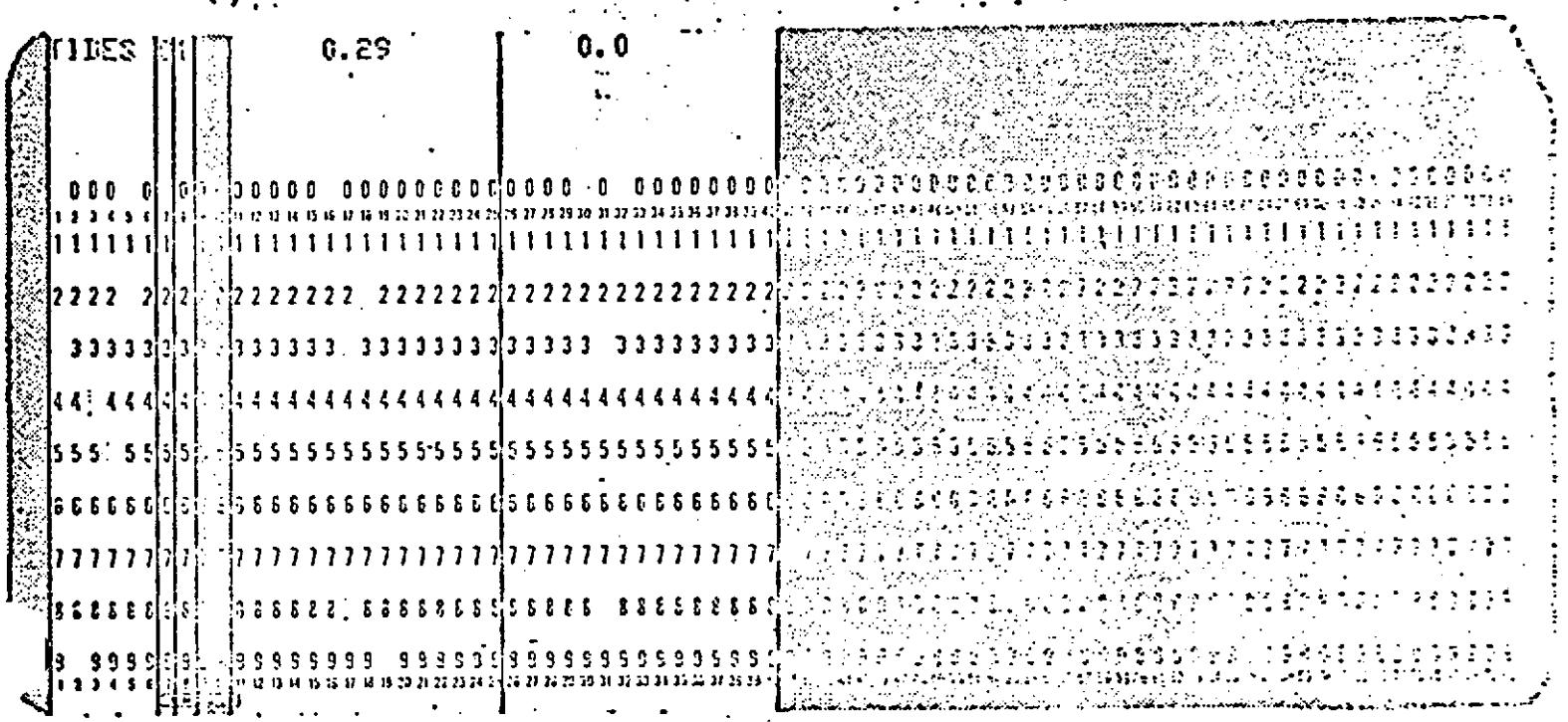
*A master block is an area bounded by lines of latitude and longitude which may be subdivided into blocks of equal size (in terms of boundary lengths in degrees of latitude and longitude) each of which has the same a priori value of surface density.

A master block may be so constructed as to contain only one block. This is the program default if the number of subdivisions is zero.

For convenience, master blocks are used in GEODYN to input surface densities.

A maximum of 674 master blocks may be specified.

COMMON SET
GROUP 2 - OPTION CARDS
TIDES



NAME	COLUMNS	FORMAT	DESCRIPTION
TIDES	1-5	A5	Modifies earth tide perturbations
	7	I1	=0, This card pertains to both Lunar and Solar tidal effects.
			=1, This card pertains only to Lunar tidal effects.
			=2, This card pertains only to Solar tidal effects.

NAME	COLUMNS	FORMAT	DESCRIPTION
	8	I1	Indicates which tidal coefficient is to be modified.

Value	Coefficient
1	K2
2	K3
3	K2 - Phase

A value of zero in this column will set all coefficients to zero.

	11-25	D15.3

Value of tidal parameter being modified.

Defaults:

Coefficient	Value
K2	0.29
K3	0.0
K2-Phase	2.5 Degrees

	26-40	D15.3

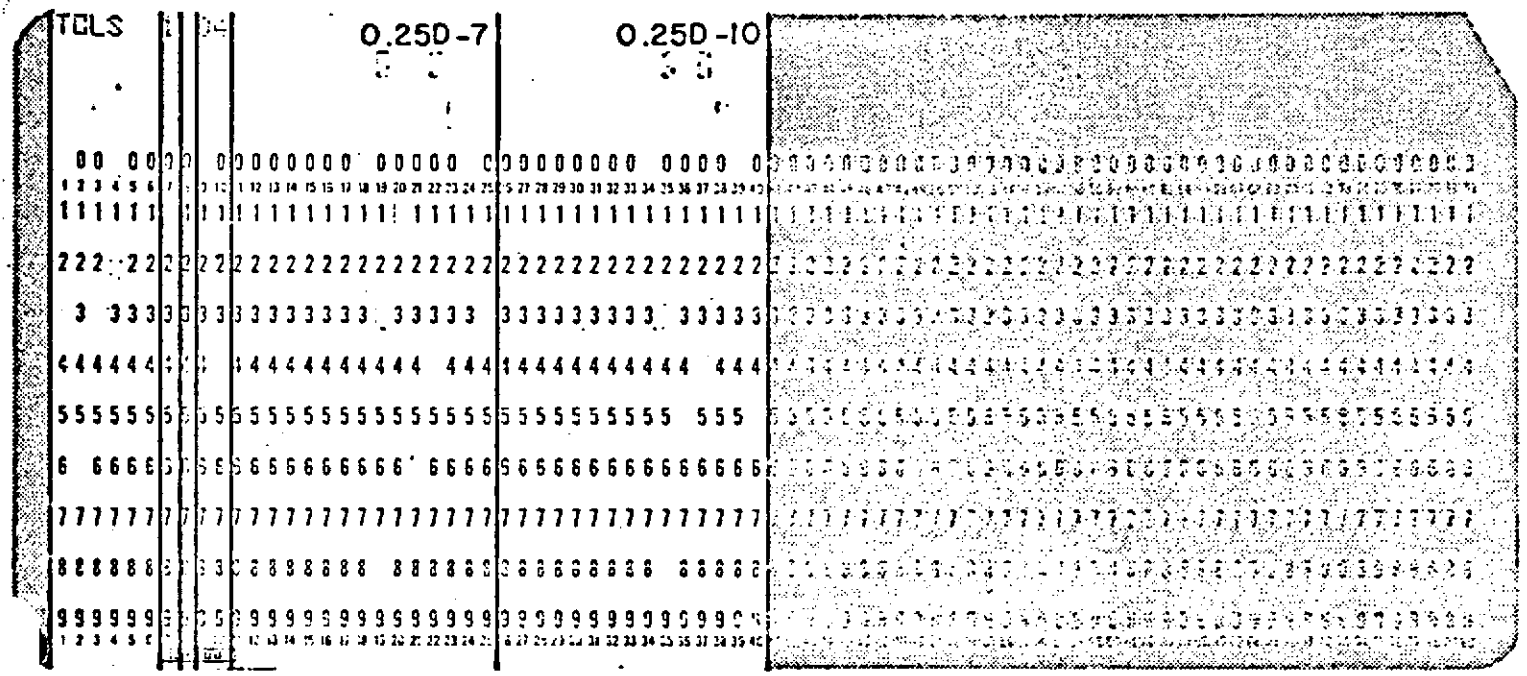
Standard deviation of tidal coefficient. If non-zero value is specified, tidal parameter will be adjusted. Default values are all zero.

If card omitted: Default values given above are used.

COMMON SET

GROUP 2 - OPTION CARDS

TOLS



NAME	COLUMNS	FORMAT	DESCRIPTION
TOLS	1-4	A4	Modifies integration tolerances.
	7	I1	Indicates for which satellite tolerances are to be modified for all arcs. = 0 both satellites = 1 first satellite = 2 second satellite
	9-10	I2	Maximum degree and order of

NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10 (Cont.)		geopotential effects to be included in the computation of the variational equations. Default = 4, Minimum = 3.
	11-25	D15.8	Desired reasonable predictor-corrector tolerance to be achieved by changing the integrator step size while in variable step integration mode. Used only in computation of new step size during step size variation. Default = 0.25D-7 m.
	26-40	D15.8	Critical predictor-corrector tolerance. Used to determine number of corrector iterations necessary at each integration step. If after 2 corrections the local error exceeds critical tolerance an error message will be printed (execution will be terminated). Default = 0.25D-10 m.
	41-55	D15.8	Maximum degree (and order) of geopotential coefficients for which constraint equations will be included in the estimation of surface densities. Default = 1.

IF CARD OMITTED: No modifications will be made to integration tolerances.

1.1.3 COMMON SET

GROUP 3 - STATION COORDINATE CARDS

STAPOS

CARD TYPE	FORMAT	COLUMNS	DESCRIPTION
Starting Card	A6	1-6	The word STAPOS beginning in column one.
	I1	7	>0 indicates station adjustment sigmas on this card apply to Earth centered fixed Cartesian coordinates.
	I1	8	>0 indicates that no station coordinates are to be used from built-in complement.
	D15.8	11-25	Sigma in seconds of arc for station latitudes or meters for station ECFX.
	D15.8	26-40	Sigma in seconds of arc for station longitudes or meters for station ECFY.
	D15.8	41-55	Sigma in meters for station height or ECFZ.

8

NOTE: If values greater than zero appear in columns 11-25, 26-40, and 41-55 then all stations will be adjusted using the sigmas input on this card. Stations for which STAEST cards are present will use the sigmas specified on the STAEST cards. Default is that only stations specified on STAEST cards will be adjusted.

GROUP 3 - STATION COORDINATE CARDS (CONT.)

CARD TYPE	FORMAT	COLUMNS	DESCRIPTION
Station Position Card for ϕ,λ,h input	A6	1-6	Station Name
	I4	7-10	Station Number
	A1	11	Sign of Latitude
D15.8	I2	12-13	Degrees Station
	I2	14-15	Minutes Geodetic } ϕ
	F10.8	16-25	Seconds Latitude
			Decimal may appear only in col. 18.
D15.8	13	26-28	Degrees Station
	I2	29-30	Minutes East } λ
	F10.8	31-40	Seconds Longitude
			Decimal may appear only in col. 33.
	D15.8	41-55	Station Height in Meters } h
	A1	56	7th character of station name.
Station Position Card for Earth-Fixed Cartesian Coordinates	A6	1-6	Station Name
	I4	7-10	Station Number
	D15.8	11-25	x in meters
	D15.8	26-40	y in meters
	D15.8	41-55	z in meters
	A1	56	7th character of station name

NOTE: GROUP 3 is necessary only if the tracking complement built into the program is to be changed or replaced.

The number of station position cards must not exceed 381.

These cards are Optional.

The station height is measured in meters above the reference ellipsoid. See EARTH card, COMMON SET, GROUP 2 - OPTION CARDS.

See Appendix D for built-in station positions.

1.1.4 COMMON SET
GROUP 4 - TERMINATION CARD.

NAME	COLUMNS	FORMAT	DESCRIPTION
DATA	1-4	A6	Designates end of COMMON SET.
	7-8	I2	Convergence criterion* for outer iterations in percent. Default is 2 percent.
	9	I1	Minimum number of outer iterations. Default is 1.
	10	I1	Maximum number of outer iterations. Default is 1.

This card terminates the COMMON SET containing cards to define information common to all arcs and is Mandatory.

*When

$$\left| \frac{\text{RMS previous outer iteration} - \text{RMS current outer iteration}}{\text{RMS current outer iteration}} \right| \times 100 < \text{converge: criterio}$$

convergence has been obtained. On the first outer iteration the values of the RMS for the previous outer iteration is, by default, 1000. This can be changed by using columns 26-40 of COMMON SET, OPTION CARD----EDIT.

Inner and outer iterations are explained in the Introduction of this manual.

1.2 ARC SET

ARC SET contains that information which is necessary to define each individual arc.

Included in ARC SET are four groups:

1. Arc description cards which are three title cards, the Reference Time card, the Epoch card, and the Epoch Orbital Element cards. (Mandatory)

2. Option cards which may be used to exercise the GEODYN individual arc capabilities. (Optional)

3. Termination card for Group 2 - Option Cards. (Mandatory)

4. Selection/deletion cards to exercise GEODYN's data selection and deletion capabilities. (Optional)

The following pages describe these groups more thoroughly.

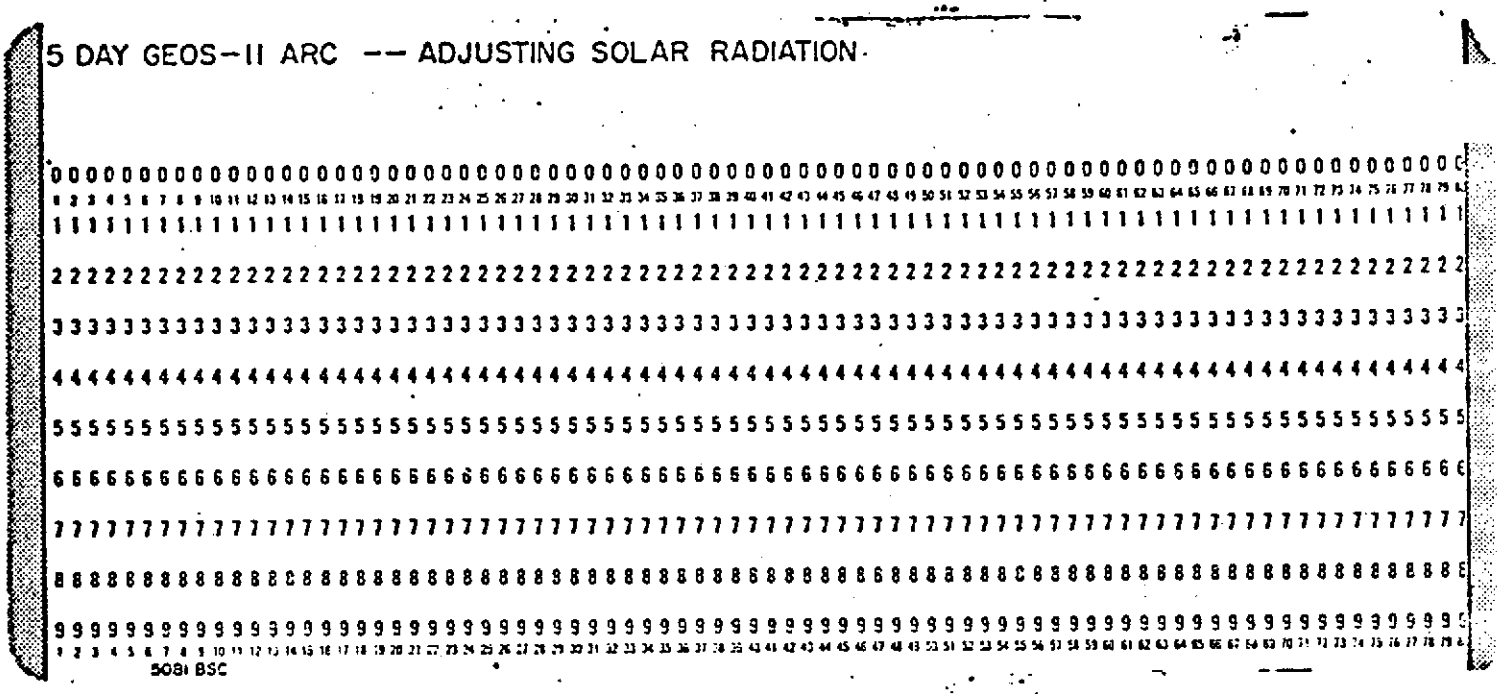
1.2.1 ARC SET
GROUP 1 - ARC DESCRIPTION

CARD NUMBER	FIELD FORMAT	DESCRIPTION
1A	10A8	Three title cards for each arc. Columns 1-80 of each card are printed as identification on all output from the arc.
1B	10A8	
1C	10A8	
2	I6	Year, month, day of the reference time (YYMMDD).
3	See Section 1.2.1.3	Epoch card.
4A	3D24.16	Element card one (Position vector).
4B	3D24.16	Element card two (velocity vector).

These cards are Mandatory for each arc and are more fully explained on the following pages.

If two satellites are in the arc cards 4A and 4B should be repeated specifying the second satellite epoch elements. (See EPOCH card.)

ARC SET
GROUP 1 - ARC DESCRIPTION
TITLE CARDS



CARD	COLUMNS	FORMAT	DESCRIPTION
1A	1-80	10A8	Identification to be printed
1B	1-80	10A8	on all output from arc.
1C	1-80	10A8	

Three title cards are Mandatory for each arc.

ARC SET

GROUP 1 - ARC DESCRIPTION

REFERENCE TIME CARD

COLUMNS	FORMAT	DESCRIPTION
1-6	I6	Year, month, day of reference date in YYMMDD.

Note: This time defines the inertial coordinate system in which the program will integrate the orbit. The reference time should precede or be the same as the epoch of the initial elements.

The input epoch elements are assumed to be in the inertial coordinate system defined by the true equator and equinox of the reference time. The estimated (adjusted) epoch elements are also in the same coordinate system.

It is critical to proper program operation that each column from 1-6 contain numerals between 0 and 9 and that no blanks be present in these columns. Columns 7-80 must remain entirely blank.

This card is Mandatory for each arc.

ARC SET
GROUP 1 - ARC DESCRIPTION
EPOCH CARD

COLUMNS	FORMAT	DESCRIPTION
1-6	I6	Epoch date of the initial elements of the arc in YYMMDD.
7-10	I4	Hours and minutes of epoch in HHMM.
11-17	F7.4	Seconds of epoch in SS.SSSS.
18	I1	Maximum number* of inner iterations on all outer iterations except the first for this arc. The default is 1.
19	I1	Maximum number* of inner iterations for this arc on the first outer iteration. The default is 1.
20	I1	Minimum number of inner iterations for this arc. The default is 1.
21-22	2PF2.0	Inner iteration convergence criteria for this arc. The default is 2 percent.
23	I1	Tape format flag. 1 - indicates GEOS-1 Data Center format 0 - indicates binary DODS data tape 2 - indicates GEOS-2 Data Center format 3 - indicates PCE format 4 - indicates SIMULATED Data format 5 - indicates GEOS-C Data format 6 - indicates RAP Binary Data format

EPOCH CARD (Cont.)

COLUMNS	FORMAT	DESCRIPTION
24-29	I6	Cutoff date for data in YYMMDD.
30-33	I4	Hours, minutes of cutoff time for data in HHMM.
34-40	F7.4	Seconds of cutoff time for data in SS.SSSS.
41-46	I6	Start date for data in YYMMDD.
47-50	I4	Hours, minutes of start time for data in HHMM.
51-57	F7.4	Seconds of start time for data in SS.SSSS.
58	I1	Number of satellites. Default = 1.
59-64	I7	DODS Data Base element set number.
65	I1	DODS Data Base element retrieval flag (See Appendix A).
66-72	I7	Satellite ID for element retrieval.
77-80	A4	This field is used to alter the atmospheric density model used for the arc. Models available are:

MNEMONIC	DESCRIPTION
J65	Jacchia 1965a modified to 1968 (see option card of same name).
J650	Old Jacchia 1965a modified to 1968 (see option card of same name).
J71	Jacchia 1971 model (see option card if same name).

This card is Mandatory for every arc.

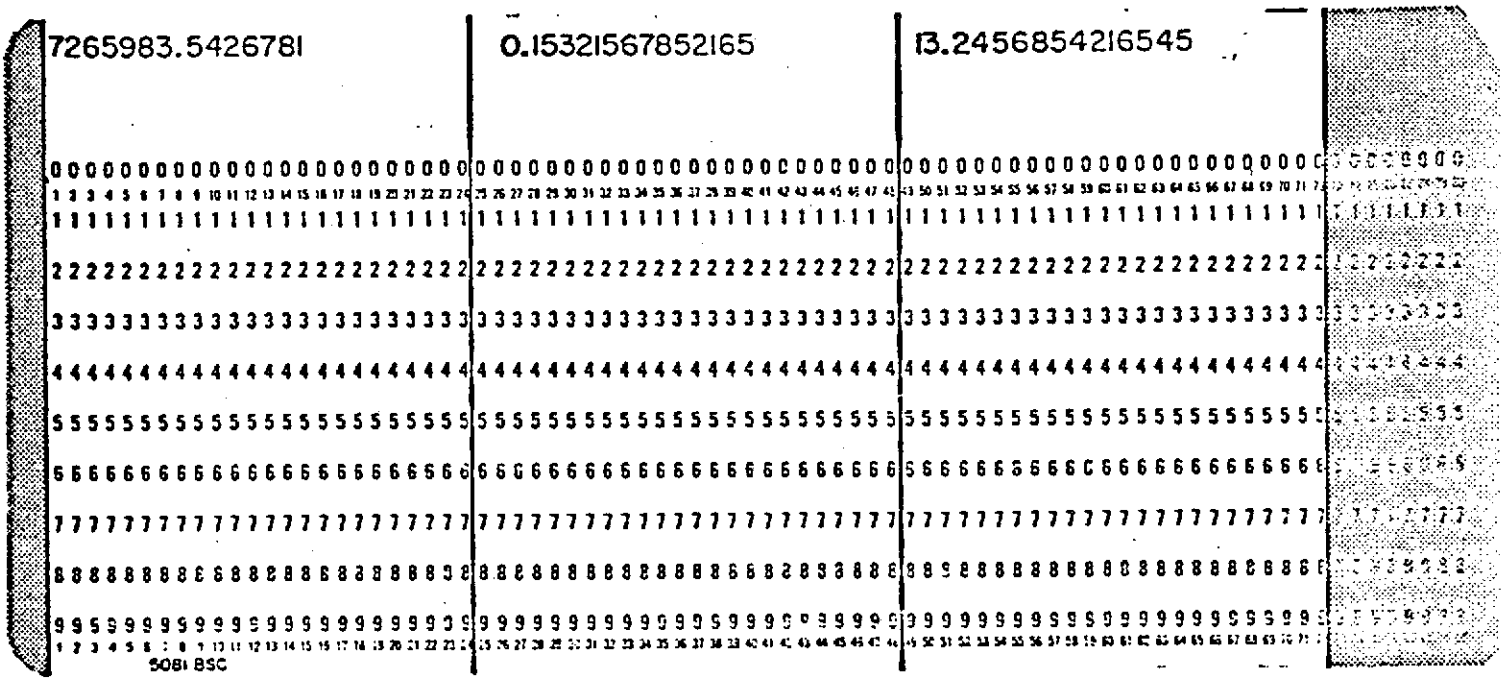
NOTES: The Epoch and start and stop times for data must be specified in the UTC time system. The default for the data start time is Epoch. No data prior to the start time or later than the cutoff time will be accepted. Orbit integration will be initiated from Epoch or the data start time, whichever is earlier. The data start time may be used during an orbit generator run to specify the earliest time for orbit integration. A cutoff time specification is mandatory only if the data is being read from the DODS data base. (See Appendix A.)

If the data start time is earlier than Epoch, integration proceeds backward from Epoch to the start. Epoch is then reset to the start time, and integration resumes forward.

Inner and outer iterations are explained in the Introduction of this manual.

*If column 18 contains a 1 and column 19 is zero or blank the defaults for the maximum number of inner iterations will be 10 for the first outer and 1 for subsequent outer iterations.

ARC SET
GROUP 1 - ARC DESCRIPTION
POSITION VECTOR



COLUMNS	FORMAT	DESCRIPTION
1-24	D24.16	x Component
25-48	D24.16	y Component
49-72	D24.16	z Component

in meters

of satellite position at epoch time, in the inertial coordinate system of the reference time, or osculating Keplerian elements.

a (in meters), e, and
i (in degrees).

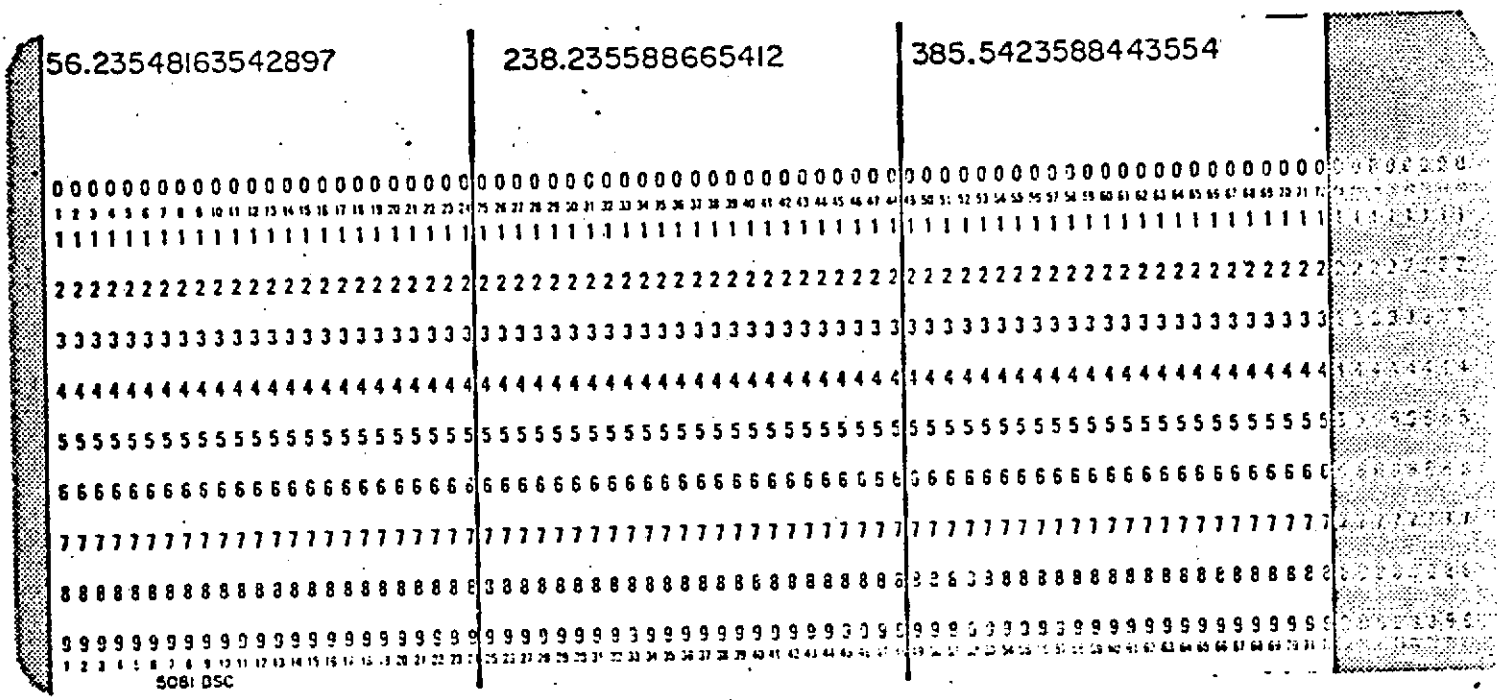
COLUMNS	FORMAT	DESCRIPTION
73	I1	=0 or blank, orbit will be elliptic.
		=1, orbit can be either elliptic or hyperbolic and the input elements are Cartesian.
		=2, orbit can be either elliptic or hyperbolic and the input elements are Keplerian.

This card is Mandatory for each arc.

ARC SET

GROUP 1 - ARC DESCRIPTION

VELOCITY VECTOR



COLUMNS	FORMAT	DESCRIPTION
1-24	D24.16	$\dot{x}$ component
25-48	D24.16	$\dot{y}$ component
49-72	D24.16	$\dot{z}$ component

in meters/sec. of satellite velocity at epoch time in the inertial coordinate system of the reference time, or osculating Keplerian elements Ω, ω and M (all in degrees).

This card is Mandatory for each arc. See Position Vector Card - Col. 73.

1.2.2 ARC SET
GROUP 2 - OPTION CARDS

Each GROUP 2 card is identified by the name beginning in column 1 and read under an A6 format. The name is followed by 9 fields:

Field Columns	Field Format
7, 8, 9, 10	4I1
11-25	D15.8
26-40	D15.8
41-55	D15.8
56-70	D15.8
71-80	D10.8

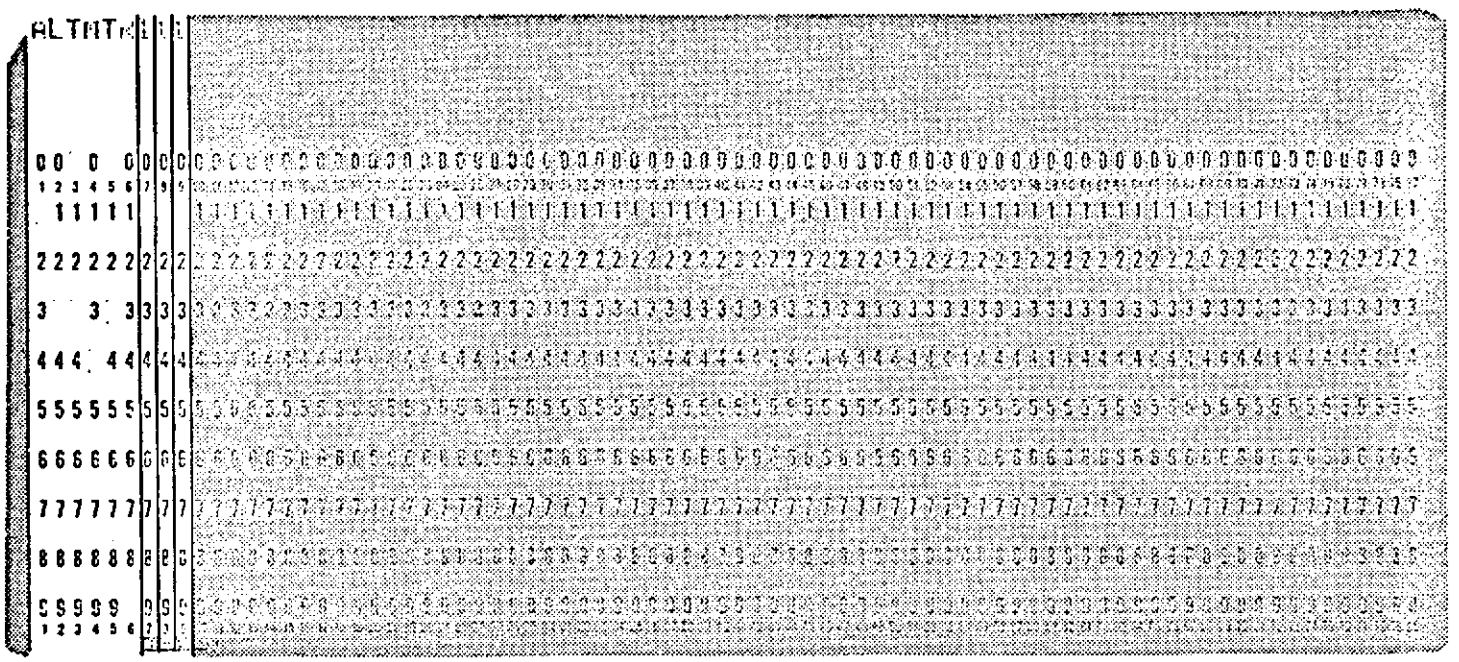
The Option Cards are:

BIAS	ELCUT	SAT
BMATRX	ORB1	SIGMA
BODIES	ORBIT	SIMDAT
CULL	OUTPUT	SOLRAD
DRAG	PREPRO	STEP
EARTH	RECOEF(COEF)	TOLS
EBIAS	RESID	VARCOV
EDIT	TERMEL	REGINT
MAXLAT		

ARC SET

GROUP 2 - OPTION CARDS

ALTMTR



NAME	COLUMNS	FORMAT	DESCRIPTION
ALTMTR	1-6	A6	Invokes altimeter data processing options.
	7	I1	=1 Requests output of an altimeter experiment file on the last iteration. Output is on unit 81.
	8	I1	=1 Requests application of altimeter attitude error correction. This correction contains a bias term which is always present. (applicable only to GEOS-C).

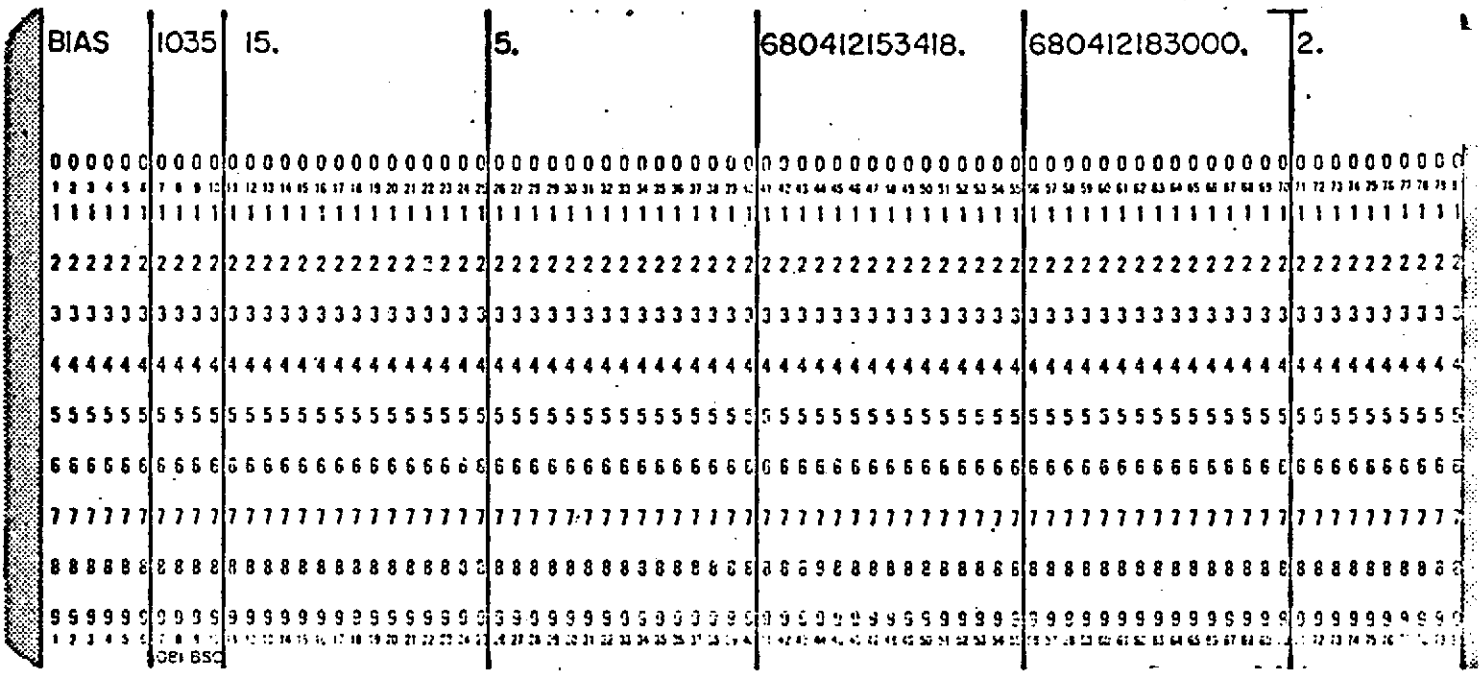
NAME	COLUMNS	FORMAT	DESCRIPTION
	9	I1	=1 Indicates that an attitude tape for GEOS-C will be input on unit 80.

IF CARD OMITTED: No such options will be applied.

ARC SET

GROUP 2 - OPTION CARDS

BIAS



NAME	COLUMNS	FORMAT	DESCRIPTION
BIAS	1-4	A4	Requests adjustment of either measurement biases or station timing biases.
	7-10	I4	Station number for which the bias is requested.
	11-25	D15.8	Optional a priori estimate of the bias value in "natural" units: Length: meters Angles: radians Time: seconds

Mathematical symbols

b - measurement bias

Δt - timing bias

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Standard deviation of the a priori bias in the same units.
	41-46	I6	Optional year, month, and day of the time at which the bias is to begin.
	47-53	F7.0	Optional hour, minute, and second of the time at which the bias is to begin. A decimal point must appear in column 53.
	56-61	I6	Optional year, month, and day of the time at which the bias is to end.
	62-68	F7.0	Optional hour, minute, and second of the time at which the bias is to end. A decimal point must appear in Column 68.
	71-80	D10.8	Bias type - same as those listed under SIGMA cards - for measurement biases or zero for timing biases.

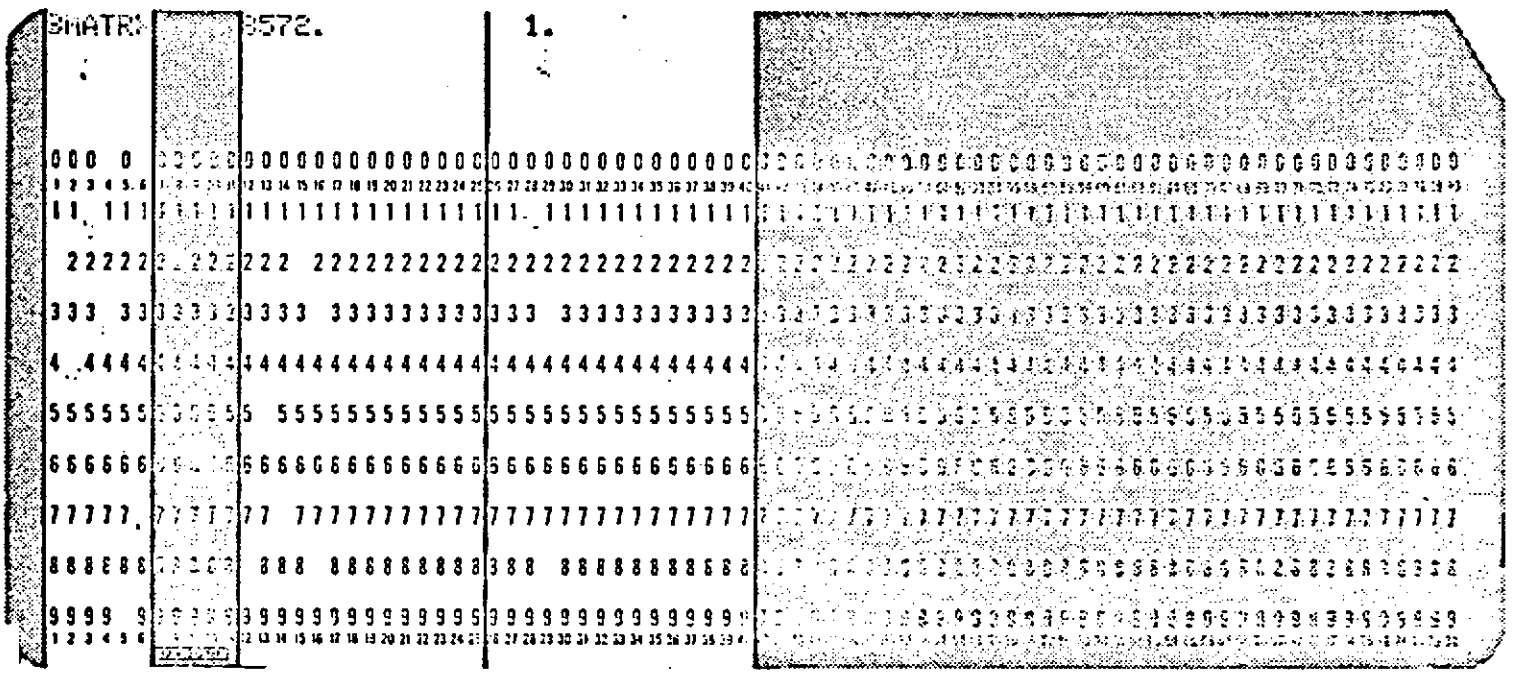
IF CARD OMITTED: No measurement or station timing biases will be adjusted.

Note: The normal procedure for bias adjustment is for independent biases to apply for each satellite pass. If this is the desired type of adjustment, columns 41-70 should be left blank. When start and end times for biases are explicitly indicated they will override the pass-by-pass assignment; however, if there are passes after the stop time, new biases will be assigned for the passes.

ARC SET.

GROUP 2 - OPTION CARDS

BMATRX



NAME	COLUMNS	FORMAT	DESCRIPTION
BMATRX	1-6	A6	Indicates that a B-matrix tape is to be written on unit 71 for this arc.
	11-25	D15.8	B-matrix number to be written on the tape. This number must be greater than zero and less than 10000.
	26-40	D15.8	>0 Requests that the B-matrix also be printed on unit 6.

IF CARD OMITTED: No B-matrix tape will be written.

NOTES: If any arcs write a B-matrix tape then the maximum number of outer iterations will be one and there will be no outer iteration adjustment.

Adjusted parameters that will be included on the B-matrix tape are the following:

Geopotential coefficients adjusted as common parameters. (See COMMON SET, OPTION CARD - RECOEF)

Master tracking stations and unconstrained adjusted tracking stations. (See COMMON SET, OPTION CARD - STAEST)

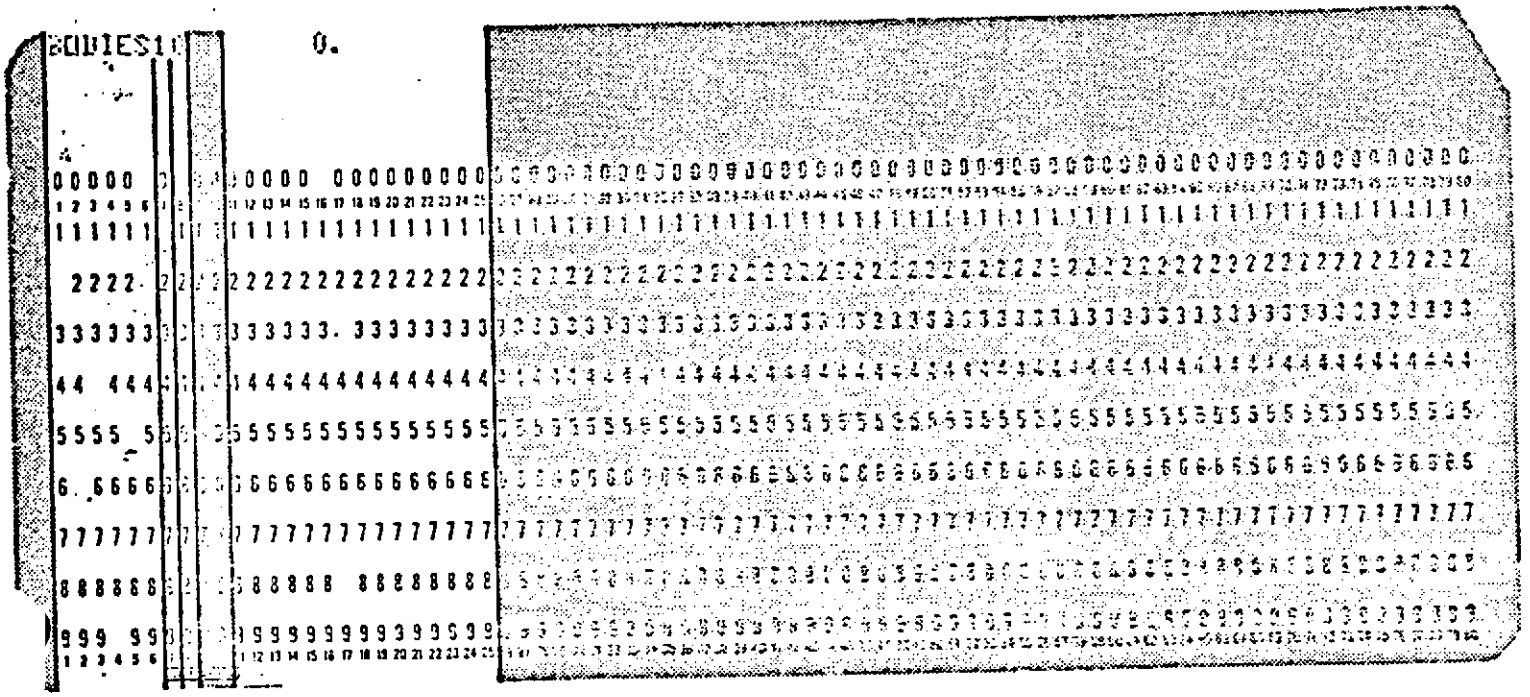
Drag and solar radiation coefficients, C_D, $\dot{C}_D$, and C_R. (See COMMON SET, OPTION CARDS - DRAG and SOLRAD)

Satellite elements. (See ARC SET, Run Description - Position and Velocity Vector cards)

ARC SET

GROUP 2 - OPTION CARDS

BODIES



NAME	COLUMNS	FORMAT	DESCRIPTION
BODIES	1-6	A6	Modifies non-earth gravity perturbations.
	7	I1	Indicates body for which gravity perturbation is to be modified 1 - MOON 2 - SUN 3 - VENUS 4 - MARS

NAME	COLUMNS	FORMAT	DESCRIPTION
	7 (Cont.)		5 - JUPITER 6 - SATURN
	8	I1	Number* of perturbing bodies to be applied (maximum of 6). Default = 2. This number may be set on any one of the BODIES cards used in the arc.
	11-25	D15.8	Value of ratio of mass of body to mass of earth. If ratio is zero perturbing effect will be zero. Default mass ratios: M_1/M_e = 0.01229997171006507 M_2/M_e = 332945.5619264376 M_3/M_e = 0.8150003229334958 M_4/M_e = 0.1074468525270073 M_5/M_e = 317.8809303 M_6/M_e = 95.14905175

IF CARD OMITTED: Lunar and solar gravitational perturbations will be applied using default mass ratios unless BODIES card is used in COMMON SET.

To omit a particular body for gravitational purposes a BODIES card representing that body must be included with the corresponding mass ratio set to zero.

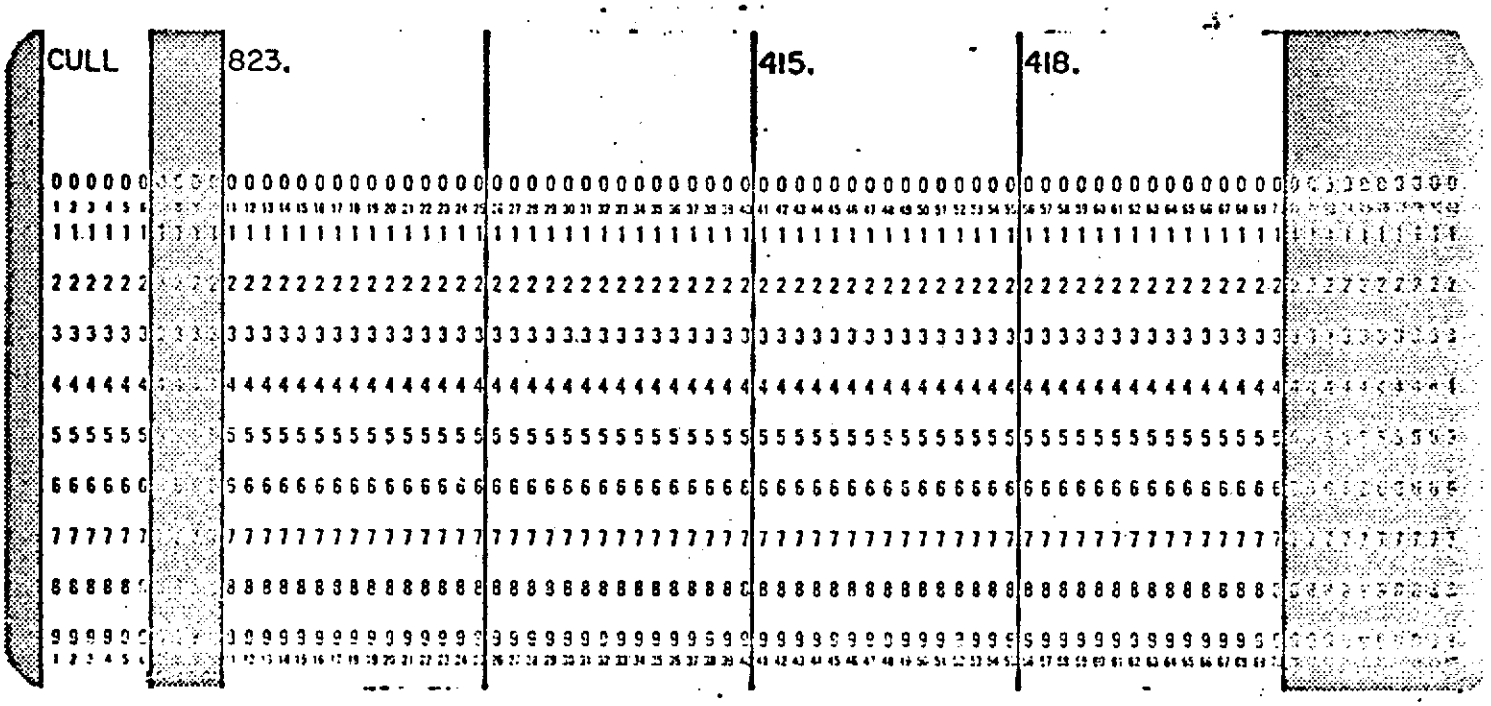
*For example, if the number of perturbing bodies is 4 then the effects of bodies 5 (Jupiter) and 6 (Saturn) will not be included, etc.

See also COMMON SET, OPTION CARD--BODIES.

ARC SET

GROUP 2 - OPTION CARDS

CULL



NAME	COLUMNS	FORMAT	DESCRIPTION
CULL	1-4	A4	Used to delete individual measurements from the solution by zero weighting.
	11-25	D15.8	The number* of the first measurement in a series to be deleted.
	26-40	D15.8	The number* of the last measurement in a series to be deleted; may be left blank if there is only one measurement in the series.

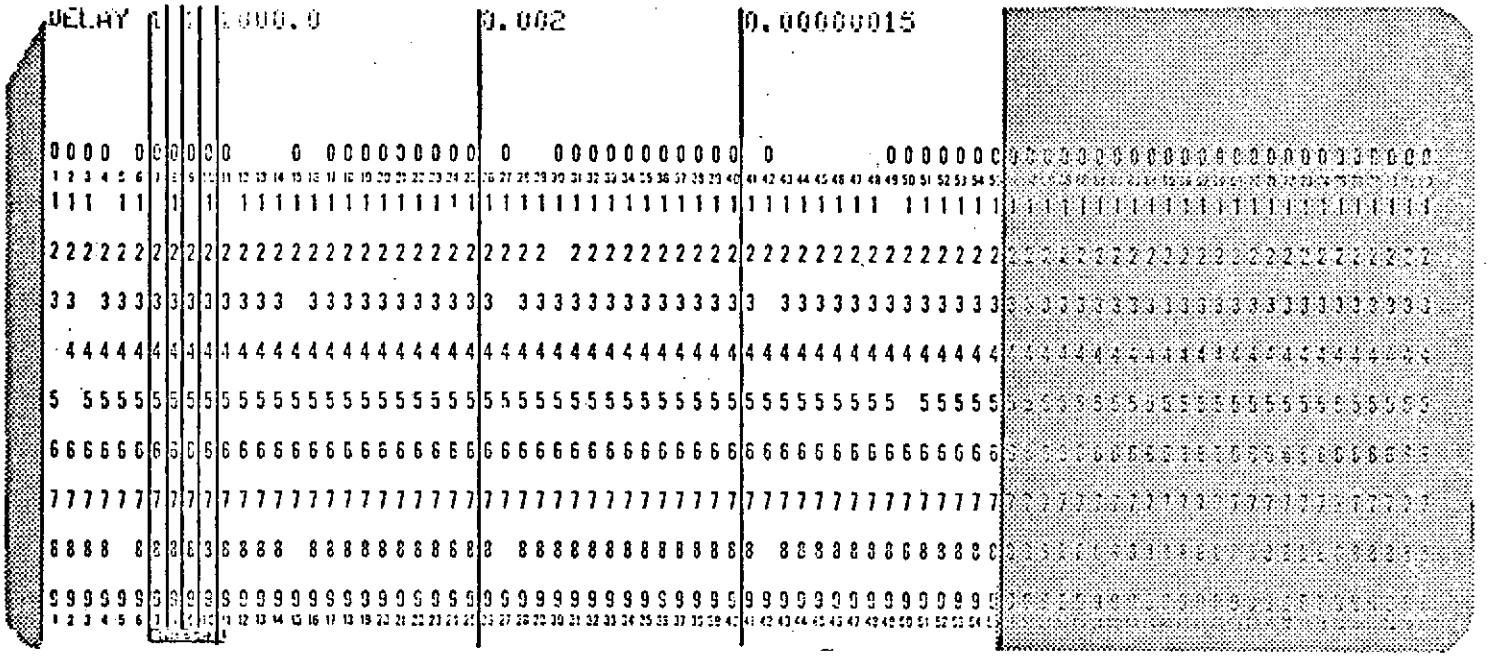
NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	The number* of the first measurement in second series to be deleted.
	56-70	D15.8	The number of the last measurement in second series to be deleted; may be left blank if there is only one measurement in series two.

IF CARD OMITTED: No measurements are deleted.

NOTE: A maximum of 50 cull cards may be used per arc. The series may fall in any order, and two series per card are not necessary.

*The numbers which correspond to each measurement are printed at the far right of the residual printout.

ARC SET
GROUP 2 - OPTION CARDS
DELAY



NAME	COLUMNS	FORMAT	DESCRIPTION
DELAY	1-5	A5	Changes transponder delay curves.
	7	I1	Transponder type - 1 VHF GRARR 2 S-Band GRARR Channel A 3 S-Band GRARR Channel B 4 S-Band GRARR Channel C 5 USB/DSN 6 ATSR 7 C-Band Coherent 8 C-Band Non-coherent
	8	I1	=n where n is the n^{th} relay for satellite to satellite data as follows:

NAME	COLUMNS	FORMAT	DESCRIPTION
	8 (Cont.)		n Transponder for SST 1 uplink delay at relay satellite 2 delay at tracked satellite 3 downlink delay at relay satellite This column must be left blank for data other than SST data.
	9	I1	The number of the tracked satellite as specified by the order of the elements following the epoch card (default = 1). =1 if 1st set of elements belong to the tracked satellite. =2 if the 2nd set of elements belong to the tracked satellite.
	10	I1	The number of the relay satellite as determined by the order of the elements following the epoch card (required only for SST). =1 if 1st set of elements belong to the relay satellite. =2 if 2nd set of elements belong to the relay satellite.
	11-25	D15.3	Transponder delay bias (in meters) (D_1)

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.3	Transponder delay coefficient (in seconds) of the linear variation with $\dot{\rho}$.(D_2)
	41-55	D15.3	Transponder delay coefficient (in sec^2/m) of the quadratic variation with $\dot{\rho}$. (D_3)

The total transponder delay in meters is computed as follows:

$$DELAY = D_1 + D_2\dot{\rho} + D_3\dot{\rho}^2$$

and the correction for range data is

$$\rho_{true} = \rho_{observed} - \frac{1}{2} DELAY$$

where:

$\dot{\rho}$ = range rate in m/sec

$\rho_{observed}$ = observed range

ρ_{true} = corrected observed range

DELAY (Cont.)

Example:

given:
(a SST situation)

$\vdots$

EPOCH CARD

X_1	Y_1	Z_1	Elements for tracked satellite, GEOS-C
$\dot{X}_1$	$\dot{Y}_1$	$\dot{Z}_1$	
X_2	Y_2	Z_2	Elements for relay satellite, ATS
$\dot{X}_2$	$\dot{Y}_2$	$\dot{Z}_2$	

$\vdots$

Since the order of the elements determines the satellite number*, the satellite number associated with the relay satellite=2, and the number associated with the tracked satellite=1.

Suppose we wished to change the transponder delay curves for the signal received:

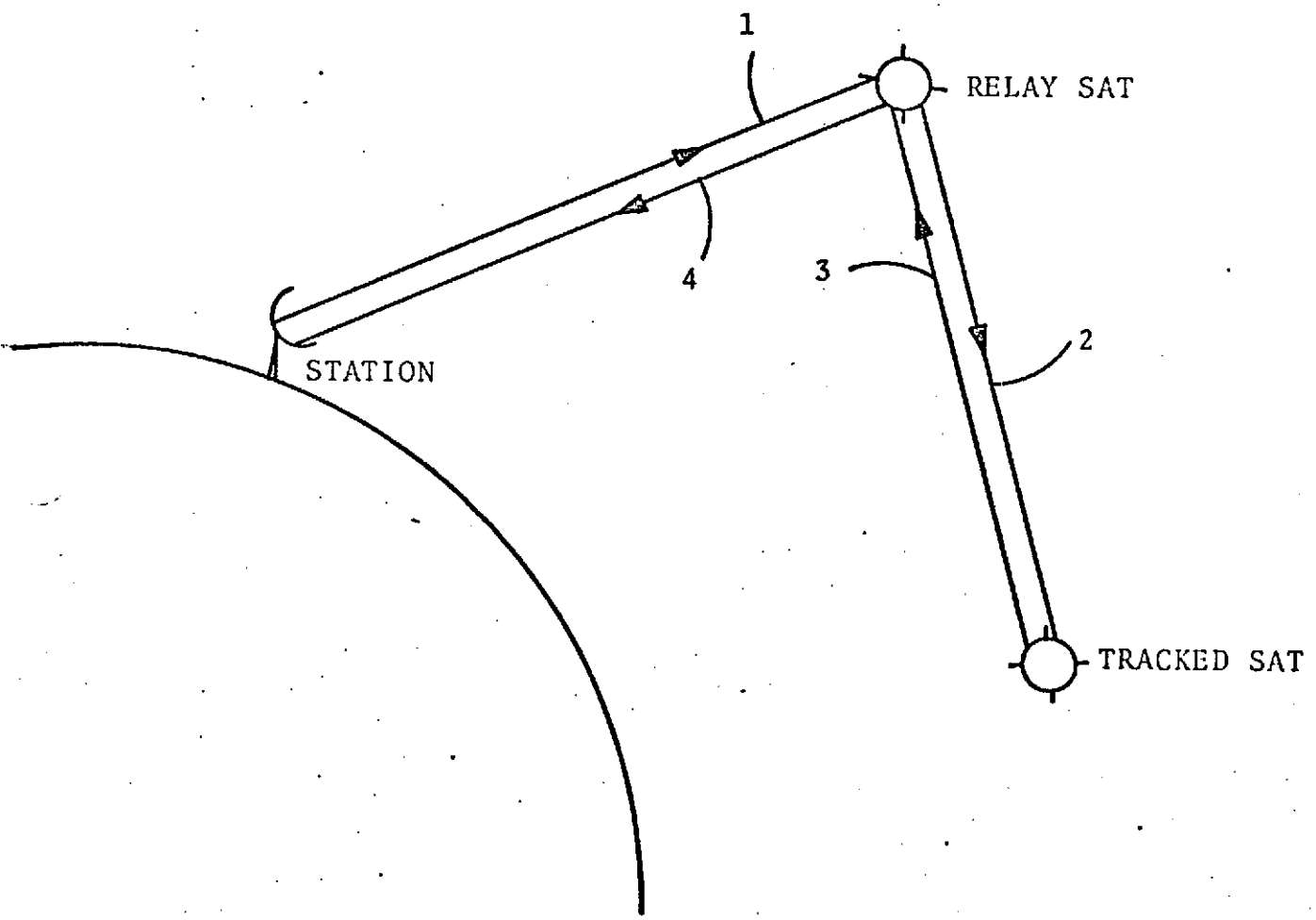
at the relay satellite from the station
at the tracked satellite from the relay satellite
at the relay satellite from the tracked satellite
(this signal goes back to the station)

*The satellite number should not be confused with the satellite ID as specified on the SAT option card (see 1.2-46) in Columns 41-55.

DELAY (Cont.)

The appropriate numbers in columns 8, 9, 10 would be as follows:

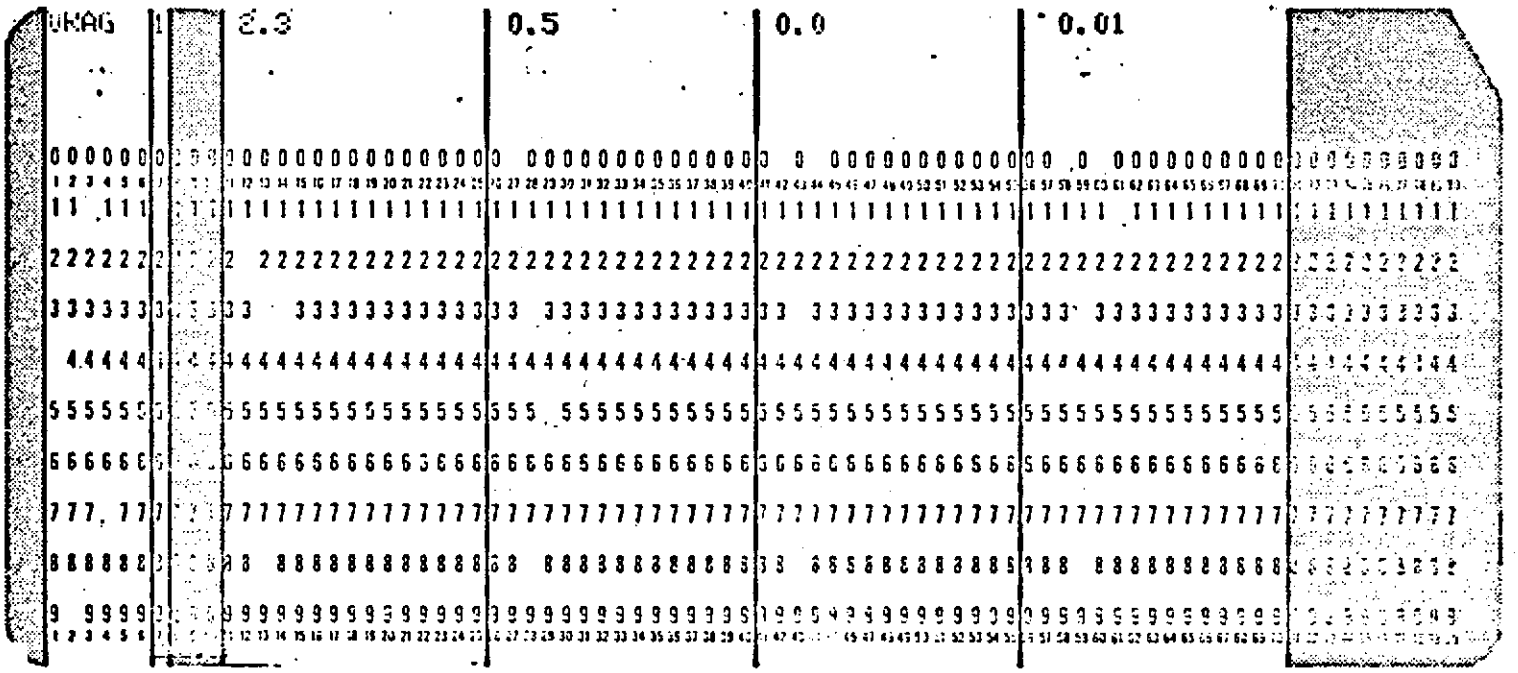
Column 8	Column 9	Column 10	Changes Delay for the Signal Received:
1	1	2	at the relay sat from the station
2	1	2	at the tracked sat from the relay sat
3	1	2	at the relay sat from the tracked satellite



In a SST situation the transponder delay can be modified:

at the RELAY SAT when signal comes from station (1)
and/or
at the TRACKED SAT when signal comes from RELAY SAT (2)
and/or
at the RELAY SAT when signal comes from the TRACKED SAT (3) and will be sent back to the station (4).

ARC SET
GROUP 2 - OPTION CARDS
DRAG



NAME	COLUMNS	FORMAT	DESCRIPTION
DRAG	1-4	A4	Modifies drag application.
	7	I1	Satellite number (1 or 2).* If less than 1 or greater than 2, applies to both satellites.
	11-25	D15.8	Drag coefficient or zero; for zero, drag is not applied. Default is 2.3 for satellites with a perigee height less than 800 kilometers. The default for all other satellites is zero. C_D - drag coefficient

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Standard deviation of drag coefficient or zero. If a non-zero standard deviation is specified the drag coefficient will be adjusted. The default is 0.5 for satellites with a perigee height less than 800 kilometers. The default for all other satellites is zero.
	41-55	D15.8	Value of drag coefficient rate of change per day. Default is zero. $\dot{C}_D$ - drag coefficient rate
	56-70	D15.9	Standard deviation of $\dot{C}_D$ in same units as $\dot{C}_D$. If a non-zero standard deviation is specified and if C_D is greater than zero, then $\dot{C}_D$ will be adjusted.

IF CARD OMITTED: Drag will be applied with default C_D only for satellites with perigee height less than 800 km.

NOTE: $\dot{C}_D$ will not be applied or adjusted unless $C_D > 0$.

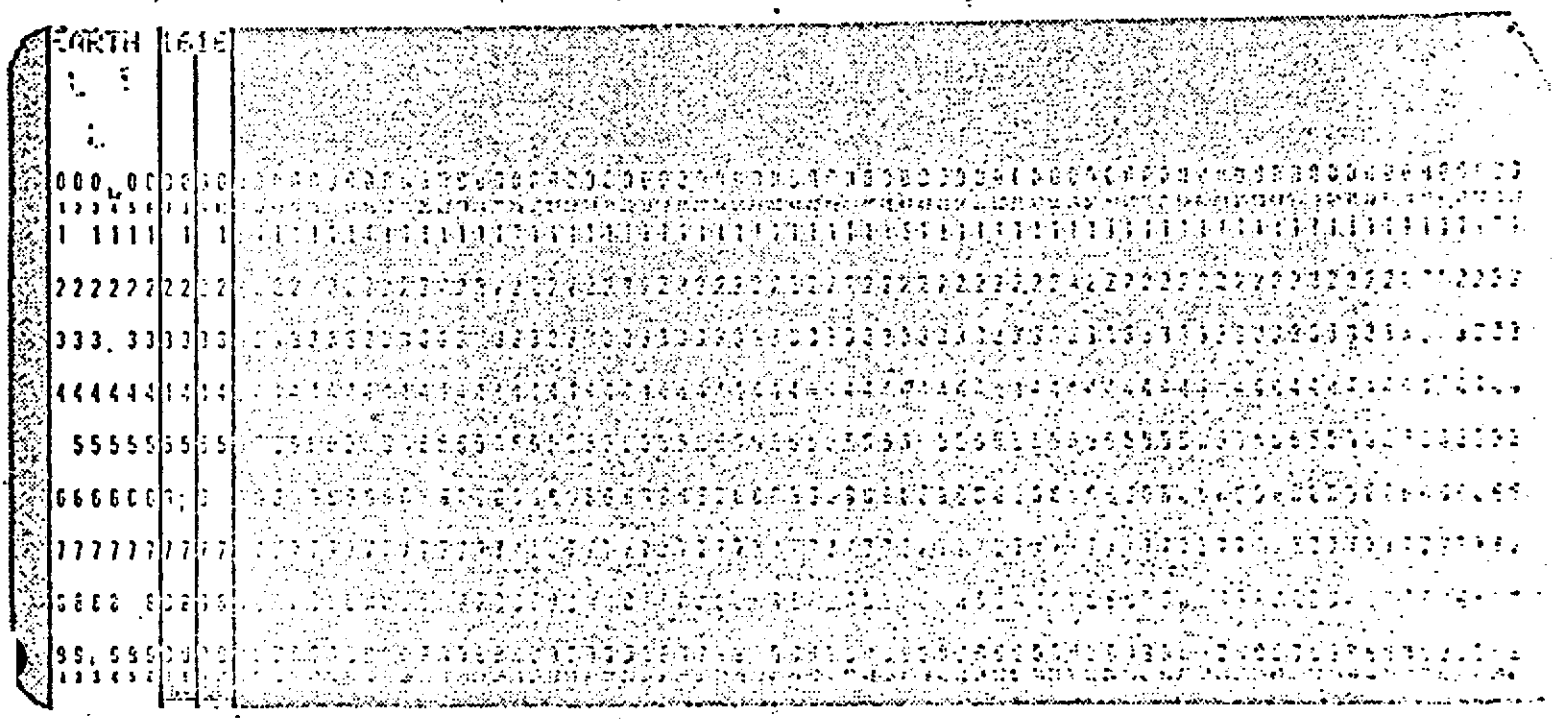
*Satellite number refers to either the first or second satellite and is applicable only th satellite-satellite tracking.

ARC SET

GROUP 2 - OPTION CARDS

EARTH

C-2



NAME	COLUMNS	FORMAT	DESCRIPTION
EARTH	1-5	A5	Modifies size of geopotential to be used for this arc.
	7-8	I2	Maximum degree coefficient to be used in the geopotential model plus 1. Default = 23, Minimum = 4
	9-10	I2	Maximum order coefficient to be used in the geopotential

NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10(Cont.)		model plus 1.
			Default = 23, Minimum = 2

IF CARD OMITTED: Effects of the geopotential will be applied using default values for degree and order unless EARTH card is used in COMMON SET.

Set-up for two-body orbit computations is explained on the following page.

See also COMMON SET, OPTION CARD - EARTH.

Two-body orbit computations may be performed in GEODYN by using the EARTH, BODIES, TIDES, and SAT cards as follows:

EARTH card

Columns 7-8 = 03
Columns 9-10 = 02
Columns 56-70 = 1.

BODIES cards (two)

Card 1 -

Column 7 = 1
Column 8 = 2
Column 11-25 = 0.

Card 2 -

Column 7 = 2
Column 8 = 0
Column 11-25 = 0.

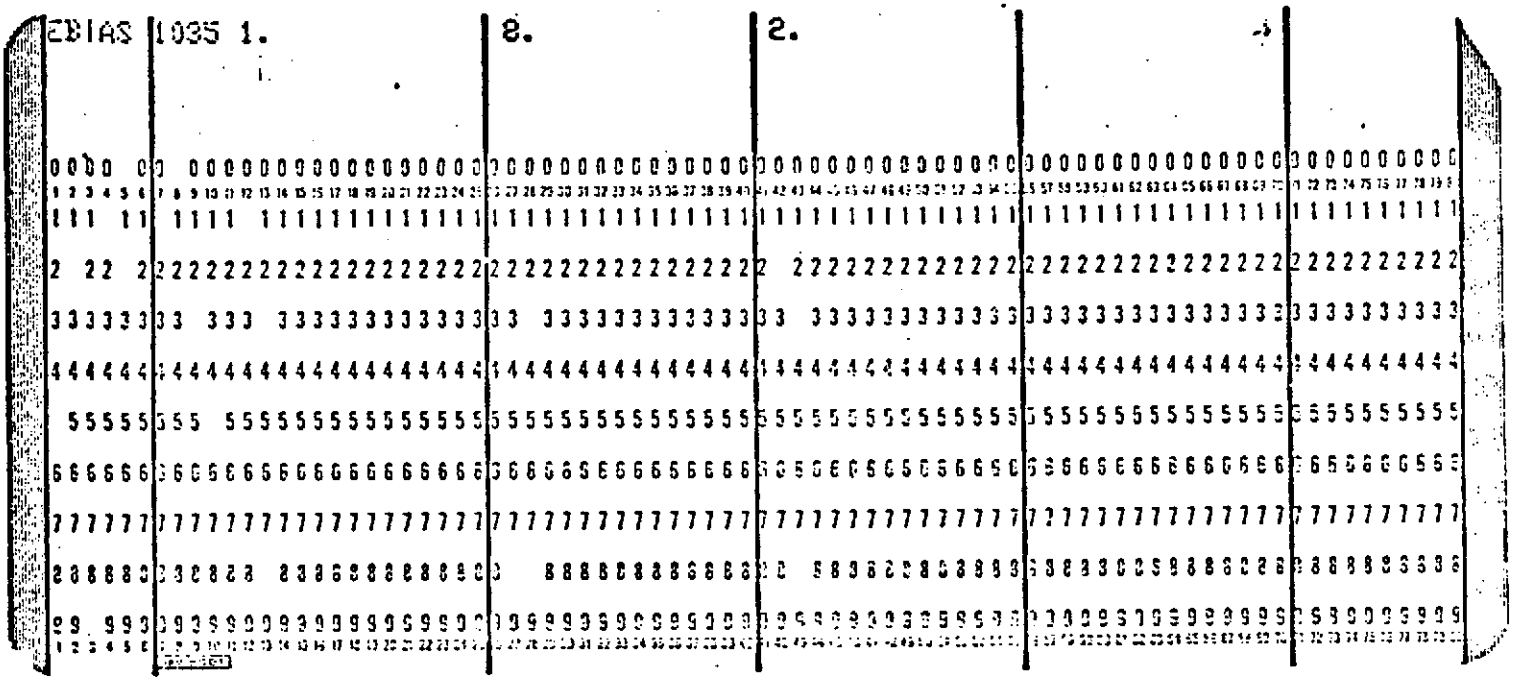
TIDES card

Columns 7-80 blank

one SAT card for each satellite

Columns 11-25 = 0.

ARC SET
GROUP 2 - OPTION CARDS
EBIAS



NAME	COLUMNS	FORMAT	DESCRIPTION
EBIAS	1-5	A5	Requests removal of electronic biases from estimation process.
	7-10	I4	Station number for which electronic bias will be removed.
	11-25	D15.8	Measurement type numbers* for which biases will be removed.
	26-40	D15.8	
	41-55	D15.8	
	56-70	D15.8	
	71-80	D10.5	

*See Measurement Types and Sigma Defaults chart under COMMON SET, OPTION CARD - SIGMA.

EBIAS (Cont.)

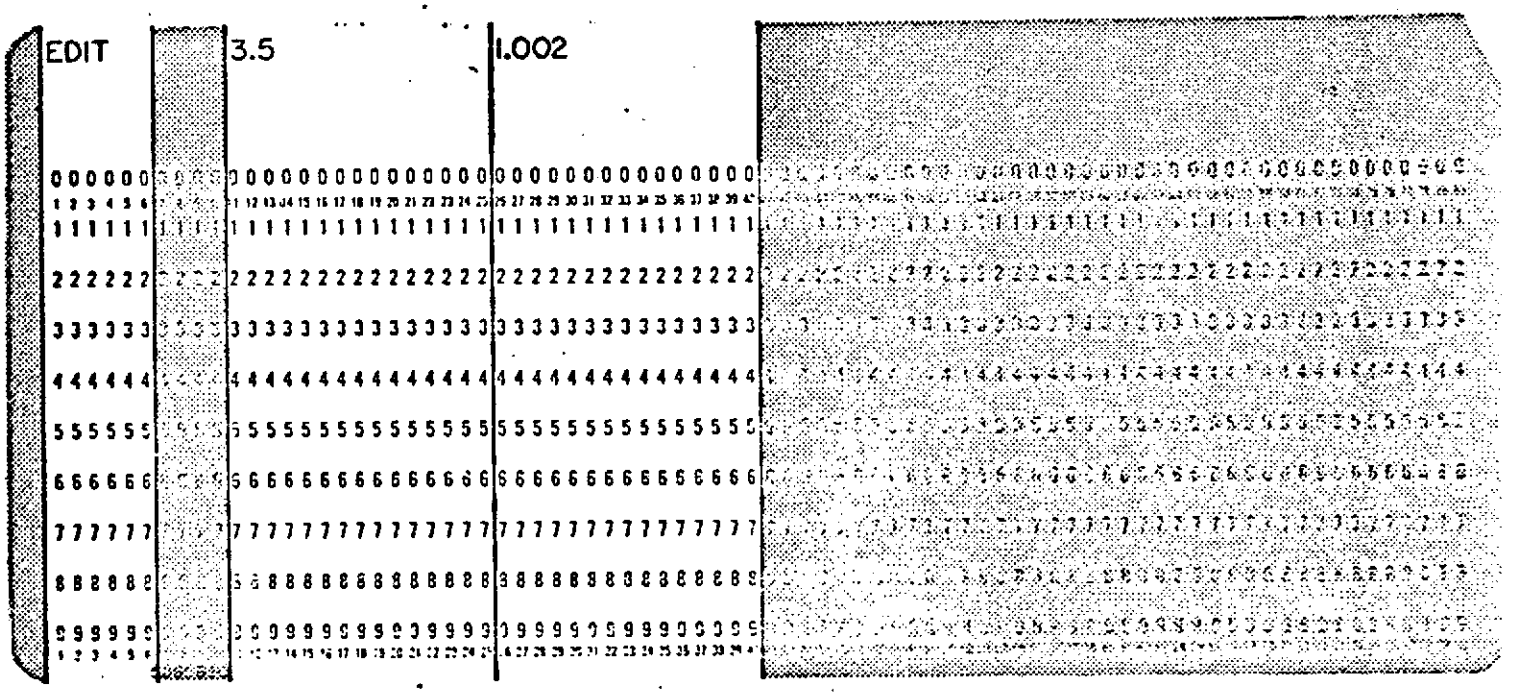
IF CARD OMITTED: No electronic biases removed.

The value of the bias is not printed but the bias is removed from the estimation process and the statistics printed in the residual summary. An 'E' will appear in the column following the ratio to sigma for measurements used in electronic bias estimations.

No a priori information is used.

There is an independent bias for every pass.

ARC SET
GROUP 2 - OPTION CARDS
.EDIT



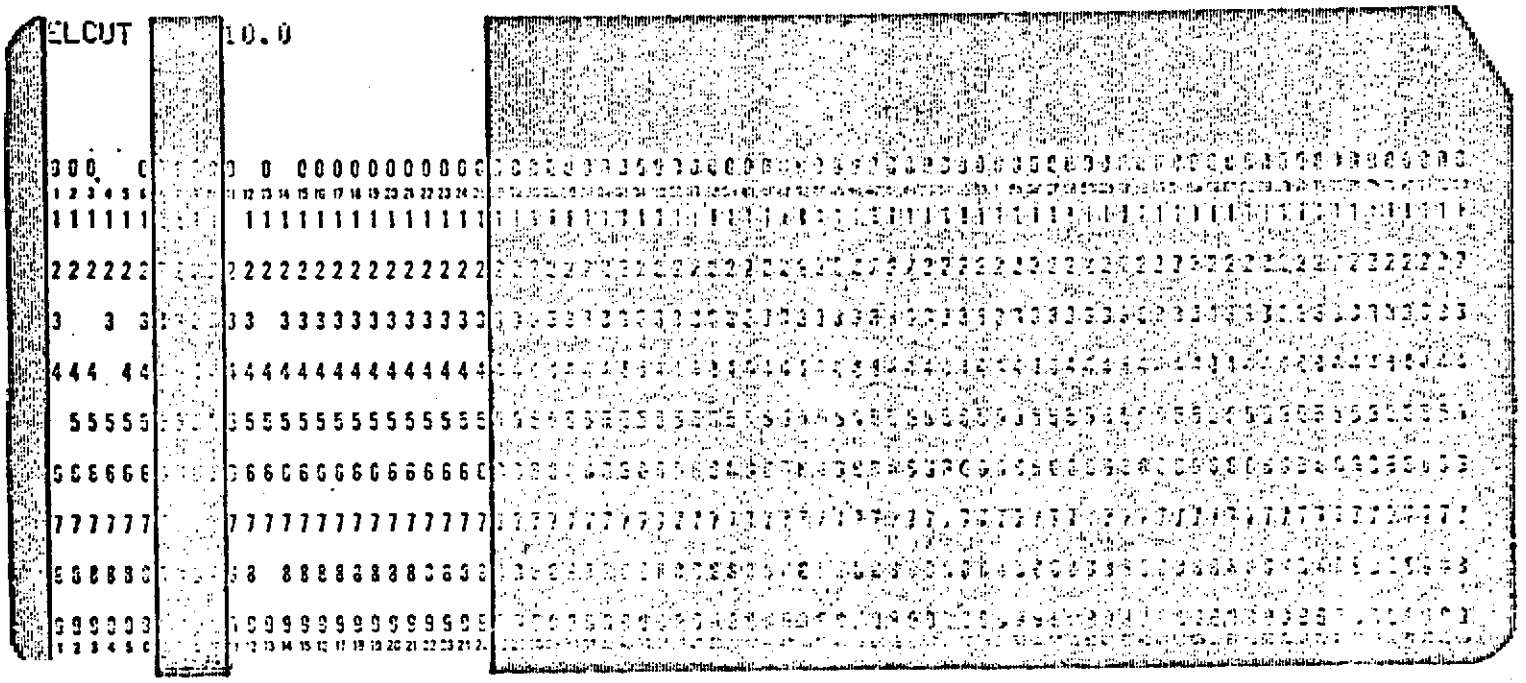
NAME	COLUMNS	FORMAT	DESCRIPTION
EDIT	1-4	A4	Removes from the estimation process any measurements with residuals greater than a specified number of standard deviations.

NAME	COLUMNS	FORMAT	DESCRIPTION
	11-25	D15.8	This is the editing multiplier.* Default is E_M = 3.5.
	26-40	D15.8	This is the initial RMS. Default is E_R = 200.
	41-55	D15.8	First iteration edit criterion for electronic bias passes. Default - use same editing as other data uses.

IF CARD OMITTED: Default editing multiplier and RMS used.

*Explanation: The product of the multipler and the RMS is the editing criterion. After the first inner iteration the RMS of all weighted measurements for the previous iteration is used to determine the editing criterion.

ELCUT



NAME	COLUMNS	FORMAT	DESCRIPTION
ELCUT	1-5	A5	Specifies the elevation angle below which measurements will be deleted from the solution.
	11-25	D15.8	Elevation cut off angle in degrees. Default = 0° or value used on ELCUT card in COMMON SET.

IF CARD OMITTED: All measurements with elevation angles less than 0° will be deleted from solution unless ELCUT card is used in COMMON SET.

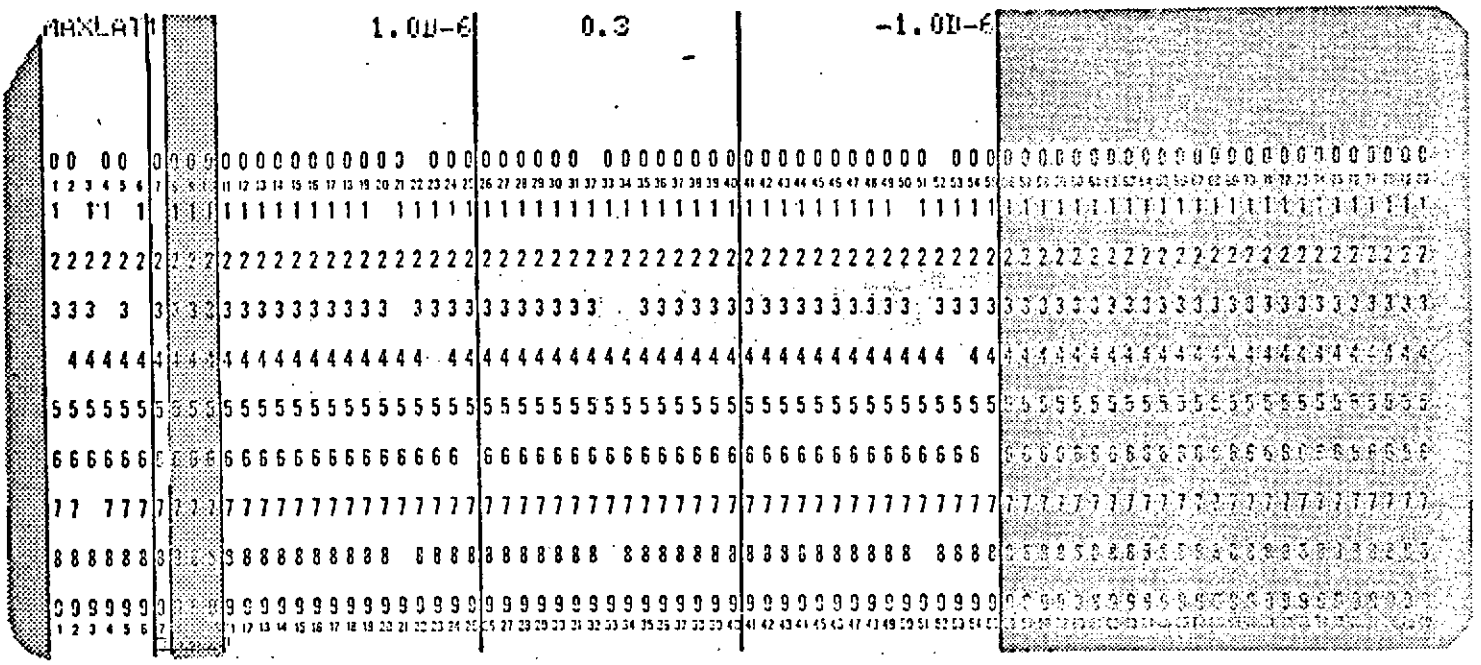
Elevation cut-off angle may be negative.

See also COMMON SET, OPTION CARD - ELCUT.

ARC SET

GROUP 2 - OPTION CARDS

MAXLAT



NAME	COLUMNS	FORMAT	DESCRIPTION
MAXLAT	1-6	A6	Requests print out of the maximum latitude obtained by the satellite during each revolution. The OUTPUT card must be used in conjunction with this option (see notes below).
	7	I1	=1 Requests that the Kepler Elements be punched in PCE format (see Appendix C) at the times of maximum satellite latitude.
	11-25	D15.8	Acceptable latitude tolerance in degrees ϵ_1.
	26-40	D15.8	Tolerance for reduction of time interval between successive latitude comparisons (units degrees). ϵ_2.

COLUMNS	FORMAT	DESCRIPTION
41-55	D15.8	Tolerance for switching back to the nominal latitude comparison interval (units degrees). ϵ_3.

IF CARD OMITTED: This option will not be invoked.

NOTES: In order to determine the needed input for this option an orbit generator run should be made, outputting a Cartesian ephemeris, (which contains latitude as well) over one revolution of the satellite at intervals of one second (see ORBIT and OUTPUT cards). ϵ_2 can then be chosen as the difference between the two latitudes immediately preceding the maximum latitude value on one revolution. The output rates of the orbit generator and MAXLAT data reduction runs should be set equal.

When the ϵ_2 tolerance has been met the time interval between successive latitude comparisons becomes 1/10 of one second. Near maximum latitudes are then defined as beginning when the difference between successive latitude comparisons becomes less than ϵ_1 and ending when the difference becomes less than ϵ_3.

The normal satellite ephemeris printout as requested on the OUTPUT card is not generated under the MAXLAT option. Instead, only one line of Cartesian ephemeris is printed on each revolution at the highest latitude to within 1/10 of one second; this latitude is determined when successive latitude comparisons <u>within</u> the period of maximum latitudes first become negative. Thus, in order to insure the proper functioning of the MAXLAT option, the tolerances on ϵ_1 and ϵ_3 cannot be too small. Suggested initial values for ϵ_1 and ϵ_3 can be determined by:

MAXLAT (Cont.)

$$\epsilon_1 = \frac{.1 \times \epsilon_2}{10 \times \text{OUTPUT RATE}} ,$$

$$\epsilon_3 = - \epsilon_1$$

If the OUTPUT card requests the Keplerian ephemeris printout, the Keplerian ephemeris over the period of maximum latitudes will be generated. If, in addition, the punching of Keplerian elements is requested on the MAXLAT card, the times of these punched elements will correspond to the lines of Cartesian ephemeris printout.

Use of this option will result in a considerable increase in program execution time.

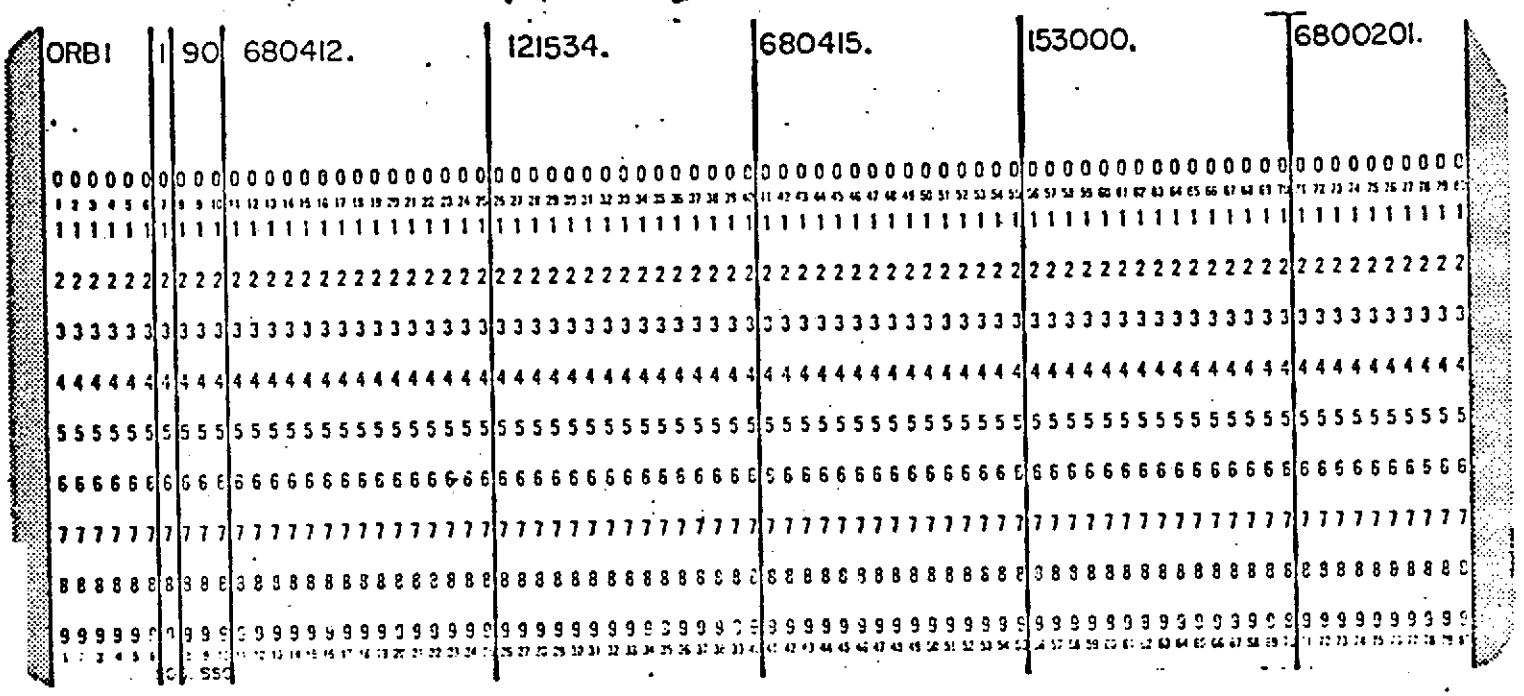
When this option is used the following must be true

$$\epsilon_1 > 0 , \quad \epsilon_2 > 0 , \quad \epsilon_3 < 0$$

ARC SET.

GROUP 2 - OPTION CARDS

ORB1



NAME	COLUMNS	FORMAT	DESCRIPTION
ORB1	1-4	A4	Requests that an ORB1 tape* be generated at the end of the last outer iteration.
	7	I1	≠0 References ORB1 output to the true equator and equinox of the reference date.
	8-10	I3	Ephemeris output rate in integral seconds.

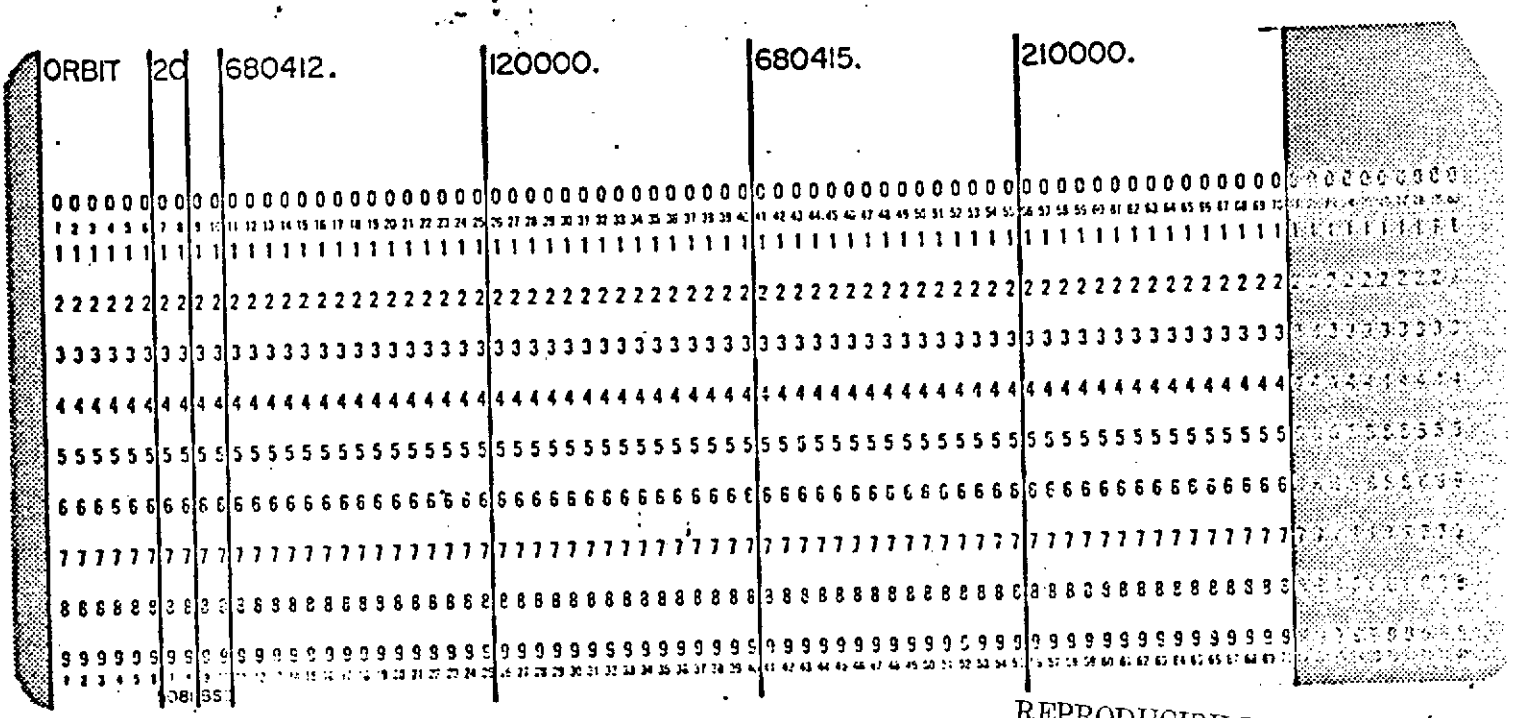
NAME	COLUMNS	FORMAT	DESCRIPTION	
	11-25	D15.8	Year, month, day (YYMMDD.)	
	26-40	D15.8	Hour, minute, seconds (HHMMSS.)	Start time
	41-55	D15.8	Year, month, day (YYMMDD.)	
	56-70	D15.8	Hour, minute, seconds (HHMMSS.)	Stop time
	71-80	D10.8	Satellite ID**	

Note: An ORB1 tape may be generated during a data reduction run or an orbit generator run. The start time must be equal to or greater than the start time for data as specified on the Epoch card.

*See Appendix C of this manual.

**If a satellite ID is specified on the ORB1 card that ID will appear on the ORB1 tape instead of the ID on the Epoch card or the data.

ARC SET
GROUP 2 - OPTION CARDS
ORBIT



NAME	COLUMNS	FORMAT	DESCRIPTION
ORBIT	1-5	A5	Requests orbit generation mode of operation.
	7-8	I2	FORTRAN unit for writing an RV tape. If no unit is specified the tape will not be written.
	11-25	D15.8	Year, month, day (YYMMDD.) of start time for ephemeris printout and RV tape generation.
	26-40	D15.8	Hours, minutes, second (HHMMSS.) of start time.

NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	Year, month, day (YYMMDD.) of stop time for ephemeris printout and RV tape generation.
	56-70	D15.8	Hours, minutes, seconds (HHMMSS.) of stop time.

NOTES: Use the OUTPUT card to specify the time interval for listing the satellite ephemeris.

If an ORBIT card is present for any arc the maximum number of outer iterations must be specified as 1 on the COMMON SET, Termination Card.

Normal ephemeris output is inertial position and velocity plus groundtrack on the printer. The coordinate system is true of date. This output may be requested in true of the reference date by use of the OUTPUT card.

An RV tape is optional and contains time in the UTC system, and position and velocity in the same coordinate system as the printer output.

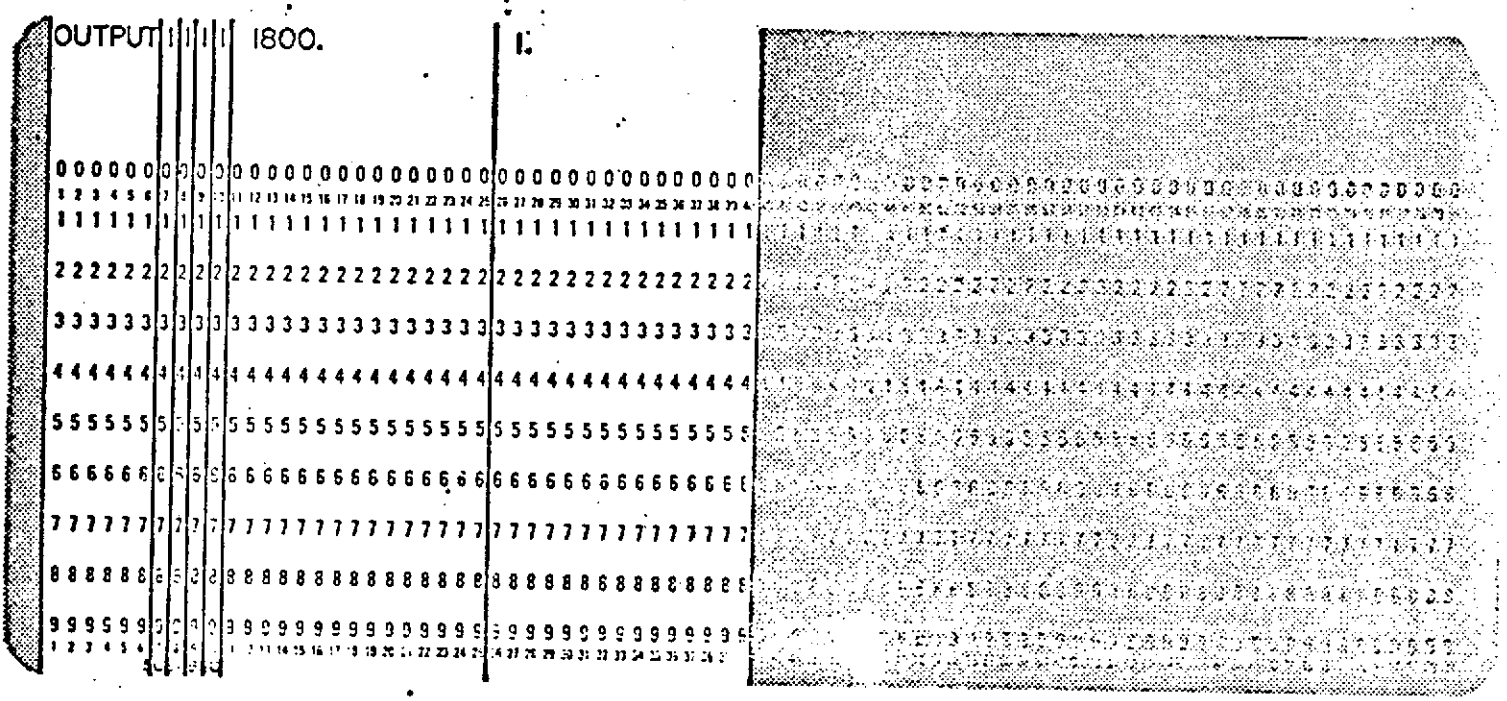
The start time for ephemeris output may be greater than or equal to the start time for data as specified on the Epoch card.

IF CARD OMITTED: Data reduction mode of operation will be requested.

ARC SET

GROUP 2 - OPTION CARDS

OUTPUT



NAME	COLUMNS	FORMAT	DESCRIPTION
OUTPUT	1-6	A6	Requests additional output or specifies the time interval for an orbit generator printout.
	7	I1	> 0 indicates that satellite XYZ and groundtrack are requested for iterations as follows, = 1 ,first inner on first outer (mandatory for orbit generator run) = 2 last inner on last outer = 3 first inner on first outer and last inner on last outer

OUTPUT (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	8	I1	A value greater than zero specifies that a ground-track tape is to be written on FORTRAN logical unit 18. The groundtrack tape is written on the first iteration.
	9	I1	= 1 requests a binary residual tape output on the last iteration. Default is no tape.
	10	I1	= 1 Requests that satellite Keplerian element ephemeris be printed at the same times as the XYZ ephemeris.
	11-25	D15.8	1. Specifies the time interval in seconds for orbit generator output. No default. 2. A value in this field for a data reduction run indicates that the XYZ and groundtrack are to be printed at the specified time interval in seconds and printed at data times. Default is output at data times only.

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	A value greater than zero references the ephemeris output to the coordinate system of the true equator and equinox of the reference time.
	41-55	D15.8	Optional change of unit number for Keplerian ephemeris. Default = 9. Unit may be changed to 6 or 8.
	56-70	D15.8	Value greater than zero requests printing of measurement partials during data reduction run.

IF CARD OMITTED:

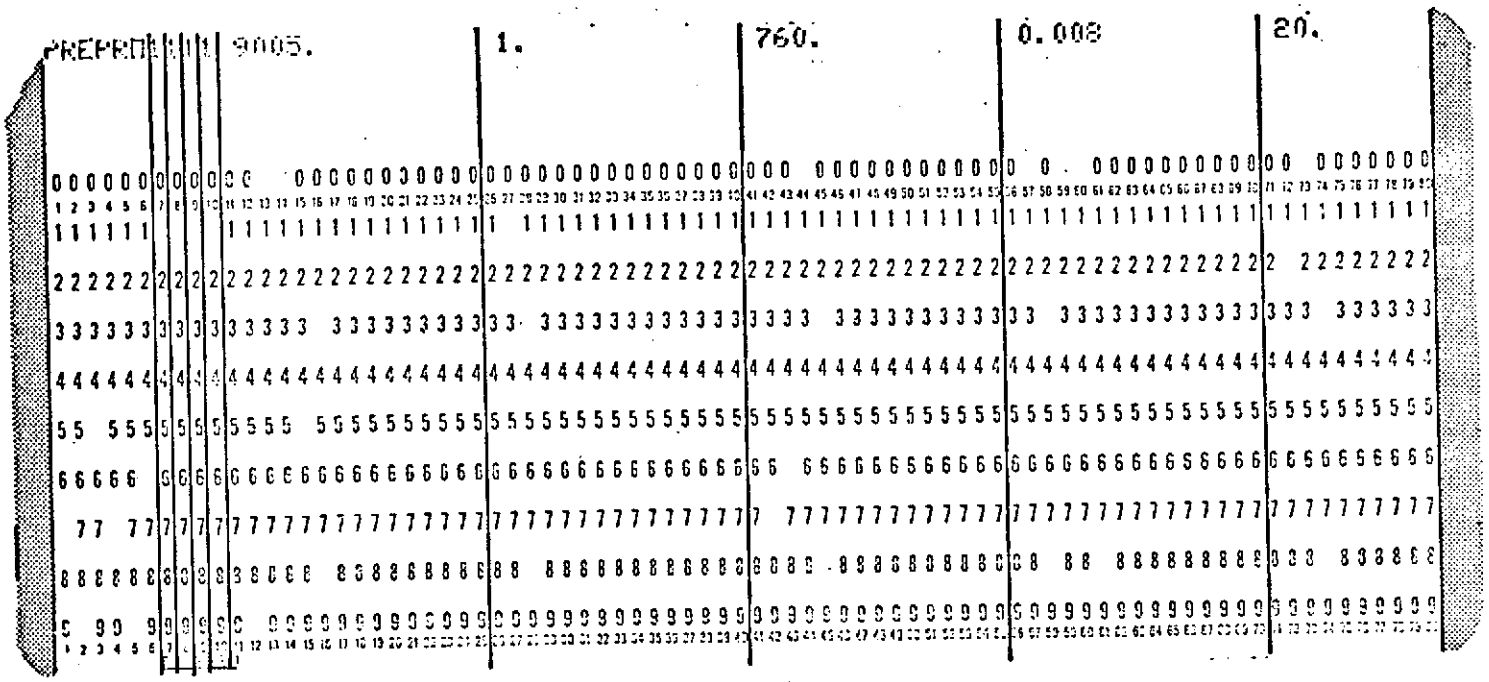
For orbit generator - There will be no printout.

For data reduction -- No additional output requested.

ARC SET

GROUP 2 - OPTION CARDS

PREPRO



NAME	COLUMNS	FORMAT	DESCRIPTION
PREPRO	1-6	A-6	Requests data preprocessing.
	7	I1	Digit in column 7 requests transit time and transponder delay corrections as indicated in Table I on page 1.2-39.1.
	8	I1	Digit in column 8 requests refraction corrections as indicated in Table II on page 1.2-39.1.
	9	I1	Digit in column 9 applies constant timing corrections.

PREPRO (cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	10	I1	Digit in column 10 requests optical data corrections as indicated in Table III on page 1.2-39.2.
	11-25	D15.8	Station number or zero; for zero, measurements from all stations will be preprocessed.
	26-40	D15.8	Measurement type or zero; for zero all measurement types will be preprocessed.
	41-55	D15.8	Surface pressure in mm of Hg for tropospheric refraction computation. Default = 760.
	56-70	D15.8	Constant timing corrections in seconds.
	71-80	D10.8	Surface temp in °C to tropospheric refraction correction computations. Default = 20.

IF CARD OMITTED: No data preprocessing is done.

TABLE I. TRANSIT TIME/TRANSPONDER DELAY CORRECTIONS

Value in Col. 7	TT	TTF	TD	VHF
0	NO	NO	NO	NO
1	YES	NO	YES	NO
2	NO	YES	YES	NO
3	NO	NO	YES	NO
4	YES	NO	YES	YES
5	NO	YES	YES	YES
6	NO	NO	YES	YES
7	YES	NO	NO	NO
8	NO	YES	NO	NO

Notation for Table I:

TT - transit time correction applied if data tape requests.
TTF - transit time corrections always applied.
TD - transponder delay corrections applied if data tape requests.
VHF - indicates VHF transmitter frequency assumed.

TABLE II. REFRACTION CORRECTIONS

Value in Col. 8	T	I	TF	IF
0	NO	NO	NO	NO
1	YES	NO	NO	NO
2	NO	NO	YES	NO
3	NO	YES	NO	NO
4	NO	NO	NO	YES
5	YES	YES	NO	NO
6	NO	NO	YES	YES
7	NO	YES	YES	NO
8	YES	NO	NO	YES

Notation for Table II:

T - tropospheric corrections applied if data requests.
I - ionospheric corrections applied if data requests.
TF - tropospheric corrections always applied.
IF - ionospheric corrections always applied.

TABLE III. PREPRO OPTIONS FOR OPTICAL DATA

Value in Col. 10	Precession & Nutation only if data requests	Parallactic Refraction	Annual Aberration	Diurnal Aberration
0	NO	NO	NO	NO
1	YES	SAO only	NO	SAO only
2	YES	YES	NO	NO
3	YES	NO	YES	NO
4	YES	YES	YES	NO
5	YES	NO	NO	YES
6	YES	YES	NO	YES
7	YES	NO	YES	YES
8	YES	YES	YES	YES

SAO only means stations with numbers greater than 8999.

Cards appearing later in deck will override earlier cards.

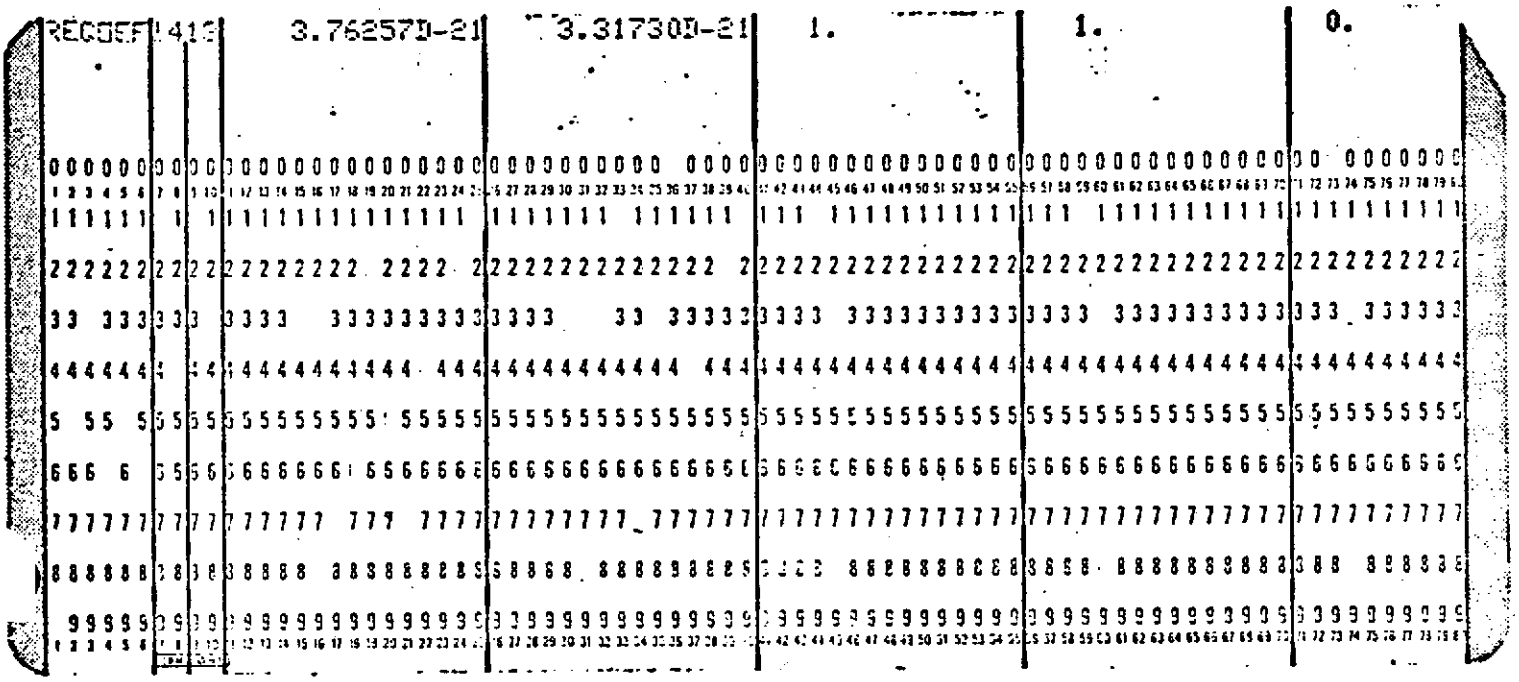
Max. of 50 PREPRO cards per arc.

ARC SET

GROUP 2 - OPTION CARDS

RECOEF

(COEF)



NAME	COLUMNS	FORMAT	DESCRIPTION
RECOEF or COEF	1-6	A6	Modifies and/or requests the estimation of coefficients in the geopotential model.
	7-8	I2	Degree of C and S coefficients (n index).
	9-10	I2	Order of C and S coefficients (m index).

RECOEF (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	11-25	D15.8	A priori (or starting) value of C coefficients.
	26-40	D15.8	A priori (or starting) value of S coefficients.
	41-55	D15.8	Standard deviation of C coefficient. Coefficient will not be adjusted if value is zero. Value is fractional uncertainty if ≥1.0D-5 ($\sqrt{1.0D-5}$ for J2) and standard deviation equals fractional uncertainty times nominal* value of a priori coefficient. Value is standard deviation if <1.0D-5 ($\sqrt{1.0D-5}$ for J2).
	56-70	D15.8	Standard deviation of S coefficient. Coefficient will not be adjusted if value is zero. Value is fractional uncertainty if ≥1.0D-5 and standard deviation equals fractional uncertainty times nominal* value of a priori coefficient. Value is standard deviation if <1.0D-5.

RECOEF (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	71-80	D10.4	=0 Values on this card will be interpreted as being un-normalized.
			>0 Entries in columns 11-40 on this card will be ignored. A priori values of coefficients are obtained from current geopotential model including all modification prior to this card. Input standard deviations are un-normalized.
			<0 Values on this card will be interpreted as being normalized.

IF CARD OMITTED: The geopotential used will be GEM 1 Model unless modified by EARTH card or modified in COMMON SET by option cards EARTH and RECOEF.

The geopotential coefficient denormalization equation used is:

$$C_n^m = C_n^{\bar{m}} * D_n^m$$

$$S_n^m = S_n^{\bar{m}} * D_n^m$$

where

$$D_n^m = \sqrt{(4n + 2) \cdot \frac{(n-m)\ !}{(n+m)\ !}} \quad \text{for } m \neq o$$

RECOEF (Cont.)

$D_n^m = \sqrt{2n + 1}$ for m = o

and

C_n^m, S_n^m are un-normalized coefficients

$\bar{C}_n^m$, $\bar{S}_n^m$ are normalized coefficients

*Nominal values of geopotential coefficients are

$$\left| J_n^m \right| = \frac{(10^{-5})\ D_n^m}{n^2}$$

A Priori Value of Adjusted Coefficients

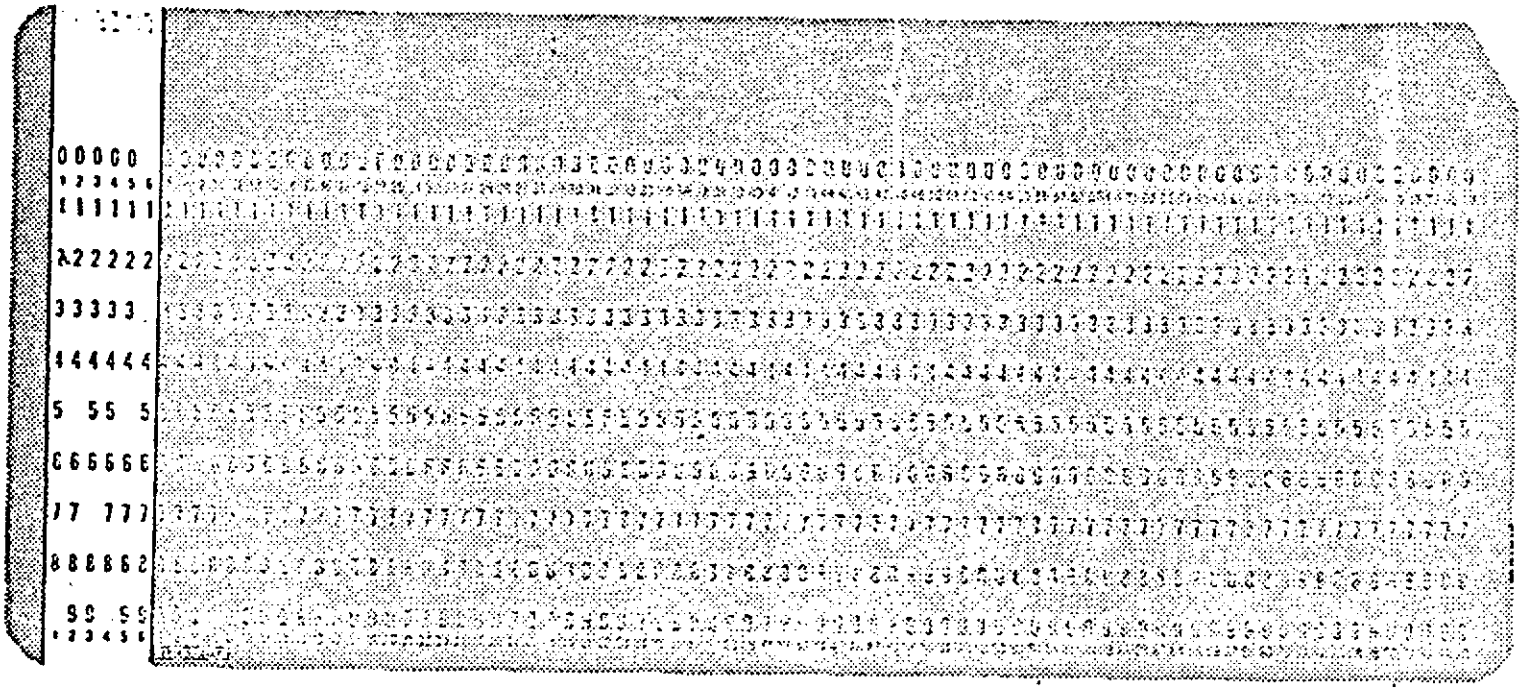
If it is desired that the starting values of geopotential coefficients be different than the a priori values for those coefficients then the RECOEF card should be used as follows:

- RECOEF cards requesting the desired coefficient adjustments should be included in the setup deck. The a priori values will be indicated on these cards.

- For each coefficient pair for which the starting value is to be different than the a priori value, an additional RECOEF card should be in the setup deck. This RECOEF card will indicate the starting value and come later in the deck than the corresponding RECOEF card requesting adjustment.

See also COMMON SET, OPTION CARD - RECOEF (COEF).

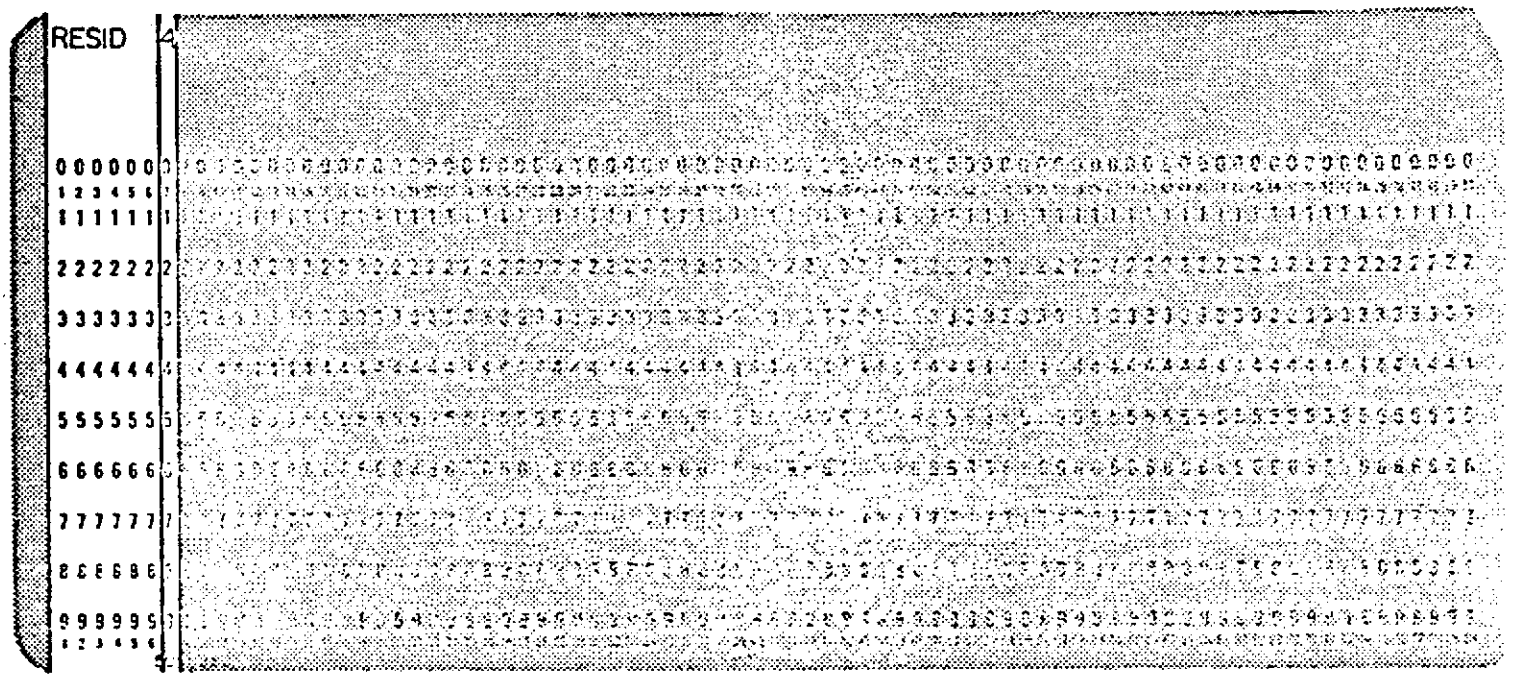
ARC SET
GROUP 2 - OPTION CARDS
REGINT



NAME	COLUMNS	FORMAT	DESCRIPTION
REGINT	1-6	A6	Indicates that numerical orbit integration is to be performed in regularized mode.

IF CARD OMITTED: Integration will not be performed in regularized mode.

ARC SET
GROUP 2 - OPTION CARDS
RESID



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NAME	COLUMNS	FORMAT	DESCRIPTION
RESID	1 - 5	A5	Controls residual printout for this arc.
	7	I1	0 - Indicates no residuals are requested for this arc.
			1 - Indicates that residuals are requested on the first inner iteration of the first outer iteration for this arc.

NAME	COLUMNS	FORMAT	DESCRIPTION cont.

2 - Indicates that residuals are requested on the last inner iteration of the last outer iteration for this arc.

3 - Indicates that residuals are requested on the first inner iteration of the first outer iteration and the last inner iteration of the last outer iteration for this arc.

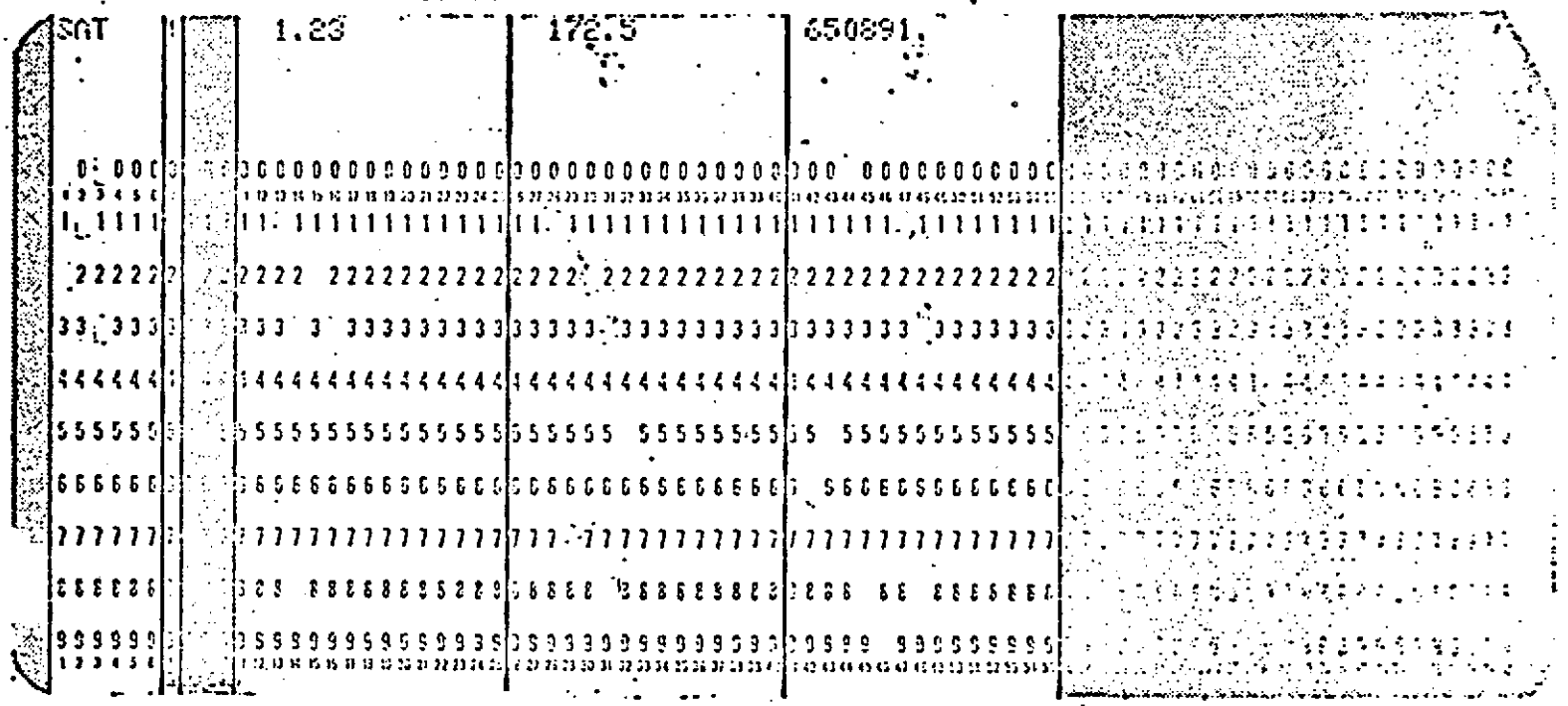
4 - Indicates residuals are requested on all iterations for this arc.

IF CARD OMITTED: Value is 3 or that value specified on the RESID card in COMMON SET.

See also COMMON SET, OPTION CARD -- RESID.

Inner and outer iterations are explained in the Introduction of this manual.

ARC SET
GROUP 2 - OPTION CARDS
SAT



NAME	COLUMNS	FORMAT	DESCRIPTION
SAT	1-3	A3	Introduces satellite area and mass for drag or solar radiation pressure calculations and satellite ID.*
	7	I1	Satellite number (1 or 2)** If less than 1 or greater than 2, applies to both satellites.
	11-25	D15.8	Cross-sectional area of satellite in square meters. Default is zero. A_s

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Mass of satellite in kilograms. Default is zero. m_s
	41-55	D15.8	Satellite ID.

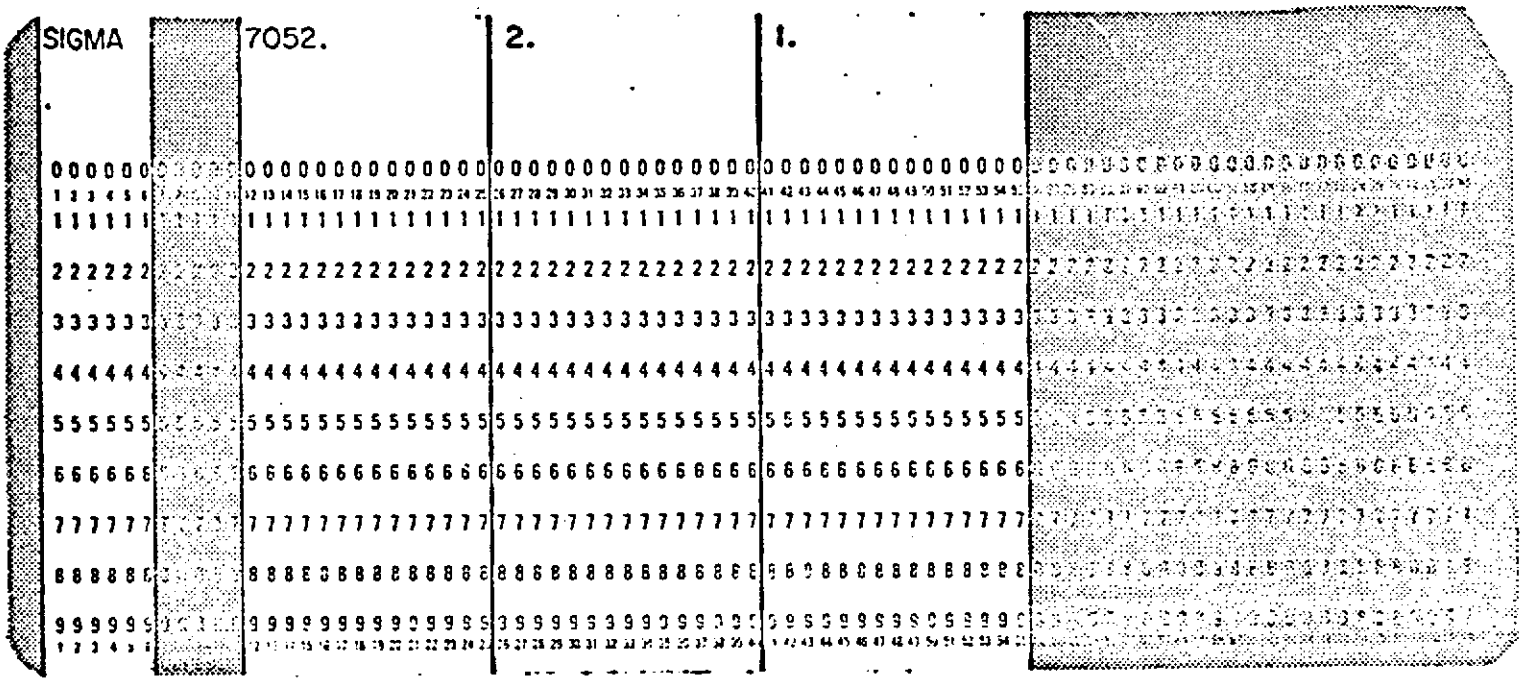
IF CARD OMITTED: No drag or solar radiation pressure perturbations will be applied even if requested by OPTION CARDS -- DRAG and SOLRAD.

*The satellite ID is necessary in the following situations.

- If there is more than one satellite in the arc.
- If data from more than one satellite is on the data tape for the arc.
- If the DODS Data Base is to be used.

**Satellite number refers to either the first or second satellite in the arc and is only applicable in satellite - satellite tracking.

ARC SET
GROUP 2 - OPTION CARDS
SIGMA



NAME	COLUMNS	FORMAT	DESCRIPTION
SIGMA	1-5	A5	Modifies measurement standard deviations.
	11-25	D15.8	Station number or zero; for zero all measurements of the type specified in columns 26-40 will be assigned the standard deviation on this card
	26-40	D15.8	Measurement type or zero; for zero all types will be assigned the standard deviation on this card.

NAME	COLUMNS	FORMAT	DESCRIPTION
	41-55	D15.8	Standard deviation of measurement or zero; for zero, residuals will appear for the measurement but the measurement will not be used in the estimation process. σ

IF CARD OMITTED: All measurements are assigned Sigma Defaults.

NOTE: If requests conflict in Sigma change decks the last of the conflicting changes takes precedence.

See following page for Measurement Types and Sigma Defaults.

MEASUREMENT TYPES AND SIGMA DEFAULTS

	MEASUREMENT	TYPE NO.	GEOS DEFAULT	DODS DEFAULT	UNITS FOR STANDARD DEVIATION
α	Right Ascension	1	Tape	2.	Seconds of arc
δ	Declination	8	Tape	2.	Seconds of arc
ρ	Range	2	Tape	25.	Meters
$\dot{\rho}$	Range Rate	3	Tape	10.	Centimeters per second
H_{alt}	Altimeter Height	4	Tape	N.A.	Meters
$\dot{H}_{alt}$	Altimeter Rate	11	Tape	N.A.	Centimeters per second
l	Direction Cosine E	5	.3	.3	Mils
m	Direction Cosine N	12	.3	.3	Mils
X_a	X angle	6	Tape	50.	Seconds of arc
Y_a	Y angle	13	Tape	50.	Second of arc
A_z	Azimuth	7	Tape	50.	Seconds of arc
E_l	Elevation	14	Tape	50.	Seconds of arc

PCE DATA

MEASUREMENT	TYPE NO.	STANDARD DEVIATION DEFAULT VALUE	UNITS
x	15	100.	Meters
y	16	100.	Meters
$\dot{z}$	17	100.	Meters
$\dot{\bar{x}}$	18	10.	Centimeters/Second
$\dot{\bar{y}}$	19	10.	Centimeters/Second
$\dot{\bar{z}}$	20	10.	Centimeters/Second
a	21	150.	Meters
e	22	15.	ppm
i	23	10.	arc seconds
Ω	24	10.	arc seconds
ω	25	20.	arc seconds
M	26	50.	arc seconds

TWO STATION MEASUREMENTS

MEASUREMENT	TYPE NO.	DEFAULT VALUE	UNITS
τ VLBI Time Delay	27	1000	Nanoseconds
ν VLBI Fringe Rate	28	100	Microhertz
$\dot{\bar{\rho}}_2$ 2-Way Average Range Rate	29	0.1	Centimeters/ Second
$\dot{\bar{\rho}}_3$ 3-Way Average Range Rate	30	0.1	Centimeters/ Seconds

SIGMA (cont.)

NOTES: GEOS Default refers to the default if the data tape is in GEOS format.

DODS Default refers to the default if the data is in DODS format.

Tape implies that the sigmas were obtained from the data tape.

The sigma for right ascension is divided by the cosine of the declination.

The sigma for azimuth is divided by the cosine of the elevation.

The sigma for direction cosines are divided by the square root of 1.0 minus the measurement squared.

The maximum number of SIGMA cards is 50 per arc.

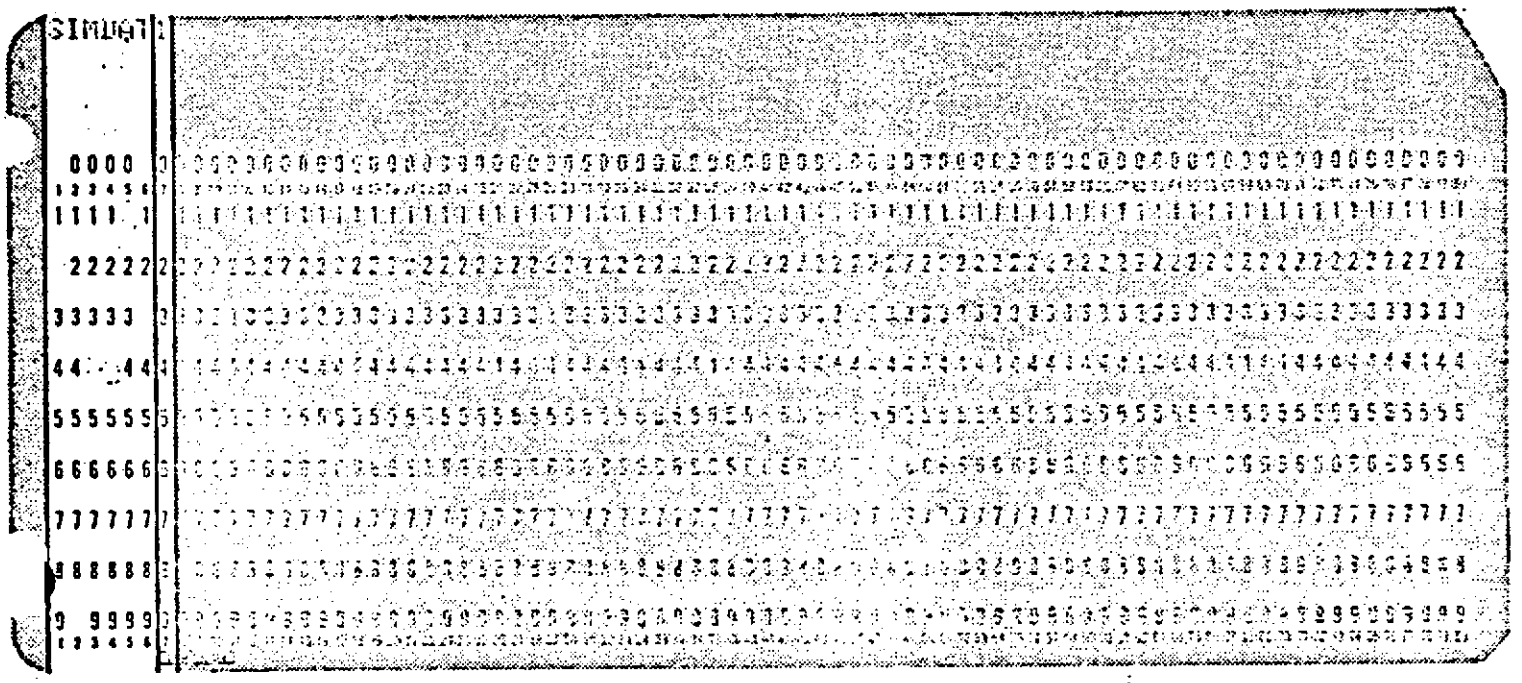
PCE sigma defaults are used only when sigmas on tape are zero.

Summed range and range rate measurement used for satellite-to-satellite tracking are handled internally as types 2 and 3 respectively.

ARC SET

GROUP 2 - OPTION CARDS

SIMDAT



NAME	COLUMNS	FORMAT	DESCRIPTION
SIMDAT	1-6	A6	Requests that data be simulated during the run and written on unit 17. If the run is in data reduction mode the data will be simulated on the first inner iteration of the first outer iteration.* This data will be of the same types, from the same stations and at the same times as the real data used in the data reduction run.

NAME	COLUMNS	FORMAT	DESCRIPTION
	1-6 (Cont.)		If the run is in orbit generator mode PCE data will be simulated at satellite ephemeris output times.
	7	I1	PCE - type indicator if in orbit generator mode. =0 X,Y,Z,$\dot{X}$,$\dot{Y}$,$\dot{Z}$ data =1 a,e,i,Ω,ω,M data

IF CARD OMITTED: Data will not be simulated or written.

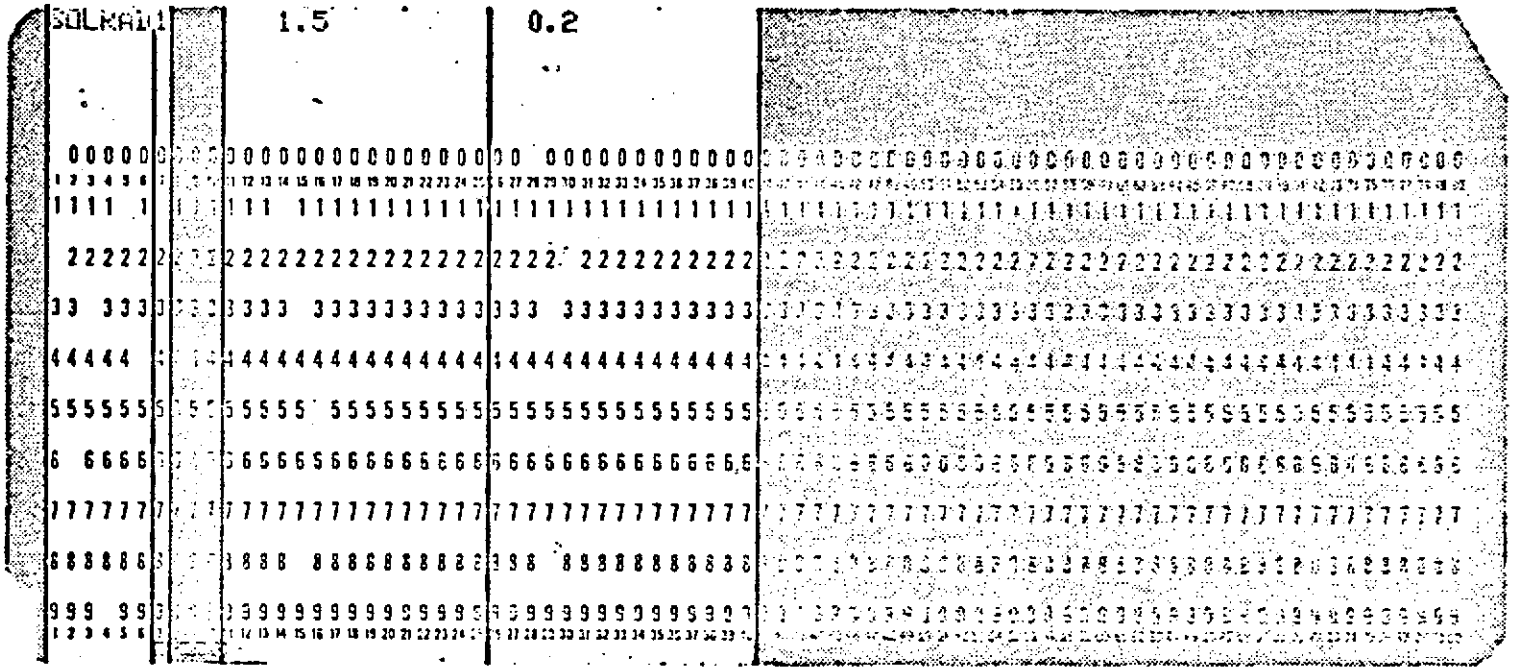
NOTE: One file will be written on unit 17 for each arc in which a SIMDAT card is present.

*See Introduction for definitions of inner and outer iterations.

ARC SET

GROUP 2 - OPTION CARDS

SOLRAD



NAME	COLUMNS	FORMAT	DESCRIPTION
SOLRAD	1-6	A6	Modifies solar radiation pressure application.
	7	D15.8	Satellite number (1 or 2).* If less than 1 or greater than 2, applies to both satellites.
	11-25	D15.8	Satellite reflectivity or zero; for zero, solar radiation pressure is not applied. Default is C_R = 1.5.

NAME	COLUMNS	FORMAT	DESCRIPTION
	26-40	D15.8	Standard deviation of satellite reflectivity or zero; for non-zero standard deviation the satellite reflectivity will be adjusted. Default is zero.

IF CARD OMITTED: Solar radiation pressure is applied with C_R = 1.5 only if SAT card is also present.

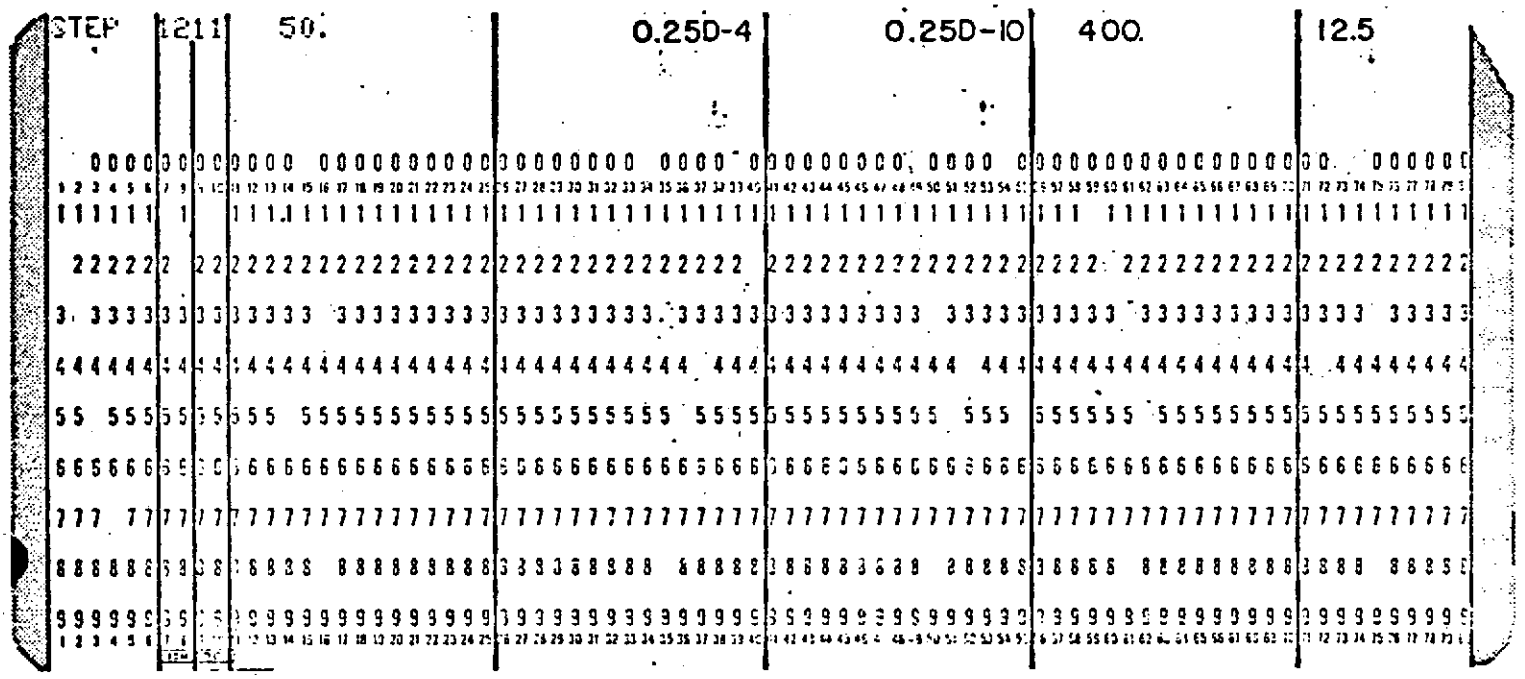
NOTE: SAT card in ARC SET must be present for solar radiation pressure to be applied.

*Satellite number refers to either the first or second satellite in the run and is applicable only in satellite-satellite tracking.

ARC SET

GROUP 2 - OPTION CARDS

STEP



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NAME	COLUMNS	FORMAT	DESCRIPTION
STEP	1-4	A4	Changes integrator step size and mode.
	7	I1	=1 Satellite 1 Equations of Motion =2 Satellite 2 Equations of Motion =3 Satellite 1 Variational Equations =4 Satellite 2 Variational Equations

NAME	COLUMNS	FORMAT	DESCRIPTION
	7 (Cont.)		=0 or > 4 applies to Equations of Motion and Variational Equations for both satellites.
	8	I1	=0 Fixed step integration =1 Variable step integration =2 Variable step integration with stepsize halving and doubling only.
	9-10	I2	Integration order. Default = 11
	11-25	D15.8	Step size in seconds; the initial step size for variable step mode.
	26-40	D15.8	Error tolerance for stepsize decrease. Default is 0.25D-4 m.
	41-55	D15.8	Error tolerance for stepsize increase. Default is 0.25D-10 m.
	56-70	D15.8	Maximum stepsize in variable step mode. Default is 400 seconds.
	71-80	D10.5	Minimum stepsize in variable step mode. Default is 12.5 seconds.

IF CARD OMITTED: Default values will be used.

NOTE: The step size and integrator mode defaults are the following:

If perigee height is less than 800 kilometers the step size is 75 seconds.

If perigee height is greater than 800 kilimeters and less than 1500 kilometers the step size is 100 seconds.

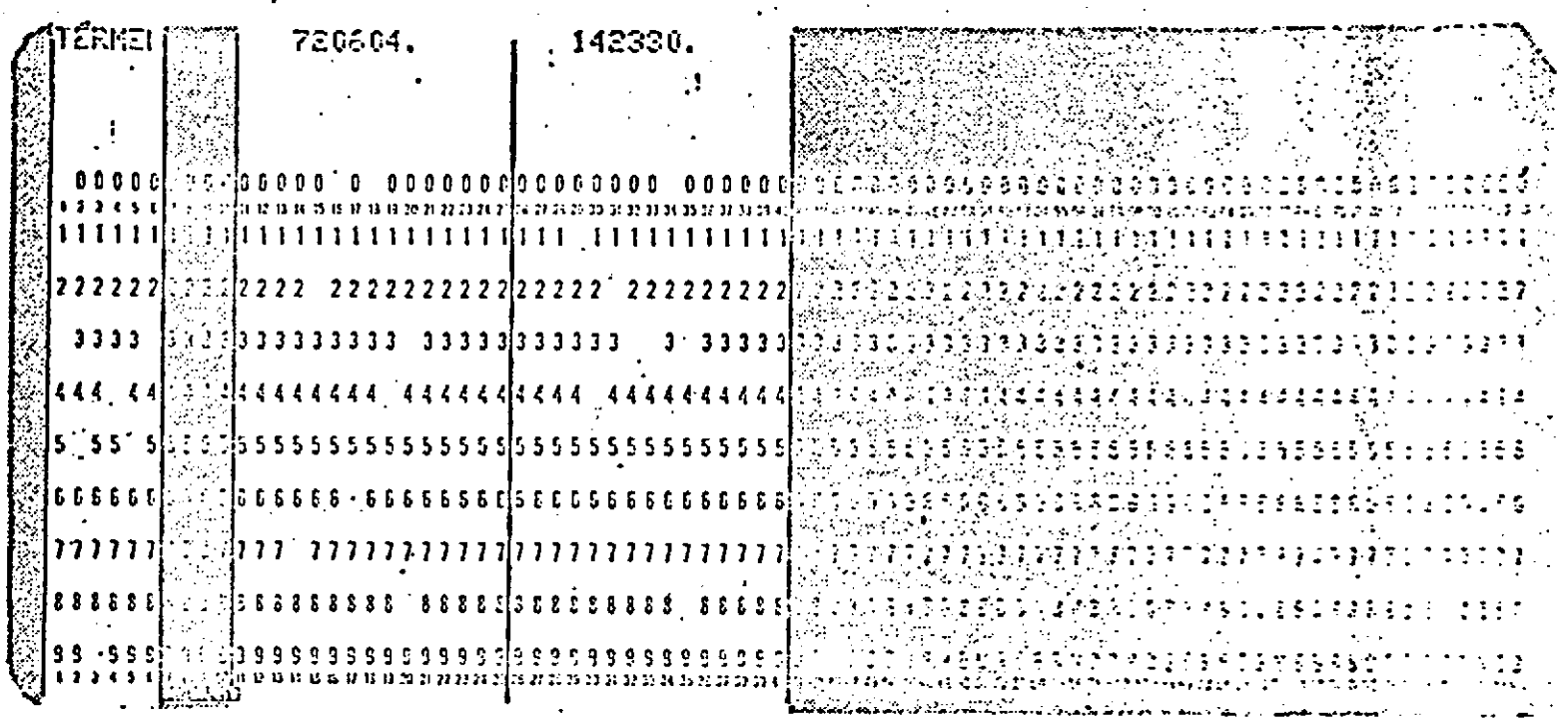
The step size is linearly interpolated from 100 seconds at 1500 kilometers perigee to 400 seconds at 36,200 kilometers perigee for satellites with an eccentricity less than 0.01.

If the perigee height is greater than 36,200 kilometers the step size is 400 seconds for circular orbits.

If the eccentricity of the orbit is greater than 0.2 the integration is done in variable step mode and the initial step size is 50 seconds.

If columns 26-40, 41-55, 56-70, or 71-80 are blank or zero, default values will be used for the corresponding parameters. The default values may be modified for all arcs by use of a STEP card in COMMON SET.

ARC SET
GROUP 2 - OPTION CARDS
TERMEL



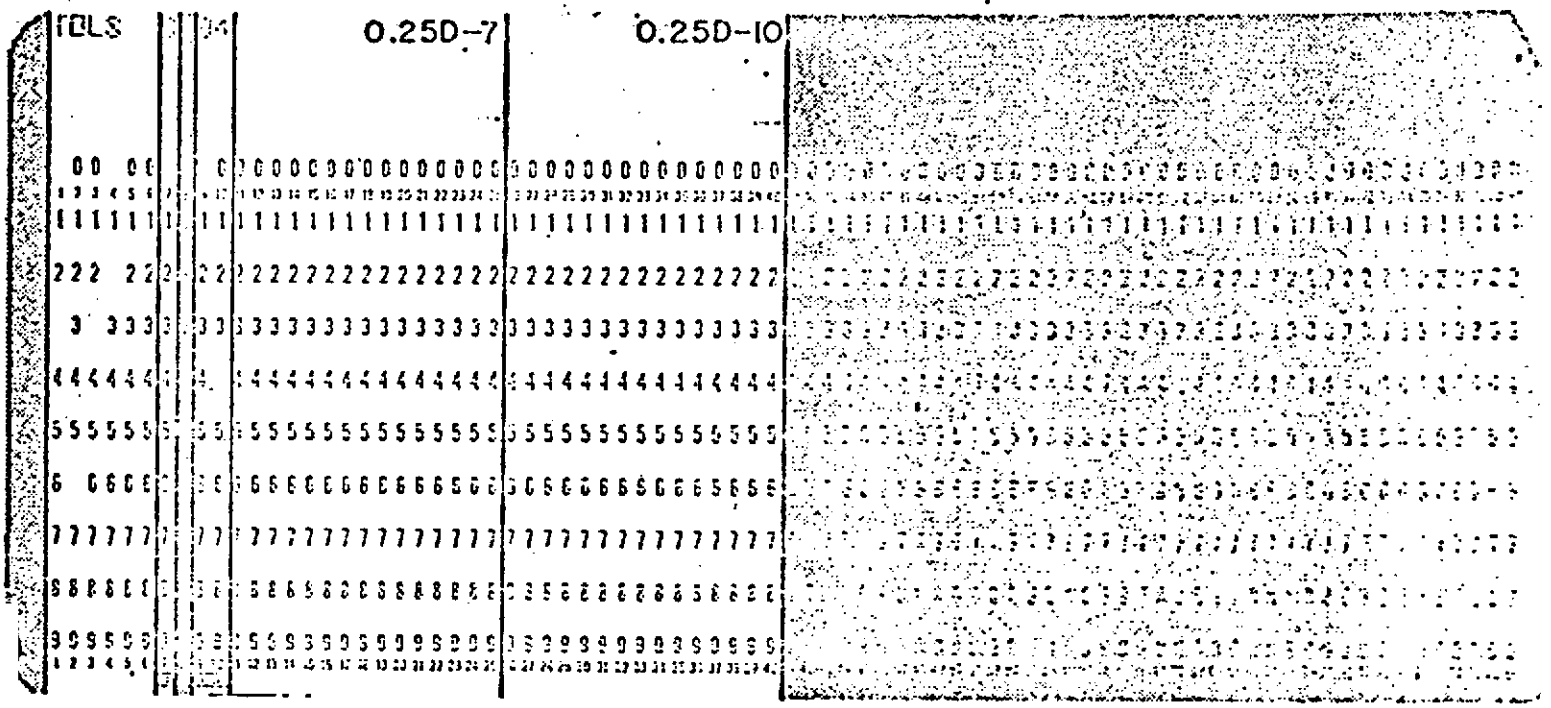
NAME	COLUMNS	FORMAT	DESCRIPTION
TERMEL	1-6	A6	Requests printing of terminus elements after end of data in a data reduction run.
	11-25	D15.8	Date of terminus elements in fo YYMMDD.
	26-40	D15.8	Time of terminus elements in fo HHMMSS.

IF CARD OMITTED: Terminus elements will not be printed.

ARC SET

GROUP 2 - OPTION CARDS

TOLS



NAME	COLUMNS	FORMAT	DESCRIPTION
TOLS	1-4	A4	Modifies integration tolerances.
	7	I1	Indicates for which satellite tolerances are to be modified for this arc. = 0 both satellites = 1 first satellite = 2 second satellite (applies to satellite - satellite tracking)
	9-10	I2	Maximum degree and order of

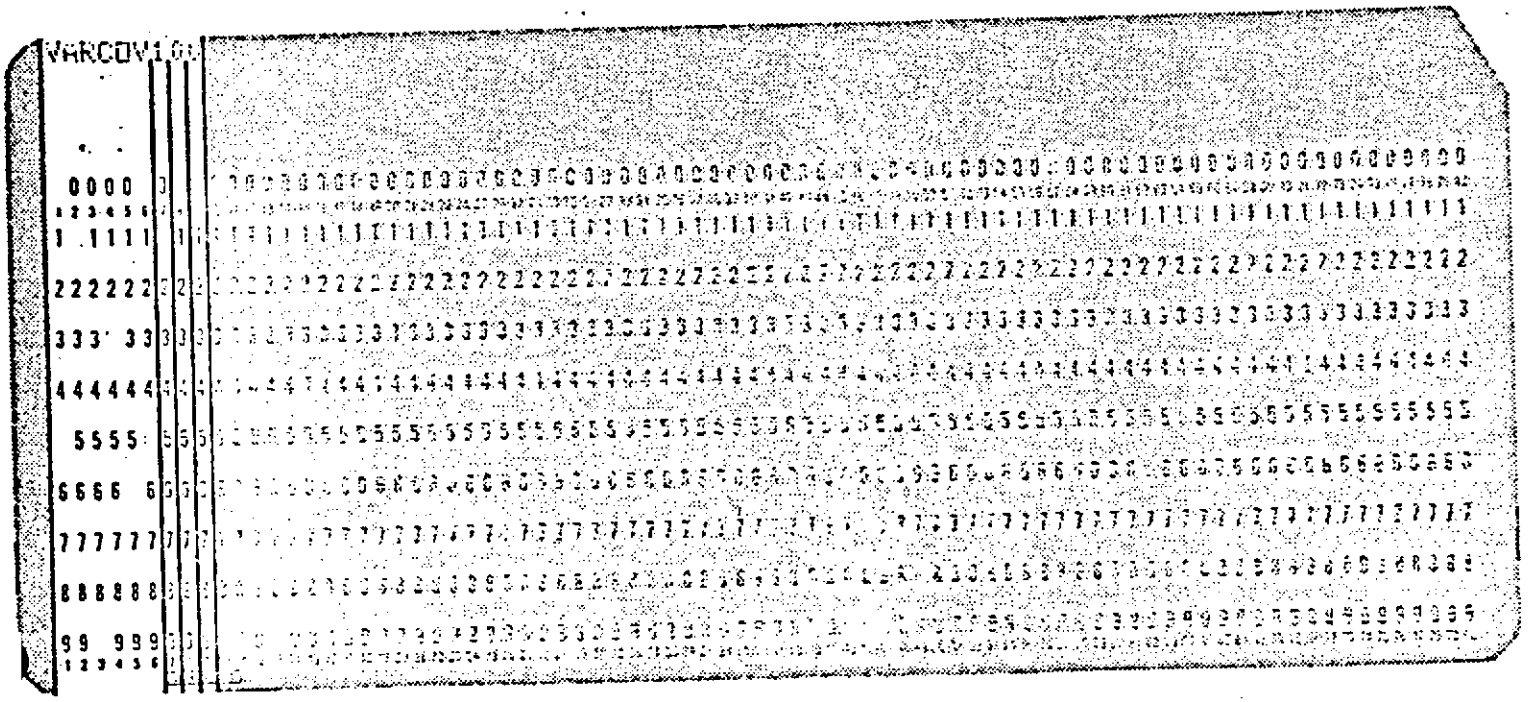
NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10 (Cont.)		geopotential effects to be included in the computation of the variational equations. Default = 4, Minimum = 3.
	11-25	D15.8	Desired reasonable predictor-corrector tolerance to be achieved by changing the integrator step size while in variable step integration mode. Used only in computation of new step size during step size variation. Default = 0.25D-7m.
	26-40	D15.8	Critical predictor-corrector tolerance. Used to determine number of corrector iterations necessary at each integration step. If after two corrections the local error exceeds critical tolerance an error message will be printed (execution will be terminated). Default = 0.25D-10m.

IF CARD OMITTED: Default values will be used.

ARC SET

GROUP 2 - OPTION CARDS

VARCOV



NAME	COLUMNS	FORMAT	DESCRIPTION
VARCOV	1-6	A6	Specifies that the a priori variance-covariance matrix (V_k) associated with the a priori orbital parameters is to be changed.
	7	I1	Satellite number (1 or 2).* Indicates for which satellite matrix will apply. If zero or greater than 2, matrices must be input for both satellites.
	8	I1	=0 Variance-covariance on epoch Cartesian elements. =1 Variance-covariance on epoch Keplerian elements.

NAME	COLUMNS	FORMAT	DESCRIPTION
	9	I1	=0 Matrix diagonal only will be input on one card in 6E12.6 format for each satellite for which the matrix is changed. This card(s) follows the VARCOV card.
			=1 Full 6x6 matrix will be input on 6 cards in 6E12.6 format for each satellite for which the matrix is changed. These cards follow the VARCOV card.

IF CARD OMITTED: No change to matrix V_k will be made.

*Satellite number refers to either the first or second satellite in the arc.

The a priori variance-covariance matrix is:

1.E+14	0.	0.	0.	0.	0.
0.	1.E+14	0.	0.	0.	0.
0.	0.	1.E+14	0.	0.	0.
0.	0.	0.	1.E+14	0.	0.
0.	0.	0.	0.	1.E+14	0.
0.	0.	0.	0.	0.	1.E+14

1.2.3 ARC SET
GROUP 3 - TERMINATION CARD FOR GROUP 2 - OPTION CARDS

DATA

There are four kinds of termination cards used to signify the end of Group 2. One of these is mandatory for every arc.

1. Termination Card for orbit generator arcs.

NAME	COLUMNS	FORMAT	DESCRIPTION
DATA	1-4	A4	Signifies the end of Group 2.

2. Termination Card for data reduction arcs with data in GEOS format.

NAME	COLUMNS	FORMAT	DESCRIPTION
DATA	1-4	A4	Signifies the end of Group 2.
	8	I1	Specification of a 1 or 3 indicates that a GEOS Data Selection is to be made and that the corresponding GROUP 4 SELECT/DELETE cards must be present.
			Specification of a 2 or 3 indicates that the data used in the arc be written onto unit 3 in GEOS II forma

TERMINATION CARD FOR GROUP 2 (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10	I2	Optional change of input unit for GEOS data tapes. Default is 20.
	11-25 26-40 41-56	D15.8 D15.8 D15.8	Additional input units for GEOS data tapes. If more than one input unit is specified the data will be merged in time order as it is read.

3. Termination Card for data reduction arcs with data in GEOS-C Card Image Format, RAP Binary Format, or DODS Binary Format.

NAME	COLUMNS	FORMAT	DESCRIPTION
DATA	1-4	A4	Signifies the end of GROUP 2.
	8	I1	A value of 1 or 3** specified here signifies that data Selection/Deletion cards follow for data in any of these formats. GEOS-C Card Image Format*** RAP* Binary Format DODS Binary Format A value of 2 or 3 indicates that the data used in this arc be written onto unit 3 in the same format that it was read.

---

*RAP Binary Format - Research and Applied Physics Binary Format.

**See APPENDIX B.

***See APPENDIX C.

TERMINATION CARD FOR GROUP 2 (Cont.)

NAME	COLUMNS	FORMAT	DESCRIPTION
	9-10	I2	Input unit for data tape. Default is 20 for card image formats and 21 for binary formats.
	11-25	D15.8	Additional data tape input units. If more than one unit is specified the data will be merged as selected.
	26-40	D15.8	
	41-55	D15.8	

4. Termination Card for data reduction arcs with data in PCE or simulated data formats.

NAME	COLUMNS	FORMAT	DESCRIPTION
DATA	1-4	A4	Signifies the end of Group 2.
	9-10	I2	The data tape input unit is specified here. Defaults are: 20 for PCE data and 21 for simulated data.

1.2.4 Arc Set

GROUP 4 - SELECTION/DELETION CARDS

1.2.4.1 Selection of Multiple Data Forms

This Selection/Deletion option is applicable to the following input data forms:

GEOS-C Card Image
RAP Binary
DODS Binary

If the data Selection/Deletion option has been specified on the card then at least one SELECT card and as many as 100 SELECT and DELETE cards will follow the DATA card. The end of this card group is indicated by an ENDALL card.

The form of the SELECT card is:

Name	Columns	Format	Description
SELECT	1-6	A6	Selects from data tape.
	7	I1	Measurement type category indicator. 1 - Right Ascension (or Hour Angle) and Declination 2 - Range or Range Difference 3 - Range Rate or Range Rate Difference 4 - Altimeter 5 - Direction Cosines 6 - X-Y Angles 7 - Azimuth and Elevation Angles

Name	Columns	Format	Description
	8	A1	Measurement Sub-Type Indicator Sub-types vary with measurement type cateogry and will not in general need to be specified. A complete list of the categories and sub-types is specified in Appendix C; columns 8-9 of the GEOS-C Card Image Format.
	9-10	I2	Measurement Modulo Number An integer n specified here indicates that only every nth data point from the stations and types specified on this card will be selected.
	11-15	I5	Receiving station number if data is in either the GEOS-C format or the RAP format.
	11-16	A6	Receiving station name if data is in DODS Format.
	18-24	I7	Satellite ID
	25-30	I6	Date in form YYMMDD for start of data selection.
	31-36	I6	Time in form HHMMSS for start of data selection.
	37-42	I6	Date in form YYMMDD for end of data selection.
	43-48	I6	Time in form HHMMSS for end of data selection.

1.2.4.2 SELECTION AND DELETION CARDS -- GEOS FORMAT

If Data Selection and/or Deletion is desired at least one and as many as 100 SELECT and/or DELETE cards must follow the DATA card. An ENDALL card must terminate this group of cards.

SELECT

The SELECT card is a Data Selection card for data tapes in GEOS format.

NAME	COLUMNS	FORMAT	DESCRIPTION
SELECT	1-6	A6	Selects data from tape.
	7-12	I6	YYMMDD* of start time for data selection.
	14-15	I2	Hours of start time for data selection.
	16-19	I4	Minutes and integral seconds of start time for data selection.
	20-23	I4	Decimal seconds of start time for data selection.
	25-30	I6	YYMMDD of stop time.
	32-33	I2	Hours of stop time.
	34-37	I4	Minutes and integral seconds of stop time.
	38-41	I4	Decimal seconds of stop time.

NAME	COLUMNS	FORMAT	DESCRIPTION
	43-47	I5	Station number; all stations if not specified.
	49	I1	Measurement type; all types if not specified.
	50-51	I2	An integer n specified here indicates that only every n^{th} data point from the stations and types specified on this this card will be selected. These columns have no meaning for the DELETE card.

This card is optional.

*If start and stop times are not specified, these times are assumed to be the start and stop times of the data on the tape.

DELETE

The DELETE card is a Data Deletion Card for data tapes in GEOS format.

NAME	COLUMNS	FORMAT	DESCRIPTION
DELETE	1-6	A6	Same format as SELECT except that all times, types, and stations refer to data deletion rather than data selection.

This card is Optional.

ENDALL,

NAME	COLUMNS	FORMAT	DESCRIPTION
ENDALL	1-6	A6	Specifies end of data selection and/or deletion cards.

This card is Mandatory when SELECTION OR DELETION cards for data tapes in GEOS format are used.

1.3 FORMAT SPECIFICATION

Key n, m = integer numbers
b = a blank space

FORMAT CODE

In Integral numbers right-adjusted in a field of n columns.
Example: 25 in an I3 format: b25

Fn.m Digits with a decimal point anywhere in a field of n columns; digits punched without a decimal point assume the point m places from the right.
Example: 30.1 in an F5.2 format:
b30.1 or 30.1b or b301b

Dn.m Digits with a decimal point anywhere in a field of n columns; digits right justified in a field of n columns with an exponent of the form D±XX, where XX is the power of 10. If there is no decimal point, assume the point m placed to the left of the D.
Example: 30.1 in a D8.5 format:
b30.1bbb or 30.1D+00 or 301.D-01

En.m Same as Dn.m except that the exponent when used, takes the form E±XX.

An n alphanumeric characters.

2.0 GEODYN JOB CONTROL LANGUAGE AND HARDWARE AND SOFTWARE RESTRICTIONS

2.1 Job Control Language (JCL)

Certain JCL cards are necessary for all GEODYN runs. These cards are:

- The EXEC card specifying the name of the program to be executed,
- The STEPLIB card specifying the program library in which the GEODYN load module is stored, and
- The DD cards specifying the characteristics of the FORTRAN Logical Units used by GEODYN.

DETERMINATION OF GEODYN CORE REQUIREMENTS

Since GEODYN's core storage requirements are dynamic, the following equations should be used to compute the REGION to be specified on the EXEC statement.

$$\text{REGION} = \frac{\text{Bytes}}{1024} + 330$$

$$\begin{aligned}\text{Bytes} = {} & 226 + 46N_1 + 146N_2 + 224N_3\,(N_2 + N_3) + 96N_3N_{13} \\ & + 150N_3 + 214N_4 + 4N_5 + 136N_6 + 16N_7 + 8N_6N_8 + 16N_8 \\ & + 8N_9 + 56N_{11} + 40N_{12} + 18N_{13} + 28N_{15} + 4N_{15}^2 + N_{19} + N_{21}\end{aligned}$$

where

N_1 = maximum number of biases in any one arc.

N_2 = number of tracking stations used.

N_3 = maximum number of satellites in any one arc.

N_4 = number of tracking stations estimated.

N_6 = number of surface densities.

N_7 = number of surface densities estimated.

N_8 = number of constraint equations for surface densities.
$N_8 = N_D\,(N_D + 2)$ where N_D is the maximum degree of geopotential for constraint equations as specified on the TOLS card in COMMON SET, GROUP 2 - OPTIONS CARDS.

N_9 = number of solid earth tides coefficients estimated (not a current capability).

N_{10} = number of geopotential coefficients estimated as common parameters.

N_{11} = $N_{10} + N_{16}$

N_{12} = $N_7 + N_9 - N_8$

N_{13} = maximum number of equations which must be integrated in any one arc. (=N_3 + Maximum of ($N_{eq1} + N_{eq2}$))

N_{14} = number of master tracking stations estimated.

N_{15} = maximum number of parameters estimated in any one arc plus N_{17} (number of common parameters estimated).

N_{16} = maximum number of geopotential coefficients estimated as arc parameters in any one arc.

$N_{17} = N_{10} + N_{14} + N_{12}$

N_{18} = greatest number of two station (i.e., 3-way average range rate or VLBI measurement) baselines associated with a single station.

$N_{19} = (N_2 + N_3)\ (N_3)\ (N_{18})$ (23)

N_{20} = maximum number of electronic biases in a single arc.

$N_{21} = (2)\ (4N_{15} + 13)\ (N_{19})$

N_5 = maximum for any arc of the following

$$N_5 = N_{INT1} + N_{INT2}$$

$$N_{INTi} = 12 + 12\,N_{eqi} + 6\,(O_{Ei} - 1)\,I_{Vi} + 6\,(O_{Vi} - 1)\,I_{Vi}\,N_{eqi} - (I_{Vi} - 1)(1 + N_{eqi})$$

where

O_{Ei} = integration order for the equations of motion of the i^{th} satellite.

O_{Vi} = integrtion order for the variation equations of the i^{th} satellite.

I_{Vi} = 1 if fixed step integration is used for i^{th} satellite.

= 2 if variable step integration is used for i^{th} satellite.

N_{eqi} = number of force model equations which must be estimated for the i^{th} satellite.

- orbital elements are six equations.
- drag, drag rate, and solar radiation are one equation each.
- geopotential coefficients are one equation each.
- one equation for each N_{12}.

= 0 for orbit generator run.

GEODYN JOB CONTROL LANGUAGE FOR THE 360/95

```
//...  JOB...
//GEODYN EXEC PGM=ZCTVMGDA,REGION=380K
//STEPLIB DD DSN=G1.GIBHP.GECSTR,DISP=SHR
//FT01F001 DD DSN=G1.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT02F001 DD DSN=PCBS,DCB=(RECFM=F,BLKSIZE=3520,BUFNO=1),UNIT=2314,
//   VOL=SER=DOOS02,SPACE=(TRK,3304),DISP=SHR
//FT03F001 DD UNIT=2400-9,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044),
//   LABEL=(,BLP),VOL=SER=GLTDATA
//FT04F001 DD DSN=PELS,DCB=(RECFM=F,BLKSIZE=3520,BUFNO=1),UNIT=2314,
//   VOL=SER=DOOS02,SPACE=(TRK,221),DISP=SHR
//FT05F001 DD DDNAME=DATAS
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//   SPACE=(800,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//   SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//   SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//   SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1004,BUFNO=1),
//   SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1800,BUFNO=1),SPACE=(CYL,2)
//FT16F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1804,BLKSIZE=1808,
//   BUFNO=1),SPACE=(CYL,5)
//FT17F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=100,BLKSIZE=3521),
//   SPACE=(CYL,3),DISP=(,PASS),DEN=&SIMDATA
//FT18F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=80,BLKSIZE=1800,BUFNO=1),
//   SPACE=(CYL,1),DISP=(,PASS),DSN=&GRNDTRK
//FT19F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=112,BLKSIZE=1804,BUFNO=1),
//   SPACE=(CYL,1),DISP=(,PASS),DSN=&GEORGE
//FT20F001 DD UNIT=2400-4,DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
//   LABEL=(,BLP),VOL=SER=GECSDATA
//FT21F001 DD UNIT=2400-9,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044),
//   LABEL=(,BLP),VOL=SER=DCCSDATA
//FT22F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=2804,BUFNO=1),
//   SPACE=(2804,50),DISP=(,PASS),DSN=&CRBI
//FT30F001  DD UNIT=2314,DCB=(RECFM=UT,BLKSIZE=29152),
//    SPACE=(29176,10)
//FT71F001 DD UNIT=2400-4,DCB=(RECFM=VBS,LRECL=8016,BLKSIZE=8020,
//   DEN=3),LABEL=(1,BLP),VOL=SER=BMATRX
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATAS DD *

GEODYN SETUP GOES HERE
```

THE FOLLOWING JCL CARDS ARE NEEDED FOR
THE 360/91 IN PLACE OF THE
STEPLIB & FT01F001 CARDS

```
//STEPLIB DD DSN=M2.ZCTVM.LOADLIB,DISP=SHR
//FT01F001 DD DSN=M2.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
```

Name	Columns	Format	Description
	49-50	F2.2	Relative Humidity*at Receiving Station (subsatellite point for altimeter)
	51-53	I3	Surface pressure in mm of Hg at Receiving Station (subsatellite point for altimeter).
	54-56	I3	Surface temperature in °C at Receiving Station (subsatellite point for altimeter).
	57-61	I5	Second station number if data is in either the GEOS-C format or the RAP format. Transmitter for average range rate Reference for VLBI Relay for SST
	57-62	A6	Second station name if data is in DODS format. Transmitter for average range rate Reference for VLBI Relay for SST
	64-70	I7	Satellite ID for Relay Satellite in SST
	71-72	F2.2	Relative Humidity* associated with second station.
	73-75	I3	Surface pressure in mm of Hg at second station.
	76-78	I3	Surface temperature in °C at second station.

NOTE: *Relative Humidity - If 40% input 40
If 100% input 1.

JCL FOR GEODYN UNIT 1 WHEN CENTER
CARD IS USED

```
//FT01F001 DD UNIT=2400-4,DCB=(RECFM=VBS,LRECL=9999,BLKSIZE=7294,
//    DEN=3),LABEL=(,NL),VOL=SER=XXXX
```

GEODYN FORTRAN LOGICAL UNITS

UNIT	SPACE	PURPOSE	DESCRIPTION
1		Ephemeris	GEODYN uses the JPL ephemeris for the moon, sun, Venus, Mars, Jupiter, and Saturn. Necessary in all runs
2		DODS Data Base Observation File	On 360/95 only. See Appendix A.
3		Data Tape Output	See Arc Set, Group 3 - Termination Card of Group 2.
4		DODS Data Base Element File	On 360/95 only. See Appendix A.
5		Card Input	System card input unit; used for GEODYN Input Cards.
6	(CYL,(10,1))	Printer	System printer output unit. 10 cylinders of primary and 15 cylinders of secondary space are allocated. 1 cylinder will hold 1060 full lines of print.
7	(CYL,1)	Punched Output	GEODYN punches updated parameter values. The one cylinder of primary space which is allocated will hold 1800 punched cards.
8	(CYL,10)	Printer	Used for satellite Cartesian ephemeris printout during data reduction runs.

UNIT	SPACE	PURPOSE	DESCRIPTION
9	(CYL,10)	Printer	Used for satellite Keplerian ephemeris printout.
10	(TRK,3)	Scratch	Necessary for all data reduction runs. Allocated primary space of 3 tracks will hold 495 records. GEODYN writes a maximum of 600 records.
11	(CYL,3)	Scratch	Necessary for all data reduction runs. Allocated primary space of 3 cylinders will hold 9060 observation data records. Sufficient space for the maximum number of data records in a single arc must be allocated.
12	(CYL,20)	Scratch	Necessary for all data reduction runs. 20 cylinders of primary space are allocated. 1 cylinder of space will hold 1720 observation data records.
13	(CYL,10)	Scratch	Necessary for all runs. 10 cylinders of primary space are allocated. 1 cylinder of space will hold 80 records. Each arc writes five records.
14	(CYL,5)	Scratch	Necessary for all runs. 5 cylinders of primary space are allocated. 1 cylinder of space will hold 80 records. The number of records per arc is variable.

UNIT	SPACE	PURPOSE	DESCRIPTION
15	(CYL,2)	Scratch	Necessary for all runs. 2 cylinders of primary space are allocated. 1 cylinder of space will hold 80 records. The number of records per arc is variable.
16	(CYL,5)	Scratch	Necessary for all runs. 5 cylinders of primary space are allocated. 1 cylinder of space will hold 80 records. The number of records per arc is variable.
17		Simulated Data Output	GEODYN can simulate tracking data or PCE data on option.
18		Groundtrack	If a groundtrack tape is requested, JCL will be required for unit 18.
19		Binary Residual Tape	A DD card is necessary for each file to be written. GEODYN writes one file for each Binary Residual tape requested.
20		Data Tape Input	GEODYN default unit for input data tapes in GEOS format or PCE format.
21		Data Tape Input	GEODYN default unit for input data tapes in DODS format or Simulated Data format.

UNIT	SPACE	PURPOSE	DESCRIPTION
22		ORB1 Tape	A DD card is necessary for each file to be written. GEODYN writes one file for each ORB1 tape requested by an ORB1 card.
30	(29176, 10)	Partitioned B-Matrix Scratch File	Necessary only for those runs where the BPART option is used. Space allocated is sufficient for 10 records to be written. B-Matrix size in bytes must be less than the number of allocated recrods times 29176.
71		B-Matrix tape	A DD card is necessary for each file to be written. GEODYN writes one file for each arc exercising the BMATRX option card.
23-29 31-70 72-99		Option I/O units	These units are not regularly used by GEODYN and may be used as additional data tape input files or as RV tape output files.

THE GEODYN OVERLAY STRUCTURE IS

```
OVERLAY ESTIM
  INSERT ESTIM1,ESTIN,POSVEL
OVERLAY ESTIM
  INSERT BFORM1,BFORM,BSOLVE,BREAD,BWRITE
OVERLAY JACCHIA(REGION)
  INSERT DENSTY
OVERLAY J71J65
  INSERT D65
OVERLAY J71J65
  INSERT D650
OVERLAY J71J65
  INSERT D71
OVERLAY PRIME(REGION)
  INSERT ACFLUX,JANTHG,ALIST,RFTMCD,FLUXM,FLUXS,CMODEL,GMODEL
  INSERT INTFLX,FLUXAP
OVERLAY PRIME
  INSERT BIAS,INOUPT,NEWARC,PRNTPR,CCEFL,SIGBLK
  INSERT SRFBLK,PDEN1,EBIAS,NCSTAR,FARTB
OVERLAY DATAREAD
  INSERT DODSRD,DATBSE,DCDELM,DCODAT
OVERLAY DATAREAD
  INSERT GEOSRD
OVERLAY SATCLCS
  INSERT SATCLC
OVERLAY SATCLCS
  INSERT SATCL2,SATC21,SATC22
OVERLAY DATAREAD
  INSERT PCERD
OVERLAY DATAREAD
  INSERT SIMRD
OVERLAY PRIME
  INSERT NONAME,CHARLY,CBROWN,SQUANT,SQANT1,CSTRET,XYZ,MCONGR,ORGBLK
  INSERT PROCS1,PROCES,COMAD1,COWELL,DATARD,DATRD1,DRAG,DRAG1
  INSERT TRUPOL,SUMMRY,CLVECT,GNDTRK,XYZOUT,CSTAT,GRHPA1,GPHRAN
  INSERT        STAIF1,STAINF,SMSTAT,TRUEP,TRUEP1,VEVAL,VEVAL1,VMAT
  INSERT        STAIF2,F,F1,OBSDOT,CESDT1,ORBIT,ORBIT1
  INSERT PREDCT,PREDC1,RESPAR,RESPR1,CORREL,CCMADJ
  INSERT SURDEN,SURDN1,PDEN,PDEN2
  INSERT TWOSTA,TWOST1,RMSCMP,UPDOWN,BSCOMP,BSCMP1
  INSERT REGION,REGION1
OVERLAY SECOND
  INSERT CCMPAR,STAINP,ARCPAR,STAPOS
  INSERT AREAS,DELTAZ,INDENT
OVERLAY SECOND
  INSERT        EGRAV,ORBTAP,SUNGRV,TIDAL,REFCOR
  INSERT CCEF,COM,INTRP,INTERF,CSLIM
OVERLAY THIRD
  INSERT START
OVERLAY THIRD
  INSERT CONCOF
OVERLAY THIRD
  INSERT ANTENA,DELAY,DILRN,DOPPLR,ICNREF,PCLE
OVERLAY THIRD
  INSERT REARG
OVERLAY THIRD
```

```
   INSERT TYPORB,GEODYN
OVERLAY THIRD
   INSERT GEOIDH,AVGPOT
OVERLAY SECOND
   INSERT UPDATE
OVERLAY EXTRA(REGION)
   INSERT ERROR
OVERLAY EXTRA
   INSERT ORBI
OVERLAY EXTRA
   INSERT HEADER
OVERLAY EXTRA
   INSERT BMTWRT
```

2.2 Hardware and Software Restrictions

Normal operation of GEODYN requires a large scale IBM 360 Computer with 500K bytes of user accessable core, one 2314 direct access disk unit, four 9 track tape drives, one 7 track tape drive, one high speed card reader, and one high speed printer. For some applications, GEODYN can operate with only one 9 track tape drive and no 7 track tape drive.

The current GEODYN program is executable under versions 14, 16, and 18 of the IBM 360 operating system.

The compilation of GEODYN requires an IBM FORTRAN IV Level G compiler and for more efficient operation also an IBM FORTRAN IV Level H compiler with level 2 optimization.

GEODYN contains four software restrictions. These restrictions and the subroutines affected are:

1. Time difference tables must be kept up to date in subroutine TDIF.

2. Polar motion data tables should be kept up to date in subroutine POLE.

3. Solar and Geomagnetic flux tables should be kept up to date in subroutines FLUXM and FLUXS.

4. Tables of the right ascension of Greenwich in blockdata subroutine CONSTS must be kept up to date.

There are no GEODYN hardware restrictions.

3.0 GEODYN JOB SUBMITTAL

To prepare a GEODYN deck for job submittal the following procedure is recommended:

1. Define the problem to be solved.
2. Prepare a deck of the necessary GEODYN Input Cards.
3. Prepare the JCL necessary for the desired GEODYN execution.
4. Assemble the deck and submit to the computer.

3.1 Preparing the necessary GEODYN Input Cards.

1. Determine those parameters of the problem definition which must be defined by COMMON SET cards (i.e., gravity model modification , lunar and/or solar gravity modification, geopotential coefficient recovery, station estimation parameters, modifications to the atmospheric density model, and modification to earth constants.)

2. Determine which COMMON SET cards are necessary and prepare these cards.

3. Determine how many arcs will be required and what parameters must be defined by each arc.

4. Determine which ARC SET cards are necessary for each arc and prepare these cards.

5. Order the cards prepared in steps 2 and 4 so that they conform to the four groups within each set and place these sets in the proper order as follows:

COMMON SET - Run description (Group 1)
COMMON SET - Option cards (Group 2)
COMMON SET - Station position cards (Group 3)
COMMON SET - Termination card (Group 4)

ARC SET - Arc description (Group 1) for ARC 1
ARC SET - Option cards (Group 2) for ARC 1
ARC SET - Termination card for Group 2 (Group 3) for ARC 1
ARC SET - Selection/deletion cards (Group 4) for ARC 1

⋮

ARC SET - Arc description (Group 1) for last arc
ARC SET - Option cards (Group 2) for last arc
ARC SET - Termination card for Group 2 (Group 3) for last arc
ARC SET - Selection/deletion cards (Group 4) for last arc

NOTES: Always required for orbit generator mode is the ORBIT card.

Usually required for orbit generator runs also is an OUTPUT card.

STAEST, CORREL, BIAS, RESID, CULL, EDIT, PREPRO, SIGMA, VARCOV, and ARC SET, GROUP 4 - SELECTION/DELETION CARDS should not be used in orbit generator runs.

An ORBIT card may not be used in a data reduction run under any circumstances.

A problem may consist of any combination of arcs in orbit generator mode and/or in data reduction mode. If any arcs are defined as being in orbit generator mode, the maximum number of outer iterations must be one, and no common parameter estimation may be requested. A common parameter estimation problem must define all arcs as being in data reduction mode.

3.2 Preparing the Necessary JCL Cards.

1. Determine which JCL cards are always necessary for a GEODYN run.
2. Determine which JCL cards are required for the specific mode of operation for the GEODYN run.
3. Determine what additional JCL cards are necessary for special output requests.
4. Combine all necessary JCL cards into their proper order as specified in section 2.0.

3.3 GEODYN Deck Assembly and Job Submittal.

1. Place the GEODYN Input Card deck into the JCL deck after the DATA5 DD card and follow with a delimeter card.
2. Submit the job to the computer with the proper job identification slip.

4.0 GEODYN EXAMPLE JOBS

On the following pages is a comprehensive set of GEODYN example job setups. GEODYN Example Jobs 1, 2, and 3 include the setup examples for the GEORGE, DELTA, ORB1 Conversion, and GROUNDTRACK programs. By combining the execution of the GEODYN Analyses and Graphics Support Programs with GEODYN execution, the most common usage of the support programs is demonstrated.

4.1 Example One

This sample run is a 4 arc station estimation run using station constraints. Included are two 2 day GEOS-I arcs and two 2 day GEOS-II arcs. GRARR biases and timing errors are estimated. Following the GEODYN execution is a GROUNDTRACK execution for arc 4.

This job was run on the 360/91 and requires core and time as follows:

	CORE	CPU	I/O
GEODYN step	394K	6.23	0.96
GROUNDTRACK step	376K	0.03m	0.02m

March 1, 1973

GEODYN EXAMPLE JOB ONE

```
//... JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=380K
//STEPLIB DD DSN=M2.ZCTVM.LOADLIB,DISP=SHR
//FT01F001 DD DSN=M2.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//   SPACE=(300,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//   SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//   SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//   SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1604,BUFNO=1),
//   SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1800,BUFNO=1),SPACE=(CYL,2)
//FT15F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1604,BLKSIZE=1608,
//   BUFNO=1),SPACE=(CYL,5)
//FT18F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=80,BLKSIZE=1800,BUFNO=1),
//   SPACE=(CYL,1),DISP=(,PASS),DSN=&GRNDTRK
//GO.FT20F001 DD UNIT=2400-9,LABEL=(,SLP),VOL=SER=DATA1,
//    DCB=(RECFM=FB,LRECL=80,BLKSIZE=32000,DEN=3)
//GO.FT25F001 DD UNIT=2400-9,LABEL=(,SLP),VOL=SER=DATA2,
//    DCB=(RECFM=FB,LRECL=80,BLKSIZE=32000,DEN=3)
//GO.FT26F001 DD UNIT=2400-9,LABEL=(,SLP),VOL=SER=DATA3,
//    DCB=(RECFM=FBS,LRECL=80,BLKSIZE=8000,DEN=3)
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATA5 DD *
STATION ESTIMATION USING 2 GEOS-II 2-DAY ARCS AND
2 GEOS-I 2-DAY ARCS WITH STATION CONSTRAINTS AND
SOLVING FOR GRARR BIASES AND TIMING ERRORS
STAEST     1037.          5.          5.          50.
STAEST     1126.          5.          5.          50.          1037.
STAFST     1042.          5.          5.          50.          1037.
STAEST     1021.          5.          5.          50.
STAPOS
1RPDIN1021  382549.7672    2625448.6130    -53.693
1FTMYR1022  263253.1400    278 8 4.1600    -42.000
1DONER1024-312325.8786     1365215.1400    130.403
1SATAS1028-33 858.7636     2691953.6617    713.890
1MOJAV1030  351647.8937     243 558.9161    876.254
1JOBUR1031-2553  1.4397     274226.2077    1540.977
1NEYE_1032  474429.2660    3071646.1400     45.000
1COLEG1033  446217.3551     212 526.7652     156.367
1GRRK 1034   48 121.5305    2625912.5072    203.162
1WHTSL1035  512646.3560     35918 7.934      90.41
1RUSMN1037   3512 7.2798    277 741.1600    849.933
1ORORL1038-353732.6617     1405714.6501    949.573
```

```
1FOSMA1642 3512 7.2342   277 740.2601    550.563
1TANAN1643-13 032.555     471755.2979   1355.777
DATA     23
ARC 1
GEOS-I GRARR AND OPTICAL DATA
MARCH 26,1965      TWO DAY ARC
660326
660326000000.0000 5   1
1255329.5070 9634          3771673.652260065            -6483531.259 17363
-6379.673711150610         3759.0961972335356           619.4033251227963
SAT    1   1.23            172.5
PREPRO11                   2.
SIGMA                      1.                2.0
SIGMA                      5.                2.0
SIGMA                      2.                10.
SIGMA                      3.                12.0
BIAS  1126 0.              10.                                             2.
BIAS  1126 0.              0.10                                            3.
DATA    120
SELECT660326               660328
ENDALL
ARC 2
GEOS-I OPTICAL DATA
NOVEMBER 24,1965    TWO DAY ARC
651124
651124000000.0000 5    1
-3837127.3038540523        -6454753.23672185            277051.53456 6173
3101.921655311633          -2291.275116019932           -6472.2313221 371379
SAT    1   1.23            172.5
SIGMA                      1.                2.0
SIGMA                      5.                2.0
DATA    120
SELECT651124               651126                       1
ENDALL
ARC 3
GEOS-II GRARR DATA
FEBRUARY 25,1968   TWO DAY ARC
680225
680225                 5   2
 -0.27256978394848640 07  0.22624766337567970 07 -0.71163460 318773300 07
 -0.10543854243755570 04  0.54082262499209746D 04  0.2312537 0360787750 04
SAT    1   1.23            211.831
SIGMA                      2.                10.
SIGMA                      3.                12.0
BIAS  1126 0.              10.                                             2.
BIAS  1126 0.              0.10                                            3.
BIAS  1128 0.              0.005
BIAS  1122 0.              0.005
DATA    125
SELECT680225               680227                       2 5
SELECT680225               680227                       3 6
ENDALL
ARC 4
GEOS-II OPTICAL DATA
MAY 22,1968    TWO DAY ARC
680522
680522                 5   2
4217217.919518084          2047163.062645225            -6063433.347272098
-3226.912307745760         -5187.073957425034           -3780.26394. 305757
SAT    1   1.23            211.831
```

```
SIGMA                          1.              2.0
SIGMA                          4.              2.0
OUTPUT 1
PREPRO1  1                     1.0
DATA   126
SELECT6CC522              6CC524                        1
ENDALL
// EXEC LINKGO,REGION.GO=500K
//LINK.SYSLIN DD *
 INCLUDE LOADLIB(ZCMLOGRK)
 INCLUDE LOADLIB(ZCSJSRFL)
 INCLUDE LOADLIB(ZCPGMTYP)
 ENTRY MAIN
//GO.FT11F001 DD DSN=&GRNDTRK,DISP=(OLD,DELETE)
//GO.DATAS DD *
IRCSMN1C37 3512 7.2758    277 741.1600     946.933
END
PLOTS
TIME       6CC522.              6CC524.
ENDPLT
DATA
LAST
```

4.2 Example Two

This sample run is a five and one half day GEOS-II data reduction run which estimates 2 pairs of resonant geopotential coefficients and a solar radiation parameter. Following the GEODYN execution is a GEORGE execution which computes ROSRAN range zero set biases and timing errors.

This job was run on the 360/91, and requires core and time as follows:

	CORE	CPU	I/O
GEODYN step	338K	4.16m	0.83m
GEORGE step	326K	0.11m	0.06m

GEODYN EXAMPLE JOB: TWO

```
//...  JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=300K
//STEPLIB DD DSN=M2.ZCTVM.LOADLIB,DISP=SHR
//FT01F001 DD DSN=M2.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//   SPACE=(800,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//   SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//   SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//.  SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1604,BUFNO=1),
//   SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1800,BUFNO=1),SPACE=(CYL,2)
//FT16F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1804,BLKSIZE=1808,
//   BUFNO=1),SPACE=(CYL,5)
//FT19F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=112,BLKSIZE=1804,BUFNO=1),
//   SPACE=(CYL,1),DISP=(,PASS),DSN=&GEONGE
//FT20F001 DD UNIT=2400-4,DCB=(RECFM=FB,LRECL=80,BLKSIZE=6000,DEN=3),
//   LABEL=(,BLP),VOL=SER=GEOSDATA
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATA5 DD *
A S 1/2 DAY GEOS-II DATA REDUCTION RUN WITH THE ESTIMATION
OF 2 PAIRS OF RESONANT COEFFICIENTS AND A SOLAR RADIATION PARAMETER
FOLLOWED BY A GEOPGE RUN COMPUTING NOSMAN GRARR TIMING ERRORS
RECOEF1312                                0.5          0.5          +1.
RECOEF1413                                0.5          0.5          +1.
DATA     2
DATA REDUCTION
GEOS-II GRARR DATA
FEBRUARY 21,1968  5 1/2 DAY ARC
680221
680221              5    2
1075143.141964078        -7546483.030124558        -901680.4779051981
-2040.195244212024        259.1950790822221        -6923.057127610592
SIGMA                      2.                10.
SIGMA                      3.                12.
SOLRAD1    .6              .1
OUTPUT  1
SAT    1    1.23           211.831
PREPRO11
DATA    1  *
SELECT680221 0000         680226 1200                  20
ENDAL
// EXEC LINKGO,REGION.GO=400K
//LINK.SYSLIN DD *
```

```
 INCLUDE LOADLIB(ZCMLOGFG)
 INCLUDE LOADLIB(ZCRGWTYP)
 ENTRY MAIN
//GO.FT15F001 DD DSN=&&EUROS,DISP=(CLG,DELETE)
//GO.DATA5 DD *
RANGE                ROSNAN
PLOT
DATA
LAST
```

4.3 Example Three

a) Arc 1 is in orbit generator mode and uses converged double precision elements to generate an ORB1 tape.

b) Arc 2 is in data reduction mode and uses the same starting elements as arc 1 and the same data period that was used to obtain the arc 1 elements. Arc 2 uses a truncated gravity model to reduce the elements. An ORB1 tape is also generated by arc 2.

c) A DELTA execution follows the GEODYN execution and computes and plots orbit differences from the two ORB1 tapes.

d) An execution of the ORB1 Conversion program follows the DELTA execution. The ORB1 tape written in arc 1 is converted to a 7 track, IBM 7094, single precision, binary ORB1 tape.

This job was run on the 360/91 and requires core and time as follows:

	CORE	CPU	I/O
GEODYN step	348K	2.36m	0.46m
DELTA step	200K	0.04m	0.03m
ORB1 CONVERSION step	154K	0.29s	0.09m

GEODYN EXAMPLE JOB THREE

```
//... JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=360K
//STEPLIB DD DSN=G1.GIBHP.GEOSTR,DISP=SHR
//FT01F001 DD DSN=G1.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT05F001 DD DDNAME=DATAS
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//  SPACE=(300,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//  SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//  SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//  SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1304,BUFNO=1),
//  SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1500,BUFNO=1),SPACE=(CYL,2)
//FT15F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1004,BLKSIZE=1008,
//  BUFNO=1),SPACE=(CYL,5)
//FT20F001 DD UNIT=2400-4,DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
//  LABEL=(,BLP),VOL=SER=GEOSDATA
//FT22F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=2804,BUFNO=1),
//  SPACE=(2404,50),DISP=(,PASS),DSN=&ORBIA
//FT22F002 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=2804,BUFNO=1),
//  SPACE=(2404,50),DISP=(,PASS),DSN=&ORBIB
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATAS DD *
A TWO ARC RUN FOLLOWED BY DELTA AND ORB1 CONVERSION
ARC 1 IS AN ORBGEN USING CONVERGED ELEMENTS
ARC 2 IS A DATA REDUCTION OVER THE SAME PERIOD WITH A TRUNCATED GRAVITY MODEL
STAPOS
DATA      1
ARC 1   ORBIT GENERATOR WITH ORB1 TAPE OUTPUT
APRIL 28,1966   ONE DAY ARC
GEOS-1 SATELLITE    STARTING ELEMENTS ARE FROM A PREVIOUS DATA REDUCTION
660428
660428              1
   0.37003515855714026 07   -.98356487557556022605   -.64594114125370415 07
   0.22306620126813816 04   0.71944193320397816 04   0.97315126322597955 02
DRAG       2.3
SAT        1.23              172.5
ORB1    300 660428.                          660429.
ORBIT       660428.                          660429.
OUTPUT1    900.
DATA
ARC 2   DATA REDUCTION WITH ORB1 TAPE OUTPUT
APRIL 28,1966   ONE DAY ARC   TRUNCATED GRAVITY MODEL
GEOS-1 SATELLITE   SAME STARTING ELEMENTS AS PRECEDING ARC
```

```
660429
660423                        5    1
   0.3760351565571492E07      -.6635642753955122E06      -.3459111.12537041E07
 -0.2236652612601361E04      0.7194417232039781E04      0.7313124322597E02
EARTH 1616
DRAG        2.3
SAT         1.23                      172.5
PREPRO1  1                          1.0
SIGMA                               1.             2.0
SIGMA                               2.             2.0
SIGMA       9424.                                   9.0
ORB1     .3J0 660428.                              660429.
DATA     1
SELECT660423               660429                         1
ENDALL
// EXEC LINKGO.REGION.GO=250K
//LINK.SYSLIN DD *
 INCLUDE LOADLIB(ZCTVMDEL)
 INCLUDE LOADLIB(ZCRG*TYP)
 ENTRY MAIN
//GO.FT20F001 DD DCB=(RECFM=FB.LRECL=6.BLKSIZE=4092.DEN=1).
//  LABEL=(.BLP).UNIT=2400-7.VOL=SER=SCRTCH
//GO.FT21F001 DD DSN=&ORB1A.DISP=(OLD.PASS)
//GO.FT22F001 DD DSN=&ORB1B.DISP=(OLD.DELETE)
//GO.DUM DD DSN=*.LINK.SYSLMOD.DISP=(OLD.DELETE)
//GO.DATAS DD *
    T61
COMPARING A CONVERGED 1 DAY ARC
WITH THE SAME ARC CONVERGED
WITH A TRUNCATED EARTH MODEL
// EXEC FORTRANG
//SOURCE.SYSIN DD *

          THE ORB1 CONVERSION FORTRAN DECK GOES HERE

// EXEC LINKGO
//GO.FT10F001 DD DSN=&ORB1A.DISP=(OLD.DELETE)
//GO.FT11F001 DD UNIT=2400-7.DCB=(RECFM=FB.LRECL=21.BLKSIZE=2100.
//  DEN=1).LABEL=(.BLP).VOL=SER=SCRTCH
```

4.4 Example Four

This sample run is a 12 day OGO-3 data reduction run which estimates a drag parameter. Both data and elements for this run were obtained from the DODS Data Base during the GEODYN execution. GEODYN chose to use a variable step size for the orbit integration. The short amount of time required for this run should be noted.

This job was run on the 360/95 and requires core and time as follows:

Core = 364K
CPU = 1.5 min
I/O = 0.2 min

This is a twelve day arc for which 4 iterations were performed for a total of 48 iteration days. The time required per iteration-day was

2 seconds/iteration-day

which is approximately five times faster than would have resulted from using a fixed 100 second step size for the integrator instead of variable step integration as GEODYN chose.

GEODYN EXAMPLE JOB FOUR

```
//...  JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=380K
//STEPLIB DD DSN=G1.GIPUP.GEOSTR,DISP=SHR
//FT01F001 DD DSN=G1.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT02F001 DD DSN=PODS,UNIT=2314,VOL=SER=DDS02,DISP=SHR,
//   SPACE=(TRK,(3304)),DCB=(RECFM=F,BLKSIZE=3520,BUFNO=1)
//FT03F001 DD UNIT=2400-9,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044),
//   LABEL=(,BLP),VOL=SER=OUTDATA
//FT04F001 DD DSN=PELS,UNIT=2314,VOL=SER=DDS02,DISP=SHR,
//   SPACE=(TRK,(221)),DCB=(RECFM=F,BLKSIZE=3520,BUFNO=1)
//FT05F001 DD DDNAME=DATAS
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//   SPACE=(800,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//   SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//   SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//   SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7292,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//   SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1304,BUFNO=1),
//   SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1800,BUFNO=1),SPACE=(CYL,2)
//FT16F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1804,BLKSIZE=1809,
//   BUFNO=1),SPACE=(CYL,5)
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATAS DD *
DATA REDUCTION FOR THE OGO 3 SATELLITE
DATA AND ELEMENTS FROM THE DODS DATA BASE
OUTPUTING THE DATA USED ONTO A TAPE ON UNIT 3
DATA
OGO-3 ARC OBTAINING DATA FROM DODS DATA BASE
SOLVING FOR A DRAG COEFFICIENT
PROGRAM DEFAULT FOR INTEGRATOR STEP SIZE AND MODE
700527
700528              5.    700510                                    1
EDIT        3.5                 1000.
DRAG        2.3                  .5
SAT        1.23                 212.5          660490.
DATA   202
```

4.5 Example Five

This sample run is a one arc geopotential recovery run with B-matrix output. Six coefficients are being estimated as follows:

Coefficient	a priori value	starting value	standard deviation
C(22,14)	-9.25362D-27	-2.51579D-26	1% of a priori value
S(22,14)	1.12578D-25	8.25801D-26	1% of a priori value
C(21,14)	SAO 1969	SAO 1969	1% of a priori value
S(21,14)	SAO 1969	SAO 1969	1% of a priori value
C(20,14)	SAO 1969	SAO 1969	1% of a priori value
S(20,14)	SAO 1969	SAO 1969	1% of a priori value

This job was run on the 360/91 and requires core and time as follows:

Core = 356K
CPU = 3.1 m
I/O = 0.97m

GEODYN EXAMPLE JOB FIVE

```
//...  JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=350K
//STEPLIB DD DSN=M2.ZCTVM.LOADLIB,DISP=SHR
//FT01F001 DD DSN=M2.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//  SPACE=(800,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//  SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//  SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//  SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1804,BUFNO=1),
//  SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1200,BUFNO=1),SPACE=(CYL,2)
//FT16F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1804,BLKSIZE=1808,
//  BUFNO=1),SPACE=(CYL,5)
//FT20F001 DD UNIT=2400-4,DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
//  LABEL=(,BLP),VOL=SER=GEOS@ATA
//FT71F001 DD UNIT=2400-4,DCB=(RECFM=VBS,LRECL=8000,BLKSIZE=8012,
//  DEN=3),LABEL=(1,BLP),VOL=SER=BMATRX
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATA5 DD *
*********
DATA REDUCTION WITH BMATRIX OUTPUT
**********
RECOEF2214   -9.253620D-27    1.125780D-25        .01          .01
RECOEF2214   -2.515790D-26    8.250010-26
RECOEF2114                                       .01          .01          1.
RECOEF2014                                       .01          .01          1.
STAPOS
1SPOIN1021  382549.7872   2825448.6130    -53.693
1STNYR1022  263253.1400    276 8 4.1600    -42.000
1POWER1024-312225.8786   1365215.1400    130.403
1SATA51028-33 853.7936   2891953.6617    713.890
1MOJAV1030  351947.8937    243 558.9161   876.254
1JOHUR1031-2553 1.4397     274226.2077   1540.977
1NEWFL1032  474429.2660   3071046.1400     48.000
1COLEG1033  645217.2551    212 936.7652     156.367
1GFORK1034   48 121.5308   2625919.5072    203.162
1KOKE_1035  512546.3960    35912 7.934      90.41
1ROSPN1037   3512 7.2794   277 741.1600    849.933
1ORDP_1038-353732.0617    1425714.8501    949.579
1ROSMA1042   3512 7.2945   277 740.5600    850.063
1TAHAN1043-19 032.585      471759.2879   1359.777
DATA
ARC 1
```

```
GEOS-I GRARR AND OPTICAL DATA
MARCH 26,1965        TWO DAY ARC
660326
660326000000.0000 3    1
1295023.5071E9694              3771673.050260065              -6433333.2597363
-6379.6737111505lC             3789.0961971335956             619.0333312279:3
EMATRX     1.             :    1.
SAT    1    1.23               172.5
PREPRO 11                      2.
SIGMA                          1.                2.0
SIGMA                          6.                2.0
SIGMA                          2.                10.
SIGMA                          3.                12.0
DATA    120
SELECT660326                   660326
ENDALL
```

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

4.6 Example Six

This sample run is a 2-day orbit generator outputing a PCE data tape with Kepler elements. A 2-body orbit was used and the core and time required on the 360/91 are as follows:

Core = 308K
CPU = 4.65s
I/O = 0.36m

GEODYN EXAMPLE JOB SIX

```
//... JOB...
//GEODYN EXEC PGM=ZCTVMGDN,REGION=380K
//STEPLIB DD DSN=M2.ZCTVM.LOADLIB,DISP=SHR
//FT01F001 DD DSN="2.ZCTVM.EPHEM,DISP=SHR,DCB=BUFNO=1
//FT02F001 DD DUMMY
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,20)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//  SPACE=(800,100)
//FT08F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT09F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//  SPACE=(CYL,10)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=FB,LRECL=46,BLKSIZE=460),
//  SPACE=(TRK,3)
//FT11F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=68,BLKSIZE=7294),
//  SPACE=(CYL,3)
//FT12F001 DD UNIT=2314,DCB=(BLKSIZE=7232,BUFNO=1),SPACE=(CYL,20)
//FT13F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1632,BUFNO=1),
//  SPACE=(CYL,10)
//FT14F001 DD UNIT=DISK,DCB=(RECFM=VS,BLKSIZE=1804,BUFNO=1),
//  SPACE=(CYL,5)
//FT15F001 DD UNIT=2314,DCB=(BLKSIZE=1000,BUFNO=1),SPACE=(CYL,2)
//FT16F001 DD UNIT=2314,DCB=(RECFM=VBS,LRECL=1504,BLKSIZE=1604,
//  BUFNO=1),SPACE=(CYL,5)
//FT17F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=100,BLKSIZE=3520),
//  SPACE=(CYL,3),DISP=(,PASS),DSN=&SIMDATA
//SYSUDUMP DD SYSOUT=A,SPACE=(CYL,1)
//DATA5 DD *
TWO BODY ORBIT GENERATOR RUN
PRODUCING A CARTESIAN AND A KEPLERIAN EPHEMERIS
WITH KEPLERIAN PCE DATA SIMULATION ONTO UNIT 17
TIDES
EARTH  2 2                                                    +1.
BODIES1    0.
BODIES2    0.
DATA
TWO BODY ORBIT GENERATOR RUN - TWO DAY ARC
NOTE THAT DRAG AND SOLAR RADIATION PRESSURE ARE ZEROED
BY LEAVING OUT THE SAT CARD
660722                  0
660722                1
  0.14857973927771580 07 -0.50266507090074550 07  0.68558728590005520 07
  0.44452078313736350 04  0.43574643035717510 04  0.30729914456307200 04
ORBIT      660722.                      660724.
OUTPUT1   1 3600.
SIMDAT1
DATA
```

5.0 GEODYN ERROR MESSAGES

The GEODYN program prints descriptive diagnostic error messages for the most commonly occuring program input errors. Most of these error messages are completely self explanatory.

5.1 DODS Data Base Errors

1. Observation Data

a) UNABLE TO READ DODS DATA BASE DATA DIRECTORY
GEODYN EXECUTION TERMINATED

b) NO DATA AVAILABLE FOR SATELLITE REQUESTED
SATELLITE ID IS ---------
GEODYN EXECUTION TERMINATED

c) NO DATA AVAILABLE FOR THE TIME PERIOD REQUESTED FOR SATELLITE ---------
GEODYN EXECUTION TERMINATED

d) DODS DATA BASE READ ERROR OCCURED FOR SATELLITE ---------
DATA RECORD NUMBER IS -----

e) GEODYN EXECUTION TERMINATED DUE TO EXCESSIVE DODS DATA BASE READ ERRORS

Messages a, b, c, and e are all followed by a hexidecimal dump of the Data Base directory and of the Data Base data record in core. For interpretation of this information see

"DODS Data Base Element File Description,"GSFC DODS Documentation

2. Element Data

a) UNABLE TO READ DODS DATA BASE ELEMENT DIRECTORY
GEODYN EXECUTION TERMINATED

b) NO ELEMENT SET IN DODS DATA BASE FOR SATELLITE ---------
GEODYN EXECUTION TERMINATED

c) DODS DATA BASE READ ERROR OCCURED IN ELEMENT FILE FOR
SATELLITE ---------
DATA RECORD NUMBER IS -----
GEODYN EXECUTION TERMINATED
LABEL = --

d) DODS ELEMENT RECORD ERROR ENCOUNTERED FOR SATELLITE ---------
ELEMENT TYPE INCORRECTLY SPECIFIED IN RECORD -----
TYPE SPECIFIED IS --
GEODYN EXECUTION TERMINATED
LABEL = --

e) UNABLE TO FIND ELEMENT SET -------
IN DODS DATA BASE ELEMENT FILE
PROGRAM SEARCHING FOR ELEMENT SET
CORRESPONDING TO EPOCH

Messages a, b, c, and d are all followed by a hexidecimal dump of the Data Base directory and of the Data Base element record in core. For interpretation of this information see

"DODS Data Base Element File Description," GSFC DODS Documentation

For read errors check JCL for Data Base files. If JCL is correct, see DODS Data Base maintenance personnel.

5.2 Ephemeris Tape Errors

a) PROGRAM TERMINATED
INSUFFICIENT EPHEMERIS DATA
LAST DATA POINT YYMMDD HHMM SS.SSSSS

b) PROGRAM TERMINATED
INSUFFICIENT EPHEMERIS DATA
FIRST DATA POINT YYMMDD HHMM SS.SSSSS

Both messages a and b indicate that Ephemeris data was requested out of range of the data available on the ephemeris tape.

a) Time requested later than available data.
b) Time requested earlier than available data.

C.3

User Response:

1) Check for mispunched, misread, or out-of-order GEODYN Input Cards

2) Check for ephemeris tape read errors.

3) Check for correct ephemeris tape JCL (including correct tape number).

5.3 General GEODYN Diagnostic Error Messages

a) STATION ---- AT TIME YYMMDD HHMM SS.SSSS NOT IN TIME ORDER

b) STATION ---- NOT FOUND

c) STATION ---- NOT FOUND IN FILE

d) OVER 200 DOPPLER PASSES - TABLE OVERFLOW

e) PROGRAM TERMINATION DUE TO ILLEGAL INPUT
EXPLANATION: INPUT CARTESIAN EPOCH ELEMENTS EQUIVALENT TO KEPLERIAN ELEMENTS WITH AN ECCENTRICITY GREATER THAN 1. PLEASE CHECK INPUT ELEMENTS AND EXAMINE INPUT DECKS FOR MISSING OR OUT-OF-ORDER CARDS.

f) PROGRAM TERMINATION DUE TO INAPPROPRIATE INPUT
EXPLANATION: ADJUSTED CARTESIAN EPOCH ELEMENTS EQUIVALENT TO KEPLERIAN ELEMENTS WITH ECCENTRICITY GREATER THAN 1.

PROBABLE CAUSES:

1) POOR FIRST ITERATION ORBIT DUE TO POOR STARTING ELEMENTS OR A STEP SIZE TOO LARGE FOR THE NUMERICAL ORBIT INTEGRATION IN THE FIXED STEP MODE.

or

1) POOR FIRST ITERATION ORBIT DUE TO POOR STARTING ELEMENTS OR INAPPROPRIATE ERROR BOUNDS.

2) THE EXISTENCE OF WILD DATA POINTS WHICH WERE NOT EDITED FROM THE SOLUTION.

g) PROGRAM TERMINATION DUE TO ILLEGAL INPUT

EXPLANATION: THE CARD ------ IN THE OPTION CARD GROUP IS ILLEGAL. PLEASE CHECK INPUT FOR KEYPUNCH ERRORS OR MISSING OR MISPLACED CARDS.

h) PROGRAM TERMINATION DUE TO INSUFFICIENT OBSERVATIONS

EXPLANATION: THE SETUP AND OPERATION OF THIS RUN WERE SUCH THAT NO OBSERVATIONS WERE AVAILABLE IN THE TIME PERIOD SPECIFIED FOR THE SATELLITE REQUESTED. PLEASE CHECK YOUR SETUP DECK OR TAPE ASSIGNMENTS.

i) PROGRAM TERMINATION DUE TO INSUFFICIENT WEIGHTED OBSERVATIONS

EXPLANATION: INPUT ELEMENTS AND EDITING CRITERIA WERE SUCH THAT FEWER THAN 8 OBSERVATIONS WERE LEFT IN THE SOLUTION.

j) PROGRAM TERMINATION DUE TO MISSING DATA CARD

EXPLANATION: PROGRAM ENCOUNTERED END OF FILE ON DATA5 BEFORE READING DATA CARD TERMINATING LAST ARC. PLEASE CHECK SETUP DECK FOR MISSING OR MISPLACED DATA CARD OR MISPLACED END OF FILE.

k) ILLEGAL STATION POSITION INPUT

EXPLANATION: MORE THAN ONE STATION POSITION CARD WAS INPUT FOR STATION -----.

PROGRAM ACTION: THE DUPLICATE OF THIS STATION HAS BEEN REMOVED FROM THE TRACKING COMPLEMENT. THE FIRST STATION ENCOUNTERED WITH THIS NUMBER WAS USED.

PROGRAM EXECUTION WILL BE CONTINUED.

l) PROGRAM TERMINATION DUE TO INSUFFICIENT A PRIORI INFORMATION

EXPLANATION: THE ADJUSTMENT OF STATION ----- HAS BEEN REQUESTED BUT NO A PRIORI POSITION WAS AVAILABLE FOR THIS STATION.

Errors a, b, c, d, and k are non-fatal. Errors e, f, g, h, i, j, and l are fatal errors. In all cases checks should be made to be sure that the setup deck has been prepared in such a manner that the problem description is correct.

All of these errors are self-explanatory and in all cases except possibly a, b, c, and d should be corrected.

m) EXECUTION TERMINATING DUE TO READ ERROR ON RANDOM ACCESS FILE ---
ERROR BUFFER IS

n) EXECUTION TERMINATING DUE TO INPUT ERROR
EXPLANATION: THE SETUP OF THIS RUN IS SUCH THAT THE ESTIMATION OF GEOPOTENTIAL COEFFICIENTS OF DEGREE (ORDER) GREATER THAN USED IN THE GEOPOTENTIAL EXPANSION HAS BEEN REQUESTED.

Both errors m and n are fatal and should be corrected.

Message m will be caused by hardware errors or improper random access file JCL.

For error n, check setup for errors. If a coefficient is to be adjusted it must be of degree and order less than or equal to the maximum degree and order used in the geopotential expansion.

o) PROGRAM TERMINATION DUE TO ILLEGAL INPUT
EXPLANATION: THE CARD ------ IN THE OPTION CARD GROUP IS MISSING A CONTINUATION. PLEASE CHECK INPUT FOR MISSING OR MISPLACED CARDS.

p) PROGRAM TERMINATION DUE TO ILLEGAL INPUT
EXPLANATION: AN ILLEGAL SURFACE DENSITY INCREMENT SIZE WAS SPECIFIED. PLEASE CHECK INPUT FOR KEYPUNCH ERRORS.

q) EXECUTION TERMINATING DUE TO INAPPROPRIATE INPUT
EXPLANATION: THE SETUP OF THIS DECK IS SUCH THAT THE NUMBER OF SURFACE DENSITY CONSTRAINT EQUATIONS IS GREATER THAN OR EQUAL TO THE NUMBER OF ADJUSTED SURFACE DENSITIES.

r) **********$ NEGATIVE ARGUMENT TO DSQRT FOR ELEMENT ------ $**********

s) **********$ NEGATIVE ARGUMENT TO DSQRT FOR ------ $*****

(DRAG, SOLRAD or DRGDOT may appear in this error statement.)

t) **********$ NEGATIVE ARGUMENT TO DSQRT FOR BIAS $******

(Errors r, s and t are not fatal errors.)

u) EXECUTION TERMINATING DUE TO INSUFFICIENT MAIN CORE STORAGE.
THE USER SHOULD SPECIFY REGION = ------ K PLUS ADDITIONAL STORAGE FOR ALL EXCESSIVELY LARGE I/O BUFFERS USED.

v) WARNING:
INPUT ON THE POSITION VECTOR CARD IN ARC ------ INDICATES THAT KEPLER ELEMENTS MAY HAVE AN ECCENTRICITY GREATER THAN 1.

w) DATE ------ ON FLUX CARD OUT OF RANGE OF TABLES.
CARD IGNORED. EXECUTION CONTINUING.

x) **********$ NEGATIVE ARGUMENT TO DSQRT FOR COMPONENT ------ OF MASTER STATION ------ $**********

y) PERMISSIBLE VALUES OF IORDER ARE 5 THROUGH 15, VALUE PASSED WAS ------ ***** RUN TERMINATED *****

z) SAT ------
INITIAL STEP TOO LARGE
RESTARTING WITH ------ SEC STEP

aa) $**********$ ACCEPTED TRANSIT TIME ERROR AFTER SIX ITERATIONS = ------ SECONDS. GREATER THAN ------ DAYS $**********$

bb) **********$ ELEVATION NEGATIVE. MAXIMUM CORRECTION FOR PARALLACTIC REFRACTION USED. $********

cc) INTEGRATION STARTING SUMS NOT CONVERGED AFTER ----- ITERATIONS.

EPS = _____
DIFF1 = _____
DIFF2 = _____

EXECUTION CONTINUING

dd) $**UPDOWN**$ ACCEPTED TRANSIT TIME ERROR AFTER SIX ITERATIONS = _____ SECONDS. GREATER THAN _____ DAYS $**UPDOWN**$

APPENDIX A
DODS DATA BASE

On the 360/95 Multi-Arc GEODYN has the capability of retrieving orbital elements and DODS format data from the DODS Data Base.

Additional job control language is required whenever the DODS Data Base is used. Unit 02 is necessary whenever data is retrieved and units 4 and 02 are necessary whenever elements are retrieved.

The DODS02 disk pack must be mounted whenever the DODS Data Base is used.

A.1 DODS DATA BASE ELEMENT RETRIEVAL

If the element retrieval flag on the Epoch card for an arc is greater than zero GEODYN will retrieve the orbital elements from the data base. The satellite ID of the desired satellite must always be specified.

There are three ways of retrieving elements:

1. By element set number.

   If the element set number is specified on the Epoch card GEODYN will search for the corresponding element set. If that element set is not available GEODYN will use the third way of retrieving elements.

2. By data.

   If the element set number is less than zero GEODYN will read the first observation from the data base observation file falling after epoch for the satellite specified. GEODYN will obtain the element set number specified on the observation record and then use the first way of retrieving elements.

3. By epoch.

   If the element set number is zero GEODYN will search for an element set on or before epoch. If no such element set can be found GEODYN will search for an element set after epoch.

If no element set can be found for the specified satellite the GEODYN execution will be terminated with a hexidecimal dump of the element set directory and the element set physical record buffer.

If an element set not corresponding to epoch is found the epoch will be reset.

If elements are retrieved from the DODS Data Base for an arc the position and velocity vector cards should not be in the deck for that arc.

A.2 DODS DATA BASE OBSERVATION RETRIEVAL

If unit 02 is specified as the data tape input unit and if column 23 on the Epoch card is left blank GEODYN will retrieve observation data from the DODS data base. The data selected will be all data, except those data types that may be deleted on the Data Type Deletion card, between and including the start and cutoff times for data as specified on the Epoch card.

The satellite ID of the satellite for which observations are desired must always be specified on the SAT card.

If no data can be found for the satellite specified the GEODYN execution will be terminated with a hexidecimal dump of the observation data directory and the observation physical record buffer.

APPENDIX B
DATA TAPE OUTPUT

If during a data reduction run the following conditions are true for an arc then a data tape* will be generated on FORTRAN logical unit 3.

- Column 23 on the Epoch card is less than 3.
- Column 7 on the DATA card for the arc is blank or zero.
- Column 8 on the DATA card is 2 or 3.

Notes: Any odd number specified in column 8 of the DATA card for an individual arc will tell GEODYN that it must read one Data Type Deletion card or Data Selection cards following the DATA card.

If a data tape is to be written the proper JCL must be specified for unit 3. Separate files on unit 3 are required for each arc generating a data tape.

* Data tape - The format of the output data tape will be the same as the input data tape.

APPENDIX C
INPUT/OUTPUT FILE FORMATS

Within this appendix are contained all input/output file formats for the GEODYN System which are not elsewhere described in this volume.

C.1 B-MATRIX TAPE FORMAT

GEODYN has the capability to write the normal equations out on tape. The word format of the binary B-MATRIX tape is as follows:

Record No.	Record Size (bytes)	Description
1	60	Header record.
2	4N+8	Matrix labels.
3	8N+12	Matrix data by rows starting with right hand side
⋮		
N+2	8N+2	
N+3	60	Parameter set identification.
N+4	4N+4	Parameter labels
N+5	8N+4	Parameter values
N+6	60	Trailer record.

Where N is the number of parameters.

Header Record

Word	Type	Value	Description
1	I	10001	Record Type
2	I	1 to 99998	B-Matrix number
3	I	N 1000	Number of parameters
4	I	N + 1	Number of parameters + 1
5	D.P.		Total variance
6	D.P.		Weighted variance
7	D.P.	0.0D0	Arc variance
8	I		Number of weighted observations

Word	Type	Value	Description
9	I	8	Matrix type
10-12	R	blanks	Matrix name

Length = 60 bytes

Matrix Labels

Word	Type	Value	Description
1	I	10002	Record Type
2	I	0	Dummy
3 to N+2	I		Parameter labels

Length = 4N+8 bytes

Matrix Data Records

Word	Type	Value	Description
1	I	10003	Record Type
2 to N+2	D.P.		Elements of J^{th} matrix row, starting with right hand side

Length = 8N+4 bytes

Parameter Set Identification Record

Word	Type	Value	Description
1	I	10011	Record Type
2	I	1 to 99998	B-matrix number
3	I		Dummy
4	I	N 1000	Number of parameters
5	I		Dummy
6	I	8	Code for parameters set
7-9	R	Blanks	Matrix name

Length = 60 bytes

Parameter Labels

Word	Type	Value	Description
1	I	10012	Record Type
2 to N+1	I		Parameter labels

Length = 4N+4 bytes

Parameter Values

Word	Type	Value	Description
1	I	10013	Record Type
2 to N+1	D.P.		Parameter values

Length = 8N+4 bytes

Trailer Record

Word	Type	Value
1	I	-19991
2-14	I	0

Length = 60 bytes

C.2 BINARY RESIDUAL TAPE FORMAT

The Binary Residual tape is written by GEODYN specifically for input to the GEORGE graphics and analysis program. The word format for this tape is the following:

Word	Type	Description	
1	I	Date in YYMMDD.	
2	I	Hours and minutes in HHMM.	
3	R	Seconds.	
4	DP	Station name.	
5	DP	Alphanumeric Measurement type.	
6	DP	Value of first observation.	
7	R	First observation residual (O-C).	
8	R	First observation residual ratio to sigma.	
9	R	Time derivative of first observation.	
10	DP	Value of second observation.	
11	R	Second observation residual (O-C).	
12	R	Second observation residual ratio to sigma.	
13	R	Time derivative of second observation.	
14	R	Elevation angle in degrees.	
15	I	Station network indicator.	
16	DP	Along track residual component	Optical Data Only
17	DP	Cross track residual component	
18	DP	Argument of Longitude in radians	
19	DP	Right Ascension of Greenwich in radians	

Total = 108 Bytes.

The last record contains blanks.

C.3 DODS DATA TAPE FORMAT

HEADER RECORD

Word Number	Bytes	Word Type	Description
1	8	D.P.	Header record flag (value is -1.0)
2-6	40	D.P.	Spares
7	4	I	Satellite ID
8-19	48	F.P.	Spares

Total 100 = Logical Record Length

DATA RECORDS

Word Number	Bytes	Word Type	Description
1	8	D.P.	Time of observation
2	8	D.P.	Station ID
3	8	D.P.	Observation
4	8	D.P.	Not Used
5	8	D.P.	Ambiguity corrections* (bits 57-60) and transponder channel** (bits 63-64)
6	8	D.P.	Observation correction
7	4	I	Satellite ID
8	4	I	Not Used
9	4	F.P.	Measurement standard deviation
10	4	F.P.	Not used
11	4	F.P.	
12	4	F.P.	
13	4	F.P.	

Word Number	Bytes	Word Type	Description
14	4	F.P.	Timing error in D.U.T.
15	4	F.P.	Time correction value in D.U.T.
16	2	I	Not Used
17	2	I	
18	2	I	DODS OBSERVATION TYPE NUMBER
19	2	I	Not Used
20	2	I	Time tag indicator; bits 1-8, 2=A1, any other value = UTC; bits 9-16, 5=satellite time, any other value = ground time.
21	2	I	Observation correction indicator
22	2	I	Not Used
23	2	I	Spare

Total 100 = Logical Record Length

No Trailing Record

NOTES:

* Ambiguity corrections;

1 = +18737031.3 meters

2 = +4684257.8 meters

3 = +936851.6 meters

** Transponder channel;

1 = A Channel

2 = B Channel

3 = C Channel

C.4 EPHEMERIS TAPE FORMAT

The ephemeris tape is a binary unformated tape containing geocentric lunar positions at half day intervals, heliocentric positions of the earth-moon barycenter and the planets, Venus, Mars, Jupiter, and Saturn at 4 day intervals, and the nutation in obliquity at half day intervals. These ephemerides were obtained by precessing and nutating to true of date coordinates the values found on the JPL planetary ephemeris. All quantities on the tape are accompanied by second and fourth differences for use in a fifth order Everett interpolation scheme. Each block of data corresponding to one record on the JPL ephemeris contains 8 days of data with the first set of quantities being the same as the last set of quantities in the previous block of data. The time of the first set of quantities in each block of data is specified in the A.1 time system. The tape word format is as follows:

Record	Word	Type	Description
1	1	I	Date of first set of quantities in YYMMDD.
1	2	I	Hours and minutes in HHMM.
1	3	R	Seconds.
1	4-54	R	Nutation quantities.
1	55-81	DP	Earth-moon barycenter quantities.
2	1-51	DP	Lunar quantities.
3	1-51	DP	Lunar quantities.
4	1-51	DP	Lunar quantities.
5	1-51	DP	Venus quantities.
5	28-54	DP	Mars quantities.
6	1-27	DP	Jupiter quantities.
6	27-54	DP	Saturn quantities.

Records 1, 5, and 6 each have lengths of 108 single words.

Records 2, 3, and 4 each have lengths of 102 single words.

The nutation quantities consist of 17 sets of values for the nutation in obliquity and its second and fourth differences. The first set corresponds to the time on the block of data and each successive set is one half day later.

The earth-moon barycenter quantities consist of the coordinates of the sun relative to the earth-moon barycenter in meters. Three sets of coordinates with their second and fourth differences are stored as follows with the first set corresponding to the time on the block of data and each successive set 4 days later.

$$X, D_x^2, D_x^4, Y, D_y^2, D_y^4, Z, D_z^2, D_z^4$$

The lunar quantities consist of the geocentric coordinates of the moon in meters. 17 sets, each one half day later than the previous appear as follows:

$$X, D_x^2, D_x^4, Y, D_y^2, D_y^4, Z, D_z^2, D_z^4$$

C.5 GEOS DATA TAPE FORMAT

Columns	Format	Description
1-6	I6	Satellite ID
7	I1	Measurement Type - same as described under option card SIGMA except 4 = doppler data. Doppler data is changed after preprocessing to type 3 for program handling.
8	I1	Observation identifier. 0 = Active 0 ≠ Passive
12-13		Time Identifier.
12	I1	<5 Station Time ≥5 Satellite Time
13	I1	1 = UT-1 2 = UT-2 3 = UT-C 4 = A.1 Default A.1
14-18	I5	Station Number.
14-17		Station number for GEOS-II satellite.
15-18		Station number for GEOS-I satellite.
19-34		Greenwich Mean Time of Observation.
19-24	I6	YYMMDD - Year, Month, Day
25-28	I4	HHMM - Hours, Minutes
29-34	I6	SS.SSSS- Seconds

COLUMNS 35-80 FOR MEASUREMENT TYPES 1, 6, 7, 8, 13 & 14

Columns	Format	Description
35-53		Observations
35-37	I3	Hours (arc) - right ascension, Degrees - azimuth or X angle.
38-39	I2	Minutes (time) - right ascension, Minutes (arc) - azimuth Decimal degrees - X angle.
40-44	I5	Seconds (time) - right ascension, Seconds (arc) - azimuth
45	A1	Sign of declination or Y angle.
46-47	I2	Degrees - declination, elevation, or Y angle.
48-49	I2	Minutes (arc) - declination or elevation. Decimal degrees - Y angle.
50-53	I4	Seconds (arc) - declination or elevation.
62-63		Equator designation
62	I1	1 = True; otherwise Mean.
63	I1	2 = Equator of reference time. 3 = Equator of date. All other values; Equator of 1950.
72-74	I3	Standard deviation. Seconds - right ascension or azimuth. Degrees - X angle.
75-77	I3	Standard deviation. Seconds - declination or elevation. Degrees - Y angle.

COLUMNS 35-80 FOR MEASUREMENT
TYPES 2, 3, &4.

Columns	Format	Description
35-53		Observation.
35-50	I16	Range in meters; range rate in meters per second; doppler in cycles per second.
51-53	I3	Millimeters of range; millimeters per second of range rate and .001 cycles per second of doppler.
64	I1	Tropospheric refraction correction indicator. =2 or 4 - correction not applied. =1 or 3 - correction applied. =9 - correction not applied. Measurement type - French Laser Range.
65-67	I3	Range standard deviation in meters.
68-70	I3	Millimeters or range standard deviation.
71-76	I6	Refraction coefficient for French Laser Data.
75-77	I3	Standard deviation of range rate in millimeters per second or doppler in .001 cycles per second.
80	I1	Transponder channel for GRARR data. =0 - A channel =1 - B channel =2 - C channel

COLUMNS 35-80 FOR
MINITRACK DATA

Columns	Format	Description
38-53		Observations.
38	A1	Sign of Cosine Alpha.
39-45	I7	Cosine Alpha (Implied decimal in 39). ℓ
46	A1	Sign of Cosine Beta.
47-53	I7	Cosine Beta (Implied decimal in 47). m

A Mod of NGSP (GEOS) Format for VLBI and Average Range Rate Input to GEODYN

Field	Columns	Format	Description
1.	1-6	I6	Satellite ID*
	1-2		Year of Launch 64 = 1964 65 = 1965 etc.
	3-5		Order of Launch
	6		Component Identifier 1 = a 2 = b etc.
2.	7-8	I2	Type of measurement 81 = time delay VLBI τ_g 82 = fringe rate VLBI ν_F 83 = two way average range rate 84 = three way average range rate } $\dot{R}$
3.	9-11		Blanks
4.	12-13		Time Identifier
	12	I1	5 = Satellite time 0 = Station received time

*as per COSPAR numbering system

Field	Columns	Format	Description
	13	I1	1 = UT1 2 = UT2 3 = UTC 4 = A.1 All other values UTC
5.	14-17	I4	Station Number For measurement type 81 and 82 Reference Station Designated. For measurement types 83 and 84 Receiving Station Designated. Network numbering systems are as follows: 0001 - 0099 USB 0100 - 0499 Not used 0500 - 0599 Deep Space (JPL) 0600 - 0999 Not used 1000 - 1999 NASA STADAN 1000 - 1099 Minitrack 1100 - 1199 S-Band Radar 1500 - 1599 Minitrack 1600 - 1699 VHF Radar 2000 - 2999 U.S. Navy Doppler 3000 - 3999 U.S. Air Force Optical 4000 - 4999 Interagency C-Band

Field	Columns	Format	Description
			5000 - 5999 U.S. Army Secor
			6000 - 6999 Worldwide BC-4 Network
			7000 - 7999 NASA SPEOPT
			8000 - 8999 International Observers
			9000 - 9999 SAO
6.	18		Blank
7.	19-34		GMT of Observation
	19-20	I2	Year 64 = 1964 65 - 1965 etc.
	21-22	I2	Month
	23-24	I2	Day
	25-26	I2	Hour
	27-28	I2	Minute
	29-30	I2	Second
	31-34	I4	.0001 Seconds
8.	35-36		Observation time correction
	35-36	I2	Time correction in microseconds to be added to GMT.

Field	Columns	Format	Description
9.	37	I1	Refraction Indicator = 0 Obs. corrected for troposphere and ionosphere = 1 Obs. corrected for ionosphere but not troposphere = 2 Obs. corrected for troposphere but not ionosphere = 3 Obs. not corrected for troposphere or ionosphere
10.	38	I1	Transmitter Frequency Indicator = 0 Unified S-Band = 1 GRARR S-Band Channel A = 2 GRARR S-Band Channel B = 3 GRARR S-Band Channel C = 4 GRARR VHF
11.	39-42	I4	Station Number For measurement types 81 and 82 the second receiving station For measurement types 83 and 84 the transmitting station Same numbering convention as columns 14-17
12.	43	I1	=IE Scale Factor Indicator for Observations Measurements should be multiplied by $10^{(IE-4)}$ to achieve nominal un For example: IE = 4 indicates $\dot{R}$ observations are in nominal units. IE = 7 indicates $\dot{R}$ observations are in Km/sec. IE = 1 indicates $\dot{R}$ observations

Field	Columns	Format	Description
13.	44-58	F15.10	Unscaled Observation (Decimal implied between columns 48 and 49) Nominal Units: (see column 43 description) τ_g - Km $\dot{\nu}_F$ - M/sec $\dot{R}$ - M/sec
14.	59-65	F7.6	Observation Sigma (Decimal implied between columns 59 and 60) Units: τ_g - Km $\dot{\nu}_F$ - M/sec $\dot{R}$ - M/sec
15.	66-80 for $\dot{R}$ only		
	66	I1	Receiver Mount Type = 1 XY (East-West) = 2 XY (North-South) = 3 Azimuth - Elevation = 4 Hour angle - Declination
	67-69	F3.1	Antenna Axis Displacement for Receiver in Meters (Decimal implied between columns 68 and 69)
	70-72	F3.1	Antenna Axis Displacement for Transmitter in Meters (Decimal implied between columns 71 and 72)

Field	Columns	Format	Description
	73	I1	Transmitter Mount Type = 1 XY (East-West) = 2 XY (North-South) = 3 Azimuth - Elevation = 4 Hour angle - Declination
	74-80	I7	Counting Interval for $\dot{\bar{R}}$ in Milliseconds

A Mod of NGSP (GEOS) Format for Altimeter and Satellite to Satellite Data Input to GEODYN

Field	Columns	Format	Description
1.	1-6	I6	Satellite ID*
	1-2		Year of Launch 64 = 1964 65 = 1965 etc.
	3-5		Order of Launch
	6		Component Identifier 1 = a 2 = b etc.
2.	7-8	I2	Type of measurement 92 = Summed Range 93 = Summed Range Rate 94 = Altimeter Height and Height Rate } Sat-sat
3.	9-11		Blanks
4.	12-13	I2	Time Identifier
	12		5 = Satellite time 0 = Station received time 6 = Satellite time corrected for satellite clock errors

*as per COSPAR numbering system

Field	Columns	Format	Description
	13		1 = UT1 2 = UT2 3 = UTC 4 = A.1 All other values UTC
5.	14-17	I4	Station Number For measurement type 94 station is always -4. For measurement types 92 and 93 Tracking Station Designated. Network numbering systems are as follows: 0001 - 0099 USB 0100 - 0499 Not used 0500 - 0599 Deep Space (JPL) 0600 - 0999 Not used 1000 - 1999 NASA STADAN 1000 - 1099 Minitrack 1100 - 1199 S-Band Radar 1500 - 1599 Minitrack 1600 - 1699 VHF Radar 2000 - 2999 U.S. Navy Doppler 3000 - 3999 U.S. Air Force Optical 4000 - 4999 Interagency C-Band 5000 - 5999 U.S. Army Secor 6000 - 6999 Worldwide BC-4 Network 7000 - 7999 NASA SPEOPT 8000 - 8999 International Observers 9000 - 9999 SAO
6.	18		Blank

Field	Columns	Format	Description
7.	19-34		GMT of Observation
	19-20	I2	Year 64 = 1964 65 = 1965 etc.
	21-22	I2	Month
	23-24	I2	Day
	25-26	I2	Hour
	27-28	I2	Minute
	29-30	I2	Second
	31-34	I4	10^{-4} Seconds
8.	35	I1	Refraction Indicator 0 = Observation not corrected for troposphere or ionosphere. 1 = Observation corrected for troposphere but not for ionosphere. 2 = Observation corrected for ionosphere but not for troposphere 3 = Observation corrected for both troposphere and ionosphere.
9.	36-54		Observation of Range, Range Rate, or Height.

Field	Columns	Format	Description
(9.cont.)	36-51	I16	Meters of Range or Height, or millimeters/second of Range Rate.
	52-54	I3	Millimeters of Range or Height, or micrometers/sec of Range Rate
	55-80		For Range or Range Rate
10.	55-60	I6	Sigma for Range in millimeters, or Range Rate in micrometers/second.
11.	61-66	I6	Satellite ID for relay satellite.
12.	67	I1	Transponder Channel 1 - A channel 2 - B channel 3 - C channel
	55-80		For Altimeter
10.	55-56	I2	Meters of Height Sigma.
11.	57	I1	10^{-1} meters of Height Sigma.
12.	58-60	I3	Centimeters/second of Height Rate Sigma.

Field	Columns	Format	Description
13.	61	I1	Subsatellite geography indicator 0 = No information available. 1 = water (ocean or sea) 2 = land (includes lakes)
14.	62-80		Height Rate Observation
	62-77	I16	Millimeters/second of Height Rate measurement.
	78-80	I3	Micrometers/second of Height Rate measurement.

INTRODUCTION

The GEOS-C satellite will be tracked by many different systems and networks of tracking stations. It is intended that this format will accomodate data taken from all tracking systems and networks as well as altimeter data taken by the satellite. As a consequence of its design characteristics this format not only meets the specifications of the GEOS-C project but also the precise orbit determination requirements of all currently existing satellites.

Since the format is a card image representation, it is ideally suited for transferring data between the different types of computer facilities supporting the GEOS-C project research. The only character images used by the format are:

integer numbers 0-9

letters of the alphabet A-Z

blanks, and

minus signs

All decimal points are implied, therefore eliminating the need for that character representation.

Descriptions of columns 1-32 for all measurement types.

Columns	Subset	Description
1-7		Satellite - ID
8-9		Measurement Type
		10-14 Right Ascension and Declination
		10 = Optical
		11 = Laser Optical
		15-19 Hour Angle and Declination
		15 = DSN S-Band Radar
		20-29 Range or Range Difference
		20 = Laser
		21 = C-Band Radar
		22 = C-Band VLBI Range Difference Radars
		23 = DSN S-Band Radar
		24 = USB Radar
		25 = GRARR S-Band Radar
		26 = GRARR ATS-R C-Band Radar
		27 = GRARR VHF Radar
		30-39 Range Rate or Range Rate Difference
		30 = Combined DSN/USB Radars
		31 = C-Band Radar
		32 = C-Band VLBI Range Rate Difference Radars
		33 = DSN S-Band Radar
		34 = USB Radar
		35 = GRARR S-Band Radar
		36 = GRARR ATS-R C-Band Radar
		37 = GRARR VHF Radar
		38 = TRANET Doppler
		39 = Geoceiver Doppler
		40-44 Altimeter Height
		45-49 Available for additional measurement types such as Altimeter Height Rate.

Columns	Subset	Description
		50-54 ℓ and m Direction Cosines
		51 = Minitrack Equatorial Mode
		52 = Minitrack Polar Mode
		55-59 Available for additional angles or cosines
		60-63 X-Y Angles (East-West)
		60 = USB Radar
		64-69 X-Y Angles (North-South)
		64 = USB Radar
		65 = GRARR S-Band Radar
		66 = GRARR ATS-R C-Band Radar
		67 = GRARR VHF Radar
		70-79 Azimuth and Elevation Angles
		70 = Laser
		71 = C-Band Radar
		73 = DSN S-Band Radar
		80-89 Available for additional Range type measurements.
		90-99 Available for additional Range Rate type measurements.
10-11		Time System Indicator
	10	0 = Ground Received Time
		1 = Satellite Transponder/Transmitter Time
		2 = Ground Transmitted Time
		3 = Satellite Receiver Time
	11	0 = UT-0
		1 = UT-1
		2 = UT-2
		3 = UT-C
		4 = A.1
		5 = A.3 (A.T. B.I.H.)
		6 = A-S (Smithsonian)

Columns	Subset	Description
12-16		Station ID
17-32		GMT of Observation
	17-18	year YY
	19-21	Day of Year DDD
	22-26	Time of Day (Seconds from midnight GMT)
	27-32	Fractional Part of Seconds (in microseconds)

Columns 33-80 for Right Ascension/Declination and Hour Angle/ Declination Data (Types 10-19)

Columns	Subset	Description
33		Beacon activity indicator 0 = Beacon Active 1 = Beacon Inactive or no Beacon
34-35		Equator and Equinox designation
	34	0 = Mean equator and equinox 1 = True equator and equinox
	35	Date of equator and equinox 1 = Standard equator and equinox (Jan. 0.0, 1950) 2 = Jan. 0.0 of year of observation 3 = Equator and equinox of date (instant of observation) 4 = DODS reference date (0 hr. Sept. 18, 1957)
36-54		Observation Data
	36-38	R.A. or H.A. (hours)
	39-40	R.A. or H.A. (minutes of time)
	41-45	R.A. or H.A. (XX.XXX Seconds of time)
	46	Sign of declination
	47-48	Declination (degrees of arc)
	49-50	Declination (minutes of arc)
	51-54	Declination (XX.XX arc seconds)
55-57		Preprocessing Indicators
	55	0 = Data has been corrected for annual aberration effects 1 = Data not corrected for annual aberration
	56	0 = Data has been corrected for parallactic refraction 1 = Data not corrected for parallactic refraction

Columns	Subset	Description
	57	0 = Data has been corrected for diurnal aberration 1 = Data not corrected for diurnal aberration
58-61		Standard deviation in R.A. or H.A. XX.XX Arc Seconds multiplied by cosine of the declination
62-65		Standard deviation in declination XX.XX Arc Seconds
66		Preprocessing Report 0 = Report not indicated 1 - 9, A - Z Values to be assigned.
67-80		Not Used.

Columns 33-80 for range and range difference* measurements (Data Types 20-29)

Columns	Subset	Description
33-35		Preprocessing Indicators
	33	0 = Data has been corrected for ionospheric refraction effects.
		1 = Data not corrected for ionospheric refraction.
	34	0 = Data has been corrected for tropospheric refraction effects.
		1 = Data not corrected for tropospheric refraction.
		2 = Data has been corrected for tropospheric refraction using the correction formulas for international laser data (see cols. 76-80).
		3 = Data not corrected for tropospheric refraction. Columns 76-80 contain coefficient for use with international laser formulas.
	35	0 = Data has been corrected for transponder delay effects.
		1 = Data not corrected for transponder delay.
36-54		Observation Data
	36-45	Range or Range Difference (Km)
	46-54	Range or Range Difference XXX.XXXXXX Meters
55-56		Preprocessing Indicators
	55	Preprocessing Report
		0 = Report not indicated
		1 - 9, A - Z values to be assigned

*Range Difference - Time Delay VLBI

Columns	Subset	Description
	56	Transponder Channel for GRARR 1 = Channel A or 1st sidetone 2 = Channel B or 2nd sidetone 3 = Channel C or 3rd sidetone or Transponder type for other systems 1 - coherent 2 - non-coherent
57-61		Reference station number for range differencing or transmitting station number for station-to-satellite-to satellite-to-station data.
62-68		Relay satellite-ID for satellite-to-satellite data.
69-73		Measurement standard deviation XX.XXX Meters
74		Range ambiguity indicator For DSN S-Band 1 - MARK 1A (824809582.0 m) 2 - TAU (151285510.38518 m) For USB 1 - 824809582.0 m For GRARR S-Band 1 - 18737031.3 m 2 - 4684257.8 m 3 - 936851.6 m
75		Not used
76-80		Tropospheric refraction correction XX.XXX Meters or, Coefficient of Tropospheric Refraction international lasers (see col. 34) XX.XXX Meters

Columns 33-80 for range rate, doppler, and range rate difference* measurements (Data types 30-39)

Columns	Subset	Description
33-35		Preprocessing Indicators
	33	0 = Data has been corrected for ionospheric refraction effects.
		1 = Data not corrected for ionospheric refraction.
	34	0 = Data has been corrected for tropospheric refraction effects.
		1 = Data not corrected for tropospheric refraction.
	35	Receiver Mount Type
		1 = X-Y (East-West)
		2 = X-Y (North-South)
		3 = Azimuth-Elevation
		4 = Hour angle-declination
36-42		Counting interval for average range rate data (Types 30,33,34). XXXXX.XX Seconds or, Tropospheric refraction correction for other range rate data types. XXXXX.XX cm/Second
43-54		Observation Data
	43-49	Range rate or range rate difference XXXX.XXX Km/Second
	50-55	Range rate or range rate difference XXX.XXX Millimeters/Second

*Range Rate Difference - Fringe Rate VLBI

Columns	Subset	Description
56		Preprocessing Report 0 = Report not indicated 1 - 9, A - Z Values to be assigned.
57-61		Reference station number for range differencing, or transmitting station number for station-to-satellite-to-satellite-to-station data or average range rate data.
62-68		Relay satellite -ID for satellite-to-satellite data.
69-73		Measurement Standard deviation XXX.XX milli-meters/second
74		Transmitter or reference station Mount type 1 = X-Y (East-West) 2 = X-Y (North-South) 3 = Azimuth-Elevation 4 = Hour angle-declination
75-77		Receiver antenna axis displacement XX.X Meters
78-80		Transmitter or reference station Antenna axis displacement XX.X Meters

Columns 33-80 for Altimeter Data (Types 40-44)

Columns	Subset	Description
33-41		Altimeter Height Measurement (O) X,XXX,XXX.XX Meters
42-44		Sigma Measurement X.XX Meters
45-47		Tropospheric Refraction = 0 - none applied ≠ 0 - value applied X.XX Meters
48-49		Ionospheric Refraction = 0 - none applied ≠ 0 - value applied .XX Meters
50-54		Geoid Height
	50	Sign of Height
	51-54	Value of Height XX.XX Meters
55-58		Tide Height
	55	Sign of Tide
	56-58	Value of Tide X.XX Meters

Columns	Subset	Description
59-65		Satellite Latitude*
	59	Sign of Latitude
	60-65	Value of Latitude XX°XXXX
66-72		Satellite East Longitude XXX°XXXX
73-77		Sea Surface Height (O-h) Altimeter Height Measurement less Satellite Height (h) above Spheroid*
	73	Sign of Height
	74-77	Value of Height XX.XX Meters
78-79		Blank
80		Preprocessing Report 0 = Report not indicated 1-9, A-Z = Values to be assigned

Columns 33-80 for Minitrack Data (Types 50-54)

Columns	Subset	Description
33-34		Refraction Indicators
	33	0 = Data has been corrected for ionospheric effects 1 = Data not corrected for ionosphere
	34	0 = Data has been corrected for tropospheric effects 1 = Data not corrected for troposphere
35		Not Used.
36-54		Observation Data
	36	Not Used.
	37-45	Cosine ℓ XXXX.XXXXX Mils
	46-54	Cosine m XXXX.XXXXX Mils
55-57		Not Used.
58-61		Standard Deviation in Cosine ℓ XX.XX Mils
62-65		Standard deviation in Cosine m XX.XX Mils
66		Preprocessing Report 0 = Report not indicated. 1 - 9, A - Z Values to be assigned.

Columns 33-80 for X-Y angles and Azimuth and Elevation angles (Types 60- 79)

Columns	Subset	Description
33-34		Refraction Indicators
	33	0 = Data has been corrected for ionospheric effects. 1 = Data not corrected for ionosphere
	34	0 = Data has been corrected for tropospheric effects. 1 = Data not corrected for troposphere
35		Not Used.
36-54		Observation Data
	36-38	Azimuth or X angle (degrees). Sign of X angle appears in column 36.
	39-40	Azimuth or X angle (arc minutes)
	41-45	Azimuth or X angle XX.XXX Arc Seconds
	46	Sign of Y angle
	47-48	Elevation or Y angle (degrees)
	49-50	Elevation or Y angle (minutes)
	51-54	Elevation or Y angle XX.XX Arc Seconds
55-57		Not Used.
58-61		Standard deviation in X angle or azimuth XX.XX Arc Minutes
62-65		Standard deviation in elevation or Y angle XX.XX Arc Minutes

Columns	Subset	Description
66		Preprocessing Report 0 = Report not indicated 1 - 9, A - Z Values to be assigned.
67-71		Tropospheric refraction correction to X angle XXX.XX Arc Minutes
72-76		Tropospheric refraction correction to Y angle or elevation XXX.XX Arc Minutes
77-80		Not used.

C.7 RAP DATA FORMAT

(To Be Determined)

C.8 GROUNDTRACK TAPE FORMAT

The Groundtrack tape is written by GEODYN specifically for input the GROUNDTRACK graphics program. The Groundtrack tape format is as follows:

Columns	Format	Description
1-6	I6	Date in YYMMDD.
9-12	I4	Hours and minutes in HHMM.
15-21	F7.4	Seconds in SS.SSSS.
24-29	A6	Station name
32-46	F15.8	Satellite Geodetic Latitude in degrees.
49-63	F15.8	Satellite East Longitude in degrees.
66-80	F15.5	Satellite height in meters.

Total = 80 bytes.

C.9 ORB1 TAPE FORMAT

An ORB1 tape is a binary satellite ephemeris tape having a logical record of 350 double precision words. There are three types of records on the tape - a title record, data records, and a sentinel record.

ORBITAL TAPE FORMAT-1 (TEB)

BINARY TITLE RECORD FORMAT

WORD NUMBER		
1	Form of data identification = 76796291	
2	Satellite number	
3		
4	Date	U.T.
5	Day count of year	Start time of satellite
6	Seconds of Day	Data
7	Date	U.T.
8	Day count of year	End time of satellite
9	Seconds of day	Data
10	Δt, interval between satellite data items in seconds	
27	Date	Coordinate system
28	Day count of year	Reference data time and position
29	Apparent sidereal time in radians	
	Spares	
80	C_d, atmospheric drag parameter	
81	Area of satellite in $cm.^2$	
82	Mass of satellite in grams	
91	Lunar perturbations indicator (= 1 indicates lunar pert. were used in determining orbit = 0 indicates solar pert. were not used)	
92	Solar perturbations indicator (= 1 indicates solar pert. were used in determining orbit = 0 indicates solar pert. were not used)	
101	t_o, epoch time (C.U.T.)	
102	a, semi-major axis at t_o (C.U.L.)	
103	e, eccentricity at t_o	
104	ν, true anomaly at t_o	(radians)
105	x	satellite position
106	y	vector $\underline{r}$ at t_o (C.U.L.)
107	z	

WORD NUMBER	BINARY TITLE RECORD FORMAT	
108	$\dot{x}$	Satellite velocity
109	$\dot{y}$	Vector r at t_o (C.U.L./C.U.T.)
110	$\dot{z}$	
111	r, magnitude of $\underline{r}$ at t_o (C.U.L.)	
112	$\dot{r}$, magnitude of $\underline{\dot{r}}$ at t_o (C.U.L./C.U.T.)	
114	M, mean anomaly at t_o (radians	
116	ω, argument of perigee at t_o (radians)	
117	i, inclination at t_o (radians)	
118	Ω, right ascension of ascending node at t_o (radians)	
120	n, mean motion at t_o (radians/C.U.T.)	
121	E, eccentric anomaly at t_o (radians)	
122	$\dot{\omega}$, rate of change of argument of perigee at t_o (radians/C.U.T.)	
123	$\dot{\Omega}$, rate of change of R.A. of ascending node at t_o (radians/C.U.T.)	
124	P, period at t_o (C.U.T.)	
125	Height of perigee at t_o (C.U.L.)	
126	Height of apogee at t_o (C.U.L.)	
191	Year (last 2 digits)	Date and Time of Epoch
192	Month	
193	Day	
194	Hour	
195	Minute	
196	Seconds x 1000	
200	Indicator of theory used to compute orbit (= 1 indicates PE orbit generator = 2 indicates Gill Integration orbit generator = 3 indicates Brouwer orbit generator)	

DATA RECORD

WORD NUMBER	DESCRIPTION	
1	Date (YYMMDD)	Time of first
2	Day Count of Year (DDD)	satellite position
3	Seconds of Day (SSSSS)	velocity vector = t
4	Δt, interval between position-velocity vectors	
5	Spare	
6	x	Satellite position vector
7	y	in km.
8	z	
9	$\dot{x}$	Satellite velocity vector in
10	$\dot{y}$	km/sec.
11	$\dot{z}$	
12-305	49 other satellite position velocity vectors at times $t+\Delta t$, $T+2\Delta t$, $t+3\Delta t$,... $t+49\Delta t$	
306-350	Spares	

Notes: If the last data record contains less than 50 position-velocity vectors, the remainder of the record is filled with nines (99999999.DO)

SENTINEL RECORD

The first word of the sentinel record contains nines (99999999.ODO). Words 2-350 are spares.

C.10 PCE DATA TAPE FORMAT

A PCE data tape may be written by GEODYN in orbit generator mode or read by GEODYN in data reduction mode. The format is as follows:

Columns	Format	Description
2-3	I2	Measurement type
		16 - X, 17 - Y, 18 - Z, 19 - $\dot{X}$, 20 - $\dot{Y}$, 21 - $\dot{Z}$ — Inertial Geocentric Cartesian Coordinates
		22 - a, 23 - e, 24 - i, 25 - Ω, 26 - ω, 27 - M — Osculating Geocentric Keplerian Elements
4-9	I6	Date of data (YYMMDD)
10-13	I4	Hours and minutes
14-21	F8.4	Seconds
22-45	D24.16	Measurement
46-55	D10.4	Measurement standard deviation

Units for measurements and sigmas are:

X,Y,Z,a - meters (σ - m)
$\dot{X},\dot{Y},\dot{Z}$ - meters/second (σ - cm/sec)
e - dimensionless (σ - ppm)
i,Ω,ω,M - degrees (σ - arc sec)

C.11 RV TAPE FORMAT

An RV tape is a satellite ephemeris tape which is output by GEODYN specifically for use by the DELTA analysis and graphics program. An RV tape is a binary tape written without format control. The RV tape word format is as follows:

Word	Type	Description
1	DP	Days from Jan 0.0 of the reference year for the arc.
2	I	Date in YYMMDD.
3	I	Hours and minutes in HHMM. UTC Time System.
4	R	Seconds.
5-10	DP	Satellite inertial position-velocity vector in meters and meters/second.
11	DP	Satellite latitude in degrees.
12	DF	Satellite longitude in degrees.
13	DP	Satellite height in meters.

Total = 92 bytes.

The last record has a value of 999.0D0 in the first word.

C.12 GEODYN SCRATCH FILES

GEODYN uses seven scratch files. Some of these files are direct access (D.A.), but most are sequential (Seq.). The uses of these files are described below:

File	Type	Description
10	Seq.	Used in the processing of doppler data in GEOS format.
11	Seq.	Used in the processing of all GEOS format data.
12	D.A.	Used for storage of all data in data reduction mode.
13	Seq.	Used for the storage of solar and geomagnetic flux data.
14	Seq.	Used for the storage of *a priori* information.
15	D.A.	Used for the storage of updated parameter values.
16	Seq.	Used for storage of that segment of the normal matrix pertaining to individual arcs.

C.13 GEODYN SIMULATED DATA TAPE

GEODYN has the capability of writing an output tape with the calculated observations in place of real observations. The tape is a binary unformatted tape designed for the purpose of testing the GEODYN estimate process. The following format is a nominal format which corresponds to internal variable names only. This format should not be interpreted rigidly for all measurement types.

Word	Type	Description
1	I	Date in YYMMDD.
2	I	Time in HHMM.
3	D.P.	Seconds.
4	D.P.	First calculated measurement.
5	D.P.	Second calcualted measurement.
6	D.P.	Standard deviation of first measurement.
7	D.P.	Standard deviation of second measurement.
8	I	Station number.
9	I*2	Measurement type.
10	I*2	Number of measurements (1 or 2).
11	I	Satellite ID.
12	D.P.	Tropospheric refraction index.
13-14	D.P.	Transit times for average range rate data.
15	I*2	Transponder channel.

The measurements and standard deviations are in "natural" units.

length - meters
time - seconds
angles - radians

The measurement types are the same as those for the SIGMA card.

C.14 SC4020 PLOT TAPE FORMAT

The SC4020 Plotter Driver Tape contains a contiguous stream of 36 bit SC4020 commands. This stream of commands is blocked 682 words of length 36 bits each to efficiently utilize the F-53-1A off-line buffer. The particular command-by-command format of any given Driver Tape is solely a function of the particular information being plotted.

APPENDIX D

BUILT-IN STATION POSITIONS

STATION NAME	NUMBER	GEODETIC LATITUDE DEG	MN	SECONDS	EAST LONGITUDE DEG	MN	SECONDS	SPHEROID HEIGHT (METERS)
MIL3	1	26	30	29.1514	279	13	23.2243	-45.000
GBM3	2	26	37	57.6003	281	45	44.0263	-46.000
BCA3	3	32	21	4.2329	295	20	30.5710	-36.000
ANG3	4	17	0	59.6273	298	14	50.5524	-27.000
CYI3	5	27	45	51.7824	344	21	52.5612	208.000
ACN3	6	-7	-57	-19.3126	345	40	20.9220	555.000
MAD3	7	40	27	19.7258	355	49	53.0274	321.000
CRO1	8	-24	-53	-23.9300	113	43	31.2150	9.000
GWM3	9	13	13	37.6858	144	44	14.9202	76.000
HSK3	10	-36	-35	-0.2445	148	58	39.8310	1149.000
HAW3	11	22	7	34.0587	200	20	5.5933	1123.000
GDS3	12	39	20	29.4543	243	7	34.3299	920.000
GY43	13	27	57	46.7313	249	15	43.5135	-28.000
TEX3	14	27	39	12.7713	262	37	16.9188	-41.000
GTC3	15	38	59	54.4482	263	9	25.4569	-5.000
PIOO	311	38	23	22.1639	243	9	1.5893	983.000
ECHO	312	38	17	59.4654	243	11	39.7211	936.000
VEN3	313	39	14	51.6255	243	12	17.8801	1040.000
MAR3	314	38	25	33.1545	243	6	37.1409	979.000
WCM3	341	-31	-22	-55.2570	136	53	14.2074	148.000
TID3	342	-35	-24	-3.2436	149	58	52.3910	573.000
JOH3	351	-25	-51	-23.7501	27	41	6.8213	1410.000
ROD3	361	40	25	43.5462	355	45	3.0565	925.000
CEB3	362	40	27	11.1359	355	37	55.3475	775.000
MRT3	371	25	28	45.9716	279	25	1.0750	-41.000
KOUR3J	1000	5	15	3.9221	307	11	41.0467	-18.000
SPOINT	1001	39	25	49.8038	282	54	48.7303	-53.593
FTMYR5	1003	26	32	53.1513	279	3	4.2737	-42.000
QUITO3	1005	0	-37	-22.3462	281	25	15.4307	3555.313
LIMAP3	1006	-11	-45	-37.0634	282	52	59.1431	50.733
SNTAG5	1007	-33	-3	-51.3076	289	13	53.7802	713.990
NEWFL3	1012	47	44	29.2867	307	15	46.2670	48.000
COLEGE	1013	64	52	17.8814	212	9	36.3525	136.367
GFORKS	1014	46	1	21.5499	262	59	19.8150	203.132
WAKFLD	1015	31	26	46.4180	359	13	5.0926	90.410
JOBURG	1016	-25	-53	-1.4508	27	42	26.2158	1540.977
MOJAVE	1017	35	17	47.9084	243	5	59.0170	876.254
COMEGA	1018	-31	-23	-25.8916	136	52	15.1963	130.403
ULASKA	1019	64	58	34.7775	212	28	30.5077	283.125
BROOIN	1021	38	25	49.8038	262	54	48.7303	-53.593
JFTMYR	1022	28	32	53.1513	278	3	4.2737	-42.000
MADGAS	1023	-19	0	-32.5919	47	17	59.3066	1359.777
ICOMEN	1024	-31	-23	-25.8916	136	52	15.1963	130.403
ICUITO	1025	0	-37	-22.3462	281	25	15.4387	3555.913
ILIMAP	1026	-11	-45	-37.0634	282	50	59.1431	50.703
ISATAG	1027	-33	-3	-53.3076	289	19	53.7802	713.990
IMOJAV	1028	35	19	47.8084	243	5	59.0170	876.254
IJOHUR	1029	-25	-53	-1.4508	27	42	26.2193	1540.977

STATION NAME	NUMBER	GEODETIC LATITUDE DEG	MN	SECONDS	EAST LONGITUDE DEG	MN	SECONDS	SPHEROID HEIGHT (METERS)
1NEWFL	1032	47	44	29.2857	307	15	46.2670	48.000
1COLEG	1033	64	52	17.8914	212	9	36.9325	156.367
1GFORK	1034	48	1	21.5499	262	59	19.5160	203.132
1WNKFL	1035	51	26	46.4160	359	13	3.0326	90.410
1ULASK	1036	64	58	35.7775	212	23	30.6077	233.125
1ROSMN	1037	35	12	7.2943	277	7	41.2732	549.033
1ORORL	1038	-35	-37	-32.6969	148	57	14.9123	949.578
1ROSMA	1042	35	12	7.3097	277	7	40.9741	350.053
1TANAN	1043	-19	0	-32.3919	47	17	59.3056	1359.777
ORORAS	1121	-35	-37	-32.6969	148	57	14.9123	949.573
MADGARS	1123	-15	-1	-14.4701	47	13	11.1896	1332.000
ROSRANS	1126	35	11	45.6550	277	7	25.9147	213.130
SNTAGRS	1127	-33	-9	-4.2954	289	20	0.6344	727.130
ALASKRS	1128	64	58	19.0511	212	29	12.1839	340.399
CARVONS	1132	-24	-54	-11.4592	113	42	58.9303	1.153
MADGARV	1522	-15	-1	-17.2074	47	13	11.4102	1391.000
ROSRANV	1526	35	11	41.4944	277	7	26.1932	814.003
SNTAGRV	1527	-33	-9	-6.7736	289	20	0.5282	727.000
ALASKRV	1528	64	58	17.3659	212	29	17.3332	340.000
CARVONV	1532	-24	-54	-15.4195	113	42	58.9769	1.000
ANTIGA	3106	17	8	55.1626	298	12	39.6937	-59.373
GRNVLE	3333	33	23	59.4714	268	59	48.2861	-15.909
GRVILL	3334	33	25	32.4554	269	5	10.4759	-15.654
USAFAC	3400	39	0	22.5137	255	9	58.4137	2141.201
BEDFRD	3401	42	27	17.5216	288	43	35.4858	30.054
SEMMES	3402	30	46	50.0993	271	44	51.0217	17.430
SWANIS	3404	17	24	19.1053	276	3	29.8715	7.448
GRDTRK	3405	21	25	48.6815	288	51	15.0579	-51.082
CURACO	3406	12	5	25.8435	291	9	44.7418	-40.731
TRNDAD	3407	10	44	35.7488	298	23	23.1375	245.515
GRANFK	3451	47	59	36.7360	262	37	9.2202	243.171
TWINCK	3452	36	7	25.9489	262	47	2.3536	253.673
ROTHGR	3453	51	24	57.5143	9	30	0.5543	368.653
ATHNGR	3463	37	53	25.1827	23	44	26.0553	83.741
TORRSP	3464	40	29	14.4369	356	34	36.0914	633.094
CHOFUJ	3465	35	40	8.4723	139	31	59.5969	68.343
KINDLY	3471	32	22	58.9471	295	19	1.8333	-13.332
EDWADS	3472	34	57	50.3114	242	5	7.0551	752.744
HUNTER	3543	32	0	6.5125	278	50	46.5341	-45.055
JUPRAF	3553	27	1	15.8015	279	53	14.0757	-35.717
ABERDN	3557	39	29	19.1003	283	55	45.5252	-54.785
HOMEST	3561	25	30	25.9856	279	35	43.0165	-49.893
CHYNYM	3902	41	7	59.1364	255	7	59.9379	1340.179
ETRSRS	4040	26	35	56.1086	281	39	7.4151	-41.937
ETRGAK	4041	28	28	53.7313	279	25	24.0711	-40.375
ETRASC	4050	-22	-16	-34.1256	22	21	28.3933	1609.255
ETRPAT	4060	28	13	34.3452	279	24	2.3720	-33.622
ETRANT	4061	17	8	37.5063	298	12	25.9309	-3.550

STATION		GEODETIC LATITUDE			EAST LONGITUDE			SPHEROID HEIGHT
NAME	NUMBER	DEG	MN	SECONDS	DEG	MN	SECONDS	(METERS)
ETPGRT	4061	21	27	45.3676	298	52	4.3242	-27.036
ETRMRT	4062	26	25	23.3711	279	20	7.5670	-42.792
ETRGBS	4063	26	38	10.1762	281	43	55.3775	-45.557
*SH122	4142	32	54	4.3479	253	34	2.3093	1217.351
*SC113	4143	32	21	29.0094	253	37	48.1722	1135.614
*SH123	4144	32	54	5.3715	253	34	2.4951	1217.551
*SS127	4145	33	48	50.0332	253	20	27.0505	1494.313
*SP124	4146	33	26	42.7072	253	32	3.9361	1577.093
*ST123	4151	33	5	46.1545	253	30	26.5874	1225.941
*THPP3	4240	37	25	51.3359	237	30	4.2329	3.276
*TATR2	4241	34	34	58.7822	239	25	19.7112	599.257
*TRTR1	4242	34	34	57.7335	239	25	18.3632	599.237
*TRPP3	4250	37	29	51.2516	237	30	0.7531	-8.032
*TRVAN	4260	34	39	56.9112	239	25	6.5131	50.205
EGLINF	4340	30	25	17.9501	273	12	6.7014	-26.147
EGLINF	4341	30	25	17.8501	273	12	6.0558	-25.757
PMRSN5	4400	33	14	45.5049	240	23	50.1421	220.970
PMRSN6	4401	33	14	46.4505	240	23	49.5333	221.250
PMRMR1	4402	22	2	2.5090	200	15	19.5523	447.413
PMRMR2	4403	22	3	3.7423	200	15	19.5369	442.937
PMRPM1	4440	34	7	17.0350	240	50	35.6203	-47.350
PMRPM2	4441	34	7	17.5054	240	50	49.4512	-47.555
PMRSN2	4442	33	14	49.9999	240	23	47.3039	218.971
PMRSN3	4443	33	14	51.5473	240	23	44.9650	220.012
PMRSN4	4444	33	14	34.0967	240	23	42.5341	219.433
PMRPM3	4445	34	7	20.2495	240	50	35.9553	-47.307
PMRPM4	4446	34	7	22.2735	240	50	42.4773	-47.306
PMRBK1	4450	22	1	17.3333	200	13	16.4144	-15.309
EDAFB3	4440	34	53	10.4201	242	4	8.4117	765.455
NLLHAR	4510	35	13	30.7608	244	54	46.5583	2737.745
NELYNV	4550	35	18	31.0033	244	54	47.4164	2776.335
NAI#2A	4732	37	52	2.0040	284	32	57.3016	-54.055
NAI#2B	4733	37	52	2.0102	284	32	57.7727	-54.050
NAIE3A	4734	37	20	49.9445	284	5	48.2517	-60.474
NAIE3B	4735	37	20	49.8495	284	5	48.2517	-60.475
NAER3A	4740	32	20	52.6352	295	20	46.7319	-35.795
NTANAN	4741	-19	0	-6.4788	47	13	33.0407	1320.107
*TRKAJ	4742	22	7	23.3621	200	20	4.2763	1127.433
NBER33	4750	32	20	52.1450	295	20	46.9643	-35.552
NCARNV	4751	-24	-53	-47.2520	113	43	1.3056	12.304
NWALI2	4540	37	50	28.5970	284	30	53.1547	-50.235
NWALI3	4800	37	51	26.7118	284	30	26.0393	-47.724
WOOR3A	4943	-30	-45	-6.9159	136	50	17.2350	124.343
JAEAHN	4943	32	7	40.7570	355	25	54.0435	132.557
RAEAHN	4943	32	7	40.2757	355	25	52.0737	132.558
MOURTN	4954	42	8	3.3374	352	49	54.3244	41.373
SANSAL	4960	24	7	7.0224	265	29	44.8365	-49.525
*TARR3	4333	34	34	57.7325	239	25	18.0511	655.537

STATION NAME	NUMBER	GEODETIC LATITUDE DEG	MN	SECONDS	EAST LONGITUDE DEG	MN	SECONDS	SPHEROID HEIGHT (METERS)
MERNON	3001	38	59	37.8512	282	40	17.2552	68.235
CUBCAL	2200	32	49	13.2221	242	52	7.5624	76.650
LARSON	2201	47	11	5.1398	240	39	45.3724	322.150
ARGTON	2202	43	33	57.7032	244	23	16.3544	426.001
GREENV	2333	33	25	32.3494	269	5	9.9105	-17.131
MAUIHA	2411	20	49	25.1332	203	32	2.9171	28.274
WALSEC	3006	37	51	33.6553	284	29	22.7159	-49.233
FTMART	3045	31	55	19.0479	278	25	0.4316	-29.333
MNTAFB	3046	32	0	4.5746	273	53	43.3370	-43.253
HOMEFL	3861	25	29	22.4725	279	37	39.5437	-43.715
BELTVL	3002	39	1	39.1535	283	10	27.5550	-15.259
VOLJGD	3014	39	13	20.0249	39	53	25.0171	150.000
EREVAN	3015	40	14	0.0175	44	30	0.0139	950.000
KIEVAA	3023	50	27	11.4504	30	30	7.0023	184.000
KRASNO	3027	45	1	42.0179	38	59	42.0153	40.000
NOVOSI	3035	54	59	0.0226	82	51	0.0351	150.000
RIAZAN	3042	54	38	5.0228	39	45	10.0165	114.000
TARTU	3061	58	20	0.0240	26	40	0.0102	75.000
TASHKI	3062	41	21	0.0179	69	11	12.0231	440.000
ASTRO	3100	39	1	39.9225	283	10	29.4461	-14.551
LYNNLK	3107	38	51	39.1437	253	55	59.1043	293.509
TIMINS	3113	48	33	56.2412	278	37	44.7496	231.431
1UNDAK	7034	48	1	21.5499	262	59	19.0150	203.162
1EDINB	7035	26	22	46.5326	261	40	7.3539	7.732
1COLBA	7037	38	53	35.2536	267	47	40.0790	212.513
1BERMD	7039	32	21	49.9432	295	20	25.5317	-27.000
1PURIO	7040	18	15	26.6836	294	0	23.6475	-13.350
1GSFCJ	7042	39	1	12.3679	283	10	20.5547	-5.143
1GSFCP	7043	39	1	15.1649	283	10	20.3451	-6.093
1CKVLE	7044	36	22	12.7080	274	21	16.4815	124.720
1DENVR	7045	39	35	49.1606	255	23	33.5733	1763.431
1JU424	7071	27	1	13.7718	279	53	12.6669	-37.675
1JU440	7072	27	1	14.1699	279	53	12.3402	-37.325
1JUPC1	7073	27	1	14.1050	279	53	13.0774	-38.165
1JURC4	7074	27	1	14.3249	279	53	13.1156	-37.515
1SUDBR	7075	46	27	21.5537	279	3	10.5277	221.005
1JAMAC	7076	18	4	34.4644	283	11	27.2460	404.755
1GSFCN	7077	38	59	56.3812	283	9	37.9195	-3.900
VALMOT	7078	37	51	34.6517	284	29	27.7435	-55.113
1CARVN	7079	-24	-54	-23.4102	113	42	13.5343	-12.941
GODLAS	7080	39	1	14.0964	283	10	15.5033	3.000
RCDLAS	7081	38	11	46.9792	277	7	26.1973	819.550
WALLAS	7082	37	51	34.0456	284	29	24.0379	-50.000
WODLAS	7083	39	1	13.4742	283	10	19.4139	-5.207
CRMLAS	7084	-24	-54	-16.4034	113	42	57.0331	-5.351
HOPLAS	7085	31	41	7.3706	249	7	15.4757	2317.413
HOMLA2	7086	31	41	7.3776	249	7	17.0775	2317.711
HODLA2	7087	39	1	14.6472	283	10	19.0115	-6.336

STATION NAME	NUMBER	GEODETIC LATITUDE DEG	MN	SECONDS	EAST LONGITUDE DEG	MN	SECONDS	SPHEROID HEIGHT (METERS)
SENLAS	7508	42	42	4.8750	283	10	17.5140	177.605
SFLLAS	7509	36	27	45.4155	353	47	36.0451	38.300
UPGLAS	7501	32	25	24.9351	253	26	48.6631	1600.000
QLILAS	7502	-25	-57	-36.0700	28	14	52.3526	1570.000
ARELAS	7507	-16	-27	-57.2964	268	30	24.5754	2490.000
HOPLAS	7521	31	41	3.1675	249	7	18.4533	2339.141
NATLAS	7529	-5	-55	-40.1820	324	50	7.5183	25.390
GRELAS	7530	38	4	42.3209	23	55	56.8132	490.323
BRNSCH	8004	52	34	55.3336	10	30	17.8221	91.533
DELFTH	8005	52	0	5.7805	4	22	15.2921	45.540
ZIMMLD	8010	46	52	37.1980	7	27	53.3435	931.220
WALVHN	8011	52	8	35.4362	358	1	53.8345	137.020
GOYDES	8013	53	44	1.9145	355	55	14.2154	309.627
ATHENS	8014	37	59	17.5322	23	43	54.9008	133.392
HAUTEP	8015	43	55	57.5722	5	52	44.7397	694.320
NICEFR	8019	43	43	33.0676	7	17	58.8359	405.220
MIGLAS	8021	43	55	57.6698	5	42	44.5065	674.371
SALLAS	8022	-24	-43	-46.9192	133	38	49.9508	6.293
MADONI	8030	40	48	22.6608	2	13	45.9419	190.010
EDINBR	8031	55	44	1.9145	356	46	14.2154	309.627
MUNICH	8032	47	42	5.3996	11	1	21.6075	961.709
FRANKF	8035	50	13	11.6031	8	43	46.3869	193.813
SANFLR	7504	36	27	48.7455	353	47	35.5345	55.375
HAUTLR	7515	43	55	55.7458	5	52	43.5970	686.092
IOHSAN	9001	32	25	24.5042	253	26	48.7848	1615.000
IOLPAZ	9002	-25	-57	-35.4700	28	14	52.3525	1570.000
WCUMB?	9003	-31	-5	-3.0846	136	47	2.3722	158.115
ISPAIN	9004	36	27	47.0058	353	47	36.4335	55.440
ITOKYO	9005	35	40	22.5344	139	32	16.2404	30.000
INATAL	9006	29	21	33.3227	79	27	27.3029	1956.000
IQUIPA	9007	-16	-27	-57.2954	293	30	24.5704	2490.000
ISHRAZ	9008	29	38	13.8103	52	31	11.2723	1563.900
ICURAC	9009	12	5	25.0918	291	9	44.6284	-24.000
IJUPTR	9010	27	1	13.9203	279	53	13.5704	-23.000
IVILCO	9011	-31	-35	-35.1591	294	53	30.3334	636.540
IMAUI1	9012	20	42	25.5812	203	44	34.2078	3031.815
DAKAR1	9020	14	44	37.4253	342	30	25.0005	171.000
HOPKIN	9021	31	41	2.9579	249	7	18.4533	2339.050
ALSIAK	9023	-21	-23	-25.1392	136	52	43.1465	138.405
JCOAIR	9025	36	0	19.9357	139	11	31.2353	879.000
DEREIT	9026	6	44	50.7115	35	57	32.3341	1901.300
NATAL2	9029	-5	-55	-40.1820	324	50	7.5183	25.390
SCHRIV	9031	-46	-53	-15.5413	292	23	15.3455	234.364
BRAZIL	9033	-5	-55	-40.3717	324	50	8.1541	44.000
JUPGCJ	9037	27	1	13.7235	279	53	12.9424	-39.735
AGUSNI	9038	42	30	30.8453	269	26	30.1265	131.454
ZIMIER	9039	46	52	37.2030	7	27	53.3535	933.000
NIGAL1	9041	36	36	53.3435	24	3	32.1770	-14.670

STATION NAME	NUMBER	GEODETIC LATITUDE DEG	MN	SECONDS	EAST LONGITUDE DEG	MN	SECONDS	SPHEROID HEIGHT (METERS)
UZHGOR	9077	48	38	1.4919	22	17	54.9870	204.690
GREECE	9091	36	4	44.4104	23	55	53.4356	490.320
CALHAC	9113	34	57	50.5816	242	5	7.5386	743.644
CCLAKE	9114	34	44	33.3732	249	57	22.2233	654.000
OSLJNR	9115	60	12	39.5205	10	45	2.6973	595.040
JOHNST	9117	16	44	38.4770	190	29	8.9239	-7.000
NTJOHN	9119	-43	-59	-20.1181	170	28	9.1710	1011.000
SANVTO	9120	40	36	19.5298	17	50	52.4474	144.000
EDWAFB	9420	34	57	50.5733	242	5	7.3429	729.174
POTSDM	9429	52	22	52.9199	13	3	56.7577	122.054
ZVENIG	9430	55	41	36.4111	36	45	0.7436	133.924
HELSIK	9435	60	9	42.3349	24	57	5.4209	40.000
DAKAR	9520	14	44	32.4213	342	30	25.0006	170.572
SANVIT	9120	40	36	19.5226	17	30	52.4454	144.010

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