Overseas 64-m RMS Program for SDS 920

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With the completion of the 64-m antennas overseas and their performance testing, an important test measurement required is the reflector distortion RMS from gravity loading. In order to provide the paraboloid best fitting capability for the available SDS 920 computers at overseas sites, the RMS program was modified to suit the typewriter and two tape units I-O capabilities of the computers. The program computes the RMS after paraboloid best fit from field angle readings using typed inputs. The constant data, such as coordinates of targets, are supplied in a data tape with the Binary Program supplied in a second tape.

I. Introduction

One of the JPL specifications required to be met by the contractor erecting the 64-m antennas overseas is the distortion RMS of the reflector structure under gravity loading. To supply a readily available checking tool for use by the JPL's alignment checking personnel, the Utku/Schmele RMS paraboloid best fitting program (Refs. 1, 2 and 3) was modified to be used with the SDS 920 computer available at the overseas sites.

To satisfy the 8000-word core size of the computer with only a typewriter and two tape input devices, the program was stripped to include only the solution for the required field measurements plus coding modifications to simplify and reduce the quantity of the input data. The constants for the 64-m antenna peculiar data were supplied in a prepared tape written with data only.

The typing data inputs required are the Z offset of the theodolite from the basic position plus the actual angle readings of the targets with the assigned target numbers.

II. Program Modifications

The coding of the Utku-Schmele RMS program was changed to compute from field data only, using as input the actual angle readings of the measuring theodolite plus the target defining number.

By predefining the target numbers and providing a map for the field personnel to use, it was possible to supply the coordinates as constants written on a data tape. By interrogating this tape when data is required, the core space requirement was minimized. Supplied also on the data tape are the correct angle readings for zero errors so that the actual field angle readings may be differenced to them and the residual would be the deflection or error.

III. Formulation and Review

The 64-m antenna specification requires a particular geometric interpretation of the theodolite data to be input to the RMS program. That is, the differential between the field angle reading and the geometrically correct angle is converted to a linear displacement normal to the correct line of sight which in turn is divided by the cosine of the instrument angle (Fig. 1 and *Subsection VI-A*). This results in a distortion component parallel to the symmetric axis of the paraboloid which is then input as a Z displacement in the RMS program.

It should be noted that the theodolite sees only the component of the distortion normal to its line of sight. In the above described calculations, the distortions are assumed to be in the direction of the symmetric axis of the paraboloid. The resulting computed rms is, at least for the 64-m antenna, smaller in value than the correct value, and the truer value seems to be output if the distortions are assumed to be normal to the paraboloid surface (Ref. 4).

The program uses a theodolite height of 38.1 cm (15 in.). Changes in this quantity are input as the "instrument height bias." The bias is equal to the actual height minus the assumed height of 38.1 cm (15 in.). Formulation used to convert the configured height to the actual height may be found in *Subsection VI-B*.

IV. Usage with SDS 920 Computer

The program is written in FORTRAN II, designed for use with the SDS 920 computer. Two input devices are employed—magnetic tape and the keyboard. All output is via the console typewriter.

To eliminate re-compilation each time the program is used, it is stored in binary form on magnetic tape. It is loaded off of logical unit 1. A listing of the FORTRAN II source program will be included with the binary tape so that any necessary changes may be made.

The invariant 64-m configuration data is stored on another magnetic tape in BCD. Due to core limitations (8K) on the SDS 920, this data is not stored in core. Thus it must remain on the tape unit during the entire execution of the program.

The program includes halts at various spots in order to give the user time to perform various functions. At the beginning of the program, it halts for the user to mount the constant data tape on logical unit 2. After each set of field data is entered, it halts again for the user to position the typewriter at the first line of the next page. This enables headings to be printed at the top of each page of output.

V. Input

The input data is divided into two sets. The first set contains constants for the 64-m antenna. It is stored on magnetic tape and is supplied with the program. It is read in off magnetic tape unit 2.

The second data set is made up of field measurements from an angle-measuring theodolite on the antenna. It is entered at the keyboard.

A. Data Description

1. *Magnetic tape data*

1st–648th records—Antenna constants

FORMAT (4F10.5)

Parameters (X, Y, U, A)

Description

X = X coordinate of target point on undeformed dish (in meters).

Y = Y coordinate of target point on undeformed dish (in meters).

U = instrument angle (in radians) to target point on undeformed dish (angle d_i in Fig. 1).

A = area of panel associated with this target point (in square meters).

Target points have been assigned point nos. 1–648. A sketch illustrating these numbered points accompanies the program. The constant data above is arranged by point number in increasing order, starting with point 1.

2. *Keyboard data*

1st Record. Instrument height bias

FORMAT (F6.3)

Parameters—(BIAS)

Description

BIAS = Instrument height bias (in meters). The program assumes an instrument height of 38.1 cm.

BIAS = (actual height)–(38.1 cm).

2nd Record—Output heading

FORMAT (12A6)

Parameters—(TITLE)

Description

TITLE = alphanumeric data which will be heading on each page of printed output.

3rd—to n Records—Field Measurements

FORMAT (I3, 2X, 3I3, 2X, 3I3)

Parameters—(K, IDEG, IMIN, ISEC, JDEG, JMIN, JSEC)

Description

K = point number of target point.

IDEG, IMIN, ISEC = Theodolite angle—reading of distorted target point (angle ϕ_i in Fig. 1) (in degrees, minutes, and seconds, respectively).

JDEG, JMIN, JSEC = Reverse theodolite angle reading (in degrees, minutes, and seconds, respectively) (approximately equal to 180 deg—theodolite angle above).

Field measurements may be entered for all or part of the target points, and need not be entered in any particular order. If more than one field measurement is entered for the same point, the latest value will be saved and all previous values will be deleted. This provides a means for the correction of typing errors.

A blank record signals the end of the data set. The program then computes the RMS after best fitting.

Provision has been made to execute multiple data sets. The program may be terminated by typing in a blank record for the first field measurement record. A block diagram illustrating the usage of the RMS program on the SDS 920 computer is shown in Fig. 3.

VI. Output

The first section of output lists the individual distortions, normal to the surface of the paraboloid, for each target point for which field measurements were entered after the best fitting of the paraboloid. The error in path-length sense is also listed in this section.

The second section lists various quantities associated with the best fit paraboloid. Included are the RMS of half path length change, focal length of the best fit paraboloid, coordinates of the vertex of the best fit paraboloid, and rotation about the X and Y axes.

A. Computation of Z-Component of Deflection Vector from Theodolite Measurement of Distortion Angle (Fig. 1).

The radial distance, in the X–Y plane, to the ith target point, R_i, is given by

$$R_i = X_i^2 + Y_i^2$$

where X_i and Y_i are the X and Y coordinates of the ith target point (right-hand coordinates system).

Therefore

$$a_i = R_i/\cos\alpha_i$$

where α_i = angle made by $\overrightarrow{QO}_i$ with the XY plane. The deflection vector normal to the line of sight, b_i, is then given by

$$b_i = (a_i)(\tan\theta_i)$$

where θ_i = theodolite measurement of distortion angle.

For small deflections, QB_i & QD_i may be considered to be parallel to QO_i, it follows that $\gamma_i = \alpha_i$

Therefore, the Y-component of the distortion vector, d_i, is then given by

$$d_i = b_i/\cos\alpha_i$$

B. Correction Calculations for Theodolite Height Changes (Fig. 2)

Figure 2 illustrates field measurements taken using a theodolite with a height bias of AB difference from the correct height of 38.1 cm (15 in.) This causes the theodolite angle for the distortion reading to be read as λ_i instead of ϕ_i. The component normal to the line of sight is therefore computed to be CE rather than DF.

To evaluate this error, for small distortions:

$$DF_{\parallel} CE \text{ and } DG = CE \text{ and } DF = GF + CE$$

It follows that since $EF = AB$, $GF = AB/\cos \alpha_i$

Therefore

$$DF = CE + AB/\cos \alpha_i$$

References

1. Utku, S. and Barondess, S. M., "Computation of Weighted Root-Mean-Square of Path Length Changes Caused by Deformations and Imperfections of Rotational Paraboloidal Antennas," Technical Memorandum No. 33-118, Jet Propulsion Laboratory, Pasadena, Calif., March 1963.
2. Katow, M. S., and Schmele, L. W., "Antenna Structures: Evaluation Techniques of Reflector Distortions," in *Supporting Research and Advanced Development*, Space Programs Summary 37-40, Vol. IV, pp. 176–184, Jet Propulsion Laboratory, Pasadena, Calif., August 1966.
3. Katow, M. S., "Antenna Structures: Evaluation of Reflector Surface Distortions," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. I, pp. 76–80, Jet Propulsion Laboratory, Pasadena, Calif., February 1971.
4. Marcus, B. and Katow, M. S., "Antenna Structures: Evaluation of Field Measurements of Reflector Distortions," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. II, pp. 113–121, Jet Propulsion Laboratory, Pasadena, Calif., April 1971.

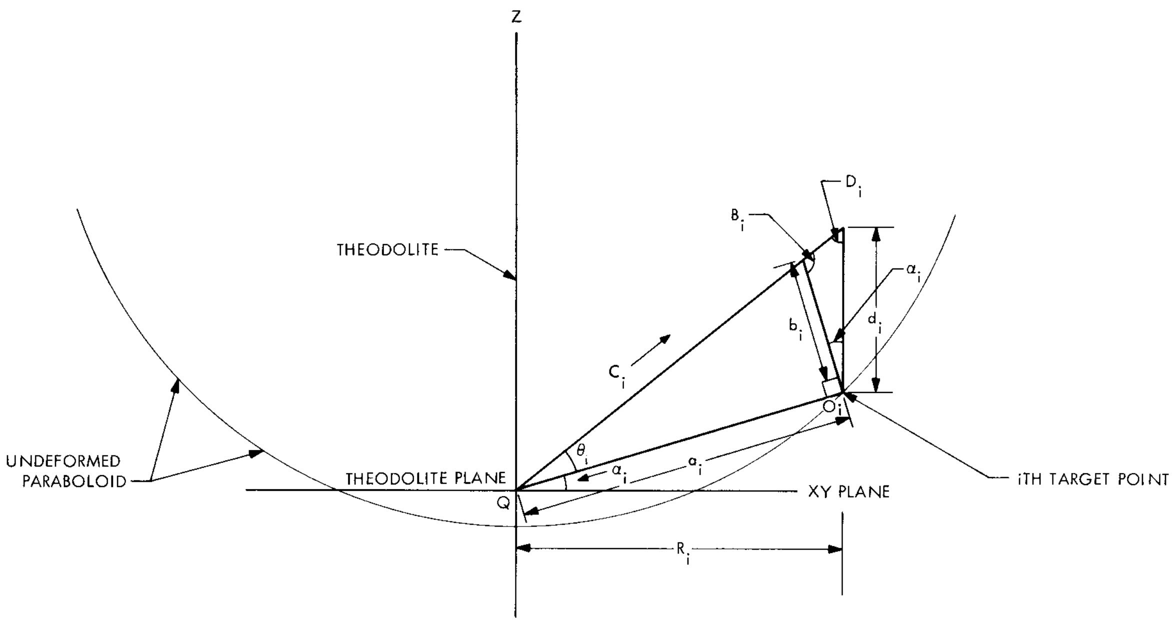

Fig. 1. Computation of Z-component of deflection vector from theodolite measurement of distortion angle

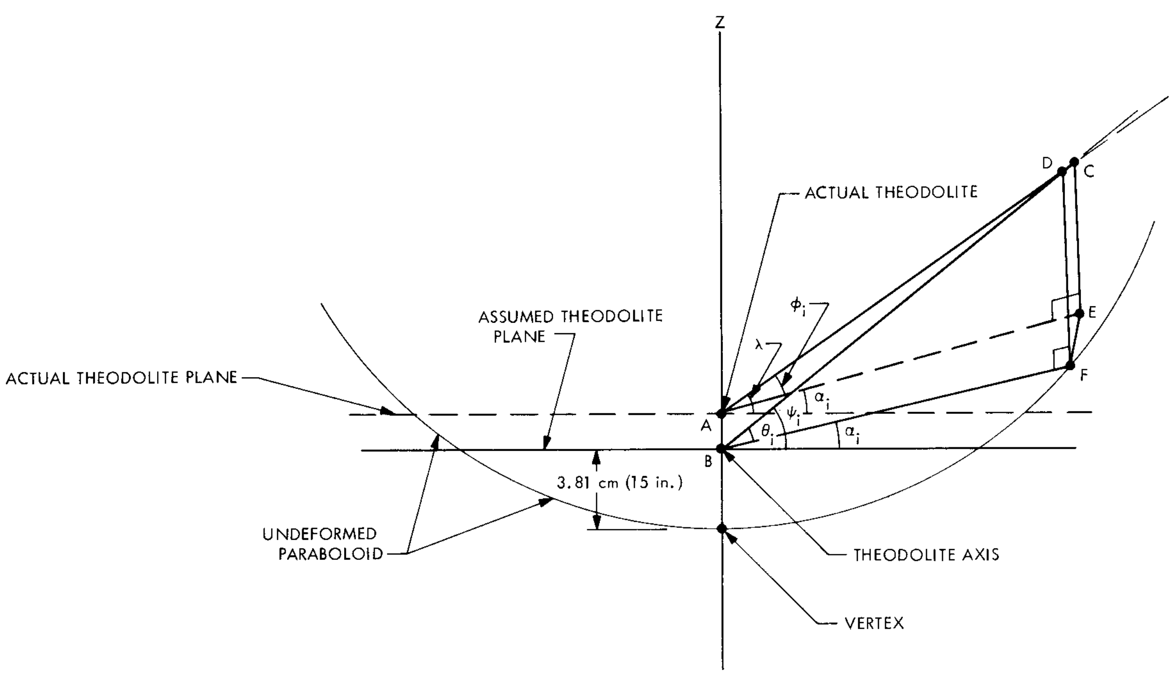

Fig. 2. Correction calculations for theodolite height changes

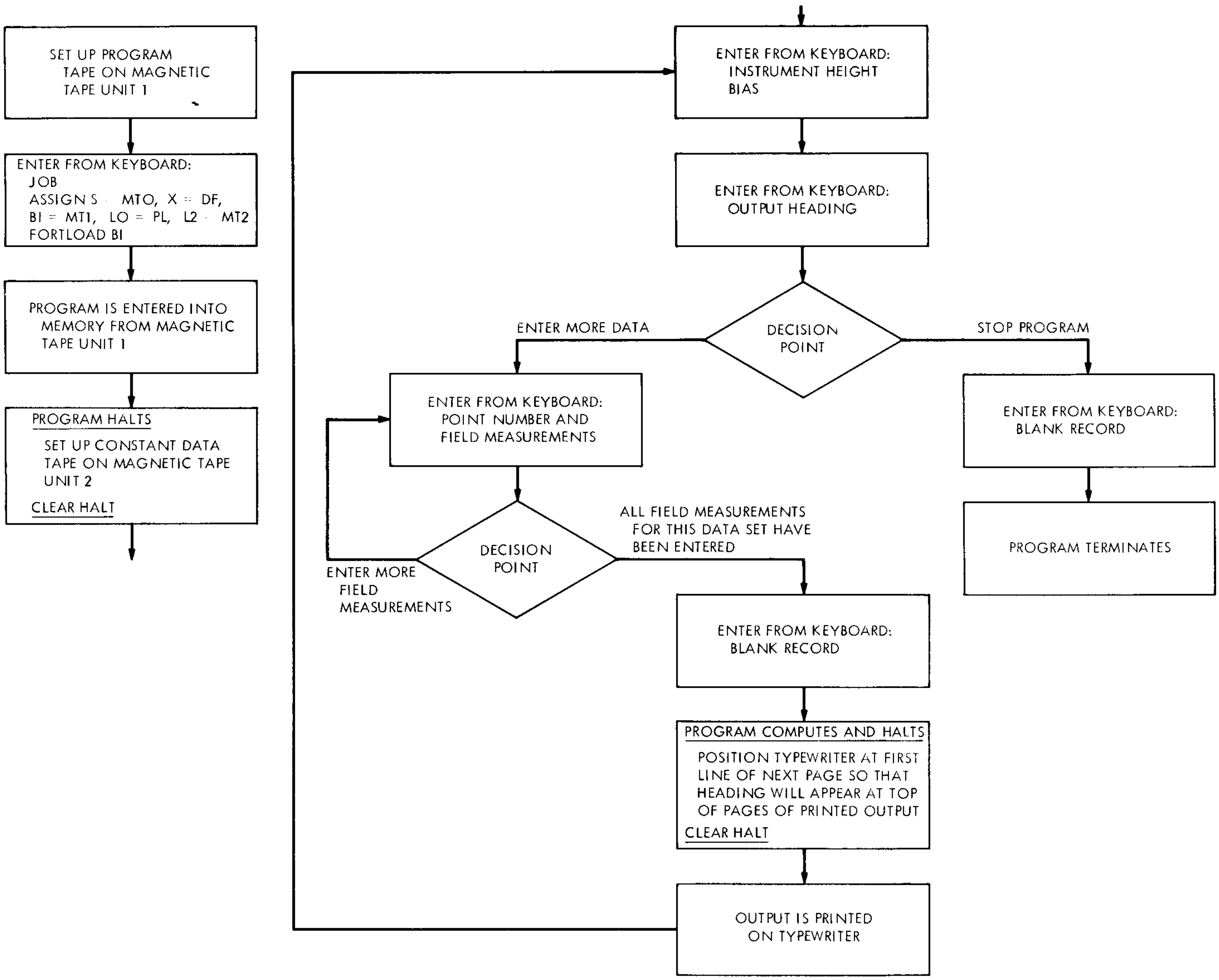

Fig. 3. Block diagram illustrating usage of RMS program on SDS 920 computer