

# **A USERS' MANUAL FOR PROGRAM GEOPAN GEODETIC PLANE ADJUSTMENT AND ANALYSIS**

**ROBIN R. STEEVES**

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**TECHNICAL REPORT  
NO. 54**

## PREFACE

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**A USERS' MANUAL FOR PROGRAM GEOPAN  
GEODETIC PLANE ADJUSTMENT AND  
ANALYSIS**

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## PREFACE

The program is a result of work done over the past few years at UNB with a major overhauling taking place during the period May to August this year. As a result of GEOPAN's youth, and although a great deal of effort has been expended in checking and debugging, the program cannot yet be absolutely guaranteed to be correct in all aspects. If the reader should find any problems or has any comments on any aspect of the package it is hoped that these will be brought to the attention of the author. User comments have played an important role in the development of GEOPAN and it is hoped that they will continue to do so.

#### ACKNOWLEDGEMENTS

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The author would like to take this opportunity to acknowledge the dedicated assistance of Miss Laurie Pach in the writing and punching of various subprograms and in the management of the corresponding disk space. Laurie's unfailing help was instrumental in completing GEOPAN. Acknowledgement is also extended to Susan Biggar for her expedient typing of this manual.



## 1. INTRODUCTION

GEOPAN is a user-oriented program package for the least-squares adjustment and analysis of small plane horizontal geodetic networks. The package is presently written in FORTRAN and is set up on the IBM system 370/158 at the University of New Brunswick in Fredericton.

This manual is simply a set of instructions with explanations on how to use the program GEOPAN. It is not a book on the theory of the least squares adjustment of geodetic networks. It is assumed herein that the reader has a certain knowledge of this subject and readers who are interested in the details of the theory behind GEOPAN are referred to the reference material.

A good indication of "what GEOPAN will do" when the specific options are selected, is given by the list of available options which is found in Chapter 3. In a sentence, GEOPAN takes observations which have been reduced for instrumental and atmospheric effects, rigorously reduces them to a specified mapping plane, and then performs a least squares adjustment on the plane. Preanalysis may also be requested. On the completion of the adjustment, several statistical tests ( $\chi^2$  test on the variance factor,  $\chi^2$  goodness of fit tests on residuals, rejection of residuals) and interpretations (error ellipses including simultaneous ellipses [6], standard deviations of adjusted distances and azimuths) are made (see Chapters 3 and 4) on the residuals and adjusted coordinates.

Various automatic checks are made on the correctness of the input data deck, the determination of the network, singularities in the normal equations, convergence and divergence. The various user options include;

- i) adjustment or preanalysis
- ii) fixed, weighted or Blaha stations (see Chapter 6)
- iii) choice of a map projection (at present in the Maritimes)
- iv) units of metres or feet
- v) confidence level
- vi) estimation of the zero error for EDM distances
- vii) rejection criterion for residuals
- viii) approximation of standard deviations of residuals
- ix) input of either covariance or weight matrix for weighted or Blaha stations
- x) reductions to observations to the mapping plane and computation of standard deviations of observations including centering errors.
- xi) maximum number of iterations
- xii) convergence criterion
- xiii) variance factor known or unknown [6]
- xiv) criteria for checking zeroth iteration misclosures
- xv) station abstracts (one page summary of each station)
- xvi) various printing of intermediate results including the entire covariance matrix of the adjusted parameters.

Various space and computational optimization procedures are employed in the solution of the normal equations by the method of Choleski including the use of a variable band-width algorithm.

## 2. BASIC USER OPTIONS

The objective of this chapter is to introduce the general structure of the input data deck and to introduce six of the most basic option codes available. The material in this chapter is all the information needed to run the program for most cases of preanalysis or adjustment. It is recommended that the reader gain a thorough understanding of this material before proceeding to Chapter 3. It should be noted here that only the input data deck is described here; the necessary Job Control Language for the use of GEOPAN as it is presently set up at UNB is described in Appendix A.

### 2.1 General Structure of the Input Data Deck

This general description of the input deck is complemented with a more complete description in Chapter 3 with a schematic summary for quick reference purposes.

The basic structure of the input deck consists of four sections. Details of these are given in section 2.2. The first section consists of exactly two cards, the title card and the codes card. The second section gives specific information on the fixed, weighted or Blaha stations. (See Chapter 6 for a description of the terms fixed, weighted and Blaha.) The third section contains the approximate coordinates and other information for each station. The fourth section contains the observations.

### 2.2 Details of the Four Basic Sections of the Input Data Deck

Each of the four basic sections of the input deck are described in detail as entities in themselves. Then the four sections

are put together in the form of a specific example.

### 2.2.1 The First Section of the Input Deck; Title and Codes Cards.

This section consists of two cards. The first of these two cards is a title card. The user may punch any desired title on this card from columns 1 - 80 inclusive. The title card may be left blank but it may not be left out! This card results in having a title printed on the printed output and also since it is the first card in the deck, it makes a good identifier for the deck itself. See Figure 2.1 for an example of the title card.

The second of these two cards is the codes card. It is with this card that the user may select any of several options by punching numbers in the correct columns. The first six options are described in Table 2-1a.

COLUMN(S)	NUMBER	SELECTED OPTION
2	0	adjustment
	1	preanalysis
3-6	n	number of fixed stations
7-10	n	number of weighted stations
11-14	n	number of Blaha stations
16	0	no map projection used
	1	NB double stereographic
	2	PEI double stereographic
	4	NS 3° Transverse Mercator, Zone 4
	5	NS 3° Transverse Mercator, Zone 5
18	0	linear units metres
	1	linear units feet

TABLE 2-1a Six of the Options which may be selected on the Codes Card

TRAVERSE # 073 - YORK STREET FROM KING TO VICTORIA - FOR LOT # 20134 - JUNE 1978

4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80

FIGURE 2.1 EXAMPLE OF THE TITLE CARD: THE FIRST CARD OF THE DATA DECK.

Some explanation is in order here. First, it should be mentioned that zeros need not be punched on the codes card. That is, attention need only be given to specific options needed which require a non-zero number punched in a certain column. For example, if the user wishes to perform an adjustment, column 2 may be left blank. However, if a preanalysis is desired, a 1 must be punched in column 2. Actually any other number punched in column 2 will result in (default to) an adjustment request. Most other options have this default feature; they are all described later in Chapter 3.

The options for which more than one column is reserved require that the corresponding number be punched in the right-most column(s), that is they must be right-justified. For example, if the user wishes to hold 2 stations fixed in the adjustment (or preanalysis) a 2 must be punched in column 6. If 12 stations are to be weighted, the 12 is punched in columns 9 and 10.

The linear units are specified in column 18. If distances and approximate coordinates are supplied to GEOPAN in units of metres a 0 (zero) may be punched in this column although it may be left blank as was mentioned earlier. If linear units are feet a 1 must be punched in column 18.

In addition to the six basic option codes described in Table 2-1a the user must specify which reductions are to be made to the observations if a specific map projection is selected. These option codes are described below in Table 2-1b. (For having the reduction corrections printed see Chapter 3).

Column	Number	Selected Option
48	0	- <u>Terrain to Ellipsoid</u> reduction correction not made to observations.
	1	- Terrain to ellipsoid reduction corrections made
50	0	- <u>Ellipsoid to mapping plane</u> reduction corrections not made to observations
	1	- Ellipsoid to plane reduction corrections made
52	0	- Reduction corrections not made for azimuths.
	1	- Reduction corrections are made for azimuths.

TABLE 2-1b Options for Observation Reduction Corrections.

Two examples of the codes card are illustrated in Figures 2.2 and 2.3.

#### 2.2.2 The Second Section of the Input Deck; Fixed, Weighted and Blaha Information.

Only the number of fixed, weighted or Blaha Stations was specified on the codes card. In the second section of the input deck more information is given for these stations. Thus this section consists of three possible sub-sections; one for the fixed stations if any, one for the weighted stations (if any) and one for the Blaha stations (if any).

The sub-section for fixed stations must only be present if there is one or more fixed stations specified on the codes card. This sub-section always has as its first card a card with FIXED punched in columns 1-5 with columns 6-80 blank. Similarly, the sub-sections for

4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
	2																		

FIGURE 2.2 EXAMPLE OF THE CODES CARD

- OPTIONS SELECTED:
- ADJUSTMENT (column 2 is blank)
  - TWO FIXED STATIONS (2 punched in column 6)
  - NO WEIGHTED STATIONS (columns 7-10 are blank)
  - NO BLAHA STATIONS (columns 11-14 are blank)
  - NO MAP PROJECTION (column 16 is blank)
  - LINEAR UNITS ARE METRES (column 18 is blank)



A diagram of a codes card, which is a punch card used for data processing. The card is rectangular with a notch in the top-left corner. It consists of a grid of 80 columns and approximately 15 rows. The top row is labeled with column numbers from 1 to 80 in increments of 4. Above the grid, the following numbers are punched into specific columns: 1 (column 2), 1 (column 6), 2 (column 10), 1 (column 14), 4 (column 16), 1 (column 18), 1 (column 48), 1 (column 50), and 1 (column 52).

FIGURE 2.3 EXAMPLE OF THE CODES CARD

- OPTIONS SELECTED:
- Preanalysis (1 punched in column 2)
  - 1 Fixed Station (1 punched in column 6)
  - 2 Weighted Stations (2 punched in column 10)
  - 1 Blaha Station (1 punched in column 14)
  - Map Projection used is Nova Scotia 3 degree transverse mercator Zone 4 (4 punched in column 16)
  - Linear units are feet (1 punched in column 18)
  - All observation corrections are made (1's punched in columns 48, 50 and 52)

weighted or Blaha stations must only be present if one or more weighted or Blaha stations are specified on the codes card. These sub-sections always begin with a card with WEIGHTED or BLAHA punched in columns 1-8 and 1-5 respectively. The order in which these three sub-sections appear is also important. This order is FIXED, WEIGHTED, BLAHA. Any combination of fixed, weighted or Blaha stations may be selected with the restriction that any one station may have only one of these specifications. For example a station may not be both fixed and Blaha held. The first card of each of these sub-sections is illustrated in later examples.

The next (second) card in each of these sub-sections is a card (or cards) specifying which stations are fixed, weighted or Blaha held. That is, the station names are punched on the card. Station names may consist of any combination of numbers and/or characters with a maximum length of eight. An example of the second section of the input deck for the case when only fixed stations are used is shown in FIGURE 2.4. It can be seen there that the station names are punched in columns 1-8 for the first, 11-18 for the second, 21-28 for the third, and so on. Station names must always be left-justified. Thus for the example of FIGURE 2.4, stations STATION1 and 4321 are held fixed. If more than eight stations are fixed (or weighted or Blaha held), an additional card or cards are used.

For weighted or Blaha stations the covariance matrix (or weight matrix; see Chapter 3) is input following the cards with the station names. Since the covariance matrix is symmetric, only the upper-

FIXED																				
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
STATION1 4321																				
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80

FIGURE 2.4 EXAMPLE OF THE SECOND SECTION OF THE INPUT DECK FOR THE CASE OF FIXED STATIONS ONLY.

triangular portion need be punched on cards. Each row of the covariance matrix is typed on a card (or cards) beginning with the diagonal element. Each card will hold 8 elements punched in F10.3 format. As an example, if the covariance matrix to be input is;

$$\begin{array}{cccc}
 0.35 \times 10^{-1} & 0.85 \times 10^{-2} & -0.93 \times 10^{-2} & 0.39 \times 10^{-2} \\
 0.85 \times 10^{-2} & 0.46 \times 10^{-1} & 0.97 \times 10^{-2} & -0.62 \times 10^{-2} \\
 -0.93 \times 10^{-2} & 0.97 \times 10^{-2} & 0.52 \times 10^{-1} & 0.93 \times 10^{-2} \\
 0.39 \times 10^{-2} & -0.62 \times 10^{-2} & 0.93 \times 10^{-2} & 0.13 \times 10^{-1}
 \end{array}$$

it would be punched on cards as shown in FIGURE 2.5. If any one row of the covariance matrix contains more than eight upper-triangular elements the row is continued on another card.

An example of the second section for the case of one fixed station (STATION1) two weighted stations (STATION2 and 345678) and one Blaha station (12B) is shown in FIGURE 2.6.

### 2.2.3 The Third Section of the Input Deck; Stations, Approximate Coordinates, etc.

This section of the input deck must always begin with a card with the word STATIONS punched in columns 1-8 and end with a card with -9 punched in columns 1 and 2. Between these two cards there must be exactly one card for each station in the network. Each card must have the station name and its (approximate) plane coordinates, X and Y, punched in the proper columns. Other information, if available, may be punched on this card: orthometric height, geoid-ellipsoid separation and deflection of the vertical components.



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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
FIXED																																																																															
STATION 1																																																																															
WEIGHTED																																																																															
STATION 2																																																																															
											3	4	5	6	7	8																																																															
				0.35D-1				0.85D-2				-0.93D-2				0.39D-2																																																															
				0.46D-1				0.97D-2				-0.62D-2																																																																			
				0.52D-1				0.93D-2																																																																							
				0.13D-1																																																																											
BLAHA																																																																															
L2B																																																																															
											0.93D-2				0.31D-2																																																																
											0.53D-2																																																																				

FIGURE 2.6 EXAMPLE OF THE SECOND SECTION OF THE INPUT DECK

All data punched on these station cards may be left justified for ease in key punching. As a reminder, station names must be left-justified. Also, all numerical data punched on the card must have their decimal point punched in the proper position when they are left-justified. Table 2-2 below is a summary of the format of the station cards.

COLUMN	INFORMATION	UNITS	FORMAT USED
1-2	blank	-	-
3-10	Station name	-	A8
11-25	Easting (X-coordinate)	metres or feet	F15.3
26-40	Northing (Y-coordinate)	metres or feet	F15.3
41-50	orthometric height	metres or feet	F10.3
51-60	geoid-ellipsoid separation	metres or feet	F10.3
61-70	deflection component (north)	arc seconds	F10.3
71-80	deflection component (east)	arc seconds	F10.3

TABLE 2-2 Format of the station cards data

An example of the third section of the input deck is illustrated in Figure 2.7.





#### 2.2.4 The Fourth Section of the Input Deck; Observation Cards

This section of the input deck must always begin with a card with the word OBSERVATIONS punched in columns 1-12 (actually only the first 8 characters, i.e. OBSERVAT, are required) and end with a card with -9 punched in columns 1 and 2. Between these two cards there must be one card for each distance, direction, angle and azimuth observation.

Table 2-3 is a summary of the format required for punching cards for distance observations.

COLUMNS	INFORMATION	UNITS	FORMAT used
1-5	observation code (1)	-	I5
11-18	from station name	-	A8
21-28	to station name	-	A8
41-50	standard deviation	metres or feet	F10.3
51-60	parts per million error	-	F10.3
61-70	distance observed	metres or feet	F10.3

TABLE 2-3 Format of the Distance Observation Cards

Of course if a preanalysis is being performed the distance observed need not be punched on the card. The observation code is 1 for distance observations.

Table 2-4 is a summary of the format required for direction observations.

COLUMNS	INFORMATION	UNITS	FORMAT used
1-5	observation code (+2)	-	I5
11-18	from station name	-	A8
21-28	to station name	-	A8
41-50	standard deviation	arc-seconds	F10.3
51-60	degrees of observation	degrees	F10.3
61-70	minutes of observation	minutes	F10.3
71-80	seconds of observation	arc-seconds	F10.3

TABLE 2-4 Format of the Direction Observation Cards

The observation code for direction observations is listed in TABLE 2-4 as  $\pm 2$ . Actually, only the last direction in a bundle is given the code -2, all others +2 or just 2. This method makes it possible for the user to arrange direction observations in any order as long as all directions in any one bundle are placed together with the smallest magnitude direction (usually 0 - 0 - 0) first. This is the only constraint on the user, otherwise observations (distances, directions, angles and azimuths) may be placed in this section of the input deck in any order. When punching degrees, minutes and seconds for any of the angular observations (directions, angles and azimuths) always include the decimal point.

Again, as with all of the observations, the observation itself need not be punched on the card if a preanalysis is being performed.

Table 2-5 is a summary of the format required for angle observations. The user should remember that these angle observations are uncorrelated,

(if correlated angles are desired they must be input as directions).

COLUMNS	INFORMATION	UNITS	FORMAT used
1-5	Observation code (3)	-	I5
11-18	At station name	-	A8
21-28	From station name	-	A8
31-38	To station name	-	A8
41-50	Standard deviation	arc-seconds	F10.3
51-60	Degrees of observation	degrees	F10.3
61-70	Minutes of observation	minutes	F10.3
71-80	Seconds of observation	arc-seconds	F10.3

TABLE 2-5 Format of the Angle Observation Cards

The notation AT, FROM, TO for angle observations is described with the aid of FIGURE 2.8. The AT station is the station at which the instrument is set up. The FROM and TO stations must be such that the observed angle is measured from the FROM station clockwise to the TO station.

Table 2-6 is a summary of the format required for azimuth observations.

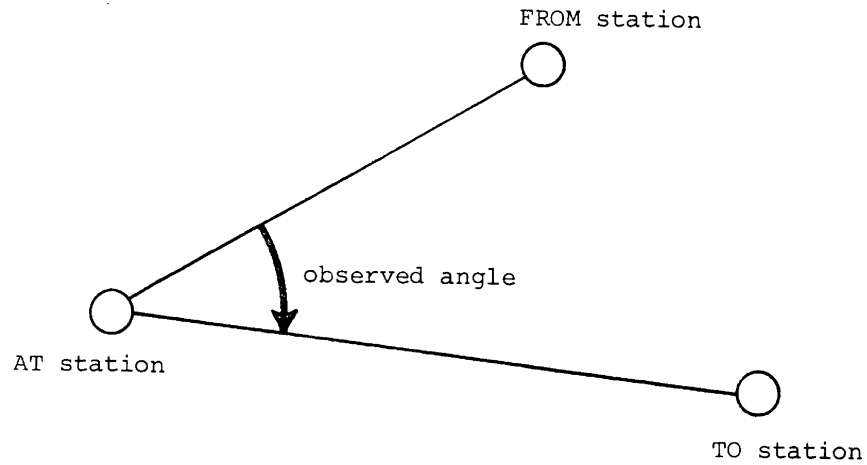


FIGURE 2.8 AT, FROM, TO terminology

COLUMNS	INFORMATION	UNITS	FORMAT used
1-5	Observation code (4)	-	I5
11-18	From station name	-	A8
21-28	To station name	-	A8
41-50	Standard deviation	arc-seconds	F10.3
51-60	Degrees of observation	degrees	F10.3
61-70	Minutes of observation	minutes	F10.3
71-80	Seconds of observation	arc-seconds	F10.3

TABLE 2-6 Format of the Azimuth Observation Card.

An example of the fourth section of the input deck is illustrated in Figure 2.9 showing a case in which at least one of each of the four types of observations are made.

Figure 2.10 shows an example of an entire input deck in which all four sections are present in the correct order.





### 3. MORE OPTIONS

In chapter 2 nine of the user options were introduced. At present there are a total of 33 options available to the user which may all be selected by punching the proper numbers in the correct columns of the codes card. Also in chapter 2, four basic sections of the input data deck were described. Actually there are three additional sections which may be present if the corresponding options are selected. It is the objective of this chapter to describe the additional options and sections of the input deck and their use and to provide tabular summaries of this information for quick reference.

The additional sections of the input deck are introduced in Figure 3.1. These are described below as separate entities.

#### 3.1 The CRITERIA Section of the Input Deck

In this section of the input deck the user may specify values for the convergence criterion, confidence level for testing and error ellipses, centering errors, and angular and linear misclosure criteria if the default values are not suitable. Subsets of these values may be specified, that is if only the confidence level need be specified it is possible to have only this value read from this card.

The criteria section consists of exactly two punched cards; one card with CRITERIA punched in columns 1-8 and one card with the specific value or values of the criteria which the user wishes to change from default values. Whether any specific value is read from the criteria card is specified on the codes card. The corresponding options on the codes card are summarized in Table 3-1.



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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
						}	TITLE AND CODES CARDS (SEE CHAPTER 2)																																													}	COMPULSORY																										
FIXED							}	FIXED STATION INFORMATION (SEE CHAPTER 2)																																													}	OPTIONAL																									
WEIGHTED								}	WEIGHTED STATION INFORMATION (SEE CHAPTER 2)																																													}	OPTIONAL																								
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CRITERIA								}	CONVERGENCE, CONFIDENCE, CENTERING, ANGULAR AND LINEAR MISCLOSEURE CRITERIA (CH 3)																																													}		OPTIONAL																							
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-9								}	SUBSET(S) OF STATIONS FOR SIMULTANEOUS ELLIPSES																																													}		OPTIONAL																							

FIGURE 3.1 SUMMARY OF THE STRUCTURE OF THE ENTIRE INPUT DECK

COLUMN	NUMBER	OPTION
46	0	- Default convergence criterion of 0.001
	1	- Convergence criterion is read.
24	0	- Default of 95.0% for testing and error ellipses
	1	- Confidence level is read
	2	- Confidence level is 39.4% (Standard)
42	0	- Default of zero for centering errors
	1	- Centering errors for the 4 types of observations are read.
70	0	- Misclosure criteria defaults of LINEAR = 100.0 m/328.0 ft. ANGULAR = 36000.0 arc seconds
	1	- Misclosure criteria are read

TABLE 3-1 Codes card options corresponding to the CRITERIA section of the input deck.

As an example suppose the user wishes to specify 0.1 (metres or feet) as the convergence criterion for the solution vector. To do so a 1 must first be punched in column 46 of the codes card and second the value 0.1 punched on the criteria card in the proper columns. The format for punching values on the criteria card is summarized in Table 3-2.

COLUMNS	INFORMATION	UNITS	FORMAT used
1-10	Convergence criterion	metres/feet	F10.3
11-20	Confidence level	%	F10.3
21-30	Centering error for distance observations	metres/feet	F10.3
31-40	Centering error for direction observations	metres/feet	F10.3
41-50	Centering error for angle observations	metres/feet	F10.3
51-60	Centering error for azimuth observations	metres/feet	F10.3
71-80	Misclosure criterion for distance observations	metres/feet	F10.3
61-70	Misclosure criterion for angular observations	arc-seconds	F10.3

TABLE 3-2 Format of data on the criterion card.

The user must remember that if the centering error option is used, values desired for the four types of observations must all be punched on the criteria card. The same applies to the misclosure criteria. (However, if a value of zero is desired for any one of them, the corresponding columns may be left blank).

If the absolute value of any misclosure on the zeroth iteration is larger than the misclosure criterion, program execution is terminated with the corresponding information printed.

### 3.2 The FACTORS Section of the Input Deck.

In this section of the input deck the user may specify that the standard deviations of the observations, as they were input on punched cards, be multiplied by a factor as specified on the factors card.

The factors section consists of exactly two cards; the first being a card with FACTORS punched in columns 1-7 and the second being the factors card with the specific aforementioned factors punched in the proper columns.

The factors option was created expressly for preanalysis runs where it is not uncommon to alter standard deviations of observations in order to meet accuracy specifications for the parameters. Using the factors option the user need not re-punch the observation cards unless changes are required in the relative magnitudes of standard deviations of any one observation type.

The factors option is selected by first punching a 1 in column 26 of the codes card and second by punching the corresponding factors on the factors card as described in TABLE 3-3.

The only restriction on the factors is that none of those for angular observations may be zero and those for distances may not both be zero.

### 3.3 The SIMULTANEOUS Section of the Input Deck

In this section of the input deck the user may specify subsets of the network for which simultaneous error ellipses [6] are required.

COLUMNS	INFORMATION	FORMAT used
1-10	Factor for standard deviations of <u>distance</u> observations	F10.3
11-20	Factor for parts per million errors for <u>distance</u> observations	F10.3
21-30	Factor for standard deviations of <u>direction</u> observations	F10.3
31-40	Factor for standard deviations of <u>angle</u> observations	F10.3
41-50	Factor for standard deviations of <u>azimuth</u> observations	F10.3

TABLE 3-3 Format of the factors card

The section consists of one card with SIMULTANEOUS punched in columns 1-12 (only the first eight characters are actually required) and cards with the names of those stations in the subset desired, the last card of which having -9 punched in columns 1 and 2. (Remember that it is the last card with station names on it that has the -9 punched on it). The simultaneous option is selected by punching a 1 in column 22 of the codes card.

It is possible to request more than one subset of the network for simultaneous ellipses. This is done by simply repeating the SIMULTANEOUS section. The format of the simultaneous station names card is given in TABLE 3-4.

Examples of the SIMULTANEOUS section of the input deck are illustrated in FIGURES 3.2 and 3.3.

COLUMNS	INFORMATION	FORMAT used
1-2	-9 (last card of subset only)	
11-18	Name of a station in the subset	A8
21-28	"	"
31-38	"	"
41-48	"	"
.	.	.
.	.	.
.	.	.
71-78	"	"

TABLE 3-4 Format of the Simultaneous Stations Card(s)

### 3.4 Summary of options

On the following pages all of the 33 available options are listed in the order that they are punched on the codes card. In the first column of these tables the codes are simply numbered. In the second column the names of the codes as they exist in GEOPAN are given. In the third column the number to be punched on the codes card is given first, then an explanation of the code is given. In the upper right corner of the third column of this table the column(s) of the codes card in which the numbers are to be punched for the specific option are given. All defaults of the options are marked with an asterisk.

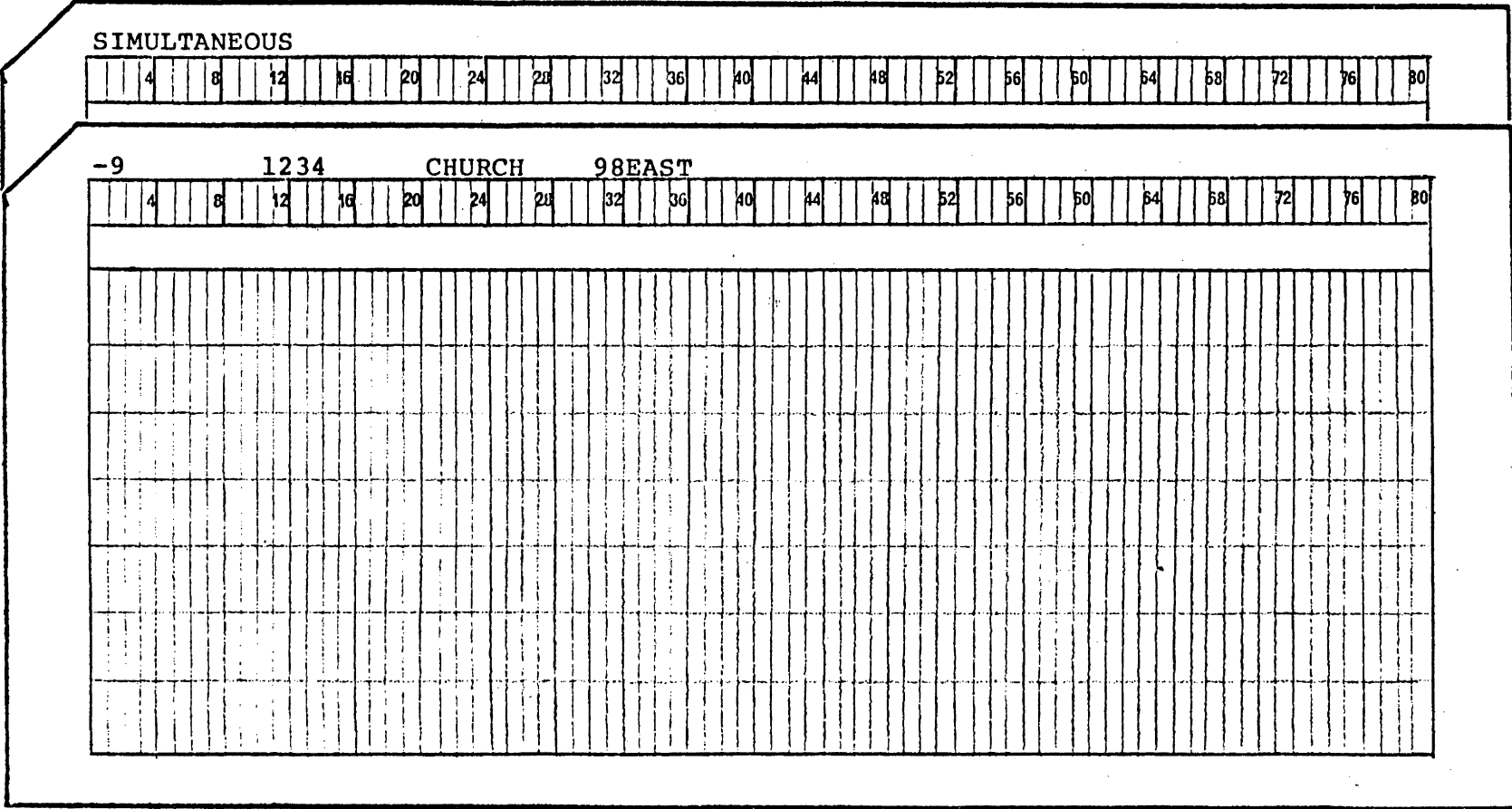


FIGURE 3.2 EXAMPLE OF THE 'SIMULTANEOUS' SECTION OF THE INPUT DECK FOR THE CASE OF 3 STATIONS

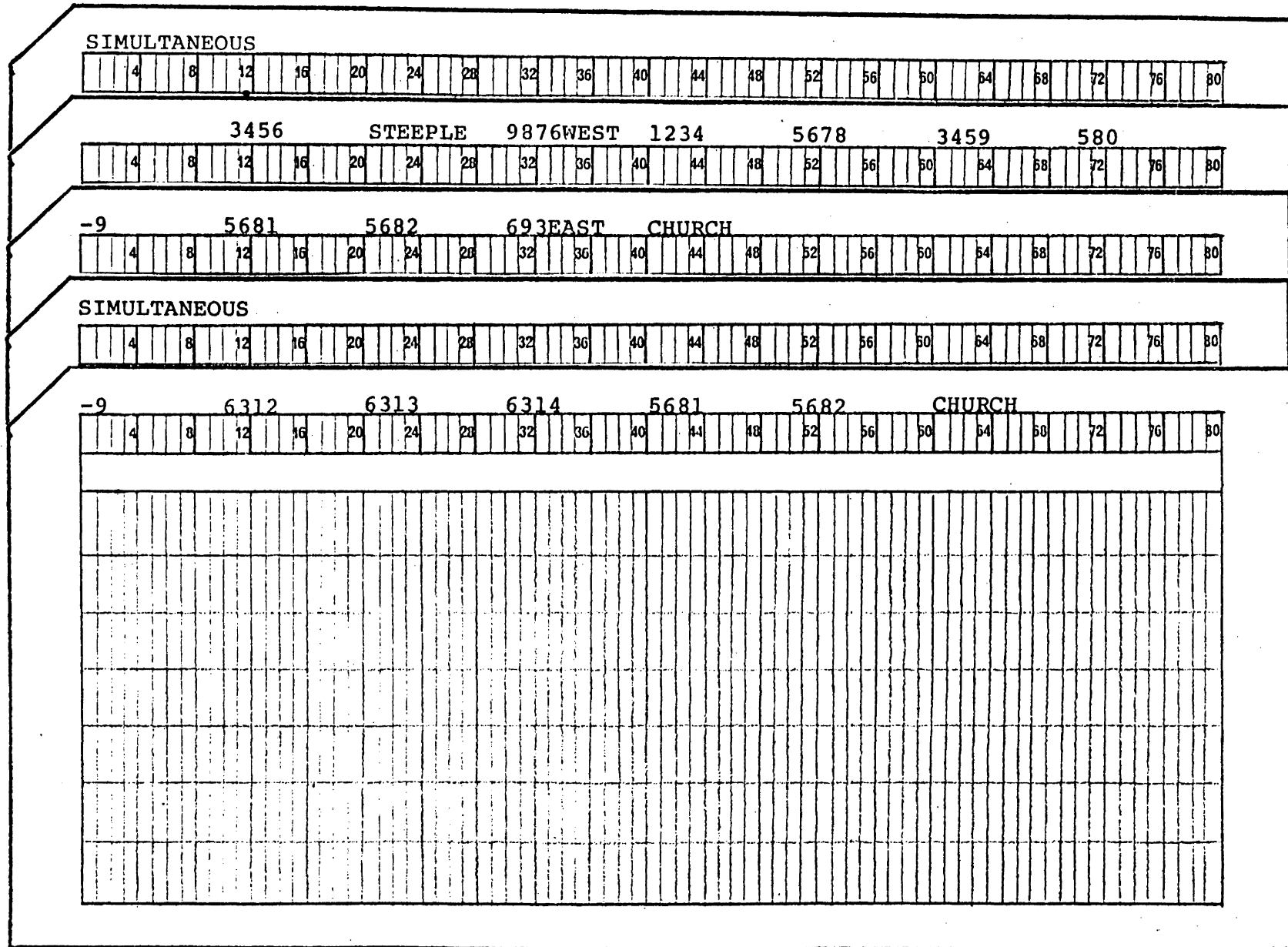


FIGURE 3.3 EXAMPLE OF THE 'SIMULTANEOUS' SECTION OF THE INPUT DECK FOR THE CASE OF TWO SUBSETS: ONE WITH 11 STATIONS, ONE WITH 6



Explanations of some of the options which have not been previously described are given below.

The NZERO option is used to estimate the zero error when distance observations are made. The zero error may be defined as a systematic error present in all distance observations which may result from a poor calibration of the EDM being used.

The NSRES option defaults to using the standard deviations of the observations as the standard deviations of the residuals. The alternative of this option is to use Pope's approximation [ 2 ] in computing standard deviations of residuals.

The NMULT option is used to multiply the inverse of the normal equations by the estimated variance factor. If a 1 is punched in column 40 the inverse of the normal equations is actually multiplied element by element by the estimated variance factor.

The NABST option may be used to have station abstracts printed in the case of an adjustment using a specific map projection. This option is not available if the adjustment was performed using no map projection. See Chapter 4 for an example of a printed abstract.

#	Code Name	Options and defaults (*)
1	NCODE	0 - ADJUSTMENT* 1 - PREANALYSIS 2
2	NF	0 - NO FIXED STATIONS* n - # OF FIXED STATIONS 3 - 6
3	NP	0 - NO WEIGHTED STATIONS* n - # OF WEIGHTED STATIONS 7 - 10
4	NB	0 - NO BLAHA STATIONS* n - # OF BLAHA STATIONS 11 - 14
5	NPROJ	0 - NO PROJECTION* 1 - NB STEREOGRAPHIC 2 - PEI 4 - NS 3° TM ZONE 4 5 - NS 3° TM ZONE 5 16
6	NUNIT	0 - METRE* 1 - FOOT 18
7	NELPS	0 - ALL ERROR ELLIPSES* 1 - STATION ELLIPSES ONLY 2 - RELATIVE ONLY 20
8	NSIMU	0 - NO SPECIAL SUBSETS OF* SIMULTANEOUS ELLIPSES 1 - <u>READ</u> SUBSETS OF STATIONS FOR WHICH SIMULTANEOUS (STATION AND RELATIVE) ELLIPSES ARE DESIRED. 22

#	Code Name	Options and defaults (*)	
9	NSTAN	0 - ALL TESTING AND ELLIPSES AT 95.0%* 1 - <u>READ</u> (1- $\alpha$ ) 2 - STANDARD	24
10	NFAC	0 - FACTORS FOR $\sigma_{OBS}$ SET TO UNITY* 1 - THESE FACTORS ARE <u>READ</u>	26
11	NZERO	0 - DO NOT ESTIMATE ZERO ERROR FOR DISTANCES* 1 - ESTIMATE ZERO ERROR	28
12	NTEST	(REJECTION CRITERION FOR RESIDUALS) 0 - TAU MAX* 1 - TAU NON-MAX 2 - NORMAL MAX 3 - NORMAL NON-MAX 4 - STUDENTS T MAX 5 - STUDENTS T NON-MAX	30
13	NSRES	0 - USE $\sigma_{OBS}$ FOR NORMALIZING RESIDUALS* 1 - USE $\hat{\sigma}_r$ (POPE'S APPROXIMATION)	32
14	NCOV	0 - COVARIANCE MATRIX READ FOR WEIGHTED STATIONS* 1 - WEIGHT MATRIX READ	34
15	NCOVB	0 - COVARIANCE MATRIX READ FOR 'BLAHA' STATIONS* 1 - WEIGHT MATRIX READ	36
16	NCORR	0 - NO OUTPUT OF REDUCTION CORRECTIONS TO OBSERVATIONS* 1 - PRINT THESE CORRECTIONS	38

#	Code Name	Options and defaults (*)	
17	NMULT	0 - DO NOT MULTIPLY $N^{-1}$ BY $\hat{\sigma}_O^2$ * 1 - MULTIPLY $N^{-1}$ BY $\hat{\sigma}_O^2$	40
18	NCENT	0 - NO CENTERING ERROR* 1 -- CENTERING ERROR FOR THE 4 TYPES OF OBSERVATIONS <u>READ</u>	42
19	NDELX	0 - PRINT ALL ITERATION CORRECTIONS TO COORDINATES* 1 - PRINT THEM ONLY ON ZERO <sup>TH</sup> ITERATION	44
20	NCRIT	0 - DEFAULT CONVERGENCE CRITERION OF 0.001* 1 - READ CONVERGENCE CRITERION	46
21	NRED1	0 - NO <u>TERRAIN TO ELLIPSOID</u> CORRECTIONS MADE TO OBS* 1 - YES (IF NPROJ $\neq$ 3 or $\neq$ 0)	48
22	NRED2	0 - NO <u>ELLIPSOID TO PLANE</u> CORRECTIONS TO OBS* 1 - YES (IF NPROJ $\neq$ 3 or $\neq$ 0)	50
23	NRED3	0 - NO <u>AZIMUTH</u> REDUCTIONS MADE* 1 - MAKE AZIMUTH REDUCTIONS IF NRED1 AND NRED2 ARE BOTH NOT ZERO	52
24	NITER	0 - DEFAULT OF 5 ITERATIONS MAXIMUM* n - # OF MAXIMUM ITERATIONS -1 - ONLY ZERO <sup>TH</sup> ITERATION ALLOWED	54

#	Code Name	Options and defaults (*)	
25	NPRA	0 - DO NOT PRINT DESIGN MATRIX A* 1 - PRINT A ON 0 <sup>TH</sup> ITERATION 2 - PRINT A ON ALL ITERATIONS	56
26	NPRN	0 - DO NOT PRINT NORMAL EQUATION MATRIX N* 1 - PRINT N ON 0 <sup>TH</sup> ITERATION 2 - PRINT N ON ALL ITERATIONS	58
27	NPRW	0 - DO NOT PRINT MISCLOSURE VECTOR W (OTHER THAN IN SUMMARY). * 1 - PRINT W ON 0 <sup>TH</sup> ITERATION 2 - PRINT W ON ALL ITERATIONS	60
28	NPRU	0 - DO NOT PRINT CONSTANT VECTOR U* 1 - PRINT U ON 0 <sup>TH</sup> ITERATION 2 - PRINT U ON ALL ITERATIONS	62
29	NPRCX	0 - DO NOT PRINT THE COVARIANCE MATRIX C <sub>X</sub> OF THE ADJUSTED PARAMETERS* 1 - PRINT C <sub>X</sub>	64
30	NSORT	0 - DO NOT PRINT CHOLESKI SQUARE ROOT T* 1 - PRINT T ON 0 <sup>TH</sup> ITERATION 2 - PRINT T ON ALL ITERATIONS	66
31	NVARF	0 - $\sigma_0^2$ UNKNOWN * 1 - $\sigma_0^2$ KNOWN	68
32	NMISC	0 - USE DEFAULTS OF LINEAR = 100.0 m/328.0 ft ANGULAR = 36000.0 seconds FOR CHECKING MISCLOSURES 1 - <u>READ</u> THESE CRITERIA	70

#	Code Name	Options and defaults (*)
33	NABST	0 - NO ABSTRACTS OF STATIONS* 1 - PRINT ABSTRACTS 72

#### 4. PRINTED OUTPUT

Although the printed output is mostly self explanatory, a clarification of some aspects may be needed. Each page of a print-out of a specific adjustment example is included at the end of this chapter and comments on them are given. (The print-outs for the preanalysis case and the case which uses no map projection are subsets of the case to be discussed here.)

The first page of the print-out is always a title page. The title, which was input on the title card, is printed first enclosed by a border of asterisks. Just below this title the date and time of the run is printed with the time in the format: hours, minutes and seconds. The remainder of this printed page summarizes the options in effect. The fixed, weighted and Blaha stations are listed under the corresponding titles. If there are no fixed stations, for example, the word NONE is printed. The word NONE therefore, should not be used as a station name. All other information on the printed page should be self-explanatory. It should be noted however, that not all of the options in effect are listed here. It is obvious that these are in effect though, from the corresponding subsequent printed output.

The second page of the printed output is a summary of the specifications of the map projection being used if any.

The next page is an echo of the input approximate coordinates. Also printed on this page are the orthometric height, geoid height (height of the geoid above the reference ellipsoid), the deflection of the vertical components (in the order: north component, east component), the

computed latitude and longitude (longitudes are taken as positive east of Greenwich), the computed point scale factor and meridian convergence. The latitude, longitude and meridian convergence are all printed in the format; degrees, minutes and seconds. On this page the stations are separated according to whether they are free, fixed weighted or Blaha stations. A simpler print out of the approximate coordinates results when no map projection is used.

The following page summarizes the reduction of observations from the terrain to the reference ellipsoid if a specific projection is being used. The type of observation and the stations between which the observation is made are printed in the first few columns (as they are when observations are printed throughout the printed output). As well as the observation type being printed, the directions in each bundle are numbered. The AT, FROM, TO terminology was explained in Chapter 2 (for distances, directions and azimuths the AT and FROM stations are the same and are printed this way). The observed value is then listed along with the various computed reduction corrections and the reduced observation (on the ellipsoid). The titles of the actual reduction correction columns have been abbreviated. The title GRAVIMETRIC stands for the so called gravimetric corrective term or deflection of the vertical term [5]. Its units are arc-seconds. The title SKEW NORMAL stands for the skew normal correction which is the geometrical correction resulting from the height of the target above the reference ellipsoid [5]. Its units are arc-seconds. The title TO GEODESIC stands for the normal section to geodesic correction [5]. Its units are arc-seconds. The title AZIMUTH



stands for the corrective term  $-\eta \tan \phi$  for azimuths, where  $\eta$  is the east component of the deflection of the vertical and  $\phi$  is the latitude of the station at which the azimuth was observed. Its units are arc-seconds. The title SPATIAL TO CHORD is the corrective term for distances in reducing them from spatial distances to a chord (of the reference ellipsoid) distance and the title CHORD TO EL stands for the corrective term in reducing the chord distance to an ellipsoidal distance. Both of these latter corrections are in units of metres or feet.

The next page of the printed output is a summary of the reduction of the observations from the ellipsoid to the mapping plane. This page is similar to the previous one and is self explanatory.

Following this an echo of the input information matrices for weighted or Blaha stations, if any is given. The columns of the matrix are labelled immediately above the matrix with the column number (eg. (col 2)). The name of the station to which each pair of columns pertain along with the labels X and Y are also printed. Row numbers are printed along the left side of the matrix. The maximum of six columns and 50 rows are printed on one page.

Next a summary of the input and reduced observations is given along with the zeroth iteration misclosures.

The next page gives a compacted printing of the design matrix if this option was selected. The coefficients of the design matrix are labelled with the station to which they correspond along with a reminder that the coefficient for the x-coordinate of that station is given first. If a station has been fixed or Blaha held the title FIXED is also printed.

Following this is a printout of the normal equation matrix (if this option was selected) printed in the same format as described earlier for the weighted or Blaha information matrix. Only the upper triangular portion of the normal equation matrix is computed, thus only these elements are printed. Zeros are printed below the diagonal.

The next pages are a listing of the misclosure elements, a listing of the constant vector elements, and a print of the Choleski square root if these options were selected.

Then a summary of the iterative corrections to the initial approximate coordinates is printed. Then the final adjusted coordinates are printed (if convergence has been reached). The residuals are then printed along with their standard deviations (computed from Pope's approximation or just taken to be equal to the observation standard deviations). All misclosures and residuals for angular observations are in units of arc seconds.

The next page is a summary of the rejection of residuals. The reader is reminded in the event that residuals are flagged for rejection; observations corresponding to rejected residuals have been used in the adjustment.

Following this is a summary of some statistical information. A summary of the computation of the degrees of freedom is given in tabular form. In this table under the "number of observations" column, the COORDINATES term refers to the number of weighted stations multiplied by two.

The following pages are summaries of  $\chi^2$  goodness of fit tests on the standardized residuals, error ellipses, the covariance matrix of the parameters (if requested) and station abstracts if requested, these being all self explanatory.

```

*****
*
*   EXAMPLE #16W - CLOSED TRAVERSE - N.B. - DIRECTIONS, DISTANCES - WEIGHTED STATIONS
*
*****
WED, NOV. 28, 1979   14:14:53

```

O P T I O N S I N E F F E C T

---

```

PREANALYSIS OR ADJUSTMENT ..... ADJUSTMENT

FIXED STATIONS          WEIGHTED STATIONS          BLAHA STATIONS
  NONE                  KNOWN1                     NONE
                       KNOWN2
                       KNOWN3
                       KNOWN4

WEIGHTED WEIGHT OR COVARIANCE MATRIX READ? ..... COVARIANCE MATRIX
MAP PROJECTION ..... NEW BRUNSWICK DOUBLE STEREOGRAPHIC
CONVENTIONAL LINEAR UNIT ..... METRE
TEST USED FOR REJECTION OF RESIDUALS ..... MAXIMUM TAU
MULTIPLY INVERSE OF NORMAL EQUATIONS BY ESTIMATED VARIANCE FACTOR? ..... YES
MAXIMUM NUMBER OF ITERATIONS ALLOWED ..... 5
CRITERION FOR SOLUTION CONVERGENCE ..... 0.001000
MAKE OBSERVATION REDUCTIONS (TERRAIN TO ELLIPSOID)? ..... YES
MAKE OBSERVATION REDUCTIONS (ELLIPSOID TO MAPPING PLANE)? ..... YES
REDUCTIONS FROM TERRIAN TO MAPPING PLANE MADE FOR AZIMUTHS ..... YES

```

SPECIFICATIONS OF THE MAP PROJECTION

PROJECTION USED : NEW BRUNSWICK DOUBLE STEREOGRAPHIC

ORIGIN : LATITUDE= 46 30 0.0 ; LONGITUDE= -66 30 0.0  
EASTING (X)= 300000.000 METRES ; NORTHING (Y)= 800000.000 METRES

SCALE AT THE ORIGIN : 0.9999120

REFERENCE ELLIPSOID : CLARK 1866

SEMI-MAJOR AXIS= 6378206.400 METRES

SEMI-MINOR AXIS= 6356583.800 METRES

TRANSLATION COMPONENTS (FROM GEOCENTRE) USED:

XO= -15.000 METRES

YO= 150.000 METRES

ZO= 180.000 METRES

INITIAL APPROXIMATE COORDINATES

FREE STATIONS:

STATION	X (EASTING)	Y (NORTHING)	ORTHOMETRIC HEIGHT	GEOID HEIGHT	DEFLECTION COMPONENTS	LATITUDE	LONGITUDE	POINT SCALE	MERIDIAN CONVERGENCE
1005	302770.000	800655.000	291.000	0.500	2.0 -1.0	46 30 21.19	-66 27 50.07	0.999912	0 1 34.3
1006	302820.000	800945.000	298.000	-0.800	2.1 -1.2	46 30 30.59	-66 27 47.72	0.999912	0 1 36.0
1007	303160.000	800865.000	248.000	-0.600	2.0 -1.0	46 30 27.99	-66 27 31.77	0.999912	0 1 47.5
1003	303265.000	800645.000	312.000	0.200	2.0 -1.1	46 30 20.86	-66 27 26.85	0.999912	0 1 51.1
1004	303570.000	800915.000	372.000	-0.900	1.9 -1.2	46 30 29.60	-66 27 12.54	0.999912	0 2 1.5

WEIGHTED STATIONS:

STATION	X (EASTING)	Y (NORTHING)	ORTHOMETRIC HEIGHT	GEOID HEIGHT	DEFLECTION COMPONENTS	LATITUDE	LONGITUDE	POINT SCALE	MERIDIAN CONVERGENCE
KNOWN1	302640.000	801160.000	325.000	-1.400	2.0 -1.0	46 30 37.55	-66 27 56.16	0.999912	0 1 29.8
KNOWN2	302530.000	800935.000	312.000	-0.200	2.0 -1.0	46 30 30.27	-66 28 1.32	0.999912	0 1 26.1
KNOWN3	303660.000	800630.000	419.000	0.600	2.0 -1.0	46 30 20.37	-66 27 8.33	0.999912	0 2 4.5
KNOWN4	303635.000	800355.000	386.000	1.200	2.1 -1.0	46 30 11.46	-66 27 9.51	0.999912	0 2 3.7

SUMMARY OF REDUCTION OF OBSERVATIONS FROM TERRAIN TO ELLIPSOID

	AT	FROM	TO	OBSERVED	GRAVI- METRIC	SKEW NORMAL	TO GE- ODESIC	AZI- MUTH TO	SPATIAL TO CHORD	CHORD TO EL	REDUCED OBSERVATION
DISTANCE	KNOWN2	KNOWN2	1005	369.387					-0.576	0.000	368.811
DISTANCE	1005	1005	1006	294.367					-0.069	0.000	294.298
DISTANCE	1006	1006	1007	352.861					-3.547	0.000	349.314
DISTANCE	1007	1007	1003	252.269					-8.475	0.000	243.794
DISTANCE	1003	1003	1004	411.634					-4.258	0.000	407.376
DISTANCE	1004	1004	KNOWN3	302.828					-3.928	0.000	298.900
DIRECTION 1	KNOWN2	KNOWN2	KNOWN1	0 0 0.0	-0.084	0.013	-0.000				0 0 0.0
DIRECTION 2	KNOWN2	KNOWN2	1005	113 20 45.000	0.030	-0.015	0.000				113 20 45.085
DIRECTION 1	1005	1005	KNOWN2	0 0 0.0	0.030	-0.016	0.000				0 0 0.0
DIRECTION 2	1005	1005	1006	50 22 59.000	-0.026	0.005	-0.000				50 22 58.966
DIRECTION 1	1006	1006	1005	0 0 0.0	-0.030	0.005	-0.000				0 0 0.0
DIRECTION 2	1006	1006	1007	273 27 30.000	0.252	-0.006	0.000				273 27 30.271
DIRECTION 1	1007	1007	1006	0 0 0.0	0.245	-0.007	0.000				0 0 0.0
DIRECTION 2	1007	1007	1003	231 14 48.000	0.011	-0.013	0.000				231 14 47.761
DIRECTION 1	1003	1003	1007	0 0 0.0	0.035	-0.010	0.000				0 0 0.0
DIRECTION 2	1003	1003	1004	73 59 49.000	-0.322	0.019	-0.000				73 59 48.672
DIRECTION 1	1004	1004	1003	0 0 0.0	-0.321	0.016	-0.000				0 0 0.0
DIRECTION 2	1004	1004	KNOWN3	293 59 30.000	0.093	-0.012	0.000				293 59 30.385
DIRECTION 1	KNOWN3	KNOWN3	1004	0 0 0.0	0.057	-0.011	0.000				0 0 0.0
DIRECTION 2	KNOWN3	KNOWN3	KNOWN4	202 43 5.000	-0.138	0.004	-0.000				202 43 4.819

SUMMARY OF REDUCTION OF OBSERVATIONS FROM ELLIPSOID TO MAPPING PLANE

---

	AT	FROM	TO	OBSERVATION (ON ELLIPSOID)	MERIDIAN CONVERGENCE	ARC TO CHORD	LINE SCALE	REDUCED OBSERVATION
DISTANCE	KNOWN2	KNOWN2	1005	368.811			0.9999120	368.779
DISTANCE	1005	1005	1006	294.298			0.9999121	294.272
DISTANCE	1006	1006	1007	349.314			0.9999121	349.284
DISTANCE	1007	1007	1003	243.794			0.9999121	243.772
DISTANCE	1003	1003	1004	407.376			0.9999121	407.341
DISTANCE	1004	1004	KNOWN3	298.900			0.9999121	298.874
DIRECTION 1	KNOWN2	KNOWN2	KNOWN1	0 0 0.0		0 0 0.00		0 0 0.0
DIRECTION 2	KNOWN2	KNOWN2	1005	113 20 45.09		0 0 -0.00		113 20 45.09
DIRECTION 1	1005	1005	KNOWN2	0 0 0.0		0 0 0.00		0 0 0.0
DIRECTION 2	1005	1005	1006	50 22 58.97		0 0 0.00		50 22 58.97
DIRECTION 1	1006	1006	1005	0 0 0.0		0 0 -0.00		0 0 0.0
DIRECTION 2	1006	1006	1007	273 27 30.27		0 0 -0.00		273 27 30.27
DIRECTION 1	1007	1007	1006	0 0 0.0		0 0 0.00		0 0 0.0
DIRECTION 2	1007	1007	1003	231 14 47.76		0 0 -0.00		231 14 47.76
DIRECTION 1	1003	1003	1007	0 0 0.0		0 0 0.00		0 0 0.0
DIRECTION 2	1003	1003	1004	73 59 48.67		0 0 0.00		73 59 48.67
DIRECTION 1	1004	1004	1003	0 0 0.0		0 0 -0.00		0 0 0.0
DIRECTION 2	1004	1004	KNOWN3	293 59 30.39		0 0 -0.00		293 59 30.39
DIRECTION 1	KNOWN3	KNOWN3	1004	0 0 0.0		0 0 0.00		0 0 0.0
DIRECTION 2	KNOWN3	KNOWN3	KNOWN4	202 43 4.82		0 0 -0.00		202 43 4.82



A PRIORI COVARIANCE MATRIX

-----

	***** KNOWN1 *****		***** KNOWN2 *****		***** KNOWN3 *****	
	X	Y	X	Y	X	Y
	(COL 1)	(COL 2)	(COL 3)	(COL 4)	(COL 5)	(COL 6)
1	0.43200000-04	0.43600000-05	0.34700000-04	0.28700000-06	0.28400000-04	0.68400000-05
2	0.43600000-05	0.64400000-04	-0.95800000-05	0.52700000-04	-0.62600000-05	0.58700000-04
3	0.34700000-04	-0.55800000-05	0.38600000-04	-0.42900000-05	0.30500000-04	-0.67800000-05
4	0.28700000-06	0.52700000-04	-0.42900000-05	0.72100000-04	-0.22800000-05	0.73000000-04
5	0.28400000-04	-0.62600000-05	0.30500000-04	-0.22800000-05	0.41500000-04	-0.69800000-05
6	0.68400000-05	0.58700000-04	-0.67800000-05	0.73000000-04	-0.69800000-05	0.87700000-04
7	0.27300000-04	0.72000000-05	0.21300000-04	0.90500000-05	0.31600000-04	0.15500000-04
8	0.12400000-04	0.34400000-04	0.46900000-05	0.44400000-04	0.77300000-05	0.52100000-04

\*\*\*\*\* KNCWN4 \*\*\*\*\*

	X	Y
	(COL 7)	(COL 8)
1	0.27300000-04	0.12400000-04
2	0.72000000-05	0.34400000-04
3	0.21300000-04	0.46900000-05
4	0.90500000-05	0.44400000-04
5	0.31600000-04	0.77300000-05
6	0.15500000-04	0.52100000-04
7	0.44300000-04	0.43600000-05
8	0.43600000-05	0.64300000-04

\*\*\* WARNING \*\*\* MORE STATION CONSTRAINTS THAN THE MINIMUM NECESSARY ARE BEING USED

SUMMARY OF INPUT OBSERVATIONS, REDUCED OBSERVATIONS AND INITIAL MISCLOSURES:

	AT	FROM	TO	OBSERVED	STD.DEV	REDUCED OBS	MISCLOSURE
DISTANCE	KNCWN2	KNCWN2	1005	369.387	0.006	368.779	0.003
DISTANCE	1005	1005	1006	294.367	0.004	294.272	0.006
DISTANCE	1006	1006	1007	352.861	0.004	349.284	0.001
DISTANCE	1007	1007	1003	252.269	0.004	243.772	0.000
DISTANCE	1003	1003	1004	411.634	0.006	407.341	-0.002
DISTANCE	1004	1004	KNOWN3	302.828	0.004	298.874	-0.001
DIRECTION 1	KNOWN2	KNOWN2	KNOWN1	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	KNCWN2	KNOWN2	1005	113 20 45.00	2.50	113 20 45.09	-2.33
DIRECTION 1	1005	1005	KNOWN2	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	1005	1005	1006	50 22 59.00	2.50	50 22 58.97	2.36
DIRECTION 1	1006	1006	1005	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	1006	1006	1007	273 27 30.00	2.50	273 27 30.27	-1.06
DIRECTION 1	1007	1007	1006	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	1007	1007	1003	231 14 48.00	2.50	231 14 47.76	-3.57
DIRECTION 1	1003	1003	1007	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	1003	1003	1004	73 59 49.00	2.50	73 59 48.67	1.04
DIRECTION 1	1004	1004	1003	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	1004	1004	KNOWN3	293 59 30.00	2.50	293 59 30.39	-2.21
DIRECTION 1	KNCWN3	KNOWN3	1004	0 0 0.0	2.50	0 0 0.0	0.0
DIRECTION 2	KNOWN3	KNOWN3	KNOWN4	202 43 5.00	2.50	202 43 4.82	7.17

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 DESIGN MATRIX A (ITERATION # 0)  
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DISTANCE	KNCWN2 (X,Y)	1005 (X,Y)
	-0.6507914D+00 0.7592566D+00	0.6507914D+00 -0.7592566D+00
DISTANCE	1005 (X,Y)	1006 (X,Y)
	-0.1699069D+00 -0.9854601D+00	0.1699069D+00 0.9854601D+00
DISTANCE	1006 (X,Y)	1007 (X,Y)
	-0.9734172D+00 0.2290393D+00	0.9734172D+00 -0.2290393D+00
DISTANCE	1007 (X,Y)	1003 (X,Y)
	-0.4307296D+00 0.9024810D+00	0.4307296D+00 -0.9024810D+00
DISTANCE	1003 (X,Y)	1004 (X,Y)
	-0.7487622D+00 -0.6628387D+00	0.7487622D+00 0.6628387D+00
DISTANCE	1004 (X,Y)	KNOWN3 (X,Y)
	-0.3011314D+00 0.9535827D+00	0.3011314D+00 -0.9535827D+00
DIRECTION 1	KNCWN2 (X,Y)	KNOWN1 (X,Y)
	-0.7358897D+03 0.3617239D+03	0.7358897D+03 -0.3617239D+03
DIRECTION 2	KNOWN2 (X,Y)	1005 (X,Y)
	0.4246628D+03 0.3639967D+03	-0.4246628D+03 -0.3639967D+03
DIRECTION 1	1005 (X,Y)	KNOWN2 (X,Y)
	-0.4246628D+03 -0.3639967D+03	0.4246628D+03 0.3639967D+03
DIRECTION 2	1005 (X,Y)	1006 (X,Y)
	-0.6907251D+03 0.1190905D+03	0.6907251D+03 -0.1190905D+03
DIRECTION 1	1006 (X,Y)	1005 (X,Y)
	0.6907251D+03 -0.1190905D+03	-0.6907251D+03 0.1190905D+03
DIRECTION 2	1006 (X,Y)	1007 (X,Y)
	0.1352556D+03 0.5748363D+03	-0.1352556D+03 -0.5748363D+03
DIRECTION 1	1007 (X,Y)	1006 (X,Y)
	-0.1352556D+03 -0.5748363D+03	0.1352556D+03 0.5748363D+03
DIRECTION 2	1007 (X,Y)	1003 (X,Y)
	0.7636223D+03 0.3644561D+03	-0.7636223D+03 -0.3644561D+03
DIRECTION 1	1003 (X,Y)	1007 (X,Y)

		-0.7636223D+03	-0.3644561D+03	0.7636223D+03	0.3644561D+03
DIRECTION	2	1003	(X,Y)	1004	(X,Y)
		-0.3356426D+03	0.3791518D+03	0.3356426D+03	-0.3791518D+03
DIRECTION	1	1004	(X,Y)	1003	(X,Y)
		0.3356426D+03	-0.3791518D+03	-0.3356426D+03	0.3791518D+03
DIRECTION	2	1004	(X,Y)	KNOWN3	(X,Y)
		0.6581077D+03	0.2078235D+03	-0.6581077D+03	-0.2078235D+03
DIRECTION	1	KNOWN3	(X,Y)	1004	(X,Y)
		-0.6581077D+03	-0.2078235D+03	0.6581077D+03	0.2078235D+03
DIRECTION	2	KNOWN3	(X,Y)	KNOWN4	(X,Y)
		0.7439059D+03	-0.6762781D+02	-0.7439059D+03	0.6762781D+02

NORMAL EQUATION MATRIX (ITERATION # 0)

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	***** 1005	*****	***** 1006	*****	***** 1007	*****
	X	Y	X	Y	X	Y
	(COL 1)	(COL 2)	(COL 3)	(COL 4)	(COL 5)	(COL 6)
1	0.70597013D+05	-0.76206625D+04	-0.46985438D+05	0.31662324D+05	-0.74739556D+04	-0.31764311D+05
2	0.0	0.98496682D+05	0.22768999D+05	-0.64675392D+05	0.12886130D+04	0.54766054D+04
3	0.0	0.0	0.11564424D+06	-0.33683057D+05	-0.53455518D+05	0.27084213D+05
4	0.0	0.0	0.0	0.12230776D+06	-0.37141762D+05	-0.77860461D+05
5	0.0	0.0	0.0	0.0	0.17310158D+06	0.62094686D+05
6	0.0	0.0	0.0	0.0	0.0	0.15697611D+06
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0

	***** 1003 *****		***** 1004 *****		***** KNOWN3 *****	
	X	Y	X	Y	X	Y
	(COL 7)	(COL 8)	(COL 9)	(COL 10)	(COL 11)	(COL 12)
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.82627364D+04	0.3943578E0+04	0.0	0.0	0.0	0.0
4	0.3511E+30D+05	0.16760210D+05	0.0	0.0	0.0	0.0
5	-0.9166776E0+05	-0.45403E41D+05	-0.20504335D+05	0.23162304D+05	0.0	0.0
6	-0.47626428D+05	-0.95646588D+05	-0.978E1597D+04	0.11054736D+05	0.0	0.0
7	0.94890C59D+05	0.27674E19D+05	0.61860905D+04	-0.95823672D+04	-0.17671118D+05	-0.55803530D+04
8	0.0	0.1238E584D+06	-0.21760750D+04	-0.51302798D+05	0.19961818D+05	0.63037321D+04
9	0.0	0.0	0.70917415D+05	0.12516110D+05	-0.95764785D+05	0.30066353D+04
10	0.0	0.0	0.0	0.10333415D+06	-0.38464135D+05	-0.61961719D+05
11	0.0	0.0	0.0	0.0	0.57001127D+06	0.34670789D+06
12	0.0	0.0	0.0	0.0	0.0	0.52102533D+06
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0

##### KNCWN4 ##### ##### KNOWN1 ##### ##### KNOWN2 #####

	X (COL 13)	Y (COL 14)	X (COL 15)	Y (COL 16)	X (COL 17)	Y (COL 18)
1	0.0	0.0	0.251362930+05	-0.122888540+05	-0.412739120+05	0.202115040+05
2	0.0	0.0	0.215453940+05	-0.105333040+05	-0.377823430+05	-0.287647920+05
3	0.0	0.0	0.0	0.0	-0.234660220+05	-0.201137340+05
4	0.0	0.0	0.0	0.0	0.404586590+04	0.346788510+04
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.391656140+05	-0.356051030+04	0.0	0.0	0.0	0.0
10	0.123680880+05	-0.112437170+04	0.0	0.0	0.0	0.0
11	-0.361342750+06	-0.135646580+06	-0.408464500+05	0.803473870+04	-0.501482410+05	-0.213790290+06
12	-0.277758890+06	-0.149634440+06	-0.153668490+06	0.277662070+05	0.897062420+05	-0.349240820+06
13	0.296757660+06	0.117255580+06	0.524599240+04	-0.168417410+04	0.309273850+05	0.160662870+06
14	0.0	0.920642050+05	0.316409230+04	-0.981889080+03	0.142299460+05	0.776005890+05
15	0.0	0.0	0.305277130+06	-0.965986600+05	-0.299323290+06	0.191761130+06
16	0.0	0.0	0.0	0.757969040+05	0.109302360+06	-0.699303440+05
17	0.0	0.0	0.0	0.0	0.406128080+06	-0.143151760+06
18	0.0	0.0	0.0	0.0	0.0	0.359865190+06



MISCLOSURE VECTOR ELEMENTS (ITERATION # 0)

	AT	FROM	TO	MISCLOSURE
DISTANCE	KNOWN2	KNOWN2	1005	0.28844305D-02
DISTANCE	1005	1005	1006	0.64536503D-02
DISTANCE	1006	1006	1007	0.14554406D-02
DISTANCE	1007	1007	1003	0.12920485D-03
DISTANCE	1003	1003	1004	-0.17005363D-02
DISTANCE	1004	1004	KNOWN3	-0.12556576D-02
DIRECTION 1	KNOWN2	KNOWN2	KNOWN1	0.0
DIRECTION 2	KNOWN2	KNOWN2	1005	-0.23309016D+01
DIRECTION 1	1005	1005	KNOWN2	0.0
DIRECTION 2	1005	1005	1006	0.23600859D+01
DIRECTION 1	1006	1006	1005	0.0
DIRECTION 2	1006	1006	1007	-0.10645540D+01
DIRECTION 1	1007	1007	1006	0.0
DIRECTION 2	1007	1007	1003	-0.35677059D+01
DIRECTION 1	1003	1003	1007	0.0
DIRECTION 2	1003	1003	1004	0.10387064D+01
DIRECTION 1	1004	1004	1003	0.0
DIRECTION 2	1004	1004	KNOWN3	-0.22091885D+01
DIRECTION 1	KNOWN3	KNOWN3	1004	0.0
DIRECTION 2	KNOWN3	KNOWN3	KNOWN4	0.71683335D+01
COORDINATES	KNOWN1	.....	(X) (Y)	0.0 0.0
COORDINATES	KNOWN2	.....	(X) (Y)	0.0 0.0
COORDINATES	KNOWN3	.....	(X) (Y)	0.0 0.0
COORDINATES	KNOWN4	.....	(X) (Y)	0.0 0.0

CONSTANT VECTOR ELEMENTS (ITERATION # 0)

STATION	(X)	(Y)
1 1005	-0.42592445D+02	-0.23647032D+03
2 1006	0.20231831D+03	0.45009737D+03
3 1007	-0.23730259D+03	-0.26024926D+03
4 1003	0.22509193D+03	0.25422938D+03
5 1004	-0.41748002D+03	-0.34817095D+03
6 KNCWN3	0.89958081D+03	0.18279747D+03
7 KNCWN4	-0.42660522D+03	0.38782293D+02
8 KNCWN1	0.13796881D+03	-0.67451416D+02
9 KNCWN2	-0.34497957D+03	-0.13564569D+02

CHOLESKI SQUARE ROOT (ITERATION # 0)

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##### 1005      #####      ##### 1006      #####      ##### 1007      #####
      X          Y          X          Y          X          Y
      (COL  1)    (COL  2)    (COL  3)    (COL  4)    (COL  5)    (COL  6)
1  0.26570098D+03 -0.29434074D+02 -0.17683577D+03  0.11916525D+03 -0.28129198D+02 -0.11954909D+03
2  0.0              0.31245883D+03  0.56212212D+02 -0.19576299D+03  0.14742939D+01  0.62657490D+01
3  0.0              0.0              0.28457989D+03 -0.56358650D+01 -0.20532199D+03  0.19620492D+02
4  0.0              0.0              0.0              0.26410697D+03 -0.13122825D+03 -0.23580288D+03
5  0.0              0.0              0.0              0.0              0.33605086D+03  0.54649809D+02
6  0.0              0.0              0.0              0.0              0.0              0.27874417D+03
7  0.0              0.0              0.0              0.0              0.0              0.0
8  0.0              0.0              0.0              0.0              0.0              0.0
9  0.0              0.0              0.0              0.0              0.0              0.0
10 0.0              0.0              0.0              0.0              0.0              0.0
11 0.0              0.0              0.0              0.0              0.0              0.0
12 0.0              0.0              0.0              0.0              0.0              0.0
13 0.0              0.0              0.0              0.0              0.0              0.0
14 0.0              0.0              0.0              0.0              0.0              0.0
15 0.0              0.0              0.0              0.0              0.0              0.0
16 0.0              0.0              0.0              0.0              0.0              0.0
17 0.0              0.0              0.0              0.0              0.0              0.0
18 0.0              0.0              0.0              0.0              0.0              0.0

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\*\*\*\*\* 1003

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\*\*\*\*\* 1004

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\*\*\*\*\* KNOWN3

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	X (COL 7)	Y (COL 8)	X (COL 9)	Y (COL 10)	X (COL 11)	Y (COL 12)
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.28994103D+02	0.1383EC95D+02	0.0	0.0	0.0	0.0
4	0.1335E238D+03	0.6375E225D+02	0.0	0.0	0.0	0.0
5	-0.20250042D+03	-0.1136E163D+03	-0.61015571D+02	0.68924996D+02	0.0	0.0
6	0.89913553D+01	-0.25158115D+03	-0.14389709D+02	0.16255042D+02	0.0	0.0
7	0.18656450D+03	-0.1092E367D+02	-0.32437235D+02	0.22765758D+02	-0.94515900D+02	-0.29847126D+02
8	0.0	0.20808208D+03	-0.62888022D+02	-0.18805279D+03	0.90968498D+02	0.28726894D+02
9	0.0	0.0	0.24895858D+03	0.23568994D+02	-0.37399711D+03	0.15444555D+02
10	0.0	0.0	0.0	0.24876021D+03	-0.41770318D+02	-0.22609752D+03
11	0.0	0.0	0.0	0.0	0.64123642D+03	0.52649173D+03
12	0.0	0.0	0.0	0.0	0.0	0.43675746D+03
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0

KNCW4

KNCW1

KNOW2

	X (COL 13)	Y (COL 14)	X (COL 15)	Y (COL 16)	X (COL 17)	Y (COL 18)
1	0.0	0.0	0.94603687D+02	-0.46250691D+02	-0.15533970D+03	0.76068609D+02
2	0.0	0.0	0.77866150D+02	-0.38067895D+02	-0.13555266D+03	-0.84893692D+02
3	0.0	0.0	0.43344417D+02	-0.21190604D+02	-0.15199642D+03	-0.66321179D+01
4	0.0	0.0	0.15956116D+02	-0.78007678D+01	-0.18310247D+02	-0.84258549D+02
5	0.0	0.0	0.40290876D+02	-0.19697762D+02	-0.11242574D+03	-0.30215409D+02
6	0.0	0.0	0.35589733D+02	-0.17399425D+02	-0.30191379D+02	-0.26018641D+02
7	0.0	0.0	0.23891420D+02	-0.11680250D+02	-0.83902786D+02	0.25689985D+02
8	0.0	0.0	0.58521317D+02	-0.28610421D+02	-0.86601793D+02	-0.20145755D+02
9	0.15731779D+03	-0.14301617D+02	0.29827284D+02	-0.14582228D+02	-0.62106539D+02	-0.10129704D+02
10	0.34313713D+02	-0.2164E30D+01	0.25738162D+02	-0.12583102D+02	-0.18781557D+02	-0.69147018D+01
11	-0.46946702D+03	-0.22008660D+03	-0.49406923D+02	0.55425818D+01	-0.11573349D+03	-0.33252758D+03
12	-0.57551591D+02	-0.78431066D+02	-0.28222880D+03	0.51977494D+02	0.33733884D+03	-0.39864199D+03
13	0.21694E11D+03	0.54271037D+02	-0.18336711D+03	0.30613369D+02	0.29642357D+02	-0.76344730D+02
14	0.0	0.18524273D+03	-0.10465002D+03	0.12981975D+02	0.68342833D+02	-0.12347929D+03
15	0.0	0.0	0.39118268D+03	-0.15894237D+03	-0.38371673D+03	0.10236014D+03
16	0.0	0.0	0.0	0.20144785D+03	0.32654689D+02	-0.14485559D+03
17	0.0	0.0	0.0	0.0	0.16382421D+03	0.67969874D+01
18	0.0	0.0	0.0	0.0	0.0	0.12094629D+03

SUMMARY OF ITERATIVE CORRECTIONS TO INITIAL APPROXIMATE COORDINATES:

ITERATION # 0						
STATION	OLD X	OLD Y	DX	DY	NEW X	NEW Y
1005	302770.000	800655.000	-0.00072	0.00097	302769.999	800655.001
1006	302820.000	800945.000	-0.00490	-0.00391	302819.995	800944.996
1007	303160.000	800865.000	-0.00344	0.00059	303159.997	800865.001
1003	303265.000	800645.000	-0.00387	0.00022	303264.996	800645.000
1004	303570.000	800915.000	0.00146	0.00298	303570.001	800915.003
KNCWN3	303660.000	800630.000	-0.00249	0.00041	303659.998	800630.000
KNCWN4	303635.000	800355.000	-0.00035	-0.00272	303635.000	800354.997
KNCWN1	302640.000	801160.000	-0.00055	0.00051	302639.999	801160.001
KNCWN2	302530.000	800935.000	-0.00024	-0.00012	302530.000	800935.000

ITERATION # 1						
STATION	OLD X	OLD Y	DX	DY	NEW X	NEW Y
1005	302769.999	800655.001	0.00000	-0.00000	302769.999	800655.001
1006	302819.995	800944.996	0.00000	-0.00000	302819.995	800944.996
1007	303159.997	800865.001	0.00000	-0.00000	303159.997	800865.001
1003	303264.996	800645.000	0.00000	-0.00000	303264.996	800645.000
1004	303570.001	800915.003	0.00000	-0.00000	303570.001	800915.003
KNCWN3	303659.998	800630.000	0.00000	-0.00000	303659.998	800630.000
KNCWN4	303635.000	800354.997	-0.00000	0.00000	303635.000	800354.997
KNCWN1	302639.999	801160.001	0.00000	-0.00000	302639.999	801160.001
KNCWN2	302530.000	800935.000	0.00000	-0.00000	302530.000	800935.000

F I N A L   A D J U S T E D   C O O R D I N A T E S

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F R E E   S T A T I O N S :

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STATION	X (EASTING)	Y (NORTHING)	LATITUDE	LONGITUDE	POINT SCALE	MERIDIAN CONVERGENCE
1005	302769.559	800655.001	46 30 21.19396	-66 27 50.07151	0.9999120	0 1 34.25
1006	302819.555	800544.996	46 30 30.52569	-66 27 47.72010	0.9999121	0 1 35.96
1007	303159.557	800865.001	46 30 27.98933	-66 27 31.77332	0.9999121	0 1 47.53
1003	303264.996	800645.000	46 30 20.86207	-66 27 26.85364	0.9999121	0 1 51.09
1004	303570.001	800915.003	46 30 29.60146	-66 27 12.53975	0.9999121	0 2 1.48

W E I G H T E D   S T A T I O N S :

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STATION	X (EASTING)	Y (NORTHING)	LATITUDE	LONGITUDE	POINT SCALE	MERIDIAN CONVERGENCE
KNOWN1	302635.559	801160.001	46 30 37.55196	-66 27 56.15892	0.9999121	0 1 29.84
KNOWN2	302530.000	800935.000	46 30 30.26607	-66 28 1.32335	0.9999120	0 1 26.09
KNOWN3	303659.558	800630.000	46 30 20.36894	-66 27 8.32633	0.9999121	0 2 4.53
KNOWN4	303635.000	800354.997	46 30 11.46251	-66 27 9.50660	0.9999121	0 2 3.67

SUMMARY OF REDUCED OBSERVATIONS, RESIDUALS AND ADJUSTED OBSERVATIONS:

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		AT	FROM	TO	REDUCED OBS	STD.DEV	RESIDUAL	STD.DEV	ADJ.OBSERVATION
1	DISTANCE	KNOWN2	KNOWN2	1005	368.779	0.009	0.002	0.002	368.781
2	DISTANCE	1005	1005	1005	294.272	0.004	0.001	0.001	294.273
3	DISTANCE	1006	1006	1007	349.284	0.004	0.002	0.002	349.285
4	DISTANCE	1007	1007	1003	243.772	0.004	0.000	0.001	243.773
5	DISTANCE	1003	1003	1004	407.341	0.006	0.004	0.002	407.345
6	DISTANCE	1004	1004	KNOWN3	298.874	0.004	0.000	0.001	298.874
7	DIRECTION	1	KNOWN2	KNOWN2	0 0 0.0	2.50	1.03	0.87	0 0 0.0
8	DIRECTION	2	KNOWN2	KNOWN2	113 20 45.09	2.50	-1.03	0.87	113 20 43.02
9	DIRECTION	1	1005	1005	0 0 0.0	2.50	-0.12	0.87	0 0 0.0
10	DIRECTION	2	1005	1005	50 22 53.97	2.50	0.12	0.87	50 22 59.21
11	DIRECTION	1	1006	1006	0 0 0.0	2.50	0.77	0.87	0 0 0.0
12	DIRECTION	2	1006	1006	273 27 30.27	2.50	-0.77	0.87	273 27 28.73
13	DIRECTION	1	1007	1007	0 0 0.0	2.50	0.16	0.87	0 0 0.0
14	DIRECTION	2	1007	1007	231 14 47.76	2.50	-0.16	0.87	231 14 47.44
15	DIRECTION	1	1003	1003	0 0 0.0	2.50	-0.66	0.87	0 0 0.0
16	DIRECTION	2	1003	1003	73 59 48.67	2.50	0.66	0.87	73 59 49.99
17	DIRECTION	1	1004	1004	0 0 0.0	2.50	-0.09	0.87	0 0 0.0
18	DIRECTION	2	1004	1004	293 59 30.39	2.50	0.09	0.87	293 59 30.57
19	DIRECTION	1	KNOWN3	KNOWN3	0 0 0.0	2.50	-1.11	0.87	0 0 0.0
20	DIRECTION	2	KNOWN3	KNOWN3	202 43 4.82	2.50	1.11	0.87	202 43 7.05



SUMMARY OF REJECTION OF RESIDUALS AT THE 95.000 % CONFIDENCE LEVEL

(TAU MAX CRITERION USED)

COMPUTED FACTOR FOR STANDARD DEVIATION OF RESIDUAL = 1.7277

REJECTED RESIDUALS:

OBSERVATION	AT	FROM	TO	RESIDUAL	STD.DEV RESIDUAL	CRITICAL POINT	
5 DISTANCE	1003	1003	1004	0.0041	0.0022	0.0038	REJECT

1 RESIDUALS ( 5 % OF THE OBSERVATIONS) WERE FLAGGED FOR REJECTION

\*\*\*\* WARNING \*\*\*\* OBSERVATIONS CORRESPONDING TO REJECTED RESIDUALS HAVE BEEN USED IN THIS ADJUSTMENT

-----  
 STATISTICS SUMMARY  
 -----

NUMBER OF ITERATIONS REQUIRED FOR CONVERGENCE --> 1  
 MAXIMUM NUMBER OF ITERATIONS ALLOWED -----> 5

NUMBER OF OBSERVATIONS		NUMBER OF UNKNOWN	
DISTANCES	0	ZERO ERROR	0
DIRECTIONS	14	ORIENTATION	7
ANGLES	0		
AZIMUTHS	0		
COORDINATES	8	COORDINATES	18
TOTALS	28		25

THE NUMBER OF DEGREES OF FREEDOM IS 3

ESTIMATED VARIANCE FACTOR= 0.812170

-----  
 CHI-SQUARE TEST ON THE VARIANCE FACTOR  
 -----

(VARIANCE FACTOR KNOWN)

0.260413 < 1.000000 < 11.291317 ?

TEST ON VARIANCE FACTOR AT THE 95.000 % CONFIDENCE LEVEL PASSES  
 -----

( 1 RESIDUALS WERE FLAGGED FOR REJECTION )

CHI-SQUARE GOODNESS OF FIT TEST

ON THE STANDARDIZED DIRECTION, ANGLE AND AZIMUTH RESIDUALS

THE NUMBER OF CLASSES IS 2  
THE NUMBER OF DEGREES OF FREEDOM FOR THE TEST IS 1

SUMMARY OF THE COMPUTATION OF THE CHI-SQUARE STATISTIC

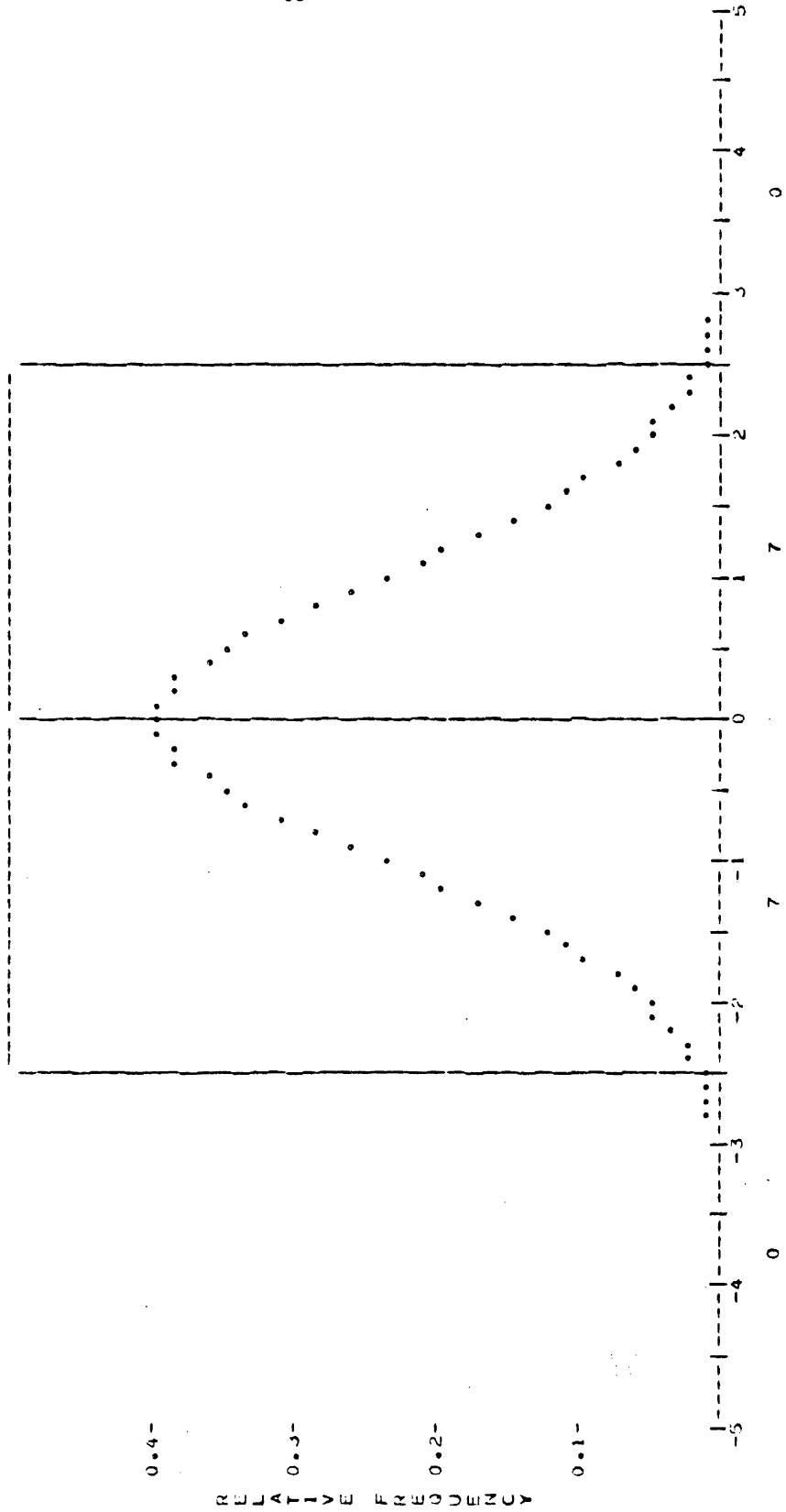
CLASS INTERVAL	OBSERVED FREQ.(O)	EXPECTED FREQ.(E)	(O-E)	(O-E)**2	(O-E)**2/E
(-2.5 ; 0.0)	7	6	1	1	0.17
( 0.0 ; 2.5)	7	6	1	1	0.17
					-----
				TOTAL (CHI-SQUARE STATISTIC) -->	0.33
				THE CHI-SQUARE CRITICAL VALUE AT THE 95.000 % CONFIDENCE LEVEL IS -->	3.84

0.33 IS LESS THAN 3.84

THE TEST PASSES

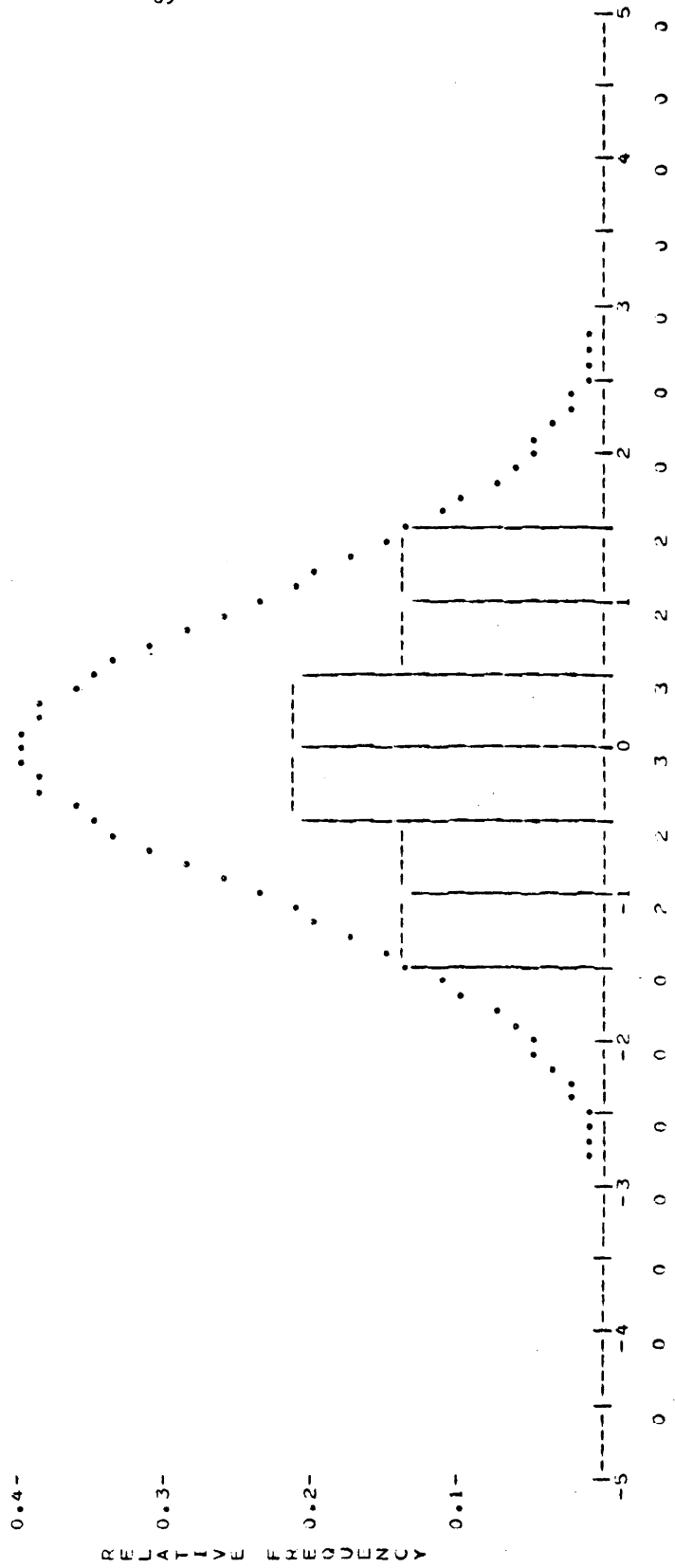
(SEE HISTOGRAM ON NEXT PAGE)

NOTE: THE HISTOGRAM IS FIRST PLOTTED WITH 2 CLASSES (THAT USED IN THE GOODNESS OF FIT TEST); THEN WITH 20 CLASSES SO THAT A MORE DETAILED REPRESENTATION OF THE ACTUAL RESIDUAL DISTRIBUTION IS GIVEN.



HISTOGRAM OF THE STANDARDIZED DIRECTION, ANGLE AND AZIMUTH RESIDUALS

(WITH CLASSES AS USED IN THE GOODNESS OF FIT TEST; A MORE DETAILED REPRESENTATION IS PLOTTED ON THE NEXT PAGE)



HISTOGRAM OF THE STANDARDIZED DIRECTION, ANGLE AND AZIMUTH RESIDUALS

CHI-SQUARE GOODNESS OF FIT TEST

ON THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)

THE NUMBER OF CLASSES IS 2  
THE NUMBER OF DEGREES OF FREEDOM FOR THE TEST IS 1

SUMMARY OF THE COMPUTATION OF THE CHI-SQUARE STATISTIC

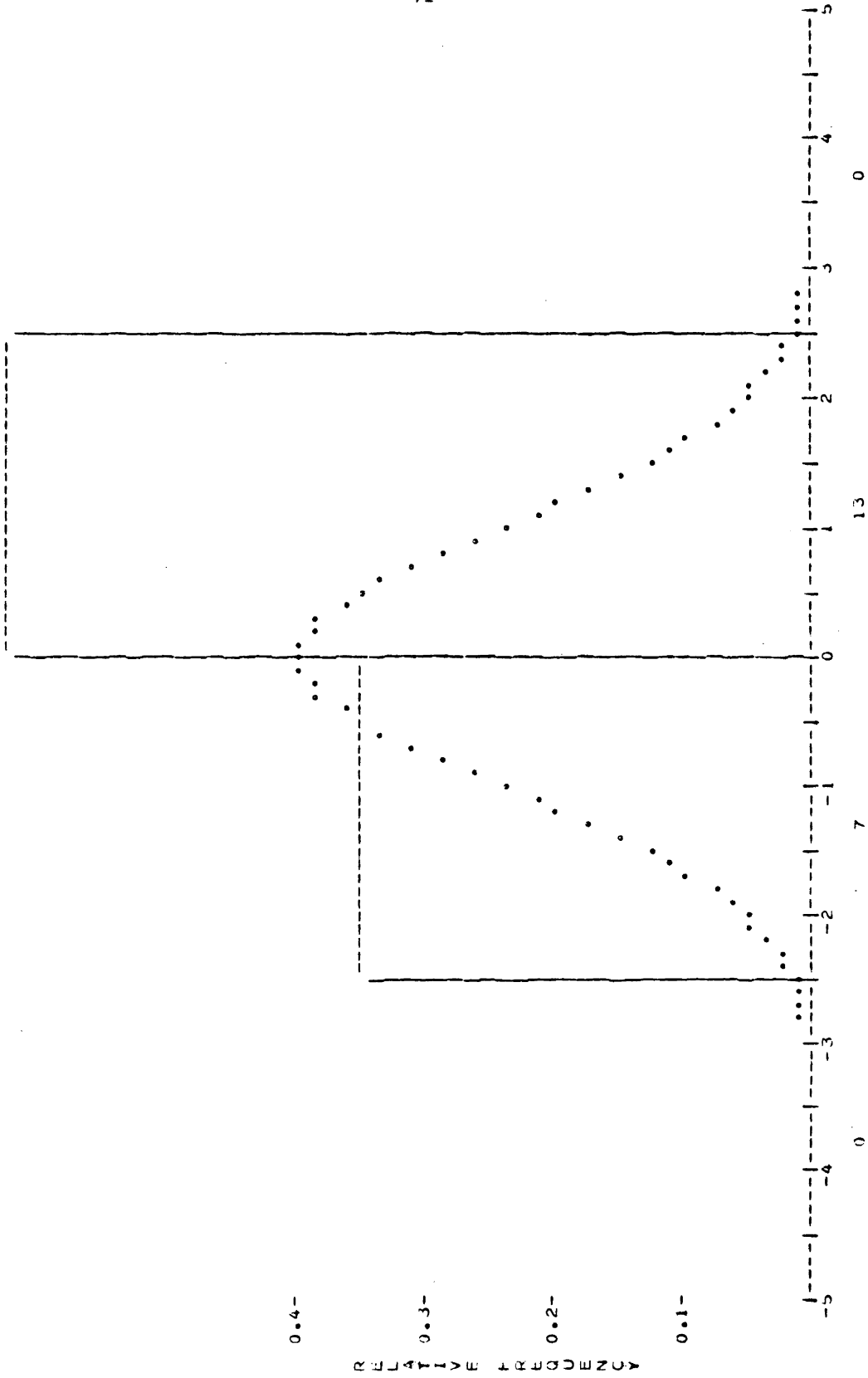
CLASS INTERVAL	OBSERVED FREQ.(O)	EXPECTED FREQ.(E)	(O-E)	(O-E)**2	(O-E)**2/E
(-2.5 , 0.0)	7	9	-2	4	0.44
( 0.0 , 2.5)	13	9	4	16	1.78
					-----
				TOTAL (CHI-SQUARE STATISTIC) -->	2.22
				THE CHI-SQUARE CRITICAL VALUE AT THE 95.000 % CONFIDENCE LEVEL IS -->	3.84

2.22 IS LESS THAN 3.84

THE TEST PASSES

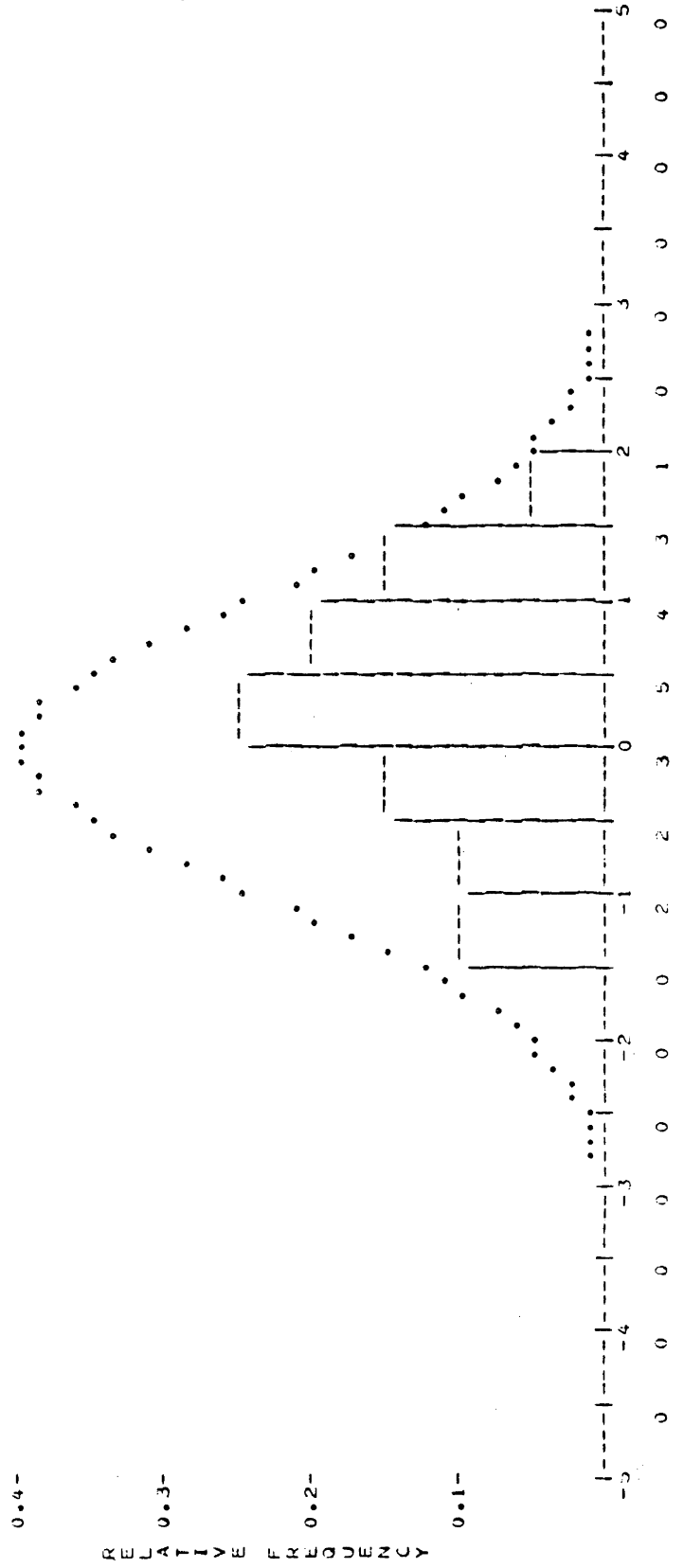
(SEE HISTOGRAM ON NEXT PAGE)

NOTE: THE HISTOGRAM IS FIRST PLOTTED WITH 2 CLASSES (THAT USED IN THE GOODNESS OF FIT TEST); THEN WITH 20 CLASSES SO THAT A MORE DETAILED REPRESENTATION OF THE ACTUAL RESIDUAL DISTRIBUTION IS GIVEN.



HISTOGRAM OF THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)

(WITH CLASSES AS USED IN THE GOODNESS OF FIT TEST; A MORE DETAILED REPRESENTATION IS PLOTTED ON THE NEXT PAGE)



HISTOGRAM OF THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)



STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484  
 (COVARIANCE MATRIX OF PARAMETERS WAS MULTIPLIED BY THE ESTIMATED VARIANCE FACTOR ( 0.812170 )).

STATION	SEMI-MAJOR AXIS	SEMI-MINOR AXIS	AZIMUTH OF SEMI-MAJOR AXIS	AREA OF ELLIPSE
1005	0.021	0.018	332 16 44	0.113760-02
1006	0.021	0.017	352 11 8	0.114320-02
1007	0.022	0.017	350 8 18	0.117290-02
1003	0.021	0.018	354 30 37	0.118790-02
1004	0.021	0.017	325 48 9	0.116900-02
KNOWN3	0.019	0.014	353 43 51	0.831070-03
KNOWN4	0.017	0.014	10 55 36	0.762340-03
KNOWN1	0.017	0.014	11 16 17	0.773860-03
KNOWN2	0.018	0.013	334 48 45	0.771980-03

TOTAL AREA OF STATION ELLIPSES = 0.894990-02

RELATIVE 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484  
 (COVARIANCE MATRIX OF PARAMLTERS WAS MULTIPLIED BY THE ESTIMATED VARIANCE FACTOR ( 0.812170 )).

FROM	TO	SEMI-MAJOR	SEMI-MINOR	AZIMUTH MAJOR	DISTANCE	PRECISION	STD.DEV. ADJ.DISTANCE	STD.DEV. ADJ.AZIMUTH	
1005	1006	0.011	0.009	69 39 54	294.273	1:	27461	0.004	2.93
1005	1007	0.014	0.011	318 35 39	442.942	1:	32301	0.005	2.58
1005	1003	0.014	0.014	309 51 20	495.098	1:	34999	0.006	2.35
1005	1004	0.016	0.014	304 6 29	841.192	1:	51573	0.006	1.54
1005	KNOWN3	0.015	0.014	43 3 6	890.349	1:	59675	0.006	1.35
1005	KNOWN4	0.019	0.017	305 46 8	915.548	1:	49361	0.008	1.56
1005	KNOWN1	0.017	0.015	41 9 48	521.464	1:	30667	0.005	2.63
1005	KNOWN2	0.013	0.012	284 11 33	365.731	1:	29219	0.005	2.72
1006	1007	0.011	0.009	14 35 27	349.285	1:	32550	0.004	2.59
1006	1003	0.014	0.011	41 49 3	536.678	1:	37668	0.005	2.23
1006	1004	0.016	0.014	332 25 7	750.606	1:	45216	0.006	1.75
1006	KNOWN3	0.016	0.012	9 46 4	897.121	1:	55101	0.005	1.52
1006	KNOWN4	0.019	0.016	346 2 18	1005.147	1:	53465	0.007	1.46
1006	KNOWN1	0.018	0.014	20 5 40	280.402	1:	15351	0.006	5.17
1006	KNOWN2	0.014	0.011	354 1 32	290.166	1:	20756	0.005	4.05
1007	1003	0.009	0.008	306 27 10	243.773	1:	26338	0.004	2.75
1007	1004	0.015	0.012	328 15 45	415.043	1:	27583	0.005	2.96
1007	KNOWN3	0.016	0.012	7 23 47	532.473	1:	33721	0.005	2.44
1007	KNOWN4	0.019	0.016	338 11 29	696.944	1:	36836	0.003	1.98
1007	KNOWN1	0.018	0.014	16 2 5	597.848	1:	32556	0.006	2.56
1007	KNOWN2	0.015	0.012	351 21 43	633.874	1:	42166	0.005	1.97
1003	1004	0.015	0.012	298 36 16	407.345	1:	26440	0.005	3.01
1003	KNOWN3	0.015	0.012	13 29 46	395.236	1:	26008	0.005	3.22
1003	KNOWN4	0.018	0.016	335 35 53	470.111	1:	26070	0.007	2.90
1003	KNOWN1	0.018	0.015	21 14 40	809.843	1:	45467	0.006	1.82

1003	KN0*W2	0.014	0.013	354	45	49	793.139	1:	55484	0.005	1.50
1004	KN0*W3	0.011	0.009	81	40	13	298.874	1:	26329	0.004	3.18
1004	KN0*W4	0.020	0.012	304	26	58	963.765	1:	27580	0.007	2.58
1004	KN0*W1	0.017	0.015	240	29	24	961.732	1:	58073	0.007	1.27
1004	KN0*W2	0.014	0.010	201	35	17	1042.194	1:	74769	0.006	0.87
KN0*W3	KN0*W4	0.015	0.005	330	22	13	276.137	1:	16140	0.005	2.98
KN0*W3	KN0*W1	0.012	0.011	355	37	4	1149.476	1:	92467	0.005	0.88
KN0*W3	KN0*W2	0.009	0.007	287	3	7	1170.436	1:	131477	0.004	0.54
KN0*W4	KN0*W1	0.016	0.011	343	59	30	1279.865	1:	77983	0.006	0.87
KN0*W4	KN0*W2	0.015	0.012	327	7	42	1247.969	1:	81127	0.006	0.85
KN0*W1	KN0*W2	0.013	0.006	22	28	29	250.450	1:	19226	0.005	1.96

----- COVARIANCE MATRIX OF THE PARAMETERS -----

	##### 1005	##### 1006	##### 1007	#####		
	X	Y	X	Y		
	(COL 1)	(COL 2)	(COL 3)	(COL 4)		
	X	Y	X	Y		
	(COL 5)	(COL 6)	(COL 5)	(COL 6)		
1	0.555986040-04	-0.813994970-05	0.430257500-04	-0.713102600-05	0.405094230-04	-0.172769890-05
2	-0.313966970-05	0.058117410-04	-0.637003030-05	0.543204920-04	-0.563162970-05	0.588933370-04
3	0.450437760-04	-0.637003030-05	0.489301300-04	-0.372664760-05	0.429364650-04	-0.709497610-05
4	-0.713102600-05	0.058117410-04	0.372664760-05	0.733394300-04	-0.297001290-05	0.670796870-04
5	0.405094230-04	-0.555986040-05	0.429364650-04	-0.297001290-05	0.504199210-04	-0.463468260-05
6	-0.172769890-05	0.555986040-05	0.709497610-05	0.670796870-04	-0.483462260-05	0.773910190-04
7	0.332389240-04	-0.733394300-05	0.377074100-04	-0.603516930-05	0.455271370-04	-0.226555370-05
8	0.153943490-05	0.543204920-04	-0.526129190-05	0.610930290-04	-0.239478150-05	0.704738310-04
9	0.370261370-04	-0.368225530-05	0.368267390-04	-0.519079230-06	0.400217120-04	-0.141777330-05
10	-0.107229170-04	0.091491610-04	-0.107592100-04	0.514453000-04	-0.100139320-04	0.591104130-04
11	0.250266740-04	-0.166840400-05	0.273521940-04	-0.115995710-05	0.291399220-04	-0.132281060-05
12	-0.133201450-04	0.477587110-04	-0.430156740-05	0.473528660-04	-0.976293020-05	0.478777280-04
13	0.173613990-04	-0.177475540-05	0.136767380-04	0.140450230-05	0.197028380-04	0.162166700-05
14	-0.192042760-05	0.319909660-04	0.112261610-05	0.369004510-04	0.212712670-05	0.3+2491720-04
15	0.241395470-04	-0.379423370-06	0.245668920-04	-0.283643130-06	0.241402890-04	0.830550690-06
16	-0.100012100-04	0.369786550-04	-0.813927020-05	0.304642930-04	-0.811668270-05	0.364306220-04
17	0.293207040-04	-0.680927810-06	0.292731120-04	-0.1944026310-06	0.235705170-04	-0.211535890-06
18	-0.874613200-05	0.498906390-04	-0.459732140-05	0.453204230-04	-0.479079770-05	0.477707190-04

	***** 1003		***** 1004		*****		***** KINUNJ *****	
	X	Y	X	Y	X	Y	X	Y
	(COL 7)	(COL 8)	(COL 4)	(COL 10)	(COL 11)	(COL 12)		
1	0.582348240-04	-0.153943400-05	0.270201570-04	-0.197226170-04	0.200260740-04	-0.153201450-04		
2	-0.735844230-05	-0.544922600-04	-0.363223530-05	0.501451010-04	-0.100440400-05	0.477687110-04		
3	0.377074100-04	-0.5249138180-05	0.363367570-04	-0.100734510-04	0.273321940-04	-0.540153740-05		
4	-0.033514820-05	0.610958290-04	-0.91972226-06	0.514433330-04	-0.115995710-05	0.473523090-04		
5	0.435251870-04	-0.230476150-05	0.406217120-04	-0.106159320-04	0.291345220-04	-0.576263020-05		
6	-0.220525300-05	0.704733010-04	-0.141777840-05	0.591194150-04	-0.133261020-05	0.47877280-04		
7	0.532354450-04	-0.208805640-05	0.360369530-04	-0.629937540-05	0.292354210-04	-0.572280150-05		
8	-0.233809940-05	0.747429650-04	-0.314658840-05	0.593523320-04	-0.133922470-05	0.448745310-04		
9	0.563869520-04	-0.514953840-05	0.535450600-04	-0.123334910-04	0.542143410-04	-0.1149143920-04		
10	-0.629937340-05	0.5966323420-04	-0.125934910-04	0.665205000-04	-0.229323620-05	0.586858710-04		
11	0.292064210-04	-0.414692470-05	0.342140410-04	-0.229625620-05	0.512133790-04	-0.551301170-05		
12	-0.672286190-05	0.338745310-04	-0.149140620-04	0.566353710-04	-0.351301170-05	0.627793830-04		
13	0.220309900-04	0.332150560-05	0.144747570-04	0.743502320-05	0.259427730-04	-0.206330640-05		
14	0.353745000-05	0.355349770-04	0.455833140-05	0.394521220-04	0.404833000-05	0.420941340-04		
15	0.24421310-04	0.4199665400-05	0.23559570-04	0.343240350-05	0.230510050-04	0.420312490-05		
16	-0.641047750-05	0.370689000-04	-0.137827910-04	0.415472380-04	-0.385497740-05	0.435435460-04		
17	0.271672350-04	-0.158707400-06	0.293301720-04	-0.230095290-05	0.243424560-04	-0.381182330-05		
18	-0.331690190-05	0.482566990-04	-0.683721130-05	0.523916400-04	-0.0913365350-05	0.5543149300-04		

	KNOWNA		KIDWNI		KINDWINZ	
	X	Y	X	Y	X	Y
1	0.170618980-04	-0.102043760-05	0.24139470-04	-0.100012100-04	0.238207660-04	-0.087461320-05
2	0.177475340-05	0.315005060-04	-0.370425370-06	0.309716350-04	-0.533927410-06	0.458903390-04
3	0.185707340-04	0.11221810-05	0.245364420-04	-0.515927020-05	0.292731120-04	-0.435732130-05
4	0.140460230-05	0.329304510-04	-0.333431370-06	0.304342350-04	-0.1194026310-05	0.43253250-04
5	0.137028330-04	0.412713670-05	0.241402540-04	-0.811306270-05	0.245703170-04	-0.479074770-05
6	0.132160730-05	0.342461720-04	0.370350640-06	0.364330220-04	-0.0211955840-05	0.477707190-04
7	0.220330900-04	0.350745000-05	0.244321510-04	-0.6641047750-05	0.271672350-04	-0.381600190-05
8	0.232150560-05	0.356343770-04	0.19563470-05	0.370639000-04	-0.151707400-06	0.48256990-04
9	0.133647570-04	0.455826140-05	0.235503570-04	-0.107627910-04	0.293301740-04	-0.683721130-05
10	0.745262220-05	0.354621220-04	0.343283550-05	0.415472380-04	-0.254309520-05	0.523916400-04
11	0.259427730-04	0.464830090-05	0.230616350-04	-0.335437740-05	0.2433424500-04	-0.5913565590-06
12	0.320833640-05	0.404041040-04	0.420312490-05	0.334465460-04	-0.381182350-05	0.543149000-04
13	0.339804450-04	0.290042060-05	0.221308350-04	0.391939500-05	0.133435950-04	0.511050570-05
14	0.249042660-05	0.444332050-04	0.444228110-05	0.270061860-04	0.337885040-03	0.348011320-04
15	0.221803350-04	0.844828110-05	0.339571250-04	0.334213660-05	0.277003000-04	-0.414500210-06
16	0.391955700-05	0.276651460-04	0.344213660-05	0.530534400-04	-0.657735070-05	0.402974580-04
17	0.18543590-04	0.337865040-05	0.277030550-04	-0.657735070-05	0.303571220-04	-0.230359170-05
18	0.511056570-05	0.348012320-04	-0.414500210-06	0.402974580-04	-0.230359170-05	0.555210540-04

ABSTRACT FOR STATION: 1005 (AS DETERMINED BY PROGRAM GEOPAN ON WED, NOV. 28, 1979)

---

EASTING (X) : 302769.999 METRES      LATITUDE : 46 30 21.19396  
 NORTHING (Y) : 809655.001 METRES      LONGITUDE : -66 27 59.07151  
 ORTHOMETRIC HEIGHT : 291.000 METRES ; GEODAL HEIGHT : 0.500 METRES  
 DEFLECTION COMPONENTS : 2.0 SECONDS (NORTH) ; -1.0 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 1 34.25 ; POINT SCALE FACTOR : 0.9999120

COVARIANCE MATRIX  
 --X--      --Y--  
 0.535980330-04    -0.813994970-05  
 -0.813994970-05    0.668117410-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
1005	KNOWN2	319 23 55.15	368.781	0 0 0.00	0.9999120
1005	1006	9 46 54.36	294.273	0 0 0.00	0.9999121

ABSTRACT FOR STATION: 1005 (AS DETERMINED BY PROGRAM GEOPAN ON WED. NOV. 28, 1979)

---

EASTING (X) : 302819.995 METRES      LATITUDE : 46 30 30.58509  
 NORTHING (Y) : 800944.996 METRES      LONGITUDE : -66 27 47.72010  
 ORTHOMETRIC HEIGHT : 298.000 METRES ; GEOIDAL HEIGHT : -0.000 METRES  
 DEFLECTION COMPONENTS : 2.1 SECONDS (NORTH); -1.2 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 1 35.96 ; POINT SCALE FACTOR : 0.9999121

COVARIANCE MATRIX  
 --X--      --Y--  
 0.439391300-04    -0.372364760-05  
 -0.372864760-05    0.755880430-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
1006	1005	189 46 54.36	294.275	0 0 -0.00	0.9999121
1006	1007	103 19 23.09	349.285	0 0 -0.00	0.9999121



ABSTRACT FOR STATION: 1007 (AS DETERMINED BY PROGRAM GEOPAN ON WED. NOV. 28, 1979)

---

EASTING (X) : 303159.097 METRES      LATITUDE : 46 30 27.98933  
 NORTHING (Y) : 800865.001 METRES      LONGITUDE : -66 27 31.77302  
 ORTHOMETRIC HEIGHT : 248.000 METRES ; GEODAL HEIGHT : -0.800 METRES  
 DEFLECTION COMPONENTS : 2.0 SECONDS (NORTH) ; -1.0 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 1 47.53 ; POINT SCALE FACTOR : 0.9999121

COVARIANCE MATRIX  
 --X--      --Y--  
 0.50419921D-04    -0.48346226D-05  
 -0.48346226D-05    0.77391019D-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
1007	1006	283 14 23.09	349.285	0 0 0.00	0.9999121
1007	1003	154 29 10.53	243.773	0 0 -0.00	0.9999121

ABSTRACT FOR STATION: 1003 (AS DETERMINED BY PROGRAM GEOPAN ON WED. NOV. 28, 1979)

---

EASTING (X) : 303264.996 METRES      LATITUDE : 46 30 20.86207  
 NORTHING (Y) : 800645.000 METRES      LONGITUDE : -65 27 26.85364  
 ORTHOMETRIC HEIGHT : 312.000 METRES ; GEODIAL HEIGHT : 0.200 METRES  
 DEFLECTION COMPONENTS : 2.0 SECONDS (NORTH); -1.1 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 1 51.09 ; POINT SCALE FACTOR : 0.9999121

COVARIANCE MATRIX  
 --X--      --Y--  
 0.532554450-04    -0.208806640-05  
 -0.208806640-05    0.747829650-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
1003	1007	334 29 10.53	243.773	0 0 0.00	0.9999121
1003	1004	48 29 0.52	407.345	0 0 0.00	0.9999121

ABSTRACT FOR STATION: 1004 (AS DETERMINED BY PROGRAM SEOPAN ON WED. NOV. 28, 1979)

---

EASTING (X) : 303570.001 METRES      LATITUDE : 46 50 29.60146  
 NORTHING (Y) : 900915.003 METRES      LONGITUDE : -96 27 12.53975  
 ORTHOMETRIC HEIGHT : 372.000 METRES ; GEOIDAL HEIGHT : -0.900 METRES  
 DEFLECTION COMPONENTS : 1.9 SECONDS (NORTH); -1.2 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 2 1.43 ; POINT SCALE FACTOR : 0.9999121

COVARIANCE MATRIX	
--X--	--Y--
0.58545520-04	-0.125934910-04
-0.125934910-04	0.685205000-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
1004	1003	228 29 0.52	407.345	0 0 -0.00	0.9999121
1004	KNOWN3	162 28 31.09	298.874	0 0 -0.00	0.9999121

ADJUSTMENT FOR STATION: KNOWN3 (AS DETERMINED BY PROGRAM GEOPAN ON WED, NOV. 23, 1979)

EASTING (X) :	303650.998 METRES	LATITUDE :	46 30 20.36894		COVARIANCE MATRIX --X-- --Y--
NORTHING (Y) :	900630.000 METRES	LONGITUDE :	-56 27 8.32653		
ORTHOMETRIC HEIGHT :	419.000 METRES	GEOIDAL HEIGHT :	0.000 METRES		
DEFLECTION COMPONENTS :	2.0 SECONDS (NORTH) ;	-1.0 SECONDS (EAST)			
MERIDIAN CONVERGENCE :	0 2 4.53 ;	POINT SCALE FACTOR :	0.9999121		0.31213579D-04 -0.35100117D-05 -0.35100117D-05 0.52779038D-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
KNOWN3	1004	342 28 31.09	298.174	0 0 0.00	0.9999121
KNOWN3	KNOWN4	185 11 38.14	276.157	0 0 -0.00	0.9999121

ABSTRACT FOR STATION: KNOXN4 (AS DETERMINED BY PIKORAM GEOPAN UN #20, NOV. 20, 1979)

EASTING (X) : 303675.000 METRES      LATITUDE : 45 30 11.46251  
 NORTHING (Y) : 800754.097 METRES      LONGITUDE : -06 27 9.50660  
 ORTHOMETRIC HEIGHT : 386.000 METRES ; GEODAL HEIGHT : 1.200 METRES  
 DEFLECTION COMPONENTS : 2.1 SECONDS (NORTH) ; -1.0 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 2 3.67 ; POINT SCALE FACTOR : 0.9999121

COVARIANCE MATRIX

0.53969450-04    0.270042960-05  
 0.290042700-05    0.484532050-04

PRO1	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
KNOXN4	KNOXN3	5 11 38.14	276.137	0 0 0.00	0.9999121

ABSTRACT FOR STATION: KADANI (AS DETERMINED BY PROGRAM GEOPAN ON WED. NOV. 23, 1979)

---

EASTING (X) :	302639.099 METRES	LATITUDE :	40 30 37.55190		. COVARIANCE MATRIX		
NORTHING (Y) :	801160.001 METRES	LONGITUDE :	-66 27 56.15892			---X---	---Y---
BATHYMETRIC HEIGHT :	325.000 METRES	GEOIDAL HEIGHT :	-1.400 METRES			0.339531250-04	0.334215860-05
DEFLECTION COMPONENTS :	2.0 SECONDS (NORTH);	-1.0 SECONDS (EAST)				0.334215860-05	0.500564400-04
MERIDIAN CONVERGENCE :	0 1 29.84	POINT SCALE FACTOR :	0.9999121				

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
KNOWN1	KNOWN2	206 3 12.12	250.450	0 0 -0.00	0.9999120

ABSTRACT FOR STATION: KNOWN2 (AS DETERMINED BY PROGRAM GLOPAN ON WED, NOV. 28, 1979)

---

EASTING (X) : 202570.000 METRES      LATITUDE : 46 30 30.28807  
 NORTHING (Y) : 990935.000 METRES      LONGITUDE : -66 28 1.32335  
 ORTHOMETRIC HEIGHT : 312.000 METRES ; GEODAL HEIGHT : -0.200 METRES  
 DEFLECTION COMPONENTS : 2.0 SECONDS (NORTH) ; -1.0 SECONDS (EAST)  
 MERIDIAN CONVERGENCE : 0 1 26.09 ; POINT SCALE FACTOR : 0.9999120

COVARIANCE MATRIX  
 --X--      --Y--  
 0.303571220-04    -0.230359870-05  
 -0.230359870-05    0.555216540-04

FROM	TO	GRID AZIMUTH	GRID DISTANCE	ARC TO CHORD	LINE SCALE
KNOWN2	1005	179 23 55.15	368.731	0 0 -0.00	0.9999120
KNOWN2	KNOWN1	26 3 12.12	250.450	0 0 0.00	0.9999120

## 5. ERROR MESSAGES

GEOPAN will print various error messages in the event that errors are encountered in the input data. This feature simplifies the debugging of the punched input deck. These error messages are listed below with some explanation of the possible causes and remedies in the event that they do occur.

The only event in which a system error should occur is when an error occurs when attempting to read data. This would be caused for example by reading a character in F10.3 FORMAT. When this occurs however, the system causes the culprit card image to be printed before program termination. Thus the remedy will be clear in these cases.

Any other error which may occur should be one of the following GEOPAN error messages. (The XXXX's stand for specific information which will be printed).

\*\*\* INPUT ERROR # 002 \*\*\* CODE # XXX on SECOND DATA CARD IS OUT OF  
ACCEPTABLE RANGE

Cause: One of the numbers punched on the codes card is not one of those specifying a legal option

Remedy: Change the culprit.

\*\*\* INPUT ERROR # 003 \*\*\* EXPECTING TO READ - FIXED - BUT FOUND -XXXXXXXX -

Cause: Fixed stations were specified on the codes card but the FIXED card was not found where it should have been

Remedy: Include the FIXED section, or put it in the proper sequence in the input deck.



\*\*\* INPUT ERROR # 004 \*\*\* EXPECTING TO READ - WEIGHTED - BUT FOUND

-XXXXXXXX-

Cause: Similar to # 003

Remedy: Similar to # 003

\*\*\* INPUT ERROR # 006 \*\*\* EXPECTING TO READ - BLAHA - BUT FOUND

-XXXXXXXX-

Cause: Similar to # 003

Remedy: Similar to # 003

\*\*\* INPUT ERROR # 008 \*\*\* OBSERVATION NO. XXXX IS FIRST AND POSSIBLY THE

ONLY DIRECTION IN A BUNDLE, SHOULD HAVE CODE 2 NOT -2

Cause: A direction which is first in a bundle has observation code -2

(columns 4 and 5 of the observation card). Since it is -2

(signifying the last direction in a bundle) it must be the only

direction in a bundle. A one direction bundle is meaningless

and GEOPAN will not accept them.

Remedy: Remove the culprit or correct the observation cards.

\*\*\* INPUT ERROR # 009 \*\*\* IN INPUT OF A PRIORI INFORMATION MATRIX ELEMENTS;

ZERO DIAGONAL ELEMENT ENCOUNTERED.

Cause: Probably a mispunched card or a misunderstanding of how the matrix

is input on punched cards.

Remedy: Re-read the corresponding part of Chapter 2. The matrix is printed

before termination so that a direct comparison can be made with the

cards read.

\*\*\* INPUT ERROR # 010 \*\*\* SINGULARITY ENCOUNTERED IN NORMAL EQUATIONS

IN POSITION (XXXX, XXXX)

Cause: A singularity encountered in the normal equations is detected during the computation of the Choleski Square root. Since all stations are previously checked that they are determinable, a singularity at this stage is a severe ill-condition caused by observation geometry eg. a poor intersection angle.

Remedy: The geometry will probably have to be altered or more observations added to better define the culprit station.

\*\*\* INPUT ERROR #011 \*\*\* STATION XXXXXXXX IS BOTH FIXED AND WEIGHTED...

ONLY ONE OF THESE OPTIONS MAY BE CHOSEN FOR ANY ONE STATION

Cause: The reference station is both in the list for fixed stations and weighted stations. GEOPAN considers that the user overlooked this fact and that it is not what was desired. Program execution is terminated.

Remedy: Fix or weight the station, not both.

\*\*\* INPUT ERROR # 012 \*\*\* STATION XXXXXXXX IS BOTH WEIGHTED AND BLAHA

HELD... ONLY ONE OF THESE OPTIONS MAY BE CHOSEN FOR ANY ONE STATION

Cause: Similar to # 011

Remedy: Similar to # 011

\*\*\* INPUT ERROR \*\*\* STATION XXXXXXXX IS BOTH FIXED AND BLAHA HELD....

ONLY ONE OF THESE OPTIONS MAY BE CHOSEN FOR ANY ONE STATION

Note: This error should be numbered # 013. This will be done in the near future.

Cause: Similar to # 011

Remedy: Similar to # 011

\*\*\* INPUT ERROR # 014 \*\*\* THE NUMBER OF DEGREES OF FREEDOM IS XXXXX; MUST BE NON-NEGATIVE.

Cause: Negative degrees of freedom. This is a severe error since the normal equations will be singular.

Remedy: Include more constraints; either in the form of observations or in the form of fixed, weighted or Blaha stations.

\*\*\* INPUT ERROR # 015 \*\*\* OBSERVED SLOPE DISTANCE BETWEEN STATIONS  
XXXXXXXXX AND XXXXXXXXX IS LESS THAN THE HEIGHT DIFFERENCE BETWEEN  
THE TWO STATIONS.

Cause: Probably misspunched distance card. This error may also occur when a near vertical line is observed. In this case simply remove that distance observation since it will add nothing to the planimetric accuracy of the stations.

Remedy: Correct or remove the corresponding distance observation card.

\*\*\* INPUT ERROR # 016 \*\*\* CODE FOR OBSERVATION NO. XXXX IS NOT ACCEPTABLE,  
MUST BE 1, 2, 3, 4 or -2

Cause: Misspunched observation card. (The code is in column 5). See chapter 2.

Remedy: Correct the corresponding observation card.

\*\*\* INPUT ERROR # 017 \*\*\* OBSERVATION NO. XXXX HAS BEEN GIVEN A ZERO  
STANDARD DEVIATION: CHECK INPUT FACTORS, IF ANY.

Cause: Misspunched observation card.

Remedy: Correct the corresponding card.

\*\*\* INPUT ERROR # 018 \*\*\* DISTANCE OBSERVATION NO. XXXX IS ZERO.

Cause: Misspunched distance observation card. This error will not occur for preanalysis cases.

Remedy: Correct the corresponding distance observation card.

\*\*\* INPUT ERROR # 019 \*\*\* OBSERVATION NO. XXXX HAS DEGREES, MINUTES OF  
SECONDS OUT OF ACCEPTABLE RANGE.

Cause: Mispunched observation card for directions, angles or azimuths.

Legal values are:

$0.0 \leq \text{degrees} \leq 359.0$

$0.0 \leq \text{minutes} \leq 59.0$

$0.0 \leq \text{seconds} < 60.0$

Remedy: Correct the corresponding card

\*\*\* INPUT ERROR # 020 \*\*\* A FACTOR FOR STANDARD DEVIATIONS OF OBSERVATIONS  
IS ZERO OR NEGATIVE

Cause: An input factor for standard deviations was input as zero or  
negative. Only positive (non-zero) values are acceptable.

Remedy: Correct the factors card.

\*\*\* INPUT ERROR # 021 \*\*\* SPECIFIC OPTIONS WERE REQUESTED FOR CONVERGENCE,  
CONFIDENCE, CENTERING OR MISCLOSURES BUT DATA CARD WITH THESE  
VALUES WAS NOT FOUND

Cause: At least one of these options was selected on the codes card  
but the CRITERIA card was not found in its proper place.

Remedy: Correct the situation by not requesting the option(s) on the  
codes card or by adding the CRITERIA cards.

\*\*\* INPUT ERROR # 023 \*\*\* OPTION TO READ FACTORS FOR OBSERVATION STANDARD  
DEVIATIONS WAS SELECTED BUT DATA CARD WITH THESE VALUES WAS NOT  
FOUND

Cause: Similar to # 021

Remedy: Similar to # 021

\*\*\* INPUT ERROR # 025 \*\*\* EXPECTING TO READ - STATIONS - BUT FOUND

-XXXXXXXX- PROBABLE CAUSE: IMPROPER SEQUENCE OF INPUT DATA

Cause: The STATIONS card was to be read at this point but -XXXXXXXX-  
was found instead.

Remedy: Correct sequence or structure of the input deck (see Chapters 2  
and 3)

\*\*\* INPUT ERROR # 027 \*\*\* EXPECTING TO READ - OBSERVAT(IONS) - BUT FOUND

-XXXXXXXX- PROBABLE CAUSE: IMPROPER SEQUENCE OF INPUT DATA

Cause: Similar to # 025

Remedy: Similar to # 025

\*\*\* INPUT ERROR # 029 \*\*\* END OF DATA ENCOUNTERED WHILE READING STATION

NAMES FOR SIMULTANEOUS ELLIPSES

Cause: Possibly the last card with station names for the simultaneous  
subset does not have -9 punched in columns 1 and 2

Remedy: Correct the SIMULTANEOUS section of the input deck. See  
Chapter 3.

\*\*\* INPUT ERROR # 030 \*\*\* EXPECTING TO READ - SIMULTAN(EOUS) - BUT

FOUND -XXXXXXXX-

Cause: Simultaneous ellipses option was selected on the codes card  
but the SIMULTANEOUS section of the input deck was not found  
in its proper place

Remedy: Either do not select the simultaneous option on the codes card  
or include the SIMULTANEOUS section in its proper place.

\*\*\* INPUT ERROR # 031 \*\*\* STATION XXXXXXXX IS NOT DETERMINED; MORE  
OBSERVATIONS REQUIRED.

Cause: The observations input which include the station mentioned are  
not sufficient to determine the position of that station.

Remedy: Include more observations from or to that station

\*\*\* INPUT ERROR # 032 FIXED WEIGHTED OR BLAHA STATION XXXXXXXX IS NOT  
PROPERLY TIED TO NETWORK: MORE OBSERVATIONS ARE REQUIRED.

Cause: The fixed, weighted or Blaha station has no observations to or  
from it in order to tie it to the network.

Remedy: Include the missing observation(s)

\*\*\* INPUT ERROR # 033 THERE IS NO POSITION CONSTRAINT: MUST BE AT LEAST  
1 FIXED, WEIGHTED OR BLAHA STATION.

Cause: Position constraint in the form of at least 1 fixed, weighted or  
Blaha station is required since GEOPAN does not yet use inner  
constraints

Remedy: Include the fixed, weighted or Blaha information as required.

\*\*\* INPUT ERROR # 034 THERE ARE NO ORIENTATION OR SCALE CONSTRAINTS: WITH  
ONLY 1 FIXED, WEIGHTED OR BLAHA STATION BOTH A DISTANCE AND AN AZIMUTH  
OBSERVATION MUST BE GIVEN.

Cause: No orientation or scale constraints on the network. Normal  
equations are singular in this case.

Remedy: Include the required constraints either in the form of observations  
or in the form of fixed, weighted or Blaha stations.

\*\*\* INPUT ERROR # 035 \*\*\* THERE IS NO SCALE CONSTRAINT: WITH ONLY 1  
FIXED, WEIGHTED OR BLAHA STATION, AT LEAST 1 DISTANCE OBSERVATION  
MUST BE GIVEN

Cause: Similar to # 034

Remedy: Similar to # 034

\*\*\* INPUT ERROR # 036 \*\*\* THERE IS NO ORIENTATION CONSTRAINT. WITH ONLY  
1 FIXED, WEIGHTED OR BLAHA STATION, AT LEAST ONE AZIMUTH OBSERVATION  
MUST BE GIVEN.

Cause: Similar to # 034

Remedy: Similar to # 034

\*\*\* INPUT ERROR # 037 \*\*\* NO INPUT DATA FOUND

Cause: Input deck was not found

Remedy: Include input deck

\*\*\* INPUT ERROR # 038 \*\*\* INCOMPLETE INPUT DATA

Cause: All of the input deck was not found.

Remedy: Include a complete input deck (See Chapters 2 and 3).

\*\*\* INPUT ERROR # 039 \*\*\* END OF INPUT DATA FOUND WHILE ATTEMPTING TO  
READ FIXED STATION NAMES

Cause: Less station names in the FIXED section of the input were supplied  
than the number stated on the codes card.

Remedy: Correct number on the codes card or include all names of stations  
which are to be fixed

\*\*\* INPUT ERROR # 040 \*\*\* END OF INPUT DATA FOUND WHILE ATTEMPTING TO  
READ WEIGHTED STATION NAMES

Cause: Similar to # 039

Remedy: Similar to # 039

\*\*\* INPUT ERROR # 041 \*\*\* END OF INPUT DATA FOUND WHILE ATTEMPTING TO  
READ BLAHA STATION NAMES

Cause: Similar to # 039

Remedy: Similar to # 039

\*\*\* INPUT ERROR # 042 \*\*\* STATION NAME XXXXXXXXX READ IN A SET FOR  
SIMULTANEOUS ELLIPSES IS NOT ONE OF THOSE IN THE NETWORK.

Cause: Probably a misspelled station name in the SIMULTANEOUS section  
of the input deck.

Remedy: Correct the card or cards in this section.

\*\*\* INPUT ERROR # 043 \*\*\* STATION NAME XXXXXXXXX APPEARS AT LEAST TWICE  
IN A SET FOR SIMULTANEOUS ELLIPSES

Cause: Repetition of a station name in the SIMULTANEOUS section of the  
input deck

Remedy: Include each station only once.

\*\*\* ERROR # 044 \*\*\* PROGRAM TERMINATION DUE TO SOLUTION DIVERGENCE:  
CHECK INPUT DATA

Cause: Divergence may be caused by poor approximate coordinates,  
blunders in observations or in ill conditioned networks.

Remedy: Check for the above causes and make the necessary changes.



\*\*\* INPUT ERROR # 045 \*\*\* STATION NAME REFERENCED AS WEIGHTED WAS NOT  
FOUND AMONG THOSE INPUT WITH APPROXIMATE COORDINATES

Cause: Probably a misspelled station name either in the STATIONS  
section or in the WEIGHTED section of the input deck

Remedy: Correct the corresponding card(s).

\*\*\* INPUT ERROR # 046 \*\*\* STATION NAME REFERENCED AS HAVING BLAHA  
INFORMATION WAS NOT FOUND AMONG THOSE WITH APPROXIMATE COORDINATES

Cause: Similar to # 045

Remedy: Similar to # 045

\*\*\* INPUT ERROR # 047 \*\*\* STATION NAME REFERENCED AS BEING HELD FIXED  
WAS NOT FOUND AMONG THOSE INPUT WITH APPROXIMATE COORDINATES

Cause: Similar to # 045

Remedy: Similar to # 045

\*\*\* INPUT ERROR # 048 \*\*\* OBSERVATION NO. XXXX REFERENCES STATION XXXXXXXX  
WHICH CANNOT BE FOUND AMONG THOSE INPUT WITH THE APPROXIMATE COORDINATES.

Cause: Similar to # 045

Remedy: Similar to # 045

\*\*\* INPUT ERROR # 049 \*\*\* STATIONS XXXX AND XXXX(AS THEY WERE READ IN)  
HAVE THE SAME NAME, NAMELY: XXXXXXXX

Cause: Identical station names given to the two referenced stations

Remedy: Give each station a unique name.

\*\*\* INPUT ERROR # 050 \*\*\* STATION NO. XXXX (AS IT WAS READ IN) HAS NO NAME

Cause: Columns allotted to the station name on the referenced approximate coordinates card (in the STATIONS section of the input deck) are blank.

Remedy: Give the station a name. (Station names may not consist entirely of blanks).

\*\*\* INPUT ERROR # 051 \*\*\* SINGULARITY ENCOUNTERED IN THE INPUT MATRIX  
FOR WEIGHTED STATIONS; POSITION (XXXX, XXXX)

Cause: Probably a mispunched card in the WEIGHTED section for the input information matrix for these stations

Remedy: Correct the input matrix data.

\*\*\* INPUT ERROR # 052 \*\*\* SINGULARITY ENCOUNTERED IN THE INPUT MATRIX  
FOR BLAHA STATIONS; POSITION (XXXX, XXXX)

Cause: Similar to # 051

Remedy: Similar to # 051

Hopefully these error messages printed by GEOPAN along with some warning messages will make the program easier to use. Should a system error occur other than the one mentioned at the beginning of this chapter, the user should contact the author since such errors (although they should not occur) will be severe.

## 6. TECHNICAL DETAILS

The objective of this chapter is to give the basics of how GEOPAN operates. Details are only given where no reference on the particular topic was immediately available to the author. Most details of the theory and mechanics of computations are found in the cited references.

First, in order that the user might find the way around in the program itself, a road map of subroutines connected by CALL statements is given in Figure 6.1 in the form of a subroutine calling tree. All of the major subroutines are shown on this figure. A simplified flowchart of GEOPAN is shown in Figure 6.2. Since all the major operations are indicated in this flowchart, details of the program will be given by moving through it and describing them on the way.

The first thing GEOPAN does is read the input data deck and store the corresponding information. Most of the details of which matrices, vectors or variables contain which data is given in the program listing documentation in Appendix B. Details of the  $i$ th row of the matrix  $AP$  are given in Table 6-1 where,

$X_i$  is the easting,

$Y_i$  is the northing,

$H_i$  is the orthometric height

$N_i^*$  is the ellipsoid-geoid separation (geoid height)

$\xi_i$  is the north component of the deflection of the vertical in arc-seconds

$\eta_i$  is the east component of the deflection of the vertical in arc-seconds

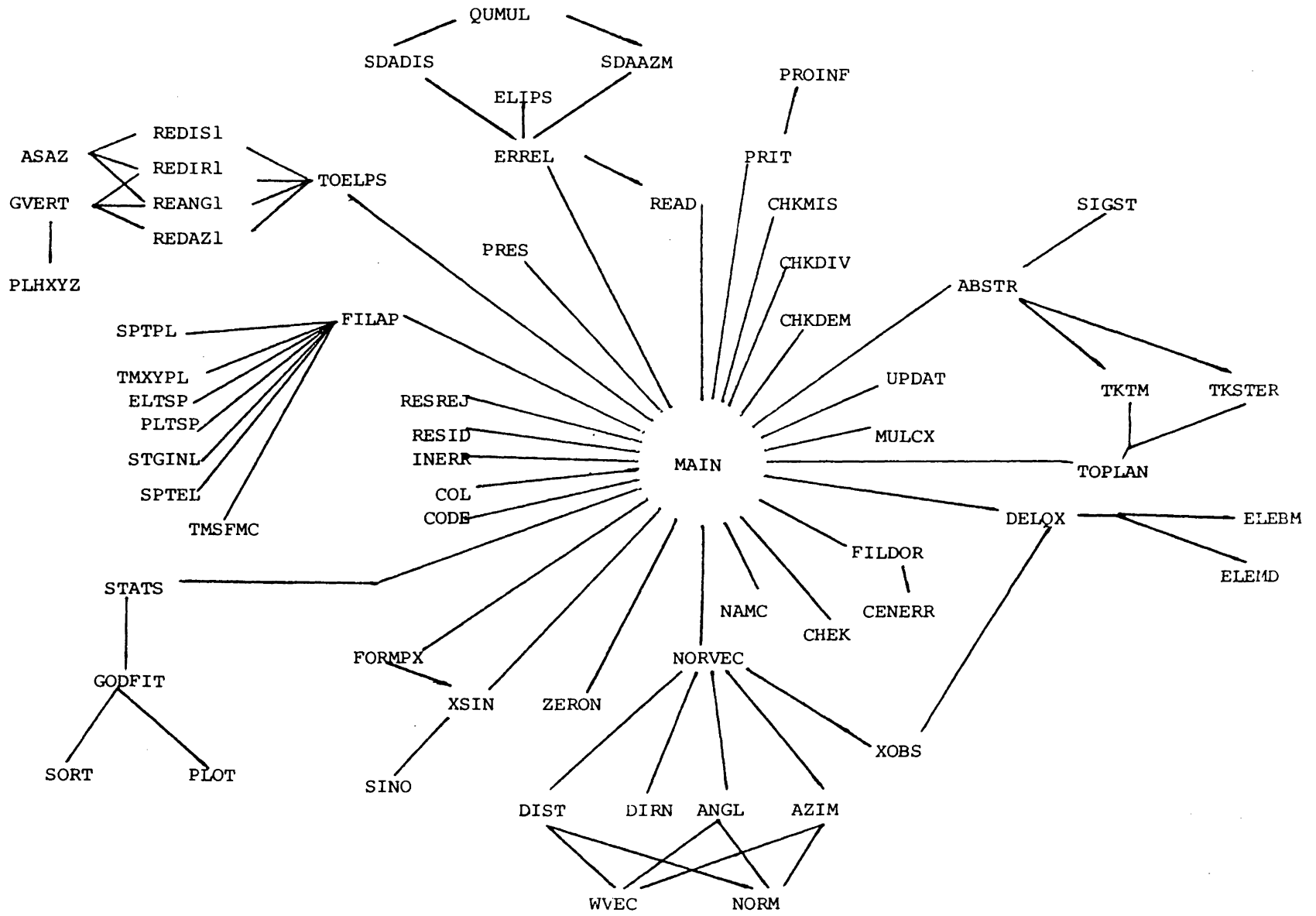


FIGURE 6.1 Subroutine Calling Tree for GEOPAN.

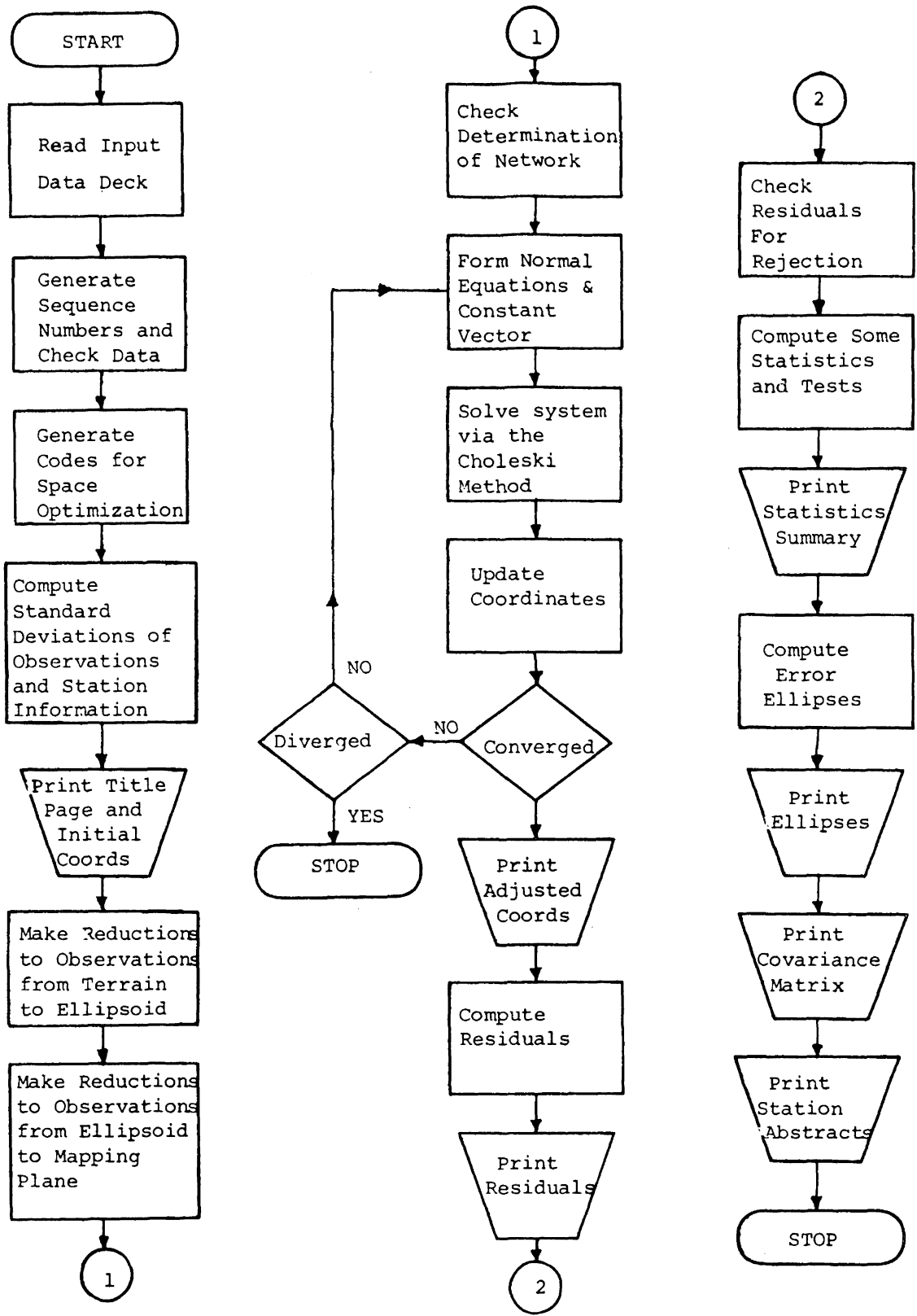


FIGURE 6.2 General Flowchart for GEOPAN

$N_i$  is the radius of curvature of the ellipsoid in the prime vertical plane,

$M_i$  is the radius of curvature of the ellipsoid in the meridian plane,

$\phi_i$  is the ellipsoidal latitude in radians

$\lambda_i$  is the ellipsoidal longitude in radians (positive east of Greenwich),

$k_i$  is the point scale factor and

$\gamma_i$  is the meridian convergence in radians at the  $i$ th station.

The information in columns 1 - 6 of AP is read; that in columns 7 - 12 computed.

Column #	1	2	3	4	5	6	7	8	9	10	11	12
Contents	$X_i$	$Y_i$	$H_i$	$N_i^*$	$\xi_i$	$\eta_i$	$N_i$	$M_i$	$\phi_i$	$\lambda_i$	$k_i$	$\gamma_i$

Table 6-1 Contents of the  $i$ th row of the Matrix AP

The next operation is the generation of sequence numbers and checking of the input data. Then codes are generated for space optimization. For each row of the design matrix (internally a six column matrix) column numbers are assigned to each element. These column numbers are the numbers of the columns in which the corresponding elements would have been if the matrix were of its theoretical dimension. Besides this, a vector is created in which the row number of the highest non-zero element in each column of the normal equation matrix is stored. Thus the system is solved using a variable band-width although no

optimization is done concerning the minimum area or height of the band.

Next, standard deviations of the observations are computed.

If no centering errors were specified all this entails is the computation of the distance standard deviations taking into account the parts per million contribution as;

$$\sigma_{\text{Distance}} = (\sigma^2 + (\text{PPM} \cdot \text{Distance})^2)^{1/2}$$

where  $\sigma$  is the standard deviation of the distance (not including the parts per million contribution) as was read in columns 41 - 50 on the observation card. PPM is the number of parts per million as read in columns 51 - 60.

If centering errors were specified their contribution to the standard deviations of observations are added (as the reader may confirm from the geometry and simple error propagation) such that: for distances;

$$\sigma = (\sigma_{\text{Distance}}^2 + 2 \cdot \text{Cent}^2)^{1/2}$$

for directions; ( $\rho = 206\,264.81$ )

$$\sigma = (\sigma_{\text{Direction}}^2 + 2 \left(\frac{\rho \cdot \text{Cent}}{S_{ij}}\right)^2)^{1/2}$$

for angles;

$$\sigma = (\sigma_{\text{angle}}^2 + 2 \left(\frac{\rho \cdot \text{Cent}}{S_{ij}}\right)^2 + 2 \left(\frac{\rho \cdot \text{Cent}}{S_{ik}}\right)^2)^{1/2}$$

for azimuths;

$$\sigma = (\sigma_{\text{azimuth}}^2 + 2 \cdot \left(\frac{\rho \cdot \text{Cent}}{S_{ij}}\right)^2)^{1/2}$$

where, Cent is the corresponding centering error read in,

$S_{ij}$  is the distance between stations i and j and,

$\sigma_{\text{direction}}$ ,  $\sigma_{\text{angle}}$ , and  $\sigma_{\text{azimuth}}$  are those read from the data cards.

At this stage the information contained in the matrix AP, as was previously discussed, is computed and stored. Then the title page and initial coordinates are printed.

The next operations are the reductions to observations. First the observations are reduced from the terrain to the ellipsoid, then from the ellipsoid to the terrain. For detail of equations and procedures of reducing observations the reader is referred to reference [ 5 ] from which all equations were taken for GEOPAN.

Checking the determination of the network, i.e. checking to see if all stations are defined by the observations, is done next. This is done by simply counting the observations to and from each station [ 3 ]. Next the normal equations and constant vector [ 4 ] are formed and the system solved by the Choleski method [ 4 ]. At this stage any singularities are detected by computing the "Googe number" [ 3 ] for each row of the normal equations.

Checking for convergence is done by simply comparing the absolute value of the solution vector elements to the convergence criterion.



Checking for divergence is done by comparing the absolute values of the elements of the present solution vector with the corresponding ones of the previous iteration. If any element of the vector increases in absolute value in any one iteration and if these values are greater than the convergence criterion, a counter is increased by unity. If two such occurrences are detected, program execution is terminated with an appropriate error message.

If convergence is reached the adjusted coordinates and residuals are printed. The residuals are then checked for rejection using the specified criterion [6]. A summary of the computation of the degrees of freedom is given, including a count of the different types of observations and unknown parameters. The  $\chi^2$  test on the variance factor is performed [6].

Next, error ellipses [6] are computed and printed. The covariance matrix of the parameters is printed if requested. Finally station abstracts are printed if the option was selected.

For a description of the theory behind Blaha stations see reference [1]. The computational algorithm used for computing the correction to the covariance matrix (of the parameters) for Blaha stations is not efficient. Instead of allocating more space for the consequent additional matrices needed for Blaha station computations, some computations are repeated. A more efficient algorithm is needed here.

The so-called weighted stations are treated as observations of coordinates. The observation equation for the input coordinates of these stations is written as;

$$X - X_{\text{obs}} = 0$$

where  $X$  represents the unknown parameter associated with the particular station and  $X_{\text{obs}}$  the "observed value" or the value from another adjustment which has an associated covariance matrix. These observation equations are treated exactly the same as those for distances, directions angles and azimuths. Although the corresponding portions of the design matrix and the misclosure vector are not explicitly created in GEOPAN these contributions are added to the normal equations and constant vector respectively in each iteration. At the time of writing this manual however, the corresponding residuals are not tested for rejection, nor are they printed. They are used in the computation of the degrees of freedom and the estimated variance factor.

For fixed stations corresponding columns of the design matrix are eliminated thus reducing the size of the normal equations to be solved.

At the time of writing this manual an insufficient amount of computer runs were made to give any definite figures on run times and costs of adjustments using GEOPAN.

## REFERENCES

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APPENDIX A

Job Control Language

A. Job Control Language

Figure A.1 shows the JCL required for a typical execution of GEOPAN.

The program has the following limits on network size:

Number of stations (total:	60
Number of fixed stations:	30
Number of weighted stations:	30
Number of Blaha stations:	30
Number of Observations:	300

