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TWONDER Mathematical  
Description

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## 1. INTRODUCTION

This TWONDER Mathematical Description documents the features, capabilities, and computational methods of the TWONDER study program. The information contained in this document is intended to supplement the TWONDER User's Manual (Reference 1) by providing an understanding of the computational methods employed by the program. In this sense, the document can be used as an aid in conducting studies related to:

- Determining the capabilities of the MOL/DORIAN system
- Design of the operational Mission Planning Software (MPS)

Section 2 of this document describes the features and capabilities of TWONDER. Section 3 gives a detailed description of the program including computational methods and flow charts. Operating instructions and usage instructions may be obtained from Reference 1.

The version of the TWONDER program currently being used and for which the documentation is applicable is found on the SOFT 11-05N flight support tape. This is SAMSO tape 755 and contains the following programs:

1.	DIRCTY	DIRECTORY
2.	DUMPL	B65CA
3.	LTAB	P41AA
4.	SIPHON	R69AA
5.	STTOMT	G80RB
6.	TANGVEL	P16DA
7.	TBCD	Q33WH
8.	TCOIN	S03EC
9.	TDETAIL	Q34AL
10.	TDISPLAY	A76AN
11.	TDMERGE	P08EG
12.	TEPHSPAN	P06EA
13.	TIRCOS	P12DA
14.	TITANIC	Q30EB
15.	TNTERP	P10EA
16.	TOVER	P11DA

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17.	TSIGMA	P17DO
18.	TSTACOR	P15DA
19.	TSTAVEC	P14DA
20.	TWACQPR	U10AQ
21.	TWASCON	U08BL
22.	TWASSP1	U32AD
23.	TWASSP2	U32AR
24.	TWEEDOFF	U04AP
25.	TWLIST	U09AC
26.	TWMOSP	U11BN
27.	TWMOSP2	U12AS
28.	TWONDER	U16AA
29.	TWONDER2	U09AI
30.	TWOPIN	U01AH
31.	TWOPS	U02AO
32.	TWOUT	U13AY
33.	TWPATW	U03AI
34.	TWPLOT1	U30AS

Numbers 1 through 5 are SDC programs. TBCD and TDETAIL are not applicable to TWONDER and are on the tape in order that TDISPLAY will be operative. TWASSP1 is a table generating program that was used in TWONDER checkout, and TWLIST is a table listing routine. All other programs have specific TWONDER functions.

The TWONDER program is compatible with the BESST 11 series of system support tapes and requires certain octal correctors found in the SOFT 11-05N convenience deck. It is planned to build a new flight support tape incorporating all of the convenience deck octals. This documentation will also be applicable to the new flight support tape.

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## 2. TWONDER CAPABILITIES

### 2.1 GENERAL DISCUSSION

The purpose of the MOL/DORIAN Mission Planning Software (MPS) is the generation of an optimum target acquisition strategy for the main optics and the two acquisition telescopes. The TWONDER study program has been developed to provide a means of evaluating the capabilities of the MOL/DORIAN photographic reconnaissance system during the development phase of the system. In addition, the program TWONDER provides a tool that will be used to facilitate development of the target selection algorithms for the operational Mission Planning Software.

An important feature in the overall design of the TWONDER target selection procedures is the progressive reduction in size and improvement in organization of the initial target list on the basis of preliminary information and using fast computational methods. This reformatting, compression, and reordering of the original target list is begun by the subfunctions TWPATW and TDMERGE and continued by the subfunctions TWOPS, TWEEDOFF, and TWASCON. It is only when the target list has been significantly reduced that the highly accurate analytic procedures and precise selection logic within TWONDER are exercised.

The targeting problem can be viewed in terms of three fundamental processing requirements which are (1) the organization and compression of the master target list into the time ordered set of visible targets, (2) the generation of optical system pointing information which defines the opportunities for main optics photography and ATS viewing, and (3) the selection of an optimum strategy for the main optics and ATS.

Because it is not necessary to perform the above step (1) with extreme accuracy so long as no visible targets are erroneously rejected, the compression and time ordering function is performed using tailored approximate trajectory equations, which greatly reduce computational times while sacrificing very little accuracy. Step (2), the generation of optical system pointing parameters, is the only step of the three that would be absolutely essential provided the input list of targets was limited to a relatively few widely spaced targets. These computations relate individual

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point targets to the orbiting photographic system to produce the parameters that describe how and when each target can be observed. Step (3), the selection of an optimum strategy, introduces the concept of conflict between the competing targets. Conflicts are identified by considering the vehicle's maneuvering capability and the pointing requirements of the various target acquisitions. Optimal sequences for the main optics and acquisition telescopes are generated by applying optimization algorithms to the set of possible acquisitions.

An introductory discussion of these three fundamental requirements is provided in the following sections. Section 2.1.1 provides a discussion of the swath sorting and time ordering performed by TWPATW and TDMERGE. These subfunctions are described in detail in Sections 3.3 and 3.4. The basic optical system pointing parameters determined by the subfunction TWOPS are described in Section 2.1.2. A detailed description of TWOPS is provided in Section 3.6. Section 2.1.3 provides a brief mathematical introduction to the optimization techniques employed by TWOSP and TWASSP2. The subfunctions are described in detail in Sections 3.8 and 3.11.

#### 2.1.1 Orbital Considerations Related to the Swath Sorting of Targets

Two obviously important properties of a reconnaissance orbit are (1) the pattern with which it acquires point targets and (2) the photographic conditions that will apply at the time a particular target is viewed. If for the moment the earth is assumed not to rotate about its poles, the set of visible targets will be confined to a narrow visibility belt underneath the orbit, as illustrated by the shaded area of Figure 2-1.

Assuming that the sun was positioned directly out from the page (in the same relative position to the figure as the reader), then it will always be daytime for those points on the near side of the earth and nighttime for those points on the back side. Moreover, it will be noontime at point B, and earlier or later than noon for points between A and C only so much as the plane of the orbit carries the vehicle to the west or east of the sun/earth line. If the orbiting vehicle moves in the direction ABC, then the opportunities for daylight photography will occur when the vehicle is moving in the north to south direction.

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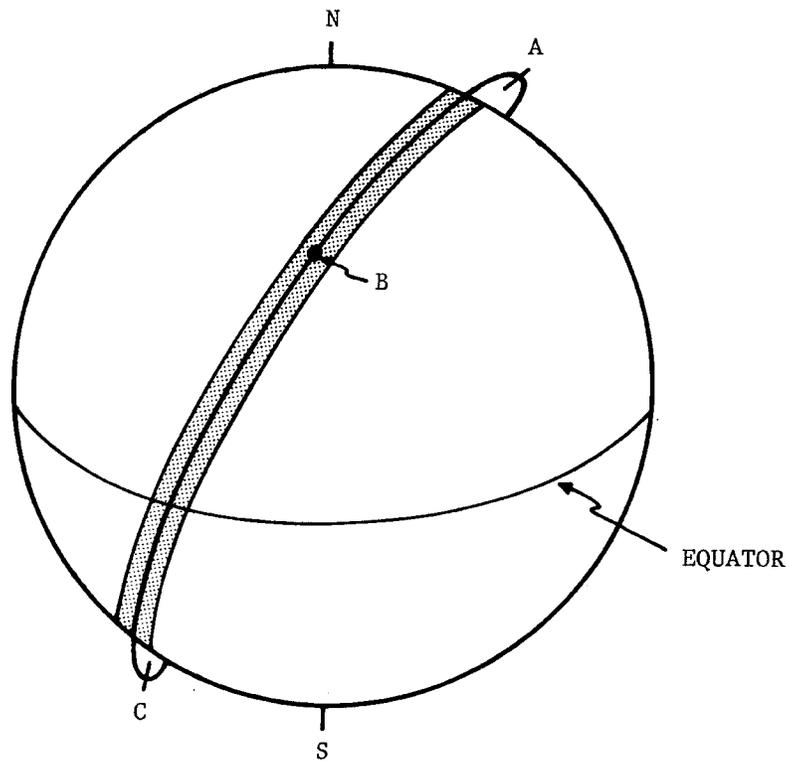


Figure 2-1. Photographic Reconnaissance Orbit Schematic

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These depicted relationships will be established by a southwesterly launch from VTS resulting in an orbit having retrograde motion, if liftoff occurs near 12 noon (i.e., the time at which VTS coincides with point B). If, in addition, perigee is established in the vicinity of point B, it will be possible to photograph the great majority of targets (visible as they shift through the doubly shaded region) at relatively low altitudes ( $\approx$  85 miles) while maintaining apogee altitudes (one-half rev removed from point B) consistent with operationally suitable orbit periods and lifetimes.

The effect of the earth's rotation is to shift new targets into the shaded visibility band between consecutive revolutions of the vehicle. Near earth orbits have periods of approximately ninety minutes from which it follows that the earth makes a complete revolution approximately every 16 revolutions. By suitable choice of orbital period, the coverage pattern can be tailored to give repeated coverage of specified areas or to provide uniform coverage on the basis of this daily cycle. Complete coverage, except in the region near the equator, can be achieved after 5 days of operation. During the same 5-day period, areas nearer the top of the orbit will be covered redundantly on consecutive days and in some cases on consecutive revs. These observations follow from consideration of the visibility swath width ( $\approx$  140 miles near perigee) and the decrease in rotational effects as a function of increasing latitude.

The described set of first order orbital characteristics can be exploited to compress and organize the master target list. This function is carried out by the TWONDER subfunctions TWPATW and TDMERGE, which first select the set of visible targets over a specified rev span (eliminating approximately four-fifths of the total set of targets for a 1-day run) and then time order these targets according to their computed acquisition times. The visibility criteria can be calibrated and qualifying targets subjected to additional constraints according to certain File 7 input parameters (SEVXXX). SEV003 specifies the absolute value of obliquity that is to apply to target acquisitions. This value must take into account anticipated errors in crosstrack distance over the prediction interval. The obliquity pad over and above the actual obliquity limits of the system can be made comfortably large since the associated penalty, which is the qualification of some additional targets, is negligible. SEV004 specifies the minimum

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sun elevation angle that must apply at a target for qualification. This parameter is also related to the visibility requirement. SEV007 and SEV008 specify the maximum slant range to the target and maximum vehicle altitude, respectively. These latter parameters can be used to establish a minimum resolution criterion for individual target acquisitions.

### 2.1.2 Pointing Parameters

The opportunities for main optics photography and ATS viewing are determined by the subfunction TWOPS. Both systems are capable of continuously tracking individual point targets, and it is therefore required that the target/vehicle orientation be defined over the duration of target visibility. The target orientation at any time is defined by stereo angle ( $\Sigma$ ) and obliquity ( $\Omega$ ) as illustrated in Figure 2-2.

The acquisition time and acquisition obliquity are determined for each target at three stereo angles defined by the File 7 input parameters SEV063, SEV064, and SEV065. These parameters are the main optics maximum forward stereo angle, vertical acquisition stereo angle, and maximum aft stereo angle.

To a first approximation, both stereo angle and obliquity can be considered to be linear functions of time. This approximation is employed by the target selection algorithms to define the pointing parameters  $\Sigma$  and  $\Omega$  over the interval of target visibility. In terms of the time at which a given stereo angle is achieved, the maximum error contributed by this approximation is about 1 second. This linear assumption has led to the derivation of the conflict parameter (Q), which is discussed in Section 3.8.

### 2.1.3 Analytical Basis of the Target Selection Algorithms

#### 2.1.3.1 Purpose of this Discussion

The purpose of this discussion is to present, in a simplified form, a mathematical discussion of the target selection problem. This discussion is limited to the consideration of a discrete time-ordered problem in which a single strategy is determined. The main optics algorithm, TWMOSP, is an extension of the basic algorithm that considers continuous variable and nontime ordering. The detailed description of this algorithm is provided

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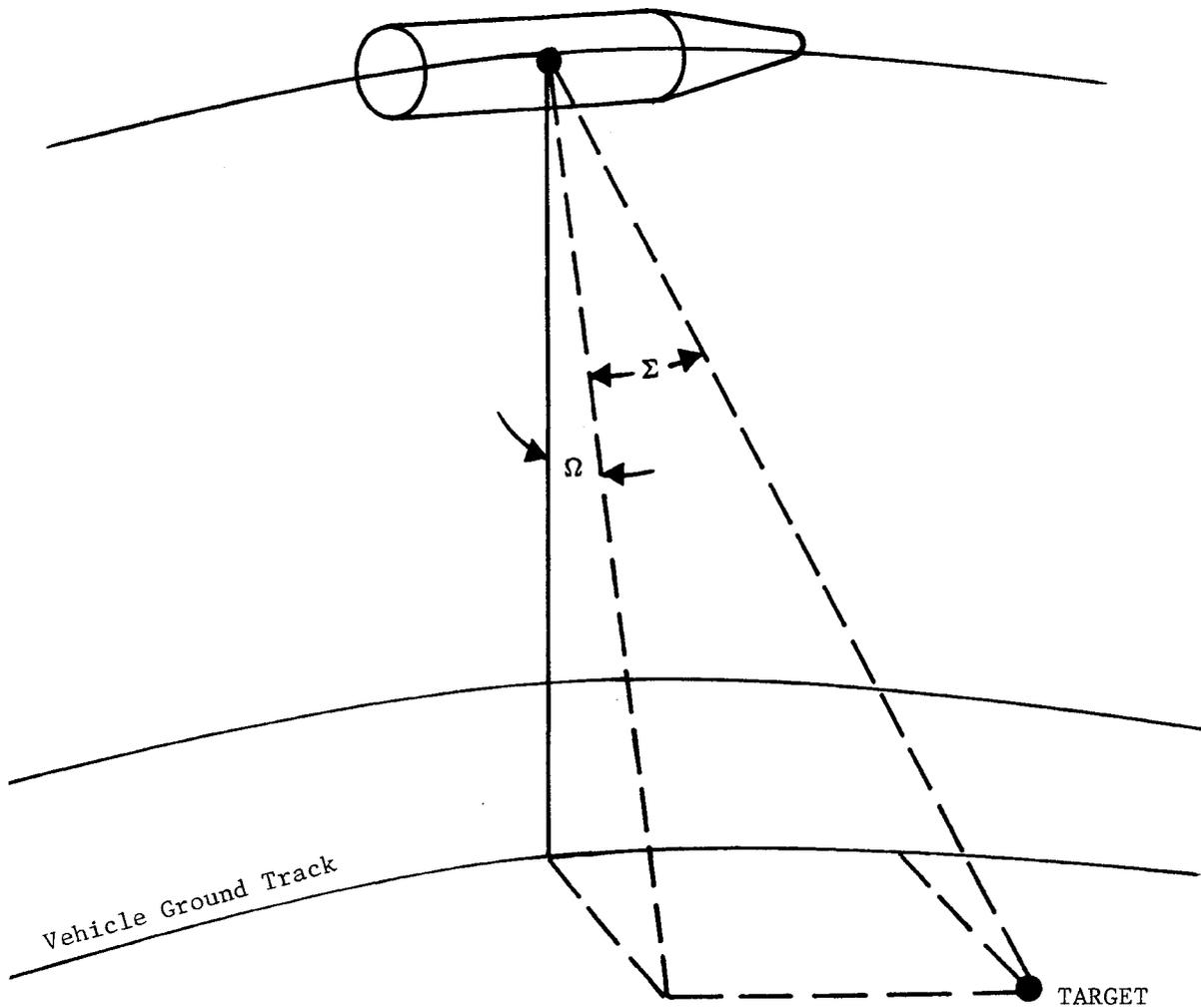


Figure 2-2. Target/Vehicle Orientation

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in Section 3.8. The ATS algorithm, TWASSP2, requires the simultaneous optimization of the strategies for the two acquisition telescopes. This algorithm is described in Section 3.11.

### 2.1.3.2 Statement of the Problem

The target selection problem is to determine, out of all possible sequences, which sequence of nonconflicting targets maximizes the total target score over some prespecified vehicle orbit span.

To facilitate a clearer presentation of the basic mathematical ideas underlying the selection algorithm, certain simplifying assumptions will now be introduced. It is assumed that:

- a. The vehicle is capable of only a single (e.g. vertical) stereo direction sighting.
- b. Obliquity slewing rate is constant.
- c. A single prespecified or precomputed value is available for the worth of each target acquisition.

Conflicting targets must, of course, exist or the problem is trivial.

### 2.1.3.3 Solution of the Problem - Analytic Aspects

Figure 2-3 depicts a particular target distribution. Targets  $T_1, T_2, \dots, T_6$  could be photographed by the vehicle (disregarding conflicts) when the vehicle is, respectively, at positions  $P_1, P_2, \dots, P_6$  along its orbit if the mirror were slewed to, respectively, obliquities  $R_1, R_2, \dots, R_6$ . In fact, however, slewing the mirror requires time. Assuming a constant slewing rate, there may be associated with each target "limit" lines (dashed lines in the figure) which define the region in the vehicle visibility swath that could not be photographed assuming the target in question is also photographed.

In the figure, both  $T_5$  and  $T_6$  are in conflict with  $T_2, T_3,$  and  $T_4$ . There are no other conflicts. For brevity, it might be written

$$T_5 \subset T_2, T_3, T_4$$

$$T_6 \subset T_2, T_3, T_4$$

$$T_1 \not\subset T_2, T_3, T_4, T_5, T_6$$

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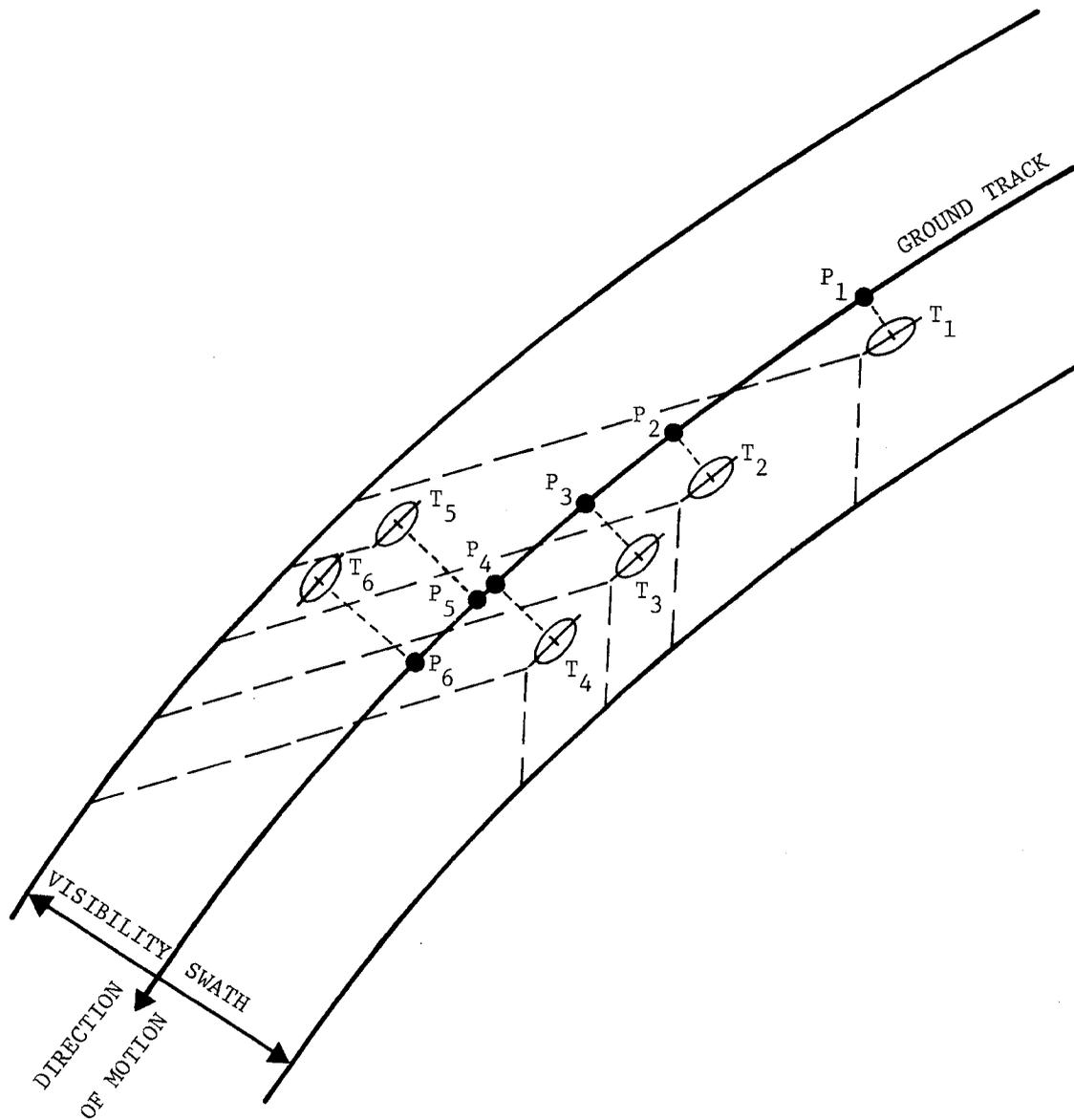


Figure 2-3. Example Six Target Distribution with Conflicts

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letting the symbol  $\underline{c}$  represent conflict and the symbol  $\underline{\neq}$  represent no conflict.

Refer to an arbitrary sequence of nonconflicting targets as an admissible policy, and the total score associated with that policy will be referred to as the return from following that policy. A policy which maximizes the return will be called an optimal policy. In general, an optimal policy will not be unique, but the maximum return or maximum score produced by following an optimal policy must, by definition, be unique.

Inasmuch as a policy, by the above definition, contains no conflicting targets, first mathematically characterize the state of conflict/no conflict among the various targets. This may be done quite succinctly with the use of a target conflict matrix.

Thus envision a (square) conflict matrix,  $C$ , with elements  $c_{ij}$  such that

$$c_{ij} = \begin{cases} 0, & \text{if } T_i \not\subset T_j \\ 1, & \text{if } T_i \subset T_j \end{cases}$$

By definition,  $c_{kk} = 1$ , that is to say, any target is in conflict with itself. The motivation for this will become apparent later.

It is clear that if  $T_i \subset T_j$ , then  $T_j \subset T_i$ , i.e.,  $C$  is symmetric. It may be concluded that the elements to the right of the main diagonal along with the diagonal itself contain all the essential information in the conflict matrix.

The conflict matrix associated with the target distribution indicated in Figure 2-3 is shown in Figure 2-4.

Assume that the targets have been chronologically ordered so that  $T_1$  is the first target to be encountered and possibly photographed,  $T_2$  is the second, and so on to  $T_N$ , which is the last target to be encountered in a particular span.

Instead of attempting to directly determine the optimal policy starting before the first target is encountered through to the last target, the optimal policy starting before the first target through to some general target will be determined. Clearly, when this problem has been

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$i \quad j$	$T_1$	$T_2$	$T_3$	$T_4$	$T_5$	$T_6$
$T_1$	1	0	0	0	0	0
$T_2$		1	0	0	1	1
$T_3$			1	0	1	1
$T_4$				1	1	1
$T_5$					1	0
$T_6$						1
$S_j$	1	2	3	4	2	3
$i_j^*$	0	1	2	3	1	5
$S_{\max j}$	1	2	3	4	4	4

Scoring

↑

Conflict

↓

Matrix

Figure 2-4. Example Six Target Conflict Matrix with Scoring

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solved for all targets, one will have the solution to the particular problem of starting before the first target and ending after the last target.

For analysis purposes, define the following function.

$S_j \triangleq$  the score obtained from the sequence of targets which ends with  $T_j$ , taking  $T_j$ , and otherwise following an optimal (score maximizing) photographic policy

Further, let  $w_j$  be the worth of a photograph of  $T_j$ . Finally, define the set of targets  $I$ , with elements  $i$ , such that

- a.  $i < j$ , i.e.,  $T_i$  is encountered previous to  $T_j$
- b.  $c_{ij} = 0$ , i.e.,  $T_i$  is not in conflict with  $T_j$

It is clear that the set  $I$  is, in general, a function of  $j$ , the particular target in question. In particular, the number of elements of  $I$  is a monotone nondecreasing function of  $j$ . Roughly speaking, the number of elements of  $I$  will be somewhat smaller than the numerical value of  $j$  because some earlier  $T_i$  are in conflict with  $T_j$ .

Now develop a simple equation which the function  $S_j$  must satisfy. It will be a recursive equation to evaluate, sequentially,  $S_j$  for all  $j$ .

Break up  $S_j$  into two parts: that score or return from taking  $T_j$ , and the previously accrued score or return just before reaching  $T_j$ . The worth of  $T_j$  is precisely  $w_j$ . Immediately preceding the taking of  $T_j$ , some other admissible predecessor target,  $T_i$ , was taken. Disregarding for the moment just how this can be ensured, it should be clear that if  $T_i$  were taken, then it should have done so via a maximum return policy from the start up to and including  $T_i$ . Now by definition, the maximum score obtainable from the start up to and including  $T_i$  with  $T_i$  taken is  $S_i$ . Inasmuch as  $w_j$  is independent of the predecessor target, it remains simply to choose that particular predecessor target,  $T_i$ , out of the admissible predecessor set  $I$ , which maximizes  $S_i$ . Mathematically,

$$S_j = w_j + \max_{i \in I} S_i$$

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As with any optimization problem, two items or quantities are of interest. First, there is the thing which is extremized - in this case, maximized. It has been denoted as  $S_j$ . Secondly, there is the thing (independent variable) which, if set to the right value, causes the return to be extremized. The variable in this problem is the optimal predecessor target associated with each target. We might call this  $i_j^*$ .

#### 2.1.3.4 Solution to the Problem - Computational Aspects

The above simple equation can be used in the following manner.

The computation is initialized at  $T_1$  and is precisely  $S_1 = w_1$ . There is no predecessor associated with the first target. Next  $T_2$  is considered. If  $T_1 \subset T_2$ , then this is so reflected in the conflict matrix by  $c_{12} = 1$ . In this case,  $I$  would be an empty set and  $S_2 = w_2$ . If  $T_1 \not\subset T_2$ , then  $c_{12} = 0$ , and  $S_2 = w_2 + S_1$ .

The situation becomes interesting, but by no means complicated in general from the third target on. Thus for  $T_3$ ,  $S_3$  equals  $w_3$  plus the maximum of  $S_i$ , where  $i < 3$  and  $c_{i3} = 0$ . In similar fashion, one evaluates  $S_j$  sequentially until  $j = N$ , the last target to be considered. This procedure is easily followed, especially on a digital computer, because the procedure involves a strictly repetitious operation, and, for any particular  $j$ , all  $S_i$ ,  $i < j$  will have been already evaluated.

As the procedure is followed for each target  $T_j$ , it is necessary to record only  $S_j$  and  $i_j^*$ . To determine the optimal policy through the target distribution, one then starts at the end of the list and examines the  $S_j$  until the largest is found. This largest value may not necessarily occur at  $j = N$ , the physically last target, but it will be near the end. The largest  $S_j$  will be the maximum possible return or score and  $T_j$  will be the last target to be photographed in the optimal sequence. Also, that target has its particular  $i_j^*$  which is the index of the immediate predecessor to  $T_j$  in the optimal sequence. In this fashion, one reconstructs the optimal sequence of targets to be photographed, albeit in a reversed time ordering.

The computational procedure will be illustrated with the six-target example of Figures 2-3 and 2-4. It becomes convenient, in performing hand calculations, to append three additional rows to the conflict matrix which

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contain, for each target, the vectors  $S_j$ ,  $i_j^*$ , and  $S_{\max j}$ , the latter being equal to  $\max S_k$ . The purpose of the last row will be indicated later.

It is observed at present that  $S_{\max j} \geq S_j$  for all  $j$ .

For simplicity, assume that  $w_j = 1$  for all  $j$ . Evaluate  $S_4$ , the maximum score obtainable from the start up to and taking  $T_4$ . From the conflict matrix it can be seen that for  $j = 4$ ,  $T_1$ ,  $T_2$ , and  $T_3 \in I$ . Therefore, from the equation,

$$S_4 = 1 + \max (1, 2, 3),$$

which is to say,

$$S_4 = 1 + 3,$$

that is,

$$S_4 = 4.$$

Further, it has been found that

$$i_j^* = 3$$

that is, in any optimal sequence, which includes  $T_4$ , the predecessor to  $T_4$  should be  $T_3$ .

In practice, one need not generate and store in a computer memory the whole of the conflict matrix before starting to perform the target selection. If memory space is limited, it may just as well determine whether or not a conflict exists between two targets  $T_i$  and  $T_j$ , i.e., determine the value of  $c_{ij}$ , when considering selecting  $T_i$  as the predecessor to  $T_j$ .

The purpose of the row headed  $S_{\max j}$  will now be indicated. According to the recursive equation, when evaluating any  $S_j$ , consider, as a predecessor target  $T_i$ , all  $i \in I$ , i.e., all  $i$  such that  $i < j$  and  $c_{ij} = 0$ . For large numerical values of  $j$ ,  $I$  will become a sizable set to be tested. This is clearly an undesirable situation. Further, it is clear that testing over all  $i$  in  $I$  is unnecessary since the optimal predecessor  $i_j^*$  will in general be relatively near  $j$ . The function of  $S_{\max j}$  is to allow the search back on  $i$  to be terminated as soon as possible.

Thus, in practice, in evaluating any  $S_j$ , only those  $i \in I$  need to be considered which further belong to the subset of  $I$ , say  $I'$ , which starts with the closest admissible  $i$  to  $j$  and ranges to that  $i$  such that

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$S_i = S_{\max i}$  for the first time working backward with decreasing  $i$ . It can be shown that the subset  $I'$  will always include the optimal predecessor,  $i_j^*$ , for any  $T_j$ .

In the example defined by Figures 2-3 and 2-4, the actual amount of search back on  $i$  for any  $j$  is shown in Table 2-1.

Table 2-1. Actual Search on  $i$  for any  $j$

$j$	Set $I$ Includes	Set $I'$ Includes
1	empty	empty
2	$i = 1$	$i = 1$
3	2, 1	2
4	3, 2, 1	3
5	1	1
6	5, 1	5, 1

While the above table indicates some savings in the amount of searching to be done, it should be clear that the savings increases greatly with a large target list. Roughly speaking, the number of elements in the set  $I$  increases linearly with  $j$ , while the number of elements in the set  $I'$  remains essentially constant and will include only a relatively small number of possible nonconflicting predecessor targets immediately preceding  $T_j$ .

## 2.2 TWONDER SUBFUNCTIONS

The program TWONDER is composed of a series of subfunctions that are called sequentially to perform the required computations. The interrelationship between these subfunctions is illustrated in the functional flow chart provided in Figure 2-5. A brief description of each of the successor functions called by TWONDER is given below.

### 2.2.1 TWOPIN

The function TWOPIN initializes all input data for TWONDER. It reads Files 1, 2, 7, and 8 of the reset tape and generates a table of constants and reference parameters. The reset parameters are stored in the tables THINGS and ALSO. These tables provide the primary means of communication between the TWONDER subfunctions. TWOPIN also reads all controlling

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TWONDER

TWONDER

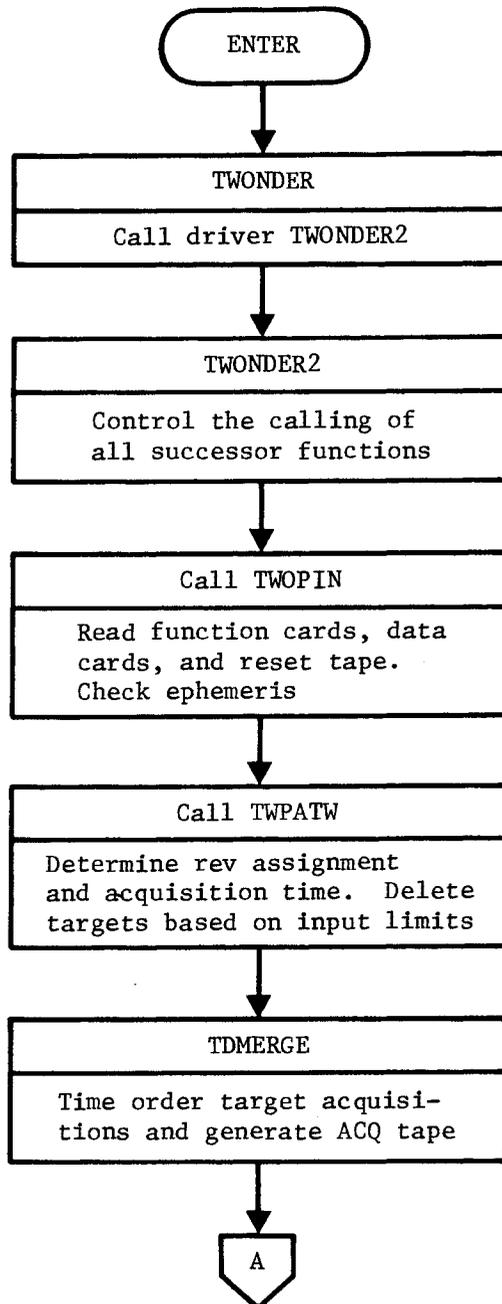


Figure 2-5. TWONDER Functional Flow Chart

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TWONDER

TWONDER

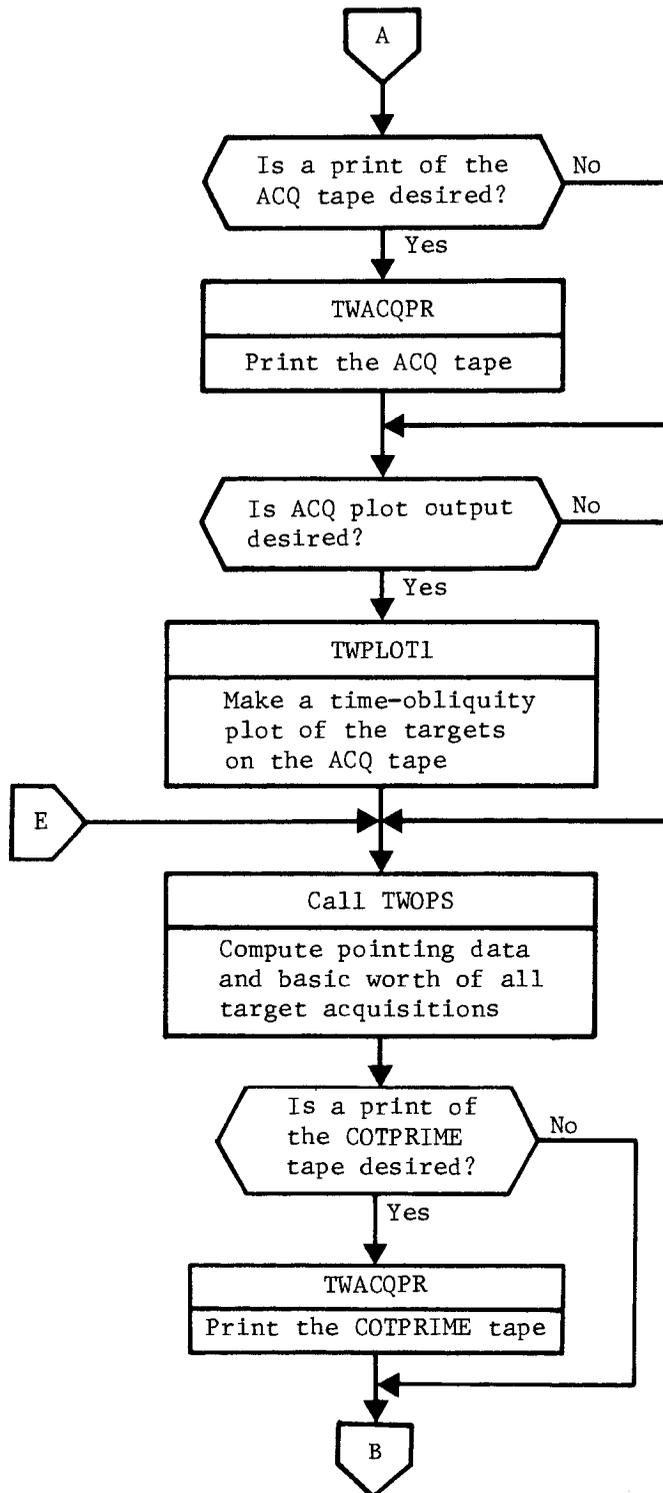


Figure 2-5. TWONDER Functional Flow Chart (Continued)

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TWONDER

TWONDER

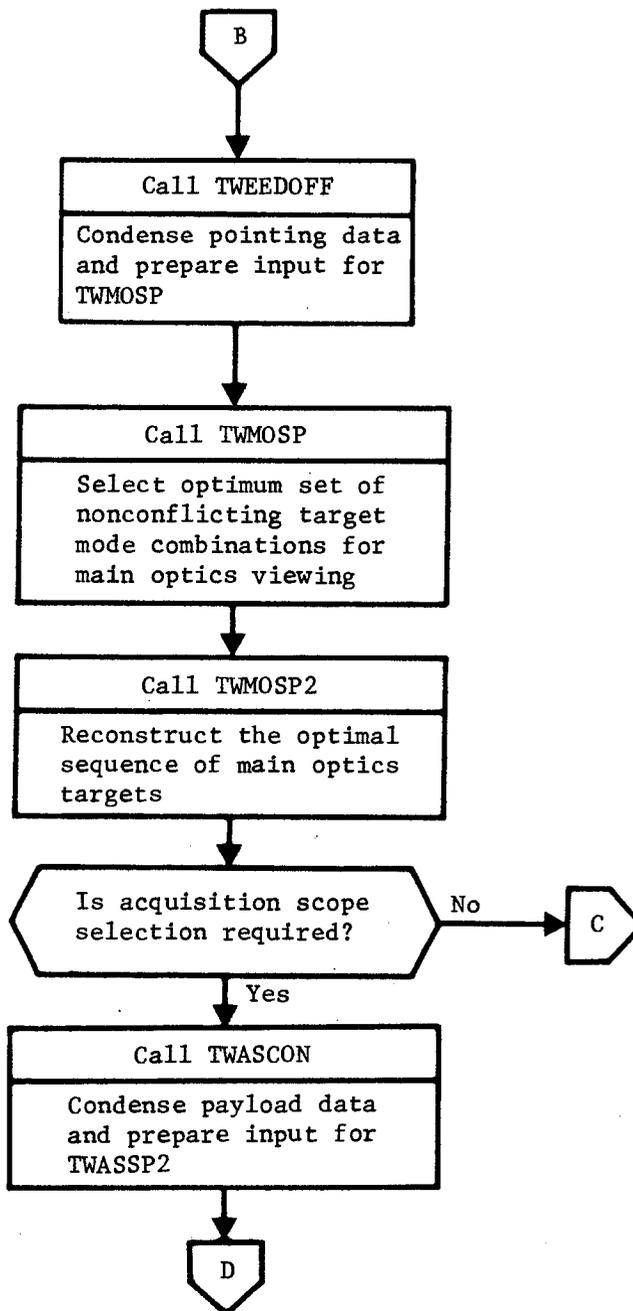


Figure 2-5. TWONDER Functional Flow Chart (Continued)

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TWONDER

TWONDER

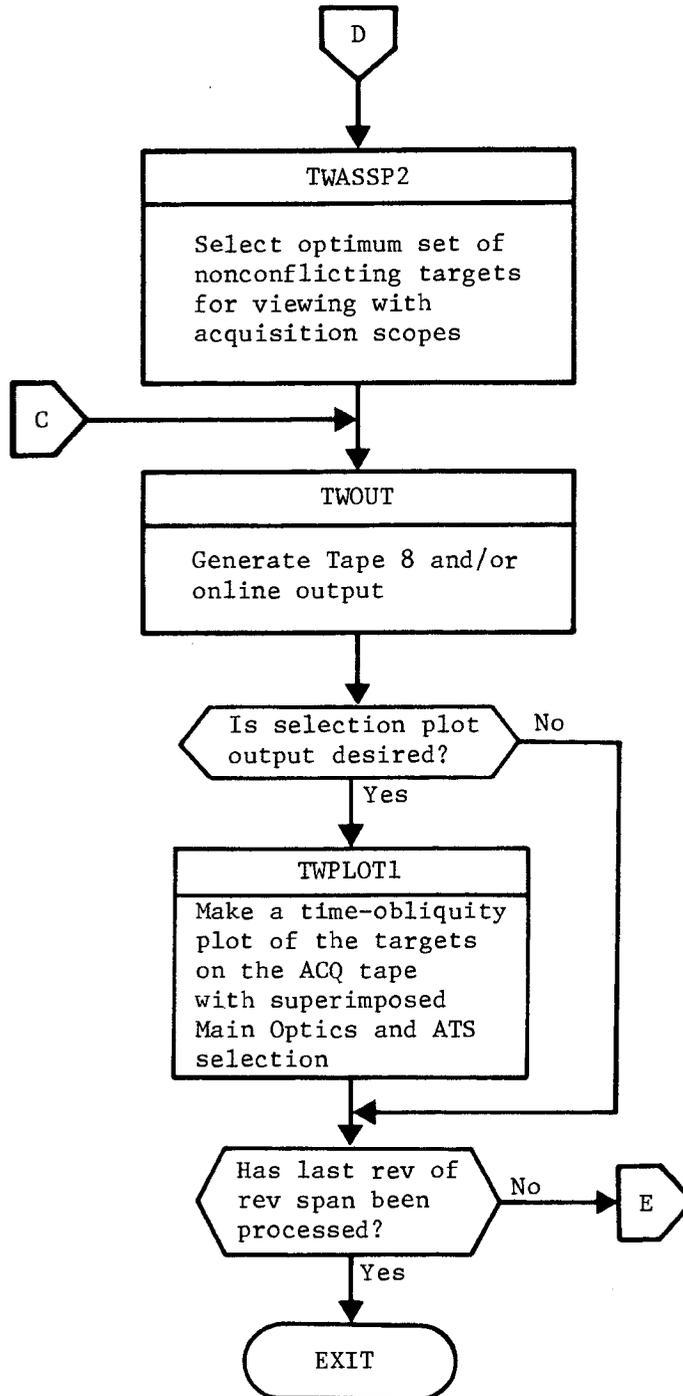


Figure 2-5. TWONDER Functional Flow Chart (Continued)

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parameters on the TWONDER function card and reads all data cards. The following types of data cards can be input: LAT, TIM, LIM, target add (A), target change (C), target delete (D). It also checks the rev span on the input DDI ephemeris tape to ensure that sufficient ephemeris coverage exists over the requested rev span.

### 2.2.2 TWPATW

TWPATW accepts data from the target tape and stored ephemeris data produced by the DDI general purpose tracking program and computes approximate target acquisition times. To increase computing speed, approximate analytic expressions are used for these computations. All targets that are impossible to photograph are eliminated. However, a conservative approach to target elimination is used, which ensures that targets that may become available for photography, through possible subsequent minor orbit variations, are retained.

Initially, the average sun vector is computed, and the vehicle analytic ephemeris is constructed (from the input ephemeris) for the rev span of interest. Also computed initially are the limiting latitudes for target acquisition. The latitude limits are based on sun angle and orbit inclination constraints.

Subsequently, the target entries are read from the target tape into the target buffers. The target card entries are decoded one at a time and operated upon serially until the entire target record has been decoded and processed, and the acquired target data stored in the acquisition buffers.

In the serial mode of processing employed by TWPATW, each target has its acquisition opportunities evaluated for the entire rev span during its processing turn. Target acquisition processing is initiated by checking the target latitude against the limits computed initially and making an initial estimate of earliest time of target acquisition. The initial estimate of acquisition time is refined in an iteration that determines the vertical acquisition time for each acquisition opportunity on the rev span.

For all targets acquired, computations are made for sun elevation angle, obliquity angle, slant range, and vehicle altitude. These parameters are checked against the input limits for each parameter, and for each target that is not deleted, the target latitude and acquisition time are checked

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against any existing latitude and/or time band deletions. For all valid target acquisitions, the data for the acquired targets are stored in the buffer area for output and subsequently on the intermediate acquisition tape preliminary to time sorting.

Options are provided that allow TWPATW to perform its operations in four different modes. These options are summarized as follows:

- a. Construct. A target tape and DDI ephemeris data are used to generate an acquisition tape. This is the basic operating mode for TWPATW.
- b. Construct with ALTER Cards. A target tape is used together with alter cards (add and/or change and/or delete) to produce an acquisition tape.
- c. Ephemeris Update. Existing acquisition tape data are updated to provide new acquisition times and acquisition parameters as a function of new or modified ephemeris base data.
- d. Ephemeris Update with ALTER Cards. Existing acquisition tape target data are revised to reflect possible ephemeris change as well as revisions specified by entries on ALTER target cards.

### 2.2.3 TDMERGE

After TWPATW has processed the target list and the target and acquisition data for all acquired targets has been written on intermediate tapes, TDMERGE sorts the targets and writes the final acquisition tape. TDMERGE reads the entries from the intermediate acquisition tapes into core storage buffer space. The targets are time ordered in core and a single target acquisition tape is written. The target data contained on the acquisition tape includes the full set of target card parameters. Also entered in the data block are the target acquisition parameters which are computed by TWPATW:

- a. Time of acquisition
- b. The difference between earliest acquisition time and vertical acquisition time
- c. Parameters at vertical acquisition
  - Obliquity angle
  - Altitude

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- Slant range
- Sun elevation angle

#### 2.2.4 TWACQPR

The subfunction TWACQPR reads either target acquisition records from the acquisition tape or COTPRIME records from the COTPRIME tape, depending upon the options requested and the calling sequence. The data are interpreted and reformatted for the listable output. The output is ordered by rev number and by vertical acquisition time within each rev. A detailed description of the acquisition table is provided in Section 3.5

#### 2.2.5 TWPLOT1

The subfunction TWPLOT1 provides a display of the target data available on the acquisition tape in the form of a swath plot. On option, both the main optics and ATS selection strategies are indicated on the swath plot.

The following information is available on the swath plot for each of the targets on the acquisition tape.

- Target I.D.
- First significant digit of target inactive priority
- Earliest acquisition time
- Vertical acquisition time
- Obliquity

In addition, the selection strategy option provides the following:

- Scheduled scope dwell time
- ATS path number
- Flag at I.D. scheduled for ATS viewing
- Group decision time
- Group number
- Scheduled main optics tracking time

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- Time during which photography actually takes place
- Flag at I.D. scheduled for photography

A detailed description of this output is provided in Section 3.13.

#### 2.2.6 TWOPS

The function TWOPS reads the acquisition tape, computes precise pointing data and the basic weights (active and inactive) for each target, and generates the COTPRIME tape, which then provides the basic source of target information for the successor functions of TWONDER. The pointing information is calculated by an iterative procedure. The acquisition times available on the acquisition tape were determined by approximate methods in TWPATW using an analytic ephemeris. These times are used as a first approximation, and the precise acquisition times are then determined for each target based on the input DDI ephemeris. The pointing information available for each target consists of acquisition time and acquisition obliquity for each of three input stereo angles. These stereo angles correspond to main optics maximum forward stereo angle, vertical acquisition (stereo angle = 0), and main optics maximum aft stereo angle. The active and inactive weight of each target is determined as a function of priority and an obliquity deweighting factor of the form  $\cos^n$  (obliquity), where n is a File 8 input.

Apart from the various geometrical constraints, the subfunction TWOPS provides the first of a series of target density filters, which selectively eliminate from further consideration and computation targets of such low worth as would not affect the ultimate main optics and ATS strategies. Two File 8 parameters control the sensitivity of this filter.

#### 2.2.7 TWEEDOFF

The function TWEEDOFF acts as a preprocessor for the main optics algorithm (TWMOSP). The basic functions performed by TWEEDOFF are:

- Abstraction of the information required by the main optics algorithm (TWMOSP) from the COTPRIME. This information is tabulated in the MOCOT.

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- Provision of a means of limiting the number of targets that must be considered by TWMO SP. This is accomplished through the use of either a priority filter or a priority/target density filter. These filters can be used to study the tradeoff between program running time and total score.
- Determination of the number of targets that are in partial conflict with each of the targets to be considered by TWMO SP. Only those targets that are in close time proximity require a detailed conflict analysis. Targets that are further removed in time are either in complete conflict or have no possible conflict. The earliest and latest targets that must be considered for partial conflict are determined by TWEEDOFF for each of the targets in the MOCOT. This information is utilized by TWMO SP to reduce the number of conflict calculations.
- Computation of the basic weight of each target to be considered by TWMO SP as either its inactive or its expected worth, depending upon a File 8 input parameter.

#### 2.2.8 TWMO SP

The main optics algorithm TWMO SP selects the best score set of non-conflicting photographic sequences. The effective worth of an individual photographic sequence is based on active target priority, inactive target priority, probability of activity, photographic mode, an obliquity deweighting function, and a pitch deweighting function.

In TWMO SP, the best score set of predecessors is determined for each of the targets available in the MOCOT. This information is tabulated in the ALMOST table, and the job of reconstructing the optimal path is delegated to the successor function TWMO SP2.

#### 2.2.9 TWMO SP2

The function TWMO SP2 abstracts the optimal sequence from the ALMOST table and outputs the Main Optics Strategy Table (MOST), which contains the selected main optics photographic sequence. The ALMOST table contains the set of all optimal sequences down to and including every target under consideration. The sequence that attains the maximum score is then the overall optimum. TWMO SP2 scans the ALMOST table to find the target that completes the largest score sequence. The predecessor information is then

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utilized to trace this sequence and to determine which targets are contained on the optimal sequence. The acquisition time and photographic mode are also determined for each of these targets. The target identifier, acquisition time, and photographic mode are then tabulated in the MOST.

#### 2.2.10 TWASCON

The function TWASCON is utilized as a preprocessor for the acquisition scope algorithm (TWASSP2). The basic inputs to TWASCON are the COTPRIME tape and the MOST. TWASCON contains a series of filters of three general types. These are:

- a. Target type filters
- b. Geometry filter
- c. Group density filter

The type filters can be used to selectively delete from consideration targets of the following type by the ATS algorithm:

- Visual intelligence targets
- Main optics selected targets
- Indicator targets
- Nonindicator targets
- Low worth targets

The geometry filter is utilized to reduce the set of candidate ATS targets. Based on acquisition scope viewing time requirements and prior main optics commitments, a set of geometric constraints is determined. Each target is then tested against the constraints and is deleted from further consideration if it is found that there is insufficient time to view the target through the acquisition scope, slew the main optics, and then photograph the target while satisfying the TWONDER ground rule that an alternate target must be compatible with the preceding and following primary.

The group density filter operates on all the candidate ATS targets surviving the previous two filters. The group filter eliminates from further consideration all but the N highest worth targets in any group, where N is a File 8 input parameter.

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For those targets that remain after the above filters are applied, entries are made in the ASCOT table, which provide the target specific information required by the ATS algorithm, TWASSP2.

#### 2.2.11 TWASSP2

TWASSP2 is employed to determine the optimal acquisition scope strategy when either one or two scopes are to be utilized. A single path is determined when NUMSCOP = 1 and two paths are determined when NUMSCOP = 2 where NUMSCOP is a File 8 input parameter. The worth of an individual target is based on active priority, inactive priority, probability of activity, probability of visibility, probability of falsely reporting a target to be active or inactive, and obliquity deweighting. The targets to be considered are obtained from the ASCOT, and the best score sequence down to and including each target is determined.

In addition, the optimal decision time is determined for each target group. A target group consists of a single primary (or main optics) target plus a number of alternate targets. Both the primary and the selected alternates are to be viewed through the acquisition scopes, and the status of each target (active, inactive, cloudy, or mandatory override) reported to the onboard computer prior to decision time. A voting logic is then employed to determine which target should be photographed by the main optics. In order to ensure that any of the selected alternates can be photographed, a decision time must be selected that is compatible with the entire group. This group decision time is optimized by the algorithm through the use of an imbedding technique, in which multiple entries are made, when necessary, to allow for the possibility of variations in decision time.

As is the case in the main optics algorithm, a list is generated that contains the optimal sequences down to and including each of the targets being considered. The best score path is determined by first scanning the list to find the target that completes the maximum score sequence and then using the predecessor information to determine which targets are contained in the sequence. The output of TWASSP2 is the Acquisition Scope Strategy Table (ASST), which provides the optimal acquisition scope target sequence.

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### 2.2.12 TWOUT

The subfunction TWOUT is the basic output routine for TWONDER. The inputs to this routine are the COTPRIME, the MOST, and the ASST. The following basic types of output are available for listing:

- Main Optics Strategy
- Acquisition and Tracking Scope Strategy
- Results of expected score calculations by group
- Rev summaries of the above three items

The output format is described in Section 3.12.

### 2.3 TWONDER CAPABILITIES AND RESTRICTIONS

The TWONDER program provides a wide range of capability through the use of program inputs as described in the TWONDER User's Manual (Reference 1). The program can optionally be run in several different modes depending on the particular study requirements. The purpose of this section is to provide an insight into the tradeoffs in running time and optimality associated with these modes of operation. In addition, there are certain restrictions to program usage that are inherent in the design of the program. These basic restrictions are also discussed in this section.

The TWONDER subfunctions TWOSP and TWASSP2 are used to determine the optimal selection of targets for the main optics and for the ATS. The running time required by these subfunctions is strongly effected by the number of targets considered. The following plots (Figure 2-6) show running time and number of targets as a function of the density filter setting controlled by EGT936 and EGT937.

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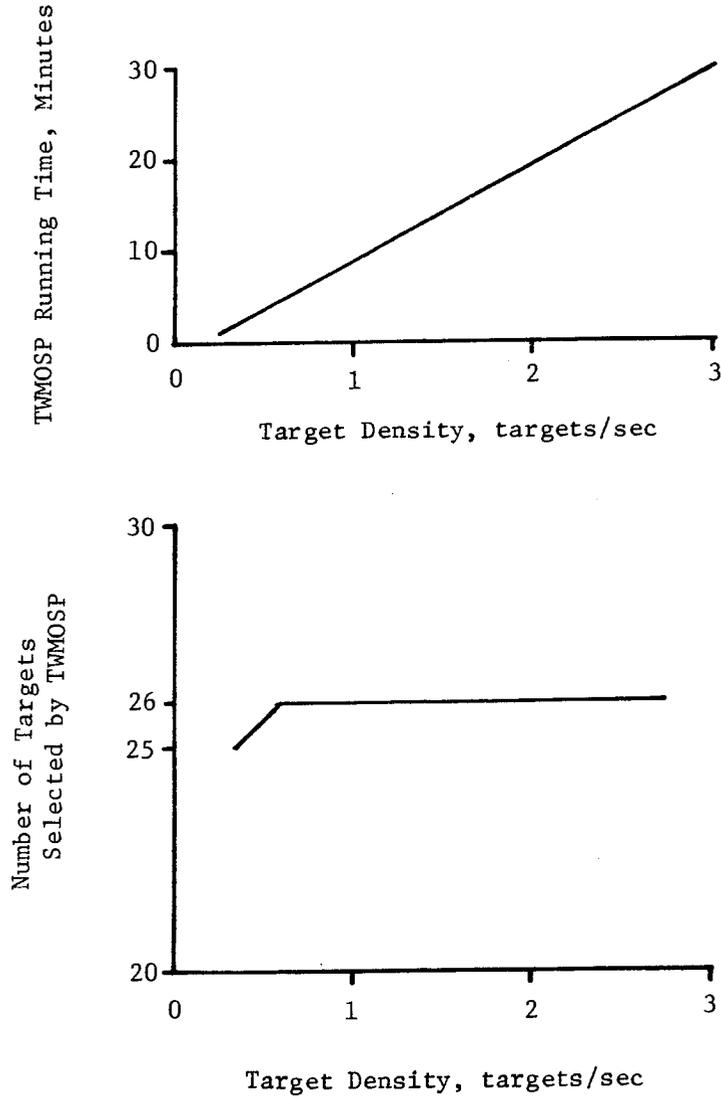


Figure 2-6. TWOSP Running Time and Number of Targets Selected as a Function of Target Density

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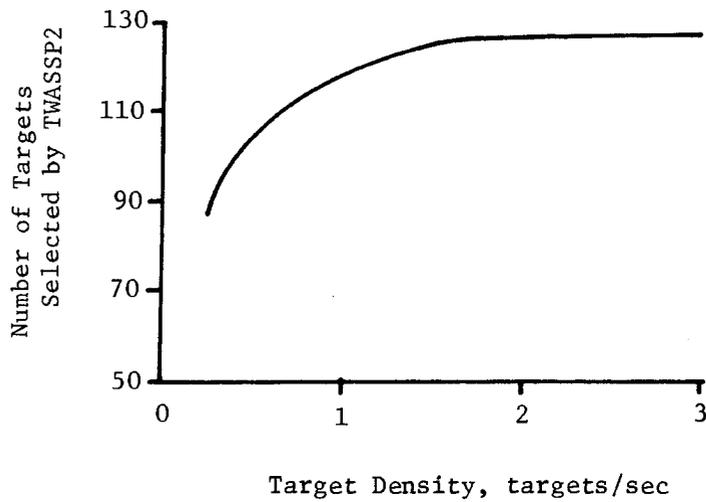
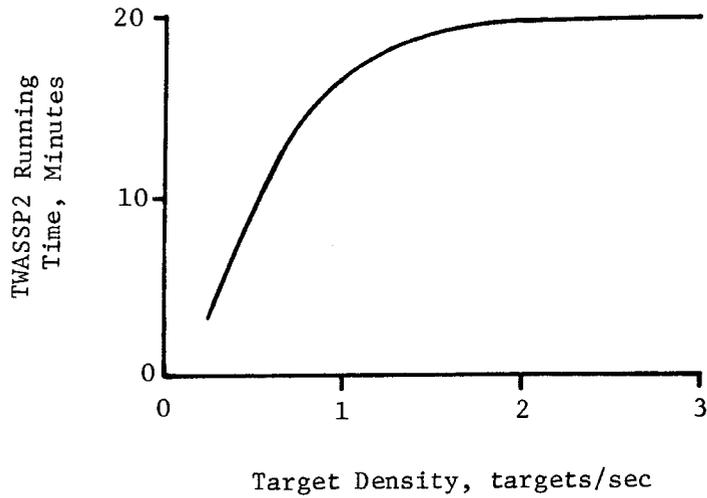


Figure 2-6. TWASSP2 Running Time and Number of Targets Selected as a Function of Target Density (Continued)

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These figures show a significant decrease in running time with target density. However, the number of targets selected remains relatively constant. More importantly, the score obtained was found to vary by less than 1 part in 100. The data shown in the above plots are taken from a particular run in which 940 candidate targets were available after swath sorting by TWPATW. The number of targets available for selection varied from 110 targets, with the density filter set to pass 1/4 target/second, to 487 targets, with the density filter set at 3 targets/second. Because of the problems of long running time and because high target densities can cause a degradation in selection, the recommended maximum target density is 2 targets/second. This density can be obtained with EGT936 = 8 and EGT937 = 4.0.

TWONDER capabilities and restrictions related to swath sorting (TWPATW and TDMERGE), main optics selection (TWMOSP), and ATS selection (TWASSP2) are provided in the following three sections. A summary of program restrictions is given in Section 2.2.4.

#### 2.3.1 TWPATW and TDMERGE

The swath sorting routines are limited to 11,200 acquisitions on a single run. With a target deck containing 15,000 targets, approximately one-fifth or 3000 will be acquired during a period of 1 day. Therefore, a rev span covering approximately 3-1/2 days would be the longest duration that could be considered in a single run using this target deck.

As described in the User's Manual (Reference 1), a stack option is provided so that an acquisition tape containing longer rev spans can be produced.

#### 2.3.2 TWMOSP

Three optimization options are available for computing the main optics selection in TWMOSP. These are interleaving, interleaving inhibit, and time order. These options are discussed in Section 3.8. Both the interleaving and interleaving inhibit options utilize nontime-ordered algorithms. The interleaving option allows interleaving of the ABA type to occur while the inhibit option does not. The time-ordered algorithm does not allow any interleaving, but of course pays the penalty of yielding a less optimal selection than a nontime-ordered algorithm. The degree to which the selection is degraded is a function of target distribution and the types of

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weighting functions employed. A comparison of the running times of these three options indicates that the time-order option is the fastest. The interleave option takes approximately three times as long, and the inhibit option has a running time of about six times as long. It has also been found that these factors tend to increase with target density.

It has also been observed that TWOSP running time is approximately inversely proportional to photo sequence time.

The worth of a photograph of a particular target is a function of the mid-sequence stereo angle. Relative worth is provided as a function of stereo angle through the use of pitch weighting function as described in the User's Manual (Reference 1). The pitch angle weighting factor is determined from File 8 input curves. These curves are described as a function of the five parameters W, RS1, RS2, E1, and E2 as indicated in Figure 2-7 where:

- W is an angle defining the area in which  $\phi(\tau) = 1$   
(measured in degrees)
- RS1 is the reciprocal slope of this line segment  
(measured in degrees)
- RS2 is the reciprocal slope of this line segment  
(measured in degrees)
- E1 is the height of this horizontal segment (non-dimensional)
- E2 is the height of this horizontal segment (non-dimensional)
- c is the desired central stereo angle (this is indicated on the target card)

Various shapes for the pitch weighting function can be obtained. However, certain limitations have been observed during program operation. The allowable settings are:

$$\begin{aligned} W &\geq 0 \\ RS1 &> 0 \\ RS2 &< 0 \\ E1 &\neq 0 \\ E2 &\neq 0 \end{aligned}$$

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These restrictions are imposed to eliminate discontinuities and zero-worth targets.

Discontinuities would be encountered if RS1 or RS2 were set equal to zero. This presents a dilemma in determining the score at the point of discontinuities. This problem is easily avoided by disallowing the discontinuity.

By setting E1 or E2 to zero, regions could be defined in which photography is worth nothing. However, the selection algorithm searches for a best score set of targets and, as currently formulated, will consider the inclusion of zero-worth items so long as nothing better can be done during a particular time period. To eliminate the selection of targets during a time period when photography is "worthless," the parameters E1 and E2 should be made negative (-1.0). The algorithm then has a clear advantage in not taking a target in a "worthless" region.

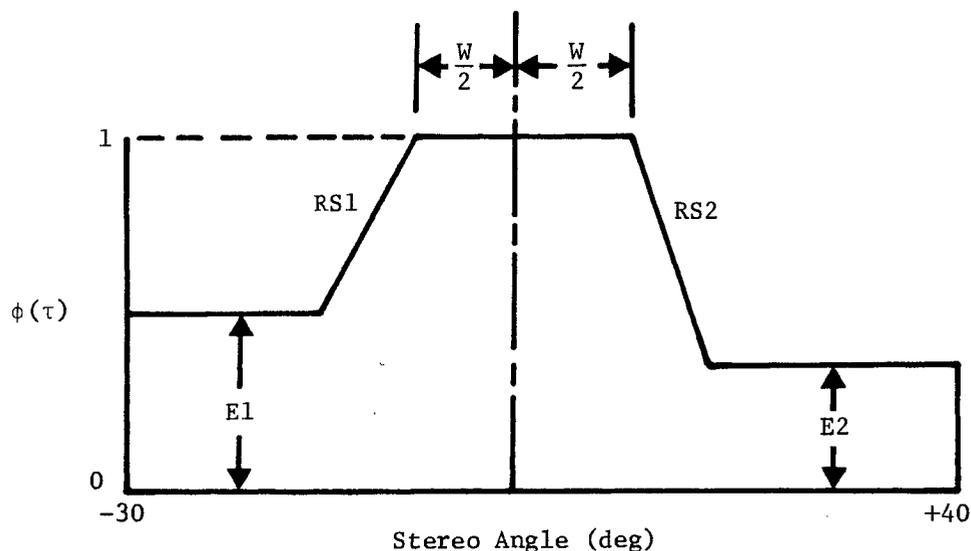


Figure 2-7. Pitch Weighting Function,  $\phi$

### 2.3.3 TWASSP2

Two filters are available to control the alternate target selection performed in TWASSP2. These are EGT908, the maximum number of targets/group considered in the selection process, and EGT940, the maximum number of list entries that may be generated for a particular pair of targets with

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a particular decision time. Both of these parameters control the size of the list generated by TWASSP2. This list contains the set of allowable predecessor pairs available at significant acquisition times and compatible with allowable group decision times. The core storage available to contain this list limits the number of predecessor possibilities that can be considered. The recommended maximum settings for the filter parameters are EGT908 = 8 targets/group and EGT940 = 15 list entries. Running time has been found to decrease significantly with the magnitude of these parameters. In addition, the target selection has been found to be relatively independent of EGT940. Further study is being performed to better define the running time and selection tradeoffs associated with these parameters.

#### 2.3.4 TWONDER Restrictions Summary

The basic program restrictions are related to the number of targets that can be handled and to allowable target density. These limitations are

- Maximum of 11,200 acquired targets per single run of the swath sorting programs
- Maximum of 4,000 acquired targets per rev
- Maximum target density of 2 targets/second considered in the selection process
- Maximum of 8 targets per group considered by TWASSP2
- Maximum of 15 list entries per target pair at a given decision time considered by TWASSP2

In addition, the definition of the pitch weighting function should not allow discontinuities or zero-worth photographic sequences to occur.

The above limitations have been discussed in previous sections with the exception of the 4000 target/rev restriction. This restriction is imposed by the subfunction TWEEDOFF. This subfunction employs a table containing the acquisition times of all targets on a rev. This table is limited to 4000 entries. Since present target distributions yield a maximum of approximately 1000 targets/rev, this limitation is not serious. In addition, density filtering is performed prior to TWEEDOFF and could be used to control the number of targets considered by this subfunction.

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### 3. TWONDER SUBFUNCTIONS

#### 3.1 TWONDER2

##### 3.1.1 Purpose

TWONDER2 is a short generalized control program that loads and executes TWONDER subfunctions in the order necessary to accomplish a given TWONDER run. This function performs no computations and is entirely concerned with sequencing and controlling the modules that perform the TWONDER task.

Figure 2-5 is a flow chart which illustrates the steps performed during a TWONDER run. Figure 3-1, the TWONDER2 flow chart, shows the method used to obtain this sequence.

The functions to be executed and the order of execution are determined by the content of the data table CALLS described in Section 3.1.2. This table contains the names of the TWONDER subfunctions. The order of the subfunctions determines the order of execution. Subfunctions in the table are identified as belonging to one or more of the following categories:

- a. Initialization of input data
- b. Rev span processing
- c. Single rev processing
- d. Unrequired subfunction (for a particular run)

##### 3.1.2 Input

The File 8 input parameters used by TWONDER2 and located in table THINGS are shown in Table 3-1. Where the input source is a Function Card parameter, the mnemonic defined in the TWONDER User's Manual (Reference 1) is given. The Function Card input parameters are depicted in Table 3-2.

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TWONDER2

TWONDER2

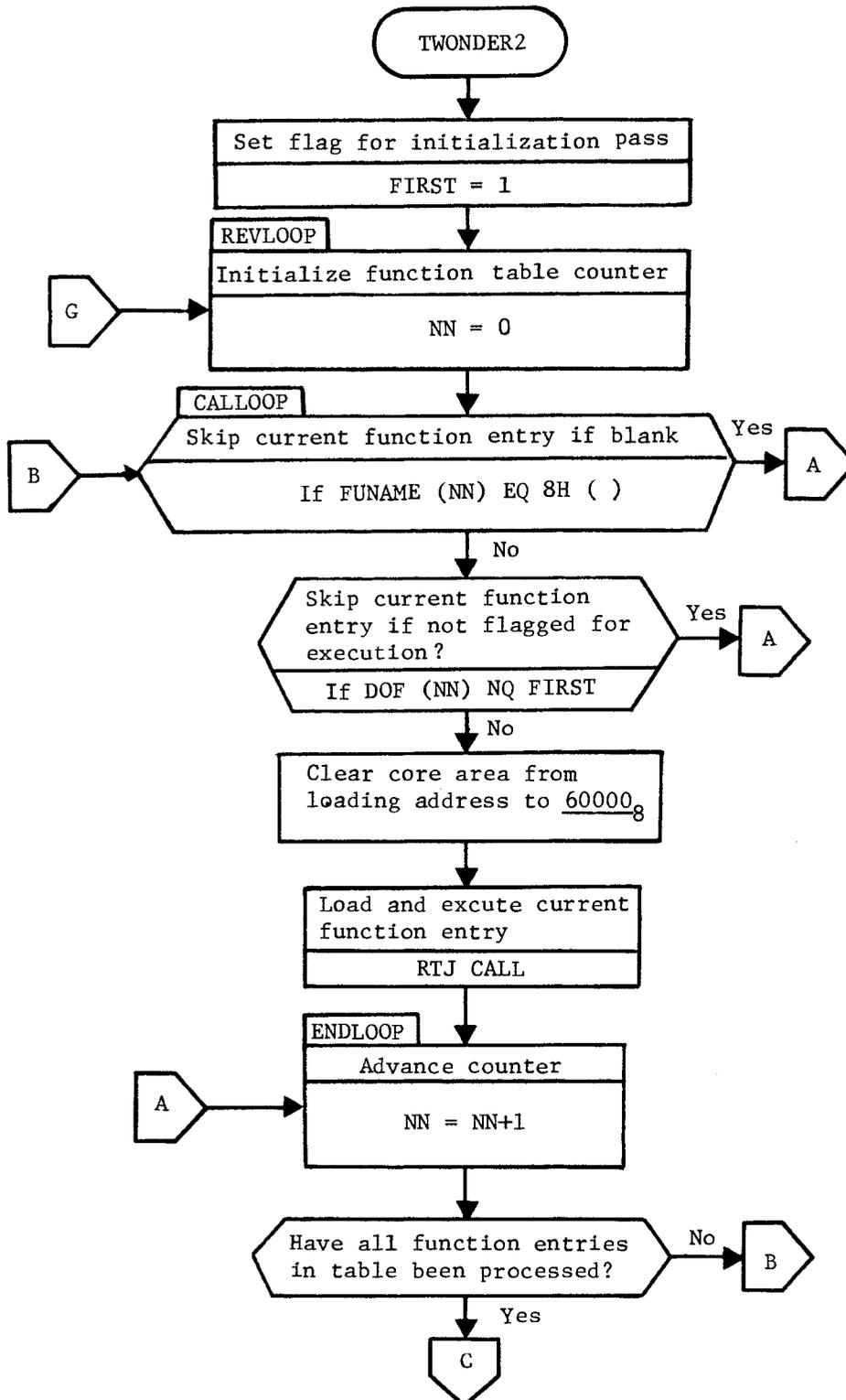


Figure 3-1. TWONDER2 Flow Chart

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TWONDER2

TWONDER2

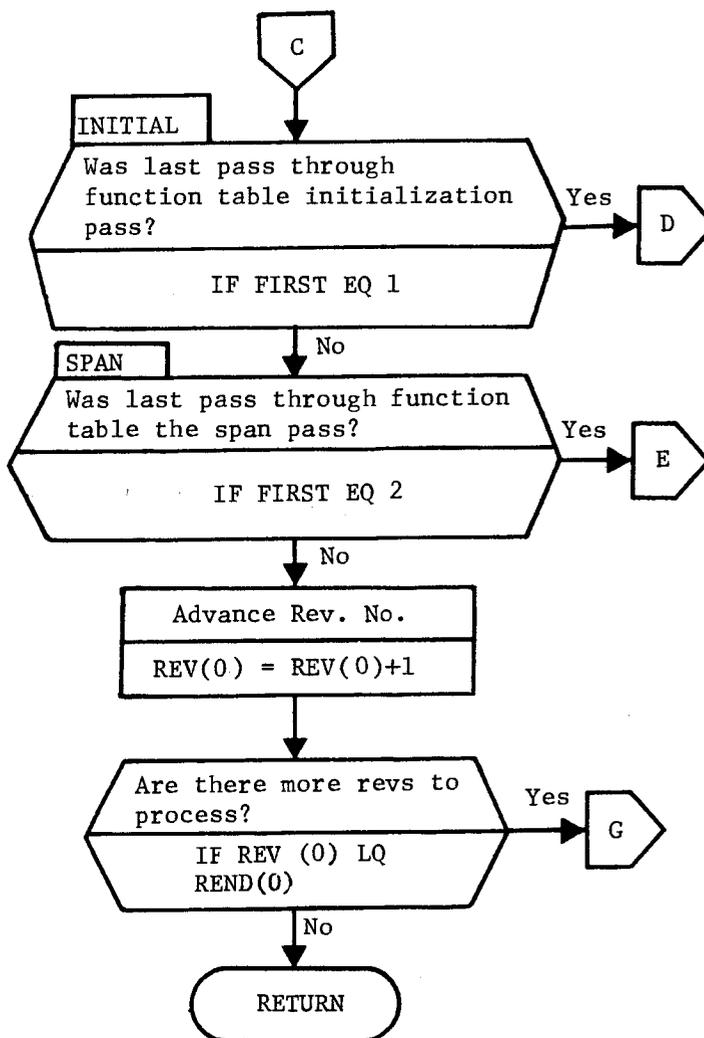


Figure 3-1. TWONDER2 Flow Chart (Continued)

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TWONDER2

TWONDER2

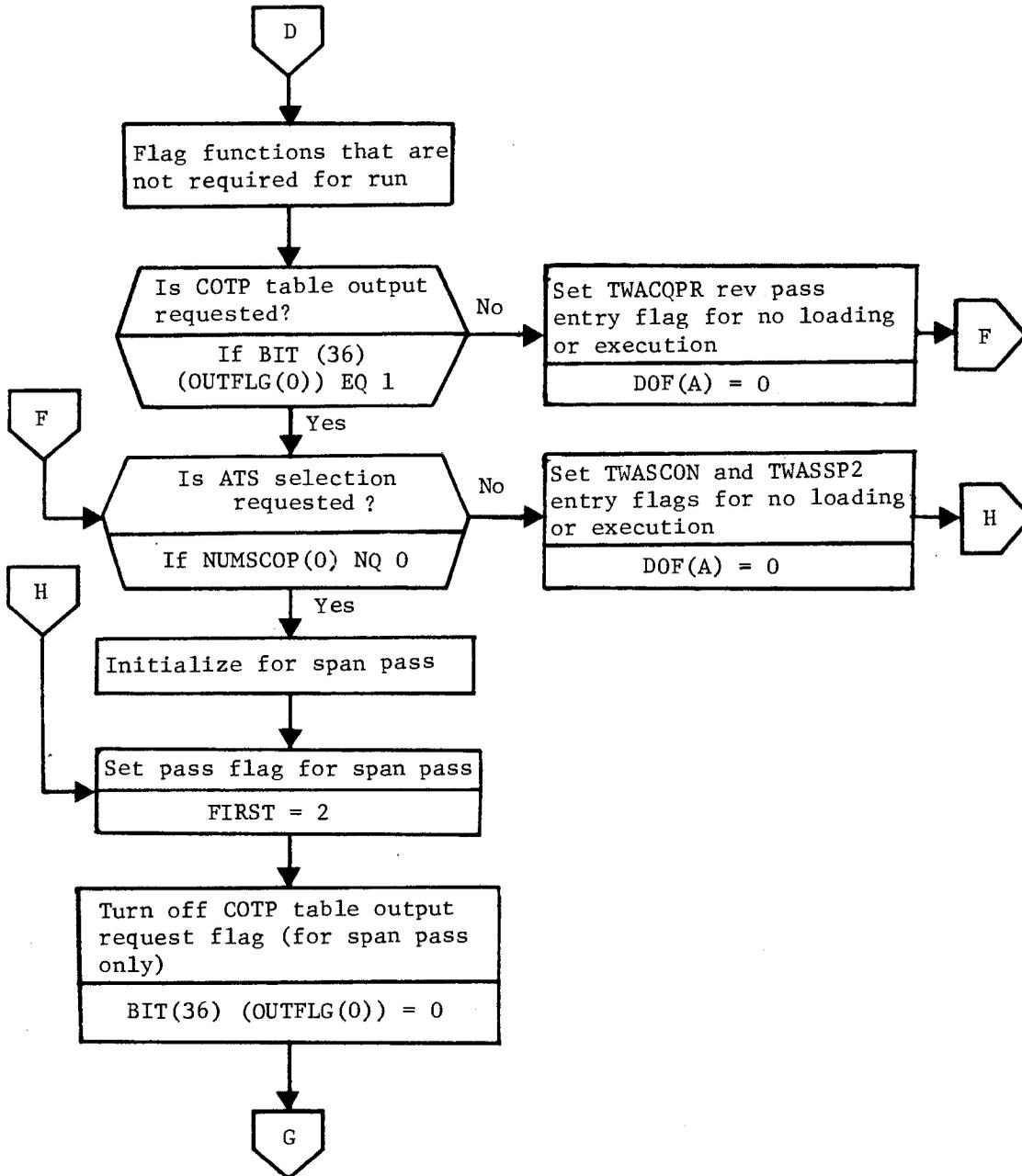


Figure 3-1. TWONDER2 Flow Chart (Continued)

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TWONDER2

TWONDER2

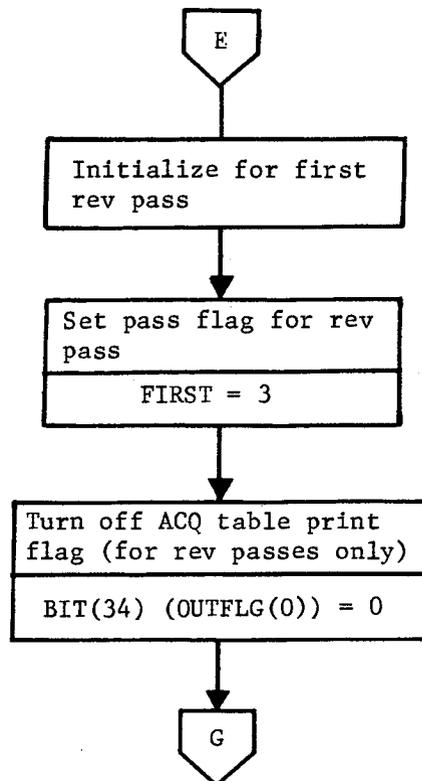


Figure 3-1. TWONDER2 Flow Chart (Continued)

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Table 3-1. File 8 Parameters Used in TWONDER2 Located in Table THINGS

Reset File Definition				Interface Table Usage			
File 8 Location	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
ECT110	I	2	n.d.	Flags for TWPLOT1 control in successor function mode 0: Do not generate PLOT 1: Generate ACQ plot 2: Generate selection plot 4: Plot (+) and (-) for forward and aft stereo times Above options summable Output control flag 1: Target selection output and plots on Tape 8 2: Target selection output and plots online 4: Intermediate Data Tables on Tape 8 8: Intermediate Data Tables online 16: ASST 32: LISTX 64: LIST 128: ASCOT 256: MOST	TRWPLOT	I 48 U 314 0	n.d.
ECT134	I	1	n.d.		OUTFLAG	I 48 U 239 0	n.d.

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Table 3-1. File 8 Parameters Used in TWONDER2 Located in Table THINGS (Continued)

File 8 Location	Reset File Definition			Interface Table Usage			
	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
ECT900	I	2	n.d.	512: ALMOST 1024: MOCOT 2048: COTPRIME Output requests are summable Number of scopes in use 0 = none, 1 = one scope 2 = two scopes	NUMSCOP	I 48 U 56 0	n.d.

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Table 3-2. Function Card Parameters Used in TWONDER2

Function Card Parameter	Symbol	JOVIAL Declaration	Definition
REV'END	REND	I 48 U 242 0	Last rev to be processed
REV'START	RSTART	I 48 U 245 0	First rev to be processed

Table CALLS contains all information necessary for TWONDER2 to load and execute the TWONDER subfunctions in the proper order; it is a rigid table in parallel format containing 15 entries of 3 words each. The item definition for the CALLS table is provided in Table 3-3.

Table 3-3. Table CALLS Item Definition

Symbol	JOVIAL Declaration	Definition
FUNAME	H 8 0 0	Function name
CALL'OPT*	I 48 U 1 0	Q register parameter word required for successor call
RETURN'TO**	B 1 0	1 = return to calling program 0 = return to system
N3'GIVEN*	B 1 3	1 = load at address N3 0 = load at CLANK
SAVECALL	B 1 6	1 = save calling sequence 0 = do not save calling sequence
N3	I 15 U 2 33	Specified loading address for successor call
DOF	I 2 U 2 23	Pass Flag 0 = never execute or load 1 = initialization pass entry 2 = span pass entry 3 = rev pass entry

\* All CALL'OPT entries are set to 0 except for bits 0, 3, and 6.

\*\* All RETURN'TO and N3'GIVEN entries are set to 1.

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The preset contents of the table are shown in Table 3-4. The order of the entries in table CALLS determines the order in which TWONDER2 loads and executes TWONDER subfunctions. The pass flag (DOF) determines on which of 3 passes a particular function should be executed. Initialization functions (DOF = 1) are executed first, then rev span functions (DOF = 2), and, finally, single rev functions (DOF = 3). A function can be entered in table CALLS as many times as required for proper run execution. Both TWACQPR and TPLOT1 have two entries since these functions must be executed during both the span pass and the single rev pass.

Table 3-4. Preset Values in Table CALLS

Entry Number	FUNAME	SAVECALL	N3(Octal)	DOF
0	TWOPIN	1	14000	1
1	TWPATW	0	13000	2
2	TDMERGE	0	13000	2
3	TWACQPR	0	13000	2
4	TWPLOT1	0	13000	2
5	TWOPS	0	13000	3
6	TWACQPR	0	13000	3
7	TWEEDOFF	0	13000	3
8	TWMOSP	0	13000	3
9	TWMOSP2	0	13000	3
10	TWASCON	0	13000	3
11	TWASSP2	0	13000	3
12	TWOUT	0	13000	3
13	TWPLOT1	0	13000	3
14	(Blank)	0	13000	3

### 3.1.3 Output

No output is provided by TWONDER2.

### 3.1.4 Method

TWONDER2 remains in core during the operation of TWONDER. This function loads and executes all TWONDER programs. The process has three phases: initialization, rev span processing, and single rev processing.

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The required subfunction names, loading addresses, pass flag settings, and loading control information are contained in table CALLS.

a. Initialization Pass

The program checks through the table CALLS and then loads and executes all functions flagged as initialization functions (pass flag = 1). The only entry so flagged is TWOPIN.

b. Option Checks

After the initialization pass is complete, the program checks the value of NUMSCOP (EGT900) to determine if Acquisition Telescope (ATS) processing has been requested. If NUMSCOP = 0 (no ATS requested) the program sets the pass flags for TWASCON (ATS target selection algorithm preprocessor) and TWASSP2 (ATS target selection algorithm) in table CALLS to zero. Setting of the pass flags suppresses loading and execution of these functions.

c. Rev Span Pass

The pass flag is initially set to 2 to indicate that a span pass is being performed. Bit 36 of OUTFLG is set to zero since COTPRIME output is not applicable during a span pass. All subfunctions in table CALLS that have a pass flag of 2 are loaded and executed in order. The subfunctions process the entire requested rev span. The applicable subfunctions are:

1. TWPATW (generate target acquisitions)
2. TDMERGE (sort target acquisitions)
3. TWACQPR (display target acquisitions)
4. TWPLOT1 (provide swath plot of target acquisitions)

d. Single Rev Processing

The pass flag is set to 3 to indicate rev by rev processing. Initially, the current rev (REV) is set equal to the first rev of the rev span (RSTART). All subfunctions in the table CALLS that have a pass flag of 3 are then loaded and executed in order. These subfunctions are:

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1. TWOPS (generate COTPRIME)
2. TWACQPR (display COTPRIME)
3. TWEEDOFF (main optics target selection algorithm preprocessor)
4. TWMOSP (main optics target selection algorithm)
5. TWMOSP2 (generate main optics selection)
6. TWASCON (ATS target selection algorithm preprocessor)
7. TWASSP2 (ATS target selection algorithm)
8. TWOUT (display selection results)
9. TWPLO1 (plot selection results)

If the current rev is equal to the last rev in the span being processed, TWONDER2 exits to the system.

If additional revs must be processed, the rev counter is incremented by 1 and the above subfunctions are again executed.

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### 3.2 TWOPIN

#### 3.2.1 Purpose

TWOPIN reads the reset tape, the control parameters from the TWONDER function card and the data cards. TWOPIN also checks the DDI ephemeris tape to ensure enough data is available to permit processing of the requested rev span.

#### 3.2.2 Input

1. Reset tape, containing all File 7 and File 8 parameters as presented in the User's Manual for TWONDER (Reference 1).
2. LAT cards, LIM cards, TIM cards and target add, change and delete cards.
3. TWONDER function card

#### 3.2.3 Output

TWOPIN stores various parameters in the THINGS and ALSO tables for use by subsequent subfunctions. TWOPIN outputs the target add tape, the target deletion tape, the target change tape and the LAT and TIM deletion tape.

#### 3.2.4 Method

TWOPIN reads Files 1, 3, 7, and 8 of the reset tape and stores the appropriate parameters in the THINGS and ALSO tables. These values are the constants, reference parameters and flag settings that form the basis for the computation and logic flow of the particular run being executed.

TWOPIN reads the control parameters on the TWONDER function card and determines the rev span and output requests. Also determined is the form of the input tape (an acquisition tape or a target tape). TWOPIN reads the data cards, i.e., LAT cards, LIM cards, TIM cards and target add, change and delete cards. The TWOPIN flow chart is shown in Figure 3-2.

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TWOPIN

TWOPIN

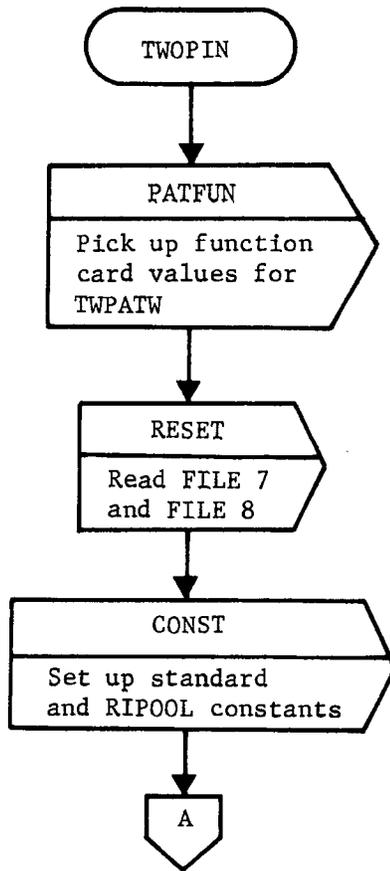


Figure 3-2. TWOPIN Flow Chart

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TWOPIN

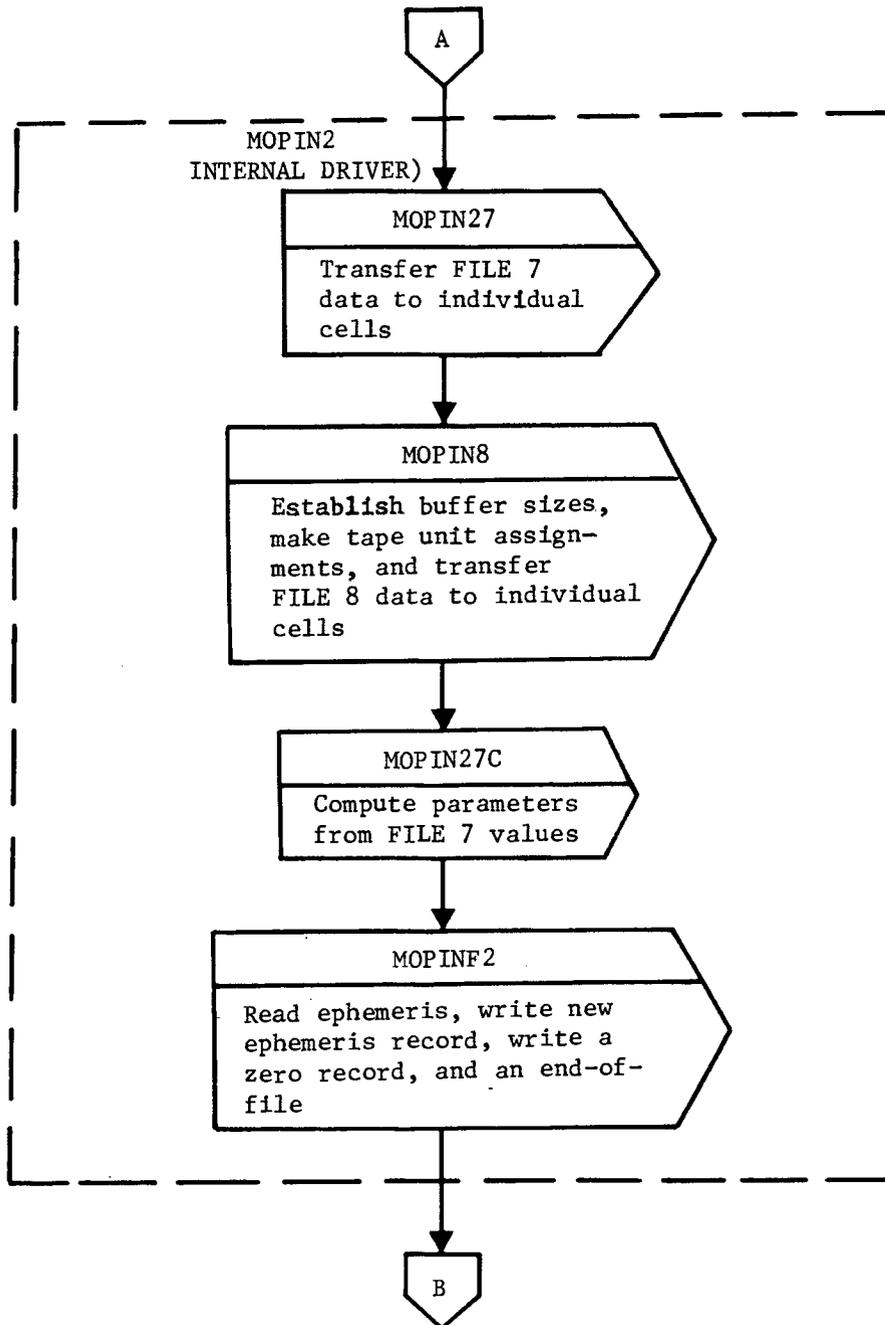


Figure 3-2. TWOPIN Flow Chart (Continued)

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TWOPIN

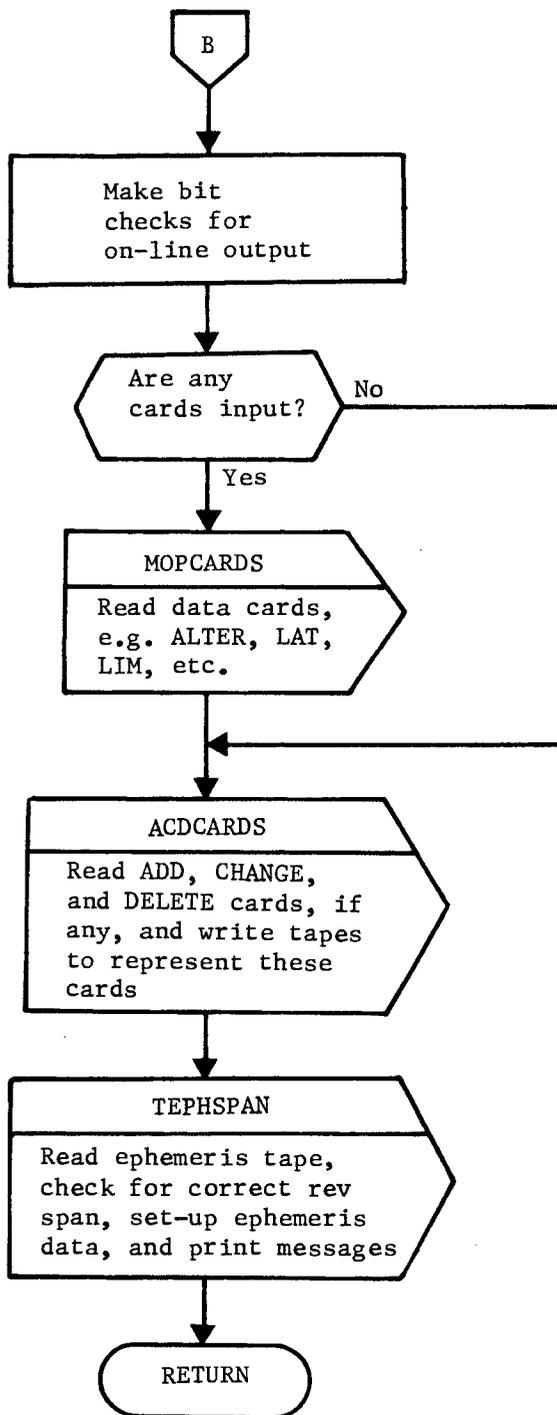


Figure 3-2. TWOPIN Flow Chart (Continued)

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### 3.3 TWPATW

#### 3.3.1 Purpose

Subfunction TWPATW controls all phases of target acquisition processing and the generation of acquisition information for the purpose of preparing the intermediate target acquisition tapes, which are processed by subfunction TDMERGE.

#### 3.3.2 Input

The inputs required by TWPATW are as follows:

- a. Target tape or acquisition tape.
- b. Ephemeris data
- c. THINGS table.

The acquisition tape is described as an output of TWPATW in Section 3.3.3. The target tape, ephemeris data and the THINGS table items required by TWPATW are described below.

##### 3.3.2.1 Target Tape

The target tape is serial in structure. Each entry corresponds to a unique target. The parameters contained within each entry on the target tape are described in Table 3-5.

##### 3.3.2.2 Acquisitions Tape

The acquisitions tape is described in Section 3.3.3.

##### 3.3.2.3 Ephemeris Data

The data from table DEPHDA of the ephemeris tape that are required for each event time which begins an orbit interval are described in Table 3-6.

The data from table DEPHID of the ephemeris tape that are required are described in Table 3-7.

Orbit adjust data from table DOADJ of the ephemeris tape which are required are described in Table 3-8.

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Table 3-5. Target Tape Entry Data

Symbol	JOVIAL Declaration	Units	Definition
DTW012	H 2 0 0	n.d.	Priority (inactive)
DT031	H 1 0 12	n.d.	Number of looks
DTW042	H 2 0 18	$\text{ft} \times 10^{-1}$	Diameter
DT063	H 3 0 36	$\text{ft} \times 10^{-2}$	Altitude
DT063S	H 1 0 30	n.d.	Sign of altitude
DTSHD	H 2 1 12	n.d.	Shade factor
DT151	H 1 1 24	n.d.	Photo mode weighting function
DT141	H 1 1 30	n.d.	Target alter card flag
DT153	H 3 1 36	n.d.	Acquisition rev number
DT181	H 1 2 6	n.d.	Direction of pass
DTLOC	H 2 2 12	n.d.	Country code
DTW222	H 2 2 30	n.d.	Priority (active)
DTW252	H 2 3 0	deg	Desired stereo angle
DTW241	H 1 2 42	n.d.	Sign of desired stereo angle
DTW271	H 1 3 12	n.d.	Scan target flag
DTW281	H 1 3 18	n.d.	Bench mark flag

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Table 3-5. Target Tape Entry Data (Continued)

Symbol	JOVIAL			Units	Definition
	Declaration				
DTW291	H	1	3 24	n.d.	Mandatory ATS view flag
DTW301	H	1	3 30	n.d.	Mandatory primary flag
DTW312	H	2	3 36	%	Probability of activity
DTW332	H	2	4 0	sec x 10 <sup>1</sup>	Specified ATS view time
DTW351	H	1	4 12	n.d.	Pitch weighting function
DT468	H	8	4 30	n.d.	I.D. - first 8 characters
DT564	H	2	5 30	n.d.	I.D. - last 2 characters
DTMSN	H	4	5 42	n.d.	TBD, mission number
DTW522	H	2	6 18	n.d.	Weather factor
DTW542	H	2	6 30	in.	Resolution requirements
DT683	H	3	6 42	n.d.	Special category code
DTW591	H	1	7 12	n.d.	Target location validity
DT743	H	2	7 18	deg	Target latitude
DT772	H	2	7 30	min	Target latitude
DT812	H	2	7 42	sec	Target latitude
DTLATD	H	1	8 6	n.d.	Target latitude (North or South)

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Table 3-5. Target Tape Entry Data (Continued)

Symbol	JOVIAL Declaration	Units	Definition
DTLAF	H 6 7 18	n.d.	Total latitude field
DT833	H 3 8 12	deg	Target longitude
DT862	H 2 8 30	n.mi.	Target longitude
DT882	H 2 8 42	sec	Target longitude
DTLONGD	H 1 9 6	n.d.	Target longitude (East or West)
DTLONF	H 7 8 12	n.d.	Total longitude field
DT621	H 1 9 12	n.d.	Card type flag
DTW761	H 1 9 18	n.d.	Visual intelligence flag

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Table 3-5. Target Tape Entry Data (Continued)

Symbol	JOVIAL Declaration			Units	Definition
DTW291	H	1	3 24	n.d.	Mandatory ATS view flag
DTW301	H	1	3 30	n.d.	Mandatory primary flag
DTW312	H	2	3 36	%	Probability of activity
DTW332	H	2	4 0	sec x 10 <sup>1</sup>	Specified ATS view time
DTW351	H	1	4 12	n.d.	Pitch weighting function
DT468	H	8	4 30	n.d.	I.D. - first 8 characters
DT564	H	2	5 30	n.d.	I.D. - last 2 characters
DTMSN	H	4	5 42	n.d.	TBD, mission number
DTW522	H	2	6 18	n.d.	Weather factor
DTW542	H	2	6 30	in.	Resolution requirements
DT683	H	3	6 42	n.d.	Special category code
DTW591	H	1	7 12	n.d.	Target location validity
DT743	H	2	7 18	deg	Target latitude
DT772	H	2	7 30	min	Target latitude
DT812	H	2	7 42	sec	Target latitude
DTLATD	H	1	8 6	n.d.	Target latitude (North or South)

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Table 3-5. Target Tape Entry Data (Continued)

Symbol	JOVIAL Declaration	Units	Definition
DTLAF	H 6 7 18	n.d.	Total latitude field
DT833	H 3 8 12	deg	Target longitude
DT862	H 2 8 30	n.mi.	Target longitude
DT882	H 2 8 42	sec	Target longitude
DTLONGD	H 1 9 6	n.d.	Target longitude (East or West)
DTLONF	H 7 8 12	n.d.	Total longitude field
DT621	H 1 9 12	n.d.	Card type flag
DTW761	H 1 9 18	n.d.	Visual intelligence flag

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Table 3-6. Ephemeris Data from Table DEPHDA

Symbol	JOVIAL Declaration	Units	Definition
DTIM	0 0	min	Event time measured from base time
DX	1 0	e.r.	ECI components of vehicle position at event time
DY	2 0	e.r.	
DZ	3 0	e.r.	
DXD	4 0	e.r./min	ECI components of vehicle velocity at event time
DYD	5 0	e.r./min	
DZD	6 0	e.r./min	
DXDD	I 48 U 7 0	n.d.	Ascending node flag
DYDD	I 24 U 10 0	n.d.	Rev number
DZDD	I 24 U 10 24	n.d.	Vehicle number
DNODE	F 7 0	e.r./min <sup>2</sup>	ECI components of vehicle acceleration at event time
DREV	F 8 0	e.r./min <sup>2</sup>	
DVEH	F 9 0	e.r./min <sup>2</sup>	

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Table 3-7. Ephemeris Data from Table DEPHID

Symbol	JOVIAL Declaration	Units	Definition
DALF	F 6 0	rad	Right ascension of Greenwich at base time
DIRUP	I 48 U 1 0	n.d.	Update number
DIRNV	I 48 U 5 0	n.d.	Number of vehicles on tape
DIRVN1	I 48 U 6 0	n.d.	First vehicle number
DIRVN2	I 48 U 7 0	n.d.	Second vehicle number
DMUK	F 21 0	e.r.	Earth gravitational constant
DOAJN	I 6 U 11 42	n.d.	Number of orbit adjusts
DTEPOC	F 11 0		Time from GMT base reference time
DVEHNO	I 48 U 1 0	n.d.	Vehicle number
DYEARK	I 48 U 2 0	yr	
DMONTH	I 48 U 3 0	month	Gregorian base reference date
DDAYK	I 48 U 4 0	day	
DOMEG	F 7 0	rad/min	Earth rotation rate

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Table 3-8. Ephemeris Data from Table DOADJ

Symbol	JOVIAL Declaration	Units	Definition
DOATIM	F 1 0	sec	Start time of orbit adjust from base time
DOATB	F 2 0	sec	Burn time of orbit adjust
DOATY	I 48 U 0 0	n.d.	Type of orbit adjust
DOAWT	F 3 0	n.d.	Weight of orbit adjust
DOAVI	F 5 0	rad	Vehicle inclination
DOAFF	F 4 0		Fuel flow of orbit adjust
DOAPIT	F 6 0	rad	Pitch of orbit adjust
DOAYAW	F 7 0	rad	Yaw of orbit adjust

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### 3.3.2.4 THINGS Table

The THINGS table items required by TWPATW as specified through File 7 and File 8 parameters are described in Table 3-9.

### 3.3.3 Output

The output of TWPATW are the intermediate acquisition tapes. These tapes are subsequently processed by TDMERGE into the acquisition tape (ACQ tape). The acquisition tape records generated by the TWPATW contain the following information:

- a. Header entries for each revolution.
- b. Target acquisition entries.

The parameters contained within each header entry are described in Table 3-10. The parameters contained within each target acquisition entry are described in Table 3-11.

### 3.3.3.1 Method

TWPATW accepts data from the target tape (construct option) or a previously generated acquisitions tape (update option), and ephemeris data produced by the DDI general purpose tracking program. TWPATW computes approximate target acquisition times and other acquisition data and stores these data on an intermediate acquisitions tape.

The target add, delete and change tapes output by TWOPIN may be processed together with either the target tape or a previously generated acquisitions tape. Thus, the following four modes of TWPATW operation are available:

- a. Construct option
- b. Construct with add, change or delete option
- c. Ephemeris update option
- d. Ephemeris update with add, change or delete option

TWPATW also processes the LAT and TIM tape. LAT entries delete all targets of a given priority range within a specified latitude band. TIM entries delete all targets of a given priority range within a specified time span.

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Table 3-9. THINGS Table Items Required by TWPATW

File 7 or 8 Location	Reset File Definition			Interface Table Usage			
	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
SEV003	FP	50.	deg	Maximum obliquity angle (for swath sort)	OBLBAR	F 114 0	rad
SEV004	FP	-5.	deg	Minimum sun angle (for swath sort)	CONSSA	F 273 0	rad
SEV007	FP	180.	n.mi.	Maximum slant range (for swath sort)	CONSRU	F 277 0	e.r.
SEV008	FP	125.	n.mi.	Maximum vehicle altitude (for swath sort)	CONSAU	F 276 0	e.r.
EGT094	FP	0.001	deg	Angular interval defining convergence for iteration on vehicle inplane angle	EFSI	F 35 0	rad
EGT111	FP	5.	deg	Increment added or subtracted from inplane angle in checking acquisi- tion azimuth of high latitude targets	DELPO2	F 23 0	rad
EGT113	I	0.	n.d.	Direction of flight flag in TWPATW 0: acquire targets NS and SN 1: acquire targets SN only -1: acquire targets NS only	DF	I 5 S 190 43	n.d.
EGT115	FP	200.	n.mi.	Half-swath width for early swath sort in TWPATW	NMD	F 100 0	n.mi.
EGT117	B	1.	n.d.	Flag for deletion comments on Tape 8 0: comments output 1: no comments	DEPRFG	B 93 47	n.d.

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Table 3-10. Acquisition Tape Header Entry

Symbol	JOVIAL Declaration	Units	Definition
DHD1	I 10 U 0 0	n.d.	Current rev number
DHD2	A 34 U 16 0 10	min	Time of ascending node
DHD3	I 4 U 0 44	n.d.	Header record flag
DHD4	A 17 S 15 1 0	rad	Limiting latitudes defining range of target latitudes within which a target can be acquired
DHD5	A 17 S 15 1 17	rad	
DHD6	I 10 U 1 34	n.d.	Initial rev of interest
DHD9	I 10 U 2 34	n.d.	Rev number of next rev
DHD10	A 17 S 15 3 0	rad	Limiting latitude defining the range of target latitudes within which a target can be acquired once per orbit period
DHD11	A 31 U 10 3 17	sec	Orbit period
DHD12	A 34 U 16 4 0	min	Start time of first rev of interest
DHD13	I 7 U 4 34	yr	Year (base reference time) referenced to 1900
DHD14	I 4 U 4 41	mo	Month (base reference time)
DHD15	A 34 U 16 5 0	min	Time ending last rev of interest
DHD16	I 5 U 8 34	day	Day of month (base reference time)
DHDF	H 48 0 0		

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Table 3-11. Acquisition Tape Target Data Entry

Symbol	JOVIAL Declaration	Unit	Definition
TBA25	I 10 U 0 0	n.d.	Rev number of target acquisition
TBA14	A 34 U 16 0 0	min	Time of vertical acquisition
TBA13	A 14 U 8 4 0	sec	Time from forward acquisition to vertical acquisition
TAB16	A 10 S 8 5 0	rad	Target obliquity at vertical acquisition
TBAVY	B 34 4 34	n.d.	Acquisition direction flag
TBASA	A 12 S 10 6 0	rad	Sun elevation angle at acquisition
TBASR	A 12 U 4 6 24	n.mi.	Slant range at vertical acquisition
TBAHT	A 12 U 4 6 36	n.mi.	Vehicle altitude at vertical acquisition
TBALA	H 8 1 0	n.d.	I.D. (first 8 characters)
TBALB	H 2 2 0	n.d.	I.D. (last 2 characters)
TBA7	A 24 S 20 2 24	rad	Longitude
TBA6	A 22 S 20 3 0	rad	Latitude
TBA8	I 11 S 20 3 22	ft x 10 <sup>-2</sup>	Altitude
TBAMS	I 14 U 4 14	n.d.	Mission number
TBA9	I 7 U 5 34	ft x 10 <sup>-1</sup>	Diameter

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Table 3-11. Acquisition Tape Target Data Entry (Continued)

Symbol	JOVIAL Declaration	Units	Definition
TBACD	I 2 U 4 36	n.d.	Target alter card
TBARV	I 10 U 4 38	n.d.	Rev number
TBA4	I 10 U 5 24	n.d.	Special category code
TBA2	I 4 U 4 28	n.d.	Photo mode weighting function
TBA3	I 7 U 3 40	n.d.	Priority (inactive)
TWPRIA	I 7 U 3 33	n.d.	Priority (active)
TWSCNSF	B 7 47	n.d.	Scan target flag
TWBMF	B 3 47	n.d.	Benchmark flag
TWMASF	B 7 45	n.d.	Mandatory ATS view flag
TWRES	I 7 U 5 41	in	Resolution requirement
TWDP	I 8 S 7 23	rad	Desired pitch angle
TWPROB	I 7 U 7 31	%	Probability of activity
TWDWL	I 7 U 7 38	sec x 10 <sup>-1</sup>	Specified ATS dwell time
TWTLV	I 4 U 2 19	n.d.	Target location validity
TWMPDF	B 4 35	n.d.	Mandatory primary flag
TWVIF	B 7 46	n.d.	Visual intelligence flag
TBAPS	I 2 U 4 32	n.d.	Direction of pass

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The discussion of the computational methods employed by TWPATW presented here is divided into two sections. The first section discusses the sequence of computations in TWPATW. The second section discusses the significant analytical techniques employed within the computational sequence. A flow chart of TWPATW is presented as Figure 3-3.

#### 3.3.3.1.1 Computational Sequence

TWPATW computes acquisition data in the following sequence:

- a. Enters closed subroutine PATTAB to develop a table of analytic ephemeris data for the specified rev span. PATTAB calls subroutines SUNDECK and LIMLAT to compute the average sun vector over the specified rev span and to compute the limiting target latitudes over the specified rev span arising from sun angle and inclination constraints. Subroutine LIMLAT also computes the latitude boundaries which define the regions in which targets may be acquired on multiple revs within one orbit period.
- b. If there are any unprocessed entries on the target add tape, or if TWPATW is operating in the construct mode and all the target add tape entries have been processed, TWPATW processes each target addition or target from the target tape as follows:
  1. Enters subroutine DTPCDT to decode and store the target data for processing.
  2. Enters subroutine PATENT. PATENT deletes those targets whose latitude exceeds the limiting latitudes computed in PATTAB and computes an approximate vertical acquisition time for those targets not deleted, to initialize the iteration technique used in subroutine CONTAK.
  3. Enters subroutine CONTAK to compute vertical acquisition time and payload operation parameters at vertical acquisition. CONTAK checks the payload parameters against input limits. CONTAK processes the target deletion and target change tapes and deletes or changes the target if affected. CONTAK calls subroutine LATBAN to process the latitude band and time band deletion tapes. If the target is not deleted CONTAK prepares an acquisition tape entry.

If TWPATW is operating in the update mode and all the target add tape entries have been processed, TWPATW processes each target on the old acquisition tape as follows:

1. Enters subroutine RDACQ to decode and store acquisition tape entry information for processing.

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2. Enters subroutine CONTAK to compute vertical acquisition time (the iteration technique is initialized with the vertical acquisition time on the old acquisition tape) and payload operation parameters at vertical acquisition. CONTAK checks the payload parameters against input limits, processes the target deletion and target change tapes and deletes or changes the target if affected, and calls subroutine LATBAN to process the latitude band and time band deletion tapes. If the target is not deleted, CONTAK prepares an acquisition tape entry.

### 3.3.3.1.2 Analytic Techniques

#### 3.3.3.1.2.1 PATTAB

Subroutine PATTAB reads and processes data from the ephemeris tape to develop an analytic ephemeris table. The ECI coordinates for key times (ascending nodes and orbit adjusts) within the specified rev span are converted to a set of orbital parameters which are in turn used to compute an average set of parameters for the orbit interval between adjacent key times. The sets of average orbit parameters computed for each orbit interval constitute the analytic ephemeris table.

The ECI quantities that define the state vector at the start of each interval are used to determine those PATTAB table parameters for the beginning of each interval through the following computational steps.

Compute vehicle radius from center of the earth,  $r_I$

$$r_I = \sqrt{x^2 + y^2 + z^2} .$$

Compute vehicle inertial velocity,  $V_I$

$$V_I = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2} .$$

Compute the quantity  $(r\dot{r})_I$

$$(r\dot{r})_I = x\dot{x} + y\dot{y} + z\dot{z} .$$

Compute total angular momentum of the orbit,  $h_I$

$$h_I = \sqrt{r_I^2 V_I^2 - (r\dot{r})_I^2} .$$

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Compute ECI components of angular momentum

$$h_x = y\dot{z} - z\dot{y}$$

$$h_y = z\dot{x} - x\dot{z}$$

$$h_z = x\dot{y} - y\dot{x}$$

Compute right ascension at the beginning of the interval with respect to the equatorial plane,  $\alpha_I$

$$\alpha_I = \tan^{-1} (h_x / -h_y)$$

$$(0 \leq \tan^{-1} \leq 2\pi)$$

Compute longitude of the vehicle at beginning of interval  $\phi_I$

$$\phi_I = \alpha_I - \alpha_o - \omega_e (t_I - t_o)$$

where  $t_I$  is the time at the beginning of the interval and  $t_o$  is the time at which right ascension of Greenwich,  $\alpha_o$ , is defined, both referenced to base time.

Compute auxiliary orbital elements related to eccentricity and true anomaly

$$e_I \sin u_I = (r\dot{r})_I h_I / \mu r_I$$

$$e_I \cos u_I = (h_I^2 / \mu r_I) - 1$$

Compute orbital eccentricity at interval beginning,  $e_I$

$$e_I = \sqrt{(e_I \sin u_I)^2 + (e_I \cos u_I)^2}$$

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Compute orbital true anomaly at interval beginning,  $u_I$

$$u_I = \tan^{-1} (e_I \sin u_I / e_I \cos u_I)$$
$$(0 \leq \tan^{-1} \leq 2\pi)$$

Compute the vehicle in-plane angle (argument of latitude),  $\psi_I$ , measured in the orbit plane from the ascending node to the vehicle.

$$\psi_I = \tan^{-1} [zh_I / (yh_x - xh_y)]$$
$$(0 \leq \tan^{-1} \leq 2\pi)$$

Compute the argument of perigee of the orbit

$$\beta_I = \psi_I - u_I$$

Compute the vehicle mean anomaly

$$M_I = u_I - 2e_I \sin u_I$$

#### Calculation of average orbital parameters

In order to provide the CONTAK acquisition iteration with more uniformly representative values over duration of an interval, average values are calculated for some orbital elements that are subject to slow change .

Compute average orbital eccentricity for interval n,  $e_n$

$$e_n = \frac{[(e_I)_n + (e_I)_{n+1}]}{2}$$

Compute average argument of perigee for interval n,  $\beta_n$

$$\beta_n = \frac{[(\beta_I)_n + (\beta_I)_{n+1}]}{2}$$

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The average vehicle anomalistic period for interval  $n$ ,  $(p_V)_n$ , is computed from the average change in time per unit change in mean anomaly

$$(p_V)_n = \frac{2\pi}{(M_I)_{n+1} - (M_I)_n} (\Delta t)_n$$

where  $(M_I)_n$  is the value of mean anomaly at the start of the  $n^{\text{th}}$  interval. The interval  $n$  time duration,  $(\Delta t)_n$ , is

$$(\Delta t)_n = (t_I)_{n+1} - (t_I)_n$$

The average orbit period for interval  $n$ ,  $(p_O)_n$  is

$$(p_O)_n = \frac{2\pi}{(\phi_I)_n - (\phi_I)_{n+1}} (\Delta t)_n$$

where  $(\phi_I)_n$  is the longitude at the start of the  $n^{\text{th}}$  interval.

#### Interval continuity parameters

In CØNTAK additional terms are used in the expressions for the quantities  $\psi_V$ ,  $\dot{\psi}_V$ , and  $h$  (vehicle in-plane angle, rate of change of in-plane angle, and vehicle altitude) in order to maintain continuity between intervals. These adjustments are made necessary by the use of constant average values of  $e$ ,  $\beta$ ,  $p_V$  and  $p_O$  in each different interval.

First, consider continuity constants which ensure the continuity of the vehicle in-plane angle,  $\psi_V$ , during acquisition iteration. The nominal expression for the in-plane angle during interval  $n$  is given by

$$(\psi_V)' = \beta_n + (u_V)_n = \beta_n + (M_V)_n + 2e_n \sin(M_V)_n$$

where

$$(M_V)_n = (M_I)_n + \frac{2\pi}{(P_V)_n} [(t_V)_n - (t_I)_n]$$

Since average values are used for  $\beta$ ,  $e$ ,  $p_O$ , and  $p_V$ , CØNTAK utilizes the following equations (to first order):

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$$(\Psi_V)_n = (\Psi_V)_n' + A_n + B_n \left[ (t_V)_n - (t_I)_n \right]$$

$$(\dot{\Psi}_V)_n = \frac{2\pi}{(p_V)_n} \left[ 1 + 2e_n \cos(M_V)_n \right] + B_n$$

where  $A_n$  and  $B_n$  are constants which provide continuity between intervals  $n$  and  $n + 1$ .

$A_n$  and  $B_n$  are computed as follows:

At the start of interval  $n$

$$(t_V)_n = (t_I)_n$$

and

$$(\Psi_V)_n = (\Psi_I)_n = \beta_n + (M_I)_n + 2e_n \sin(M_I)_n + A_n$$

Hence,

$$A_n = (\Psi_I)_n - \beta_n - (M_I)_n - 2e_n \sin(M_I)_n \quad (13.1-19)$$

At the end of interval  $n$ , i.e., at time  $(t_I)_{n+1}$

$$(t_V)_n = (t_V)_{n+1} = (t_I)_{n+1}$$

and

$$(\Delta M)_n = (M_I)_{n+1} - (M_I)_n = \frac{2\pi}{(p_V)_n} \left[ (t_V)_n - (t_I)_{n+1} \right] = \frac{2\pi}{(p_V)_n} (\Delta t)_n$$

At this point

$$(\Psi_V)_n = \beta_n + (M_I)_{n+1} + 2e_n \sin(M_I)_{n+1} + A_n + B_n (\Delta t)_n$$

and it is desired to make  $\Psi_V$  continuous such that at  $(t_I)_{n+1}$

$$(\Psi_V)_n = (\Psi_V)_{n+1} = (\Psi_I)_{n+1}$$

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Thus

$$B'_n = B_n (\Delta t)_n = (\Psi_{I_{n+1}})^{-\beta_{n+1}} - (M_{I_{n+1}})^{-2e_n \sin(M_{I_{n+1}})} - \left[ (\Psi_{I_n})^{-\beta_n} - (M_{I_n})^{-2e_n \sin(M_{I_n})} \right]$$

$$= (\Psi_{I_{n+1}})^{-\beta_{n+1}} - (\Psi_{I_n})^{-\beta_n} + 2e_n \left[ \sin(M_{I_n}) - \sin(M_{I_{n+1}}) \right] - \frac{2\pi(\Delta t)_n}{(p_V)_n}$$

and the continuity constant  $B_n$  is defined by

$$B_n = B'_n / (\Delta t)_n$$

Procedure CØNTAK makes a second-order correction in the vehicle in-plane angle to account for periodic errors by replacing  $(\Psi_V)_n$  with

$$(\Psi_V)_n - \Delta\bar{\Psi} \sin(\Psi_V)_n$$

where  $\Delta\bar{\Psi}$  is an empirical correction factor. This correction factor, however, does not significantly affect acquisition convergence in CØNTAK.

The vehicle altitude during interval  $n$  for continuous values of  $\beta$  and  $e$  is nominally given by

$$h'_n = \frac{1}{(1/r)_n} - 1 + f \sin^2 i \sin^2(\Psi_V)_n$$

where  $f$  is the flattening of the earth, and

$$\left( \frac{1}{r} \right)_n = \frac{1}{(r_I)_n} \left[ \frac{1 + e_n \cos(\Psi_{V_n} - \beta_n)}{1 + e_n \cos(\Psi_{I_n} - \beta_n)} \right] + \frac{J}{(r_I)_n^3} \left\{ 1 - \cos(\Psi_{V_n} - \Psi_{I_n}) \right.$$

$$+ \frac{\sin^2 i}{3} \left( 2 \left[ \cos \Psi_{I_n} \cos \Psi_{V_n} - 1 \right] + \sin^2 \Psi_{V_n} + \sin^2 \Psi_{I_n} \right.$$

$$\left. \left. \left[ 7 \cos(\Psi_{V_n} - \Psi_{I_n}) - 6 \right] \right) \right\}$$

But with the use of average values for  $\beta$  and  $e$ , altitude is computed (in CØNTAK) by

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$$h_n = h_n' + C_n [(t_V)_n - (t_I)_n] .$$

At time  $(t_I)_{n+1}$ , it is necessary that  $h_n^+ = h_{n+1}^-$  for altitude to be continuous; at this point

$$(\psi_V)_n = (\psi_V)_{n+1} = (\psi_I)_{n+1} \quad \text{and} \quad \left(\frac{1}{r}\right)_{n+1}^- \text{ reduces to } \frac{1}{(r_I)_{n+1}} .$$

Thus,

$$h_{n+1}^- = (r_I)_{n+1} - 1 + f \sin^2 i \sin^2 (\psi_I)_{n+1} ,$$

$$h_{n+1}^+ = \frac{1}{(1/r)_n^+} - 1 + f \sin^2 i \sin^2 (\psi_I)_{n+1} + C_n (\Delta t)_n ,$$

and it follows that

$$C_n = \frac{1}{(\Delta t)_n} \left[ (r_I)_{n+1} - \frac{1}{(1/r)_n^+} \right]$$

where

$$\left(\frac{1}{r}\right)_n^+ = \frac{1}{(r_I)_n} \left[ \frac{1 + e_n \cos(\psi_{I_{n+1}} - \beta_n)}{1 + e_n \cos(\psi_{I_n} - \beta_n)} \right] + \frac{J}{(r_I)_n^3} \left[ 1 - \cos(\psi_{I_{n+1}} - \psi_{I_n}) + C_n' \frac{\sin^2 i}{3} \right]$$

and

$$C_n' = 2 (\cos \psi_{I_n} \cos \psi_{I_{n+1}} - 1) + \sin^2 \psi_{I_{n+1}} + \sin^2 \psi_{I_n} \left[ 7 \cos(\psi_{I_{n+1}} - \psi_{I_n}) - 6 \right]$$

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Subsequent to the determination of orbital parameters for storage in the analytical ephemeris table, PATTAB calls closed subroutines SUNDEK and LIMLAT. SUNDEK computes the average sun vector over the specified rev span. LIMLAT computes limiting latitudes for acquisition over the specified rev span arising from sun angle, inclination and miss distance constraints. Subroutine LIMLAT also computes the latitude boundaries which define the regions in which targets may be acquired on multiple revs within one orbit period.

#### 3.3.3.1.2.2 PATENT

PATENT compares the latitude of the target in progress to the maximum and minimum latitudes computed in LIMLAT based upon sun angle and inclination constraints. If the latitude of the target is outside of those bounds the target is deleted.

PATENT interrogates the direction flag DF stored in table THINGS to determine if targets are to be acquired on both North-South (NS) and South-North (SN) passes, or only on NS passes, or only on SN passes. The flag DF is set through File 8 parameter EGT113.

The quantity,  $t_{zo}$ , which is subsequently used by CONTAK to initialize the iterative procedure employed therein to determine the time at vertical acquisition is computed as discussed below.

PATENT compares the latitude of the target to the latitude limits computed in LIMLAT which determine the possibility of multiple acquisitions per orbit period. If multiple acquisitions of the target per orbit period are possible, PATENT computes  $t_{zo}$  as the earliest time the vehicle will be at maximum latitude (for targets in the northern hemisphere) or at minimum latitude (for targets in the southern hemisphere). The equations employed follow:

$$t_{zo} = t_1 + 1/4(p_v),$$

for targets in the northern hemisphere.

$$t_{zo} = t_1 + 3/4(p_v),$$

for targets in the southern hemisphere, where  $t_1$  is the start time of the first orbit interval,  $p_v$  is the average vehicle period for the first orbit interval (computed in PATTAB).

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If multiple acquisitions of the target per orbit period are not possible, PATENT computes  $t_{z0}$  as the earliest time at which the target is in the orbit for a SN acquisition, or a NS acquisition or both as dictated by direction flag DF. A discussion of the equations employed follows.

If at some time the target lies within the orbit plane, then at that time, the angle between the target and the ascending node measured in the equatorial plane,  $\Omega_S$ , is equal to

$$\Omega_S = \begin{cases} \sin^{-1}(\tan \theta_S / \tan i) & \text{SN} \\ \pi - \sin^{-1}(\tan \theta_S / \tan i) & \text{NS} \end{cases}$$

where  $\theta_S$  is the latitude of the target,  $i$  is the inclination of the orbit. Suppose that at time  $(t_I)_n$ , the initial time of orbit interval  $n$ , the ascending node of the orbit is located at longitude  $(\phi_I)_n$ . Then at time  $(t_I)_n$  the angle between the target and the ascending node measured in the equatorial plane, is equal to  $\phi_S - (\phi_I)_n$ , where  $\phi_S$  is equal to the longitude of the target. Thus if the target is to lie within the orbit plane, the ascending node must rotate by the quantity,  $\Delta\Omega_S$  where

$$\Delta\Omega_S = \Omega_S - (\phi_S - (\phi_I)_n)$$

The average orbit period over orbit interval  $n$  is  $(p_O)_n$ . Therefore it may be written that the change in the location of the ascending node over interval  $n$  is equal to

$$\Delta\Omega_S = \frac{2\pi}{(p_O)_n} (t - (t_I)_n)$$

where  $t$  = time measured from reference time.

At  $t_{z0}$  the target is to lie in the orbit plane, therefore,

$$\frac{2\pi}{(p_O)_n} (t_{z0} - (t_I)_n) = \Omega_S - (\phi_S - (\phi_I)_n)$$

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and, thus

$$t_{zo} = \begin{cases} (t_I)_n + \frac{(p_O)_n}{2\pi} \left( \sin^{-1} \left[ \frac{\tan \theta_s}{\tan i} \right] - \phi_S + (\phi_I)_n \right) \text{ SN} \\ (t_I)_n + \frac{(p_O)_n}{2\pi} \left( \pi - \sin^{-1} \left[ \frac{\tan \theta_s}{\tan i} \right] - \phi_S + (\phi_I)_n \right) \text{ NS} \end{cases}$$

The computation presented above is repeated for each orbit interval within the specified rev span until a  $t_{zo}$  is found for an interval  $n$  such that

$$(t_I)_n \leq t_{zo} \leq (t_I)_{n+1}.$$

### 3.3.3.1.2.3 CONTAK

Closed subroutine CONTAK employs an iterative procedure to determine the value of the time at vertical acquisition. The procedure is initialized by setting the current estimate of vertical acquisition time equal to either the value  $t_{zo}$  computed in PATENT (if the target entered TWPATW as an add target or on a target list) or to the acquisition time on the old acquisition tape (if the target acquisition data is being updated).

CONTAK locates the orbit interval containing the current estimate of acquisition time. Using the PATTAB computed orbit parameters associated with that interval and the current estimate of acquisition time, the vehicle in-plane angle from the ascending node at the estimated acquisition time. That angle,  $\psi_V$ , is computed as follows.

$$\psi_V = \beta + U + A + B (t - t_I)$$

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where

$\beta$  = average argument of perigee for the orbit interval

A, B = orbit interval continuity constants

U = true anomaly at time t

t = current estimate of acquisition time

$t_1$  = start time of interval containing t

The true anomaly at time t is computed as follows:

$$U = M + 2e \sin M$$

where

e = average eccentricity for the orbit interval

M = mean anomaly at time t

The mean anomaly at time t is computed as follows:

$$M = M_1 + \frac{2\pi}{(P_V)}(t - t_1)$$

where

$M_1$  = mean anomaly at time  $t_1$

$P_V$  = average vehicle period for the orbit interval

After completing the computation of  $\Psi_V$ , CONTAK computes the angle  $\Psi_S$ .  $\Psi_S$  is the vehicle in-plane angle from the ascending node required for vertical acquisition at the current estimate of vertical acquisition time.  $\Psi_S$  is computed on the basis of geometrical considerations at follows:

$$\psi_S = \tan^{-1} \left[ \frac{\cos i \cos \theta_s \sin \Omega_s + \sin i \sin \theta_s}{\cos \theta_s \cos \Omega_s} \right]$$

where

i = orbit inclination

$\theta_s$  = target latitude

$\Omega_s$  = angle between the target and the ascending node measured in the equatorial plane

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$\Omega_s$  is computed as follows

$$\Omega_s = \phi_s - \phi_I + \frac{2\pi}{p_0} (t - t_I)$$

where  $\phi_s$  = target longitude

$\phi_I$  = longitude of ascending node at  $t_I$

$p_0$  = average orbit period over orbit interval

$t$  = current estimated vertical acquisition time

$\psi_V$  and  $\psi_s$  are computed using the current estimate of vertical acquisition time. If the estimate is correct,  $\psi_V = \psi_s$ . If  $\psi_V \neq \psi_s$  a new estimate of vertical acquisition is obtained through solution of the equation

$$t_{\text{new}} = t_{\text{old}} - \frac{\psi_s - \psi_V}{\dot{\psi}_s - \dot{\psi}_V}$$

where .

$t_{\text{new}}$  = new estimate of vertical acquisition time

$t_{\text{old}}$  = old estimate of vertical acquisition time

$\dot{\psi}_s$  = derivative with respect to  $t$  of  $\psi_s$

$\dot{\psi}_V$  = derivative with respect to  $t$  of  $\psi_V$

The process is repeated until

$$\psi_V = \psi_s \pm \text{EPSI}$$

where

EPSI = convergence constant stored in table THINGS,  
specified through EGT094.

Subsequent to the determination of a vertical acquisition time which satisfies the constraints imposed by EPSI, CONTAK determines whether the target can be acquired on multiple revs within an orbit period.

If multiple acquisitions of the target are possible, CONTAK determines the direction of pass (NS or SN) for the acquisition time found, deletes the acquisition if the pass direction is not to be allowed, and increments the acquisition times by one vehicle period. CONTAK recycles

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to search for a new acquisition time using the incremented acquisition time as the initial estimate. (THINGS table item DELP02, specified through File 8 parameter EGT111, is employed in the determination of pass direction.)

If multiple acquisitions of the target are not possible, CONTAK increments the acquisition time found by one orbit period, and recycles to search for a new acquisition time using the incremented acquisition time to initialize the iterative procedure.

Subsequent to the computation of each acquisition time CONTAK computes the values of sun angle, target obliquity, slant range to the target and vehicle altitude at that time.

CONTAK compares the values computed to input constraints on these quantities. Targets which fail to meet the constraints are deleted. THINGS table parameters CONSSA, OBLBAR, CONSRU, and CONSAU are, respectively, the minimum sun angle, the maximum obliquity, the maximum slant range, and the maximum vehicle altitude. CONSSA, OBLBAR, CONSRU, and CONSAU are specified through File 7 parameters SEV004, SEV003, SEV007 and SEV008.

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TWPATW

TWPATW

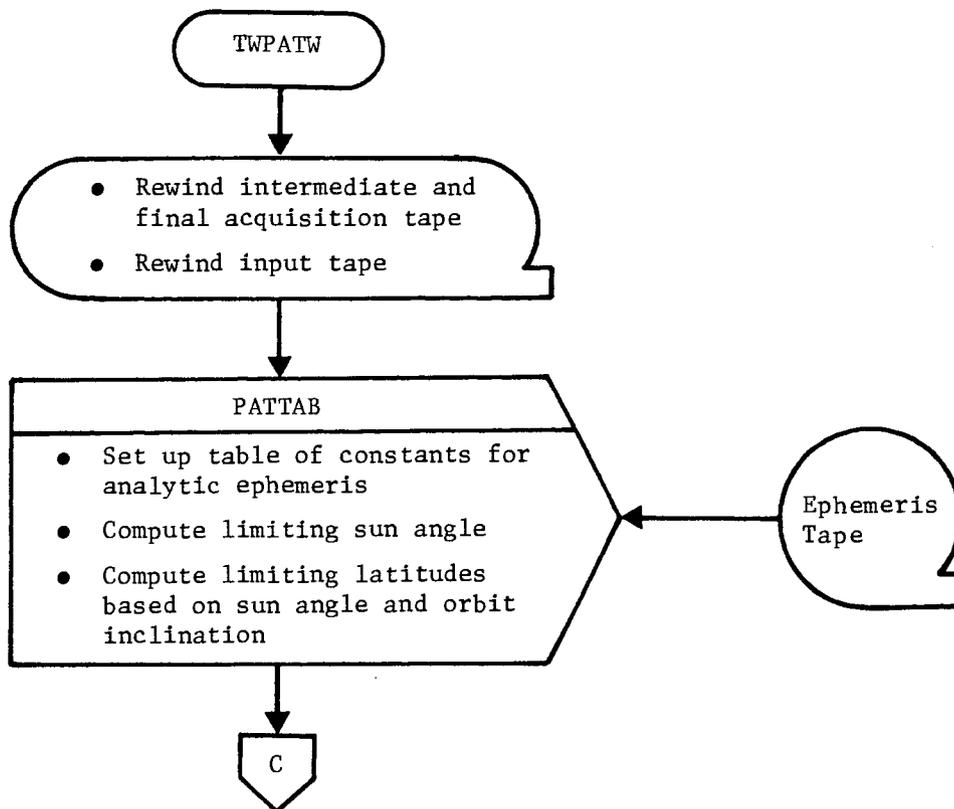


Figure 3-3. TWPATW Flow Chart

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TWPATW

TWPATW

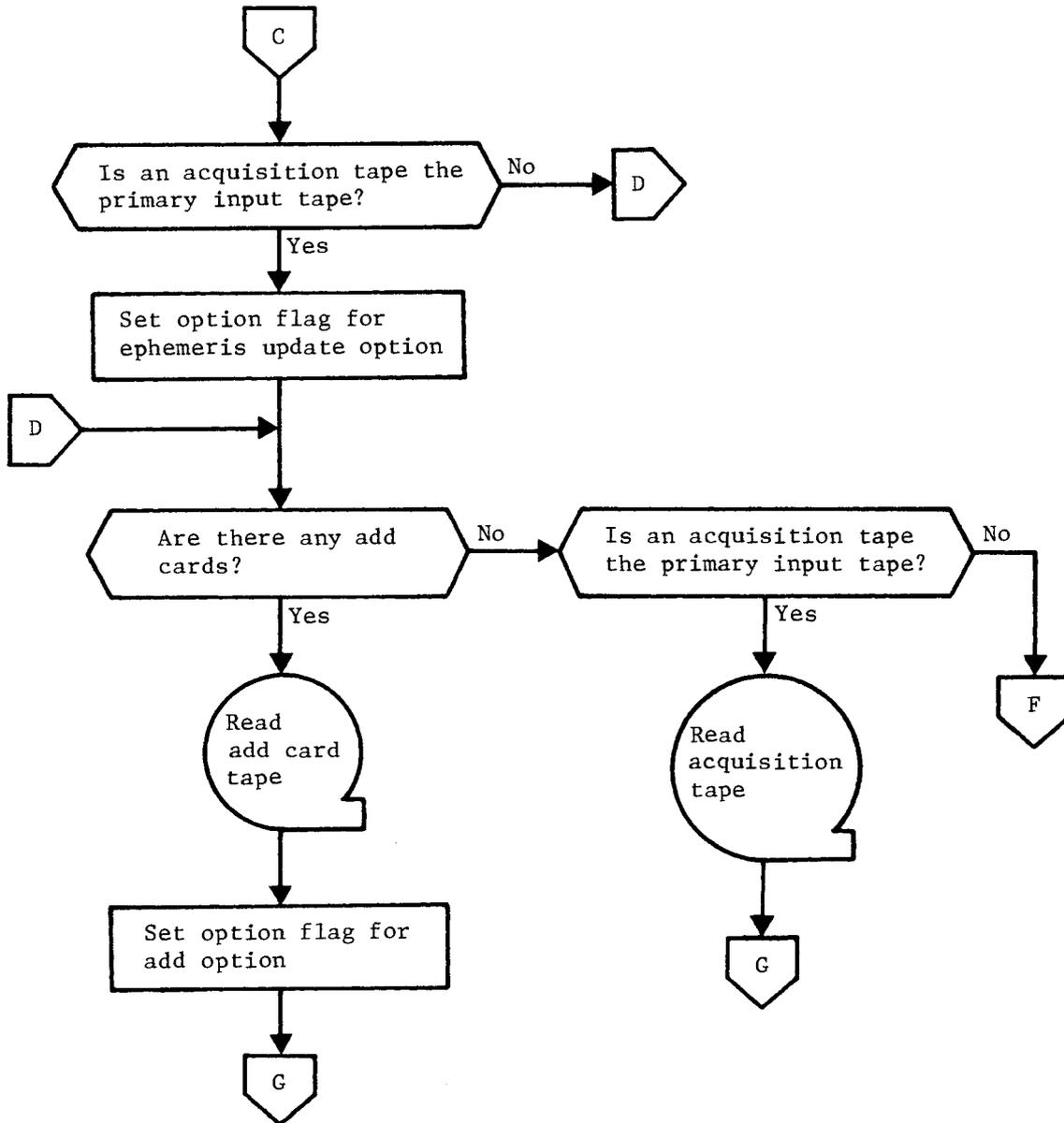


Figure 3-3. TWPATW Flow Chart (Continued)

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TWPATW

TWPATW

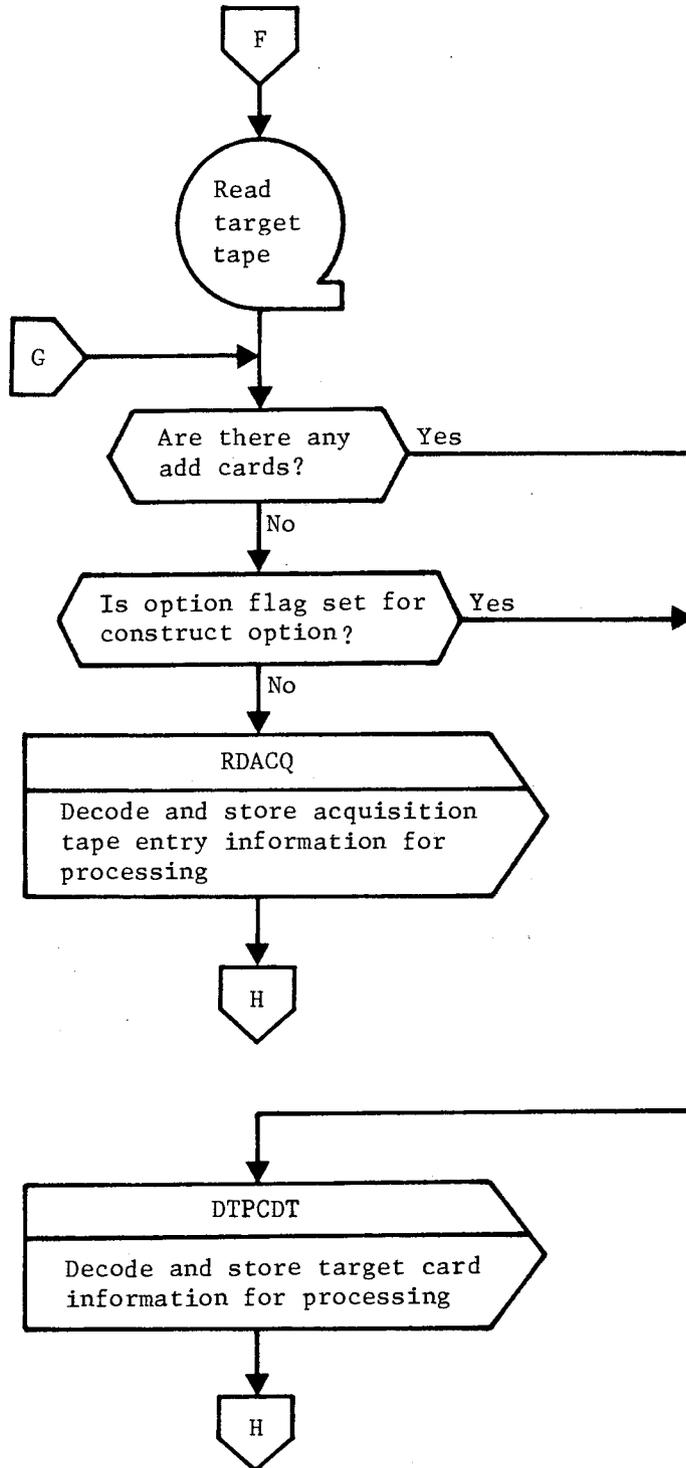


Figure 3-3. TWPATW Flow Chart (Continued)

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TWPATW

TWPATW

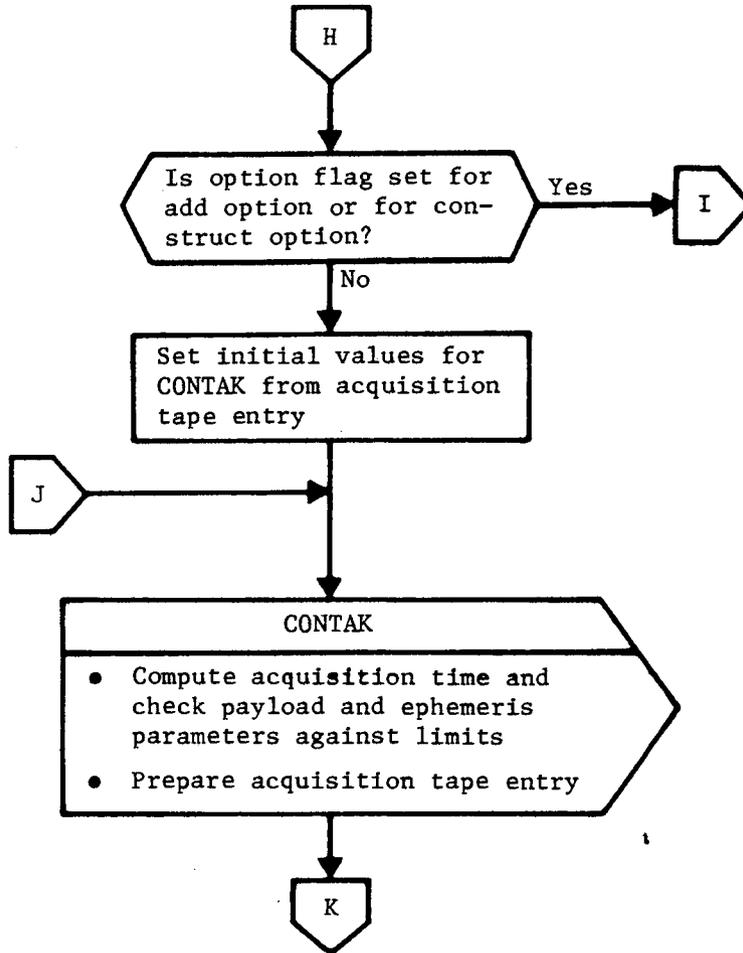


Figure 3-3. TWPATW Flow Chart (Continued)

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TWPATW

TWPATW

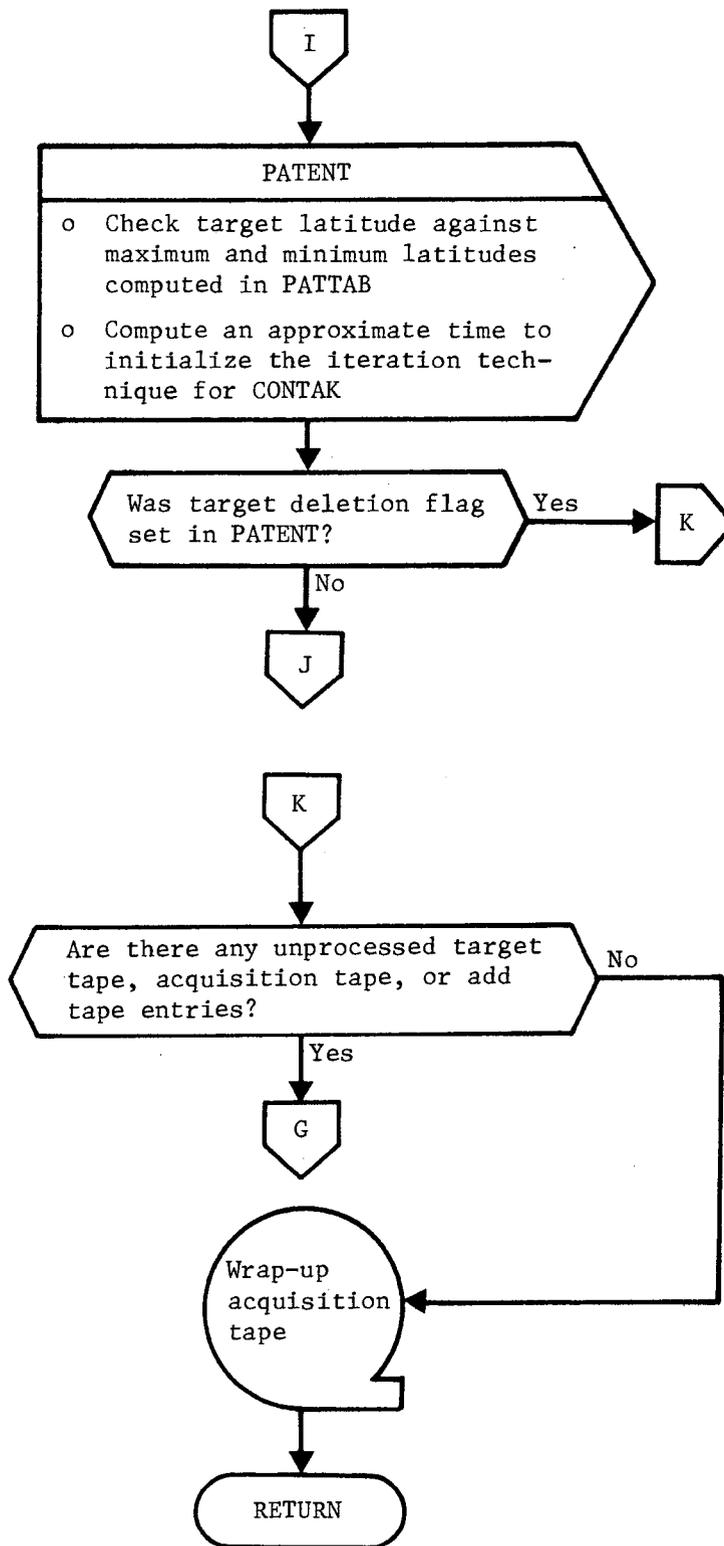


Figure 3-3. TWPATW Flow Chart (Continued)

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PATTAB

PATTAB

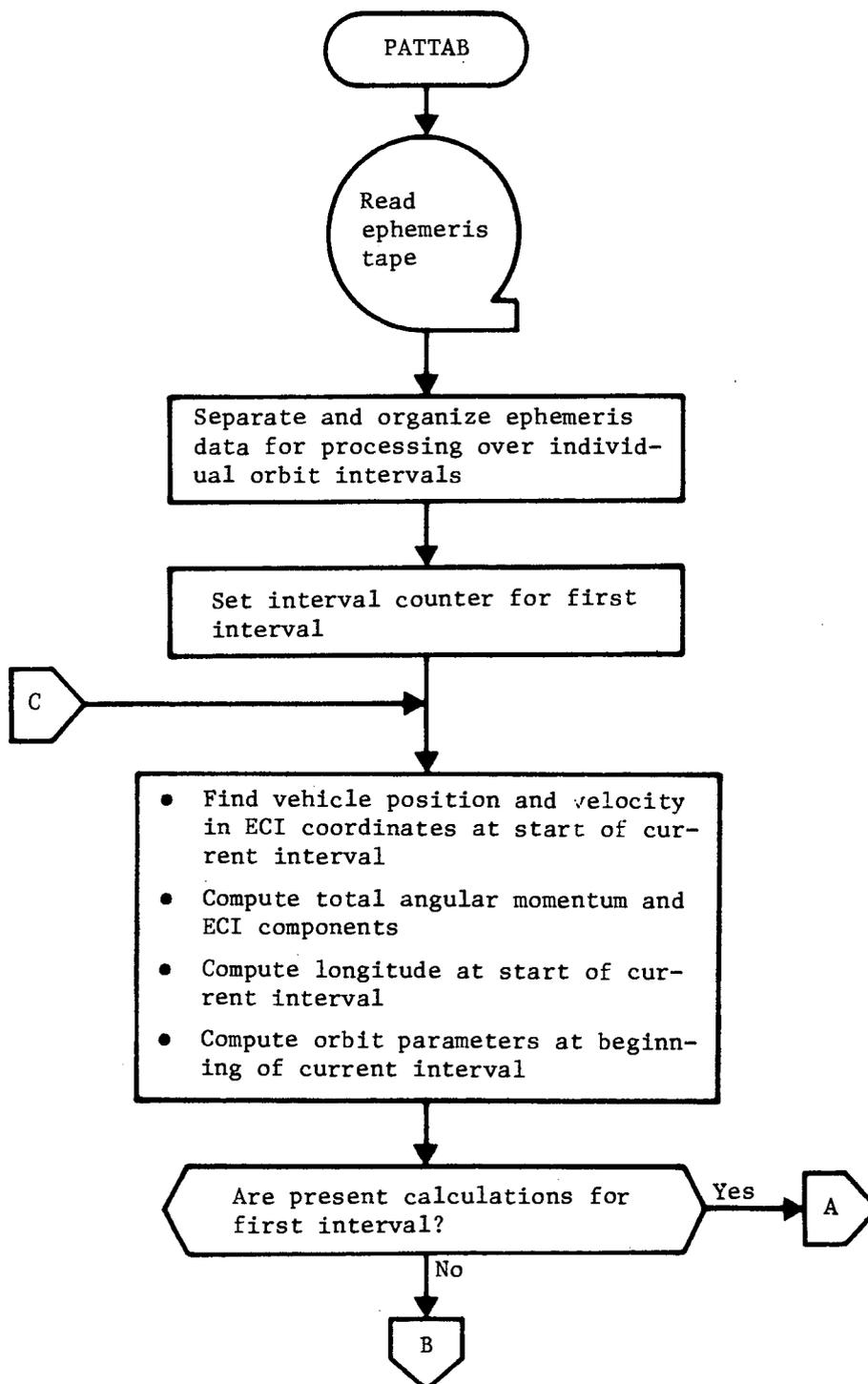


Figure 3-3. TWPATW Flow Chart (Continued)

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PATTAB

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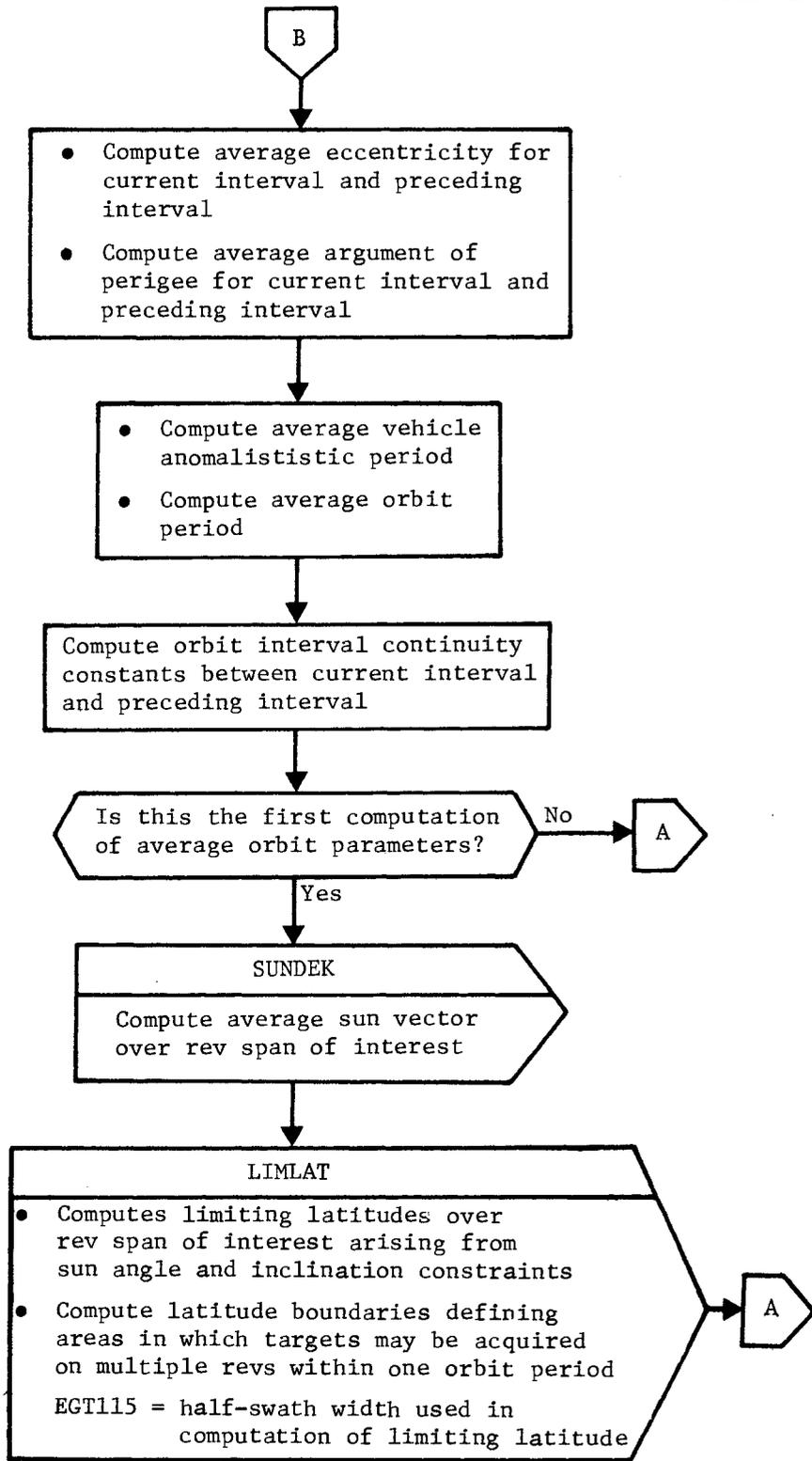


Figure 3-3. TWPATW Flow Chart (Continued)

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PATTAB

PATTAB

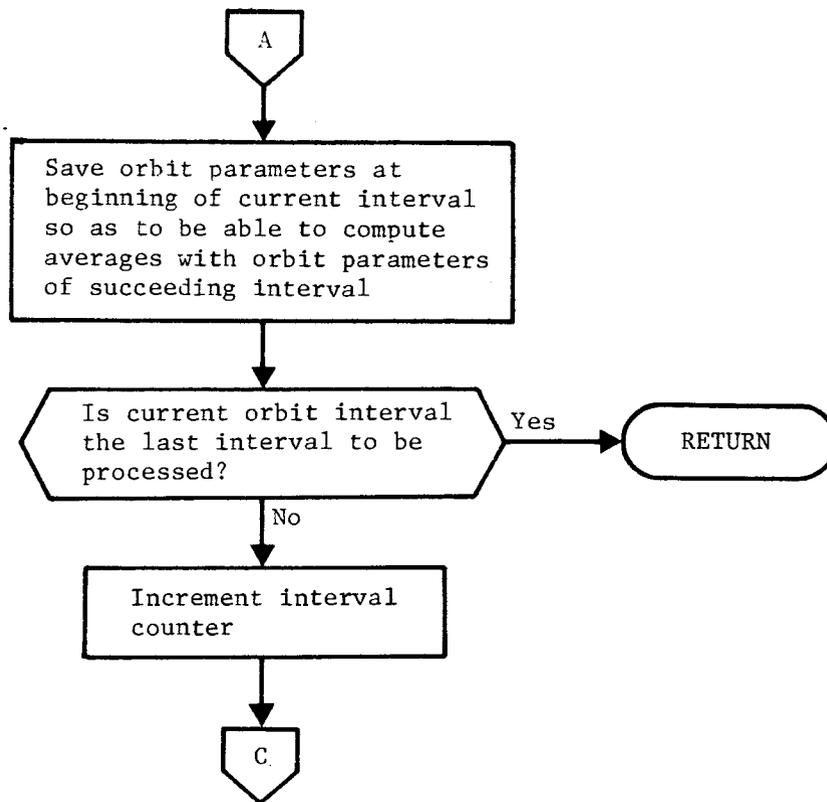


Figure 3-3. TWPATW Flow Chart (Continued)

PATENT

PATENT

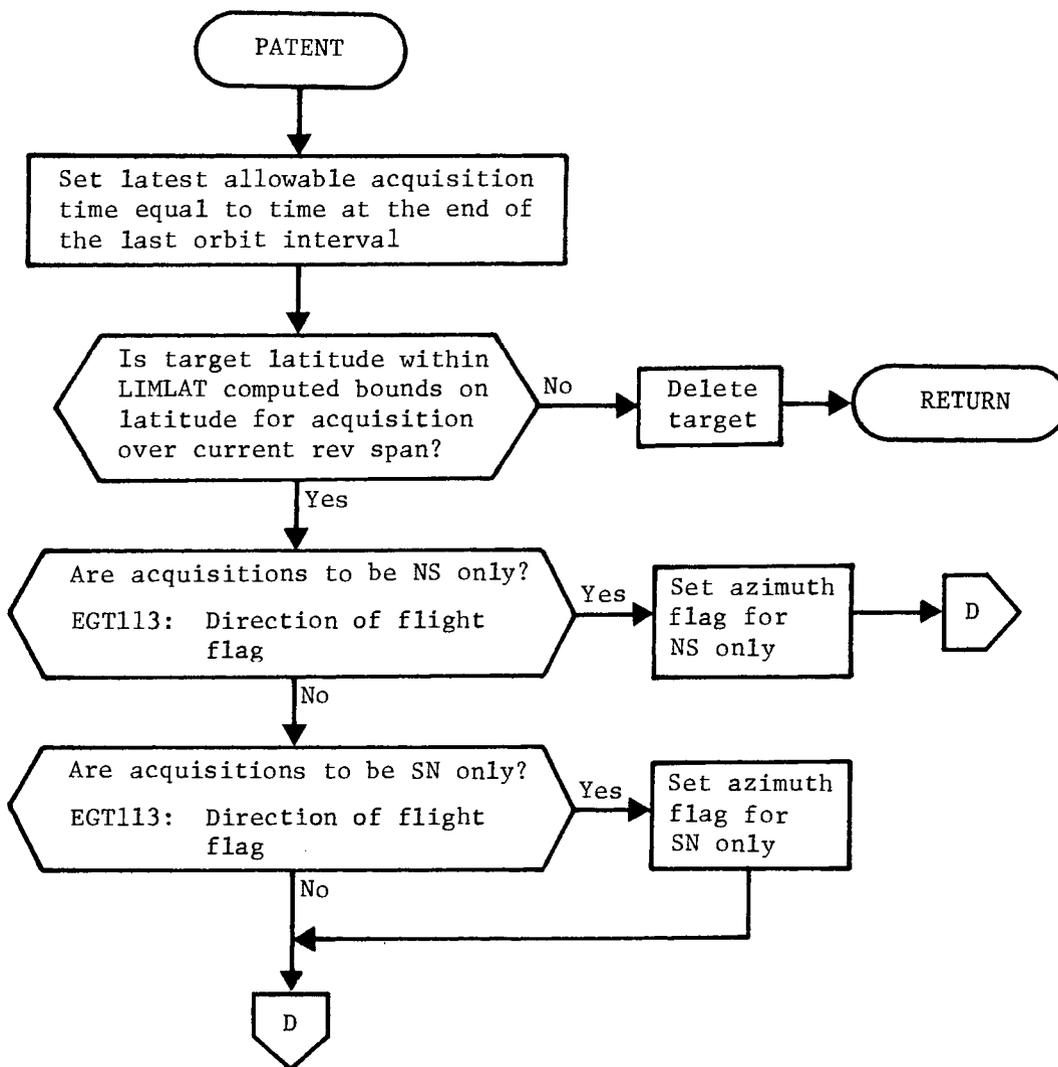


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

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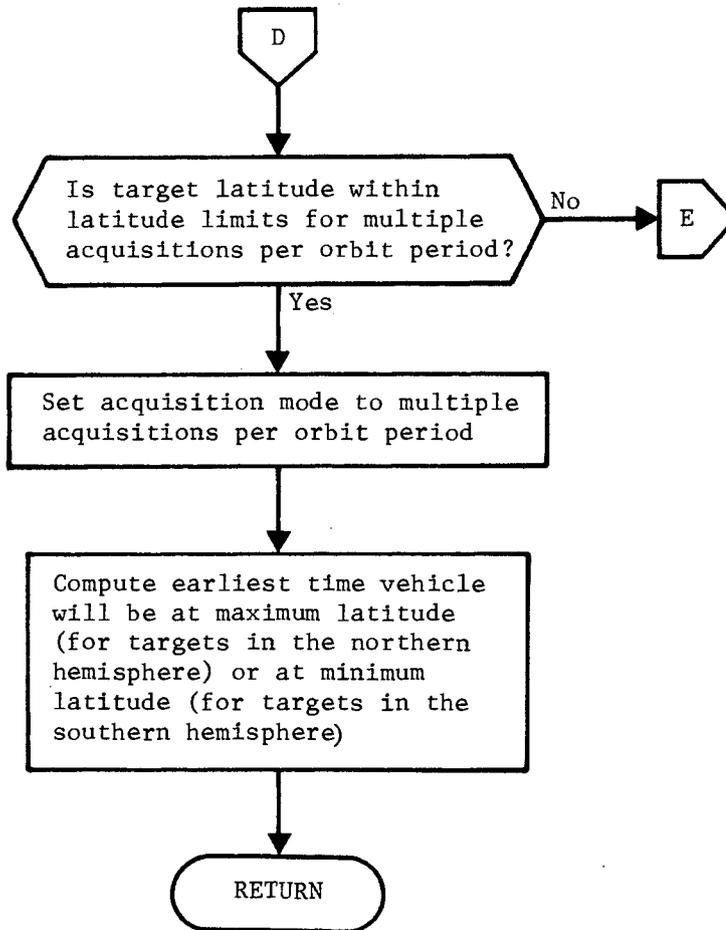


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

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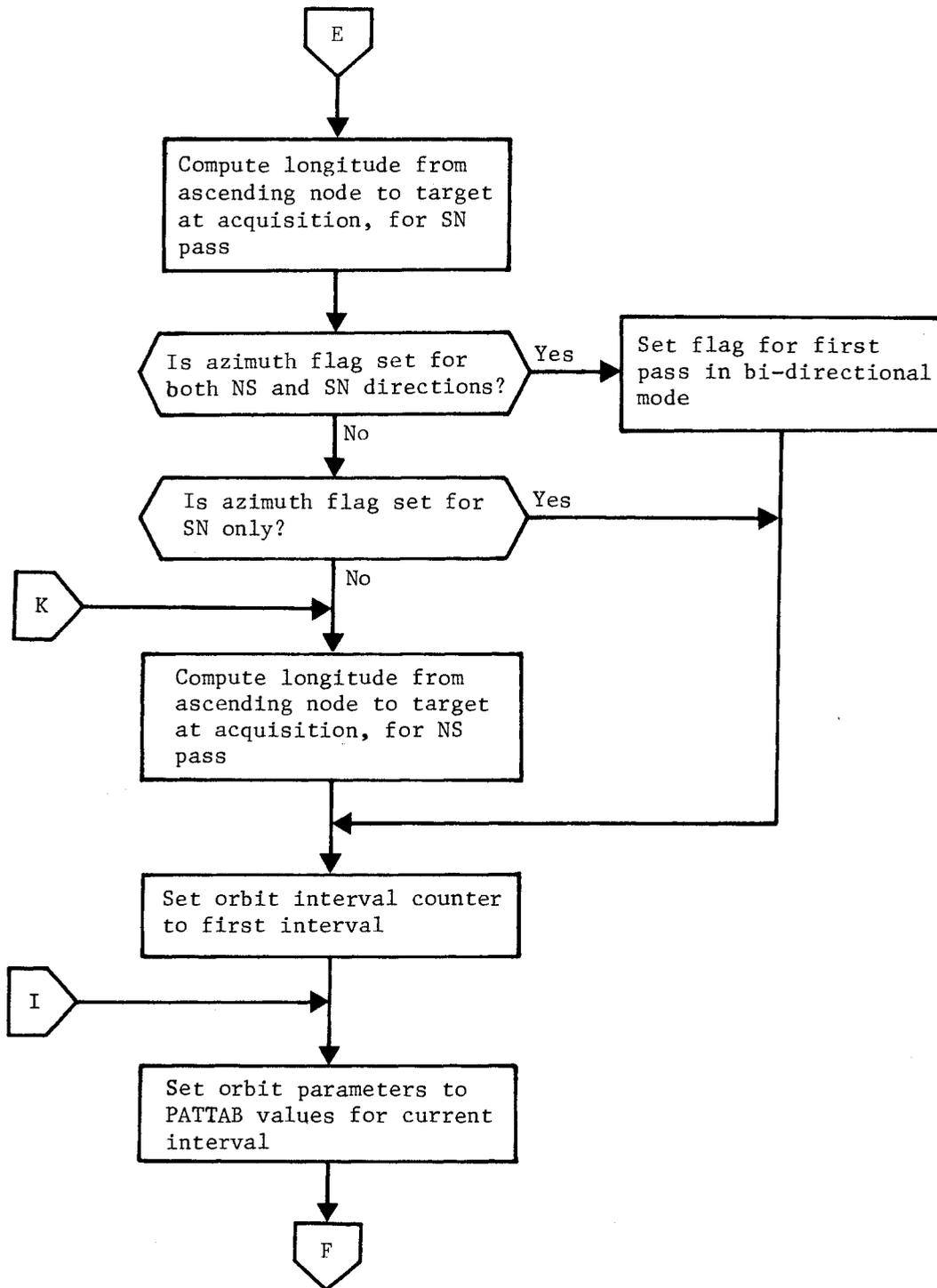


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

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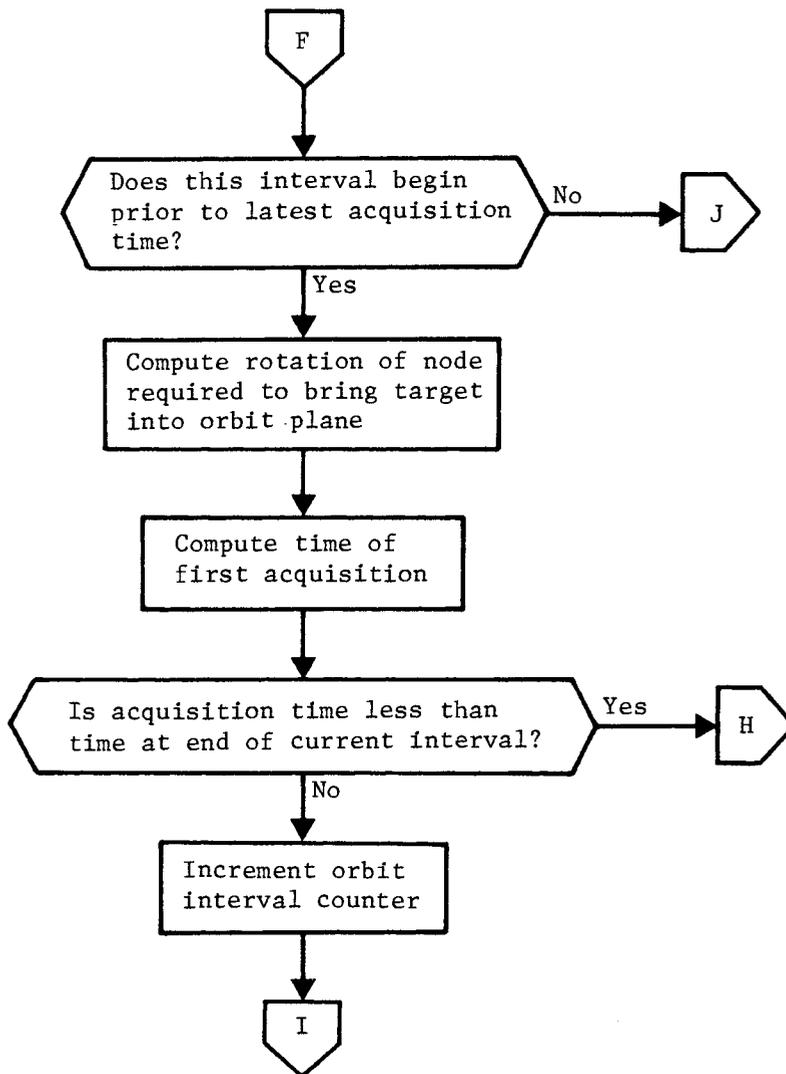


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

PATENT

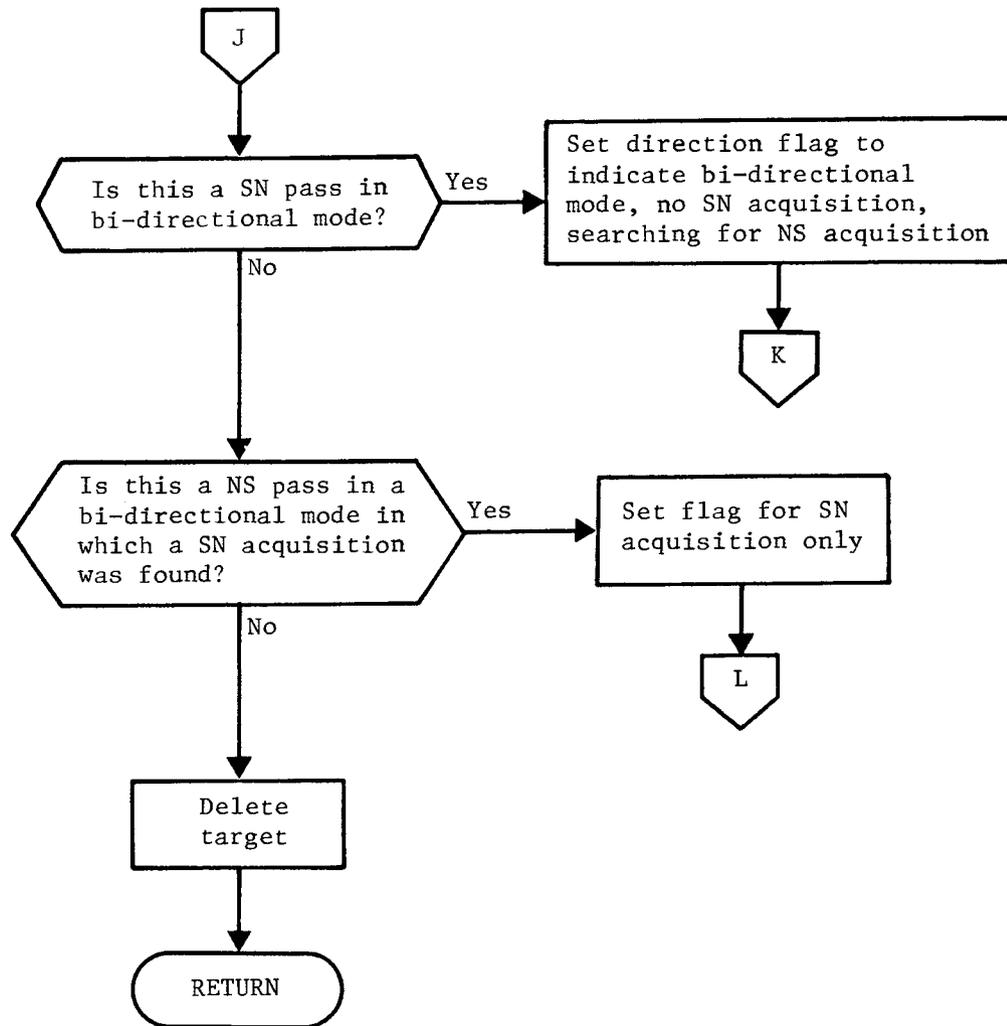


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

PATENT

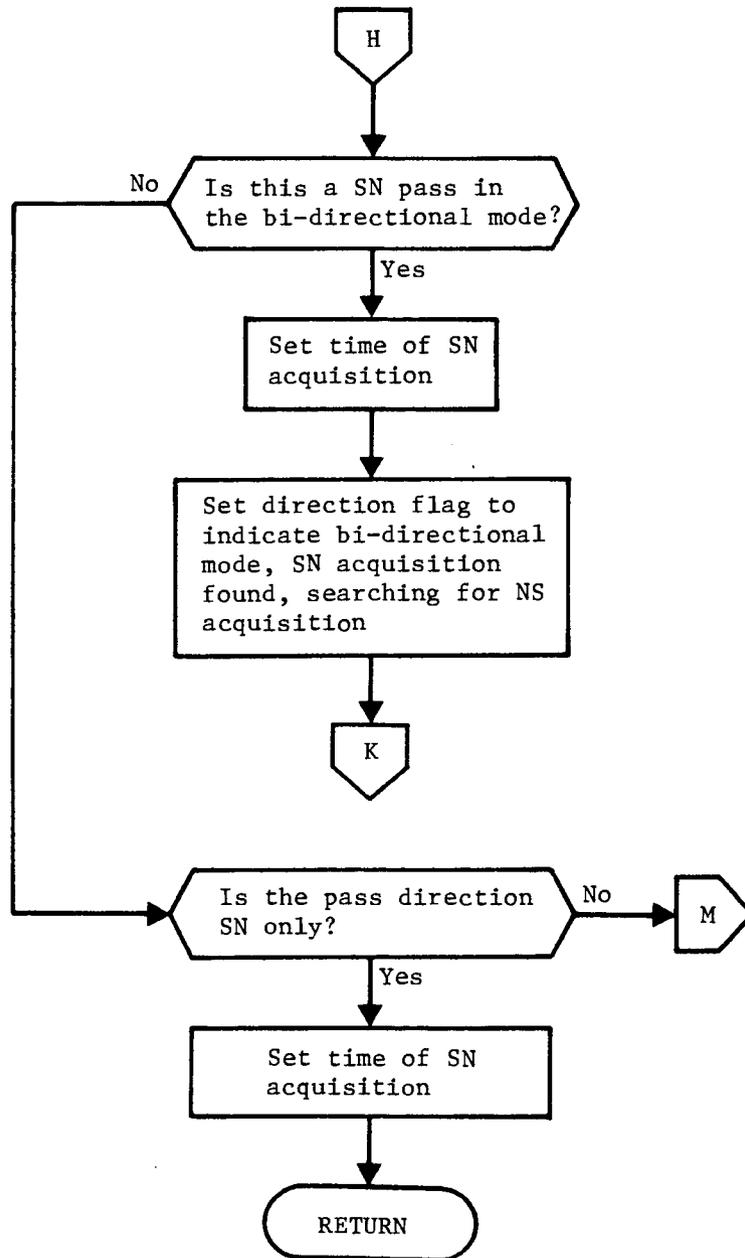


Figure 3-3. TWPATW Flow Chart (Continued)

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PATENT

PATENT

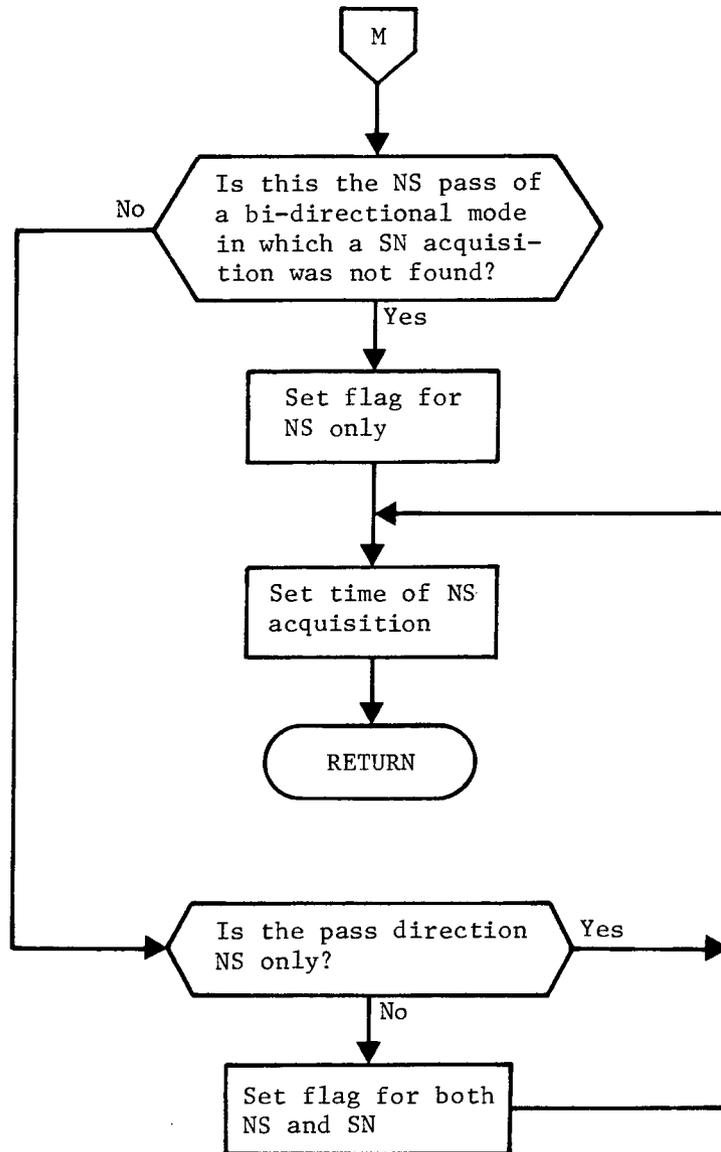


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

CONTAK

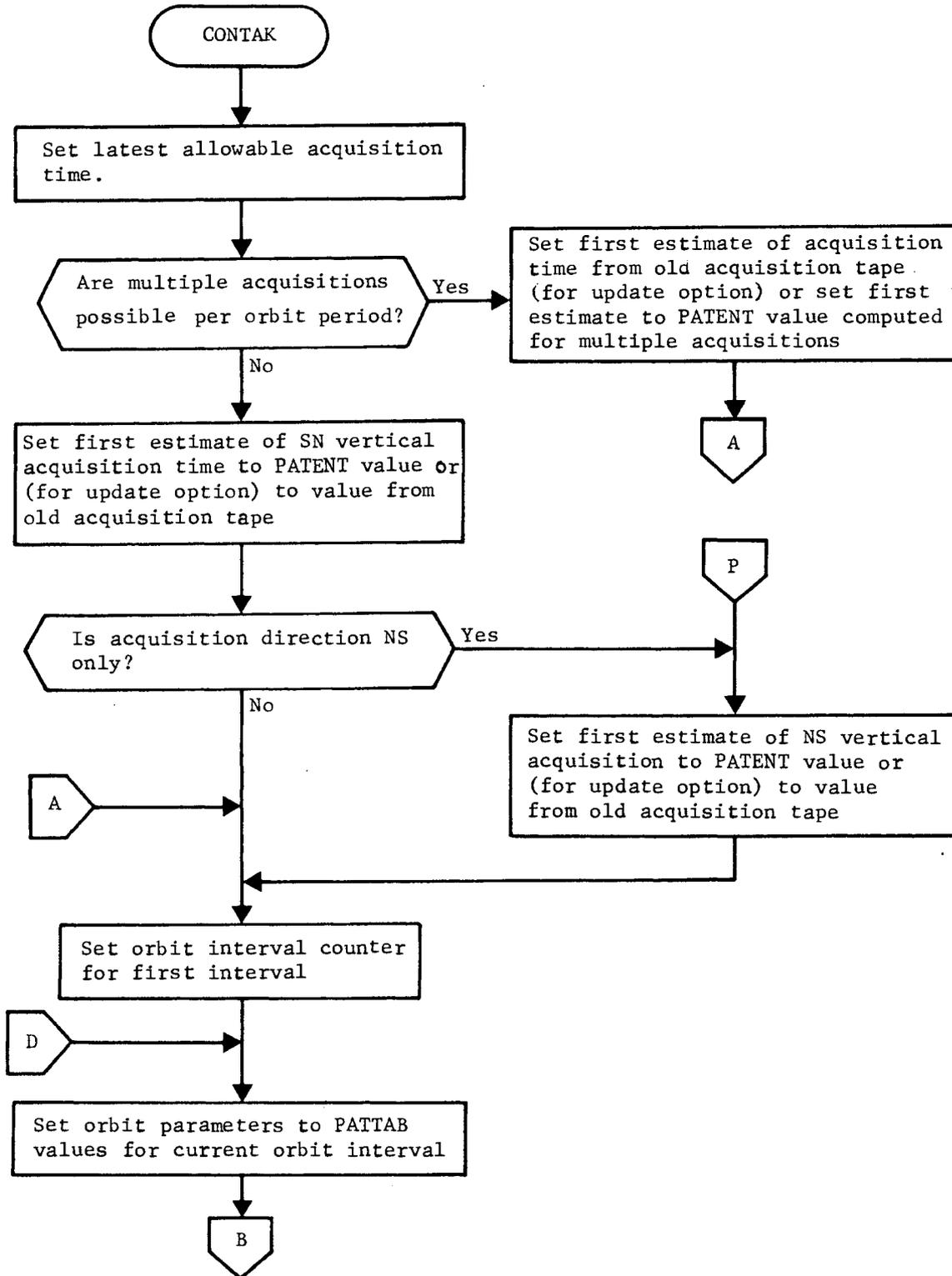


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

CONTAK

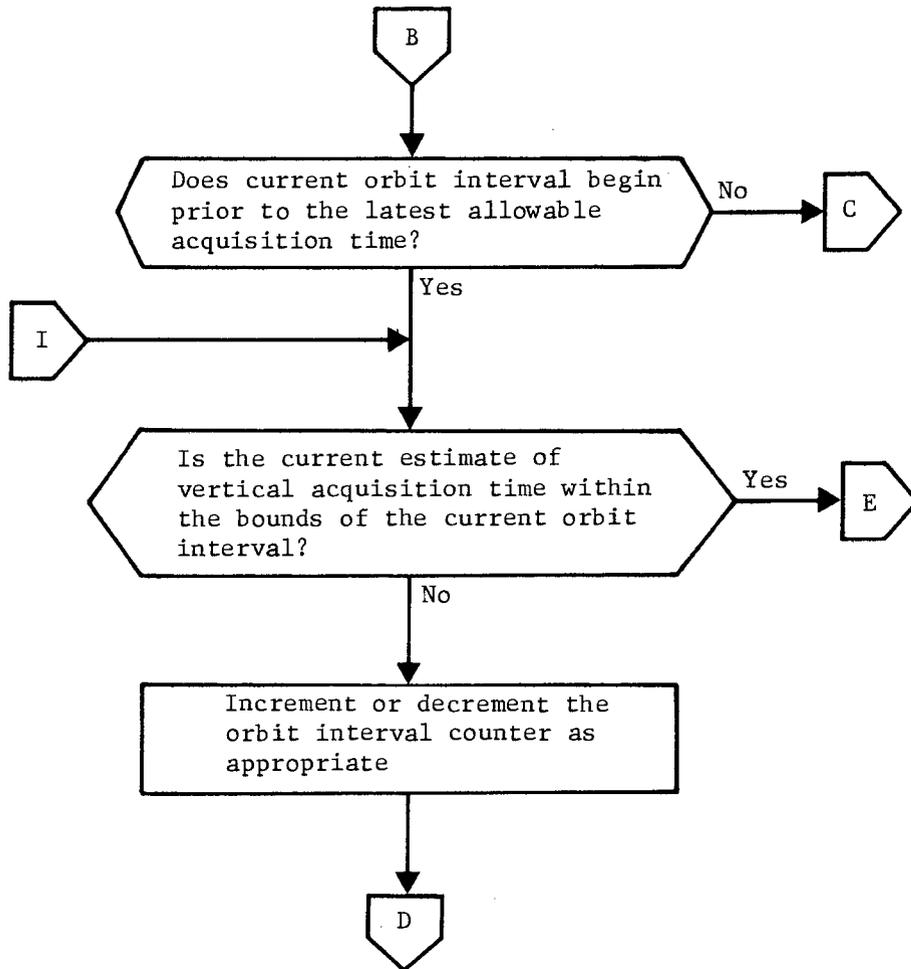


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

CONTAK

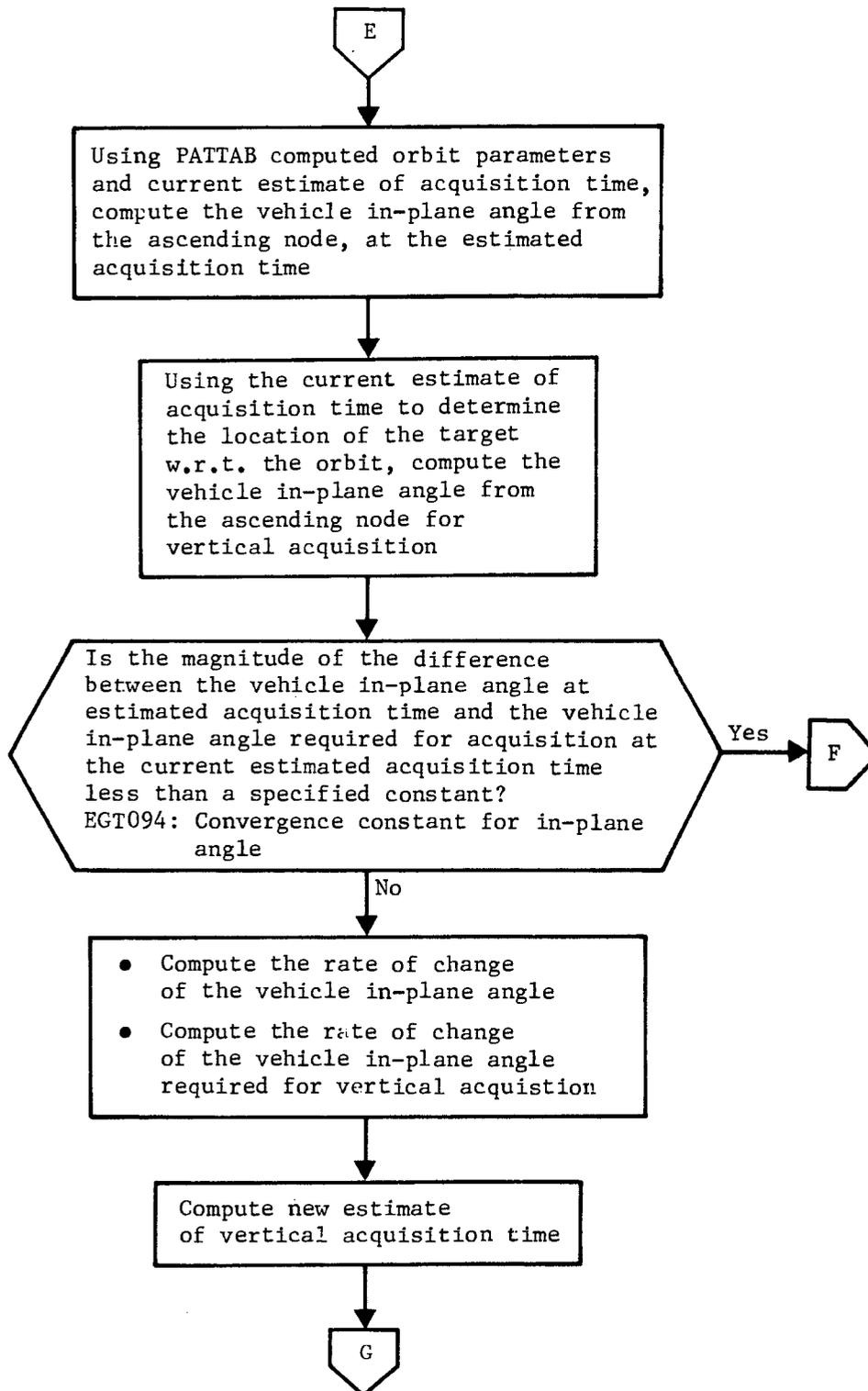


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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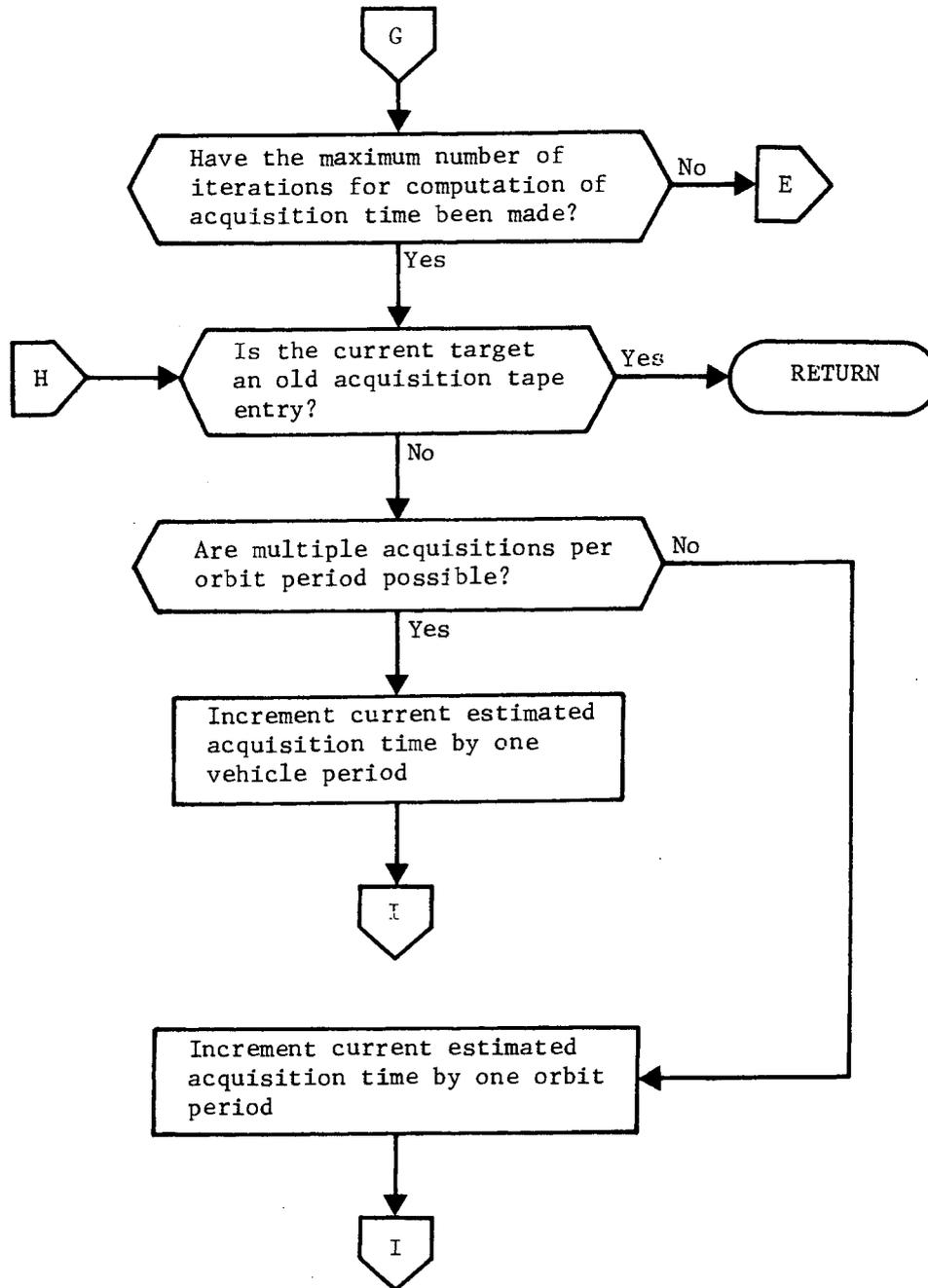


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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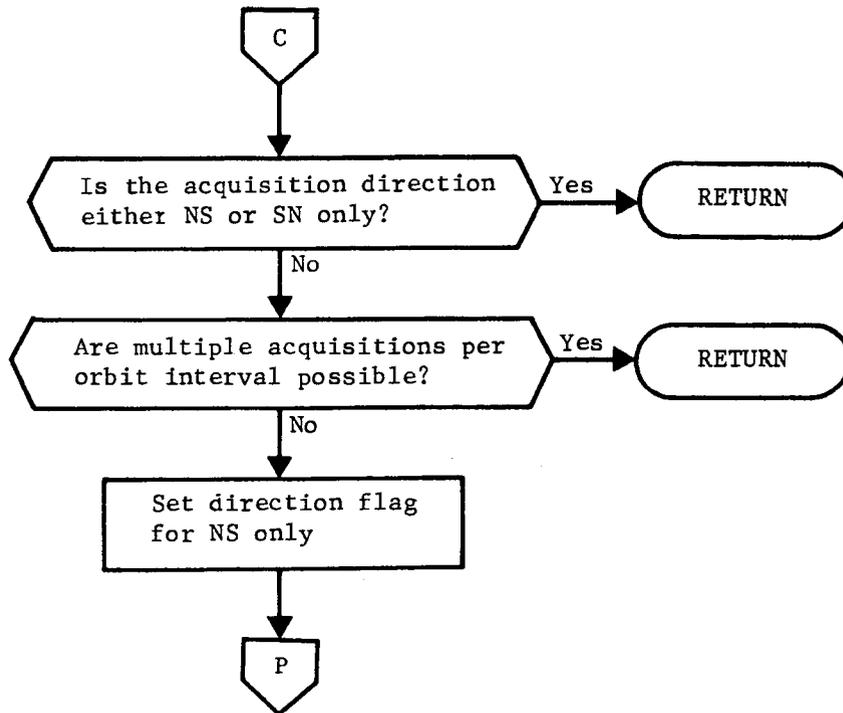


Figure 3-3. TWPATW Flow Chart (Continued)

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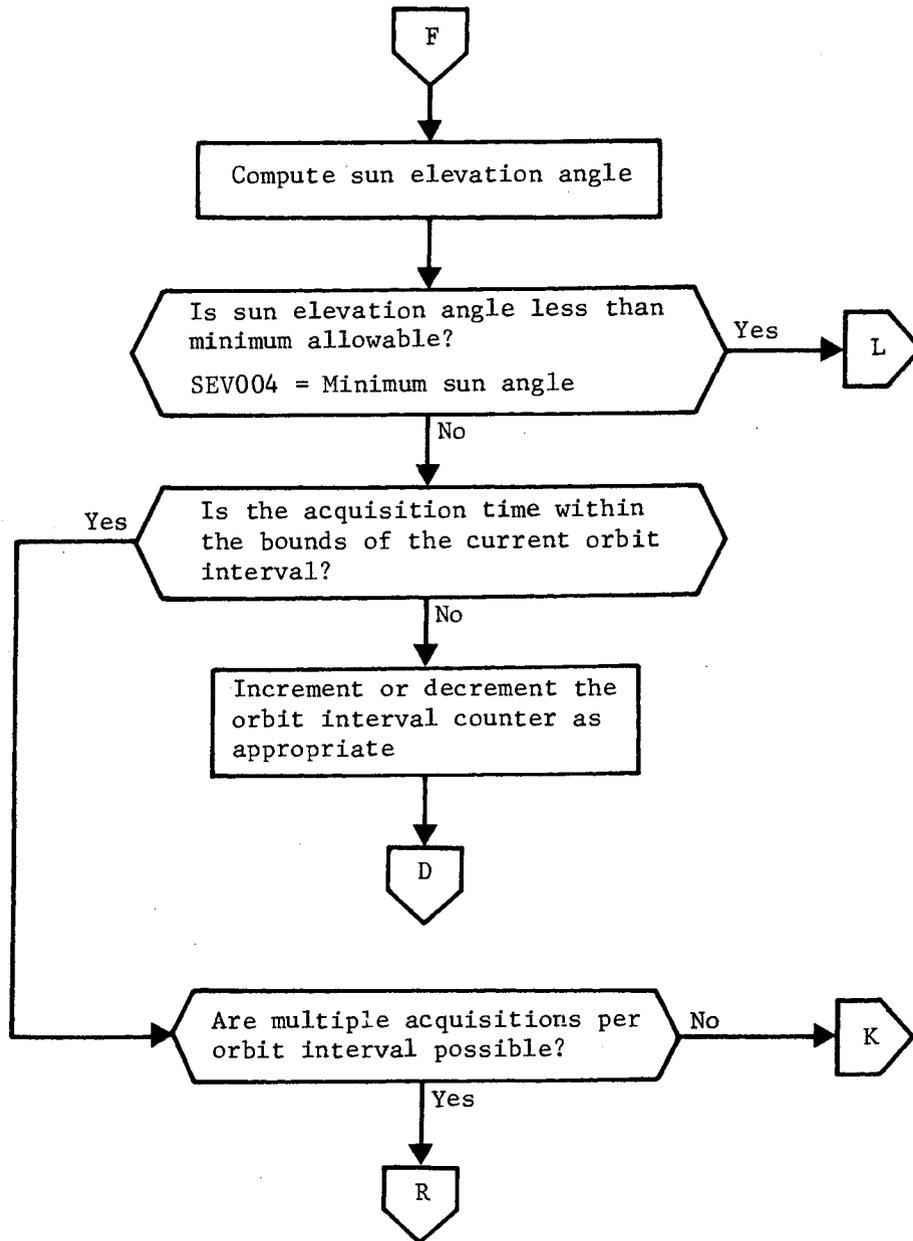


Figure 3-3. TWPATW Flow Chart (Continued)

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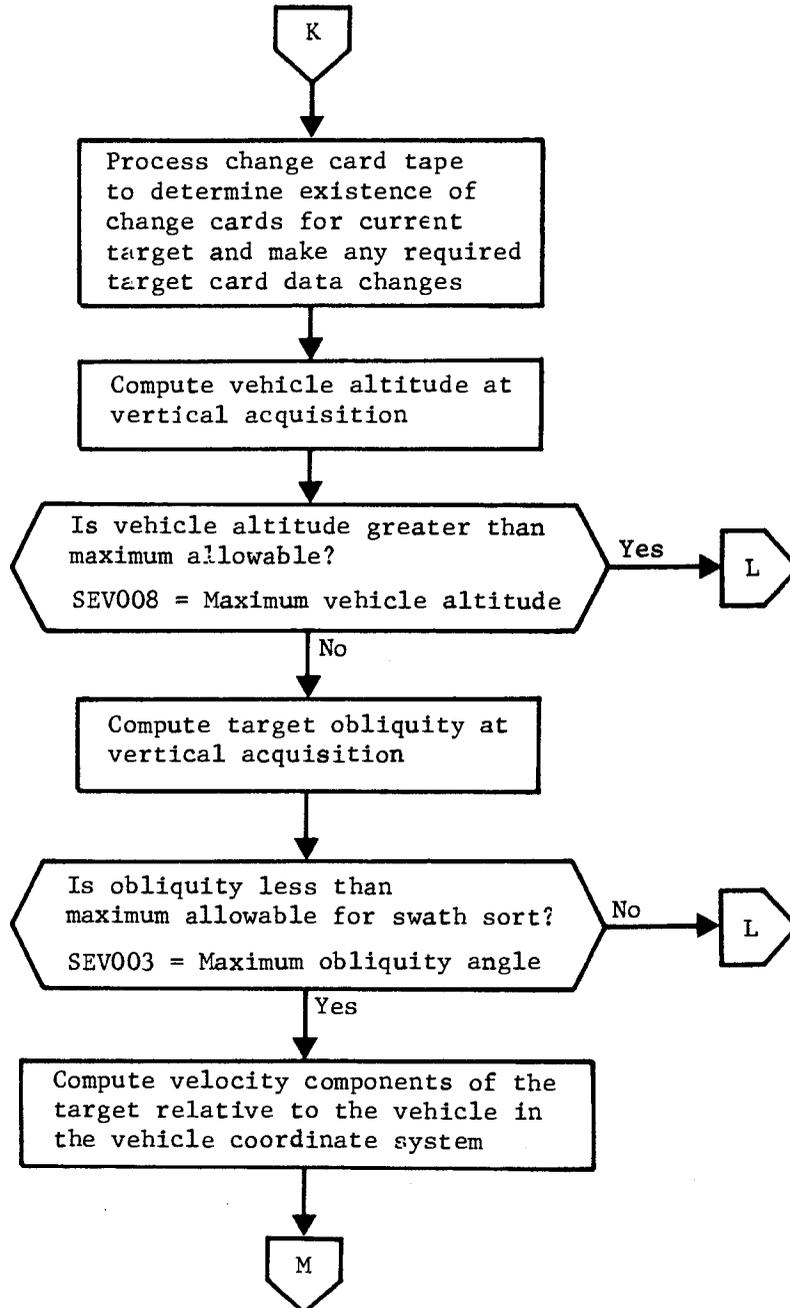


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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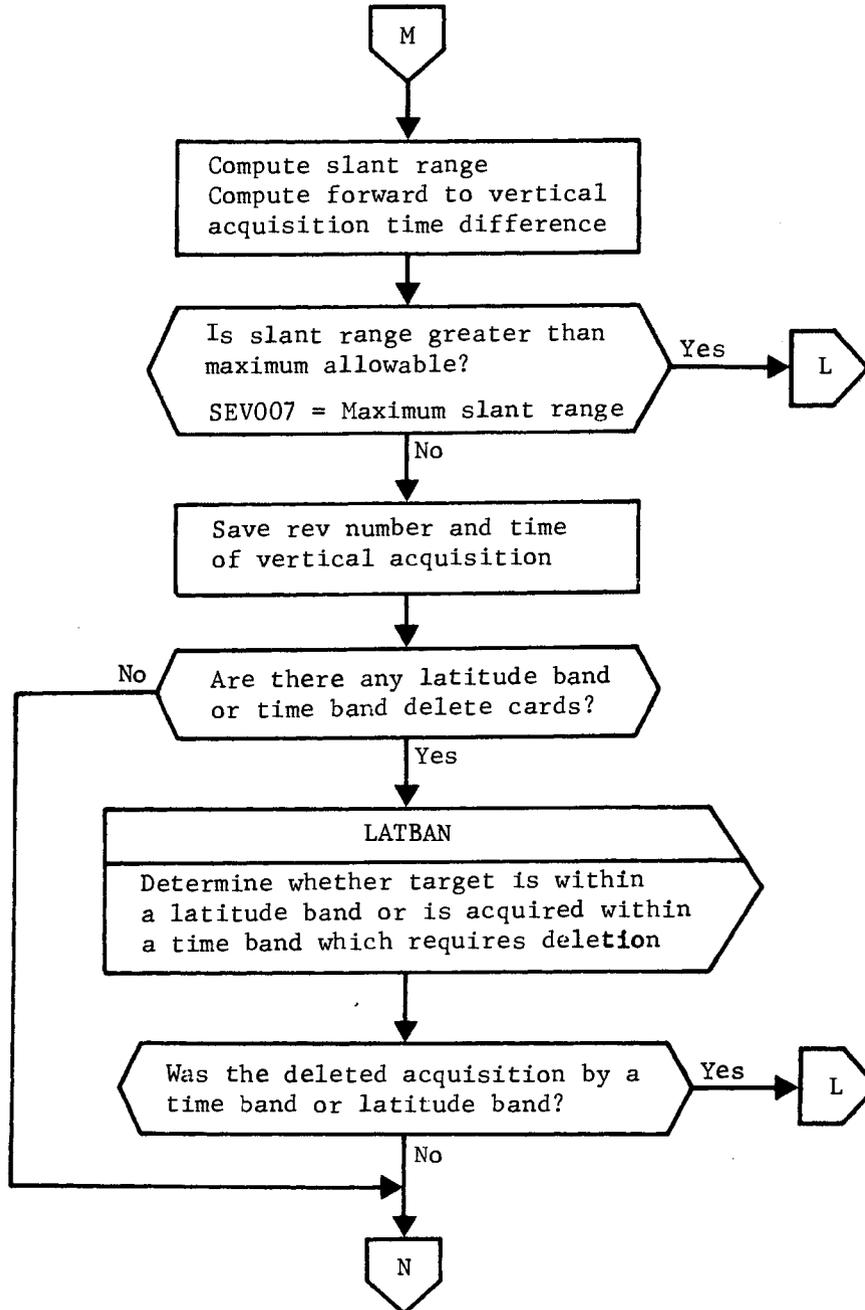


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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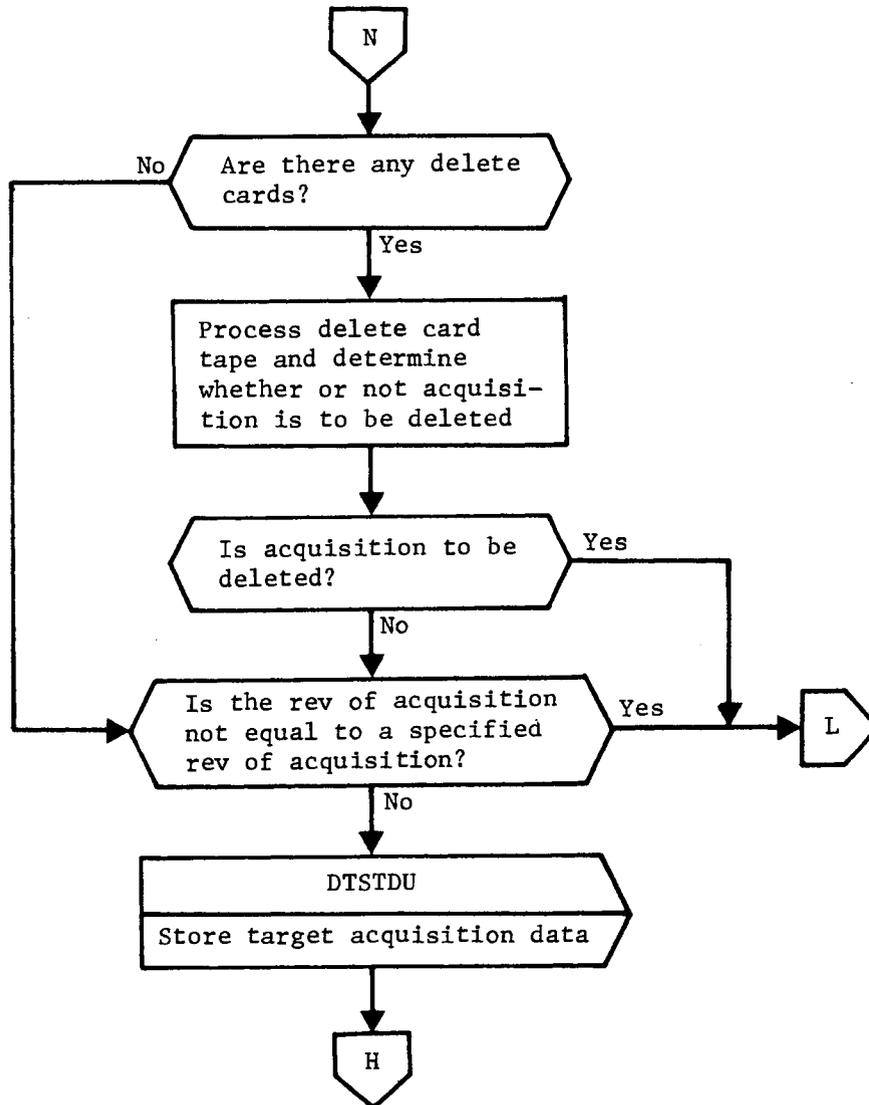


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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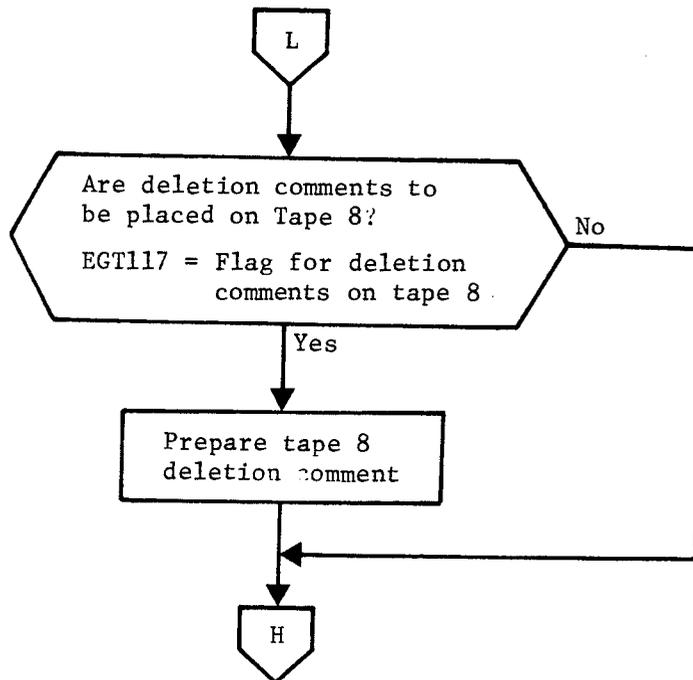


Figure 3-3. TWPATW Flow Chart (Continued)

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CONTAK

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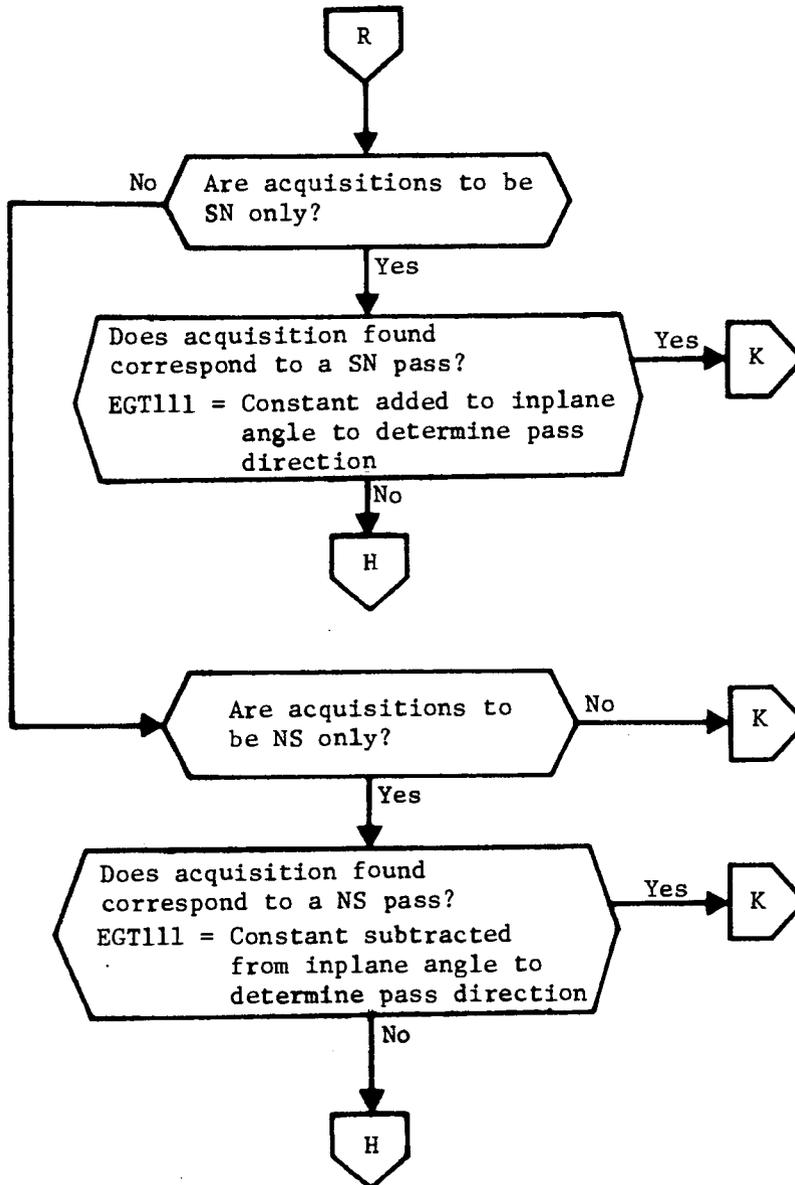


Figure 3-3. TWPATW Flow Chart (Continued)

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### 3.4 TDMERGE

#### 3.4.1 Purpose

After TWPATW has processed the target list, and the target and acquisition data for all acquired targets has been written on intermediate tapes, TDMERGE sorts the targets and writes the final time ordered acquisition tape. On option, new acquisition data can be stacked onto an existing acquisition tape.

#### 3.4.2 Input

The input to TDMERGE consists of the intermediate acquisition tapes output by TWPATW. The acquisition data is described in Section 3.3.

#### 3.4.3 Output

The output of TDMERGE is the final acquisition tape. The format of the entries on this tape is the same as that of the intermediate acquisition tape (see Section 3.3). The data contained on the acquisition tape include the full set of target card parameters. Also entered in the data block are the target acquisition parameters computed by TWPATW:

- a. Time of vertical acquisition
- b. The difference between earliest acquisition time and vertical acquisition time
- c. Parameters at vertical acquisition
  - Target obliquity
  - Altitude
  - Slant range
  - Sun elevation angle

The final acquisition tape is time ordered on the basis of vertical acquisition time.

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#### 3.4.4 Method

If all the acquisitions from the intermediate acquisition tapes can be simultaneously placed in core (2800 acquisition entries maximum), the acquisitions are sorted by acquisition time, and the final acquisition tape is written.

If the total number of acquisitions exceeds 2800, up to four intermediate merge tapes are generated, each containing a maximum of 2800 acquisitions. These intermediate merge tapes are time ordered as they are generated. When all the acquisitions have been written on the merge tapes, these tapes are merged to form the final acquisition tape.

If it is desired to stack current acquisitions behind the entries on an existing acquisition tape, then the final two significant data records of the existing acquisition tape are also merged with the intermediate acquisition tapes. No acquisition times of the current run may precede acquisition times on the existing acquisition tape. A flow chart of TDMERGE is shown in Figure 3-4.

#### 3.4.5 Restrictions

The maximum number of acquired targets that can be processed by TDMERGE is 11,200. This limits the rev span that can be handled in a single run. As discussed in Section 2.1.1, the number of acquisitions per day is approximately one-fifth of the total target population (assuming 16 revs per day and a highly inclined orbit). For a target deck of 15,000 targets, approximately 3000 per day will be acquired. Therefore, a time period of about 3-1/2 days would be the maximum duration that could be considered in a single run. For rev spans covering a longer time period, the stack option can be employed.

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TDMERGE

TDMERGE

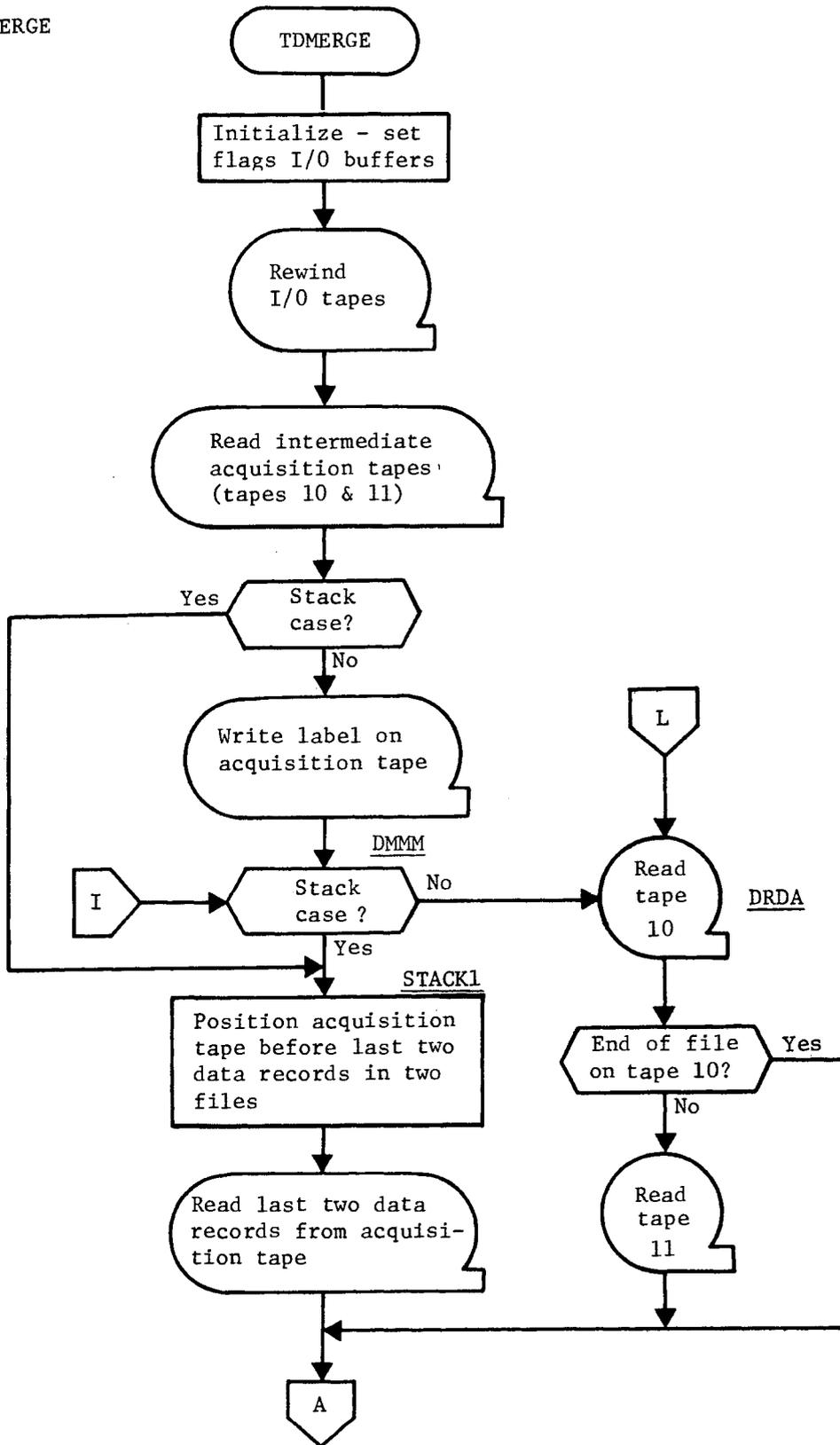


Figure 3-4. TDMERGE Flow Chart

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TDMERGE

TDMERGE

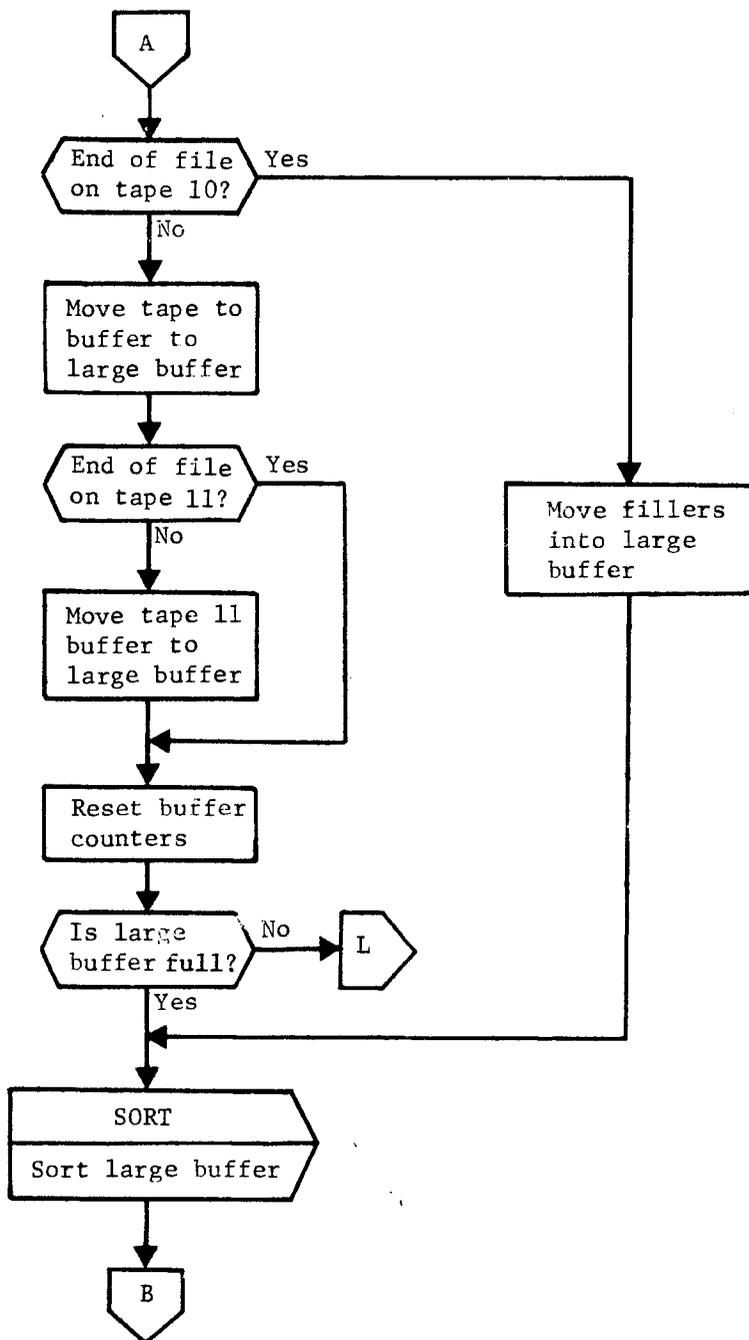


Figure 3-4. TDMERGE Flow Chart (Continued)

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TDMERGE

TDMERGE

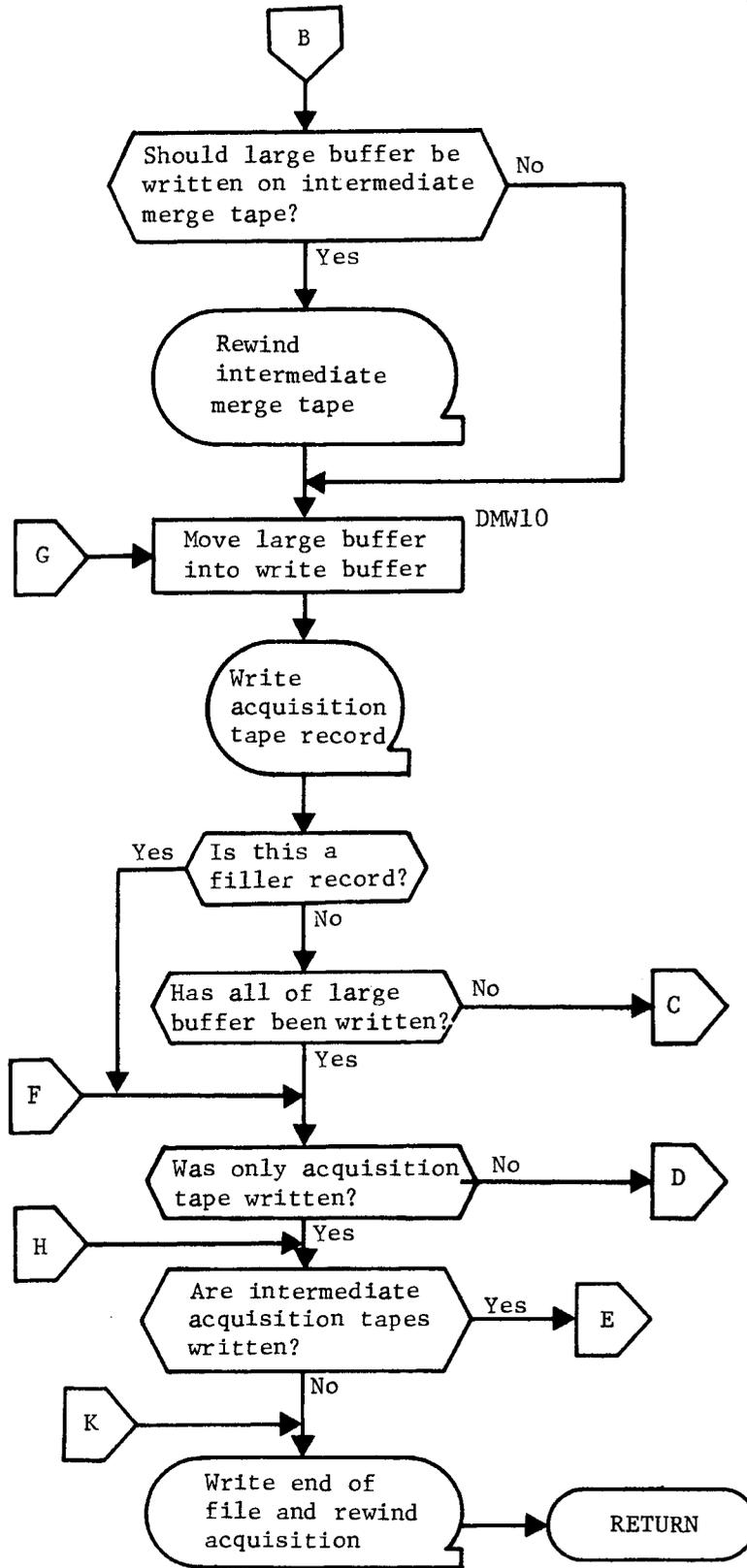


Figure 3-4. TDMERGE Flow Chart (Continued)

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TDMERGE

TDMERGE

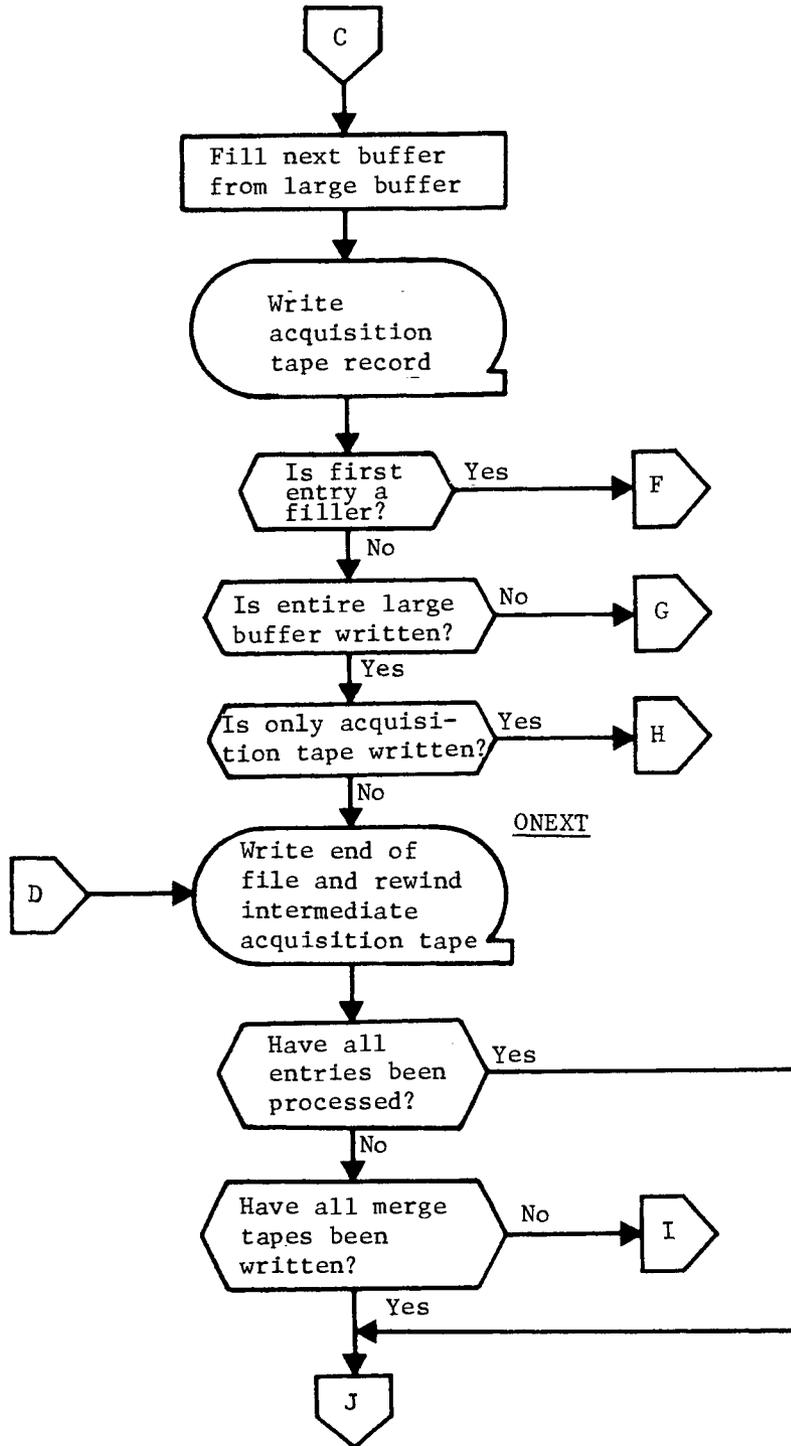


Figure 3-4. TDMERGE Flow Chart (Continued)

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TDMERGE

TDMERGE

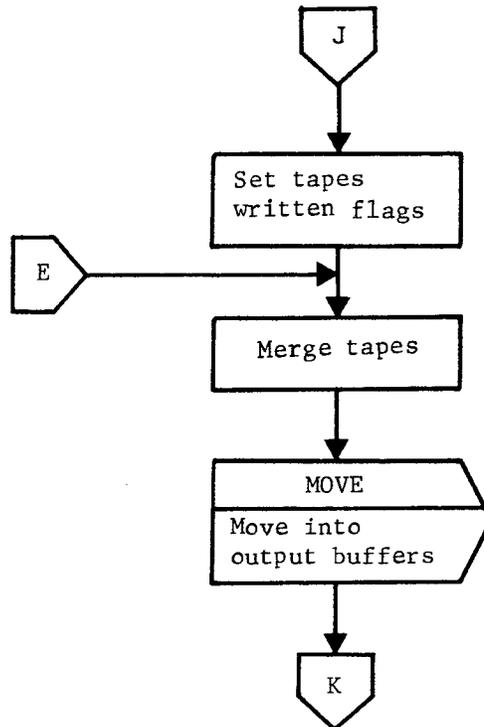


Figure 3-4. TDMERGE Flow Chart (Continued)

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### 3.5 TWACQPR

#### 3.5.1 Purpose

The subfunction TWACQPR reads either target acquisition records from the acquisition tape or COTPRIME records from the COTPRIME tape, depending upon the options requested and the calling sequence. The data are interpreted and reformatted to provide listable output. This output is ordered by rev number and by vertical acquisition time within each rev.

#### 3.5.2 Input

On option, either an acquisition tape (see Section 3.3) or a COTPRIME tape (see Section 3.6) is employed as the primary input to TWACQPR. In addition, the setting of two File 8 parameters controls the usage of TWACQPR. The parameter EGT109 controls the printing of the acquisition data (1 = print, 0 = don't print). The printing of COTPRIME data is controlled by the summable print flag EGT134 as described in the TWONDER User's Manual (Reference 1).

#### 3.5.3 Output

The output of TWACQPR consists of a formatted data display of information from the input tape. A sample of the acquisition output is provided in Table 3-12. Definitions of the column headers are provided in Table 3-13. The COTPRIME output, as shown in Table 3-14, consists of the acquisition data described in Table 3-12 plus additional parameters that define target worth and pointing information. These additional items are defined in Table 3-15.

#### 3.5.4 Method

TWACQPR first determines the type of tape being input and then extracts appropriate information for output according to a predetermined format. The program consists of a set of logical decisions based upon fixed input and does not perform a mathematical or computational function.

Flow charts describing the subfunction TWACQPR are provided in Figure 3-5 .

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Table 3-12. Acquisition List

ID	P1	SMD	M	D	W	SCC	S	FL	PR	WF	DATE	TIME	LAT	LONG	ALT	DWFL	SA	OBL	WDP	P-2	S/R	VALT	PAGE
											6/22/66	ASCENDING	MODE	TIME	33388.8	SEC							13
99F2410A	90	-50	5	34	J	U	0	12	9	0	0	34977.58	541300N	0302800E	5.	.4	59.0	45.2	15	20	93.8	65.38	
99F9846F	90	-50	3	24	J	U	0	30	7	0	0	34977.82	541400N	0302500E	4.	.4	59.0	44.5	15	10	92.5	65.38	
99F1593	40	0	5	32	4	U	0	32	13	0	0	34978.65	543100N	0302000E	5.	.4	58.6	33.6	12	20	78.7	65.38	
99F8662	40	0	3	13	5	U	0	21	17	0	0	34978.65	543100N	0302000E	5.	.4	58.6	33.6	6	20	78.7	65.38	
99F8394C	90	-50	6	13	J	U	0	07	13	0	0	34979.24	551800N	0291100E	5.	.4	57.8	-10.3	15	20	66.4	65.38	
99F8394	30	0	4	30	4	U	0	17	16	0	0	34979.35	551700N	0291100E	5.	.6	57.8	-9.6	10	20	66.3	65.38	
99F1598	90	-50	3	18	4	U	0	23	14	0	0	34979.58	552300N	0290300E	5.	.4	57.7	-15.7	13	20	67.6	65.38	
99F8394B	50	0	7	23	4	U	0	24	19	0	0	34979.58	552200N	0290400E	5.	.4	57.7	-14.8	10	20	67.6	65.38	
99F8662B	40	0	4	37	3	U	0	17	6	0	0	34979.82	543000N	0295300E	5.	.4	58.6	32.9	15	20	77.8	65.38	
99F8662G	80	28	3	17	2	U	0	07	12	0	0	34979.93	542800N	0295400E	5.	.6	58.7	33.8	6	20	78.9	65.38	
99F8394D	90	-50	5	26	4	U	0	21	10	0	0	34980.04	551800N	0290400E	5.	.4	57.8	-11.9	8	10	66.8	65.38	
99F8662C	30	0	4	34	4	U	0	05	16	0	0	34980.05	542900N	0295200E	5.	.7	58.7	32.9	13	20	78.1	65.38	
99F6780	60	-50	4	18	4	U	0	22	11	0	0	34980.09	543600N	0294500E	5.	.4	58.5	27.9	12	20	73.9	65.38	
99F8662A	70	28	4	16	4	U	0	24	13	0	0	34980.17	542900N	0294400E	5.	.4	58.5	26.9	7	10	73.4	65.38	
99F8662E	40	0	3	25	2	U	0	05	10	0	0	34980.17	542900N	0295100E	5.	.4	58.7	32.7	13	10	78.0	65.38	
99F8662M	90	-50	7	24	2	U	0	13	19	0	0	34980.43	543300N	0294500E	6.	.4	58.6	29.3	14	10	75.3	65.38	
99F8662D	70	28	3	17	2	U	0	03	6	0	0	34980.55	543500N	0294200E	5.	.4	58.6	27.8	11	10	74.0	65.38	
99F8394A	50	0	4	27	3	U	0	21	11	0	0	34980.62	551800N	0285900E	5.	.7	57.8	-13.0	9	10	67.1	65.38	
99F86170	80	-50	4	21	3	U	0	23	13	0	0	34980.74	551100N	0290500E	7.	.5	57.9	-16.5	7	20	69.4	65.38	
99F9845	90	-50	5	28	3	U	0	24	14	0	0	34980.82	544400N	0293100E	6.	.4	58.4	19.7	14	10	69.4	65.38	
99F8617N	90	-50	3	25	3	U	0	20	12	0	0	34981.08	550900N	0290400E	7.	.4	57.9	-5.1	8	20	65.6	65.38	
99F8662F	40	0	3	32	4	U	0	05	17	0	0	34981.12	542900N	0294300E	6.	.4	58.6	31.3	10	20	76.8	65.38	
99F8374	90	-50	7	37	4	U	0	23	14	0	0	34981.28	544300N	0292800E	6.	.6	58.4	19.7	9	10	69.4	65.38	
99F8610	30	0	5	16	5	U	0	36	11	0	0	34981.87	544200N	0292400E	6.	.4	58.4	19.5	6	10	69.4	65.38	
99F8610A	90	-50	3	22	4	U	0	20	12	0	0	34982.10	544200N	0292200E	6.	.4	58.4	19.0	9	10	69.2	65.38	
99F8617J	30	0	5	18	5	U	0	07	15	0	0	34982.12	550800N	0285600E	8.	.4	57.9	-6.3	10	10	65.7	65.38	
99F7487	90	-50	3	21	5	U	0	14	17	0	0	34982.24	550200N	0290100E	7.	.5	58.0	-5.4	12	10	65.3	65.38	
99F8617F	90	-50	4	22	3	U	0	21	10	0	0	34982.59	550600N	0285400E	7.	.4	58.0	-5.4	6	10	65.6	65.38	
99F8617M	90	-50	4	18	5	U	0	20	13	0	0	34982.70	550800N	0285100E	8.	.5	57.9	-7.6	14	10	65.9	65.38	
99F8617C	90	-50	4	18	2	U	0	13	8	0	0	34982.93	550700N	0285000E	8.	.4	58.0	-6.9	10	10	65.8	65.38	
99F9230	90	-50	4	18	5	U	0	17	9	0	0	34983.05	550700N	0284900E	7.	.4	58.0	-7.2	11	10	65.8	65.38	
99F8617E	90	-50	5	17	2	U	0	25	8	0	0	34983.16	550700N	0284800E	7.	.7	57.9	-7.4	6	10	65.8	65.38	
99F8617D	90	-50	2	19	3	U	0	33	11	0	0	34983.16	550600N	0284900E	7.	.4	58.0	-6.5	8	20	65.7	65.38	
99F8617L	30	0	3	22	2	U	0	14	17	0	0	34983.17	550300N	0285200E	7.	.4	58.0	-3.6	8	20	65.4	65.38	
99F8617	90	-50	7	13	3	U	0	35	14	0	0	34983.28	550600N	0284800E	10.	.4	58.0	-6.7	8	20	65.8	65.38	
99F8617B	90	-50	4	17	3	U	0	36	16	0	0	34983.28	545900N	0285500E	16.	.6	58.1	.2	13	20	65.3	65.38	
99F8617I	90	-50	3	16	5	U	0	05	9	0	0	34983.63	550500N	0284600E	7.	.5	58.0	-6.9	13	10	65.7	65.38	
99F8617H	90	-50	6	14	2	U	0	31	6	0	0	34983.63	550300N	0284800E	7.	.6	58.0	-4.5	8	10	65.4	65.38	
99F8617G	90	-50	6	25	5	U	0	24	11	0	0	34983.85	550700N	0284200E	8.	.5	57.9	-9.0	14	20	66.1	65.38	
99F2196	60	46	6	32	3	U	0	21	11	0	0	34984.32	545800N	0284700E	7.	.5	58.1	.7	9	10	65.3	65.38	
99F2196A	90	-50	6	27	3	U	0	04	18	0	0	34984.32	545800N	0284700E	7.	.4	58.0	-6.7	8	20	65.8	65.38	
99F8617A	90	-50	4	21	4	U	0	31	8	0	0	34984.44	546000N	0284400E	7.	.7	58.0	-3.1	9	10	65.3	65.38	
99F9968	40	0	6	14	5	U	0	00	6	0	0	34984.59	543300N	0292900E	5.	.4	58.9	37.4	15	20	82.6	65.38	
99F1164A	90	-50	4	14	4	U	0	31	5	0	0	34984.66	543800N	0290400E	6.	.6	58.4	17.9	6	10	68.7	65.38	
99F1164	90	-50	4	35	2	U	0	11	5	0	0	34984.78	543900N	0290200E	6.	.4	58.4	16.8	12	20	68.3	65.38	
99F11458	80	-50	4	24	5	U	0	37	15	0	0	34985.45	542300N	0291200E	5.	.6	58.7	29.1	10	20	75.0	65.38	
99F9850D	50	0	5	33	5	U	0	02	14	0	0	34986.53	544000N	0284600E	6.	.7	58.4	12.3	9	20	66.8	65.38	
99F9850	90	-50	3	24	5	U	0	02	7	0	0	34986.65	543800N	0284700E	5.	.5	58.4	14.1	9	20	67.3	65.38	
99F9850C	90	-50	6	24	3	U	0	04	9	0	0	34986.88	543700N	0284600E	6.	.4	58.4	14.5	14	20	67.4	65.38	

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Table 3-13. Acquisition List Key

<u>Item</u>	<u>Target Card Column</u>	<u>Definition</u>
ID	38-47	Target identifier
P1	1-2	Priority (inactive)
SHD	10-12	Shade factor
M	13	Photo mode weighting function
D	4-5	Target diameter (ft x 10 <sup>-1</sup> )
W	35	Pitch weighting function
SCC	56-58	Special category code
S	21	Exposure setting sequence
FL		Two octal digits containing the following flags:
	28	Benchmark flag (20 <sub>8</sub> )*
	30	Mandatory primary flag (10 <sub>8</sub> )*
	29	Mandatory ATS view flag (04 <sub>8</sub> )*
	76	Visual intelligence flag (02 <sub>8</sub> )*
	27	Scan target flag (01 <sub>8</sub> )*
		*FL is formed by summing the octal codes indicated ( ) for those flags which are set.
PR	31-32	Probability of activity (%)
WF	35	Weather factor
14-17	14-17	Target alter flag and specified rev number
TIME	none	Time of vertical acquisition (system time, sec)
LAT	60-66	Target latitude (deg, min, sec, north or south)
LONG	67-74	Target longitude (deg, min, sec, east or west)
ALT	6-9	Target altitude (ft x 10 <sup>-2</sup> )
DWEL	33-34	Specified ATS view time (sec x 10 <sup>-1</sup> )
SA	none	Sun elevation angle (deg)
OBL	none	Target obliquity (deg)
WDP	24-26	Desired pitch (+ deg)
P2	22-23	Priority (active)
S/R	none	Target-vehicle slant range (n.mi.)
VALT	none	Vehicle altitude (n.mi.)

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Table 3-14. COTPRIME Output

ID	P1	SHD	M	U	M	SCC	S	FL	PR	WF	TIME	LAT	LONG	ALT	DMFL	SA	OBL	ADP	P2	S/R	VALT	PAGE	
99F2144A	90	-50	6	24	2	0	0	22	8	0	16155.71	392800N	1262500E	0	51.6	-26.0	0	20			89.0	78.88	
											T2= 102555.740												
											T3= 102573.372												
											OM2= -26.052162												
											OM3= -23.790647												
99F2135	90	-50	5	35	3	0	0	03	6	0	16155.71	392800N	1262500E	0	4.0	53.6	-26.0	0	20		89.0	78.88	
											T2= 102555.740												
											T3= 102573.372												
											OM2= -26.052165												
											OM3= -23.790647												
99F1688A	90	-50	4	24	3	0	0	02	6	0	16155.74	392800N	1264400E	2	4.0	53.5	-16.8	0	20		82.4	78.88	
											T2= 102555.767												
											T3= 102573.382												
											OM2= -16.873418												
											OM3= -14.569704												
99F4237	70	28	5	19	5	0	0	00	8	0	16155.96	392700N	1275800E	5	4.0	53.2	22.8	0	20		85.7	78.88	
											T2= 102555.991												
											T3= 102573.737												
											OM2= -27.962438												
											OM3= 24.794045												
99F1688	90	-50	4	37	2	0	0	23	7	0	16156.47	392500N	127000E	1	5.0	53.4	-3.8	0	10		78.9	78.88	
											T2= 102556.503												
											T3= 102574.548												
											OM2= -3.773604												
											OM3= -1.496054												
99F2583	30	0	5	32	4	0	0	00	5	0	16156.93	392300N	126400E	0	4.0	53.6	-18.8	0	10		83.4	78.88	
											T2= 102556.944												
											T3= 102573.749												
											OM2= -18.766571												
											OM3= -16.464139												
99F3853	90	50	3	17	3	0	0	01	13	0	16157.67	392000N	1270400E	1	5.0	53.5	-6.3	0	10		79.3	78.88	
											T2= 102557.703												
											T3= 102573.808												
											OM2= -6.405710												
											OM3= 4.110321												
99F2737	30	0	4	27	3	0	0	21	9	0	16157.92	391900N	1270500E	0	8.0	53.5	-5.1	0	10		79.1	78.88	
											T2= 102557.944												
											T3= 102574.032												
											OM2= -5.256170												
											OM3= -2.966207												
99F2144	30	0	5	24	5	0	0	00	7	0	16159.07	391400N	1261800E	2	5.0	53.8	-28.9	0	20		90.3	78.88	
											T2= 102559.094												
											T3= 102577.157												
											OM2= -28.442683												
											OM3= -26.594951												
99F4240	30	0	6	33	3	0	0	02	12	0	16160.30	390900N	1274500E	3	6.0	53.9	19.0	0	20		83.5	78.88	
											T2= 102560.127												
											T3= 102578.448												
											OM2= 19.162908												
											OM3= 21.099425												
99F2123	80	-50	5	22	2	0	0	01	9	0	16162.24	390100N	1265700E	3	8.0	53.9	-9.2	0	10		79.9	78.88	
											T2= 102562.267												
											T3= 102578.448												
											OM2= -9.113297												
											OM3= -6.816350												
99F4258	30	0	5	18	2	0	0	02	14	0	16165.11	384900N	127400E	1	7.0	53.8	18.1	0	10		83.1	78.88	
											T2= 102565.136												
											T3= 102582.315												
											OM2= 14.323505												
											OM3= 20.286604												
99F6677	80	-50	3	19	4	0	0	21	12	0	16166.81	384200N	1265900E	2	8.0	54.2	-7.4	0	10		79.6	78.88	
											T2= 102566.835												
											T3= 102583.973												
											OM2= -7.417283												
											OM3= 5.1096149												

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Table 3-15. COTPRIME\* Key

Item	Definition
T1	Initial acquisition time
T2	Vertical acquisition time
T3	Final acquisition time
WI	Inactive weight
WA	Active weight
OM1	Obliquity at time T1
OM2	Obliquity at time T2
OM3	Obliquity at time T3

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\* The COTPRIME contains these parameters in addition to the acquisition data described in Table 3-12.

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TWACQPR

TWACQPR

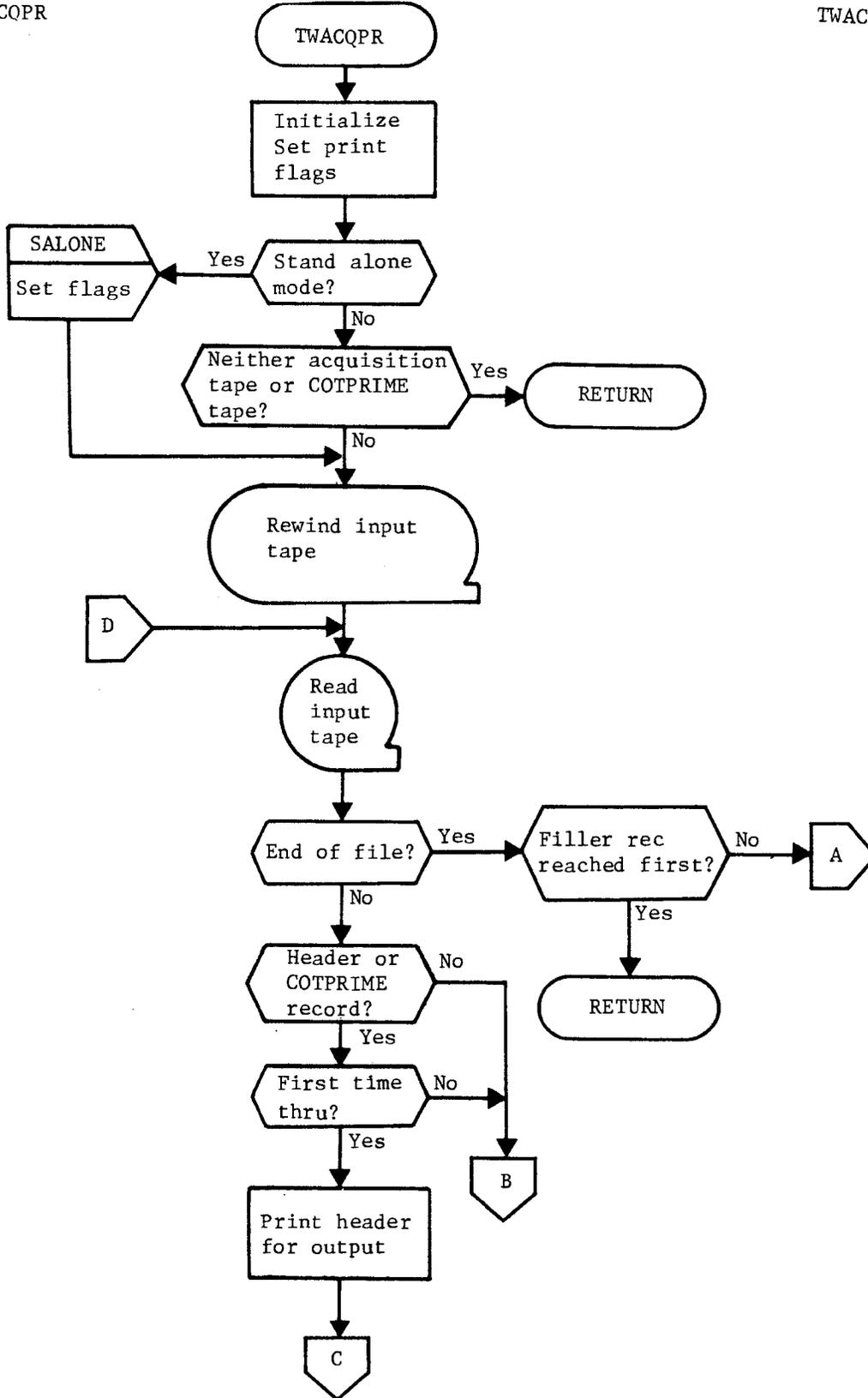


Figure 3-5. TWACQPR Flow Chart

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TWACQPR

TWACQPR

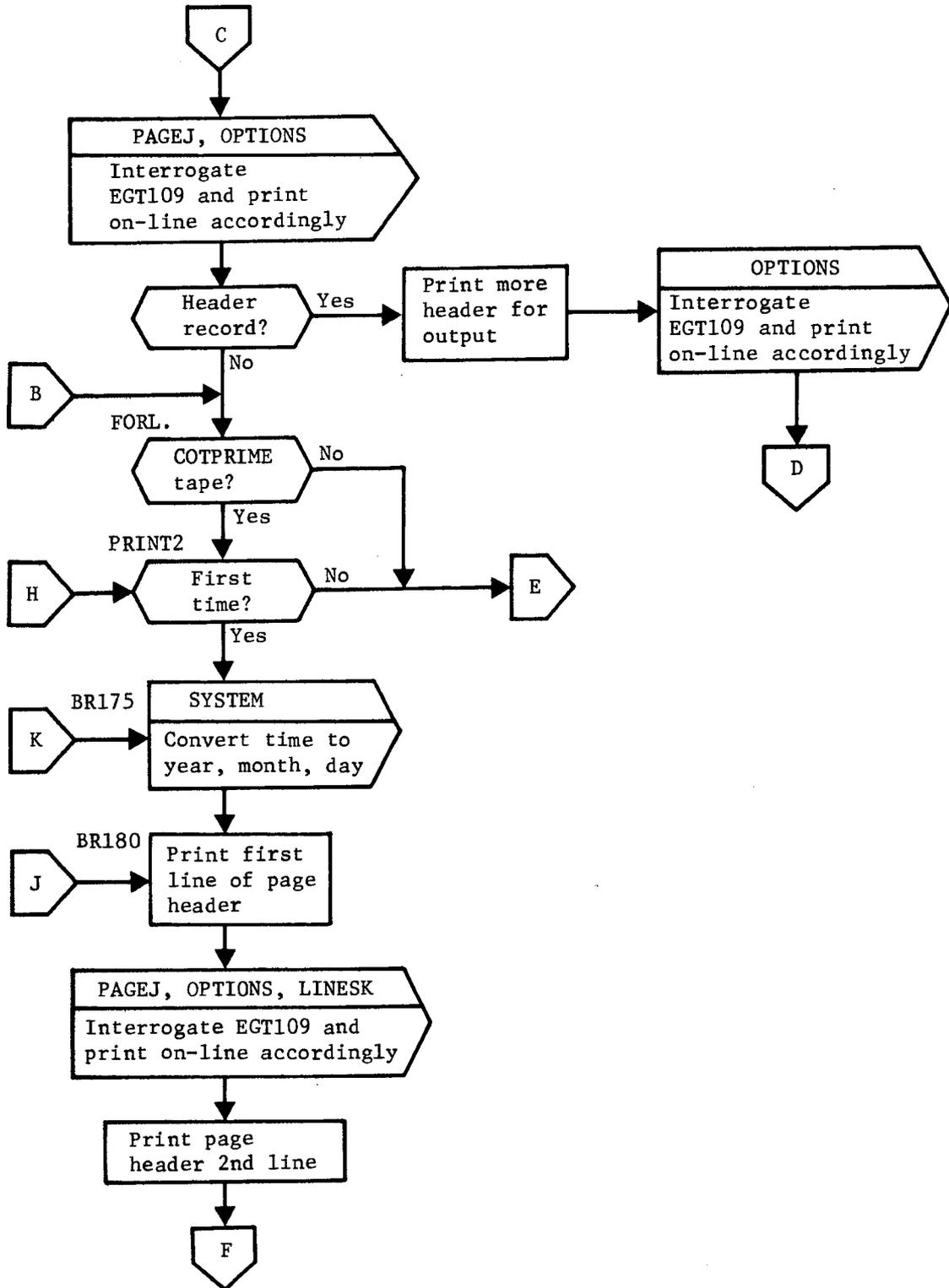


Figure 3-5. TWACQPR Flow Chart (Continued)

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TWACQPR

TWACQPR

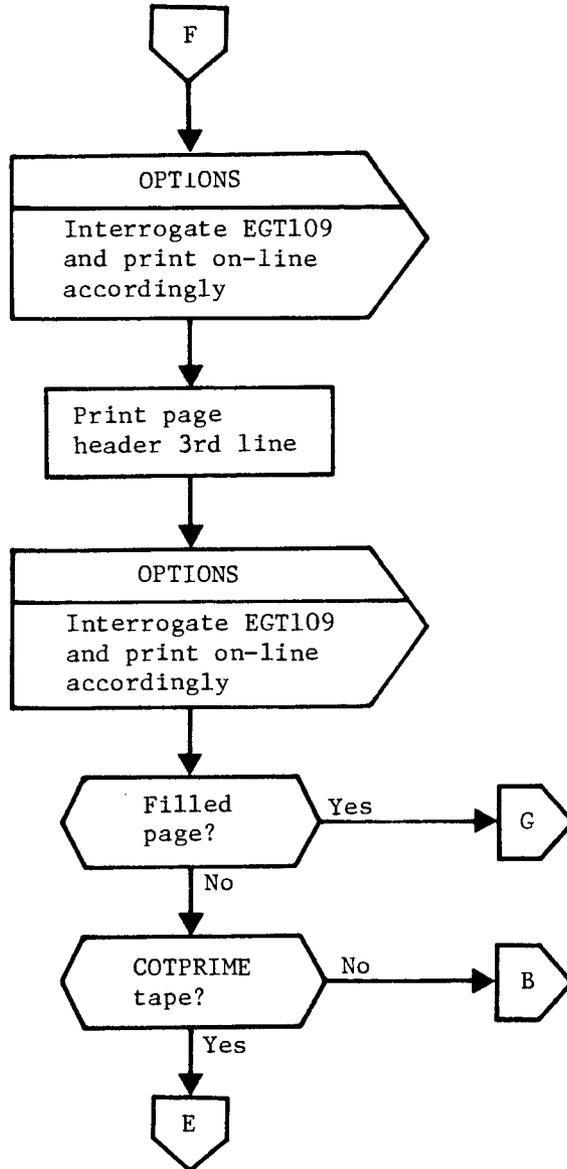


Figure 3-5. TWACQPR Flow Chart (Continued)

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TWACQPR

TWACQPR

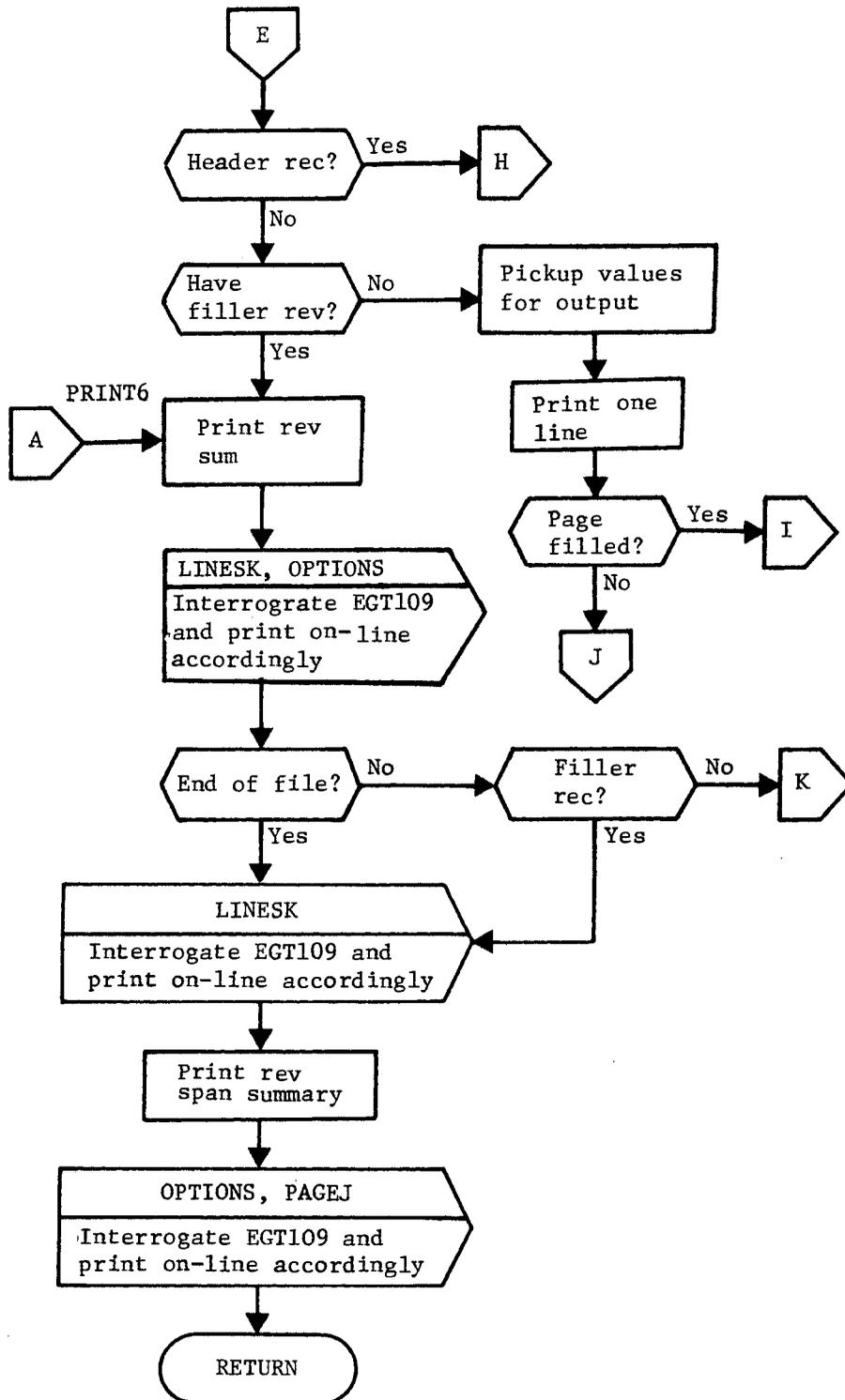


Figure 3-5. TWACQPR Flow Chart (Continued)

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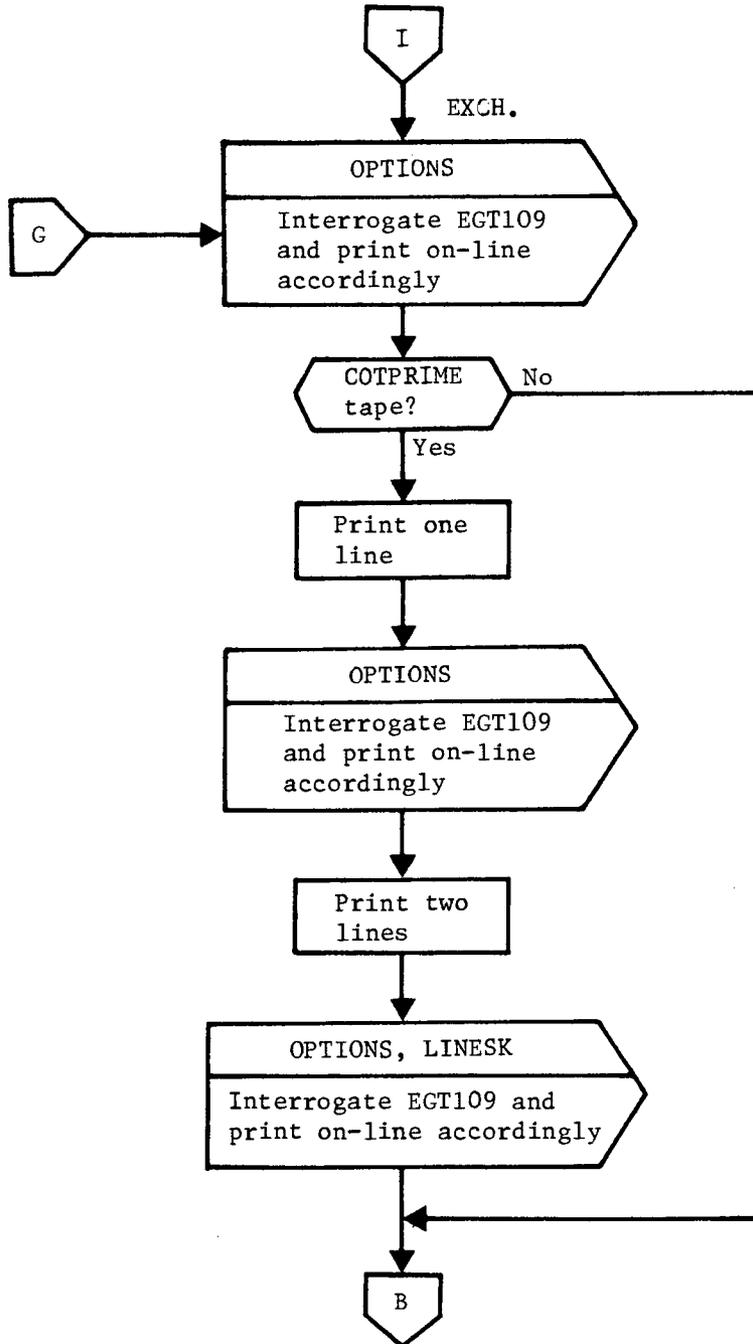


Figure 3-5. TWACQPR Flow Chart (Continued)

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### 3.6 TWOPS

#### 3.6.1 Purpose

The purpose of TWOPS is to compute precise pointing data and the active and inactive worths (weighted as a function of target obliquity at vertical acquisition), and to generate the COTPRIME tape which subsequently becomes the basic source of target information for the successor functions of TWONDER.

#### 3.6.2 Input

The inputs required by TWOPS are as follows:

- a. Acquisition tape
- b. Ephemeris data
3. THINGS and ALSO tables

The acquisition tape required is as described in Section 3.3.3. The ephemeris data required are as described in Section 3.3.2. The THINGS and ALSO table items required are described in Table 3-16.

#### 3.6.3 Output

The output of TWOPS is the COTPRIME tape. The parameters contained within each entry are described in Table 3-17.

#### 3.6.4 Method

TWOPS reads in and checks each record of the acquisition tape one record at a time. After a record is read, each entry in that record is checked to ensure that the associated target is acquired within the input specified rev span; COMOPERA is called to compute the precise pointing data and weights to be stored on the COTPRIME tape.

COMOPERA sets the forward, vertical, and aft main optics stereo angles to the values stored in table THINGS (SIGMAF, SIGMAV, and SIGMAA) which are specified through File 7 inputs, SEV063, SEV064, and SEV065, respectively. Initial estimates of the forward, vertical, and aft acquisition times are set based upon the vertical acquisition time and the difference between the vertical acquisition time and the forward acquisition

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Table 3-16. THINGS and ALSO Table Items Required by TWOPS

File Locations	Form of Data	Nominal Value	Units	Definition	Interface Table Usage		
					Internal Symbol	JOVIAL Definition	Internal Units
SEV063	FP	30.	deg	Maximum forward stereo angle for main optics	SIGMAF	F 150 0	rad
SEV064	FP	0.	deg	Vertical acquisition stereo angle for main optics	SIGMAV	F 151 0	rad
SEV065	FP	-40.	deg	Maximum aft stereo angle for main optics	SIGMAA	F 149 0	rad
EGT044	FP	0.	deg	Specified reference obliquity in calculation of the obliquity deweighting factor	OBLZRO	F 120 0	rad
EGT093	FP	0.000001	n.d.	Convergence constant used in double iteration for intersection of optical axis with earth's surface	EPS	F 34 0	n.d.
EGT095	FP	0.001	deg	Constant for control of iteration on pitch angle	ESIG	F 36 0	rad
EGT117	B	1.	n.d.	Flag for deletion comments on Tape 8	DEPRFG	B 93 47	n.d.
				0: comments output			
				1: no comments			
EGT140	FP	2.	n.d.	Cosine $\Omega$ exponent for obliquity deweighting	NOBL	F 286 0	n.d.
EGT147	F	40.	deg	Maximum obliquity angle	OMEGMX	F 77 0	rad
EGT251 to EGT260	FP	-	n.d.	Target weight as a function of priority	CW	10 3 F ARRAY	n.d.

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Table 3-16. THINGS and ALSO Table Items Required by TWOPS (Continued)

File 7 Locations	Reset File Definition			Interface Table Usage			
	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
ECT922	FP	0.05	n.d.	Probability of activity	PROBA	F 2 0	n.d.
ECT936	I	8.	Number of Targets	Maximum number of higher worth tar- gets allowed in time interval before deleting target by density filter	DNUM	I 48 U	Number of Targets
ECT937	F	4.0	sec	Time interval in density filter	DTIME	F 111 0	sec

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Table 3-17. COTPRIME Entry Data

Symbol	JOVIAL Declaration	Units	Definition
TT1	F	8 sec	Time at forward acquisition
TT2	F	9 sec	Time at vertical acquisition
TT3	F	10 sec	Time at aft acquisition
TOMEGAL	F	11 rad	Obliquity at forward acquisition
TOMEGA2	F	12 rad	Obliquity at vertical acquisition
TOMEGA3	F	13 rad	Obliquity at aft acquisition
TEEE	F	0 rad	Sun angle
TSR	A 14 U 4	15 0 n.mi.	Slant range
TVH	A 14 U 4	15 14 n.mi.	Vehicle altitude
TWI	F	16 n.d.	Inactive worth
TWA	F	17 n.d.	Active worth
TWENTNO	I 12 U 15	15 n.d.	COTPRIME entry number
TTIME	A 34 U 4	0 sec	Total acquisition time
TOTID	H 10	1 0 n.d.	Total I.D.
TPRII	I 7 U	3 40 n.d.	Priority (inactive)
TDDD	I 7 U	5 34 ft x 10 <sup>-1</sup>	Diameter

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Table 3-17. COTPRIME Entry Data (Continued)

Symbol	JOVIAL Declaration				Units	Definition
TALT	I	11	S	3 22	ft x 10 <sup>-2</sup>	Altitude
TSHADE	I	8	5	7 11	n.d.	Shade factor
TMODE	I	4	U	4 28	n.d.	Photo mode weighting function
TREV	I	10	U	0 0	n.d.	Acquisition rev number
TNSF	I	2	U	4 32	n.d.	Direction of pass
TESS	I	4	U	0 44	n.d.	Exposure setting sequence
TPRIA	I	7	U	3 33	n.d.	Priority (active)
TSIGMAD	I	8	5	7 23	rad	Desired pitch angle
TSC	B			7 47	n.d.	Scan target flag
TBENCHF	B			3 47	n.d.	Benchmark flag
TMATSF	B			7 45	n.d.	Mandatory ATS view flag
TMPF	B			4 35	n.d.	Mandatory primary flag
TPROBA	I	7	U	7 31	%	Probability of activity
TDWELL	I	7	U	7 38	sec x 10 <sup>1</sup>	Specified ATS view time
TSHAPE	I	4	U	4 28	n.d.	Pitch weighting function
TIDA	H	8		1 0	n.d.	Target I.D. (first 8 characters)

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Table 3-17. COTPRIME Entry Data (Continued)

Symbol	JOVIAL Declaration		Units	Definition
TIDB	H 2	2 0	n.d.	Target I.D. (last 2 characters)
TWX	I 7	U 2 12	n.d.	Weather factor
TRR	I 7	U 5 41	in	Resolution requirement
TSCC	I 10	U 5 24	n.d.	Special category code
TTLV	I 4	U 2 19	n.d.	Target location validity
TLAT	A 22	S 20 3 0	rad	Latitude
TLONG	A 24	S 20 2 24	rad	Longitude
TVIF	B	7 7 46	n.d.	Visual intelligence flag

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time, both of which are computed through approximate methods in TWPATW, and stored on the acquisition tape. The CW array stored in table ALSO and set through File 8 parameters EGT251 through EGT260 is employed, using a linear interpolation technique, to determine the active and inactive target worths based upon target active and inactive priorities. Upon completing these operations COMOPERA calls the closed subroutines TITANIC and CONDUCT three times, once for each main optics stereo angle position. TITANIC computes the acquisition time and the target position and velocity in vehicle coordinates for the specified stereo angle. CONDUCT computes the slant range to the target and the target obliquity at the acquisition time of the specified stereo angle.

Prior to calling TITANIC for the computation of the vertical and aft acquisition times, the initial estimates of these times, based upon the data on the acquisition tape, are biased to take advantage of the previous passes through TITANIC. The equations employed are as follows:

$$t'_{SIGV} = t_{SIGV} + (t_F - t_{SIGF})$$

$$t'_{SIGA} = 2(t_V) - t_F$$

where

$t'_{SIGV}$  = Initial estimate of vertical acquisition time used by TITANIC

$t'_{SIGA}$  = Initial estimate of aft acquisition time used by TITANIC

$t_{SIGF}$  = Forward acquisition time from acquisition tape

$t_{SIGV}$  = Vertical acquisition time from acquisition tape

$t_F$  = TITANIC computed value of forward acquisition time

$t_V$  = TITANIC computed value of vertical acquisition

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The closed subroutine TITANIC is the driver which controls the generation of precise pointing data. TITANIC accepts as input the stereo angle, the estimated acquisition time, the target latitude, longitude, and altitude, and a block of ephemeris data for the rev on which the target is acquired; TITANIC then calls subroutine COMPOSE to compute a precise acquisition time, and the target position and velocity in vehicle centered coordinates. COMPOSE calls procedures TINTERP, TOVER, TIRCOS, TSTACOR, TANGVEL, TSTAVEC and TSIGMA.

#### TINTERP

TINTERP obtains the vehicle state vector in the ECI coordinate system corresponding to the current estimated acquisition time. The origin of the ECI system is located at the center of the earth, the X axis points to the Vernal Equinox, the Z axis points up through the north pole, and the Y axes completes the right handed orthogonal system. The ephemeris data points which bound the time interval containing the current estimated acquisition time are found. The ECI position and velocity of the vehicle is then computed at precisely the current estimated acquisition time by a Lagrange interpolation technique between these points.

#### TOVER

TOVER computes the vehicle altitude and the direction cosines between geodetic vertical and the ECI coordinate axes.

The earth's figure is defined by the surface S, where

$$S = x_e^2 + y_e^2 + \frac{z_e^2}{b^2} - 1 = 0,$$

where  $x_e$ ,  $y_e$ ,  $z_e$  are the ECI coordinates of points on the earth's surface per unit equatorial radius and b is the ratio of the polar radius to the equatorial radius.

The altitude vector,  $\bar{h}$ , is defined by the equation

$$\bar{h} = \bar{r} - \bar{r}_n = h \frac{\nabla S}{|\nabla S|}$$

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where  $\bar{r}$ , vehicle position =  $x\bar{e}_x + y\bar{e}_y + z\bar{e}_z$

$\bar{r}_n$ , nadir position =  $x_n\bar{e}_x + y_n\bar{e}_y + z_n\bar{e}_z$

$h$  = scalar altitude

$\frac{\nabla S}{|\nabla S|}$  = unit vector normal to the earth's surface

If the scalar parameter,  $k$ , is defined as follows:

$$k = 2 \frac{h}{|\nabla S|}$$

then the vehicle position and nadir position are related by the following equations:

$$x_n = \frac{x}{1+k}$$

$$y_n = \frac{y}{1+k}$$

$$z_n = \frac{z}{1 + \frac{k}{b^2}}$$

Since the nadir point must be on the earth's surface,  $k$  must satisfy the quartic equation:

$$S = \frac{x^2 + y^2}{(1+k)^2} + \frac{z^2 b^2}{(b^2 + k)^2} - 1 = 0$$

A solution for  $k$  is obtained by starting with the circular earth solution ( $b = 1$ )

$$k_o = \sqrt{x^2 + y^2 + z^2} - 1$$

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and iterating as follows:

Denoting  $k_{n+1} = k_n + (\Delta k)_n$

then  $S_{n+1} = S_n + \left(\frac{dS}{dk}\right)_n (\Delta k)_n = 0$

hence  $(\Delta k)_n = -\frac{S_n}{\frac{dS}{dk}_n}$

since  $\frac{dS}{dk} = -\frac{2}{1+k} \left[ 1 + S + z^2 \frac{b^2(1-b^2)}{(b^2+k)^3} \right]$

then  $(\Delta k)_n = \frac{1}{2} \frac{(1+k_n) S_n}{1 + S_n + z^2 \frac{b^2(1-b^2)}{(b^2+k_n)^3}}$

When  $k$  is determined, the altitude vector is given by

$$\bar{h} = \frac{kx}{1+k} \bar{e}_x + \frac{ky}{1+k} \bar{e}_y + \frac{kz}{b^2+k} \bar{e}_z$$

Defining

$$\rho_Z = \sqrt{x^2 + y^2 + z^2 \frac{(1+k)^2}{(b^2+k)^2}} = (1+k) \sqrt{1 + z^2 \frac{(1-b^2)}{(b^2+k)^2}}$$

then the altitude and direction cosines are given by

$$h = \frac{k}{1+k} \rho_Z$$

$$Z_x = \frac{x}{\rho_Z}$$

$$Z_y = \frac{y}{\rho_Z}$$

$$Z_z = \frac{z}{\rho_Z} \left[ \frac{1+k}{b^2+k} \right]$$

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TIRCOS

TIRCOS computes the direction cosines between the vehicle centered coordinate axes and the ECI coordinate axes. The origin of the vehicle coordinate system is taken at the center of the vehicle, the Z axis points up along the instantaneous geodetic vertical, the Y axes is orthogonal to the orbit plane, the X axis lies in the orbit plane and completes a right handed orthogonal system.

Thus

$$\bar{e}_y = \frac{\bar{v} \times \bar{h}}{e_y}$$

$$\bar{e}_x = \bar{e}_y \times \bar{e}_z$$

where

$\bar{e}_y$  = direction cosines between vehicle y axis and ECI coordinates

$\bar{e}_x$  = direction cosines between vehicle x axis and ECI coordinates

$\bar{e}_z$  = direction cosines between vehicle z axis and ECI coordinates (computed in TOVER)

$\bar{v}$  = vehicle velocity vector in ECI coordinates

$\bar{h}$  = vehicle altitude vector in ECI coordinate

$$e_y = |\bar{v} \times \bar{h}|$$

TSTACOR

TSTACOR computes the target position and velocity in ECI coordinates at the current estimated acquisition time.

The radius of the earth per unit equatorial radius at the station is given by

$$r_s = \sqrt{\frac{1 + b^4 \tan^2 \theta_s}{1 + b^2 \tan^2 \theta_s}}$$

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where  $\theta_s$  is the geodetic latitude of the station and  $b$  is that ratio of the polar radius to the equatorial radius. If the station altitude is given in terms of geodetic height,  $h_s$ , then the ECI coordinates of the station are given by

$$x_s = (r_s \cos \delta_s + h_s \cos \theta_s) \cos \alpha_s$$

$$y_s = (r_s \cos \delta_s + h_s \cos \theta_s) \sin \alpha_s$$

$$z_s = r_s \sin \delta_s + h_s \sin \theta_s$$

where

$\delta_s$  = station declination (geocentric latitude)

$\alpha_s$  = station right ascension ( $\alpha_{g_0} + \omega_e t + \phi_s$ )

$\alpha_{g_0}$  = right ascension of Greenwich at base time

$\omega_e$  = earth's rotation rate

$\phi_s$  = station longitude

since

$$\tan \delta_s = b^2 \tan \theta_s$$

then

$$\cos \delta_s = \frac{1}{\sqrt{1 + b^4 \tan^2 \theta_s}}$$

$$\sin \delta_s = \frac{b^2 \tan \theta_s}{\sqrt{1 + b^4 \tan^2 \theta_s}}$$

and

$$x_s = \left[ \frac{1}{\sqrt{1 + b^4 \tan^2 \theta_s}} + h_s \cos \theta_s \right] \cos \alpha_s$$

$$y_s = \left[ \frac{1}{\sqrt{1 + b^4 \tan^2 \theta_s}} + h_s \cos \theta_s \right] \sin \alpha_s$$

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$$z_s = \frac{b^2 \tan \theta_s}{\sqrt{1 + b^2 \tan^2 \theta_s}} + h_s \sin \theta_s$$

The velocity components are determined by differentiation.

$$\dot{x}_s = -\omega_e y_s$$

$$\dot{y}_s = \omega_e x_s$$

$$\dot{z}_s = 0$$

TANGVEL

TANGVEL computes the components of the angular velocity of the vehicle coordinate system.

The angular velocity of the vehicle centered coordinate system is determined from two conditions. First, the negative  $\bar{e}_z$  axis must point at the instantaneous nadir position, and second, the inertial acceleration must have a zero component on the  $\bar{e}_y$  axis.

Starting with the equation for vehicle altitude,  $\bar{h}$  which is the difference between the radius vector to the vehicle,  $\bar{r}$ , and the radius vector to the vehicle nadir,  $\bar{r}_n$

$$\bar{h} = h\bar{e}_z = \bar{r} - \bar{r}_n$$

and differentiating

$$\dot{\bar{h}} = \dot{h}\bar{e}_z + \bar{\omega} \times (h\bar{e}_z) = \bar{v} - \bar{v}_n$$

where the angular velocity,  $\bar{\omega}$ , is defined as follows:

$$\bar{\omega} = \omega_x \bar{e}_x + \omega_y \bar{e}_y + \omega_z \bar{e}_z$$

Thus

$$\bar{v} - \bar{v}_n = h\omega_y \bar{e}_x - h\omega_x \bar{e}_y + \dot{h} \bar{e}_z$$

and

$$\omega_x = - \frac{(\bar{v} - \bar{v}_n) \cdot \bar{e}_y}{h}$$

$$\omega_y = \frac{(\bar{v} - \bar{v}_n) \cdot \bar{e}_x}{h}$$

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Using the same notation as defined in TOVER, the vector  $\bar{r} - \bar{r}_n$  is given by

$$\bar{r} - \bar{r}_n = \bar{h} = \frac{kx}{1+k} \bar{e}_x + \frac{ky}{1+k} \bar{e}_y + \frac{kz}{b^2+k} \bar{e}_z$$

Differentiating

$$\begin{aligned} \frac{d}{dt} (\bar{r} - \bar{r}_n) = \bar{v} - \bar{v}_n = & \left[ \frac{k\dot{x}}{1+k} + \frac{kx}{(1+k)^2} \right] \bar{e}_x + \\ & + \left[ \frac{k\dot{y}}{1+k} + \frac{ky}{(1+k)^2} \right] \bar{e}_y + \left[ \frac{k\dot{z}}{b^2+k} + \frac{b^2\dot{k}z}{(b^2+k)^2} \right] \bar{e}_z \end{aligned}$$

Since

$$h = \frac{k}{1+k} \rho_z$$

then

$$\begin{aligned} \omega_X = -\frac{1}{\rho_z} \left[ \dot{x}Y_x + \dot{y}Y_y + \dot{z}Y_z \frac{1+k}{b^2+k} \right] + \\ - \frac{\dot{k}}{k(1+k)\rho_z} \left[ xY_x + yY_y + zY_z \frac{b^2(1+k)^2}{(b^2+k)^2} \right] \end{aligned}$$

$$\begin{aligned} \omega_Y = \frac{1}{\rho_z} \left[ \dot{x}X_x + \dot{y}X_y + \dot{z}X_z \frac{1+k}{b^2+k} \right] + \\ + \frac{\dot{k}}{k(1+k)\rho_z} \left[ xX_x + yX_y + zX_z \frac{b^2(1+k)^2}{(b^2+k)^2} \right] \end{aligned}$$

Using the relations

$$\begin{aligned} \dot{x}Y_x + \dot{y}Y_y + \dot{z}Y_z &= 0 \\ xY_x + yY_y + zY_z &= -zY_z \left[ \frac{1-b^2}{b^2+k} \right] \\ xX_x + yX_y + zX_z &= -zX_z \left[ \frac{1-b^2}{b^2+k} \right] \end{aligned}$$

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then

$$\omega_X = -\frac{Y_Z}{\rho_Z} \left( \dot{z} - \frac{\dot{k}z}{b^2+k} \right) \frac{1-b^2}{b^2+k}$$

$$\omega_Y = \frac{1}{\rho_Z} \left[ \dot{x}X_x + \dot{y}X_y + \dot{z}X_z \right] - \frac{X_Z}{Y_Z} \omega_X$$

$\dot{k}$  is evaluated by differentiating the equation

$$\frac{x^2 + y^2}{(1+k)^2} + \frac{z^2 b^2}{(b^2+k)^2} = 1$$

to obtain

$$\dot{k} = \frac{\frac{\dot{x}\dot{x} + \dot{y}\dot{y}}{(1+k)^2} + \frac{b^2 z \dot{z}}{(b^2+k)^2}}{\frac{2x}{(1+k)^3} + \frac{b^2 z}{(b^2+k)^3}}$$

then

$$\dot{z} - \frac{\dot{k}z}{b^2+k} = -\frac{\rho_Y \rho_Z^2 X_Z}{x^2 + y^2 + b^2 z^2} \frac{(1+k)^3}{(b^2+k)^3}$$

since

$$x^2 + y^2 + b^2 z^2 \frac{(1+k)^3}{(b^2+k)^3} = \frac{k(1+k)^2 + b^2 \rho_Z^2}{b^2+k}$$

then

$$\omega_X = \frac{\rho_Y \rho_Z X_Z Y_Z (1-b^2)}{b^2 \rho_Z^2 + k(1+k)^2}$$

The determination of  $\omega_Z$  is based on the condition that the inertial acceleration must have a zero component on the  $\bar{e}_Y$  axis. The inertial velocity in the vehicle centered system is given by

$$\bar{v} = (\dot{x}X_x + \dot{y}X_y + \dot{z}X_z) \bar{e}_X + (\dot{x}Z_x + \dot{y}Z_y + \dot{z}Z_z) \bar{e}_Z$$

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Differentiating to obtain the acceleration

$$\bar{a} = \frac{d}{dt} (\dot{x}X_x + \dot{y}X_y + \dot{z}X_z) \bar{e}_X + \frac{d}{dt} (\dot{x}Z_x + \dot{y}Z_y + \dot{z}Z_z) \bar{e}_Z + \bar{\omega} \times \bar{v}$$

For the Y component to be zero

$$\omega_Z = \omega_X \frac{\dot{x}Z_x + \dot{y}Z_y + \dot{z}Z_z}{\dot{x}X_x + \dot{y}X_y + \dot{z}X_z}$$

TSTAVEC

TSTAVEC computes the components of target position and velocity in the vehicle coordinate system.

The direction cosines computed in TOVER and TIRCOS are used to transform the vector difference between the station position and vehicle position to the vehicle system.

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} X_x & X_y & X_z \\ Y_x & Y_y & Y_z \\ Z_x & Z_y & Z_z \end{vmatrix} \begin{vmatrix} x_s - x \\ y_s - y \\ z_s - z \end{vmatrix}$$

Since

$$xX_x + yX_y + zX_z = -z \frac{1-b^2}{b^2+k} X_z$$

$$xY_x + yY_y + zY_z = -z \frac{1-b^2}{b^2+k} Y_z$$

$$xZ_x + yZ_y + zZ_z = \rho_Z - z \frac{1-b^2}{b^2+k} Z_z$$

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then

$$X = x_s X_x + y_s Y_y + \left( z_s + z \frac{1-b^2}{b^2+k} \right) X_z$$

$$Y = x_s Y_x + y_s Y_y + \left( z_s + z \frac{1-b^2}{b^2+k} \right) Y_z$$

$$Z = x_s Z_x + y_s Z_y + \left( z_s + z \frac{1-b^2}{b^2+k} \right) Z_z - \rho_z$$

The apparent velocity of the station relative to the vehicle is obtained by differentiating the station position vector.

Denoting the station position vector by  $\bar{R}_s$  where

$$\bar{R}_s = \bar{r}_s - \bar{r} = X \bar{e}_X + Y \bar{e}_Y + Z \bar{e}_Z$$

then

$$\frac{d\bar{R}_s}{dt} = v_X \bar{e}_X + v_Y \bar{e}_Y + v_Z \bar{e}_Z + \bar{\omega} \times \bar{R}_s$$

Thus

$$\begin{vmatrix} v_X \\ v_Y \\ v_Z \end{vmatrix} = \begin{vmatrix} X & X & X \\ x & y & z \end{vmatrix} \begin{vmatrix} \dot{x}_s & -\dot{x} \\ \dot{y}_s & -\dot{y} \\ \dot{z}_s & -\dot{z} \end{vmatrix} + \begin{vmatrix} \omega_Z Y & -\omega_Y Z \\ \omega_X Z & -\omega_Z X \\ \omega_Y X & -\omega_X Y \end{vmatrix}$$

Since

$$\dot{z}_s = 0$$

$$\dot{x}_Y + \dot{y}_Y + \dot{z}_Z = 0$$

then

$$v_X = (\dot{x}_s - \dot{x}) X_x + (\dot{y}_s - \dot{y}) X_y - \dot{z} X_z + \omega_Z Y - \omega_Y Z$$

$$v_Y = \dot{x}_s Y_x + \dot{y}_s Y_y + \omega_X Z - \omega_Z X$$

$$v_Z = (\dot{x}_s - \dot{x}) Z_x + (\dot{y}_s - \dot{y}) Z_y - \dot{z} Z_z + \omega_Y X - \omega_X Y$$

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TSIGMA

TSIGMA computes an improved estimate of the time at which the stereo angle is equal to the specified stereo angle. TSIGMA computes the actual stereo angle at the new estimated acquisition. If the difference between this actual stereo angle and the specified stereo is less than ESIG, a convergence constant stored in table THINGS, the new estimate of acquisition time is taken as the required output; if the difference is greater than ESIG the entire computational cycle of COMPOSE is repeated using the TSIGMA value as the current estimated acquisition time. THINGS table item ESIG is specified through File 8 parameter EGT095.

The stereo angle,  $\Sigma$ , and the time rate of change of stereo angle,  $\dot{\Sigma}$ , are computed from the equations

$$\Sigma = -\tan^{-1} \left[ \frac{X}{\sqrt{Y^2 + Z^2}} \right]$$
$$\dot{\Sigma} = \frac{X(YV_Y + ZV_Z) - V_X(Y^2 + Z^2)}{(X^2 + Y^2 + Z^2)(Y^2 + Z^2)^{1/2}}$$

where X, Y, Z are the station position coordinates and  $V_X$ ,  $V_Y$ ,  $V_Z$  are the station apparent velocity components relative to the vehicle in the vehicle centered coordinate system.

If the computed value for  $\Sigma$  is different than a desired value,  $\Sigma_0$ , then an estimate of the time for which  $\Sigma = \Sigma_0$  can be computed using the equations

$$t_{n+1} = t_n + (\Delta t)_n$$

$$(\Delta t)_n = \frac{\Sigma_0 - \Sigma_n}{\dot{\Sigma}_n}$$

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This technique will not converge if the initial time estimate is greatly in error. To insure convergence in all cases it is necessary to provide bounds on the time increment  $\Delta t$ .

The proper bounding procedure can be determined by solving for the approximate variation in stereo angle with time as the vehicle rotates around the earth with the stereo mirror tracking an earth-fixed station. For this analysis it will be assumed that the vehicle is in a circular orbit and the Y coordinate of the station is zero. Furthermore, the rotation of the earth about the polar axis will be disregarded. Defining  $\gamma$  as the apparent angle of rotation of the earth below a stationary vehicle then

$$X = R \sin \gamma$$
$$Z = - [(R+h) - R \cos \gamma]$$

and

$$\tan \Sigma = \frac{R \sin \gamma}{h + R (1 - \cos \gamma)}$$

$$\gamma = \frac{2\pi}{p_V} (t - t_o)$$

where  $p_V$  = period of the vehicle

$t_o$  = time at which station is at vehicle nadir

For a low altitude circular orbit

$$p_V \approx 2\pi \sqrt{\frac{R}{g}}$$

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The maximum and minimum values of  $\Sigma$  are obtained when

$$\cos \gamma = \frac{R}{h+R}$$

which can be approximated by

$$\gamma = \pm \sqrt{\frac{2h}{R}}$$

hence

$$\tan \Sigma_{\substack{\text{max} \\ \text{min}}} = \pm \sqrt{\frac{R}{2h}}$$

The time interval between  $\Sigma_{\text{max}}$  and  $\Sigma_{\text{min}}$  is given by

$$\Delta t_{\Sigma} = 2 \sqrt{\frac{R}{g}} \sqrt{\frac{2h}{R}} = 2^{3/2} \sqrt{\frac{h}{g}}$$

The maximum increment in time is set at half this time interval

$$(\Delta t)_{\text{max}} = \sqrt{\frac{2h}{g}}$$

TSIGMA is the last procedure within COMPOSE. Subsequent to the operation of TITANIC and COMPOSE to determine the acquisition time for the specified stereo angle, COMOPERA calls subroutine CONDUCT to compute the slant range and target obliquity at the specified stereo angle. CONDUCT consists basically of two equations

$$\text{Obliquity} = \tan^{-1} (Y/-Z)$$

$$\text{Slant Range} = \sqrt{X^2 + Y^2 + Z^2}$$

where

X, Y, Z = target location in vehicle centered  
coordinates

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CONDUCT returns program control to COMOPERA. COMOPERA computes the obliquity weighting factor for the target obliquity corresponding to the current stereo angle, and determines whether pointing data has been generated for all three stereo angles (forward, vertical, and aft). If pointing data has not been generated for the three stereo angles, COMOPERA recycles through TITANIC and CONDUCT for the next stereo angle.

The following equation is used to compute the obliquity weighting factor:

$$\text{Obliquity Weighting Factor} = \cos^n(\text{Obliquity} - \text{Ref. Obliquity})$$

where

Ref. Obliquity = THINGS table item, OBLZRO, specified reference obliquity in calculation of obliquity weighting factor

n = THINGS table item, NOBL, cosine exponent for obliquity weighting

THINGS table items OBLZRO and NOBL are specified through File 8 parameters EGT044 and EGT140, respectively.

At the completion of the generation of pointing data for the three stereo angles, COMOPERA computes the obliquity weighted active and inactive worths, determines whether or not the target obliquity is within the main optics obliquity constraints, operates as a target density filter, prepares a COTPRIME entry for the target, and returns control to TWOPS. TWOPS determines whether any unprocessed entries remain on the input acquisition tape. Each of the unprocessed entries which remain is in turn processed through the computational cycle described above. If all the acquisition tape entries have been processed, TWOPS completes the COTPRIME tape and returns control to TWONDER2.

The final computations within COMOPERA proceed as described in the following text.

COMOPERA obliquity weights the active and inactive worths of each target through multiplication of those worths by the value of the obliquity weighting factor, computed for the target obliquity at vertical acquisition.

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The target obliquity at vertical acquisition is compared to THINGS table item OMEGMX. If the target obliquity is greater than OMEGMX the target is deleted. OMEGMX is specified through File 8 parameter EGT147.

The last operation performed by COMOPERA is to delete those targets which fail to pass through a target density filter. The filter compares the basic worth of the target in process with the basic worths of targets already stored in the COTPRIME. The basic worth of each target is computed as follows:

$$\text{Basic Worth} = W_I (1 - P_A) + W_A (P_A)$$

where

$W_I$  = the obliquity weighted inactive worth of the target

$W_A$  = the obliquity weighted active worth of the target

$P_A$  = probability of activity

The probability of activity is a target card parameter which is stored on the acquisition tape. If the probability of activity on the acquisition tape for the current target is equal to zero, COMOPERA sets the probability of activity equal to THINGS table item PROBA. PROBA is specified through File 8 parameter EGT922. The density filter operates as follows:

The previously generated COTPRIME entries are searched to find all those entries whose vertical acquisition time occurs within a specified number of seconds (THINGS table item DTIME, EGT937) before the vertical acquisition time of the current target. If there are too many COTPRIME entries among those found whose basic worth is greater than the basic worth of the current target, the current target is deleted (THINGS table item DNUM, EGT936, is the maximum number of higher worth targets allowed in time interval DTIME before deleting).

Flow charts illustrating the computational processes within TWOPS are presented as Figure 3-6.

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TWOPS

TWOPS

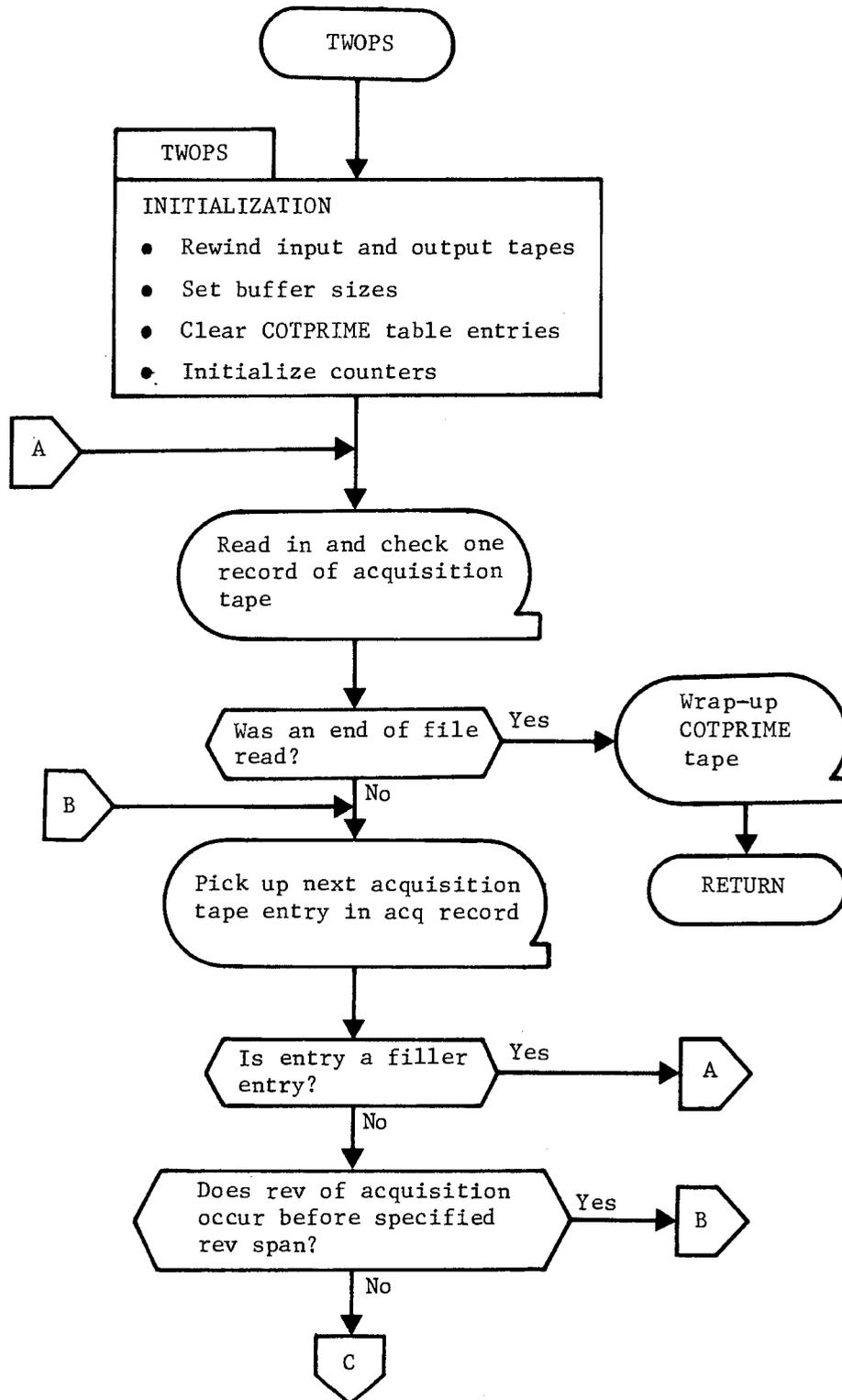


Figure 3-6. TWOPS Flow Chart

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TWOPS

TWOPS

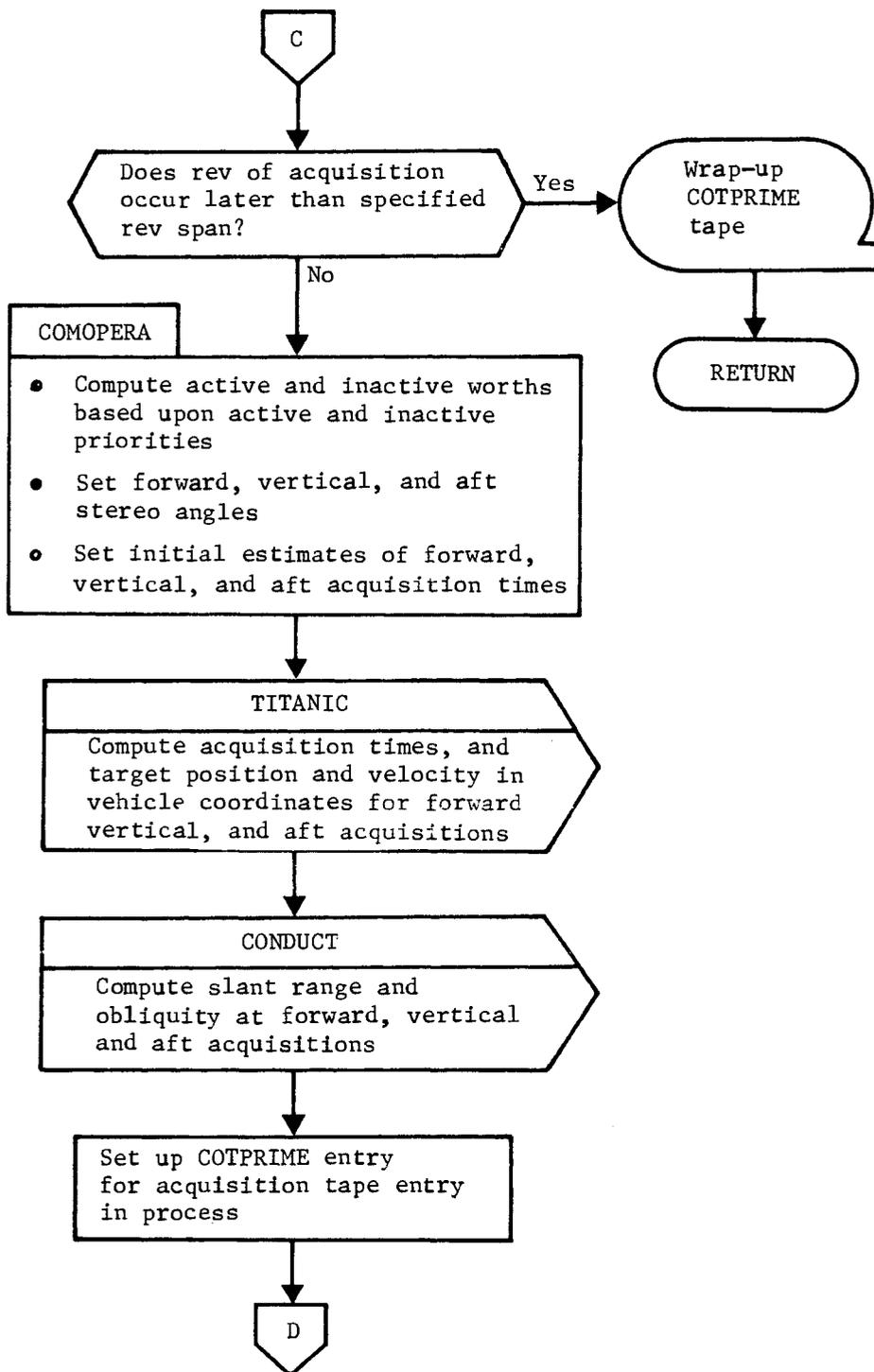


Figure 3-6. TWOPS Flow Chart (Continued)

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TWOPS

TWOPS

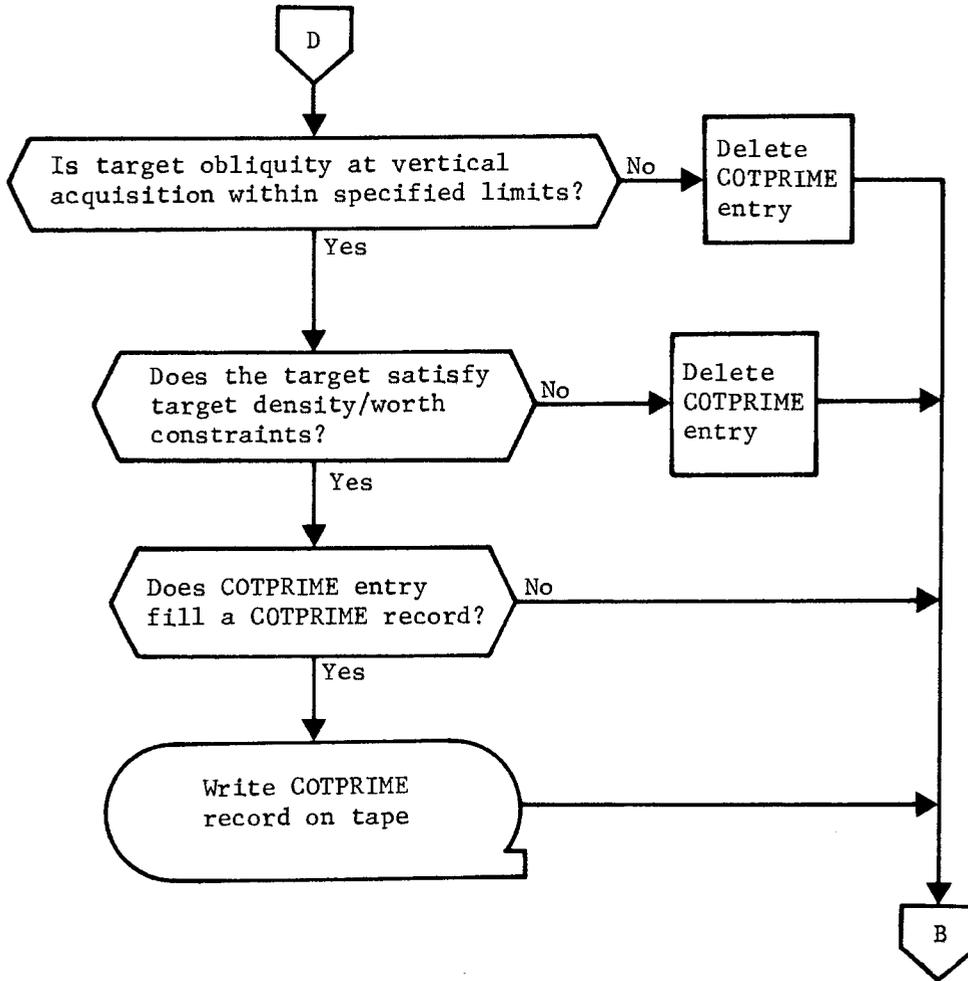


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

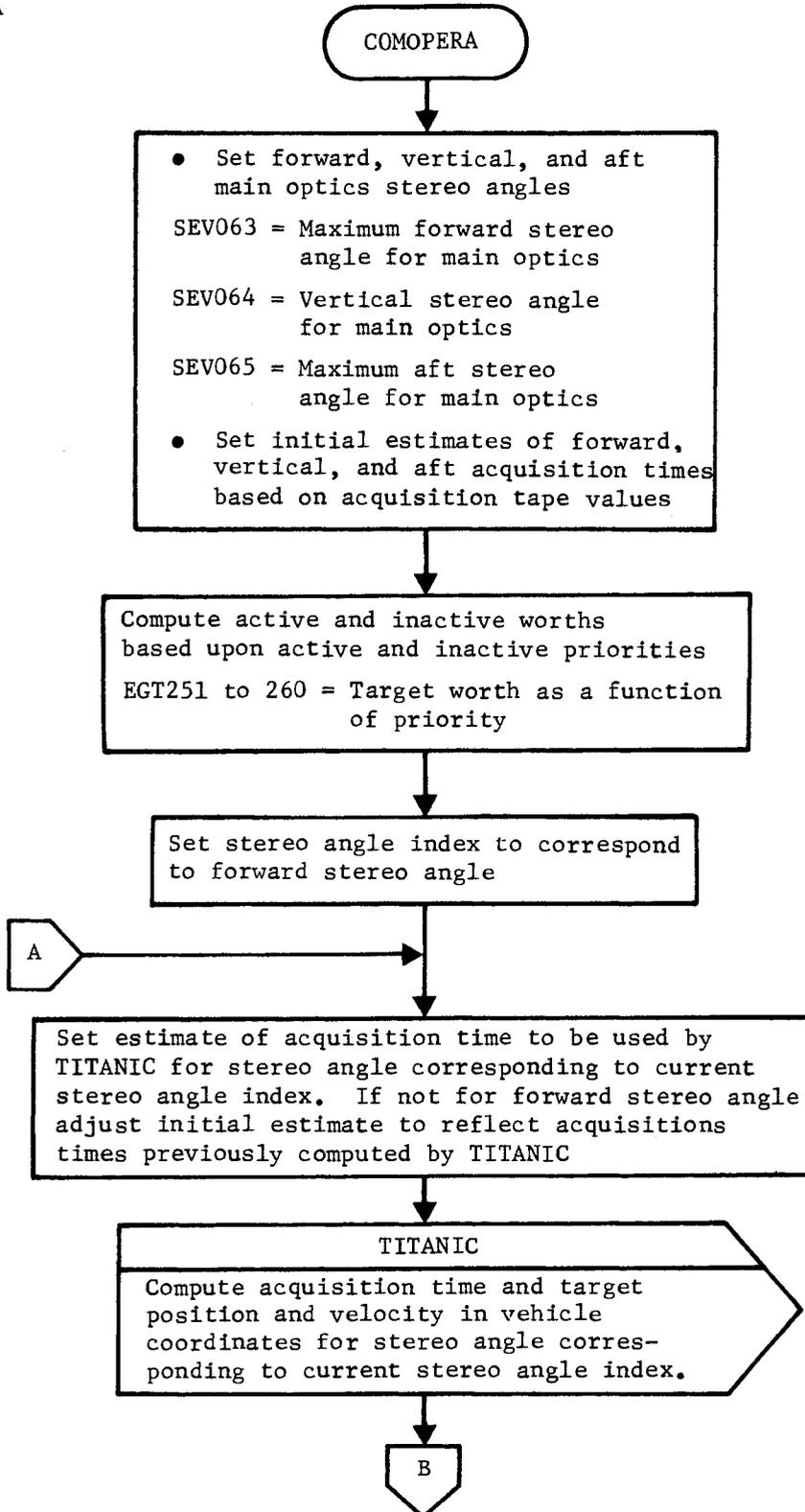


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

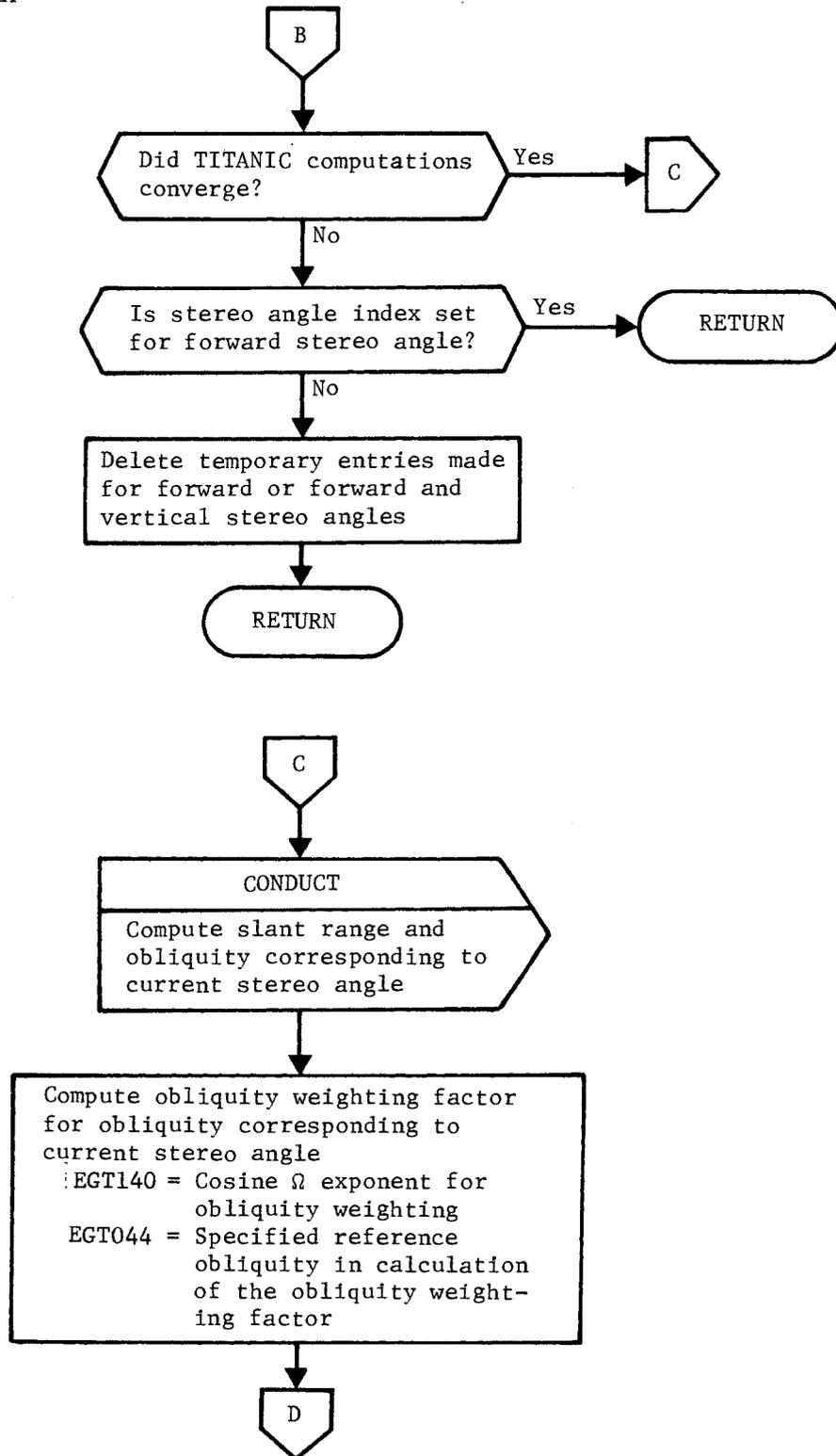


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

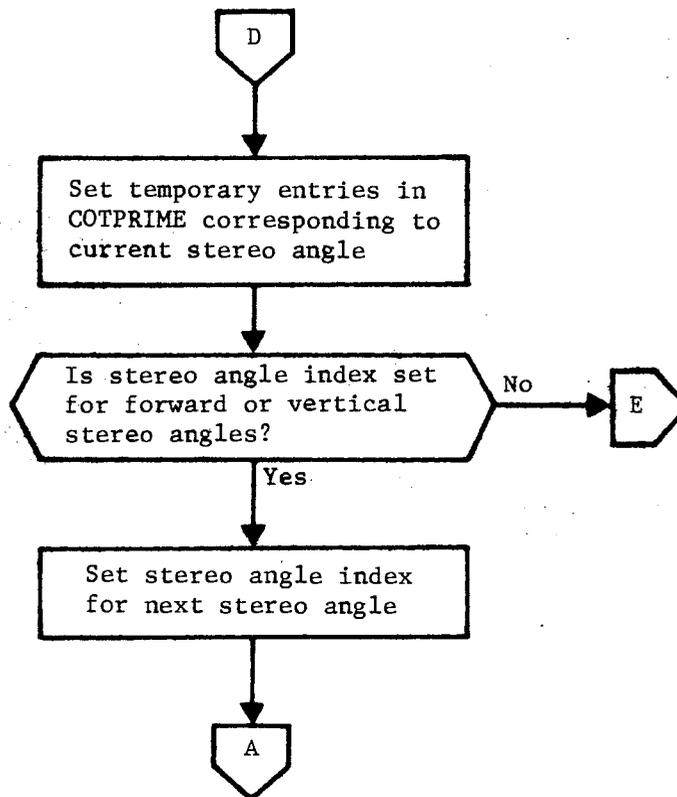


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

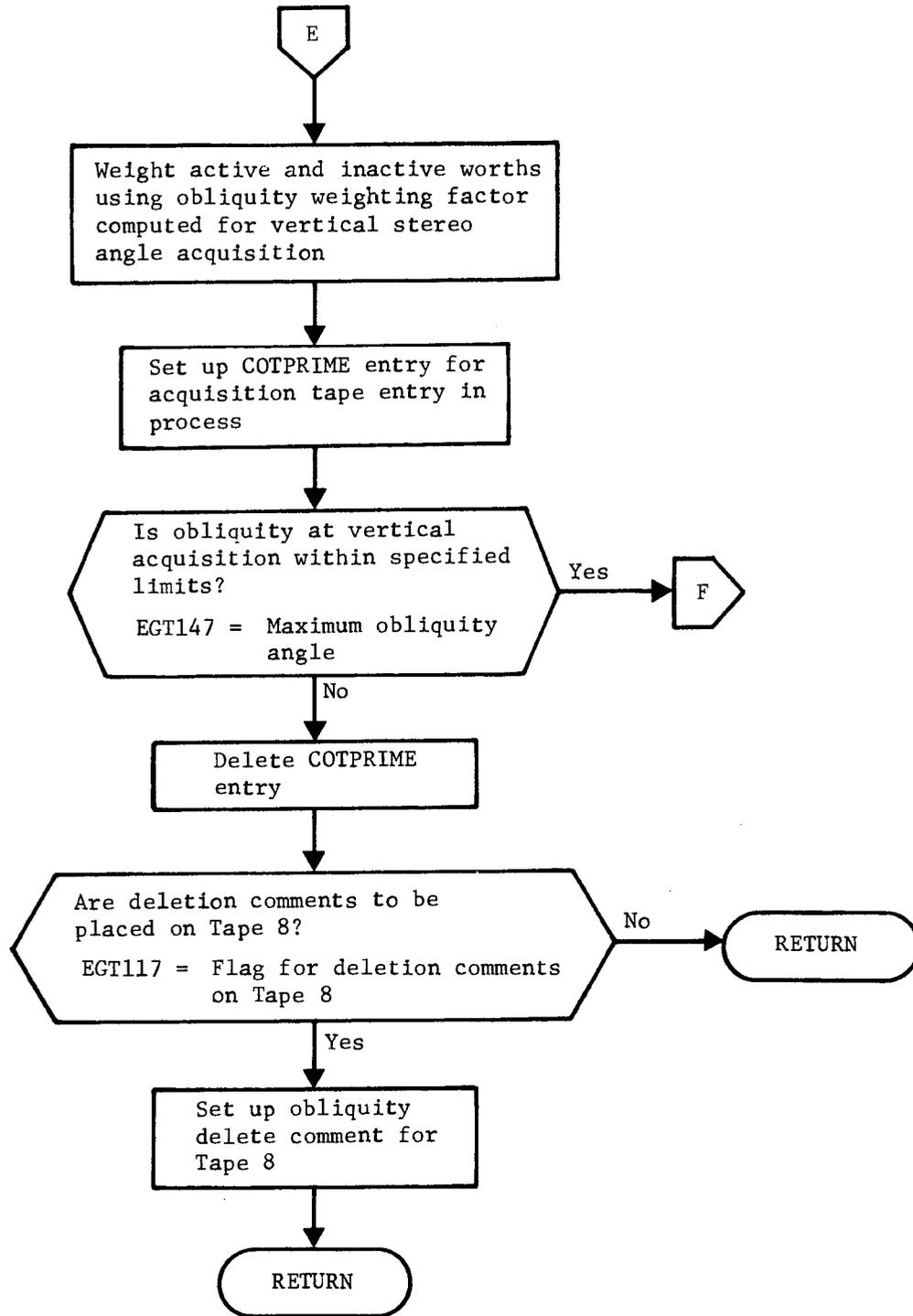


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

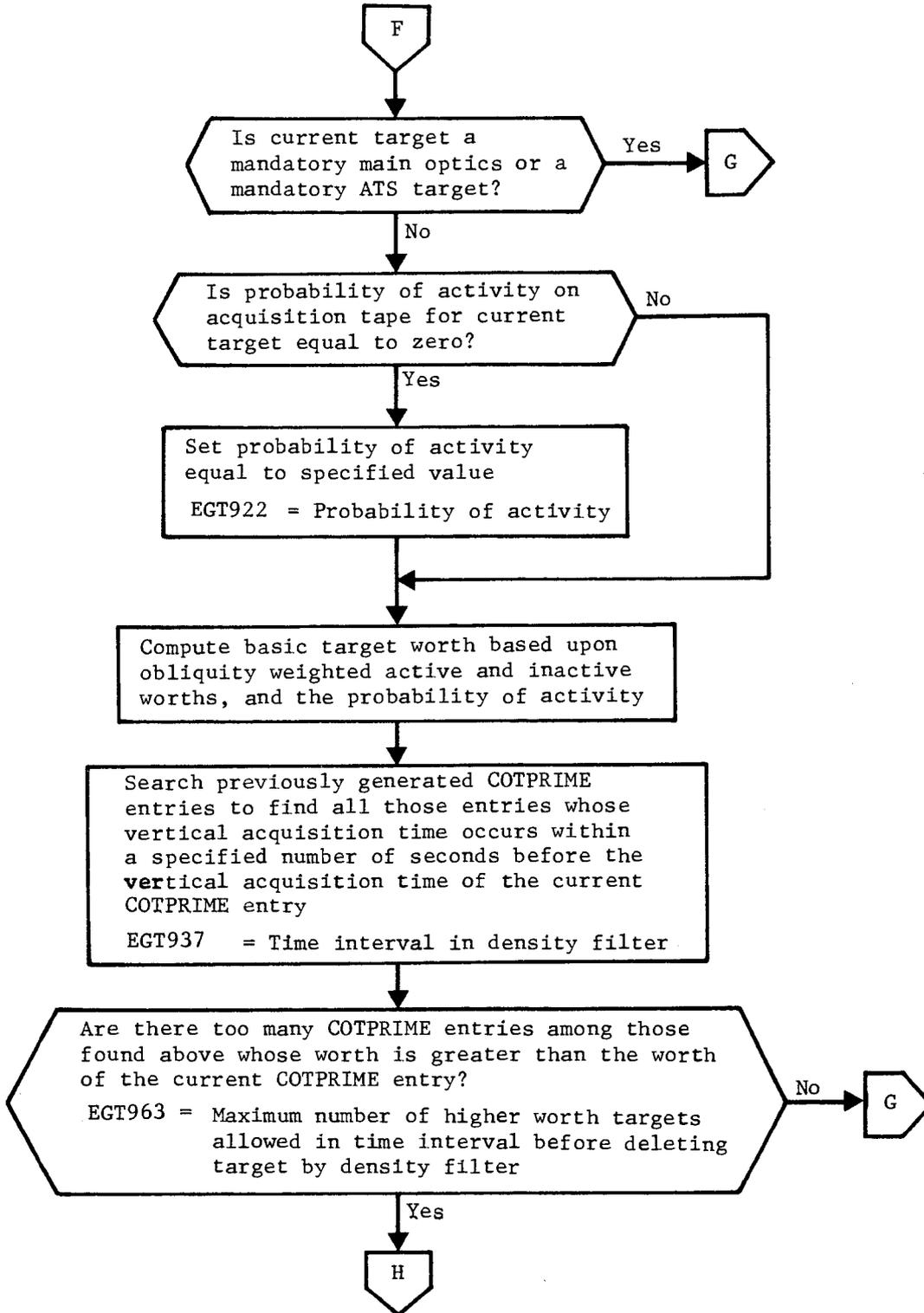


Figure 3-6. TWOPS Flow Chart (Continued)

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COMOPERA

COMOPERA

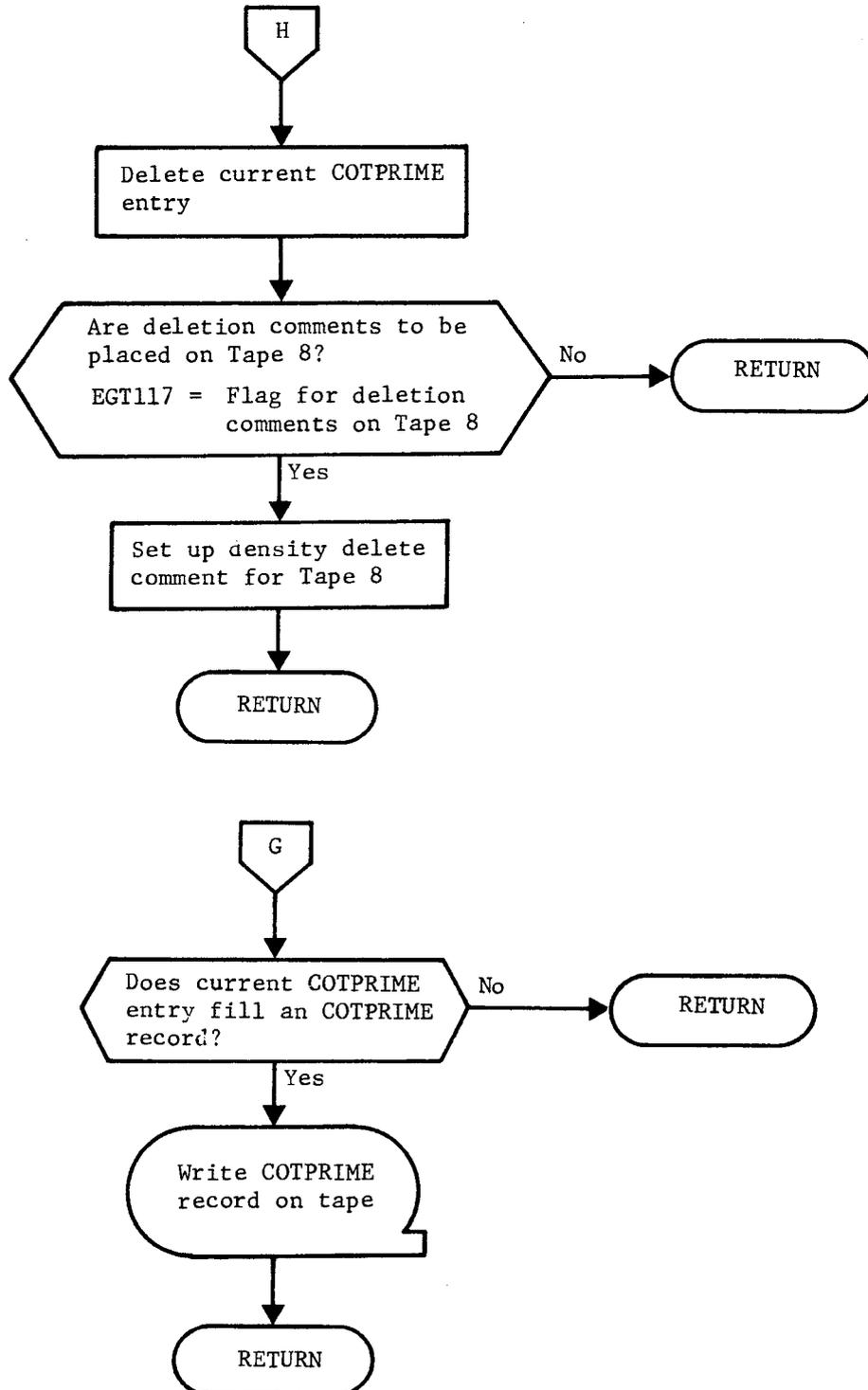


Figure 3-6. TWOPS Flow Chart (Continued)

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TITANIC

TITANIC

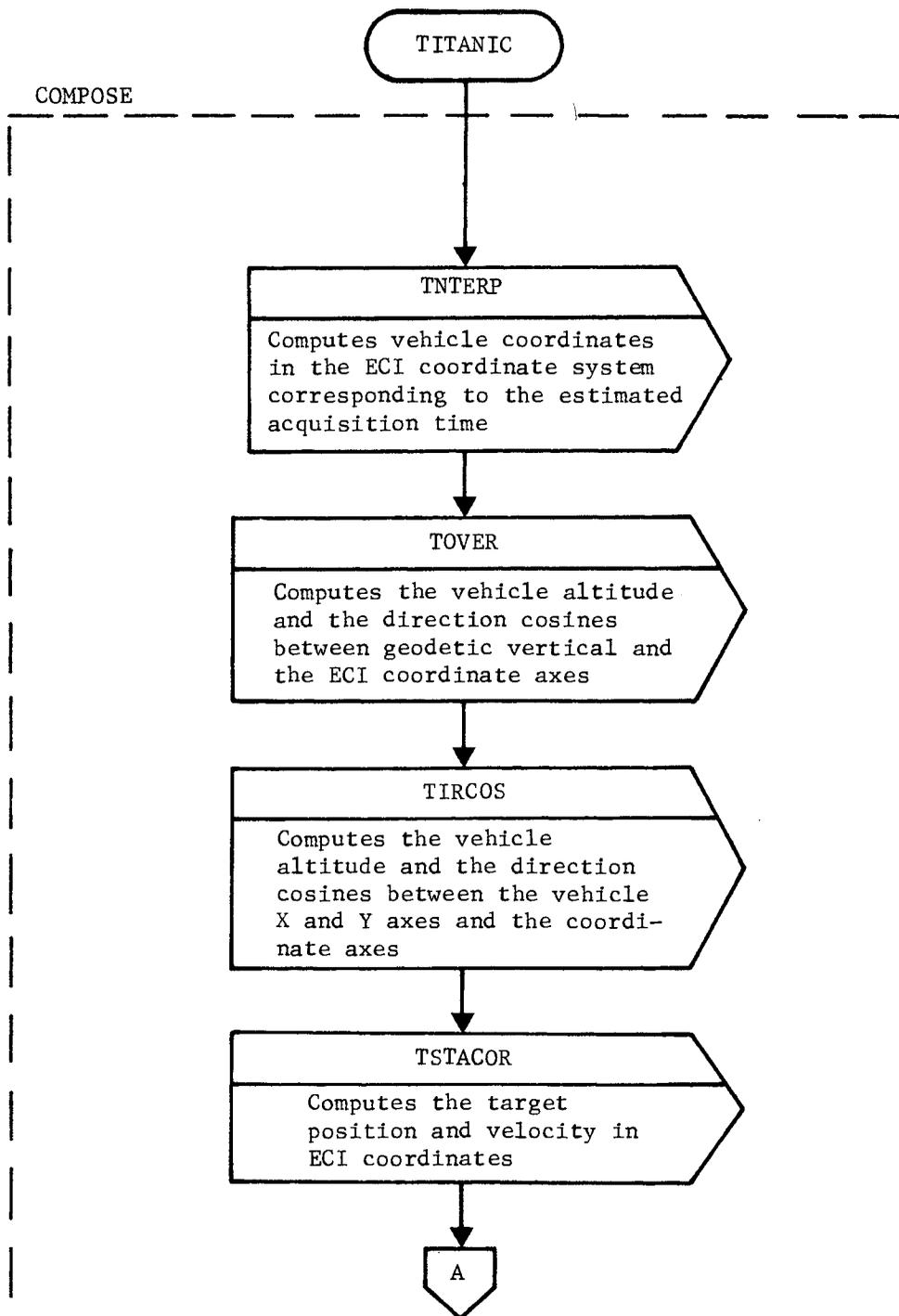


Figure 3-6. TWOPS Flow Chart (Continued)

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TITANIC

TITANIC

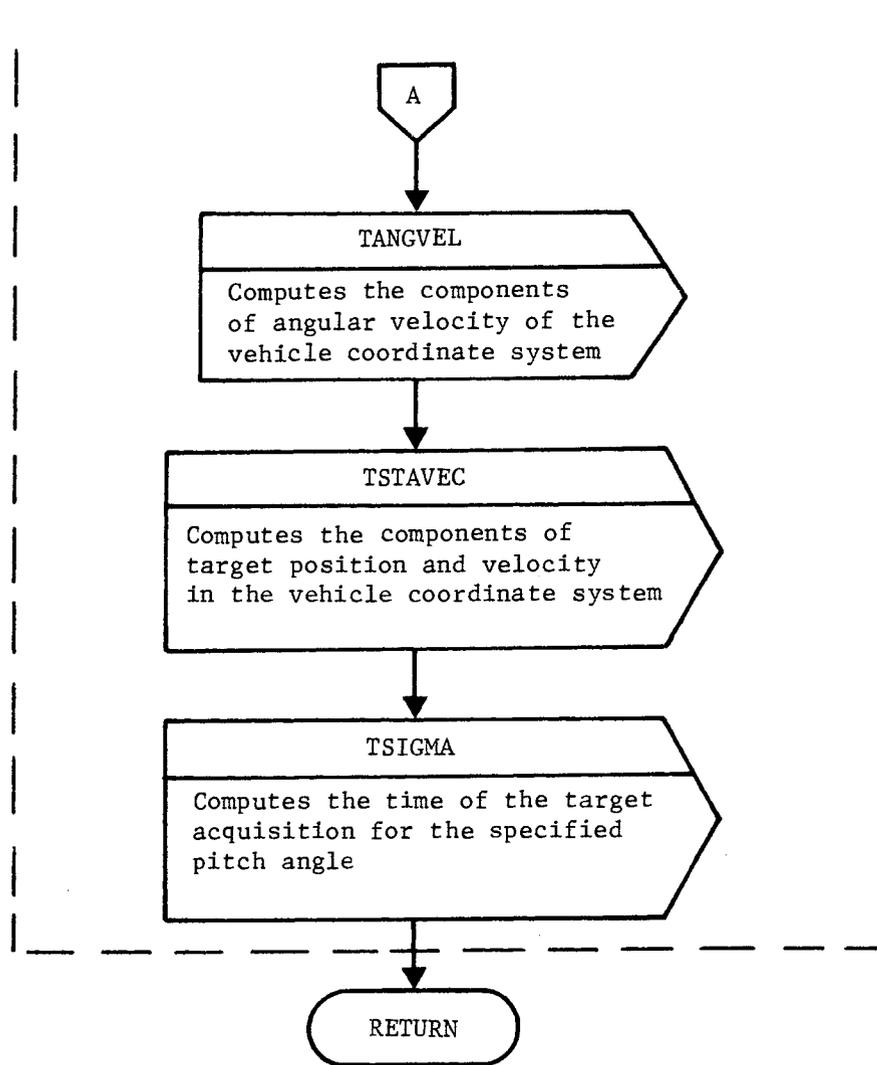


Figure 3-6. TWOPS Flow Chart (Continued)

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TOVER

TOVER

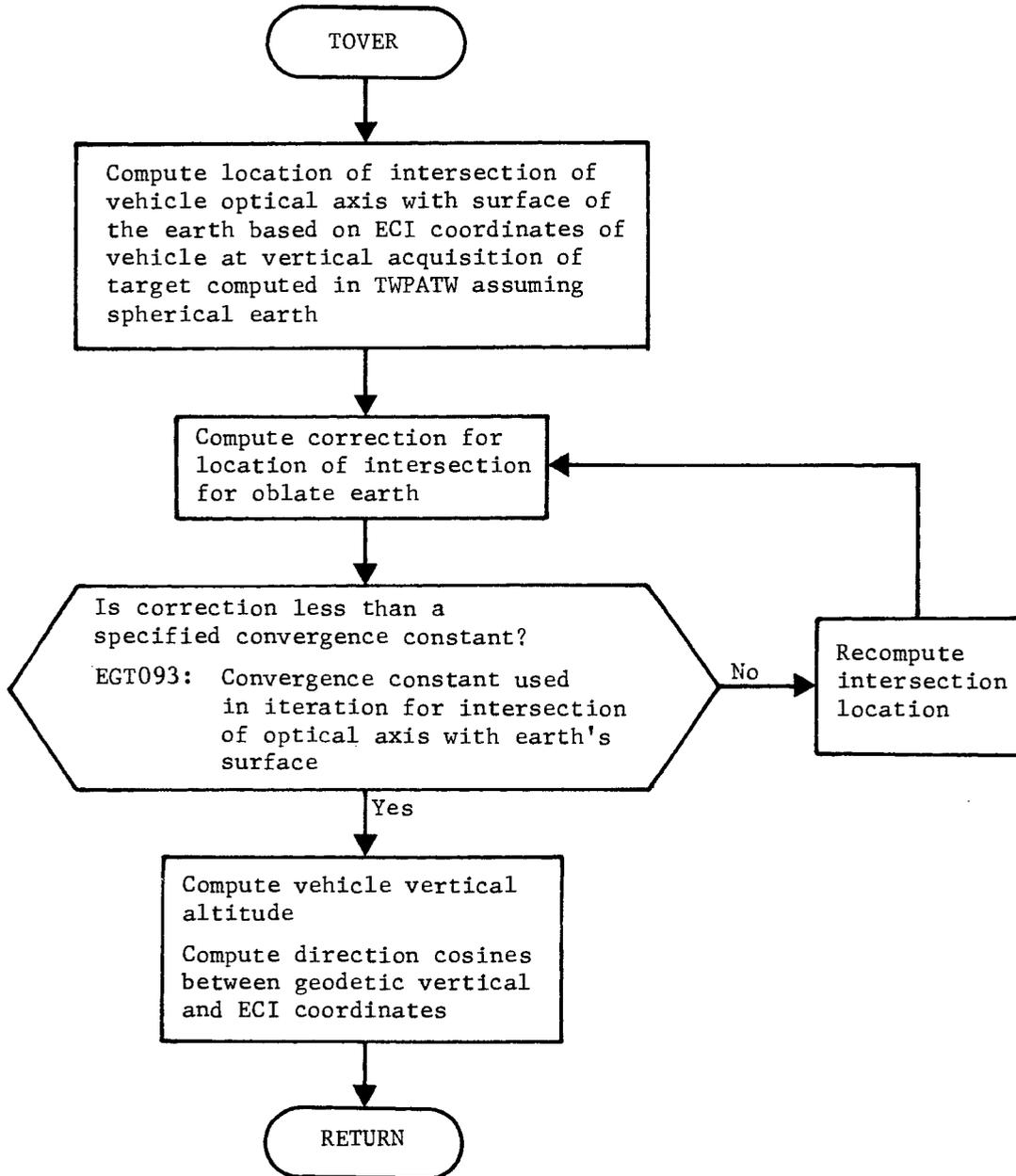


Figure 3-6. TWOPS Flow Chart (Continued)

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CONDUCT

CONDUCT

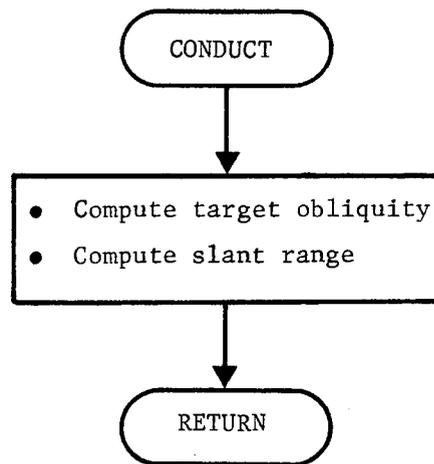


Figure 3-6. TWOPS Flow Chart (Continued)

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TSIGMA

TSIGMA

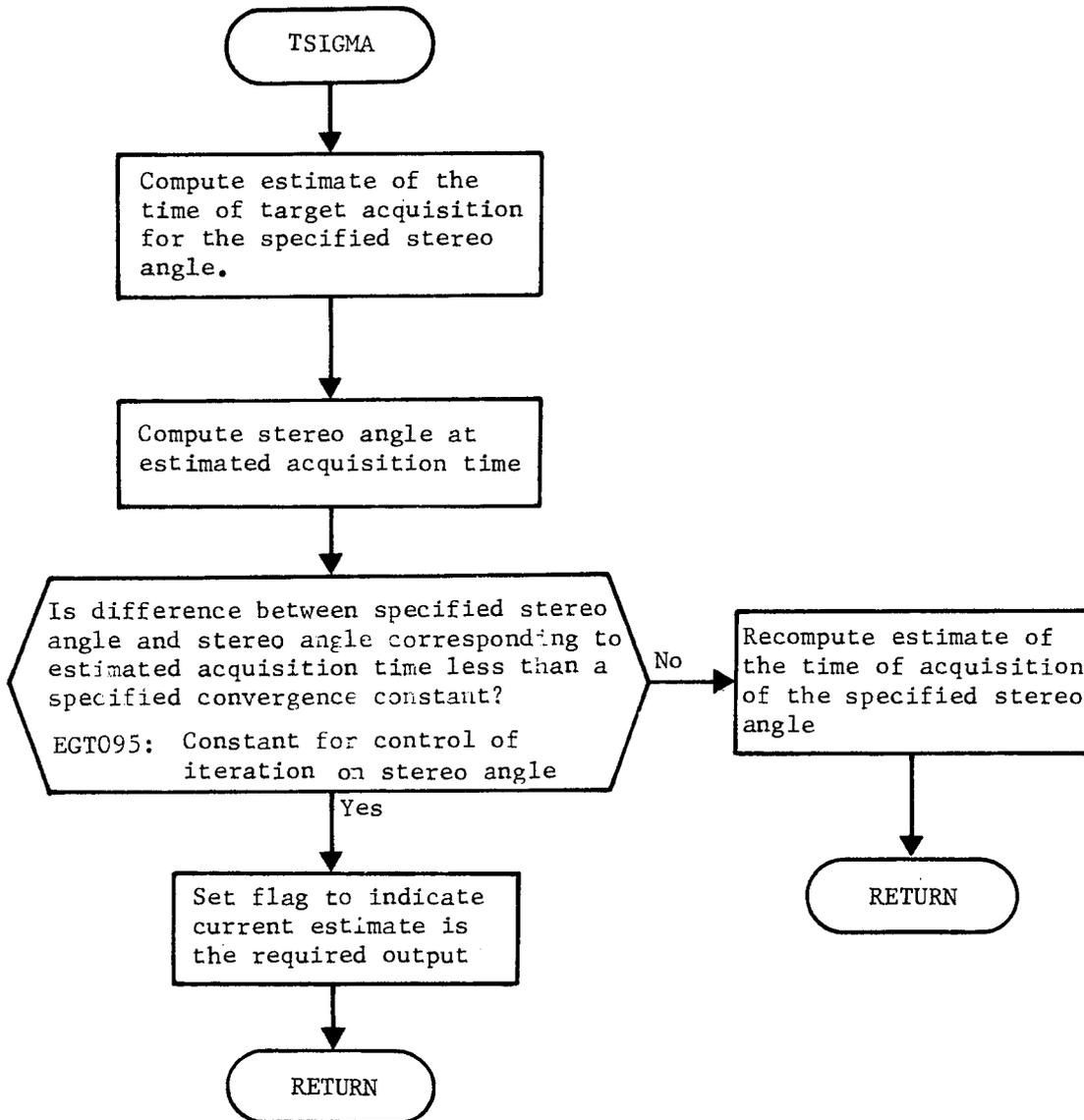


Figure 3-6. TWOPS Flow Chart (Continued)

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### 3.7 TWEEDOFF

#### 3.7.1 Purpose

The subfunction TWEEDOFF acts as a preprocessor for the main optics algorithm (TWMOSP). The basic functions performed by TWEEDOFF are:

- a. Abstraction of the information required by the main optics target selection algorithm (TWMOSP) from the COTPRIME. This information is then tabulated in the MOCOT.
- b. Provision of a means of limiting the number or targets that must be considered by TWMOSP. This is accomplished by means of either a priority filter or a priority/target density filter.
- c. Determination of the number of targets which can be considered as predecessor candidates for each target in TWMOSP.
- d. Setting of the basic weight of each target to be considered by TWMOSP to be either its inactive or its expected worth, depending upon a File 8 input parameter.

#### 3.7.2 Input

The target specific information required by TWEEDOFF is obtained from the COTPRIME Table (see Section 3.6.3). File 7 and File 8 parameters used by TWEEDOFF and located in table THINGS are depicted in Table 3-18. Input arrays located in table ALSO are provided in Table 3-19.

#### 3.7.3 Output

The output of TWEEDOFF is contained in the MOCOT Table. This table provides four words of information about each target as shown in Table 3-20. This information is required by the main optics algorithm (TWMOSP) in order to determine the optimal strategy for main optics photography.

#### 3.7.4 Method

The following sections describe the computations included in this subfunction. In addition to performing these computations, the subfunction TWEEDOFF abstracts target specific information from the COTPRIME for entry in the MOCOT.

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Table 3-18. File 7 and File 8 Parameters Used in TWEEDOFF Located in Table THINGS

File 7 or File 8 Location	Form of Data	Reset File Definition			Interface Table Usage		
		Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
SEV063	FP	30.	deg	Maximum forward stereo angle for main optics	SIGMAF	F 150 0	rad
SEV064	FP	0.	deg	Vertical acquisition stereo angle for main optics	SIGMAV	F 151 0	rad
EGT145	F	0.	n.d.	Lowest effective weight to be con- sidered in main optics selection	MOWGT	F 306 0	n.d.
EGT146	F	1000.	TGTS/ sec	Maximum allowable target density for main optics selection	MODENS	F 307 0	TGTS/sec
EGT147	F	40.	deg	Maximum obliquity angle	OMECMX	F 77 0	rad
EGT148	F	2.	sec	Minimum duration for photographic sequence	PMIN	F 78 0	sec

Table 3-19. File 8 Parameters Used in TWEEDOFF Located in Table ALSO

File 8 Location	Form of Data	Reset File Definition			Interface Table Usage		
		Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
EGT950 to EGT953	FP	-	sec	Slewing time for main optics pitch slewing table	DELTP	local ARRAY	sec
EGT954 to EGT957	FP	-	deg	Delta pitch angle for main optics pitch slewing table	DELP	local ARRAY	rad
EGT958 to EGT961	FP	-	sec	Slewing times for main optics roll slewing table	DELTR	local ARRAY	sec
EGT962 to EGT965	FP	-	deg	Delta roll angle for main optics roll slewing table	DELR	local ARRAY	rad

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Table 3-20. MOCOT Table

Symbol	JOVIAL Declaration	Units	Definition
MTI	F 0 0	sec	Initial acquisition time of target
MTDUR	A 24 S 15 I 0	sec	Total time on target from initial acquisition to final acquisition.
MOMEGAL	A 24 S 18 I 24	rad	Obliquity at MTI
MOMEGAD	A 24 S 18 2 0	rad	Change in obliquity from first acquisition time to last acquisition time.
MSIGMAD	A 24 S 18 2 24	deg	Desired stereo angle for photography.
MWI	F 3 0	n.d.	Upon option, this parameter may be either the inactive worth of the target or its computed basic worth dependent upon both active and inactive worth of target and its probability of activity.
MMODE	I 6 U 4 0	n.d.	Desired photographic mode.
MSHAPE	I 6 U 4 0	n.d.	Shape to be used for scoring function.
MOCIENT	I 12 U 4 12	n.d.	COTPRIME entry number of target.
MTM	I 12 U 4 24	n.d.	The smallest MOCOT entry number of those targets which are in partial conflict with the target of interest (whose MOCOT entry number is MOCIENT)
MTM	I 12 U 4 36	n.d.	The largest MOCOT entry number of those targets which are in partial conflict with the target of interest (MOCOT entry number MOCENT)

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#### 3.7.4.1 Filtering

The filtering of low priority targets is accomplished through the use of File 8 parameters MOWGT (EGT145) and MODENS (EGT146). MOWGT is the lowest effective weight that will be considered in the main optics selection. Those targets having a weight, MWI, less than MOWGT are not entered in the MOCOT table. The parameter MODENS is the maximum allowable target density measured in targets per second. When it is determined that the target density exceeds this value, the lowest worth (highest numerical priority) targets are selectively eliminated until the allowable density is attained. There is currently a more effective filter in TWOPS. The target density filter was designed in the earlier stages of program development and although still in use the majority of the target density filtering is done in TWOPS.

A fixed number of targets (200) is used in the determination of target density. This number corresponds to the number of targets in a COTPRIME record and was used for convenience. The allowable number of targets, TOTNO, is calculated from the equation

$$\text{TOTNO} = \Delta t \times \text{MODENS}$$

where

$$\Delta t = \text{TT1 (199)} - \text{TT1 (0)}$$

TT1 (199) = First acquisition time of the last target  
in the record

TT1 (0) = First acquisition time of the first target  
in the record where TT1 is a COTPRIME  
parameter.

When the allowable number of targets, TOTNO, is found to be less than the 200 targets available in a COTPRIME record, the lowest worth targets are selectively deleted.

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3.7.4.2 MOCOT Predecessor Range

Another major function of TWEEDOFF is the determination of the number of targets that must be considered as possible immediate predecessors by the TWMOSE selection algorithm. This problem can be visualized as is shown in Figure 3-7. Target A, having a first acquisition time of  $t_1$ , is shown on an obliquity-time swath plot. Three regions can then be defined which correspond to total conflict, partial conflict, and no conflict. The times LUTM and LUTN define the boundaries between these regions such that all targets having a first acquisition time between LUTM and LUTN are in the partial conflict region. These times are determined using the following equations:

$$LUTM = \frac{|\Omega| + \Omega_{\max}}{MR} + (t_3 - t_1) \cos \Omega / \cos \Omega_{\max} + S_{\max}$$

$$LUTN = (t_3 - t_1) - 2P_{\min} + S_{\min} - \left| \frac{(A+B)(1-P_{\min})}{MP * T_{\max}} - \frac{(A+B)(P_{\min} + S_{\min})}{(t_3 - t_1)} \right|$$

The quantities  $\Omega$ ,  $t_1$ , and  $t_3$  are, respectively, the obliquity, first acquisition time, and last acquisition time of the target being considered. These items are obtained from the COTPRIME. The remaining quantities define the physical limitations. These are defined as follows:

$\Omega_{\max}$	maximum obliquity
A	maximum forward stereo angle
B	maximum aft stereo angle
MP	maximum pitch slewing rate
MR	maximum roll slewing rate
$S_{\max}$	maximum settling time
$S_{\min}$	minimum settling time
$P_{\min}$	minimum photographic sequence duration

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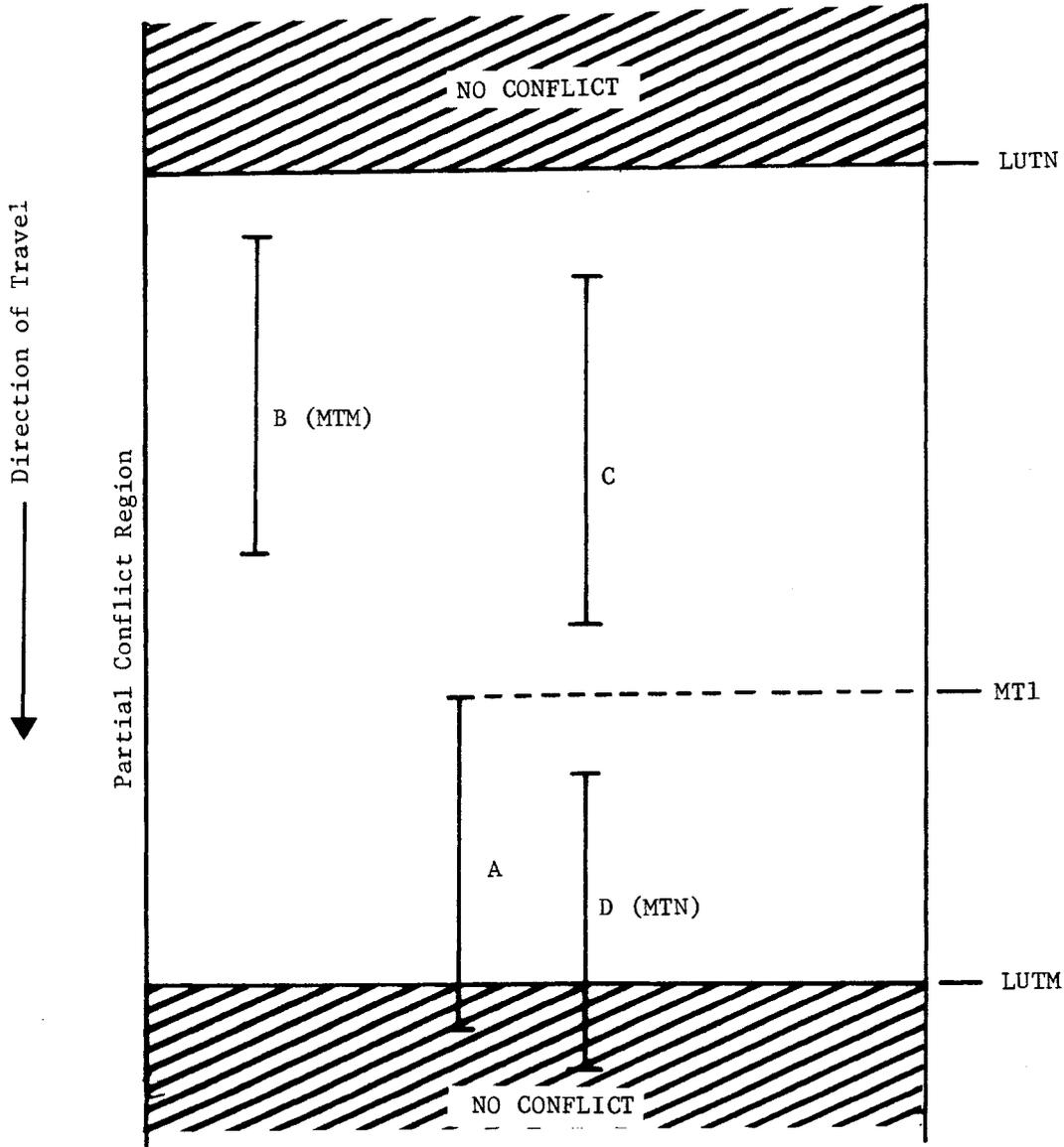


Figure 3-7. Definition of MTM and MTN

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Using these parameters, the above equations conservatively determine the region of partial conflict. The quantities  $\Omega_{\max}$ , A, B, and  $P_{\min}$  are obtained directly from the input parameters EGT147, SEVO63, SEVO65, and EGT148, respectively.

The settling times and maneuvering rates are obtained from the input parameters that define main optics maneuvering capability (EGT950 to EGT965).

After the times LUTM and LUTN have been determined for a particular target (A), the quantities MTM and MTN can be determined. MTM is the MOCOT entry number of the earliest target (based on first acquisition time) in the partial conflict region, and MTN is the MOCOT entry number of the latest target in the partial conflict region. For the example shown in Figure 3-7, MTM would be set equal to the MOCOT entry number of target B and MTN would be the MOCOT entry number of target D.

#### 3.7.4.3 Target Worth

The target weight or worth (MWI) is calculated for each target entered in the MOCOT. If the target has been designated as a mandatory primary (through target card input), MWI is set equal to the worth of a zero priority target. Otherwise, MWI is optionally set equal to either the inactive target worth (TWI) or the average worth depending on the setting of EGT 938. Average worth is calculated from the following equation:

$$MWI = TWI(1 - PROBA) + TWA*PROBA$$

where TWI and TWA are the inactive and active target worths obtained from the COTPRIME. PROBA is the probability of activity. This quantity can be input as either a target specific parameter on the target card or as a constant used for all targets using EGT922. When the target card probability is set to zero, the File 8 probability is utilized.

#### 3.7.4.4 Flow Charts

Flow charts of the subfunction TWEEDOFF and its key procedures, ENTMO and LUSERCH, are provided in Figure 3-8.

#### 3.7.5 Restrictions

The maximum number of targets that can be considered on a single rev is 4000. Since 4000 targets are considered to be the limit for a given revolution, no special measures have been taken to deal with a larger number.

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TWEEDOFF

TWEEDOFF

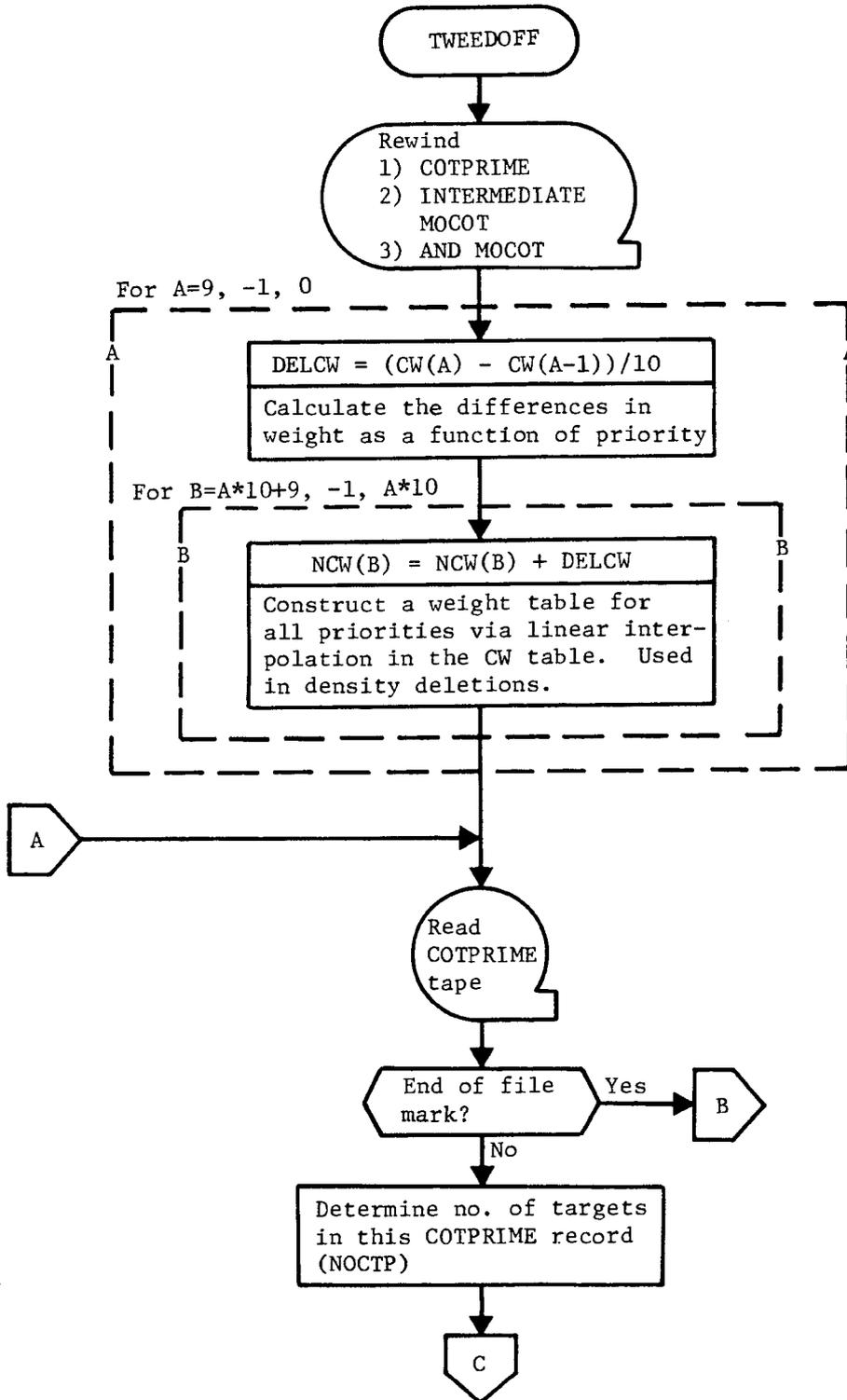


Figure 3-8. TWEEDOFF Flow Chart

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TWEEDOFF

TWEEDOFF

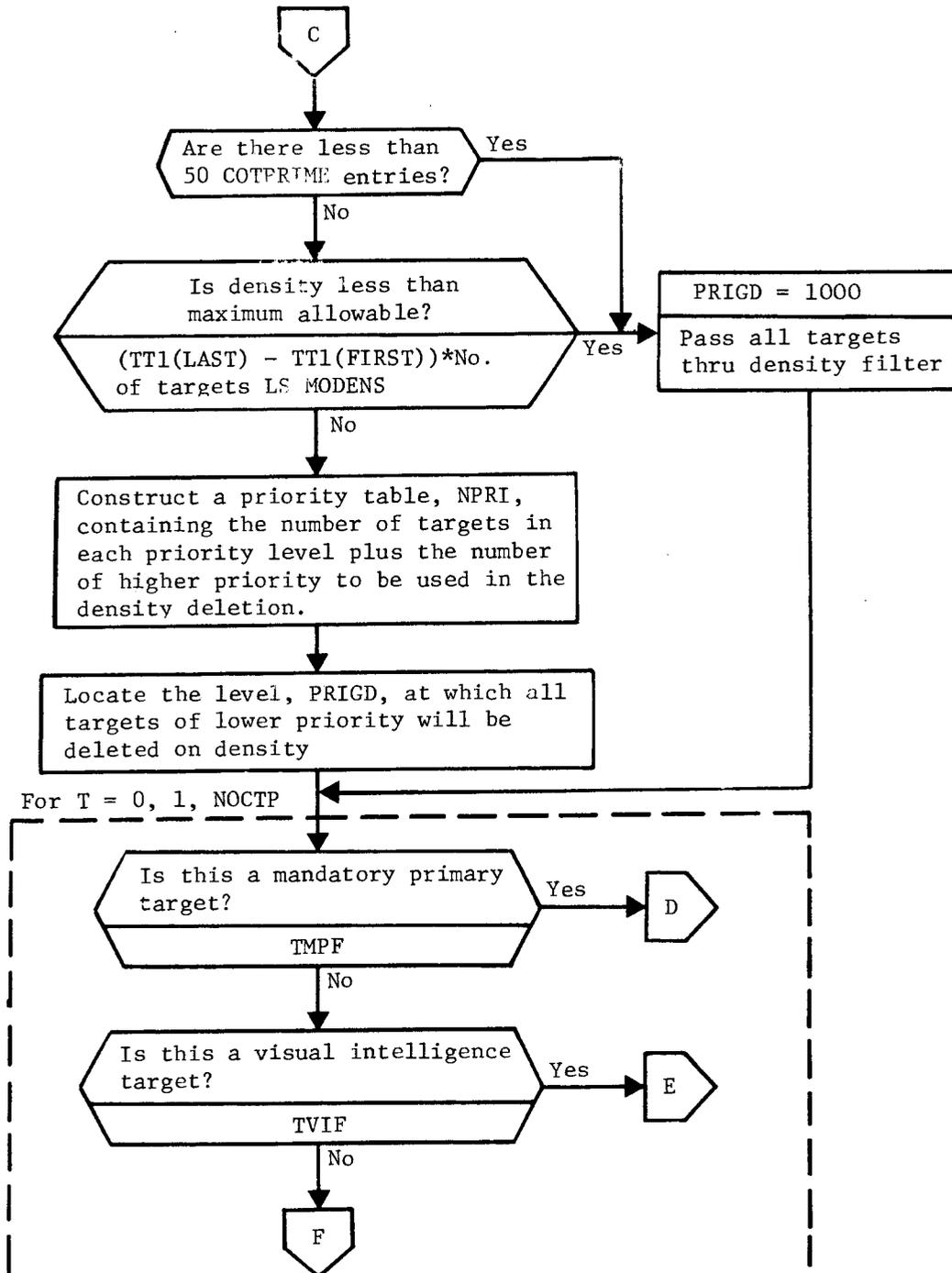


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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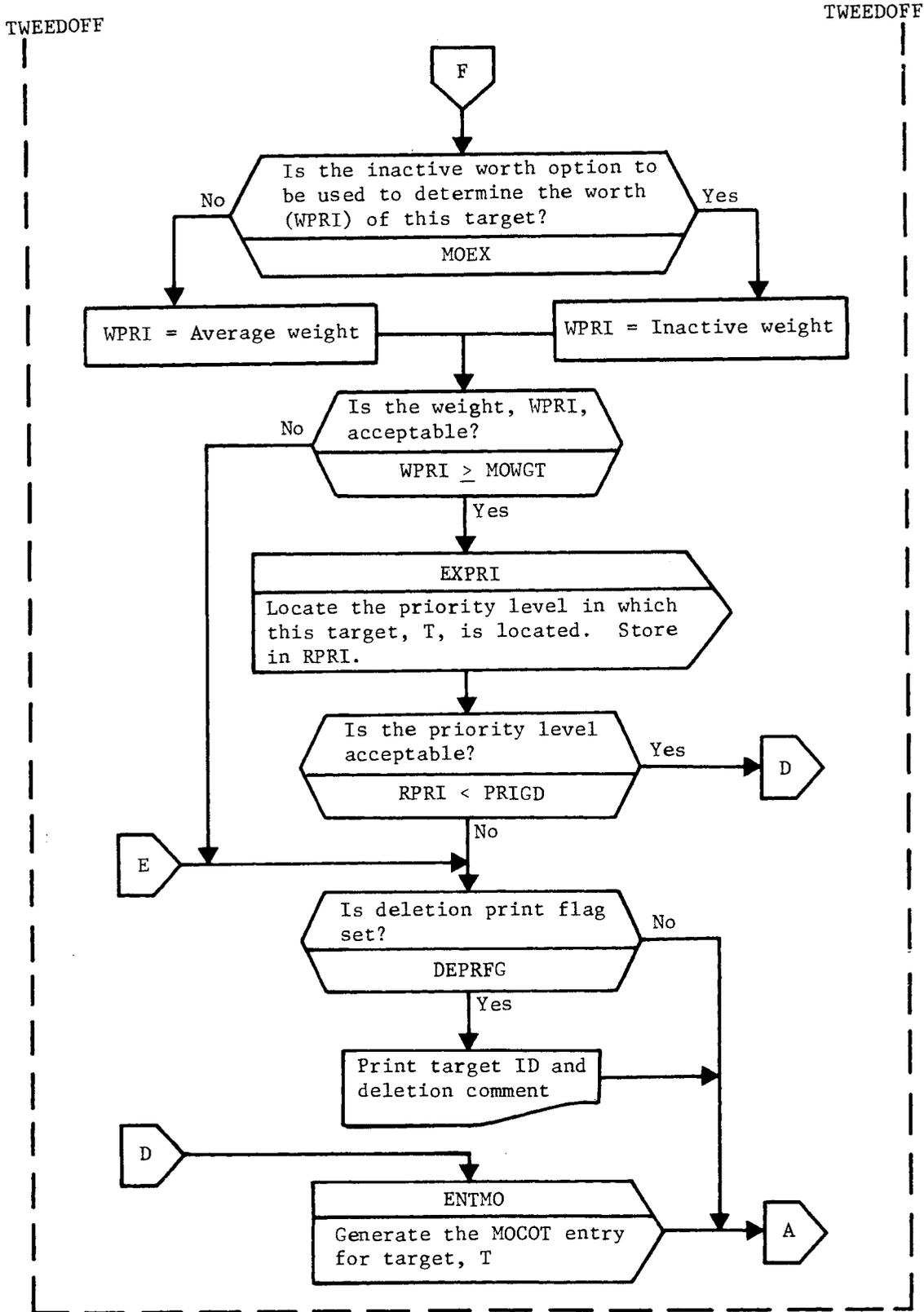


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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TWEEDOFF

TWEEDOFF

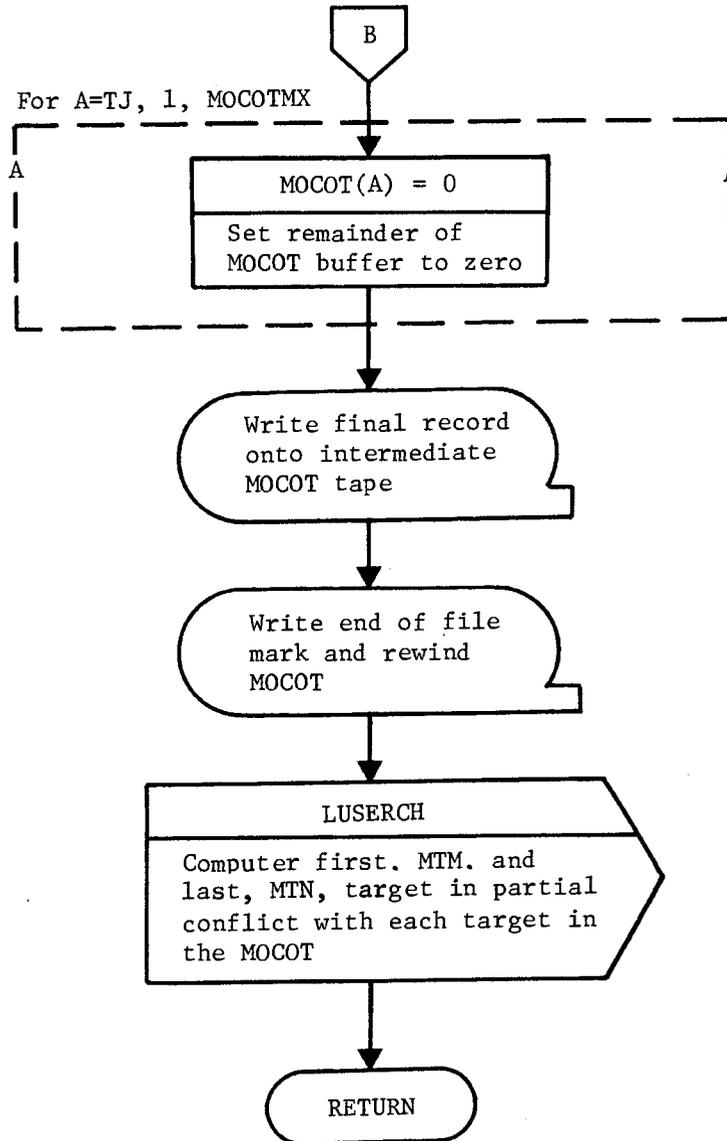


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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ENTMO

ENTMO

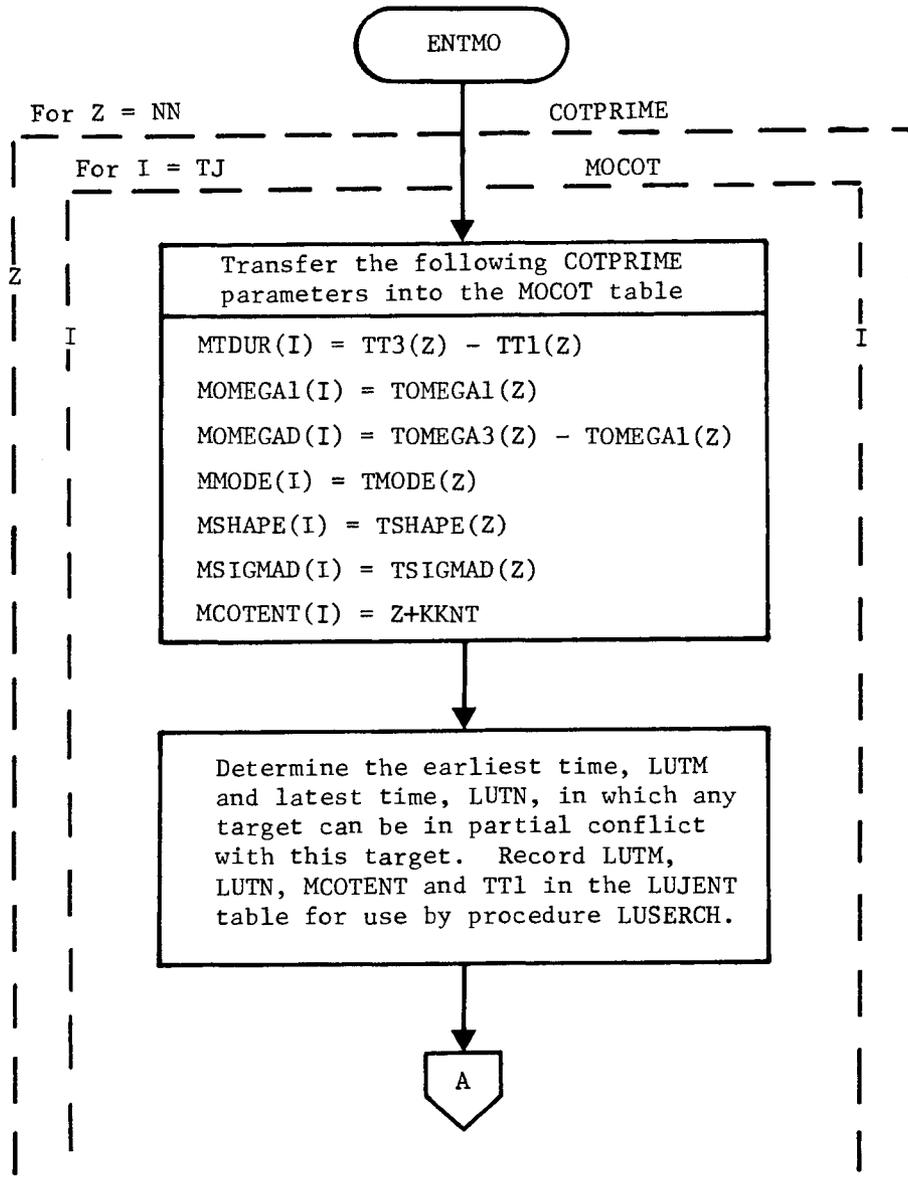


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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ENTMO

ENTMO

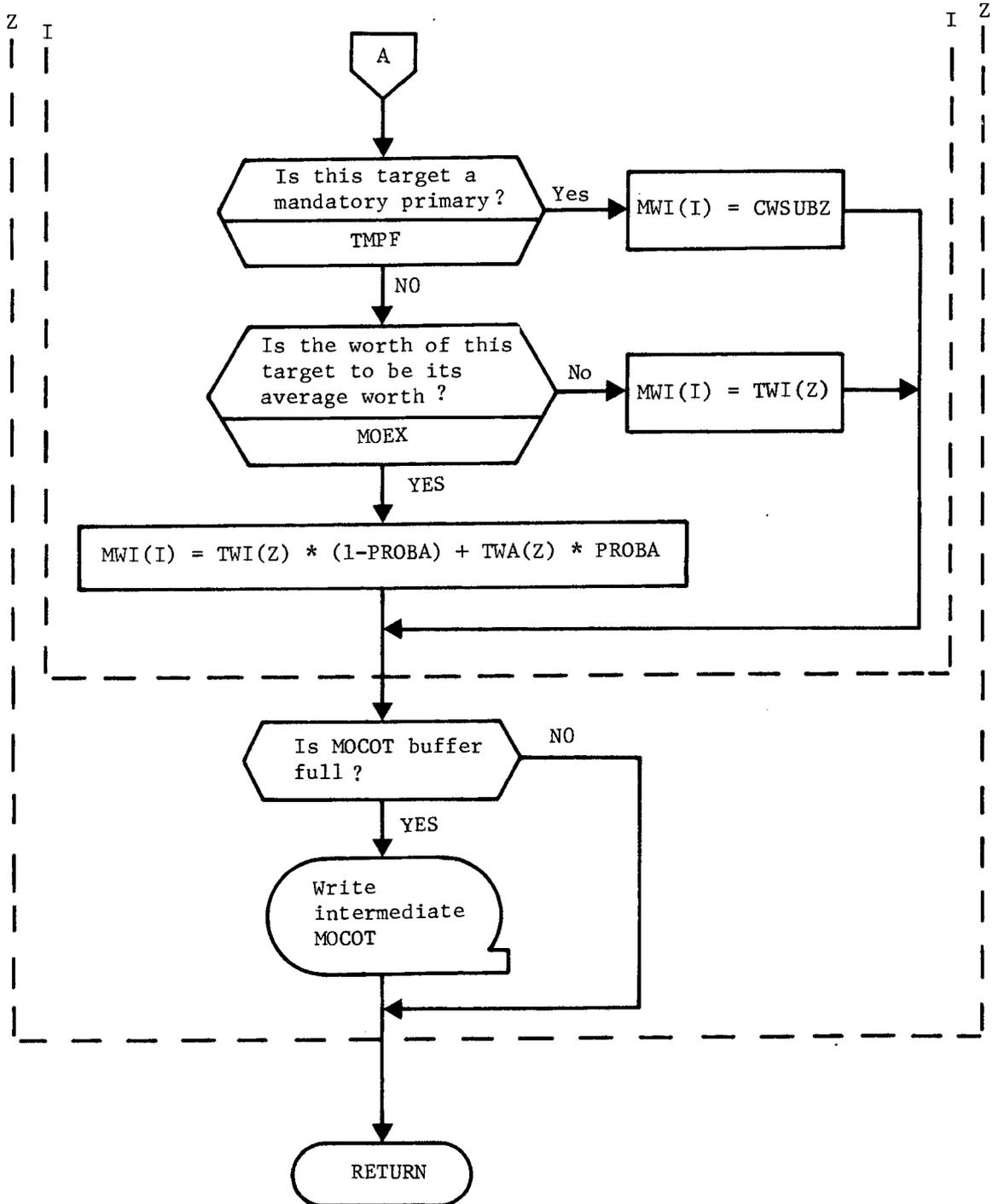


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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LUSERCH

LUSERCH

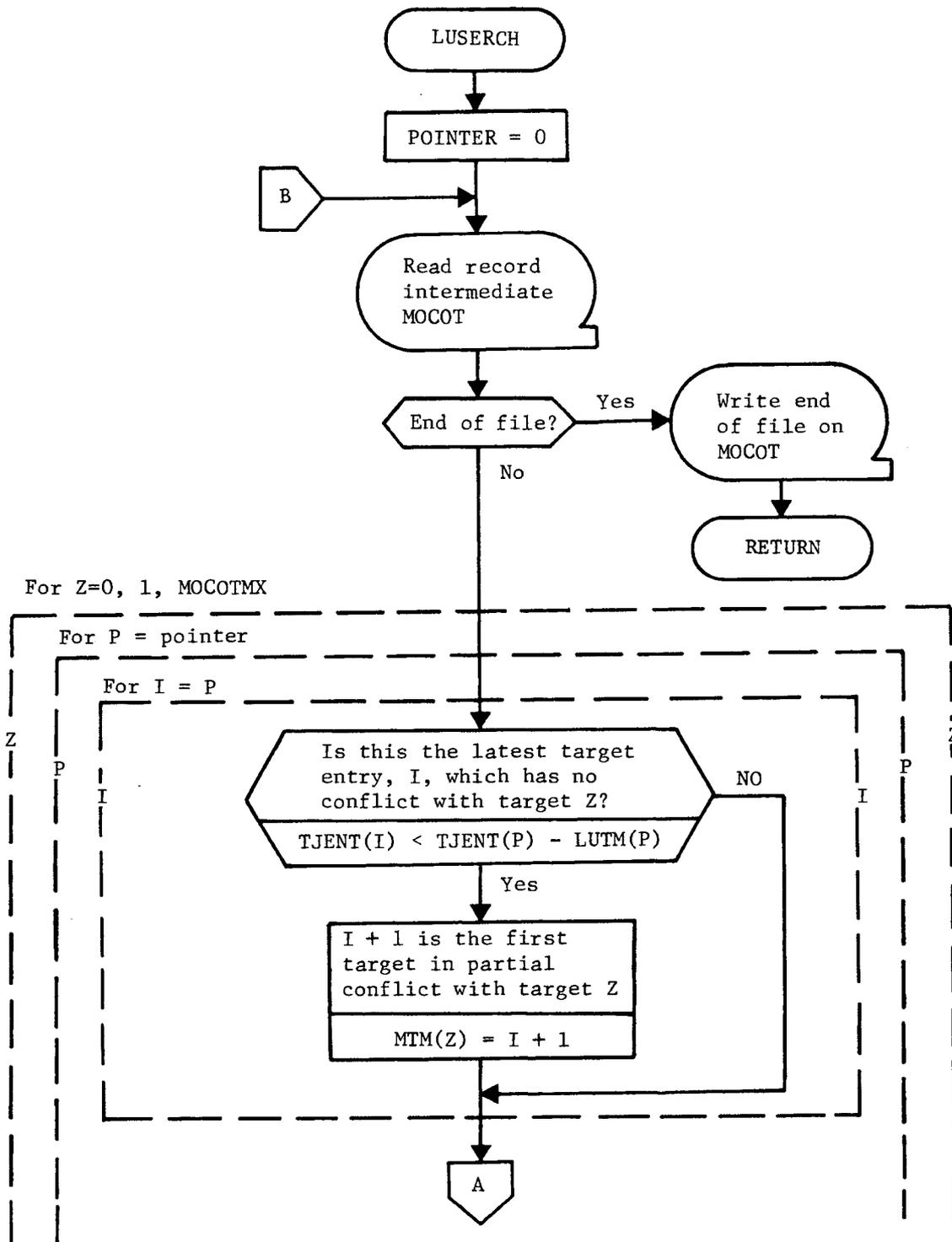


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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LUSERCH

LUSERCH

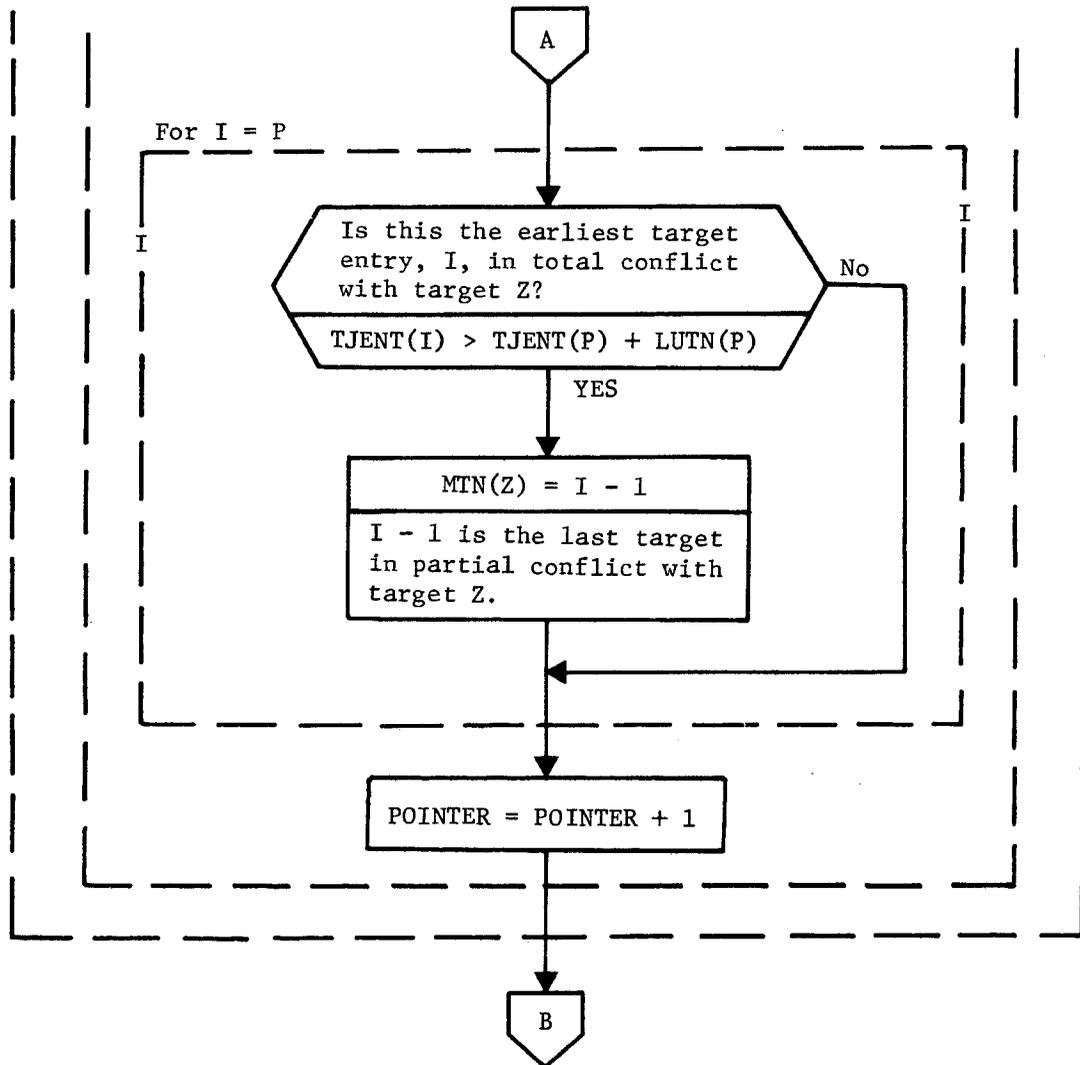


Figure 3-8. TWEEDOFF Flow Chart (Continued)

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### 3.8 TWOSP

#### 3.8.1 Purpose

The main optics algorithm TWOSP selects the best score set of non-conflicting photographic sequences. The effective worth of an individual photographic sequence is based on the active target priority, the inactive target priority, the probability of activity, the photographic mode, an obliquity weighting function, and a stereo weighting function.

In TWOSP, the best score set of predecessors is determined for each of the targets available in the MOCOT. This information is tabulated in the ALMOST table, and the job of reconstructing the optimal path is delegated to the successor function TWOSP2.

There are three options in TWOSP:

- a. Interleave Select an optimal sequence of targets regardless of whether the same target is selected more than once.
- b. Time Order Select an optimal sequence of targets with the constraint that a predecessor for a given target will have an earlier initial acquisition time. This eliminates the possibility of selecting a target more than once.
- c. Interleave Inhibit Select an optimal sequence of targets with the limitation that a target (A) cannot be selected more than once if there is only one other target (B) between consecutive photographs of A; i.e., the sequence ABA is prohibited.

#### 3.8.2 Input

The MOCOT table, described in Section 3.7.3, provides the target specific information required by TWOSP. The File 7 and File 8 parameters required as input located in Table THINGS are depicted in Table 3-21. The File 8 parameters required as input located in Table ALSO are depicted in Table 3-22.

#### 3.8.3 Output

The output of TWOSP is contained in the ALMOST table. The content of this table is shown in Table 3-23.

The ALMOST table consists of two files labeled File 1 and File 2. File 1 contains data necessary to construct an optimal sequence of targets to be photographed which will terminate with any arbitrary target  $j$  at some finish time  $a_j + \tau_j$ . Each record consists of a variable number of

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Table 3-21. File 7 and File 8 Parameters Used in TWMO SP Located in Table THINGS

File 7 or File 8 Location	Reset File Definition			Interface Table Usage			
	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
SEV063	FP	30.	deg	Maximum forward stereo angle for main optics	SIGMAF	F 150 0	rad
SEV065	FP	-40.	deg	Maximum aft stereo angle for main optics	SIGMAA	F 149 0	rad
EGT941	I	1	n.d.	Main optics algorithm time order flag 0: No time order 1: Time order	MOFLG	B 105 47	n.d.
EGT942	I	0	n.d.	Interleave flag 0: Inhibit interleave 1: Allow interleave	INLEVE	B 113 47	n.d.

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Table 3-22. File 8 Parameters Used in TWOSP Located in Table ALSO

Reset File Definition					Interface Table Usage		
File 8 Location	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
150 to 159	FP	-	sec	Photographic time as a function of photographic mode (forward stereo)	DELTAT1	10 F ARRAY	sec
160 to 169	FP	-	sec	Photographic time as a function of photographic mode (aft stereo)	DELTAT2	10 F ARRAY	sec
170 to 179	FP	-	deg	Delta stereo angle as a function of photographic mode	DELTAS	10 F ARRAY	rad
180 to 229	FP	-	n.d.	Pitch weighting factor as a function of pitch weighting mode	PWF	10 5 F ARRAY	n.d.
950 to 953	FP	-	sec	Slewing time for main optics pitch slewing table	DELTP	local ARRAY	sec
954 to 957	FP	-	deg	Delta pitch angle for main optics pitch slewing table	DELP	local ARRAY	rad
958 to 961	FP	-	sec	Slewing times for main optics roll slewing table	DELTR	local ARRAY	sec
962 to 965	FP	-	deg	Delta roll angle for main optics roll slewing table	DELRL	local ARRAY	rad

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Table 3-23. Format of the ALMOST Table Entry  
File 1 ALMOST

Word Number	Symbol	JOVIAL Declaration	Units	Definition
0	N.A.	N.A.	N.A.	Number of valid words in entry
1	MCOTENT FLAGA	I 12 U B 0 35	0 36 n.d. 0 35 n.d.	COTPRIME entry number (j) Bit denoting first or second best version of target
2	JJ	I 48 S	1 0 n.d.	Counter denoting number of words in entry
3	MT1	F 2 0	sec	Initial acquisition time ( $a_j$ ) of target
4	ALPHAJ1	F 3 0	sec	Relative start time of this target from MT1 ( $\alpha_j$ )
5	ALPHABAR	F 4 0	sec	Relative finish time of this target from MT1 ( $\bar{\alpha}_j$ )
6	PMODE	I 6 U	5 0 n.d.	Best mode over region from TAUM to next mode entry or to $\bar{\alpha}_j$
	TAUM	A 42 S	9 5 6 sec	Start time relative to MT1 from which PMODE is the best mode
7	N.A.	N.A.	N.A.	Number of predecessor targets to follow (number of predecessor)
8	QUE	A 18 S	9 0 0 sec	Time of conflict between COTPRIME ENTRY (j) and predecessor ( $Q_{kj}$ )
	TAU	A 17 S	9 0 18 sec	Time relative to MT1 at which the predecessor becomes the best
	FF	B 0 35	n.d.	Predecessor maximum score function is best (= 0) or second best (= 1) version of this predecessor

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Table 3-23. Format of the ALMOST Table Entry (Continued)

File 1 ALMOST

Word Number	Symbol	I	12	U	0	36	n.d.	Predecessor	JOVIAL Declaration	Units	Definition
8	PREDNO	I	12	U	0	36	n.d.	Predecessor	COTPRIME	entry number	
8 + number of pred.	N.A.								N.A.	n.d.	Number of FLATFUN entries to follow
8 + number of pred. + 1	FLATAU BBFLAT	A	47	S	9	0	1	sec			Time relative to MT1 at which flattened or unflattened interval begins flag; = 0 for unflattened; = 1 for flattened
		B				0	0				Repeat above word for each FLATFUN entry

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entries, and each entry is variable in length. The first word in each record gives the number of 48 bit words in the record.

The second word of the record is the start of an entry. An entry is target specific and will contain information derived from the maximum score function or from the alternate maximum score function for an interval of time  $(\alpha, \bar{\alpha})$ . The maximum and alternate maximum score functions are constructed piecewise, and the information derived from these functions is put into the ALMOST table as the functions are constructed.

From the above discussion, the tabular listing File 1 in Table 3-23 cannot be complete, but is intended to show what would be present in one entry. The process is repeated for each entry. The maximum number of words in a record is 348.

File 2 consists of one record of four words which specifies the last target to be photographed in the optimal sequence, the finish time, the optimal score, and the initial acquisition time.

#### 3.8.4 Method

There are three different options in the program; the option which allows interleaving will be described first since the other two algorithms are variations of it. Section 3.8.4.1 describes the basic algorithm. This is followed by sections describing the scoring function for an individual target,  $\phi$ , the conflict parameter,  $Q_{kj}$ , and the method used to construct the maximum score function  $\Phi$ . These are the key parameters employed in the determination of the optimal sequence. The time ordered algorithm is then discussed in Section 3.8.4.5, and the interleave inhibit algorithm is described in Section 3.8.4.6. Section 3.8.4.7 contains a discussion of the TWMOSP flow charts.

##### 3.8.4.1 The Statement of the Interleave Algorithm

The algorithm calculates for each target the maximum score obtainable by photographing a sequence of non-conflicting targets which terminates at that target at a specified finish time. For each target an optimal predecessor is given as a function of finish time. The following notation is used for the statement of the algorithm:

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$\Phi_{j,\ell}(\tau)$  = the maximum score obtainable by a sequence of non-conflicting photographs which terminates with the photograph of target  $j$  in photographic mode  $\ell$ . The finish time of the photographic sequence is  $\tau$  measured from the initial acquisition time of target  $j$ .

$\Phi_{j,\ell}^*(\tau) = \text{Max}_{\tau < \tau} \Phi_{j,\ell}(\tau)$

$\text{Flat}(j,\ell,\tau) = \begin{cases} 1, & \text{if } \Phi_{j,\ell}^*(\tau) > \Phi_{j,\ell}(\tau) \\ 0, & \text{if } \Phi_{j,\ell}^*(\tau) = \Phi_{j,\ell}(\tau) \end{cases}$

$\text{Pred}(j,\ell,\tau)$  = Optimal predecessor to target  $j$  when the mode of the photography on  $j$  is  $\ell$  and the photographic finish time is  $\tau$  (measured from initial acquisition time of  $j$ ).

$Q_{kj}$  = a conflict parameter which is used to determine whether the target  $k$  is a valid predecessor of target  $j$ . If  $\tau_j$  and  $\tau_k$  are the finish times for photography on targets  $j$  and  $k$  respectively then

$$\tau_j - \tau_k \geq Q_{kj} + P_{j,\ell} \quad \text{where } P_{j,\ell} \text{ is the time}$$

required to photograph  $j$  in mode  $\ell$ . See Section 3.8.4.3 for additional information on the conflict parameter.

$K\phi_j(\tau,\ell)$  = The score for photographing target  $j$  in mode  $\ell$  at finish time  $\tau$  (measured from initial acquisition time of target  $j$ ). This term is written in this way because the shape of the function is basically determined by the stereo weighting function  $\phi_j(\tau)$ .

$$\Phi_k^*(\tau) = \text{Max}_{k,\ell} \Phi_{k,\ell}^*(\tau) = \Phi_{k,\bar{\ell}}^*(\tau)$$

where

$$\ell = 1, \dots, N_\ell$$

$$\text{Mode}(k,\tau) = \bar{\ell}$$

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The algorithm for calculating  $\Phi_j(\tau_j, \ell)$  and  $\text{Pred}(j, \tau_j, \ell)$  is then

$$\begin{aligned}\Phi_j(\tau_j, \ell) &= K\Phi_j(\tau_j, \ell) + \text{Max}_{k \neq j} \Phi_k^*(\tau_j - Q_{kj} - P_{j, \ell}) \\ &= K\Phi_j(\tau_j, \ell) + \Phi_{\bar{k}}^*(\tau_j - Q_{\bar{k}j} - P_{j, \ell})\end{aligned}$$

$$\text{where } \bar{k} = \text{Pred}(j, \ell, \tau_j)$$

The selection of the last target in the optimal sequence<sup>†</sup> is then done as follows:

$$\begin{aligned}\text{Best Score} &= \text{Max}_j (\text{Max}_\tau \Phi_j^*(\tau)) \\ &= \Phi_{\bar{j}}^*(\tau_{\bar{j}})\end{aligned}$$

Then  $\bar{j}$  is the last target to be photographed in the optimal sequence and

$$\tau_{\bar{j}} = \text{Min } \tau_{\bar{j}}$$

at which

$$\Phi_{\bar{j}}^*(\tau) = \text{Best Score}$$

This algorithm allows  $\tau_j$  to take on any value over its range, rather than having  $\tau_j$  chosen from a discrete set of values. The algorithm as stated will permit interleaving. The occurrence of interleaving can be prohibited by the use of an option which employs a modification of the above stated algorithm. This is discussed in a later section.

<sup>†</sup>The optimal sequence of targets to be photographed is selected recursively in TWMO SP2 by finding an optimal finish time and an optimal predecessor for each target in the sequence.

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#### 3.8.4.2 The Individual Scoring Function For a Given Target

The value of a specific target is a function of the Basic worth calculated in TWEEDOFF and the parameters MMULT and  $\phi(\tau)$ . Thus the value of a target takes into account such factors as obliquity, activity of the target, stereo angle, and priority. In TWMOSE, the value of a specific target using a specific kind of photographic sequence (a specific mode) is a function only of the finish time  $\tau_j$  of the photographic sequence.

The individual score or weight,  $W(\tau)$ , of a given target  $j$  with a photographic finish time  $\tau$  is calculated as follows:

$$W(\tau) = \text{Basic Worth} \times \text{MMULT} \times \phi(\tau)$$

or

$$W(\tau) = K \times \phi(\tau)$$

where

$$K = \text{TWI} \times \text{MMULT}$$

MMULT is the photographic mode multiplier which is a function of the mode requested and the mode selected. This coefficient is a number between zero and one which is input by the File 8 parameters EGT300 through EGT399 (see Reference 1).

TWI is the basic worth of a target as computed by the subfunction TWEEDOFF and stored in the MOCOT table (see Section 3.7).

The stereo angle deweighting factor,  $\phi(\tau)$ , is determined from the File 8 parameters EGT180 to EGT229, which can be used to define up to 10 stereo weighting functions. The function to be used for a particular target is specified as a target card parameter. A description of the function  $\phi(\tau)$  is provided in Figure 3-9.

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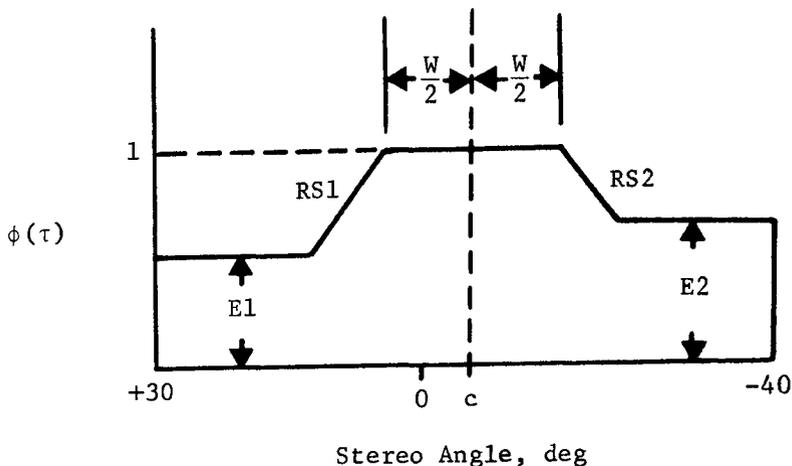


Figure 3-9. Stereo Angle Weighting Function

where

- W is an angle defining the area in which  $\phi(\tau) = 1$  (measured in degrees)
- RS1 is the reciprocal slope of this line segment (measured in degrees)
- RS2 is the reciprocal slope of this line segment (measured in degrees)
- E1 is the height of this horizontal segment (non-dimensional)
- E2 is the height of this horizontal segment (non-dimensional)
- c is the desired central stereo angle (this is indicated on the target card)

It should be noted that the input function is provided in terms of stereo angle,  $\Sigma$ , rather than time. The conversion from stereo angle to time is performed by the procedure PHIC which is used to determine the  $\phi(\tau)$  function for each target. The stereo angle used to define the input function is the stereo angle at the midpoint of the photographic sequence.

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Since the algorithm is based on finish times rather than mid sequence times, a translation of the function is required. This is also performed by the procedure PHIC.

### 3.8.4.3 The Conflict Equations and the Determination of Possible Predecessor Targets

The range of possible predecessors is limited by the quantities MTM and MTN which are computed in the subfunction TWEEDOFF. That is, the MOCOT number  $k$  of a possible predecessor to  $j$  is such that

$$MTM \leq k \leq MTN.$$

When considering a target  $k$  as an immediate predecessor to a target  $j$  with a photographic finish time  $\tau_j$ , there are three possibilities.

- a. It is possible to photograph target  $k$  for its maximum score at some finish time  $\tau_k$ , maneuver from  $k$  to  $j$ , and settle in time to initiate photography of  $k$  and finish at time  $\tau_j$ .
- b. It is impossible to photograph  $k$  for any score and still have time to maneuver from  $k$  to  $j$ , settle, and initiate photography on  $j$  and finish at time  $\tau_j$ .
- c. The time required to slew from target  $k$  to target  $j$ , settle, and initiate photography on  $j$  with finish time  $\tau_j$  is such that it is not possible to photograph  $k$  with a maximum score. It is possible, however, to obtain some score from  $k$ .

Consider a method used to distinguish between the three cases. The following definitions are needed in the analysis:

- $a_j$  = time when it is first possible to acquire target  $j$  with main optics
- $T_j$  = time interval between first and last possible acquisition times of target  $j$  with the main optics
- $-A$  = minimum main optics stereo angle (stereo required at time  $a_j$  for acquisition of target  $j$  by main optics)
- $B$  = maximum main optics stereo angle (stereo required at time  $a_j + T_j$  for acquisition of target  $j$  by main optics)
- $b_j$  = main optics obliquity angle required for acquisition of target  $j$  at time  $a_j$
- $\delta b_j$  = change in main optics obliquity angle between times  $a_j$  and  $a_j + \tau_j$
- $P_j$  = time required to photograph target  $j$
- $\tau_j$  = time at which the photography of target  $j$  is finished (measured from  $a_j$ )

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Assume that target k is photographed first with finish time  $\tau_k$  and, then, target j is photographed with finish time  $\tau_j$ . The required obliquity angle through which the main optics must move in order to finish photography of k at  $\tau_k$  and be ready to photograph j at time  $\tau_j - P_j$  is  $\Delta R_{req}$

where

$$\Delta R_{req} = \left( b_j + \frac{\delta b_j}{T_j} (\tau_j - P_j) \right) - \left( b_k + \frac{\delta b_k}{T_k} \tau_k \right)$$

Similarly, the required stereo angle change  $\Delta P_{req}$  is

$$\Delta P_{req} = \left( -A + \frac{B+A}{T_j} (\tau_j - P_j) \right) - \left( -A + \frac{B+A}{T_k} \tau_k \right)$$

Let

$$\Delta b = b_j - b_k$$

$$\Delta \tau = \tau_j - \tau_k$$

$$\sigma = T_j - T_k$$

$$\Delta a = a_j - a_k$$

and

$$\begin{aligned} \Delta t &= (a_j + \tau_j - P_j) - (a_k + \tau_k) \\ &= \Delta a + \Delta \tau - P_j \end{aligned}$$

Moreover, let

$$\alpha_{kj} = \frac{\left( \frac{\delta b_j}{T_j} + \frac{\delta b_k}{T_k} \right)}{2}$$

and assume that

$$\frac{\delta b_j}{T_j} \stackrel{\circ}{=} \alpha_{kj} \stackrel{\circ}{=} \frac{\delta b_k}{T_k}$$

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This latter assumption will introduce some error in  $\Delta R_{req}$ , but this error is small (see Reference 2 pp.96-97). Thus, the equations for  $\Delta R_{req}$  and  $\Delta P_{req}$  can be rewritten as

$$\Delta R_{req} = \Delta b + \alpha_{kj} \Delta t - \alpha_{kj} \Delta a$$

$$\Delta P_{req} = \frac{B+A}{T_k} \left( \Delta t - \Delta a - \frac{\sigma(\tau_j - P_j)}{T_j} \right)$$

If the finish time  $\tau_j$  of photography of target  $j$  is fixed, then  $\Delta P_{req}$  and  $\Delta R_{req}$  are linear functions of  $\Delta t$ . The time required to perform various stereo and obliquity maneuvers is assumed to be a piecewise linear function of time as shown in Figure 3-10.

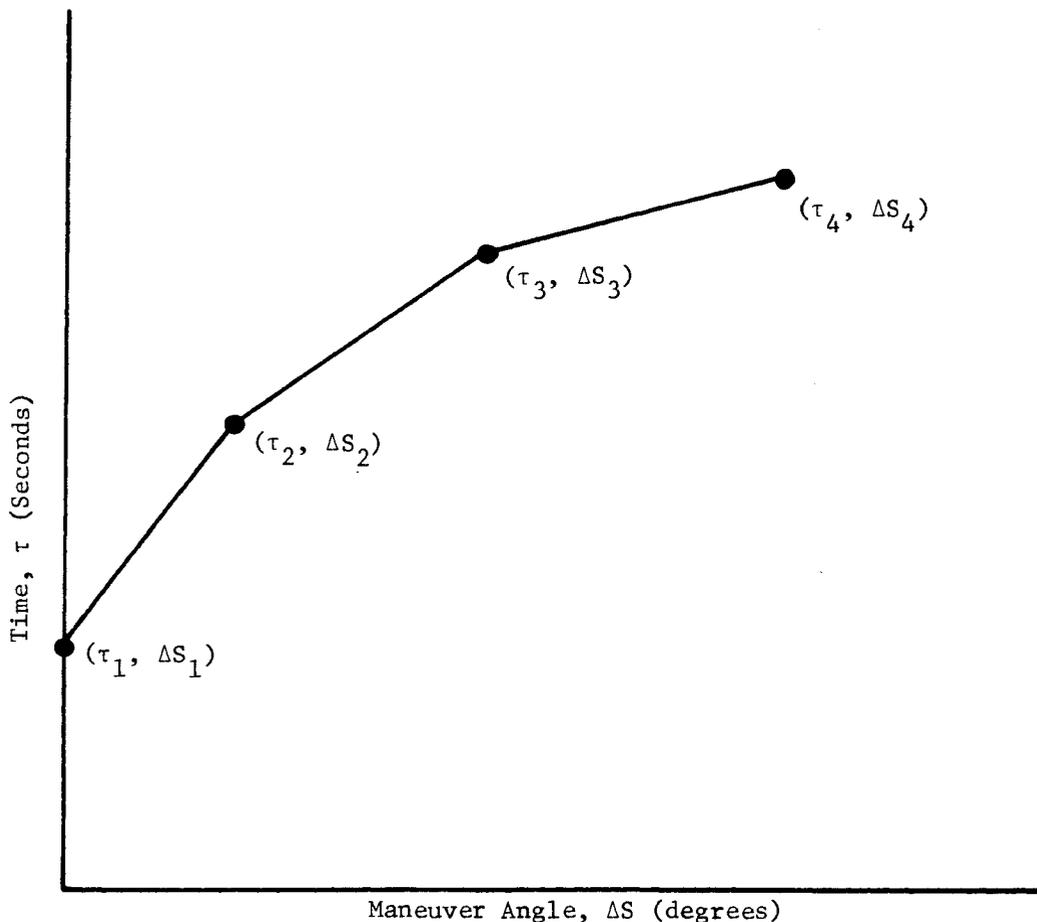


Figure 3-10. Maneuver Time Required vs Maneuver Magnitude

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These functions are determined by the points  $(t_i, \Delta S_i)$  ( $i = 1, 2, 3, 4$ ) which are defined by the File 8 input parameters EGT950 through EGT 965. The quantity  $\Delta S$  in the previous figure represents both obliquity ( $\Delta R$ ) and stereo ( $\Delta P$ ) maneuvers. Denote the obliquity angle achievable in a time interval  $\Delta t$  by  $\Delta R(\Delta t)$ . Then, in order for a  $\tau_k$  to be feasible, the relation  $\Delta R_{req} \leq \Delta R(\Delta t)$  must hold. Figure 3-11 below shows  $\Delta R_{req}$  and  $\Delta R(\Delta t)$  plotted as a function of  $\Delta t$ . At the point G,  $\Delta R_{req} = \Delta R(\Delta t)$ , and for  $\Delta t < \Delta t_G$  the required obliquity maneuver cannot be performed in the time available.

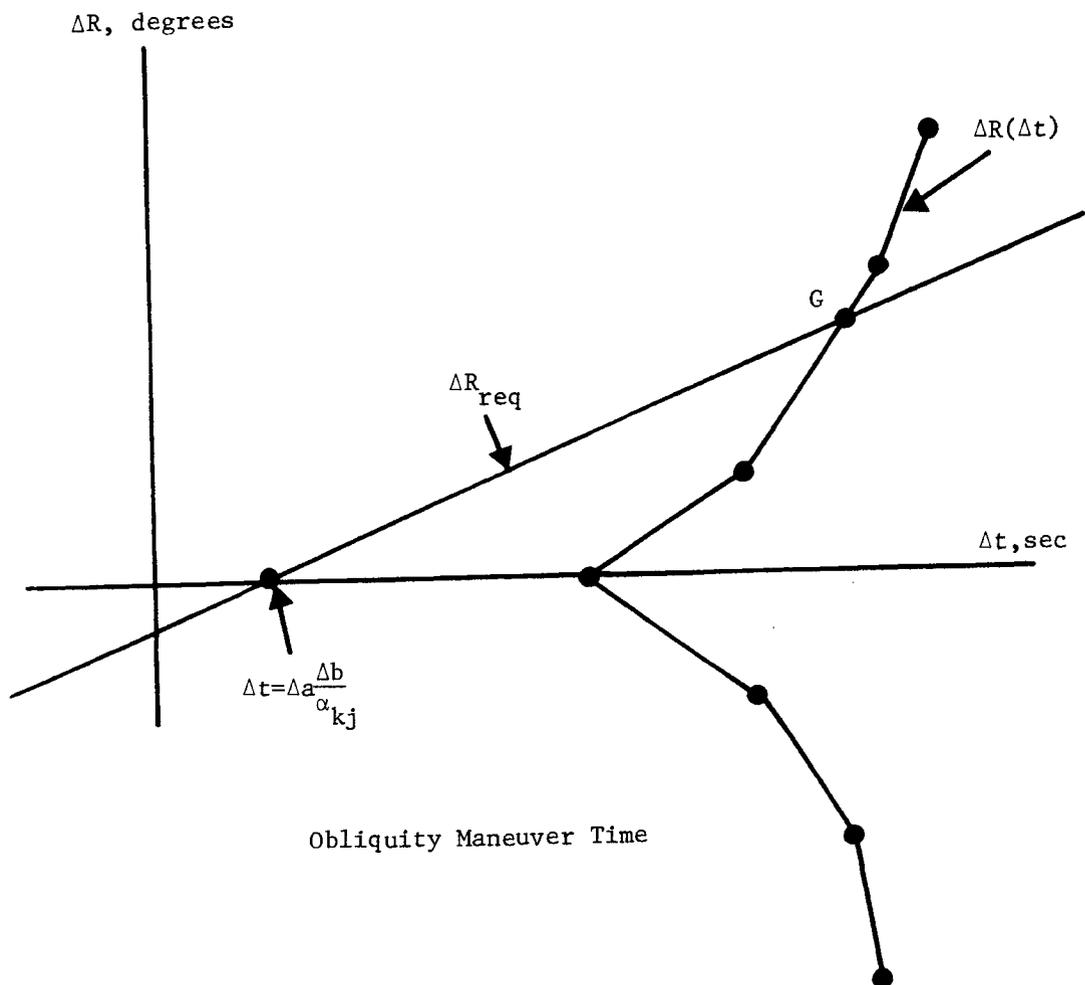


Figure 3-11.  $\Delta R_{req}$  and  $\Delta R(\Delta t)$  vs  $\Delta t$ .

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Similarly, denoting the stereo angle change achievable in time  $\Delta t$  by  $\Delta P(\Delta t)$ , the relation

$$\Delta P_{\text{req}} \leq \Delta P(\Delta t)$$

must be satisfied in order for a time  $\tau_k$  to be feasible. A plot similar to that shown in Figure 3-11 can then be drawn for stereo versus  $\Delta t$ . This yields a  $\Delta t_H$  such that for  $\Delta t < \Delta t_H$ , the required stereo maneuver cannot be achieved in the time available.

The piecewise linear functions which yield  $\Delta P(\Delta t)$  and  $\Delta R(\Delta t)$  are specified as:

$$\Delta P = \pm M_p(m) (\Delta t - S_p(m))$$

for

$$\Delta t_p(m-1) \leq \Delta t \leq \Delta t_p(m)$$

and

$$m = 1, \dots, M$$

$$\Delta R = \pm M_R(n) (\Delta t - S_R(n))$$

for

$$\Delta t_R(n-1) \leq \Delta t \leq \Delta t_R(n)$$

$$n = 1, \dots, N$$

where

$$\frac{A+B}{T_k} < M_p(1) < M_p(2) < \dots < M_p(m)$$

$$\alpha_{kj} < M_R(1) < M_R(2) < \dots < M_R(n)$$

The M's are the slopes of the lines, the S's are the intercepts of the lines, and the  $\Delta t$ 's are the limits of the domains of definition for each line segment. The parameters  $Q_{kjR}$  and  $Q_{kjP}$  are then defined by the equations given below. These parameters then define  $Q_{kj}$  which satisfies the relation

$$\Delta \tau \geq Q_{kj} + P_j$$

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The following equations are used by the procedure CONFLICT to determine the parameter  $Q_{kj}$ .

$$Q_{kjR}^{+P_j} = \min_{n=1, \dots, N} \left( \frac{\Delta b - \alpha_{kj} \Delta a + M_R(n) S_R(n)}{M_R(n) - \alpha_{kj}} \right) + P_j - \Delta a$$

for

$$\Delta a - \frac{\Delta b}{\alpha_{kj}} < S_R(1)$$

or

$$Q_{kjR}^{+P_j} = \min_{n=1, \dots, N} \left( \frac{\Delta b - \alpha_{kj} \Delta a - M_R(n) S_R(n)}{-M_R(n) - \alpha_{kj}} \right) + P_j - \Delta a$$

for

$$\Delta a - \frac{\Delta b}{\alpha_{kj}} > S_R(1)$$

for the obliquity. Similarly, for the stereo

$$Q_{kjP}^{+P_j} = \min_{m=1, \dots, M} \left( \frac{\Delta a}{\beta(m)-1} + \frac{\sigma \beta(m) (\tau_j - P_j)}{T_j (\beta(m)-1)} - \frac{S_P(m)}{\beta(m)-1} \right) + P_j$$

for

$$\Delta a + \frac{\sigma (\tau_j - P_j)}{T_j} < S_P(1)$$

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or

$$Q_{kjP} + P_j = \min \left( \frac{\sigma\beta(m) (\tau_j - P_j)}{T_j(1+\beta(m))} - \frac{\Delta a}{1+\beta(m)} + \frac{S_p(m)}{1+\beta(m)} \right) + P_j,$$

for

$$\Delta a + \frac{\sigma(\tau_j - P_j)}{T_j} > S_p(1) .$$

So, it is necessary that

$$\Delta\tau > Q_{kjP},$$

$$\Delta\tau > Q_{kjR},$$

and

$$\tau_j - \tau_k = \Delta\tau > Q_{kjP} + P_j$$

where

$$Q_{kj} = \max (Q_{kjP}, Q_{kjR}) .$$

Since  $0 \leq \tau_j < T_j$  and  $0 \leq \tau_k \leq T_k$ , the limits of  $\Delta\tau = \tau_j - \tau_k$  are  $T_j \geq \Delta\tau \geq -T_k$ . At the beginning of this section, three possible cases for  $k$  being a predecessor of  $j$  were discussed. These are related to  $Q_{kj}$  as follows:

- 1)  $Q_{kj} + P_j \leq -T_k$ ;  $k$  is a predecessor of  $j$  for the entire range
- 2)  $Q_{kj} + P_j > T_j$ ;  $k$  is not a feasible predecessor of  $k$
- 3)  $T_j \geq Q_{kj} + P_j \geq -T_k$ ;  $k$  is a predecessor of  $j$  for some of the range of values of  $\Delta\tau$

The calculation of  $Q_{kj}$  is discussed in more detail in Reference 2 on pp. 91-124.

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### 3.8.4.4 The Construction of $\phi_j^\dagger$

The computation  $\phi_j(\tau_j)$  requires  $\phi_{j,l}(\tau_j)$  for each mode  $l$  ( $1 \leq l \leq L_j$ ). In computing the function  $\phi_{j,l}(\tau_j)$  for each of the modes  $l$  ( $1 \leq l \leq L_j$ ), the computation must, in general, be done over only part of the range  $0 \leq \tau_j \leq T_j$  of that target. The interval over which computation may be carried out is  $\alpha_j \leq \tau_j \leq \bar{\alpha}_j$ . Furthermore, the construction of  $\phi_{j,l}(\tau_j)$  is dependent upon the existence of  $\phi_k^*(\tau_k)$  for each predecessor  $k$  of  $j$ . There are two important decisions to be made in computing  $\phi_{j,l}(\tau_j)$ ; the choice of the proper  $j$  and the determination of the largest possible range  $\alpha_j \leq \tau_j \leq \bar{\alpha}_j$  over which calculations can be carried out.

The parameters  $\alpha_j$  defines the extent to which the function  $\phi_j$  has been completed. Since  $\alpha_j$  is referenced to initial acquisition time, this corresponds to a time  $a_j + \alpha_j$ . The target that has the lowest numerical value of  $a_j + \alpha_j$  is then the earliest uncompleted target (provided that  $\alpha_j < T_j$ , since  $\alpha_j = T_j$  implies that the function for this target has been completed). The process of finding the proper target to analyze is performed by simply finding the target that has the minimum value of  $a_j + \alpha_j$  subject to the constraint that only targets that have not already been completely defined are considered. Initially,  $\alpha_j$  is set equal to zero for all targets. The first target to be considered is then the target that has the earliest first acquisition time,  $a_j$ .

The extent to which the function  $\phi_j$  can be developed is limited by the state of completion of the candidate predecessors with respect to target  $j$ . If all predecessor functions  $\phi_k(\tau_k)$  have been completed over the allowable range  $0 \leq \tau_k \leq T_k$ , then the target  $j$  can be completed (i.e.,  $\bar{\alpha}_j = T_j$ ). If the predecessor functions have not been completed, the target  $j$  can be developed up to the time  $\bar{\alpha}_j$  where

$$\bar{\alpha}_j = \text{Min}_{k \neq j} (Q_{kj} + P_j + \alpha_k)$$

Beyond this time, the predecessors to target  $j$  are not properly defined. The computations then proceeds by developing segments of individual targets until all targets have been completed.

<sup>†</sup>Symbols used are defined in Sections 3.8.4.1 and 3.8.4.2.

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After the target  $j$  has been chosen and the parameters  $\bar{\alpha}_j$  has been determined, the function  $\Phi_{j,\ell}(\tau_j)$  is determined for each photographic mode  $\ell$ .

Thus,

$$\Phi_{j,\ell}(\tau_j) = \text{Max}_{k \neq j} \Phi_k^*(\tau_j - Q_{kj} - P_j) + K\Phi_j(\tau_j, \ell)$$

where  $MTM \leq k \leq MTN$  and  $\alpha_j \leq \tau_j - Q_{kj} - P_j \leq \bar{\alpha}_k$ .

Therefore,

$$\Phi_{j,\ell}(\tau_j) = \Phi_{\bar{k}}^*(\tau_j - Q_{kj} - P_j) + K\Phi_j(\tau_j, \ell)$$

for some  $\bar{k}$ . The optimal predecessor is then  $\bar{k}$ , and  $\text{pred}(j, \ell, \tau_j) = \bar{k}$ . The use of  $\tau_j - Q_{kj} - P_j$  translates the time axes of each feasible predecessor  $k$  by the photography time  $P_j$  plus the minimum time required to maneuver from  $k$  to  $j$  and settle.

The function  $\Phi_{j,\ell}(\tau_j)$  is then flattened, that is, the function  $\Phi_{j,\ell}^*(\tau_j)$  is calculated for the mode  $\ell$ . This calculation is

$$\Phi_{j,\ell}^*(\tau_j) = \text{Max}_{\tau \leq \tau_j} \Phi_{j,\ell}(\tau)$$

A flattening table  $\text{Flat}(j, \ell, \tau)$  is also constructed defining, the regions where  $\Phi_{j,\ell}^*$  is greater than  $\Phi_{j,\ell}$ . This table contains the  $\tau$  values at the beginning and end of each flattened region and a bit ( $ff$ ) that identifies where flattening has occurred. A setting of  $ff=1$  identifies the beginning of a flattened region and  $ff=0$  indicates the beginning of an unflattened region.

NOTE: The parameters  $MTM$  and  $MTN$  are MOCOT table entries. For their description, see Section 3.7.3.

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An example of a flattening is shown in Figure 3-12. The dotted lines show where  $\phi_{j,l}^*(\tau) > \phi_{j,l}(\tau)$

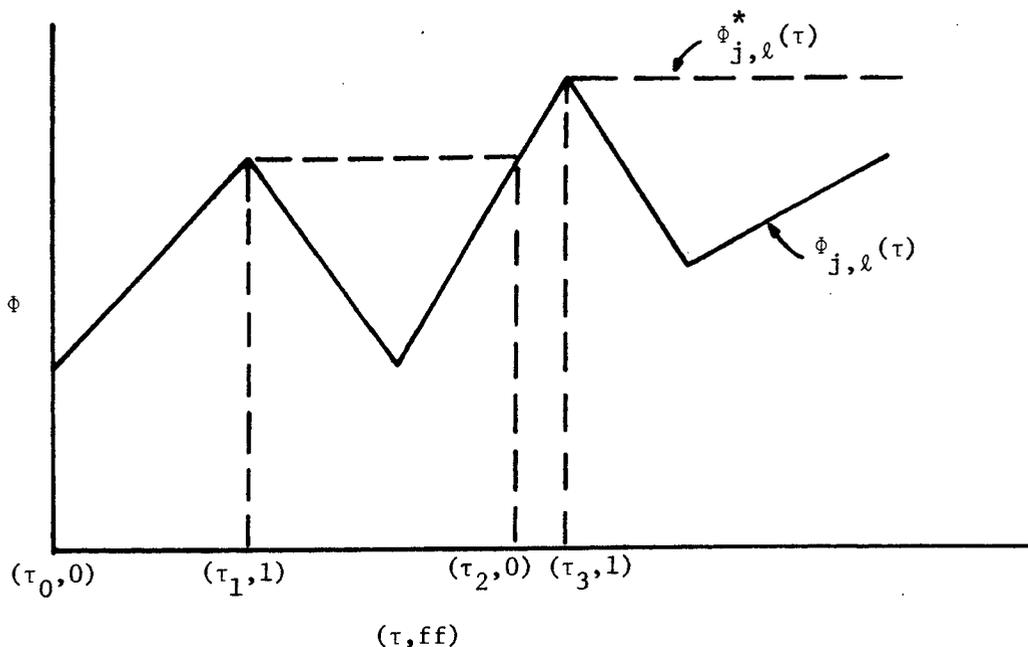


Figure 3-12. Example of Flattened  $\phi$  Function

The entire process is repeated for each possible photographic mode of target  $j$  to yield a maximum score function  $\phi_{j,l}(\tau)$  for each mode  $l = 1, 2, \dots, L_j$ . Then,

$$\phi_j^*(\tau_j) = \text{Max}_{l=1, \dots, L_j} \phi_{j,l}^*(\tau_j) = \phi_{j, l_{\tau_j}}^*(\tau_j)$$

where  $l_{\tau_j}$  = the optimal mode for the  $j$ th target and photographic finish time  $\tau_j$ .

The optimal predecessor at  $\tau_j$  is  $\text{pred}(j, \tau_j)$  for mode  $l(\tau_j)$ .

The construction of  $\phi_j(\tau_j)$  is continued until all of the targets in the MOCOT have been completed. Then the target with the largest maximum score is found, and this information is entered in the second file of the ALMOST Table.

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#### 3.8.4.5 Construction of $\phi_j(\tau)$ for the Time Ordered Algorithm

When EGT941 is set equal to 1, the following modifications are made in the construction of  $\phi_j(\tau)$ .

- a. The value of MTN for each target is set equal to the MOCOT number of the target.
- b. For a given target  $j$ , only those predecessors  $k$  are considered whose initial acquisition time  $a_k$  is less than or equal to  $a_j$ , the initial acquisition time of the target  $j$ . In the case of  $a_k = a_j$ , the target  $k$  is considered as predecessor of  $j$  only if its maximum score function  $\phi_k(\tau)$  has already been computed.
- c. The entire range of values of  $\phi_j(\tau)$  is computed at one time. That is,  $\alpha_j = T_j$  which is the maximum of  $\tau$  for target  $j$ .

The principle effect of the above modifications is to shorten running time considerably. The reasons for this are fairly obvious. The number of possible predecessors for a given target is often reduced, and the  $\phi_j(\tau)$  for each target is computed for the entire range  $0 \leq \tau \leq T_j$  at one time. The reduction in running time is, of course, dependent on the particular selection of targets passed to TWOSP in the MOCOT. Since the time ordered algorithm limits the number of possible predecessors to a given target, the resultant selection may be suboptimal. However, the conditions under which this represents a significant decrease from the optimum are not known and this option will require further study.

#### 3.8.4.6 Construction of $\phi_j(\tau)$ and $\phi_{jA}(\tau)$ for the Inhibit Interleave Algorithm

The output of TWOSP may result in a selection of targets for the main optics which contains the same target more than once. If targets are denoted by A, B, and C, then the inhibit interleaving option (EGT042=1) is designed to prohibit a selection of targets for the main optics where A is photographed then B, and then A again (ABA). The algorithm will not specifically prohibit other types of interleaving such as ABCA. This option computes a maximum score function  $\phi_j^*(\tau)$  and an alternate maximum score function  $\phi_{Aj}^*(\tau)$  for each target  $j$ . The algorithm for computing these functions is very similar to that used in 3.8.4.1 for computing  $\phi_j^*(\tau)$ . The notation used for the statement of the algorithm is as follows:

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$\Phi_{j,\ell}(\tau_j)$  = Maximum score obtained by photographing a sequence of targets ending with target  $j$  and finishing the photography of  $j$  at time  $\tau_j$ . The mode of photography of  $j$  at time  $\tau_j$ . The mode of photography on  $j$  is  $\ell$ . The sequence will not contain ABA inter-leaving.

$\Phi_{j,\ell}^*(\tau_j)$  = Max  $\Phi_{j,\ell}(\tau)$   
 $\tau \leq \tau_j$

Pred ( $j, \ell, \tau_j$ ) = Optimal predecessor of  $j$  when the photographic mode of  $j$  is  $\ell$  and the finish time of the photography is  $\tau_j$ .

Flat ( $j, \ell, \tau_j$ ) =  $\begin{cases} 1, & \text{if } \Phi_{j,\ell}^*(\tau_j) > \Phi_{j,\ell}(\tau_j) \\ 0, & \text{otherwise} \end{cases}$

$\Phi_j^*(\tau_j)$  = Max  $\Phi_{j,\ell}^*(\tau_j)$  =  $\Phi_{j,\ell_{\tau_j}}^*(\tau_j)$   
 $\ell=1, \dots, L_j$

Mode ( $j, \tau_j$ ) =  $\ell_{\tau_j}$  in the above definition

$\Phi_{A,j,\ell}(\tau_j)$  = Alternate maximum score obtained by photographing a sequence of targets such that:

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- a) the sequence terminates with target j
- b) the mode of photography on j is  $\ell$
- c) the finish time of the photography on j is  $\tau_j$
- d) the predecessor of j in the "alternate optimal sequence" is not  $\text{pred}(j, \ell, \tau_j)$
- e) the sequence will not interleave.

$\text{Pred}_A(j, \ell, \tau_j)$  = The alternate optimal predecessor to j. That is, the predecessor used to compute  $\Phi_{A,j,\ell}(\tau_j)$ . By its definition,  $\text{Pred}_A(j, \ell, \tau_j) \neq \text{Pred}(j, \ell, \tau_j)$

The terms  $\text{Pred}_A(j, \ell, \tau_j)$ ,  $\text{Flat}_A(j, \ell, \tau_j)$ ,  $\Phi_{Aj}^*(\tau_j)$ , and  $\text{Mode}_A(j, \tau_j)$  are defined analogously to the terms  $\text{Pred}(j, \ell, \tau_j)$ ,  $\text{Flat}(j, \ell, \tau_j)$ ,  $\Phi_j^*(\tau_j)$ , and  $\text{Mode}(j, \tau_j)$ . The statement of the algorithm is:

$$\begin{aligned} \Phi_{j,\ell}(\tau_j) &= K\Phi_j(\tau_j, \ell) \\ &+ \text{Max} \left\{ \delta \Phi_k^*(\tau_j - Q_{kj} - P_j) + (1-\delta) \Phi_{Ak}^*(\tau_j - Q_{kj} - P_j) \right\} \end{aligned}$$

$$\text{MTM} \leq k \leq \text{MTN}$$

$$\text{where } \delta = \begin{cases} 1 & \text{if } \text{Pred}(k, \ell, \tau_j - Q_{kj} - P_j) \neq j, \\ 0 & \text{otherwise} \end{cases}$$

$$\text{and } 0 \leq \tau_j - Q_{kj} - P_j \leq \bar{\alpha}_j.$$

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Then

$$\phi_{j,\ell}(\tau_j) = K\phi_j(\tau_j) + \begin{cases} \phi_k^*(\tau_j - Q_{kj} - P_j), & \text{if } \delta=1 \\ \phi_{A\bar{k}}^* - (\tau_j - Q_{kj} - P_j), & \text{if } \delta=0 \end{cases}$$

and

$$\text{Pred}(j,\ell,\tau_j) = \bar{k}$$

The computation of  $\phi_{Aj,\ell}(\tau_j)$  is the same as  $\phi_{j,\ell}(\tau_j)$  except that the predecessor  $k$  cannot equal  $\text{Pred}(j,\ell,\tau_j)$ . The computation of  $\text{Flat}(j,\ell,\tau_j)$ ,  $\text{Mode}(j,\tau_j)$ , and  $\text{Mode}_A(j,\tau_j)$  is done the same as in Section 3.8.4.3.

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### 3.8.4.7 Flow Charts

A few remarks concerning the flow charts shown in Figure 13 are in order. The parameters  $f$  and  $g$  are used in the inhibit interleaving option to identify maximum score functions and alternate maximum score functions. The parameter  $f$  refers to the target whose score function is being computed. The parameter  $g$  refers to the target which is being considered as a predecessor. A setting of 0 indicates that the function is the maximum score function and 1 identifies the alternate maximum score function.

The flow of computations is roughly as follows.

- a. Read in data from MOCOT as memroy space is available.
- b. Select target,  $j$ , whose maximum score function is to be computed.
- c. The score function is computed piecewise, and the time interval  $\alpha_j \leq \tau_j \leq \bar{\alpha}_j$  over which computation is done is computed. If the time ordered solution is being computed, then the entire range of values for the score function is computed at once.
- d. For each feasible predecessor  $k$  of  $j$ , the following is done:
  1. If the predecessor  $k$  is not in total conflict then translated  $\phi_k$  is translated by  $Q_{kj} + P_j$ .
  2. If interleaving is to be inhibited then the scoring function of  $k$  is set equal to zero where the predecessor of  $k$  is  $j$ . This will inhibit a selection of  $j$   $k$   $j$ .
  3. When the alternate maximum score function ( $f = 1$ ) is being constructed, the predecessors of the maximum score function ( $f = 0$ ) are disallowed. This is accomplished by setting the worth of a predecessor to zero in regions where this predecessor is included in the maximum score function.
  4. The resultant predecessor score functions are used to find a maximum score function of  $j$ .

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5. The process is repeated for all feasible predecessors. A table of optimal predecessors is computed.
- e. The resultant maximum score function is added to the basic scoring function of j.
- f. The resultant sum is flattened by the formula

$$\bar{\phi}_j^*(\tau_j) = \text{Max } \bar{\phi}_j(\tau).$$

$$\tau \leq \tau_j$$

The flattening table is also computed at this time.

- g. The foregoing calculations are repeated for each mode and the resultant family of maximum score functions for j (one for each mode) is then maximized to form a maximum score function for j. An optimal mode table is also computed.
- h. The resultant target information to be used in TWOSP2 is stored in the MOST table and read into tape as necessary.
- i. The process is repeated for (f = 1) if the inhibit interleaving option is to be used.
- j. When all of the functions have been computed for each target, the last target to be photographed in the optimal sequence along with its finish time, initial acquisition time and the maximum score attained are stored in the ALMOST table and read onto tape.
- k. The program exits from the subfunction.

### 3.8.5 Restrictions

The maximum number of targets that can be contained in core is 220. This becomes a problem only if the target density is such that the number of acquired targets exceeds 220 within approximately 50-60 seconds. If this happens, the program will produce an optimal target selection until the density gets too high and then print an error message. The selection achieved to that point can be obtained by continuing the run or the run can be restarted using a tighter setting of the TWOPS density filter (EGT936 and EGT937).

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To inhibit A-B-A type interleaving, a maximum of 20 targets can be stored as valid predecessor of a given target. This limit is liberal for realistic maneuver and settle times for the vehicle and realistic photography sequence times. A-B-A interleaving can occasionally be forced to occur in high target density areas with infinite maneuver rates and short photographic sequences.

A set of 20 discrete points is available to describe the function representing the sum of the basic scoring function of the target and the resultant maximum function of all possible predecessors. This limit may occasionally be exceeded in regions of dense target distribution. If so, an error analysis is performed to determine which points can be removed producing the minimum amount of error in the function. No discernable errors in the optimal selection have even been detected, due to the limitation.

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TWMOSP

TWMOSP

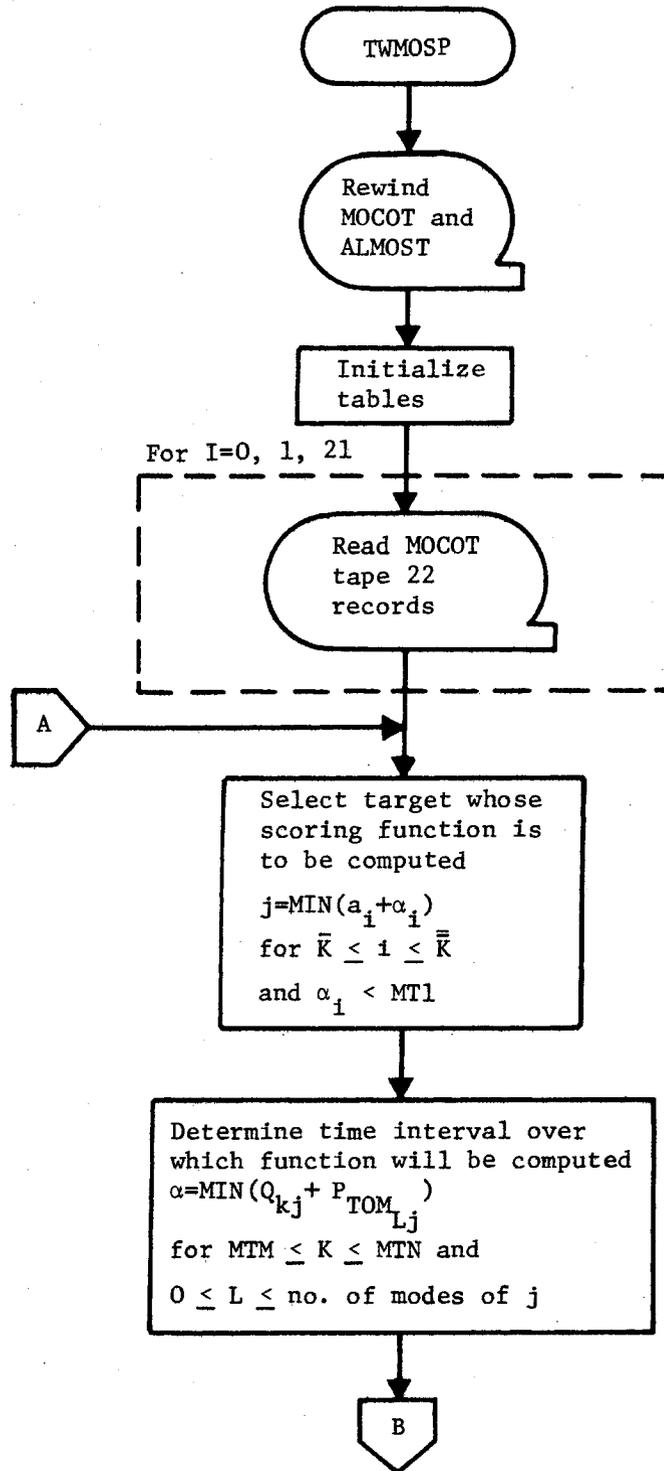


Figure 3-13. TWMOSP Flow Chart

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TWMOSP

TWMOSP

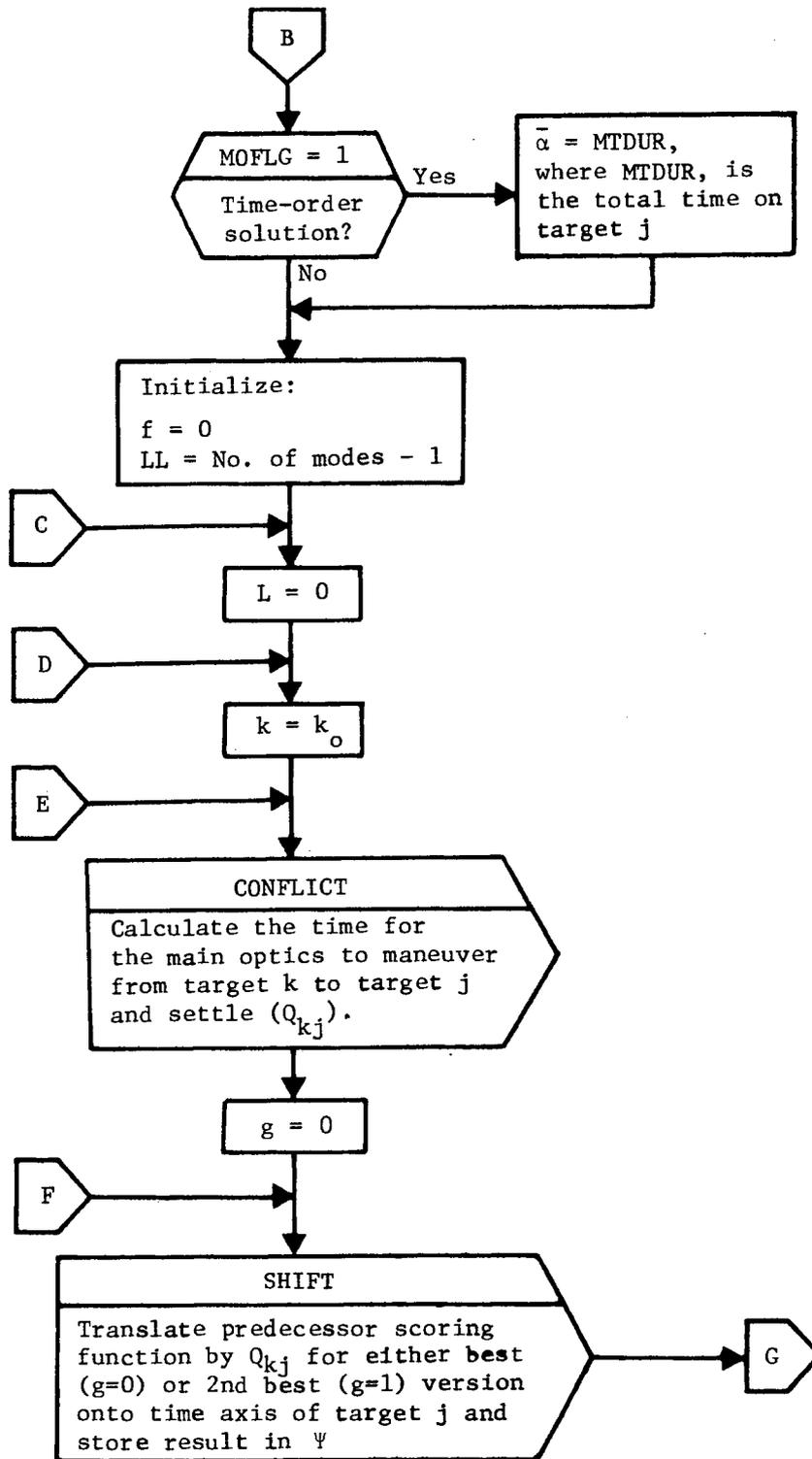


Figure 3-13. TWMOSP Flow Chart (Continued)

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TWMOSP

TWMOSP

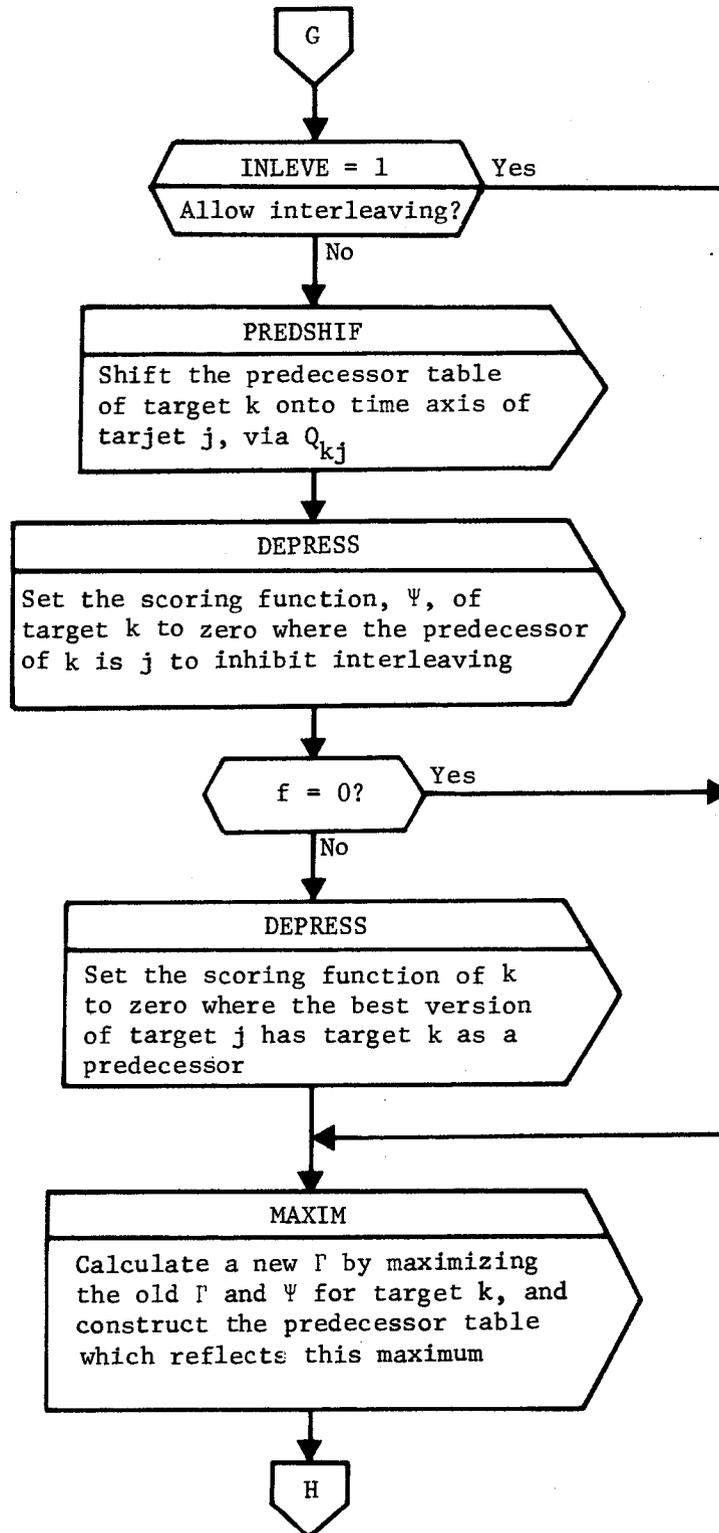


Figure 3-13. TWMOSP Flow Chart (Continued)

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TWMOSP

TWMOSP

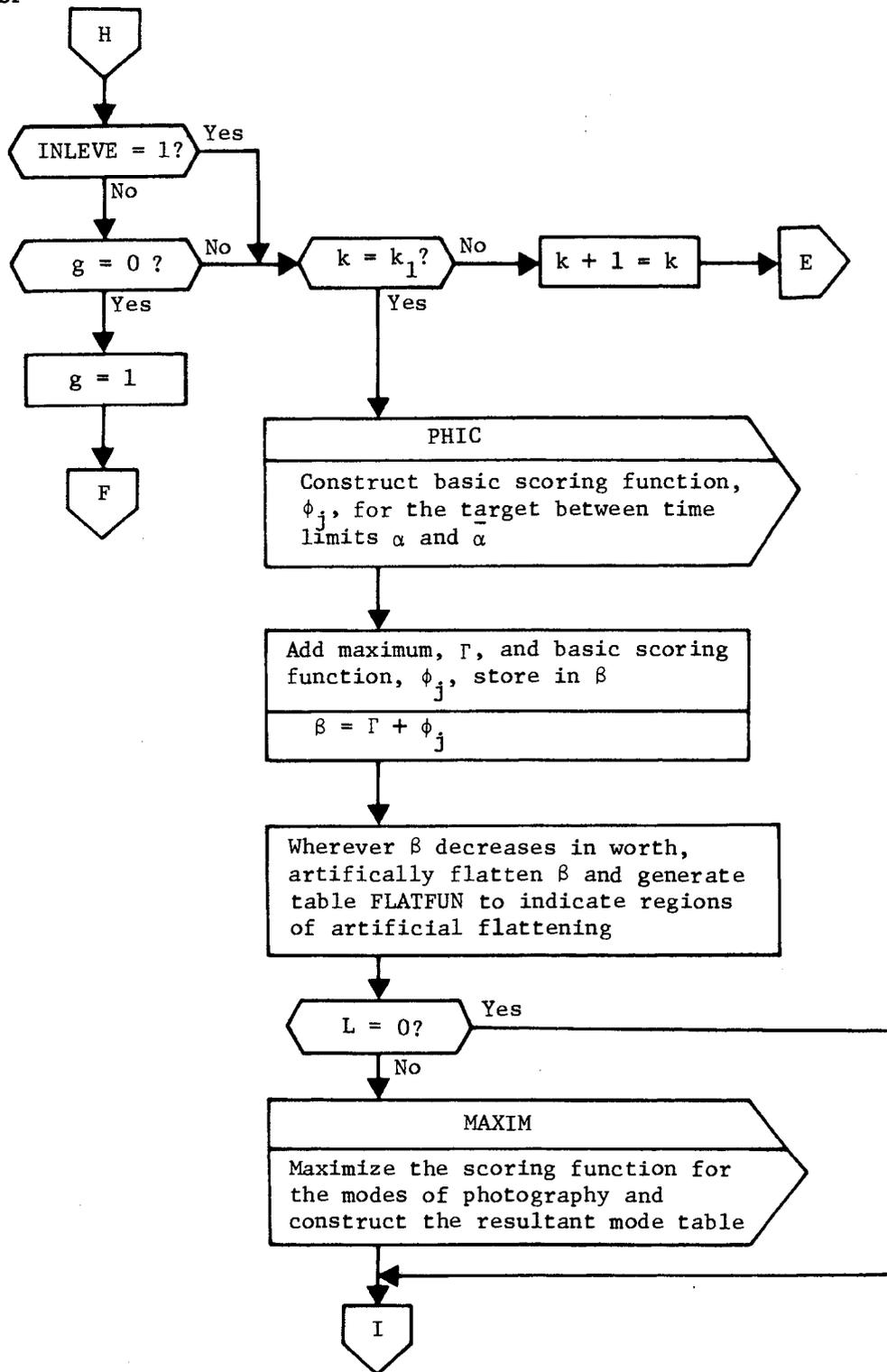


Figure 3-13. TWMOSP Flow Chart (Continued)

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TWMOSP

TWMOSP

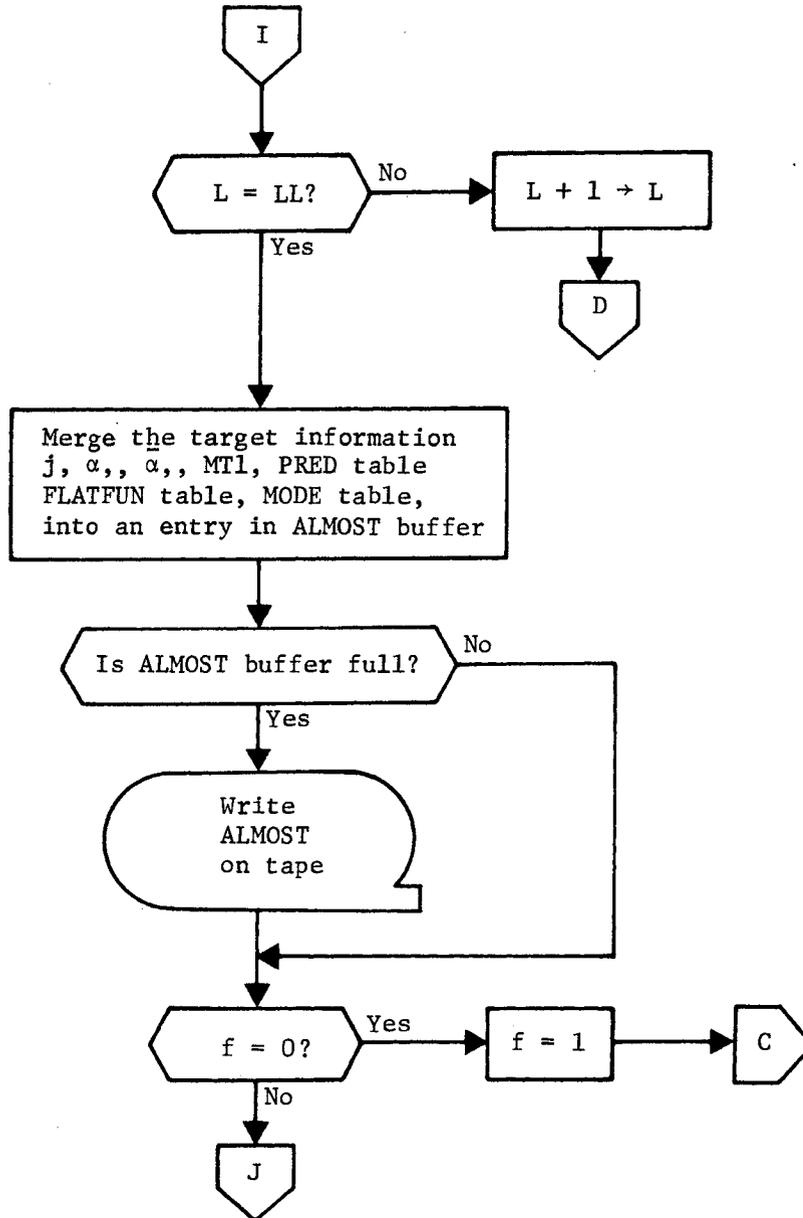


Figure 3-13. TWMOSP Flow Chart (Continued)

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TWMOSP

TWMOSP

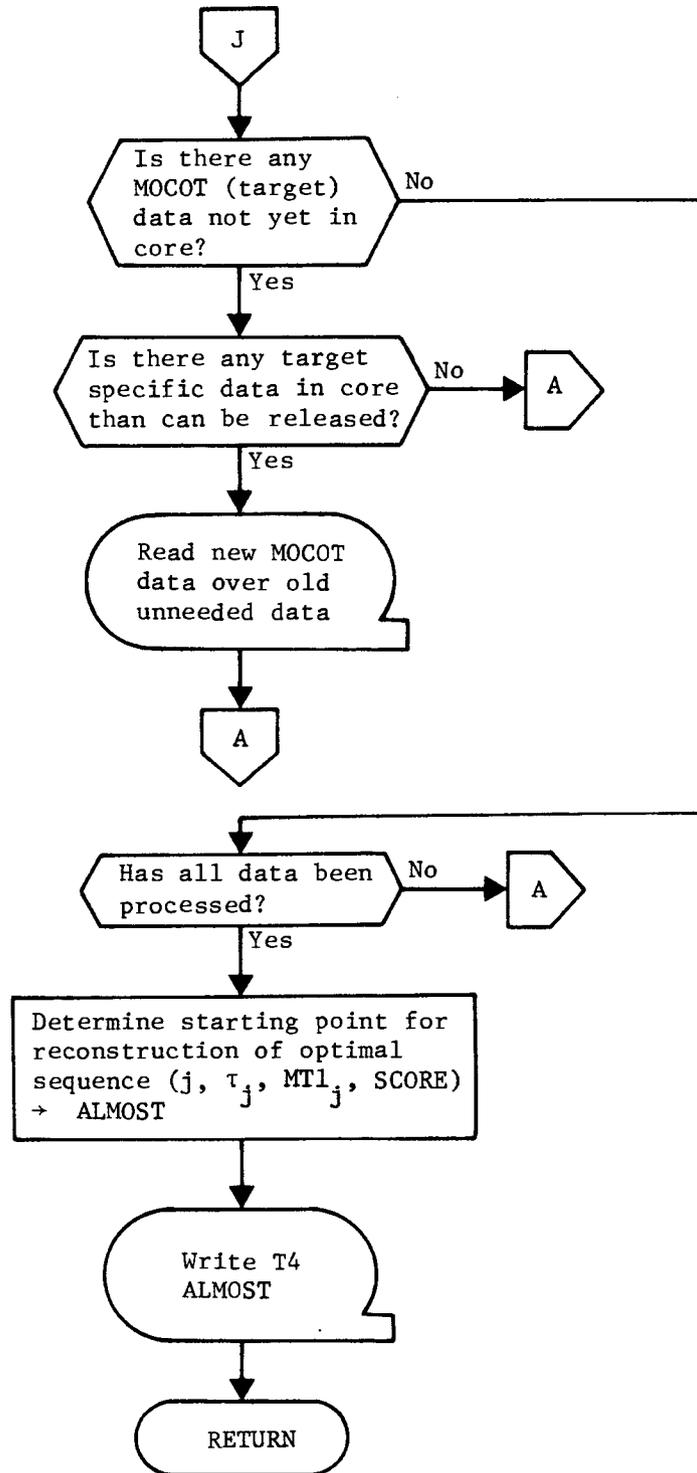


Figure 3-13. TWMOSP Flow Chart (Continued)

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DEPRESS

DEPRESS

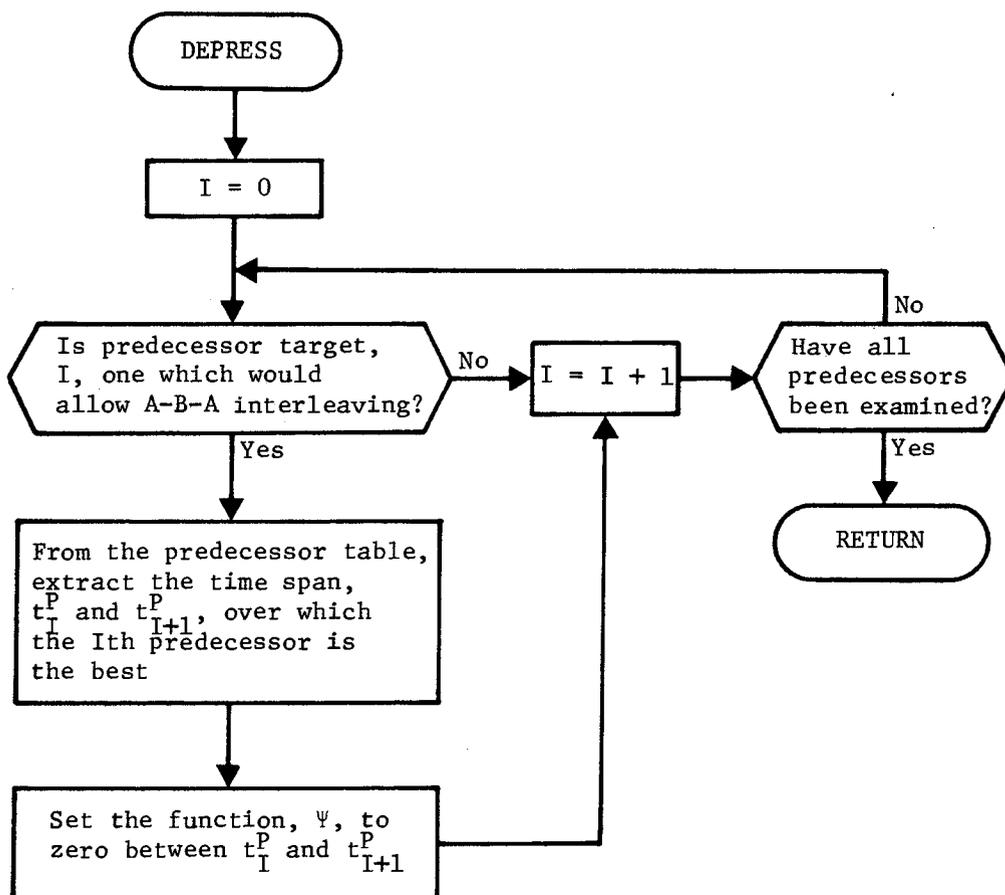


Figure 3-13. TWOSP Flow Chart (Continued)

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MAXIM

MAXIM

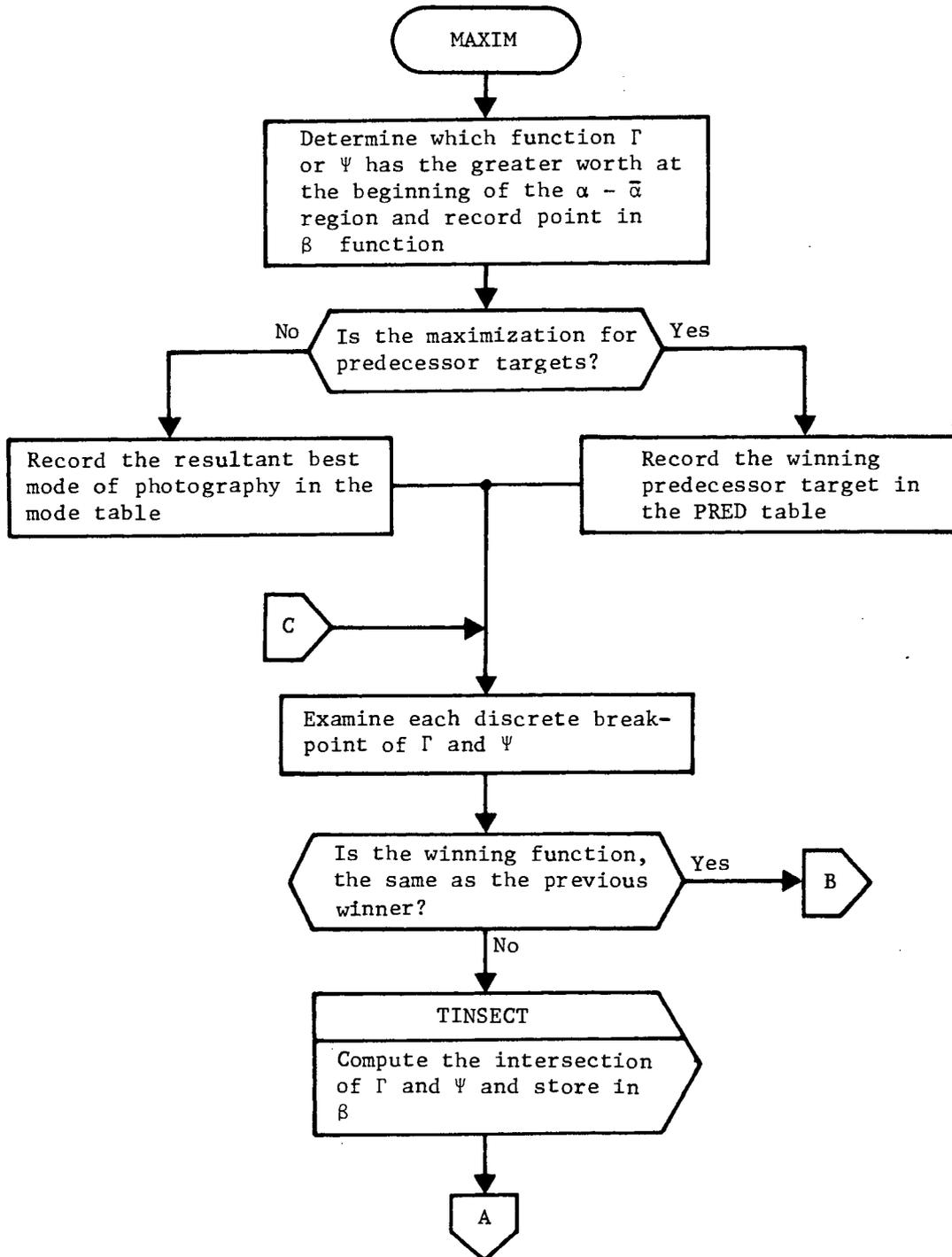


Figure 3-13. TWOSP Flow Chart (Continued)

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MAXIM

MAXIM

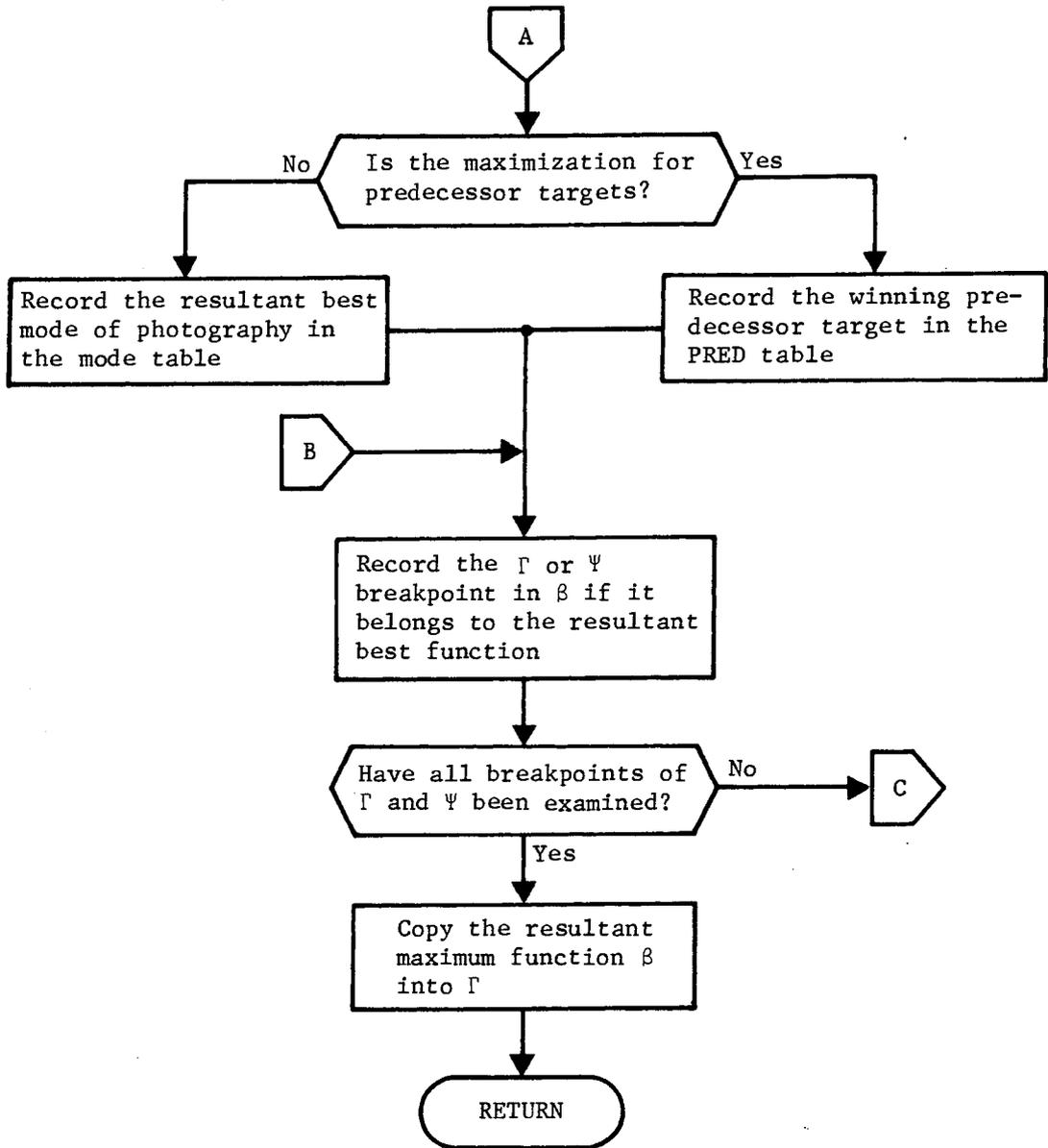


Figure 3-13. TWOSP Flow Chart (Continued)

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CONFLICT

CONFLICT

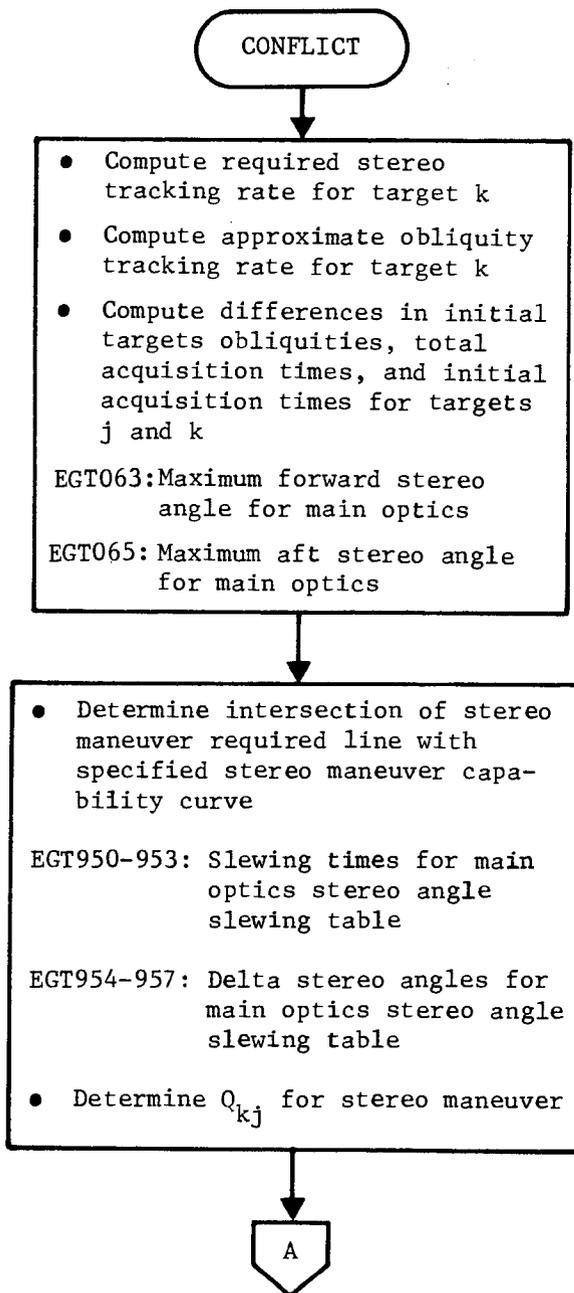


Figure 3-13. TWOSP Flow Chart (Continued)

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CONFLICT

CONFLICT

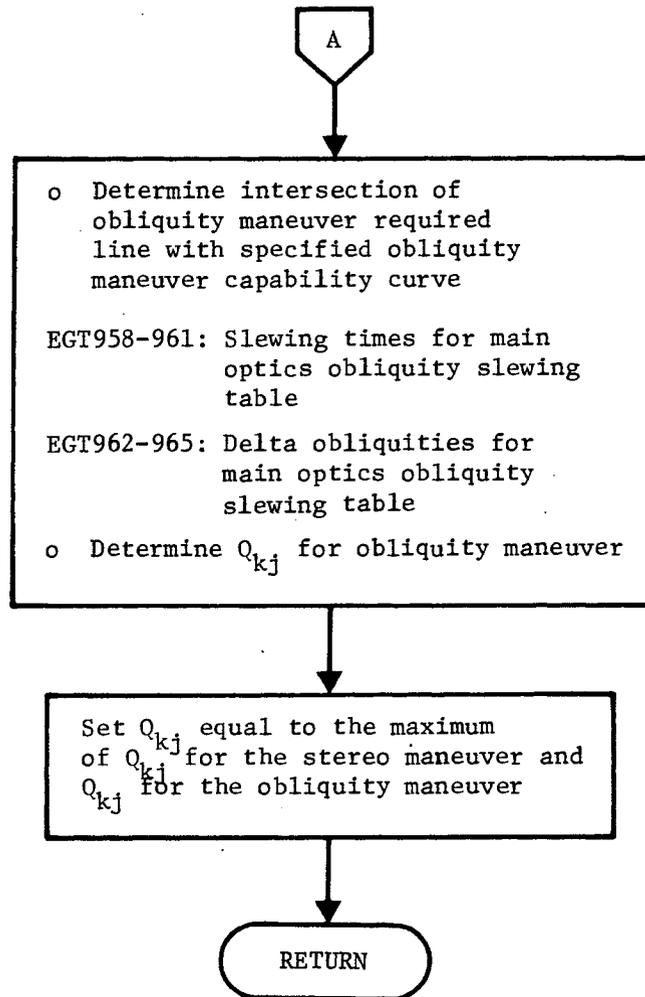


Figure 3-13. TWMOSP Flow Chart (Continued)

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### 3.9 TWOSP2

#### 3.9.1 Purpose

The subfunction TWOSP2 abstracts the optimal main optics photographic sequence from the ALMOST table and outputs that sequence in the Main Optics Strategy Table (MOST). The ALMOST table contains the set of optimal sequences down to and including every target under consideration. The sequence that attains the maximum score is then the overall optimum. TWOSP2 scans the ALMOST table to find the target that completes the largest score sequence. The predecessor information is then utilized to trace this optimum sequence and to determine which targets are contained therein. The acquisition time and photographic mode are also determined for each of these targets. The target identifier, acquisition time, and photographic mode are then tabulated in the MOST.

#### 3.9.2 Input

The input to TWOSP2 is the ALMOST table described in Section 3.8.3

#### 3.9.3 Output

The output of TWOSP2 is the MOST table. The contents of the MOST are shown in Table 3-24. The MOST table contains the sequence of targets that yields an optimal score. For each target in the optimal sequence, there are two words in the MOST table. They contain the finish time, the optimal photographic mode, and the COTPRIME entry number of the target.

Table 3-24. MOST Table

Symbol	JOVIAL Declaration	Units	Definition
PPFIN	F            0   0	sec	The time that photography will be complete on this target (i.e., finish time)
PMODE	I 4   U       10	n.d.	Mode in which photograph is to be taken
PCOTENT	I 2   U       14	n.d.	COTPRIME entry number of target

Repeated for each target in the main optics selection.

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#### 3.9.4 Method

File 2 of the ALMOST yields the last target  $j$ , to be photographed along with its finish time,  $\tau_j$ . File 1 is then searched until the data on this last target,  $j$ , is found which covers the finish time  $\tau_j$ . The optimal mode  $\ell_{\tau_j}$  selected from the mode table, and the predecessor and flattening tables corresponding to this mode are then selected.

The finish time will fall between two consecutive entries in the flattening table, e.g.,  $\tau_p \leq \tau_j \leq \tau_{p+1}$ . If the flattening bit  $ff(\tau_p)$  is equal to zero, then the finish time is kept at the value  $\tau_j$ . If, however,  $ff(\tau_p)$  is equal to one, then the finish time is set equal to  $\tau_p$  since a larger total score can be obtained by completing photography at this earlier time. In either case, this finish time is used to select an optimal predecessor,  $k$ . The finish time is translated by  $Q_{kj} + P_j$  to yield a finish time  $\tau_k$  for the predecessor  $k$ . The finish time for target  $k$  is determined from the relation  $\tau_k = \tau_j - Q_{kj} - P_j$  where  $Q_{kj}$  is the conflict parameter described in Section 3.8 and  $P_j$  is the time required to photograph target  $j$ . The process is repeated until a special kind of predecessor called the pseudo target is encountered. The pseudo target simply designates that a target has no predecessor. Therefore, the target in the optimal sequence which has the pseudo target as its predecessor is the first target in the optimal sequence. The MOST table is then written on tape and the program exits from TWMO SP2. Figure 3-14 presents the TWMO SP2 flow chart.

#### 3.9.5 Restrictions

The subfunction TWMO SP2 can produce a Main Optics Strategy Table (MOST) consisting of up to 150 targets. If there are any more than 150 targets belonging to the optimal sequence set, they would be lost from the sequence. Since 150 targets is considered to be the limit for a single rev, no provision was made to produce a larger set.

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TWMOSP2

TWMOSP2

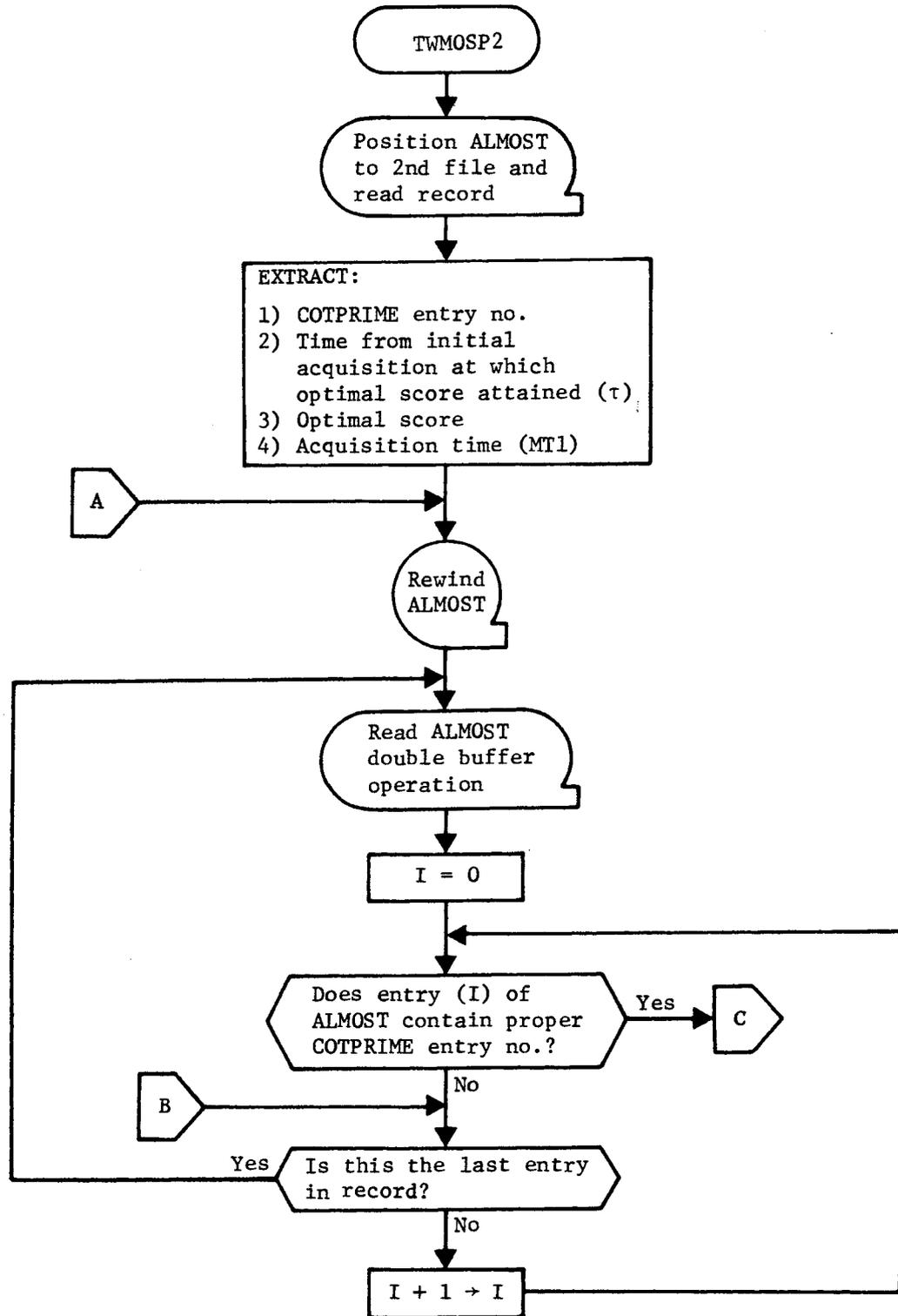


Figure 3-14. TWMOSP2 Flow Chart

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TWMOSP2

TWMOSP2

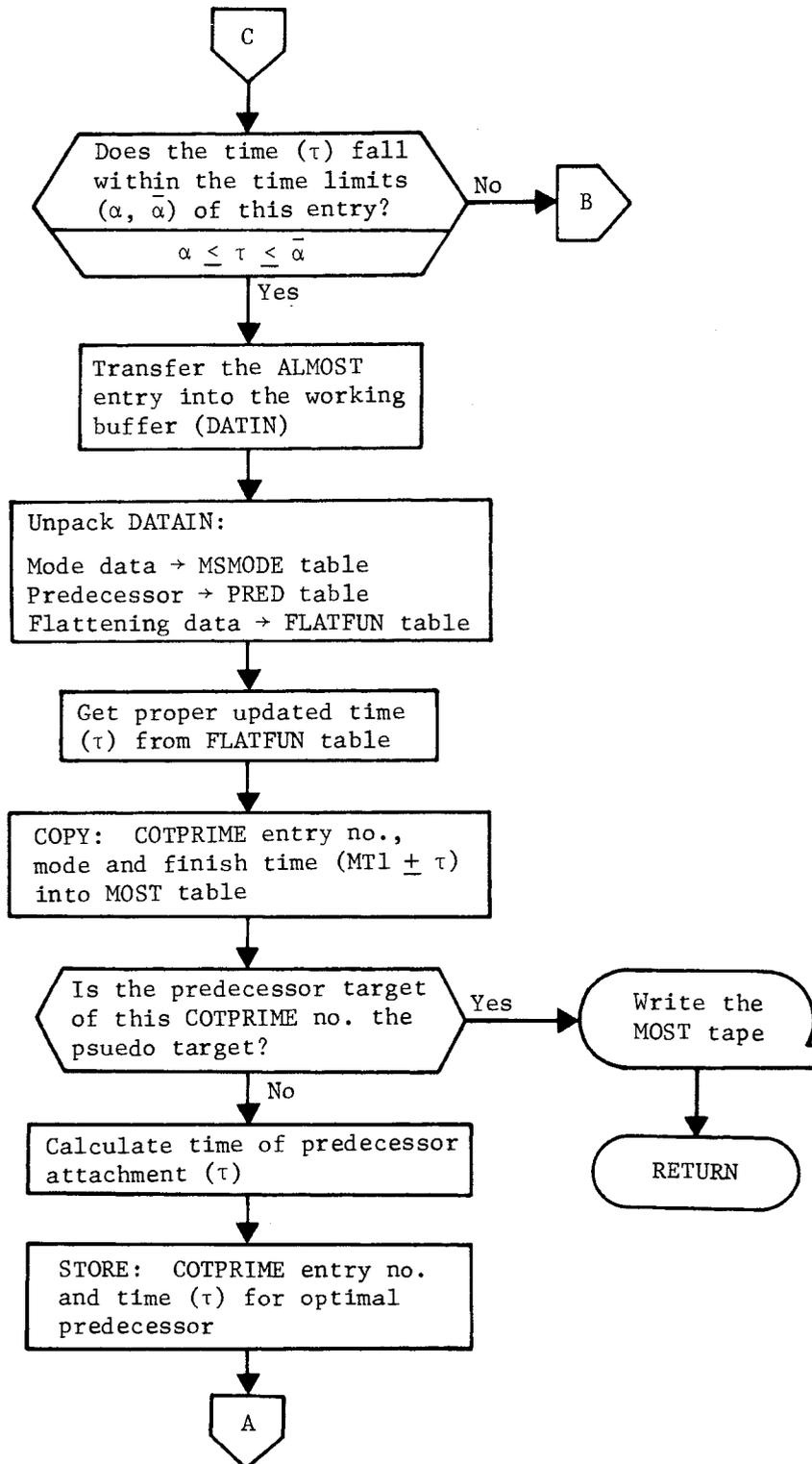


Figure 3-14. TWMOSP2 Flow Chart (Continued)

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### 3.10 TWASCON

#### 3.10.1 Purpose

The Acquisition Telescope (ATS) portion of the TWONDER program simulates the area of the mission in which the human factor plays an important role. By means of tracking telescopes, the crew views an optimally selected number of targets. These targets are of three types: targets selected by the main optics algorithm for photography; targets that can be substituted for a main optics target because some important variable used in the main optics selection is changed; or visual intelligence targets (VITs) for which main optics photography is not required. If, for instance, heavy cloud cover obscures the primary target, it might be possible to photograph a nearby target without interrupting the remainder of the main optics sequence. Another possibility is the crew detecting something about a target not previously known that would make photography of this target quite valuable. In both of these instances, the crew must make a decision or help an on-board computer make a decision whether to photograph a target other than the previously determined primary.

Targets that might be substituted for a primary target or for which there is no photographic requirement are referred to as alternate targets. It is the purpose of the ATS to view all primary targets as selected by the main optics algorithm and all alternate targets as selected by the ATS algorithm.

The subfunction TWASCON provides a list of potential alternate targets that will be considered in the ATS algorithm employed in the subfunction TWASSP2. This list of alternates is determined by investigating all available targets and deleting certain ones because of physical constraints, conflicts, or other pertinent reasons.

#### 3.10.2 Input

The primary inputs to TWASCON are the THINGS table, the COTPRIME information generated by TWOPS, the MOST data generated by the main optics selection algorithm, the PCURVE and RCURVE table generated in TWOPIN, and the DELTAT1, DELTAT2, and DELTAS arrays obtained from ALSO table. The File 8 parameters required as input are depicted in Tables 3-25 and 3-26.

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Table 3-25. File 8 Parameters Used by TWASCON Located in Table THINGS

File 8 Locations	Form of Data	Reset File Definition		Definition	Interface Table Usage			
		Nominal Value	Units		Internal Symbol	JOVIAL Definition	Internal Units	
EGT117	B	1	n.d.	Flag for deletion comments on Tape 8 0: comments output 1: no comments	DEPRFG	B	93 47	n.d.
EGT134	I	1	n.d.	Output control flag 1: target selection output and plots on Tape 8 2: target selection output and plots online 4: Intermediate Data Tables on Tape 8 8: Intermediate Data Tables online 16: ASST 32: LISTX 64: LIST 128: ASCOT 256: MOST 512: ALMOST 1024: MOCOT 2048: COTPRIME Output requests are summable	OUTFLAG	I 48 U	239 0	n.d.

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Table 3-25. File 8 Parameters Used by TWASCON Located in Table THINGS (Continued).

Reset File Definition				Interface Table Usage			
File 8 Locations	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
EGT143	FP	0.	deg	Roll attitude during inactive periods	NULLR	F 327 0	rad
EGT144	FP	0.	deg	Pitch attitude during inactive periods	NULLP	F 328 0	rad
EGT900	I	2	n.d.	Number of scopes in use 0 = none, 1 = one scope, 2 = two scopes	NUMSCOP	I 48 U 56 0	n.d.
EGT901	B	1	n.d.	1 = do, 0 = do not view primary targets	SCVUPRIF	B 57 47	n.d.
EGT902	B	1	n.d.	1 = do, 0 = do not view weather alternates	SCVUWXF	B 58 47	n.d.
EGT903	B	1	n.d.	1 = do, 0 = do not view activity alternates	SCVUAAF	B 59 47	n.d.
EGT904	B	1	n.d.	1 = do, 0 = do not view visual inspection alternates	SCVUVIF	B 60 47	n.d.
EGT905	B	1	n.d.	1 = do, 0 = do not view mandatory ATS targets	SCVUMANF	B 61 47	n.d.
EGT906	B	1	n.d.	0 = base ATS selection on active weight for activity alternates or inactive weight for weather alternates, 1 = base ATS selection on effective weight	PROBGAME	B 308 47	n.d.
EGT908	I	8	Targets/ group	Maximum number of targets allowed in a group	DENSCNT	I 48 U 72 0	Targets/ group

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Table 3-25. File 8 Parameters Used by TWASCON Located in Table THINGS (Continued)

File 8 Locations	Reset File Definition			Interface Table Usage			
	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
ECT925	FP	0.	n.d.	Minimum probability of activity for which a target will be considered in ATS selection	PROBAMIN	F 29 0	n.d.
ECT927	FP	0.	n.d.	Minimum weather alternate target weight for inclusion in ATS selection	OKWXWGT	F 330 0	n.d.
ECT928	FP	0.	n.d.	Minimum active alternate target weight for inclusion in ATS selection	OKACTWGT	F 65 0	n.d.
ECT929	FP	10.	sec	Main optics maneuver and settle time pad for lone indicator target	SETUPT	F 322 0	sec
ECT930	FP	25.	sec	Delta time for initiation of first main optics maneuver, measured back from first target acquisition	DOITNOW	F 321 0	sec
ECT931	FP	1.	n.d.	Probability that a target will be unclouded	PROBV	F 319 0	n.d.
ECT932	FP	30.	deg	Maximum AFT pitch angle for ATS viewing	MINSKOPA	F 317 0	rad
ECT935	FP	40.	deg	Maximum obliquity for ATS	SIDESOP	F 320 0	rad

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Table 3-26. File 8 Parameters Used by TWASCON Located in Table ALSO

Reset File Definition				Interface Table Usage			
File 8 Locations	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
EGT950 to EGT953	FP	-	sec	Slewing time for main optics pitch slewing table	DELTP	local ARRAY	sec
EGT954 to EGT957	FP	-	deg	Delta pitch angle for main optics pitch slewing table	DELP	local ARRAY	rad
EGT958 to EGT961	FP	-	sec	Slewing times for main optics roll slewing table	DELTR	local ARRAY	sec
EGT962 to EGT965	FP	-	deg	Delta roll angle for main optics roll slewing table	DELR	local ARRAY	rad

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The following THINGS table items are referenced by TWASCON and are not File 8 parameters, but values calculated or set by certain routines to be used by later routines.

ASIG = Maximum forward stereo angle for main optics

BSIG = Maximum aft stereo angle for main optics

NASCOTE = Number of ASCOT entries

NMOSTE = Number of MOST entries

T1  
T2  
T4  
T5 } Logical tape unit assignments

The pitch and roll rates and settle times for the main optics are acquired from the tables PCURVE and RCURVE where

PCURVE = table calculated by TWOPIN using the input arrays DELTP and DELP

RCURVE = table calculated by TWOPIN using the input arrays DELTR and DELR

The forward and aft photography times are obtained from the DELTAT1 and DELTAT2 arrays as a function of mode and the stereo angle is obtained from the array DELTAS as a function of mode.

### 3.10.3 Output

The primary output of the subfunction TWASCON is the ASCOT table. This is a serial table of 200 entries per record and 7 words per entry. The items that make up the ASCOT are as follows:

RCOTENT = COTPRIME entry number

ROMEGA = mean obliquity

RTDWELL = dwell time

RTFIRST = earliest ATS viewing start time

RTLAST = latest ATS viewing start time

RWGTHI = high order weight

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RWGTLO = low order weight  
RGROUP = group number  
RT3TI = total time target is visible through main optics  
RTI = earliest time target is visible through main optics  
RLASTDT = last decision time

The number of ASCOT entries, NASCOTE, is set in the THINGS table.

The COTPRIME table is added to by TWASCON and the extended table is written. The new items are:

TSCOPON1 = earliest ATS on time  
TSCOPON2 = latest ATS on time  
TREASON = reason target was deleted from ASCOT  
TNOTOKF = NOT OK or delete flag  
TWXAF = weather alternate flag  
TAAF = activity alternate flag  
TPRIF = primary or MO flag  
TWGTHI = high order weight  
TWGTLO = low order weight  
TMOSTENT = MOST entry number  
TMOSTGP = MOST group number  
TLASTDT = last decision time

The capability of writing the ASCOT table provides additional output. This can be either on-line, off-line, or both, and is a function of an input option.

The following comments are output from TWASCON:

NUMBER OF ITEMS ACQUIRED BY ASCON = XXXX, and is simply a statement of the number of items in the ASCOT table.

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NUMBER OF TWASCON DELETIONS DUE TO GROUP SIZE = XXXX, which tells the total number of deletions from the ASCOT because the individual group sizes exceeded the maximum acceptable.

When deletion print is requested, all COTPRIME items that have their delete flag set are listed along with the reason they were deleted.

#### 3.10.4 Method

By using various filters, the number and type of targets that are passed on to the algorithm can be closely controlled. The density control is especially necessary to the proper functioning of TWASSP2. The number of targets in an ATS group, which consists of all the targets that could possibly be viewed as an alternate to a main optics selected target, must be kept under a certain maximum. An unlimited number of candidate alternates leads to an inefficient and time consuming solution. Filtering as to particular types gives the program greater flexibility and contributes to program efficiency and faster computation times.

In addition to filtering, targets are not considered as potential alternates if there is any physical conflict, either of a hardware nature or an imposed software condition. By definition, a target is an acceptable alternate if it is possible for the main optics to change its predetermined path, move to the alternate instead of the primary, complete requested photography, and return to the next primary in the main optics sequence. If any of these conditions cannot be met, the target cannot be an alternate and, consequently, is not inserted in the list of potential alternates.

When all the potential alternates input to TWASCON have been checked for acceptability, the completed list of alternates, called the ASCOT table, is passed on to the subfunction TWASSP2. Here the optimization algorithm selects for viewing those targets that produce the best score. Every target in the ASCOT table meets all the conditions of an alternate, and the only reason a target would not be viewed is if it is not found to fit into one of the optimum (score maximizing) paths.

In addition to the main program, the subfunction TWASCON is composed of three main procedures. The procedures are TYPEFILT, GEOMFILT, and GENASCOT and are included in the TWASCON flow chart, Figure 3-15.

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TYPEFILT performs the filtering of particular types, GEOMFILT makes the calculations necessary for the geometric compatibility checks, and GENASCOT constructs the ASCOT table. There are also several smaller routines whose functions will be discussed as they are referred to.

The main program performs most of the table and item definition and initialization functions in TWASCON. The primary tables used are the MOST table, the COTPRIME and COTPRIMEX tables, the ASCOT and ASCOTX tables, and the THINGS table. The MOST table contains the data read from the MOST tape generated by the main optics selection algorithm. The COTPRIMEX table is the buffer used for reading and writing the COTPRIME tape. The COTPRIME table is the buffer used as working storage while processing the individual records of the COTPRIME tape. The ASCOT table is the buffer used to build the ASCOT tape, and the ASCOTX table is the buffer used for writing the ASCOT tape.

The main program reads the MOST tape and the COTPRIME tape. The COTPRIME buffer is designed to contain the record currently being processed, the last half of the previous record, and the record to be processed next. This is required as the targets necessary to complete each alternate group may occur earlier or later than the primary for that group. The COTPRIME table is a very large buffer defined as 500 entries (since each record is 200 entries) at 23 words per entry.

#### 3.10.4.1 ADDMOST

After reading the MOST tape, the program must then compute the start times for each target in the MOST table, since the main optics algorithm does not pass this information. These calculations are done in the procedure ADDMOST by the following equation:

$$\begin{aligned} \text{PPSTART} &= \text{PPFIN} - ((\text{DELTAT1} + \text{DELTAT2}) + \\ &\quad (\text{DELTAS}) (\text{TT3}-\text{TT1})/(\text{ASIG} + \text{BSIG})) \end{aligned}$$

where

PPSTART = start time of Main Optics photography  
PPFIN = finish time of Main Optics photography  
DELTAT1 = forward photographic time as a function of mode

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DELTAT2 = aft photographic time as a function of mode  
DELTAS = stereo angle as a function of mode  
TT3 = latest possible photography time  
TT1 = earliest possible photography time  
ASIG = maximum forward stereo angle for main optics  
BSIG = maximum aft stereo angle for main optics

#### 3.10.4.2 TYPEFILT

The procedure TYPEFILT is then called. This routine determines if the targets are visual intelligence targets (VITs), primaries, activity alternates, or weather alternates. It then checks the individual target type view flags which are input, and, if a particular type is not to be viewed, sets a flag (called the NOT OK FLAG) to prevent this type from being placed in the ASCOT table when it is constructed. The probability of activity and dwell time are set for all targets that are acceptable for viewing. The probability of activity is simply a percentage chance that any infrequent but unusually high intelligence value situation exists at the target site, while the dwell time is an input specifying the amount of time the crew has to look at a target through a scope before the scope moves to another target.

#### 3.10.4.3 GEOMFILT

Having determined which of the targets are to be considered for viewing, it is necessary to determine which of them it is possible to view taking into account the physical limitations imposed on the system. This is done in the procedure GEOMFILT. For each target the NOT OK FLAG is checked and, if set, no further calculations are made for the target. For VITs and primaries that are to be viewed, target weights are computed. The weight equations will appear later, but it should be noted that the word defining the weight has two parts, a high order part and a low order part. The high order bits are used as flags to signal if the target is a mandatory ATS target (one that must be viewed) or a primary. The low order bits contain the actual computed weight in an integer form. The weights are computed either considering or not considering probability factors depending upon the option requested by input.

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For targets other than VITs and primaries, i.e., activity or weather alternates, a NEARMOST table is generated. This is a table that contains the earliest and latest possible photographic times for the target if considered as an alternate for any nearby main optics targets. These earliest and latest times are calculated in the subroutines CALCALFA and CALCBETA. The latest possible main optics photography time is calculated, and the primary that this time is associated with is noted. Weights are then calculated for the activity and weather alternates.

If probability factors for the various conditions are to be considered, the low order weights for all alternates are calculated by the equation:

$$\begin{aligned} \text{TWGTLO} = & \text{PROBV} [(\text{TPROBA}/100) (\text{PROBREC}) (\text{TWA}) + (1-\text{TPROBA}/100) \\ & (\text{PROBFA}) (\text{TWI})] + (1-\text{PROBV}) [(\text{TPROBA}/100) (\text{TWA}) \\ & + (1-\text{TPROBA}/100) (\text{TWI})] \end{aligned}$$

where

TWGTLO = low order weight, actual target worth  
PROBV = probability of visibility  
TPROBA = probability of activity  
PROBREC = probability of recognition of activity  
TWA = nominal active weight  
PROBFA = probability of falsely reporting activity  
TWI = nominal inactive weight

If probability factors are not to be considered, the low order weights for activity alternates are set equal to their nominal active weights

$$\text{TWGTLO} = \text{TWA}$$

and the low order weights for all other alternates are set equal to their normal inactive weights

$$\text{TWGTLO} = \text{TWI}$$

Using strictly hardware constraints, the earliest possible scope on time and the latest possible scope on time are calculated for each target.

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Then, the latest possible decision time for the target as an alternate is calculated. This decision time is the time at which the main optics must begin maneuvering to photograph the alternate target and is calculated by the procedure CALCDECN. Unless there is a physical conflict, the actual latest possible scope on time is this decision time minus the dwell time.

#### 3.10.4.4 GENASCOT

By now all the significant parameters necessary for each target for its consideration as an alternate have been determined, and the construction of the ASCOT table can begin.

The ASCOT table construction is done in the procedure GENASCOT. The ASCOT buffer used during building of the ASCOT table is a 400 entry buffer. Because the ASCOT is first time ordered, and then ordered according to group number, it is necessary for several entries beyond those to be written out on tape to be processed and, consequently, properly ordered. This is accomplished by filling the entire 400 entry buffer, ordering the entire buffer, and then moving 200 of these entries to the ASCOTX buffer to be written onto tape. The remaining 200 entries are then used to start the next phase of table building, and any ordering to be done is not likely to reach back into the table beyond 200 entries.

In the actual table construction, the program first checks the NOT OK FLAG for each target and those targets whose flag is set are not included in the table. ASCOT entries are made for all others. When the buffer is full, the entries are ordered by time and then group number.

As was mentioned earlier, it is necessary to hold the group size below a certain maximum number of targets; each group in the ASCOT buffer is checked, and if there are too many in the group, it is sized. The group is ordered by weight, and a deletion flag is set for all targets beyond the maximum allowable number (and consequently, of lower worth). When the program prepares to write the ASCOT tape, it checks each entry, and those whose deletion flags are set are purged from the table.

GENASCOT also calls the procedure WRTASCOT that determines if the ASCOT table is to be listed.

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### 3.10.4.5 CALCALFA

Procedure CALCALFA calculates the earliest possible time to start photography on an alternate target coming from a main optics target. The times at which the obliquity and stereo maneuvers are completed are calculated and the later of the two times is the earliest start time.

After the difference in the obliquity between the main optics target and the alternate is determined, the time required to perform the obliquity maneuver to negotiate this angular change (a function of the RCURVE table) is found by solving the following equation:

$$TESR = (BB - AL(SRMO))/(AL \pm MRMO) + SRMO$$

where

TESR = time required for obliquity maneuver

BB = change in obliquity between Main Optics (MO) and alternate

AL = rate of obliquity change of the alternate target

SRMO = settle time required by MO for given obliquity rates

MRMO = obliquity rates for MO

A similar calculation is then performed to determine the time required for the stereo maneuver. The equation for this calculation is:

$$TESP = (PP - AA - GA(SPMO))/(GA \pm MPMO) + SPMO$$

where

TEST = time required for stereo maneuver

PP = total target stereo angle traveled while photographing previous primary

AA = total change in stereo while target is viewable

GA = rate of change of stereo of target

SPMO = settle time required by MO for given stereo rates

MPMO = stereo rates for MO

These maneuver times are added to the finish photography time of the previous primary to establish the earliest start time for the alternate.

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### 3.10.4.6 CALCBETA

CALCBETA determines the latest time that the MO may finish photography on an alternate and still maneuver to initiate photography of the next scheduled primary. Again, both the stereo and obliquity maneuvers must be considered, and the one taking the longer time is the constraining maneuver.

By first finding the rate of obliquity change at the alternate and the difference in obliquities of the alternate and primary at the start time of photography for the primary, the time to complete the required obliquity maneuver is determined by use of the equation:

$$TLFR = (BB \pm (MRMO) (SRMO)) / (AL \pm MRMO)$$

where

TLFR = time required to complete obliquity maneuvers

BB = difference in obliquities of the two targets

MRMO = obliquity rate of the MO

SRMO = settle times for obliquity rates of MO

AL = rate of change of obliquity of alternate target

This time combined with the time to start photography of the next primary gives the latest time to finish photography on the alternate considering the required obliquity change.

For the stereo maneuver, the stereo angle at the start time of photography for the primary and the change in stereo angle at the alternate from first view time to the start time of photography for the primary are found. Then, the time required to complete the stereo maneuver from the alternate to the primary in time to start photography of the primary is calculated as follows:

$$TLFP = (PP - AA \pm (MPMO) (SPMO)) / (GA \pm MPMO)$$

where

TLFP = time to complete stereo maneuver

PP = stereo angle at start time of photography to primary

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- AA = change in stereo of primary by start time for photography
- MPMO = stereo rate of MO
- SPMO = settle time for stereo rate of MO
- GA = rate of change of stereo at alternate

The time to complete the stereo maneuver is combined with the start time of photography for the next primary to determine the latest time photography of the alternate can be concluded.

The earlier of the latest times required for completion of the stereo and obliquity maneuvers is the latest time that the MO can complete photography of the alternate.

#### 3.10.4.7 CALCDECN

When photography is finished on the previous primary and the main optics are maneuvering to the next projected primary, there exists a time at which it is still possible to decide to photograph an alternate instead of the primary. After this time it would be impossible to get to the alternate, perform the required photography, and return to the next primary. This latest time to start the maneuvering is called decision time and is calculated by the procedure CALCDECN. The calculation is performed by considering the time at which photography of the alternate must start to satisfy the conditions of the photographic mode requested and the latest time at which maneuvering must begin to return to the next primary.

There are two equations involved in the calculation of decision time. If the maneuvering to the next primary is in the direction of the alternate, the equation used is:

$$F4 = F2 - F3 \pm MM (STANT3 - STANT1 - SS) / (\pm MM)$$

where

- F4 = time increment from previous primary until maneuvering begins to alternate
- F2 = attitude (stereo or obliquity) of MO
- F3 = attitude (stereo or obliquity) of alternate
- MM = stereo or obliquity rate

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STANT3 = start time of photography for alternate  
STANT1 = end time of photography for previous primary  
SS = settle time for this maneuver rate

However, if the initial maneuver to the next primary is away from the alternate, the equation used is:

$$F4 = (F3 + MM (STANT3 - STANT1 - SS) - F1) / (+ 2MM)$$

where every term is the same as in the earlier equation and:

F1 = attitude (stereo or obliquity) of previous primary

#### 3.10.4.8 WRTASCOT

The ability to write out the ASCOT internal table is a function of input. If the proper bit of the input parameter OUTFLG is set, the ASCOT can be output on-line, off-line, or both. If the bit is not set, WRTASCOT does nothing. The procedure first calculates the number of ASCOT entries to be written, and then one entry at a time is taken from the ASCOTX buffer and moved to the locations used in the printout. After determining whether the output is to be on-line, off-line, or both, one line of output is generated by a call to the system routine OUTPUT. This listing of one entry at a time is continued until all ASCOTX entries have been processed.

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TWASCON

TWASCON

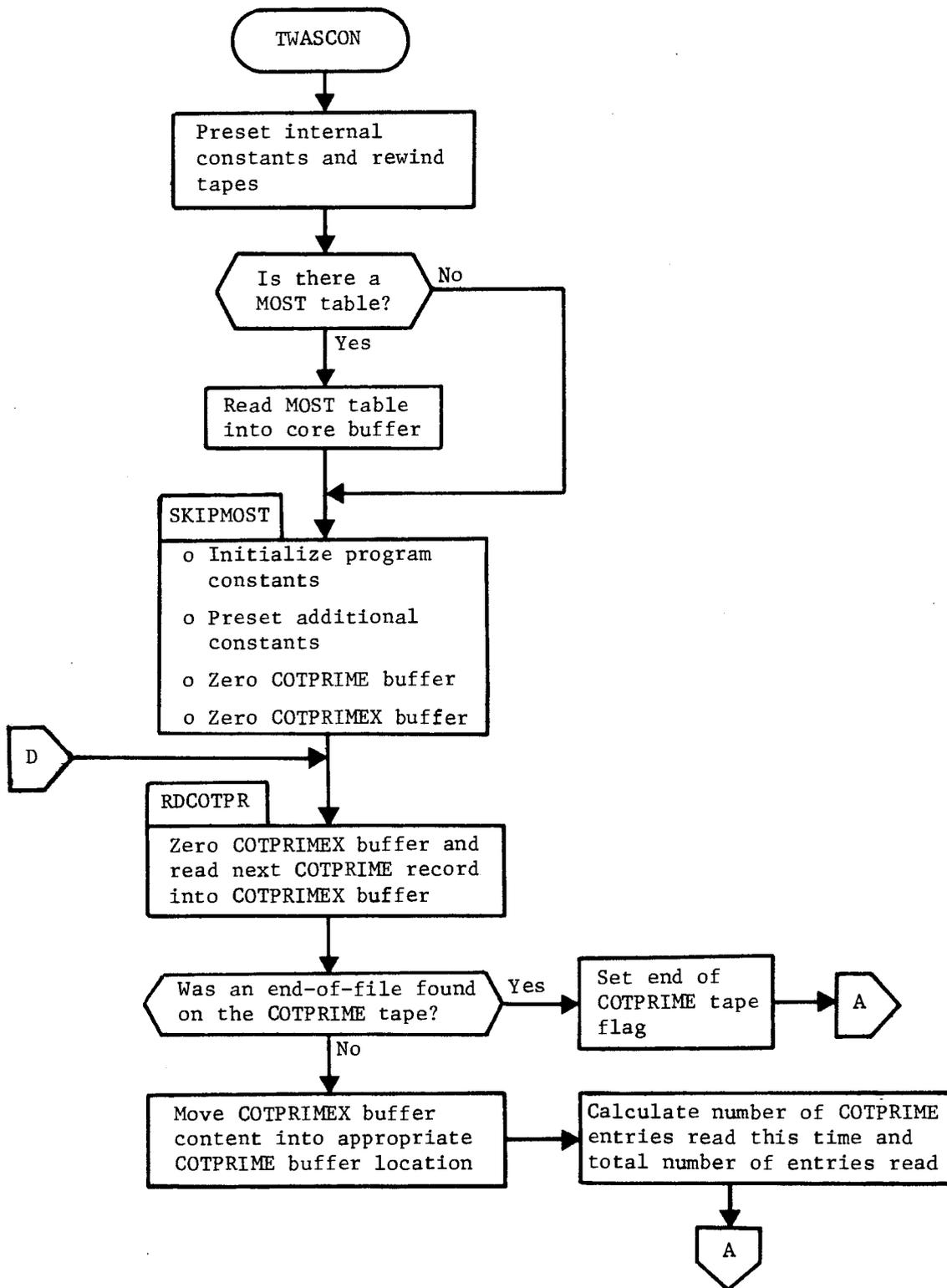


Figure 3-15. TWASCON Flow Chart

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TWASCON

TWASCON

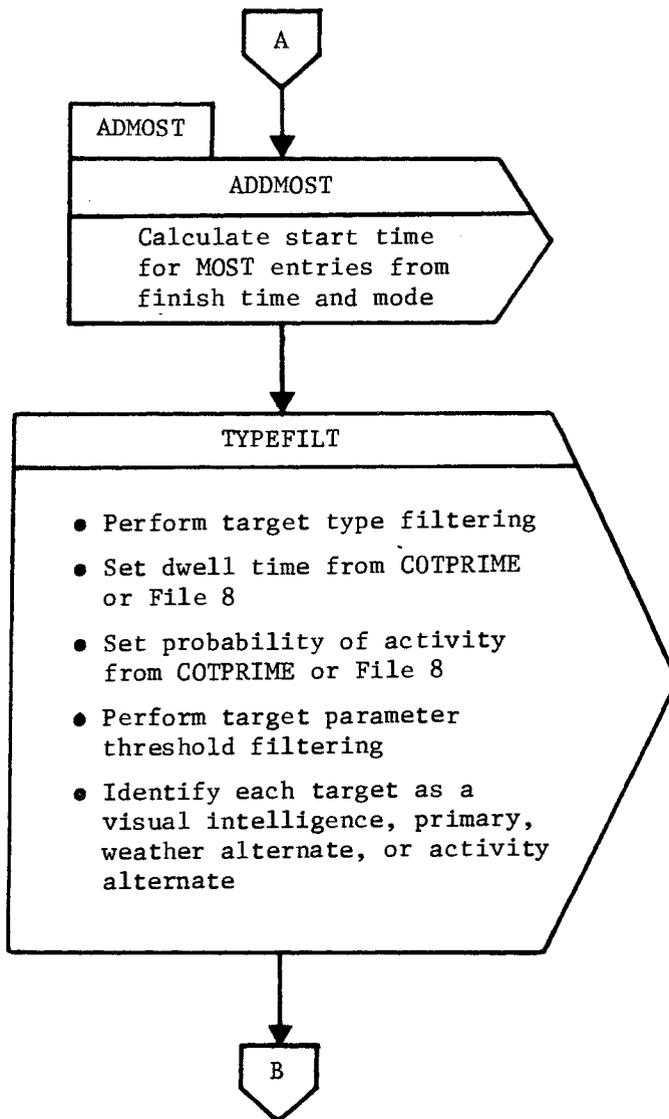


Figure 3-15. TWASCON Flow Chart (Continued)

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TWASCON

TWASCON

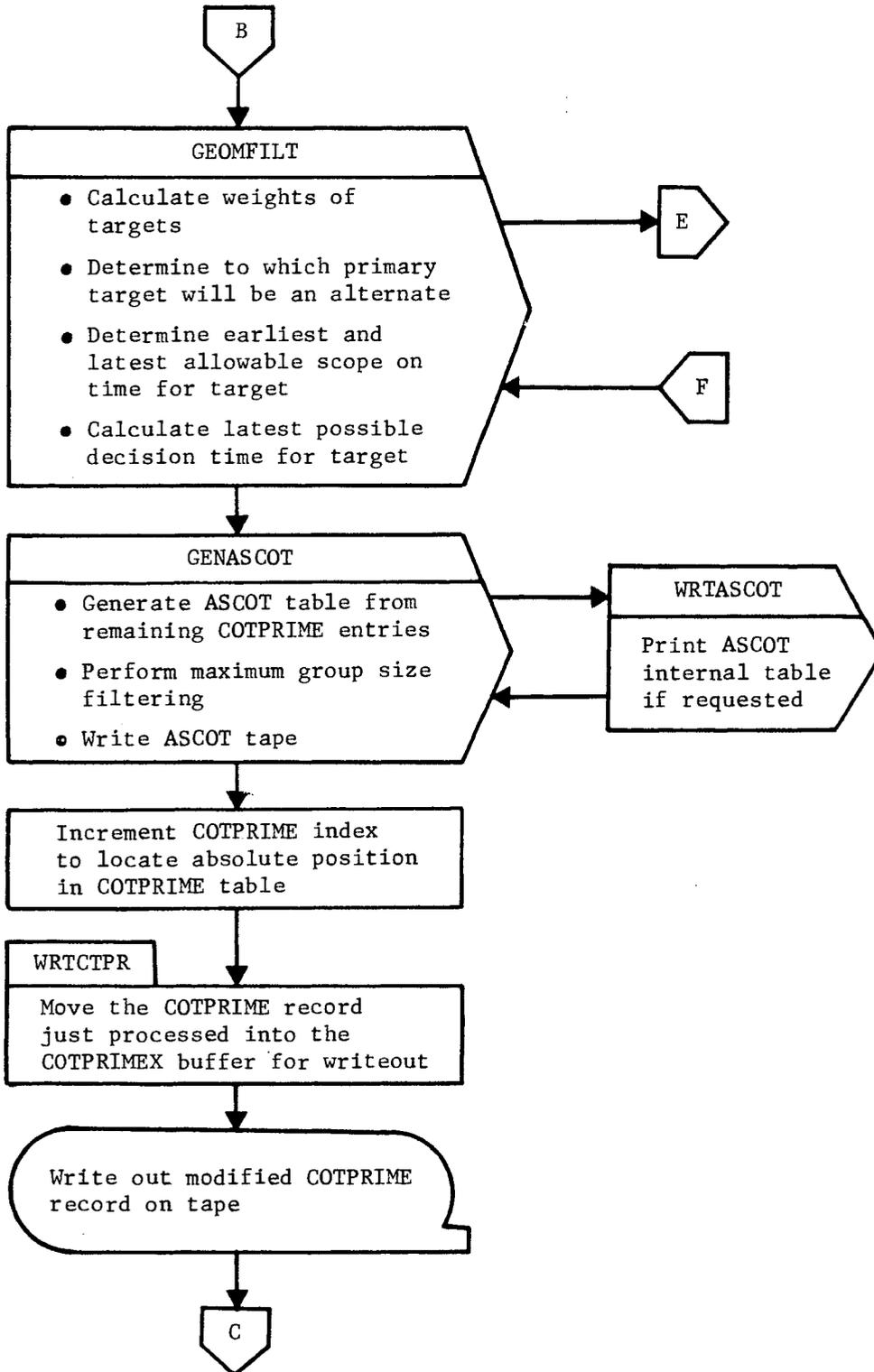


Figure 3-15. TWASCON Flow Chart (Continued)

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TWASCON

TWASCON

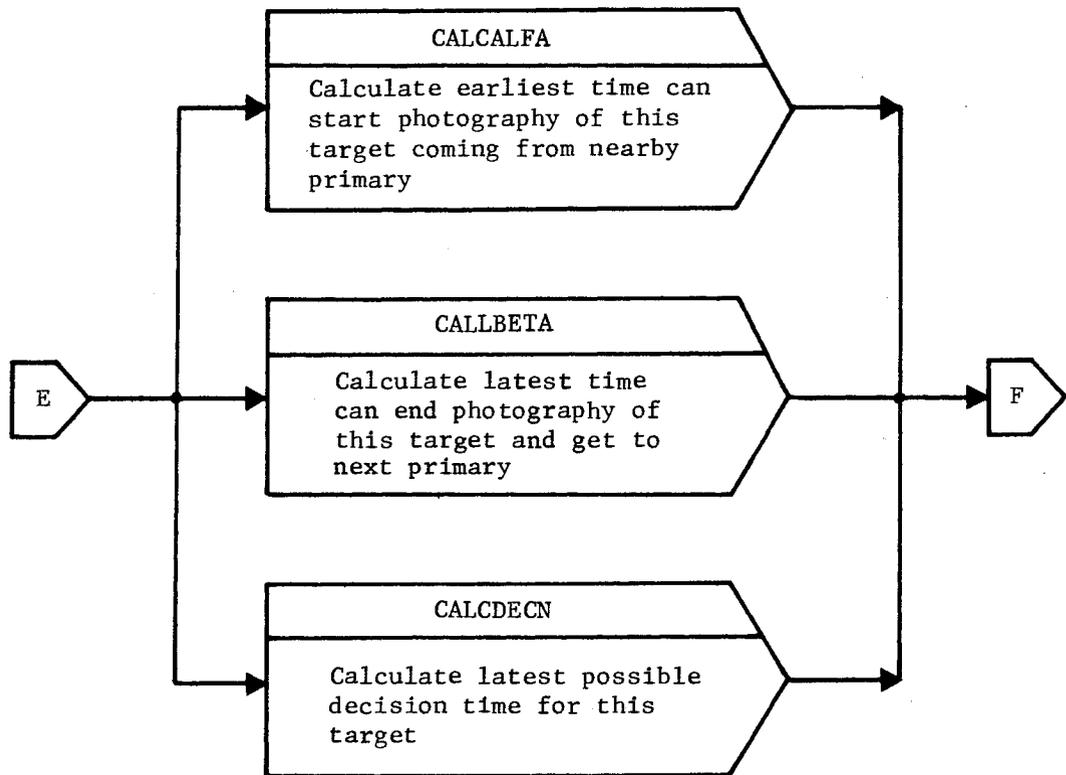


Figure 3-15. TWASCON Flow Chart (Continued)

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TWASCON

TWASCON

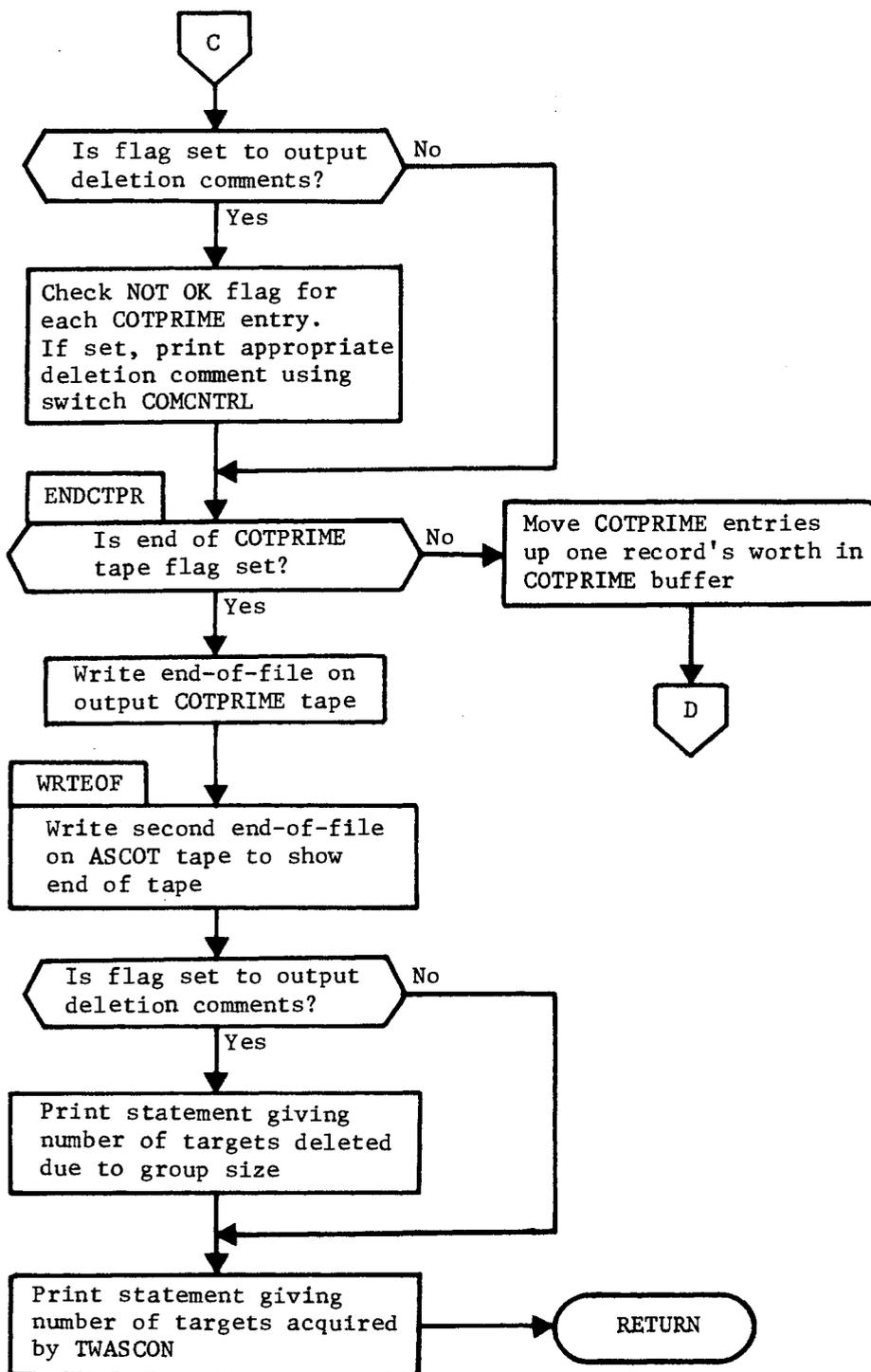


Figure 3-15. TWASCON Flow Chart (Continued)

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ADDMOST

ADDMOST

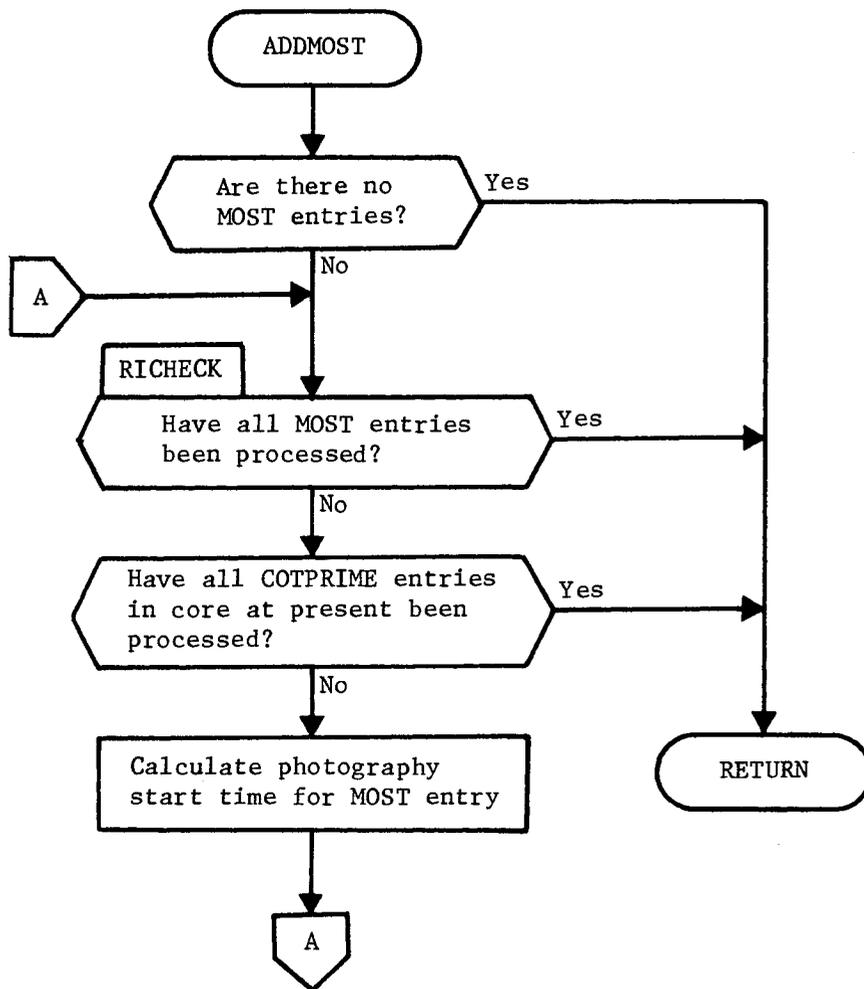


Figure 3-15. TWASCON Flow Chart (Continued)

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TYPEFILT

TYPEFILT

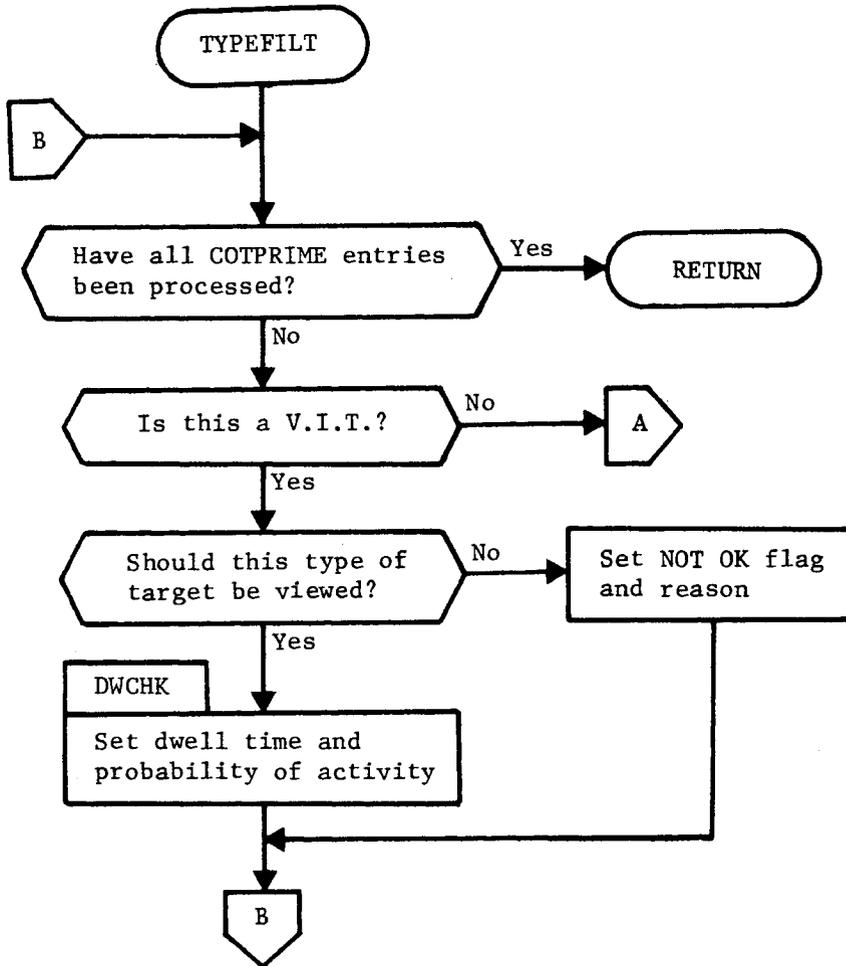


Figure 3-15. TWASCON Flow Chart (Continued)

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TYPEFILT

TYPEFILT

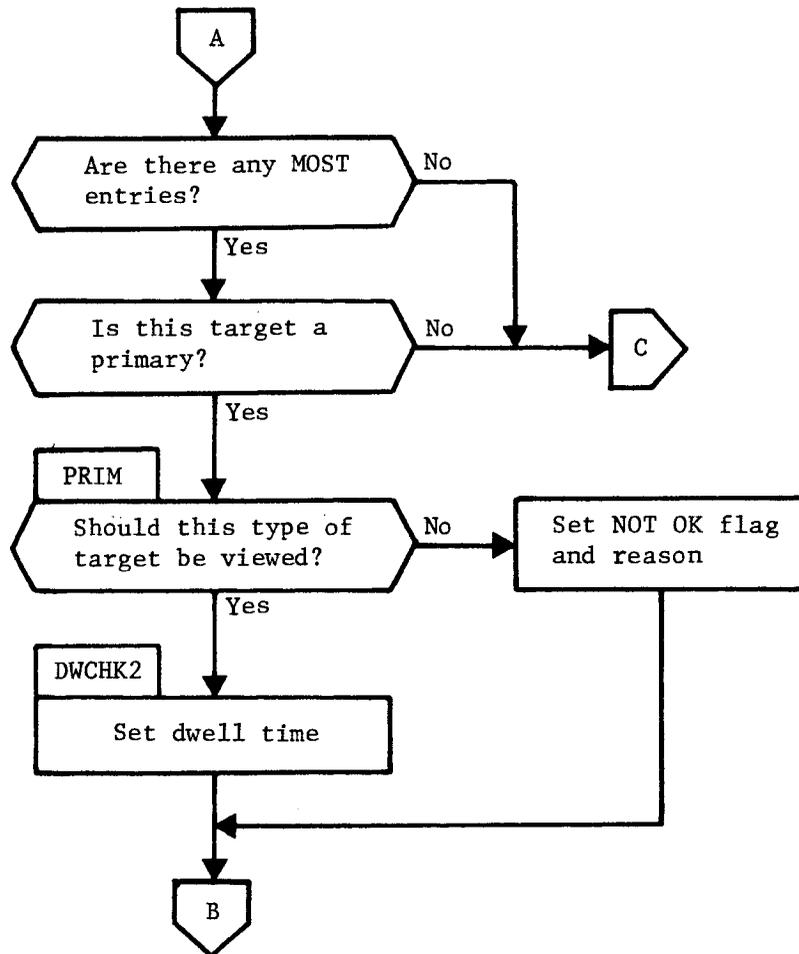


Figure 3-15. TWASCON Flow Chart (Continued)

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TYPEFILT

TYPEFILT

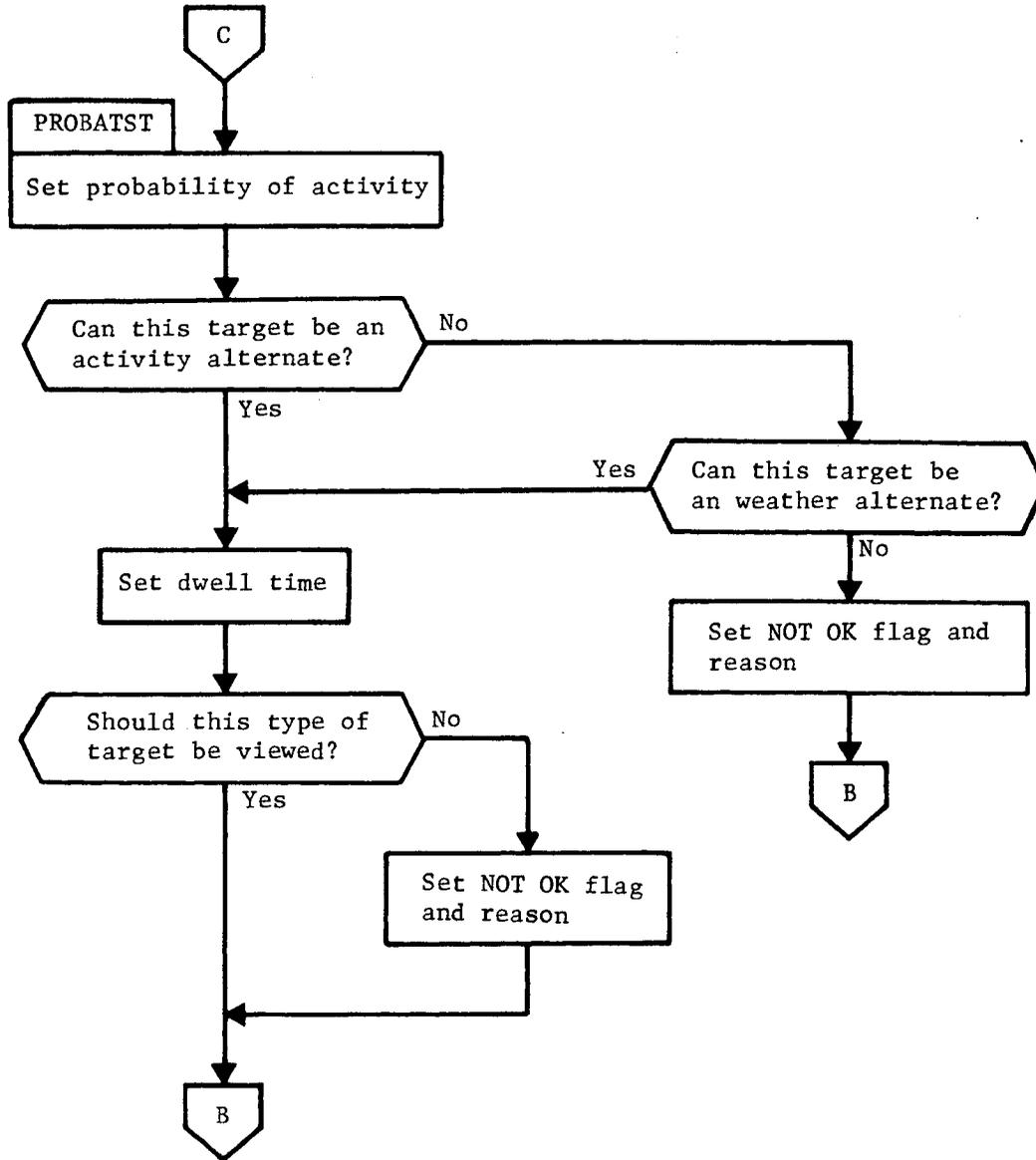


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

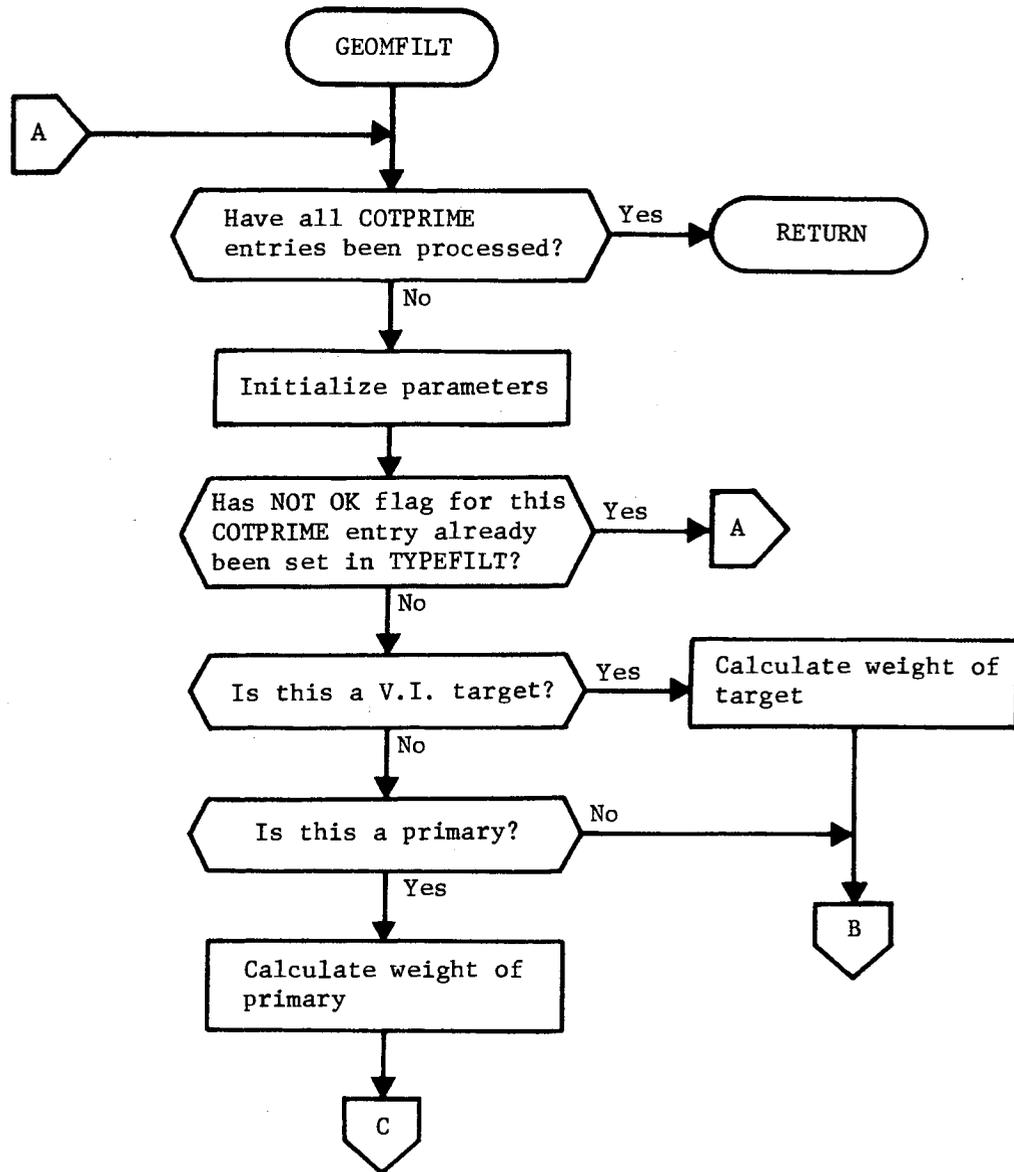


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

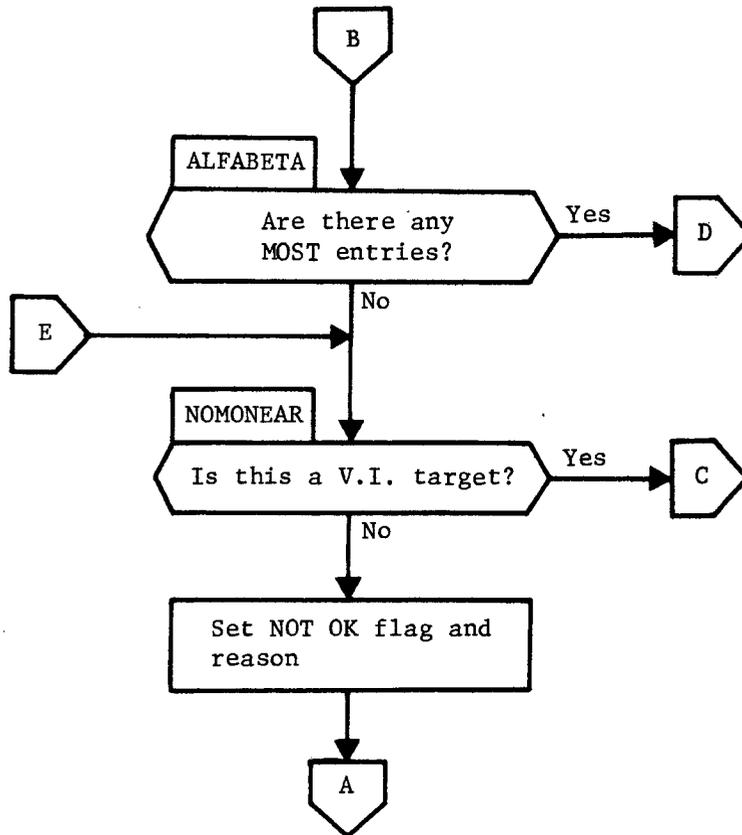


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

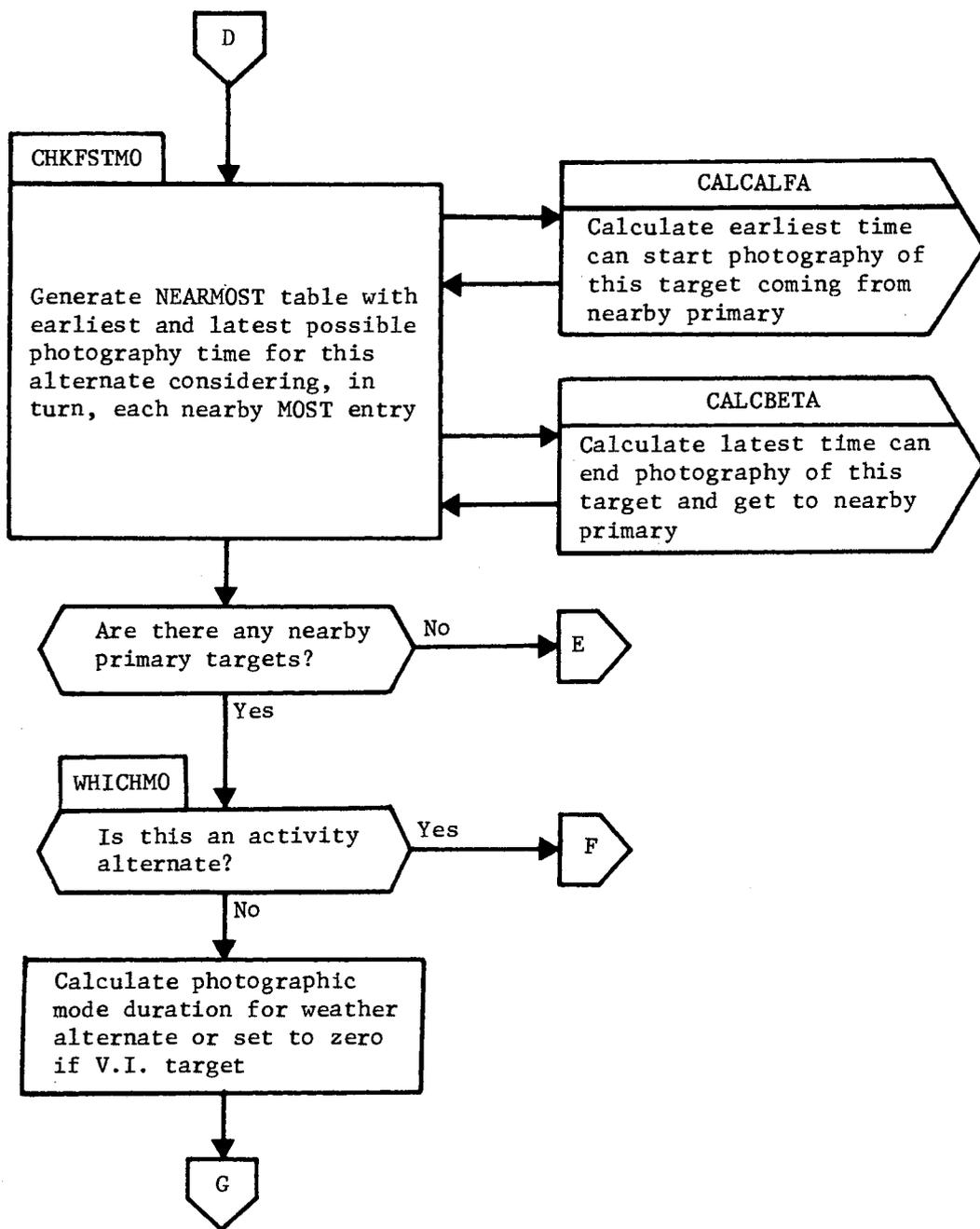


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

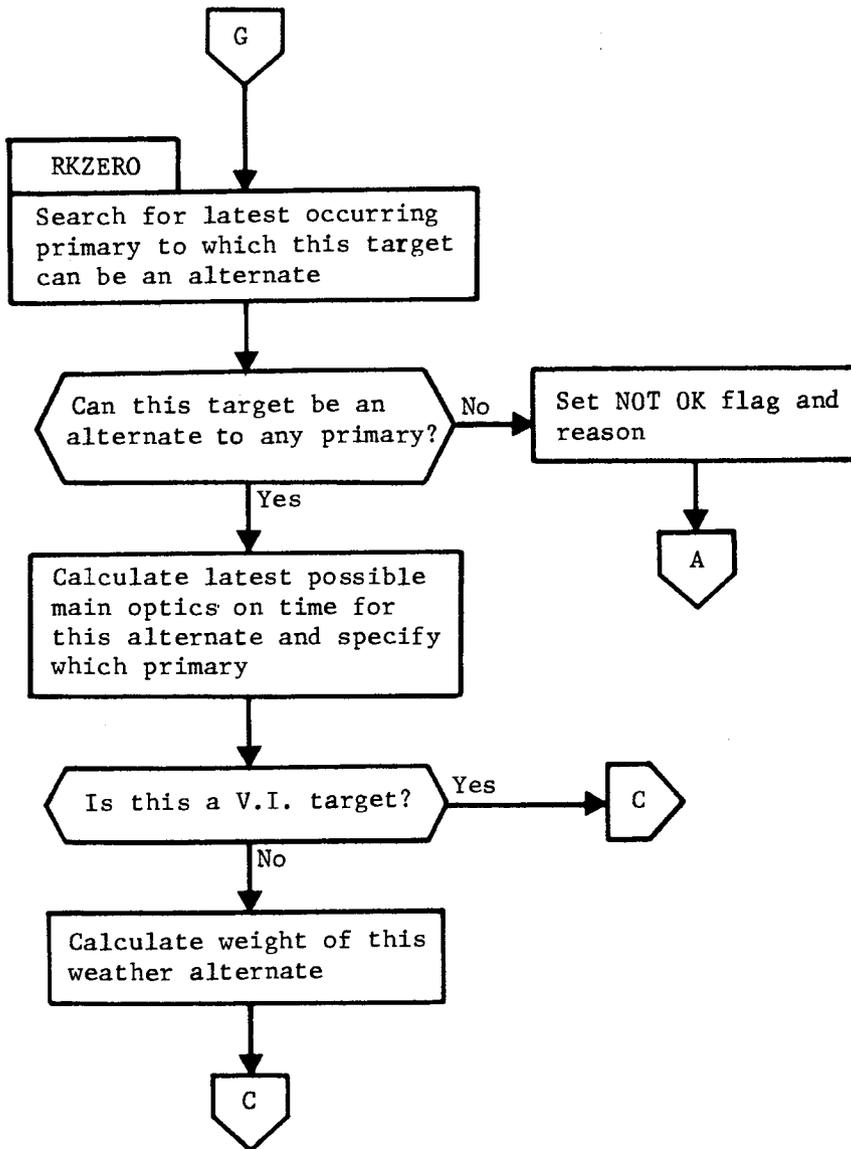


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

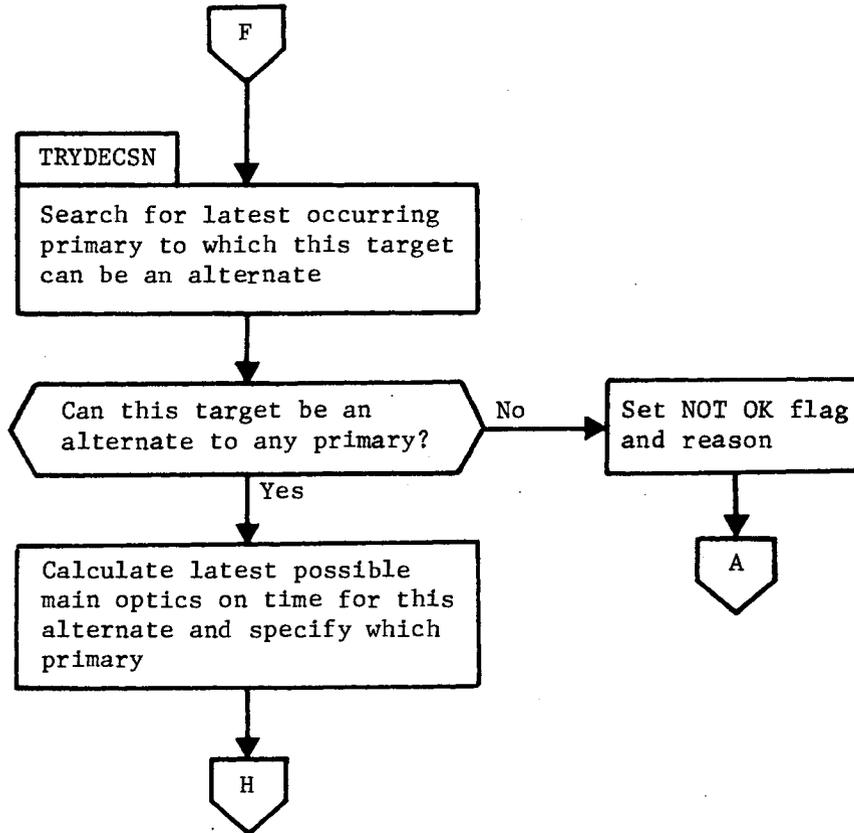


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

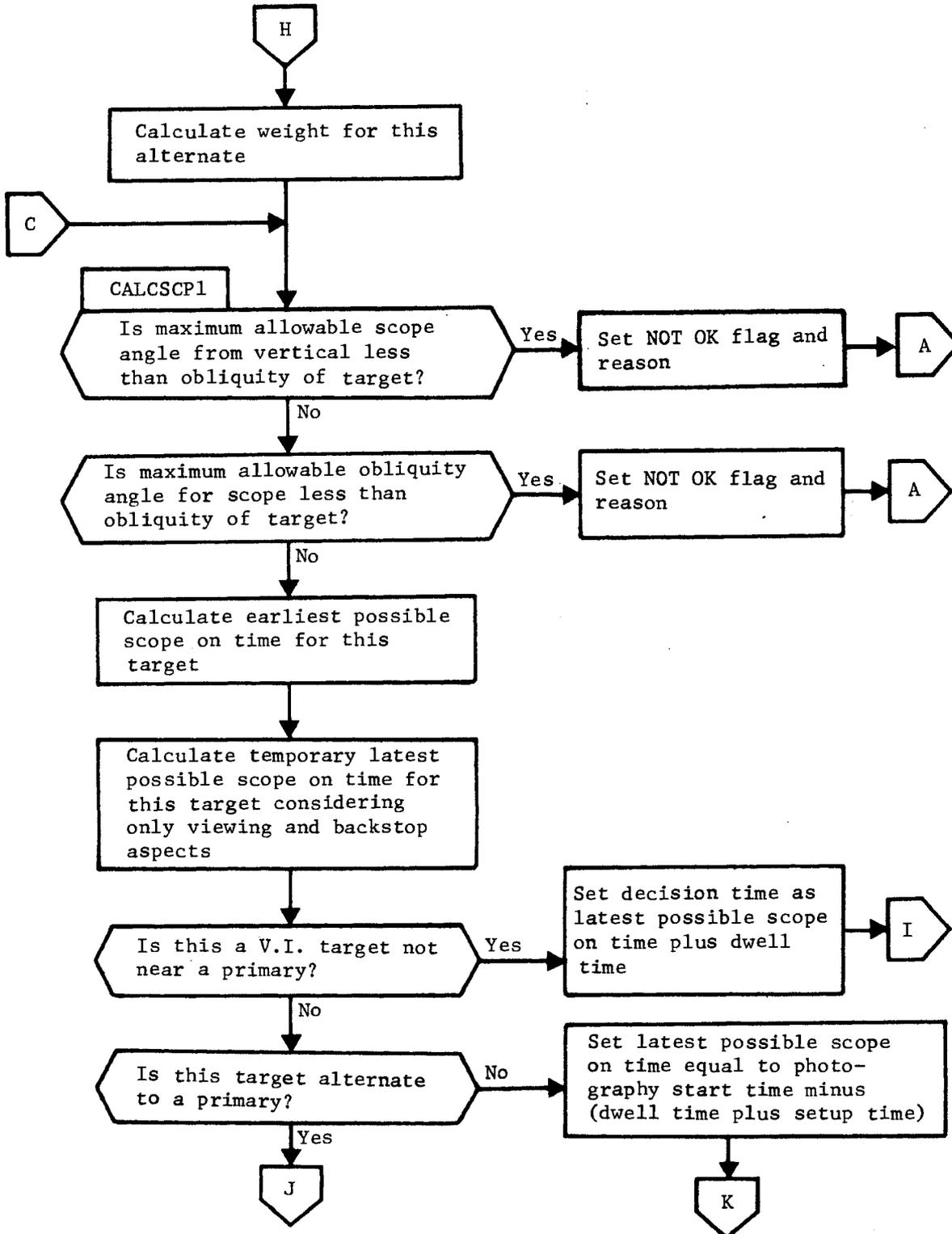


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

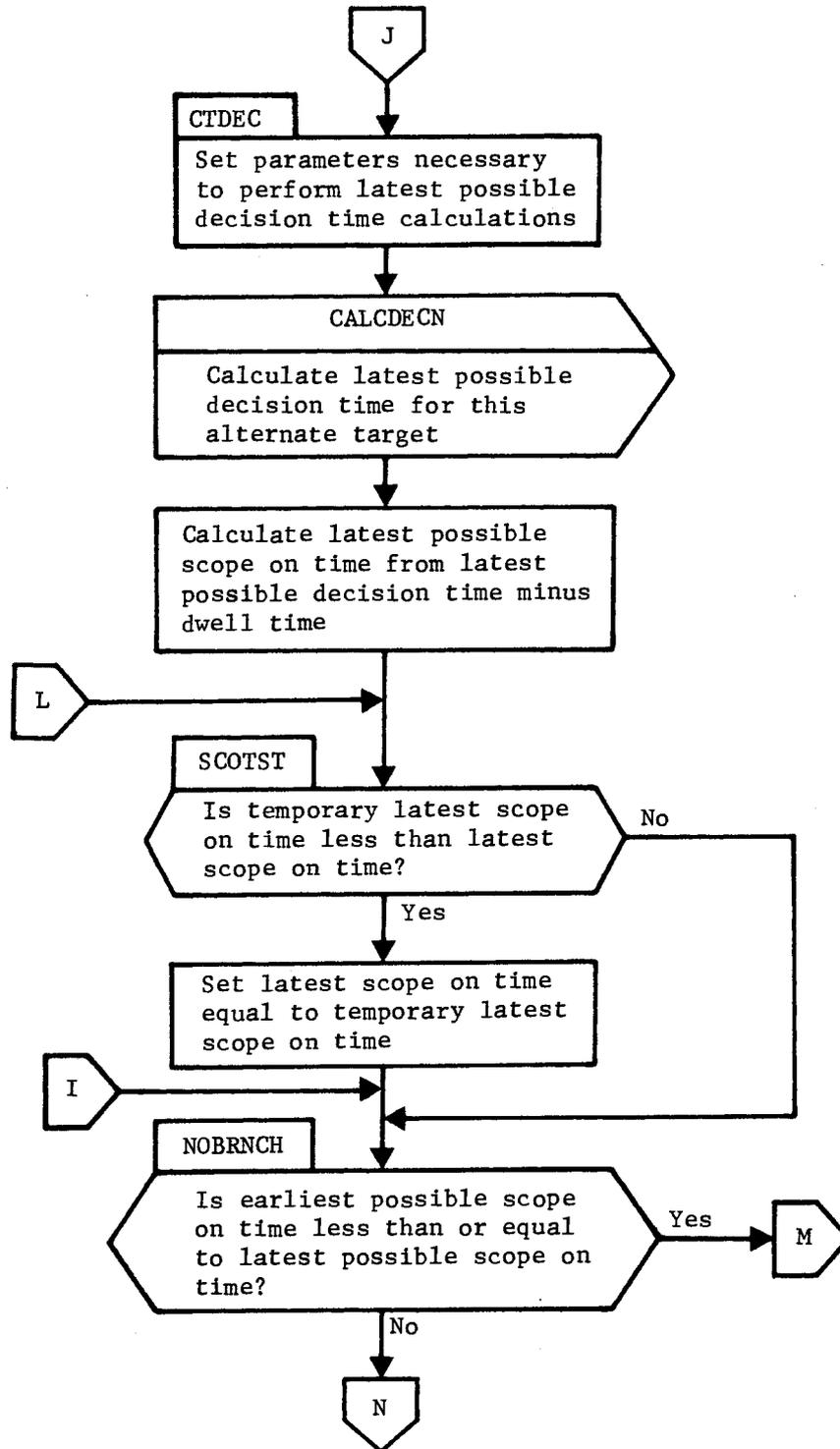


Figure 3-15. TWASCON Flow Chart (Continued)

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GEOMFILT

GEOMFILT

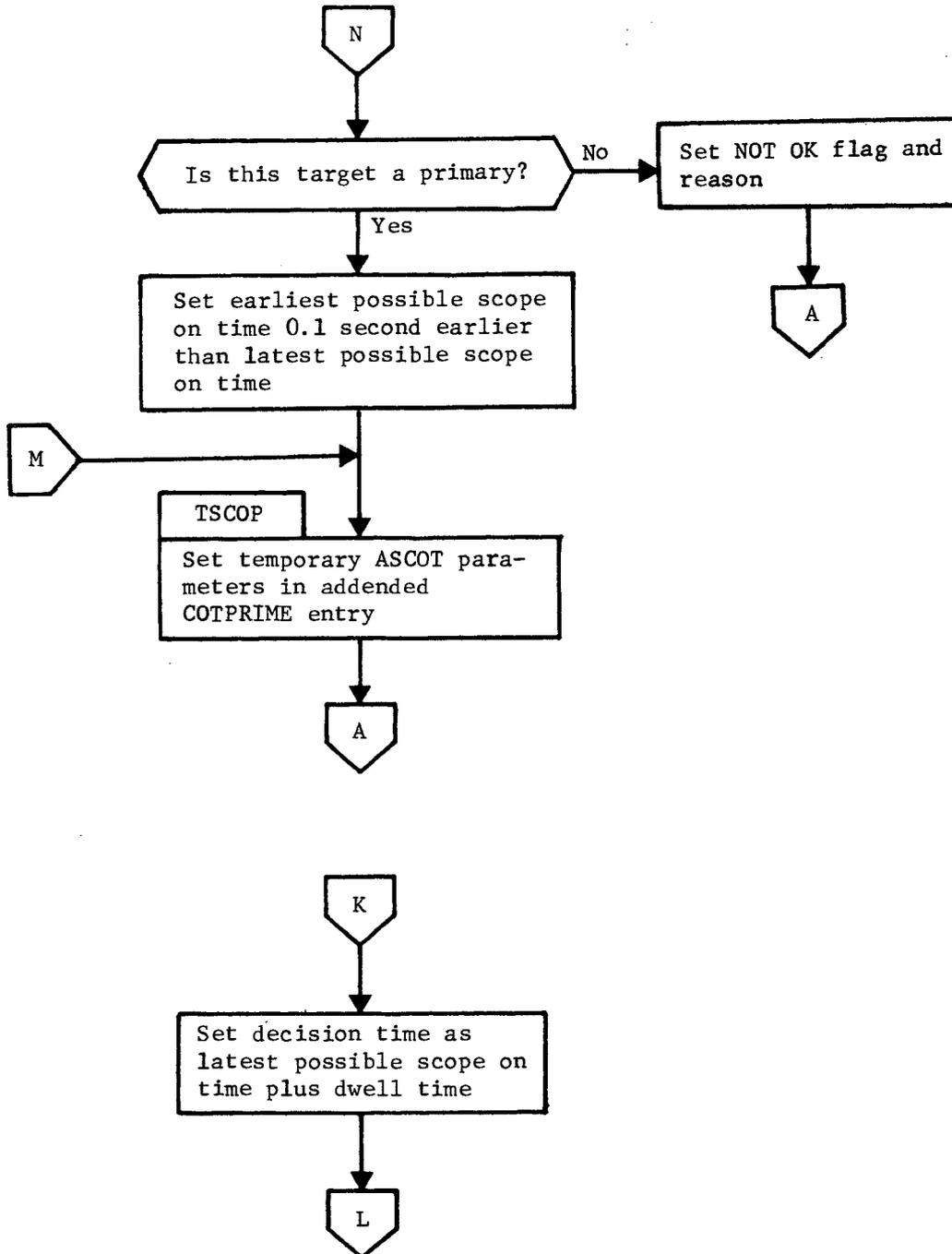


Figure 3-15. TWASCON Flow Chart (Continued)

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GENASCOT

GENASCOT

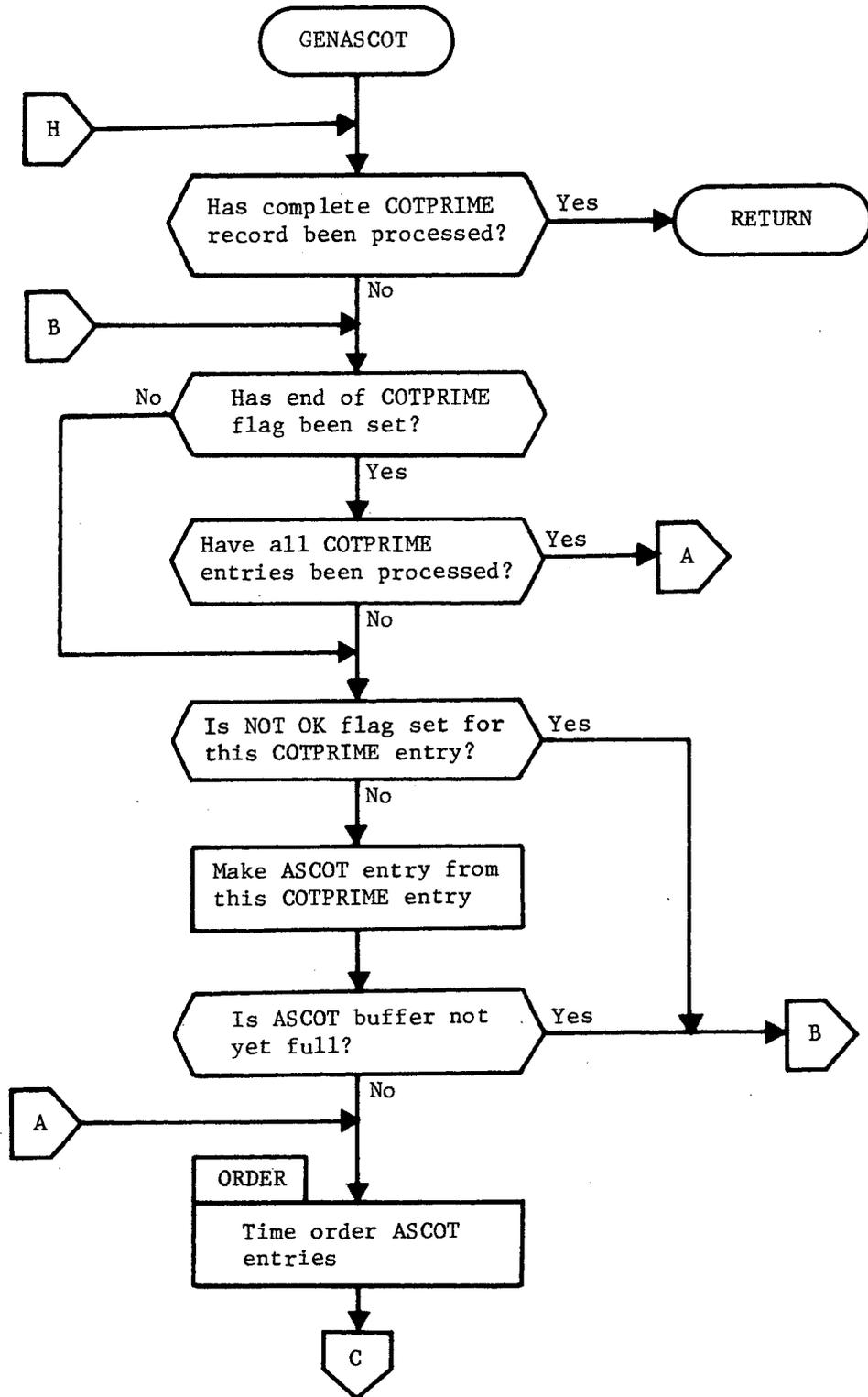


Figure 3-15. TWASCON Flow Chart (Continued)

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GENASCOT

GENASCOT

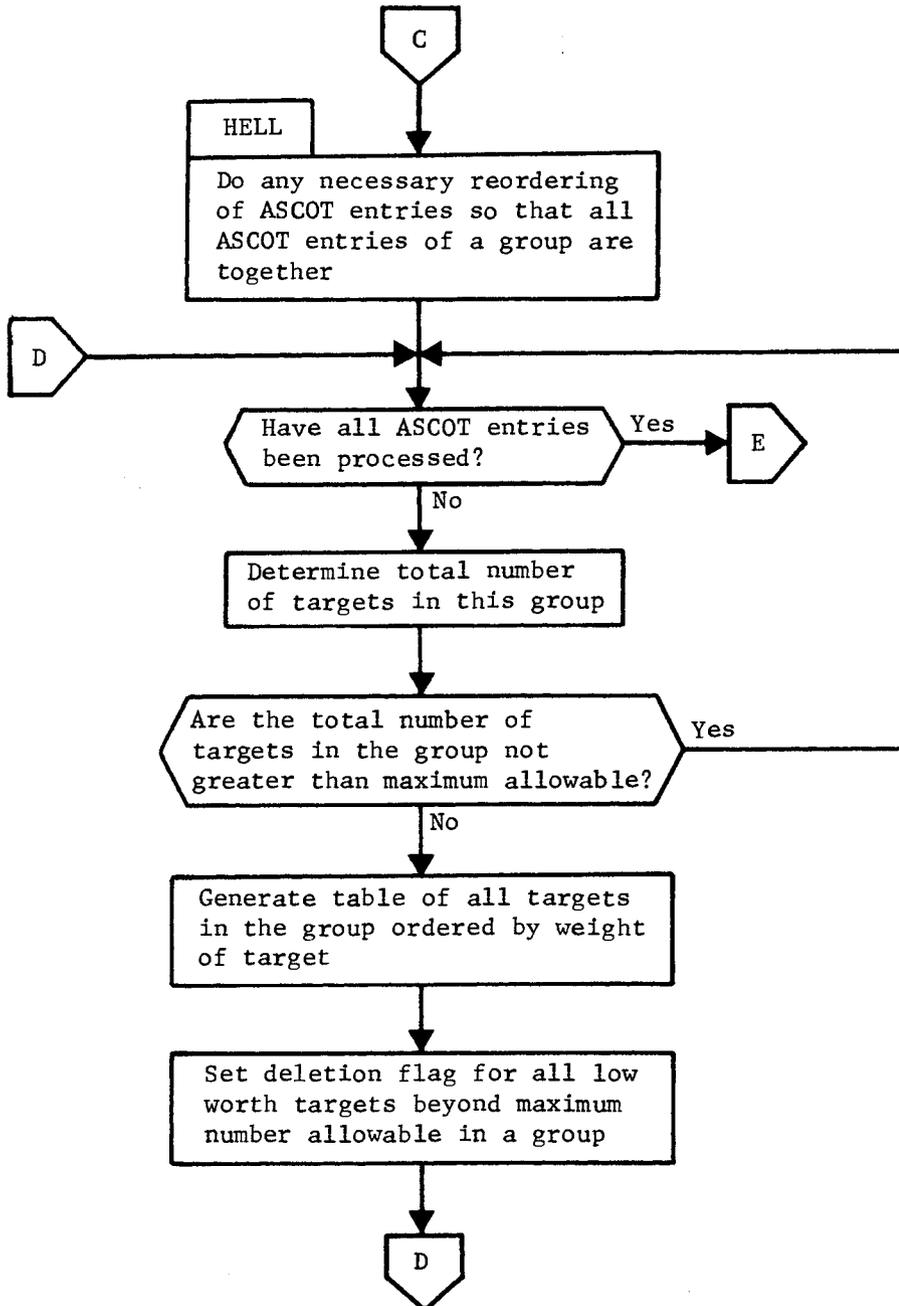


Figure 3-15. TWASCON Flow Chart (Continued)

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GENASCOT

GENASCOT

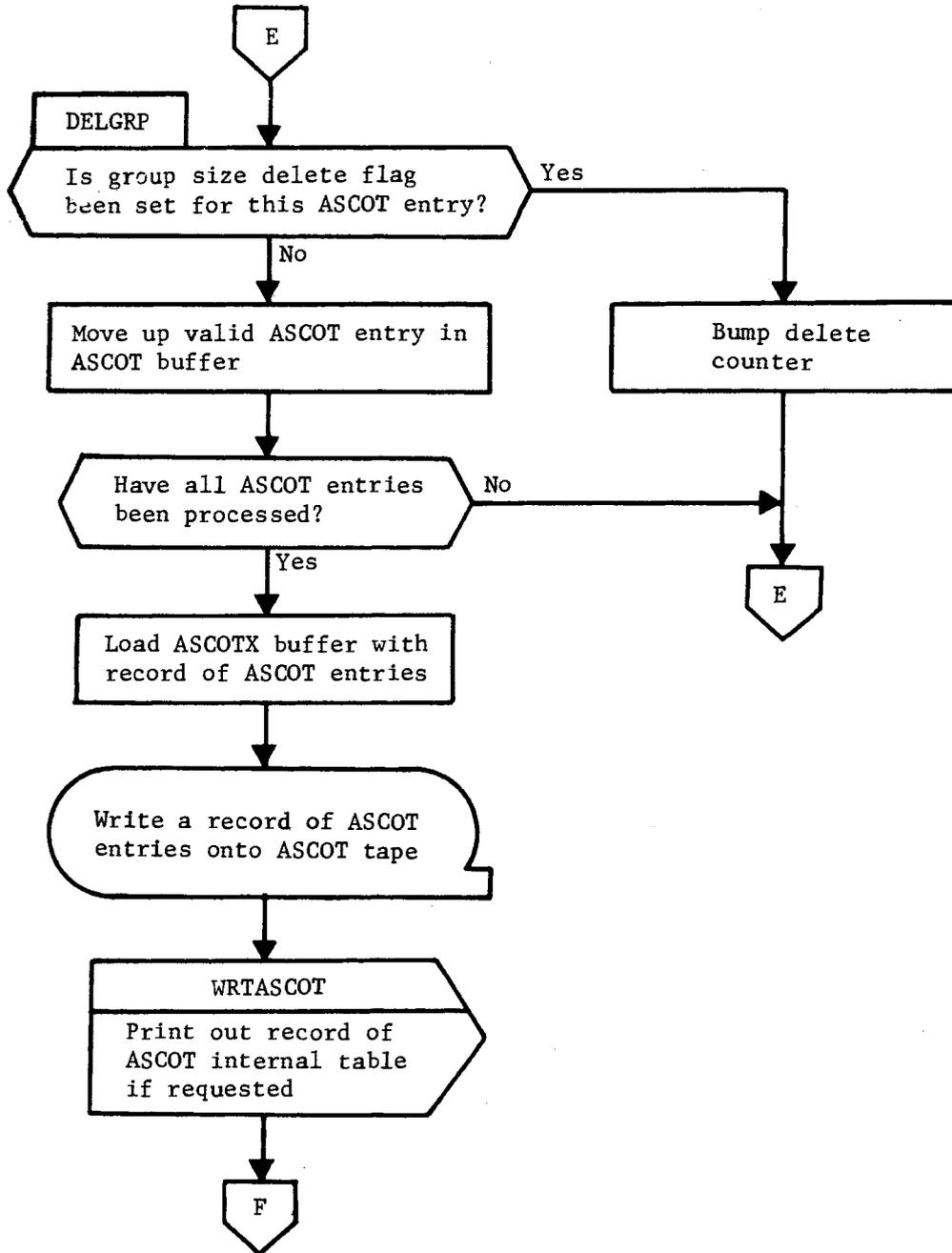


Figure 3-15. TWASCON Flow Chart (Continued)

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GENASCOT

GENASCOT

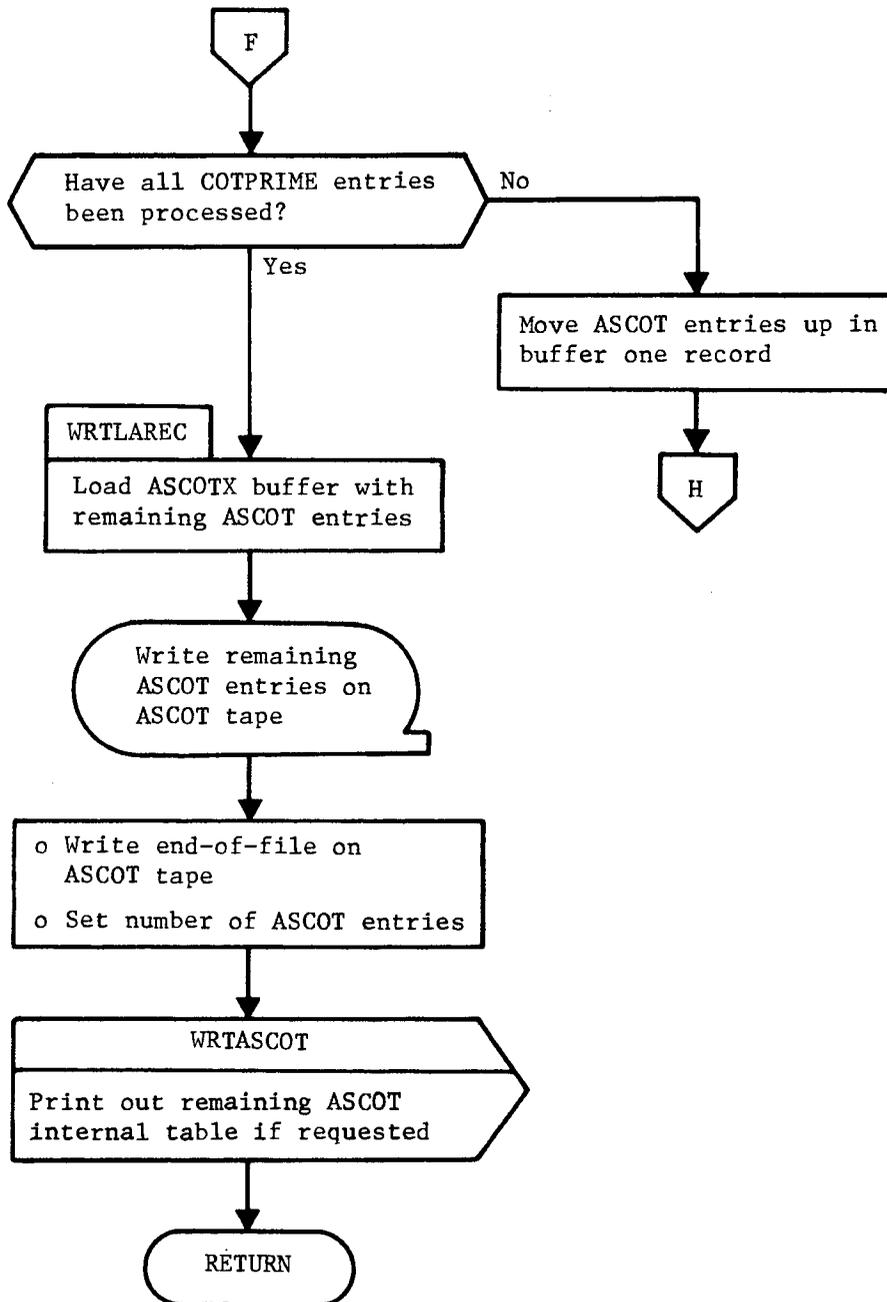


Figure 3-15. TWASCON Flow Chart (Continued)

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CALCALFA

CALCALFA

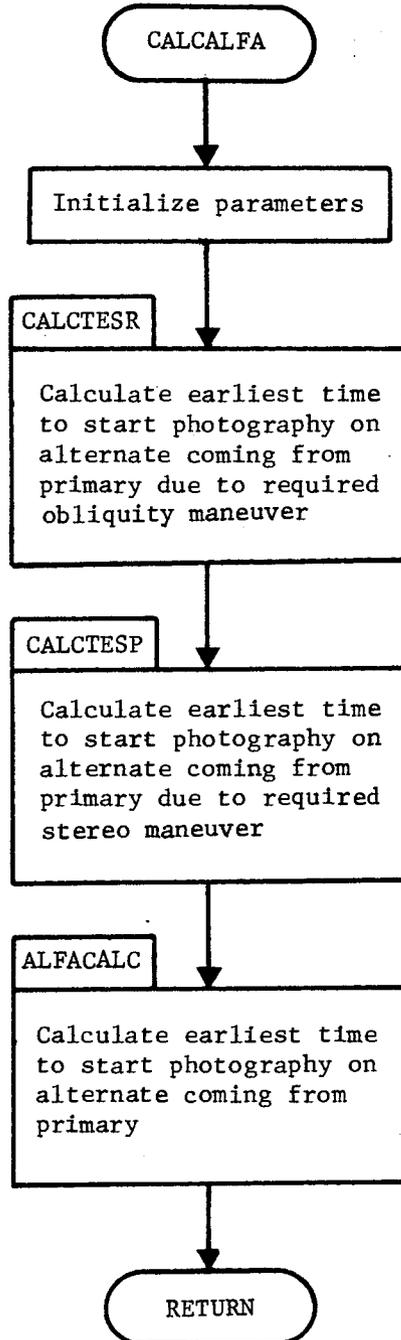


Figure 3-15. TWASCON Flow Chart (Continued)

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CALCBETA

CALCBETA

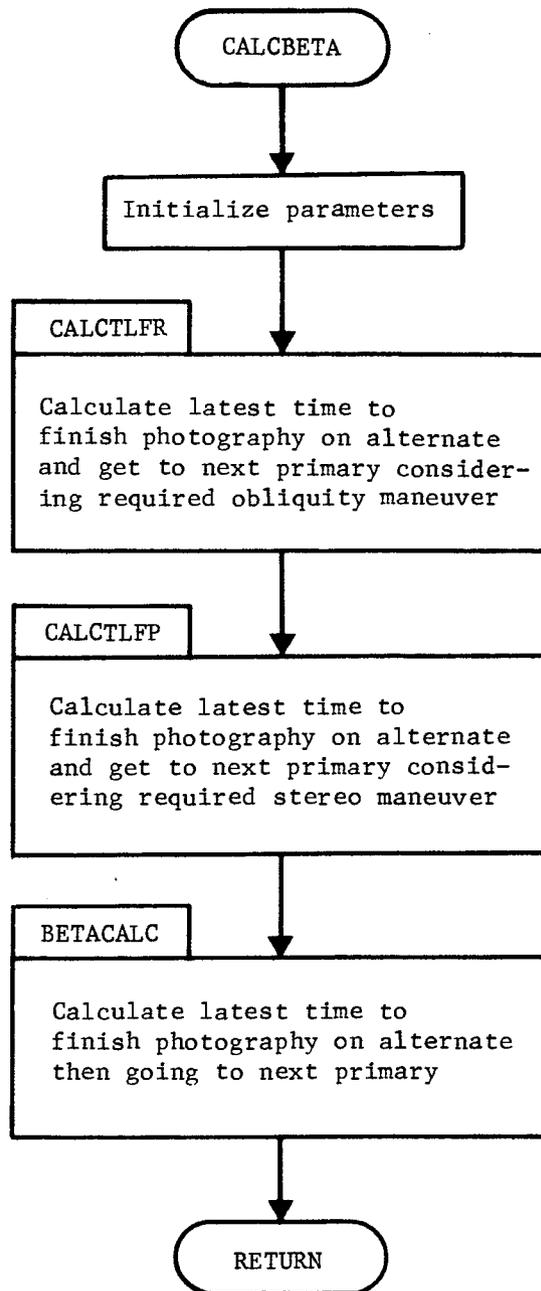


Figure 3-15. TWASCON Flow Chart (Continued)

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CALCDECN

CALCDECN

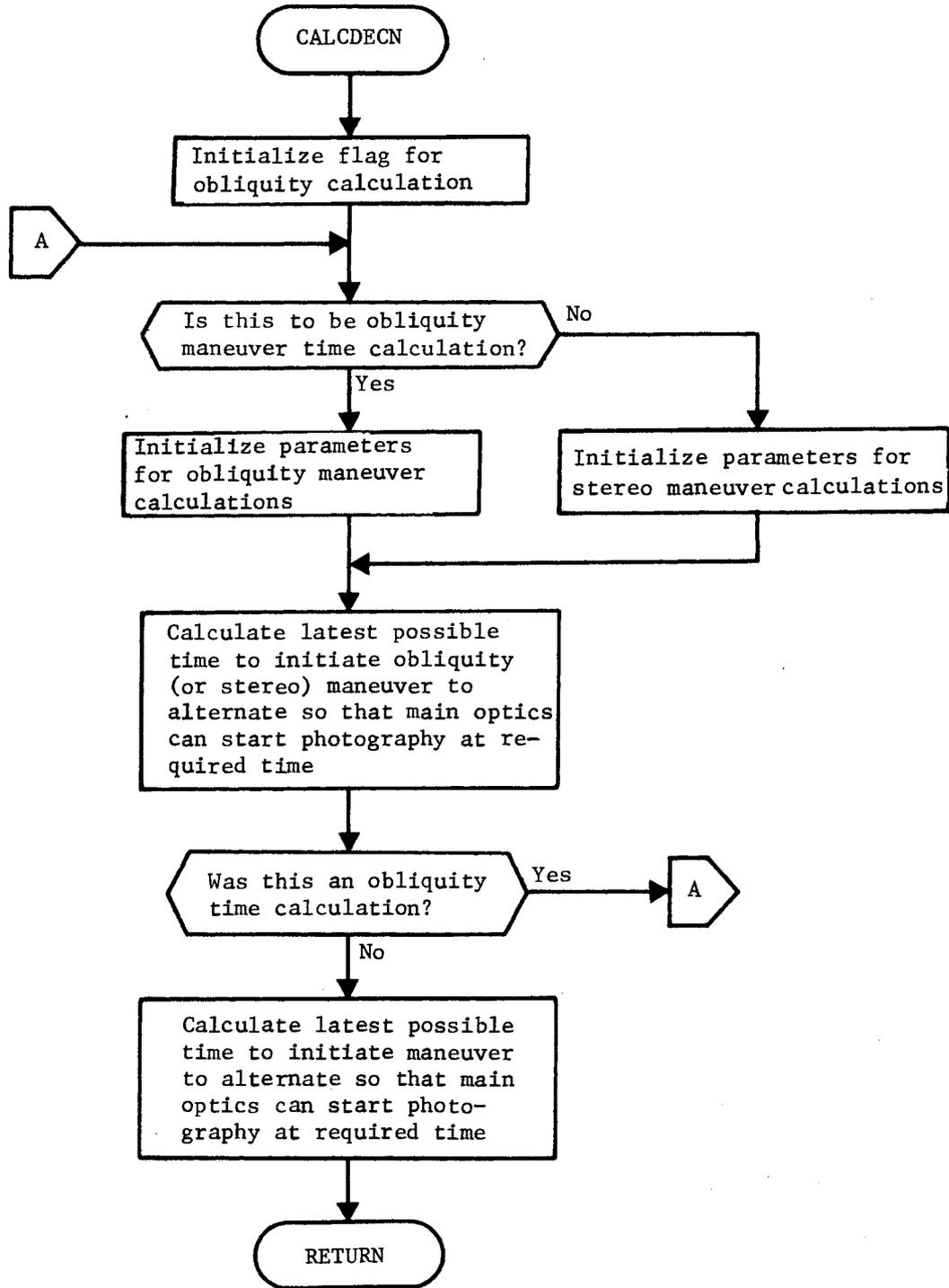


Figure 3-15. TWASCON Flow Chart (Continued)

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### 3.11 TWASSP2

#### 3.11.1 Purpose

TWASSP2 is employed to determine the optimal acquisition scope strategy when either one or two scopes are to be utilized. The worth of an individual target is based on active priority, inactive priority, probability of activity, probability of visibility, probability of falsely reporting a target to be active or inactive, and obliquity weighting. The targets to be considered are obtained from the ASCOT, and the best score sequence down to and including each target is determined.

In addition, the optimal decision time is determined for each target group. A target group consists of a single primary (or main optics) target plus a number of alternate targets. Both the primary and the selected alternates are to be viewed through the acquisition scopes, and the status of each target (active, inactive, cloudy, or mandatory override) reported to the onboard computer prior to decision time. A voting logic is then employed to determine which target should be photographed by the main optics. In order to ensure that any of the selected alternates can be photographed, a decision time must be selected that is compatible with the entire group. This group decision time is optimized by the algorithm through the use of an imbedding technique, in which multiple entries are made, when necessary, to allow for the possibility of variations in decision time.

As is the case in the main optics algorithm, a list is generated that contains the optimal sequences down to and including each of the targets being considered. The best score path is determined by first scanning the list to find the target that completes the maximum score sequence and then using the predecessor information to determine which targets are contained in the sequence. The output of TWASSP2 is the Acquisition Scope Strategy Table (ASST), which provides the optimal acquisition scope target sequence.

#### 3.11.2 Input

The ASCOT table, described in Section 3.10.3, and the THINGS table, described in Section 3.2.3, provide the information required by TWASSP2. The File 8 parameters required as input are depicted in Table 3-27.

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Table 3-27. File 8 Parameters Used in TWASSP2  
Located in Table THINGS

File 8 Location	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Def.	Internal Units
900	I	2	n.d.	Number of scopes in use:0=none, 1=one scope, 2=two scopes	NUMSCOP	I 48 U 56 0	n.d.
920	FP	20.	deg/ sec	Obliquity slewing rate for ATS	MRAS	F 309 0	rad/ sec
921	FP	20.	deg/ sec	Stereo slewing rate for ATS	MPAS	F 310 0	rad/ sec
926	FP	1.	sec	Settle time for ATS	SAS	F 25 0	sec
940	I	25	n.d.	Maximum number of list entries allowed per tar- get pair and decision time	MAXLATE	I 48 U 112 0	n.d.

3.11.3 Output

The output of TWASSP2 is the Acquisition Scope Strategy Table (ASST) intermediate data tape which contains the optimal target viewing schedule of the operating scopes. The format of the ASST is depicted in Table 3-28.

Table 3-28. ASST Format

Symbol	JOVIAL Declaration	Units	Definition
GCOTENT	I 15 U 0 0	n.d.	COTPRIME entry number
GASCOT	I 14 U 0 15	n.d.	ASCOT entry number
GGROUPNO	I 14 U 0 29	n.d.	Target group number
GEXTRA*	I 4 U 0 43	n.d.	Unused bits
GPATH	B 0 47	n.d.	Target path: 0 denotes Path 2 1 denotes Path 1
GWGT	I 48 U 1 0	n.d.	Target weight
GTSTART	F 2 0	sec	Time scope initiates target viewing
GDECIS	F 3 0	sec	Target group decision time

\* Not printed out.

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### 3.11.4 Method

The optimal acquisition scope target sequence is determined by a front to end dynamic programming approach for both the case of one and two scopes being utilized. The recurrence relation, which is the basis of the acquisition scope target selection algorithm, is

$$S_{i,k} = w_i + w_k + \max_{\substack{j \in J \\ m \in M \\ j \neq m}} S_{j,m} \quad (1)$$

where

$S_{i,k}$  = the maximum score possible starting before the rev distribution is encountered down to and including targets i and k

$w_i$  = worth of target i

$w_k$  = worth of target k

J = set of all nonconflicting candidate predecessor targets of target i

M = set of all nonconflicting candidate predecessor targets of target k

j = immediate predecessor of i

m = immediate predecessor of k

A nonconflicting candidate predecessor target of target i must satisfy the following conditions:

- It must be a target other than i or k.
- Its earliest scope on time must be earlier than the earliest scope on time of i.

The requirements for a nonconflicting predecessor of target k are equivalent.

The reasoning behind Equation (1) is that since the score maximized paths to every valid predecessor pair j,m of target pair i,k have already been determined, this knowledge can be used to find the score maximized

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paths to target pair  $i,k$ . That predecessor pair  $\hat{j},\hat{m}$  which, in conjunction with target pair  $i,k$ , yields the best score is chosen as the immediate predecessor pair of target pair  $i,k$ . Since the optimal paths to predecessors  $\hat{j}$  and  $\hat{m}$  have been previously determined, the optimal paths to targets  $i$  and  $k$  are now known.

It is readily apparent that the solution for one scope being employed is just a special case of the solution for two scopes where variables  $k$ ,  $m$ , and  $w_k$  are not employed.

It is necessary to include the selection of the group\* decision time (TD) in the acquisition scope target selection algorithm. Choosing an early group decision time can cause deletion of targets whose earliest possible scope on times plus dwell times terminate after this decision time. Choosing a late group decision time can cause the deletion of targets whose latest possible scope on times plus dwell times terminate before this decision time. The inclusion of the selection of the optimal (score maximizing) group decision time is accomplished by imbedding the above particular problem into the whole class of problems characterized by consideration of all the meaningful decision times (TD) for each group.

The appropriate equation now becomes

$$S_{i,k}(\text{TD}) = w_i + w_k + \max_{\substack{j \in J \\ m \in M \\ j \neq m}} S_{j,m}(\text{TD}) \quad (2)$$

where TD is a particular decision time compatible with both targets  $i$  and  $k$  such that both the following relationships are simultaneously satisfied.

---

\* A target group consists of a primary target plus feasible alternate targets for the main optics to photograph if it is determined by the onboard voting procedure to be more desirable to do so than to photograph the primary target. Such a situation can occur if bad weather conditions preclude photographing the primary target, or an alternate target is active while the primary target is inactive and the score of the active alternate target exceeds that of the inactive primary target.

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$$TFIRST_i + TDWELL_i \leq TD \leq TLAST_i + TDWELL_i \quad (3)$$

$$TFIRST_k + TDWELL_k \leq TD \leq TLAST_k + TDWELL_k \quad (4)$$

where

$TFIRST_x$  = earliest possible scope on time for target x

$TLAST_x$  = latest possible scope on time for target x

$TDWELL_x$  = length of time scope views target x

All such compatible decision times are termed mutual decision times.

It is initially assumed that each target is viewed commencing at its earliest scope on time  $TFIRST$ . If the scope is not able to maneuver from a target predecessor j to the target i rapidly enough to initiate viewing at time  $TFIRST$ , a conflict is said to exist. However, if the scope could maneuver to initiate viewing at a later time  $TLATE_i$ , where  $TLATE_i \leq TLAST_i$ , the conflict could be resolved. Therefore, it is necessary to include provisions for consideration of such possibilities in the algorithm to ensure that the solution will be optimal. A new target  $LATE_i$  is designated with the same characteristics as target i, with the one exception that

$$TFIRST_{LATE_i} = TLATE_i \quad (5)$$

Thus, TWASSP2 can be segmented as illustrated in Figure 3-16. The incorporation of group decision time and the conflict of the type described may be seen to have significant effect on the operation of the algorithm.

To illustrate the methodology of the algorithm, the solution of a simplified example problem will be performed where there is one primary target (3) and three alternate targets (0,1,2) to be viewed by the acquisition scopes. The targets are depicted in Figure 3-17 and are time ordered by their earliest possible scope on time. The target parameters that are of primary importance in the algorithm are the following:

$TFIRST$  = earliest scope on time

$TLAST$  = latest scope on time

$TDWELL$  = scope dwell time

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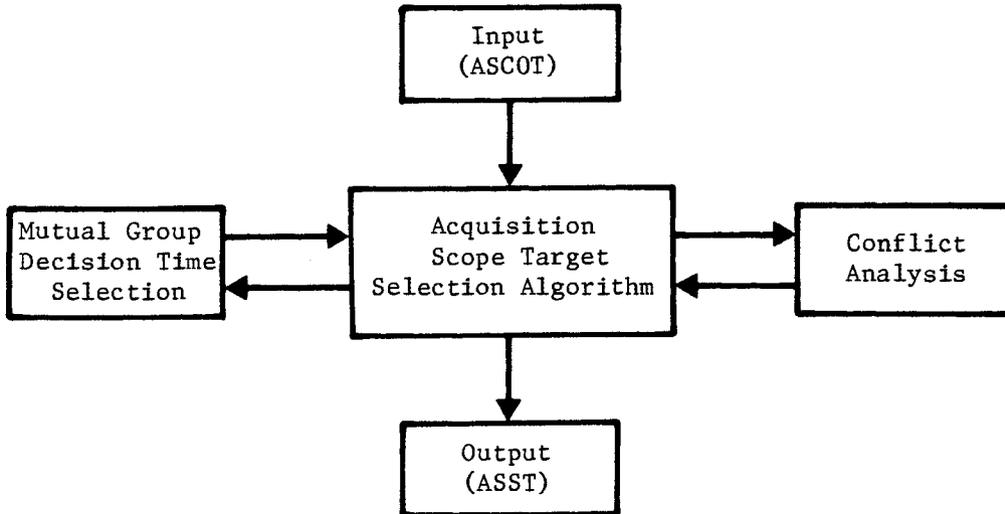
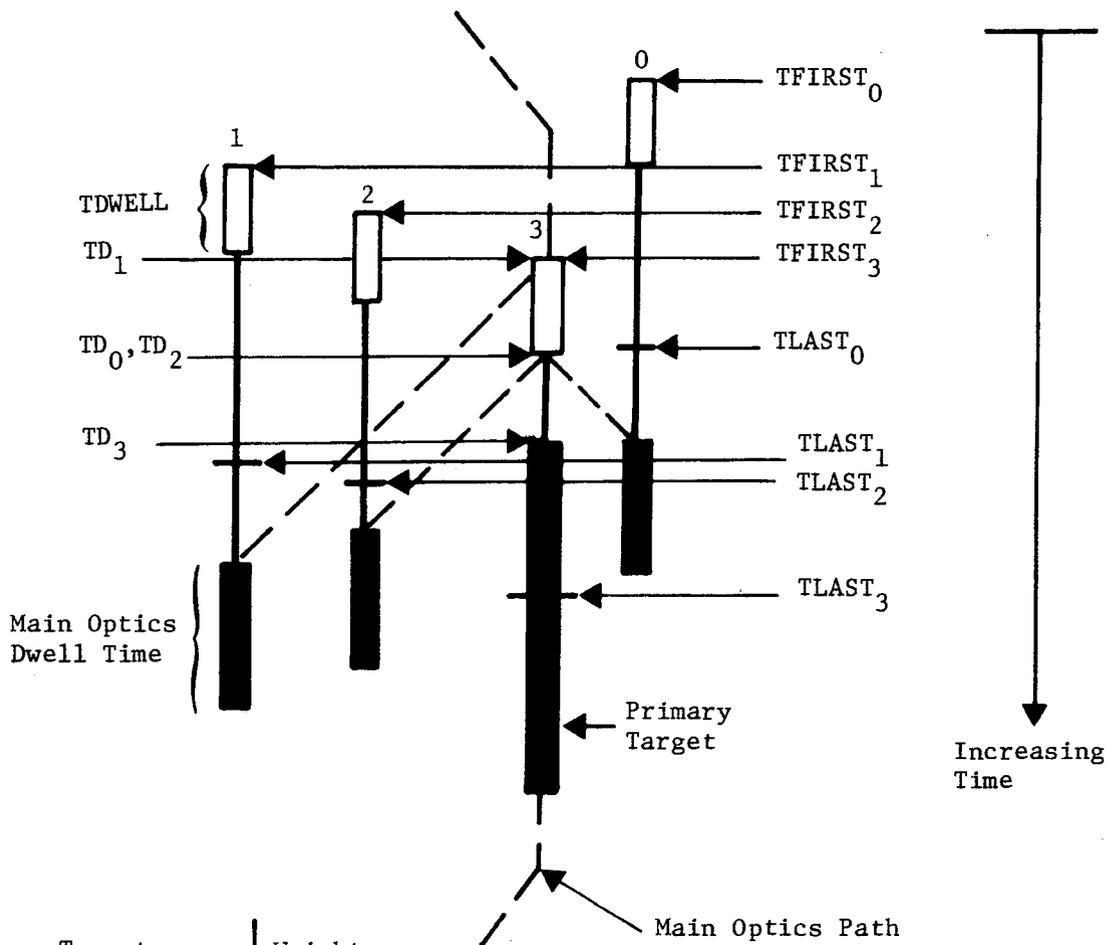


Figure 3-16. TWASSP2 Function Flow Chart

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TARGET GROUP NUMBER = 1

Figure 3-17. Example Target Distribution

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TD = latest possible decision time

WGT = weight

GROUP = group number

and are given in Figure 3-17.

The scope parameters that are of primary importance in the algorithm are the following:

EGT920, MRAS = scope obliquity slewing rate

EGT921, MPAS = scope stereo slewing rate

EGT926, SAS = scope settle time

The operation of the program will be specifically illustrated for two separate target pairs. The first example will be the illustration of the scope target selection algorithm and the mutual group decision time selection operation for the first target pair to be considered so that the initial pass through the program is depicted, and a general understanding of the program methodology can be obtained.

The second example will be the illustration of the acquisition target selection algorithm and the conflict analysis processes for an arbitrary target pair, which will serve to provide a more comprehensive understanding of the program methodology as well as the construction of the Acquisition Scope Selection Table (ASST) which contains the optimal Path 1 and Path 2 target selections.

3.11.4.1 Example 1: Initial run through the acquisition scope target selection program

#### MAIN PROGRAM (Executive Procedure)

The procedure MAIN PROGRAM is the TWASSP2 executive routine. It defines all data and tables, performs program initialization, and inhibits multiple viewing of a target.

#### TWASSP2 (MAIN PROGRAM Logic Block)

TWASSP2 initializes the program variables and indices as well as rewinds the ASCOT, LIST, and ASST tapes. It calls procedures ASREAD and NEXTTHHK.

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ASREAD (Procedure)

The procedure ASREAD reads the ASCOT tape, which contains all the target information required for the determination of the optimal scope strategy, and loads the ASCOT buffer in core. Because of storage limitations, it is not possible to read the entire ASCOT tape into the ASCOT buffer. For convenience of data handling, a buffer entry number is assigned to each target entry when it is read into the ASCOT buffer. This entry number is related to the actual ASCOT entry number by the parameter ASCOTO, which provides a measure of the preceding ASCOT entries that have been stored and removed from the ASCOT buffer prior to the insertion of the current ASCOT entries. Thus, the actual ASCOT entry number is given by the sum of ASCOTO and the ASCOT buffer entry number.

NEXTHIHK (Procedure)

The first time that procedure NEXTHIHK is entered, the number of scopes to be employed is specified by the File 8 parameter:

0, no scopes employed  
EGT900: NUMSCOP = 1, 1 scope employed  
2, 2 scopes employed

However, the driver routine, TWONDER2, does not call the acquisition scope target selection algorithm if EGT900 = 0, so EGT900 will always be 1 or 2.

The first pair (HI, HK) to be considered, as well as the applicable mutual decision times, are determined. Each succeeding time NEXTHINK is called, it determines the next target pair to be considered along with the applicable group decision times. Although in the equations previously developed targets were identified by lower case letters, the use of JOVIAL requires the following terminology to be employed.

HI = target i (target viewed by Scope 1)  
HK = target k (target viewed by Scope 2)  
HN = entry number of target pair i, k  
IHM = predecessor j of i (viewed by Scope 1)  
KHM = predecessor m of k (viewed by Scope 2)

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HM = entry number of predecessor pair j,m of target pair i,k

HISTART = first target in group (target with earliest TFIRST)

The first target to be considered is that target in the first group with the earliest scope on time TFIRST. This is Target 0 and it is viewed first by Scope 1; thus, HI is set equal to zero. For the first target pair, it is assumed that no target is viewed by Scope 2. Such a case might occur if it would be optimal for Scope 2 to maneuver to view another target with a later TFIRST, while Scope 1 was viewing a target. HK is set equal to -1, which is a dummy value to indicate that Scope 2 is not viewing any target and is considered to be viewing a "pseudo target." Similarly, if Scope 1 was not viewing any target, HI would be set equal to -1. This target pair is then analyzed for every different compatible target decision time in the group.

STORETDS (NEXTTHHK Logic Block)

The decision times for all the targets in the group being considered are collected. These times would be  $TD_0$ ,  $TD_1$ ,  $TD_2$ , and  $TD_3$ .

ORDERTDS (NEXTTHHK Logic Block)

The decision times are now time ordered in the group decision time table:  $TD_1$ ,  $TD_0$ ,  $TD_2$ ,  $TD_3$ .

ONCEMOR (NEXTTHHK Logic Block)

All entries with identical decision times are eliminated and the remaining entries are reindexed. Thus, since  $TD_0$  and  $TD_2$  are identical, only entries for  $TD_1$ ,  $TD_2$ , and  $TD_3$  are made in the group decision time table.

MUTUAL (NEXTTHHK Logic Block)

The earliest and latest time bounds for decision times for each target of the target pair being considered are set by Equations (3) and (4). For target pair HI,HK(0,1), the Equation (3) requirement is:

$$TFIRST_0 + TDWELL_0 \leq TD \leq TLAST_0 + TDWELL_0 \quad (7)$$

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Since target HK is a pseudo target, dummy values of zero and  $\infty$  are entered for  $TFIRST_{-1}$  and  $TLAST_{-1}$ , which results in Equation (4) allowing TD to be virtually unrestricted in magnitude.

SETB1 (NEXTTHIK Logic Block)

The earliest and latest time bounds for the mutual decision times of target pair HI, HK are set. Thus, TD is constrained by the greatest lower bound and the least upper bound of Equations (3) and (4). For the case of interest, both the earliest and latest bounds are given by Equation (3), and are  $TFIRST_0 + TDWELL_0$  and  $TLAST_0 + TDWELL_0$ , respectively.

BIB2 (NEXTTHIK Logic Block)

The earliest and latest decision time bounds are checked to insure that the earliest bound is not greater than the latest bound, which implies that there is no decision time that is compatible for both targets. All valid decision times for this target pair are then stored. For the example, the valid mutual decision times are found to be  $TD_1$  and  $TD_2$ , as  $TD_3$  violates the latest bound.\*

BUMPHN (MAIN PROGRAM Logic Block)

The first mutual decision time ( $TD_1$ ) is selected for the target pair HI, HK(0, -1) under consideration.

SCREWUP2 (MAIN PROGRAM Logic Block)

The mutual decision time specific parameters are initialized. The LIST entry number HN for the first target pair HI, HK(0, -1) for the first mutual decision time to be considered ( $TD_1$ ) is set at 1. The current candidate predecessor and corresponding score indices are set to zero, and the LIST entry number HM of the first candidate predecessor pair to be tested is set equal to HN-1.

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\*The NEXTTHIK logic blocks which have not been described are not employed the first time that NEXTTHIK is entered and will be described in Example 2.

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HIHKPARS (Procedure)

The ASCOT target parameter values are entered for the target pair HI, HK(0, -1). A list of these parameters is given in Table 3-29.

CHECKTOP (MAIN PROGRAM Logic Block)

The part of the LIST that contains target pair entries located in the LIST buffer is searched to determine if candidate predecessor pairs for the target pair HN(1) exist in core.\* Since HN(1) is the first LIST entry, no predecessors exist as HM is zero. Thus, there are no possibilities of conflicts or of selecting a better solution because only one solution exists for specified decision time (TD<sub>1</sub>). Therefore, none of the conflict logic is required, and control is transferred to LISTGEN.

Table 3-29. ASCOT Target Values Entered for Target Pair HI, HK(0, -1) Parameter Values

Parameter	Real Target HI(0)	Pseudo Target HK(-1)
COTPRIME entry number	XCONTENTI	-1
Earliest scope on time	XTFIRSTI	1.0
Latest scope on time	XTLASTI	1.0
Scope dwell time	XDWELLI	0
Target weight	XWGII	0
Target obliquity	XOMEGAI	-
Target group number	XGROUPI	XRGROUP (HI)
Earliest main optics acquisition time	XT1I	-
Time of interval between earliest and latest main optics acquisition times	XT3T1I	-

\* Only the part of the LIST stored in core is searched for predecessors to avoid excessive running time caused by data transfer into and out of core.

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LISTGEN (MAIN PROGRAM Logic Block)

LISTGEN governs the selection of target-predecessor pair LIST entries as well as the future target pairs and mutual decision times to be considered. It calls procedures GENLIST and NEXTTHHK.

GENLIST (Procedure)

The procedure GENLIST generates the LIST, which contains the best target predecessor LIST entry for a specified mutual decision time for each target pair. It also performs another task that will be discussed in Example 2.

STARTER (GENLIST Logic Block)

A LIST entry is made for the target pair mutual decision time under consideration. If the score obtained with this target pair is not exceeded by any previous score, the MAXIMER flag is set. The purpose of this flag is to facilitate the selection of an optimum predecessor pair for the target pair and will be more fully discussed in Example 2.

For the case of the example initial target pair HN:HI, HK, TD(1:0, -1, TD<sub>1</sub>), an entry is made in the LIST buffer in the format depicted in Table 3-30. This analysis is then repeated for target pair (0, -1) for all the remaining mutual decision times (TD<sub>2</sub>). The target pair HI, HK, TD(0, -1, TD<sub>2</sub>) is given a LIST entry number of HN(2).

After all the decision times have been considered for the target pair of interest, the procedure NEXTTHHK is entered to select the next target pair to be considered as well as the mutual decision times.

3.11.4.2 Example 2: Arbitrary run through the acquisition scope target selection program

Any run through the program subsequent to the first run for the initial target pair of LIST entry HN(1) originates in the procedure NEXTTHHK called by MAIN PROGRAM logic block LISTGEN. The analysis commencing with target pair LIST entry HN:HI, HK, TD(22:3, 2, TD<sub>2</sub>) will now be illustrated to further explain the scope selection algorithm, the conflict analysis process, and the generation of the ASST. Since target pair LIST entry HN(22) is to be examined, the analysis has been concluded for previous target pairs LIST entries HN (1, ..., 21). The LIST that contains the best target

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Table 3-30. LIST Format for Target Pair HN:HL, HK, TD(1:0, -1, TD<sub>1</sub>)

LIST Entry Number	Start of Scope View Time	Target	Total Score	Predecessor LIST Entry Number	MAXIMER Flag	Mutual Decision Time
HN	Path 1 TSTARTI	Path 2 TSTARTK	SUMSCOR	PREDNUM		TDECIS
1	TFIRST <sub>0</sub>	-1.0	2	0	1	TD <sub>1</sub>

COTPRIME Target Entry Number	Group Number	ASCOT Target Entry Number	Number of LIST Entries for Target Pair and Specified Decision Time	Target Weight
Path 1 COTPI	Path 2 COTPK	Path 1 ASCOTI	Path 2 ASCOTK	LISTCNT
0	-1	1	0	-1
		1	0	-1
		1	1	2
		1	1	0

\* This column is not generated in the LIST, but is presented to aid in the understanding of the algorithm.

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predecessor LIST entry for a specified mutual decision time has already been constructed for these target pairs by use of Equation (1), and a modified version of it is depicted in Table 3-31. For the purpose of illustration, entries that would have been deleted because of violation of the requirement that the primary target may only be viewed by Scope 1 or because no mutual decision times exist are also shown in Table 3-31, as are the remaining entries, HN(22) and HN(23), to be made. Note that the format used in Table 3-31 is not the actual LIST format previously illustrated, but rather a modified version which better illustrates the methodology of the algorithm.

NEXTHIHK (Procedure)

This procedure determines the next target pair to be considered as well as the mutual decision times. The list of all target pairs along with their mutual decision times is presented in Table 3-32. Note that if it is desired that primary targets always be viewed by a specific scope, all that is required is to delete those entries where a primary target is viewed by the other scope. Since, for the example being considered, all primaries are to be viewed by Scope 1 and Target 3 is the primary target, all entries where  $HK = 3$  are deleted. Similarly, if only one scope is specified to be operating, all entries where Scope 2 is viewing a target are deleted, i.e., all entries other than  $HK = -1$  are deleted.

The analysis associated with target pair  $HI, HK, TD(3, 2, TD_2)$  of LIST entry HN(22) will now be illustrated to further explain the acquisition scope target selection algorithm and the conflict analysis. Since the procedure NEXTHIHK is not being entered for the first time, the initial NEXTHIHK logic block entered is THISTHAT.

THISTHAT, IFHKPRIM, BUMPHI (NEXTHIHK Logic Blocks)

These three logic blocks determine the next target pair to be considered. A description of each individual logic block is given first, and then an illustration of how they function together is presented.

THISTHAT (NEXTHIHK Logic Block)

This logic block switches the scope assignments for target pair  $HI, HK$ . Scope 1 is assigned the target currently assigned to Scope 2, and Scope 2 is assigned the target currently assigned to Scope 1. The File 8 parameter

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Table 3-31. Example Modified LIST

LIST Entry Number HN/HM	Path 1 Target HI	Path 2 Target HK	Mutual Decision Time TD	Optimal Predecessor Path LIST Entry HM	MAXIMER Flag	Path 1 Target Weight $w_i$	Path 2 Target Weight $w_j$	Score $S_i$
→ 1	0	-1	TD <sub>1</sub>	0	1	2	0	2
2	0	-1	TD <sub>2</sub>	0	1	2	0	2
3	-1	0	TD <sub>1</sub>	0	1	0	2	2
4	-1	0	TD <sub>2</sub>	0	1	0	2	2
5	1	-1	TD <sub>1</sub>	0	1	3	0	3
6	1	-1	TD <sub>2</sub>	0	1	3	0	3
7	-1	1	TD <sub>1</sub>	1	1	0	3	5
8	-1	1	TD <sub>2</sub>	2	1	0	3	5
9	1	0	TD <sub>1</sub>	0	1	3	2	5
10	1	0	TD <sub>2</sub>	0	1	3	2	5
11	0	1	TD <sub>1</sub>	0	1	2	3	5
12	0	1	TD <sub>2</sub>	0	1	2	3	5 *
13	2	-1	TD <sub>2</sub>	8	1	1	0	5
14	-1	2	TD <sub>2</sub>	6	0	0	1	4
15	2	0	TD <sub>2</sub>	0	0	1	2	3
16	0	2	TD <sub>2</sub>	0	0	2	1	3
17	2	1	TD <sub>2</sub>	0	0	1	3	4
18	1	2	TD <sub>2</sub>	0	0	3	1	4
19	3	-1	TD <sub>2</sub>	12	1	10	0	15
20	3	-1	TD <sub>3</sub>	0	0	10	0	10
X	-1	3	Deleted					
X	-1	3	Deleted					
21	3	0	TD <sub>2</sub>	0	0	10	2	12
X	0	3	Deleted					
X	3	1	None	Deleted				
X	1	3	Deleted					
→ 22	3	2	TD <sub>2</sub>	2	0	10	1	13
X	2	3	Deleted					
→ 23	Late 3	Late 2	TD <sub>2</sub>	12	1	10	1	16 *
X	Late 2	Late 3	Deleted					

\* Maximum score solution

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Table 3-32. Example Target Pairs and Mutual Decision Times

LIST Entry HN	Path 1 Target HK	Path 2 Target HK	Mutual Decision Time TD
1	0	-1*	TD <sub>1</sub>
2	0	-1*	TD <sub>2</sub>
3	-1	0	TD <sub>1</sub>
4	-1	0	TD <sub>2</sub>
5	1	-1*	TD <sub>1</sub>
6	1	-1*	TD <sub>2</sub>
7	-1	1	TD <sub>1</sub>
8	-1	1	TD <sub>2</sub>
9	1	0	TD <sub>1</sub>
10	1	0	TD <sub>2</sub>
11	0	1	TD <sub>1</sub>
12	0	1	TD <sub>2</sub>
13	2	-1*	TD <sub>2</sub>
14	-1	2	TD <sub>2</sub>
15	2	0	TD <sub>2</sub>
16	0	2	TD <sub>2</sub>
17	2	1	TD <sub>2</sub>
18	1	2	TD <sub>2</sub>
19	3	-1*	TD <sub>2</sub>
20	3	-1*	TD <sub>3</sub>
21	-1	3**	TD <sub>2</sub>
22	-1	3**	TD <sub>3</sub>
23	3	0	TD <sub>2</sub>
24	0	3**	TD <sub>2</sub>
25	3	1	None
26	1	3**	None
27	3	2	TD <sub>2</sub>
28	2	3**	TD <sub>2</sub>

\* Only these entries are made if only one scope is employed, all others are deleted.

\*\* Entry is deleted if primary target must always lie on Path 1.

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EGT900: NUMSCOP is employed to determine the number of operating scopes. If only one scope is being employed (NUMSCOP = 1), only pseudo targets (HK = -1) are allowed for Path 2, and all other target pair entries are deleted.

Example: NUMSCOP = 2, therefore real targets are allowed on Path 2.

IFHKPRIM (NEXTTHHK Logic Block)

The entry HK is examined to determine whether the current target pair has a primary target on Path 2, which is disallowed. The validity of the current target pair is checked as well as whether this combination has been previously generated. If required, the Path 2 assigned target entry HK is incremented.

Example: Primary Target 3 is on Path 1 as HI is 3.

BUMPHI (NEXTTHHK Logic Block)

The Path 1 assigned target entry, HI, is incremented, and it is determined whether all targets have been examined by observing whether the incremented value of HI exceeds the last target entry number in the ASCOT. If so, the flag DONE is set, and control is transferred to MAIN PROGRAM logic block ASSTGEN.

Example: The last target entry number in ASCOT is 3. Since HI = 3, the ASCOT number is not exceeded, and the flag DONE is not set.

MORASCOT (NEXTTHHK Logic Block)

If more ASCOT entries are required to be placed in the ASCOT buffer, procedure ASREAD is called to read in another record of ASCOT entries into the ASCOT buffer. The top portion of the ASCOT entries are written over in core, the remaining ASCOT entries in the ASCOT buffer are moved up to the top portion, and the buffer target entry numbers are reset.

SCREWUP1 (NEXTTHHK Logic Block)

If the new Path 1 target is a member of the same group as the previous Path 1 target, control is transferred to MUTUAL; if it is a member of a new group, control is transferred to STORETDS, ORDERTDS, and ONCEMOR, where the decision times for all the targets in the new group are collected,

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time ordered, and redundant entries deleted, respectively, as previously described in Example 1.

Example: The target pair of interest is HN:HI, HK, TD(22:3, 2, TD<sub>2</sub>). Currently in storage is LIST entry HN:HI, HK, TD<sub>2</sub> (21:3, 0, TD<sub>2</sub>). Logic block THISTHAT is entered and HI and HK are switched, resulting in HI, HK(0, 3). Control is then transferred back and forth between NEXTHIHK logic blocks THISTHAT, IFHKPRIM, BUMPHI, MORASCOT, and SCREWUP1 until the next valid target pair is finally determined to be HI, HK(3, 2).

Control is then transferred to MUTUAL, SETB1, and B1B2, where mutual decision times are determined for the current target pair HI, HK.

Example: The only valid mutual decision time for target pair HI, HK(3, 2) is TD<sub>2</sub>.

BUMPHN (MAIN PROGRAM Logic Block)

The first mutual decision time is selected for target pair HI, HK.

Example: For HI, HK(3, 2), the first mutual decision time is TD<sub>2</sub>.

SCREWUP2 (MAIN PROGRAM Logic Block)

The mutual decision time specific parameters are initialized, the LIST entry number HN for the target pair HI, HK(3, 2) is set, the current score and predecessor indices are reset to zero, and the first candidate predecessor pair LIST entry number HM is determined.

Example: HN = 23  
HM = 22

HIHKPARS (Procedure)

The ASCOT target parameter values are entered for the target pair HI, HK.

Example: A list of these parameters is given in Table 3-29.

CHECKTOP (MAIN PROGRAM Logic Block)

The part of the LIST which contains target pair entries located in core is examined to determine if any candidate predecessor pairs for the target pair HN:HI, HK exist in core. If no entries exist, control is transferred to LISTGEN, where the target pair HN:HI, HK generates a new target pair chain.

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Example: Candidate predecessor pair LIST entries exist for target pair HN(22).

SEARCHUP and YESCON (MAIN PROGRAM Logic Blocks)

The LIST is searched backwards starting from the immediately preceding target pair HM(HN-1) for a predecessor pair which yields a score greater than presently achieved. If the search reaches the beginning of the LIST stored in the LIST buffer without finding a predecessor entry which yields a score greater than that achieved so far, control is transferred to LISTGEN, where a new target pair chain is generated.

When a candidate predecessor pair HM:IHM,KHM,TD is chosen where IHM is the predecessor of target HI and KHM is the predecessor of target HK, a check is made to insure that neither target HI or HK is a predecessor of itself or of the other target.

Example: HI  $\neq$  IHM or KHM, and HK  $\neq$  IHM or KHM

Furthermore, checks are made to insure that targets HI and HK have not been included in any LIST entry that serves as a predecessor pair to entry HN:HI,HK,TD. If either HI or HK has been previously assigned to a scope, logic block YESCON determines if there are any more candidate predecessor pairs for the specified target pair. If so, SEARCHUP is repeated; otherwise, LISTGEN is entered.

If neither HI or HK has been a predecessor of itself or the other target, control is transferred to CHKGROUP.

Example: The LIST, which has been already calculated by use of Equation (2), is depicted in Table 3-31 for target pair HN:HI,HK,TD<sub>2</sub>(22:3,2,TD<sub>2</sub>). The immediate predecessor LIST entry for HN(22) is HM:IHM,KHM,TD(21:3,0,TD<sub>2</sub>). But for this case, target HI(3) is a predecessor of itself, and HM(21) is not a valid predecessor pair LIST entry for HN(22). The next candidate predecessor entry to be examined is HM(20). However, once again, HI is a predecessor of itself. Either HI or HK is a predecessor of itself or of the other for predecessor LIST entries HM(19) through HM(13), so these candidate predecessor pairs are also eliminated. The first candidate predecessor pair examined where such is not the case is HM:IHM,KHM,TD(12:0,1,TD<sub>2</sub>).

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CHKGROUP (MAIN PROGRAM Logic Block)

The current target pair LIST entry HN and the candidate predecessor pair LIST entry HM are examined, first, to determine if they belong to the same group, and, second, if they do belong to the same group, whether they have the same mutual decision time. If both target pairs belong to the same group and have the same mutual decision time, control is transferred to CONCON and the analysis is continued. If the groups or mutual decision times are different, examination of a different candidate predecessor pair is initiated by YESCON.

Example: Since both candidate predecessor pair HM:IHM,KHM,TD (12:0,1,TD<sub>2</sub>) and target pair HN:HI,HK,TD(22:3,2,TD<sub>2</sub>) belong to the same group and have the same mutual decision time TD<sub>2</sub>, this test is satisfied.

CONCON (MAIN PROGRAM Logic Block)

Logic block CONCON controls the conflict analysis portion of the program. Its basic purpose is to determine whether a scope can maneuver to a target from a predecessor to initiate viewing at the earliest possible scope on time TFIRST. If such a maneuver is not possible, a conflict is said to exist. CONCON determines whether such a conflict can be eliminated by delaying the time at which the target is viewed, and if such is the case, whether the resulting score is worth the delay encountered.

The procedures called by CONCON are HMPARS, ASSP2CON, and IKDELAY, and ASSP2CON calls procedure CONFLICT. HMPARS sets the LIST entry and ASCOT entry numbers for the candidate predecessor pair HM:IHM,KHM,TD. ASSP2CON, in conjunction with CONFLICT, determines whether the time required to maneuver the scopes from the candidate predecessor pair to the target pair results in an inability for either or both targets to be viewed at the earliest possible time scope on TFIRST. IKDELAY determines if it is possible to resolve the conflict by delaying the viewing of the target or targets in conflict and if the score obtained by doing so is worth the time delay, in which case this information is stored for future use. If a conflict is found to exist, CONCON transfers control to YESCON. If a no-conflict situation is found, CONCON determines if there can exist any predecessor pairs not yet tested which can yield a better score than

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that obtained by the current best predecessor pair. This process is performed by use of the MAXIMER flag. The MAXIMER flag is set for every target pair LIST entry whose score is greater than or equal to that achieved by any previous target pair LIST entry. Thus, if a target pair HN:HI, HK, TD can have as a valid predecessor pair HM:IHM, KHM, TD for which the MAXIMER flag is set, it is impossible for the score achieved by choosing a predecessor pair for target pair HN whose entry number is less than HM to exceed this score, and no more predecessor pairs need be tested. That such is indeed the case can be best illustrated by referring to LIST entry HN(20) in Table 3-31. The score is 10 and the MAXIMER flag is not set. Thus, it is possible for a target pair with an earlier LIST entry to yield a better score, which is indeed the case for LIST entry HN(19), which attains a better score of 15. However, since the MAXIMER flag is set for HN(19), no target pair with an earlier LIST entry, i.e., HN(1) through HN(18) can have a better score, as can be seen in Table 3-31.

If the MAXIMER flag is set for the candidate predecessor pair, no more predecessor pairs will be tested, and control is transferred to LISTGEN. If the flag is not set, control is transferred to CHECKTOP where another candidate predecessor pair will be tested.

Example: The MAXIMER flag is set for LIST entry HM(12) so there is no possibility of attaining a better score by considering target pairs with LIST entries of less than HN(12). However, predecessor pair LIST entry HM(12) is found to conflict with target pair LIST entry HN(22). Therefore, at the conclusion of the conflict analysis for predecessor pair HM(12), testing of a different candidate predecessor pair is initiated by YESCON. The results of this predecessor testing will be summarized below, and a discussion of the conflict analysis procedure for HM(12) will commence with the description of the procedure HMPARS.

Target pairs HM(11,9,7,5,3) are rejected by CHKGROUP because their mutual decision times are different from that of target pair HN(22). Target pairs HM(10,8,6,4) are rejected by CONCON as both predecessors conflict with the targets of target pair HN(22). Predecessor pair HM:IHM, KHM, TD(2:0, -1, TD<sub>2</sub>) is found to be a valid predecessor pair of target pair HN(22), as the mutual decision times are the same and there is no conflict. Since the MAXIMER flag is set for HM(2), the score achieved by choosing this predecessor cannot be exceeded by searching back for additional predecessor pairs. Since both targets of target

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pair HI, HK(3,2) are being viewed at the earliest possible times, no time saving can be obtained by use of another predecessor pair. Thus, the predecessor pair search is terminated and control is transferred to LISTGEN.

HMPARS (Procedure)

Procedure HMPARS sets the LIST entry and ASCOT entry numbers for the candidate predecessors HM:IH,KHM,TD to be examined in conflict analysis.

Example: Predecessor pair HM:IHM,KHM,TD (12:0,1,TD<sub>2</sub>) will be examined.

TESTIHM and TESTKHM (HMPARS Logic Blocks)

Candidate predecessors IHM and KHM are examined to determine whether they are real predecessors of HI and HK or pseudo predecessors where Scopes 1 or 2 is setting up for HI or HK, respectively, rather than actually viewing a target.

Example: For target pair IHM,KHM(0,1), both targets IHM and KHM are real targets as neither are equal to -1.

MIPARS and MKPARS (HMPARS Logic Blocks)

The LIST entry of the real predecessor of HI is stored in TEMPHMI, and the LIST entry of the real predecessor of HK is stored in TEMPHMK. The ASCOT entries of the real predecessors are also stored in the ASCOT buffer.

TRIP1 and TRIP2 (HMPARS Logic Blocks)

If either the immediate predecessor of HI or of HK is not real, a real earlier predecessor LIST entry is searched for in core. If none is found, the corresponding predecessor is left as a pseudo target and a no-conflict relationship is assumed. If a real predecessor LIST entry is found, control is transferred to MIPARS or MKPARS, where its LIST and ASCOT entries are stored.

ASSP2CON (Procedure)

ASSP2CON, in conjunction with the procedure CONFLICT, determines whether a conflict exists between the candidate predecessor pair and the specified target pair, and if so, the magnitude of the conflict. CONFLICT determines the time required for the scopes to maneuver from the predecessor pair to the target pair, and ASSP2CON determines if this required time causes a conflict.

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ASSP2CON (ASSP2CON Logic Block)

If the candidate predecessor target IHM is a pseudo target, the ASCOT entry of IHM is not in core, i.e., no data for target IHM is stored in core, or the current target is a pseudo target, control is transferred to HOOKONI, where a no-conflict situation is designated for HI and IHM. A similar procedure is performed for the Path 2 target and candidate predecessor by KAYBABY. Otherwise, the following target and predecessor parameters listed in Table 3-33 are set for conflict analysis.

Example: The time at which the stereo and obliquity maneuver from IHM(0) to HI(3) is completed is computed in procedure CONFLICT and is given by the parameter BAUMTE. This time is then compared to the earliest scope on time for target HI(3), TFIRST<sub>3</sub>. If it exceeds TFIRST<sub>3</sub>, a conflict is said to exist as it is impossible for the scope to view the target at the earliest possible time. For the example, BAUMTE < TFIRST<sub>3</sub>; thus no conflict exists.

HOOKONI (ASSP2CON Logic Block)

A no-conflict condition is noted for the Path 1 target and predecessor, HI and IHM by setting the conflict flag YACON to zero, and inputting zero into CONI, which gives the magnitude of any conflict.

KAYBABY (ASSP2CON Logic Block)

Logic Block KAYBABY is a duplicate of ASSP2CON for the Path 2 target and predecessor HK and KHM.

Example: The time at which the stereo and obliquity maneuver from KHM(1) to HK(2) is given by BAUMTE, and exceeds TFIRST<sub>2</sub> indicating that a conflict exists. This results in the conflict flag YACON being set, and magnitude of the conflict, BAUMTE - TFIRST<sub>2</sub> is stored in CONK, i.e., CONK = BAUMTE - TFIRST<sub>2</sub>.

HOOKONK (ASSP2CON Logic Block)

It is indicated that a no-conflict condition exists for the Path 2 candidate predecessor and target in the same manner as done in HOOKONI.

CONFLICT (Procedure)

The procedure CONFLICT computes the time at which both the stereo and obliquity maneuvers from a candidate predecessor to a target are completed.

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Table 3-33. Target and Predecessor Parameters  
Set For Conflict Analysis

Parameter	Candidate Predecessor	Target
Time of interval between earliest and latest main optics acquisition times	BIRNT	BAUMT
Earliest main optics acquisition time	BIRNTT1	BAUMTT1
Scope departure time	BIRNT1	--
Obliquity	BIRN01	BAUM01

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CONFLICT (CONFLICT Logic Block)

The time at which the completion of the obliquity maneuver, including the settle time, occurs is computed by use of the equation:

$$TER = BIRNT1 + |DELO| / MRAS + SAS \quad (8)$$

where

TER = time at which obliquity maneuver is completed  
BIRNT1 = time at which scope departs predecessor  
DELO = difference in obliquity of predecessor and target (rad)  
MRAS = EGT920, scope obliquity slewing rate (rad/sec)  
SAS = EGT926, scope settle time (sec)

BOMB1 (CONFLICT Logic Block)

The time at which the completion of the stereo maneuver, including the settle time, occurs is computed by use of the equation

$$TEP = TEP1 + BIRNT1 + SAS \quad (9)$$

where

TEP = time at which stereo maneuver is completed  
TEP1 = time required for pitching of scope which is a function of EGT921, MPAS, the scope stereo slewing rate (rad/sec)  
BIRNT1 = time at which scope departs predecessor  
SAS = EGT926, scope settle time (sec)

SETTE (CONFLICT Logic Block)

The larger of TER and TEP is specified to be the time at which the stereo and obliquity maneuver from predecessor IHM to target HI is completed and stored as BAUMTE. This process is later performed for predecessor IHK and target HK.

IKDELAY (Procedure)

If a conflict exists, procedure IKDELAY determines if the conflict can be eliminated by delaying the viewing times of the targets in conflict, and if the resulting score is worth the delay encountered. If so, a LATEIK entry is made to save this information.

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IKDELAY (IKDELAY Logic Block)

It is first determined if the start of the delayed viewing time of the target for which a conflict exists exceeds the latest allowable target viewing start time TLAST, i.e., is  $TLATE > TLAST$ . If so, the conflict is not resolvable, the target pair HM:IHM,KHM,TD containing the conflicting predecessor is not an acceptable predecessor pair, and the procedure IKDELAY is exited.

Example:  $TLATE_3 < TLAST_3$  and the delayed starting time is acceptable.

The next test is whether the delayed target viewing start time plus the dwell time TDWELL exceeds the group decision time TD presently being considered, i.e., if the relation  $TLATE + TDWELL > TD$  is true. If this is the case, it will be impossible to complete viewing of the target before it is necessary to make a decision as to which target in the group shall be viewed by the main optics. Thus, the conflict is not resolvable and procedure IKDELAY is exited.

Example:  $TLATE_3 + TDWELL_3 < TD_2$  and the decision time is compatible.

If the analysis currently being performed is for the first time that the viewing time for target HI and/or HK of LIST entry HN has been delayed, control is transferred to NEWLATER, otherwise control is transferred to CHKDELAY.

NEWLATER (IKDELAY Logic Block)

If there is no conflict, the procedure IKDELAY determines whether or not the number of late entries (i.e., the number of times the viewing times of either or both targets of HN:HI, HK, TD have been delayed by different amounts) exceeds the maximum number allowable, which is specified by EGT940, MAXLATE. If EGT940 has been exceeded, the procedure IKDELAY is exited and no entry is made for the case under consideration. The EGT940 parameter is required because of core storage limitations and is currently set at 15. Thus for each target pair HN:HI, HK for the specified decision time TD, there are 15 entries allowable for delayed viewing times. If the EGT940 parameter is not exceeded, a LATEIK entry is made containing:

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- Delayed viewing start time(s)
- Score
- Predecessor LIST entry number

Example: These values are:

Late entry number	LATECNT	1
Tentative LIST entry number	HATE (HN+LATECNT)	23
Target 3 delayed viewing time	TSTART <sub>3</sub>	TFIRST <sub>3</sub>
Target 2 delayed viewing time	TSTART <sub>2</sub>	TLATE <sub>2</sub>
Score	SSCORE HM(23)	16
Predecessor LIST entry number	GOODHM (23)	12

After a late entry is made, the late entry counter is incremented by one and control is transferred to CHKDELAY.

CHKDELAY (IKDELAY Logic Block)

The current candidate LATEIK entry is compared with all valid late entries previously generated for this particular target pair and decision time HN:HI, HK, TD(22:3, 2, TD<sub>2</sub>). If the current candidate LATEIK entry has the same or greater score than a previous entry and is delayed less in time, the old late entry is deleted and the process is repeated for another valid late entry.

If the current candidate LATEIK entry has the same or less score than a previous late entry, and it is delayed more in time, no late entry is made for it. Otherwise, a new late entry is made for the current candidate LATEIK entry. In both cases, the procedure IKDELAY is then exited. Thus, only entries are kept which either improve the score previously obtained or lessen the amount of time delay.

Example: The candidate LATEIK entry is the first late entry considered for target pair HN:HI, HK, TD(22:3, 2, TD<sub>2</sub>) and the score of 16 is better than any previous entry. Thus, a late entry is made.

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LISTGEN (MAIN PROGRAM Logic Block)

LISTGEN governs the selection of target-predecessor pair LIST entries as well as the future target pairs and mutual decision times to be considered. It calls procedures GENLIST and NEXTTHHK.

GENLIST (Procedure)

GENLIST generates the best target-predecessor pair LIST entry for a specified mutual decision time, and generates all valid LATEIK LIST entries for this specified mutual decision time.

STARTER (GENLIST Logic Block)

A LIST entry is made for the current target pair HN:HI, HK, TD

Example: LIST entry HN(22) is made for target pair HI, HK(3,2) for decision time TD(TD<sub>2</sub>). The score is calculated by use of Equation (1)

$$S_{3,2} = w_3 + w_2 + \text{Max}_{\substack{j \in J \\ m \in M}} S_{j,m}$$

to be 13 where

$$\begin{aligned} S_{3,2} &= 13 \\ w_3 &= 10 \\ w_2 &= 1 \\ j &= 0 \\ m &= -1 \\ S_{0,-1} &= 2 \end{aligned}$$

If the score achieved by this target under consideration is greater than or equal to all previous scores, the MAXIMER flag is set and control is transferred to LISTOUT.

Example: For target pair HN(22), the score of 13 is exceeded by the score of target pair HN(19), which is 15. Consequently, the MAXIMER flag is not set for HN(22).

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ANYLATER (GENLIST Logic Block)

If there are no late entries to be made where the viewing times of target HI and/or HK have been delayed, control is transferred to LISTOUT.

Example: There is one late entry to be made for target pair HI, HK, TD(3,2,TD<sub>2</sub>). In reality, there are many more possibilities that can be generated by the conflict analysis procedure. But it would serve no useful purpose in this document to list all these possibilities, so it will be assumed that the only valid late entry for the example problem is the one described.

ADDLIST (GENLIST Logic Block)

If the score obtained for each LATEIK LIST entry is greater than or equal to all previous entries, the MAXIMER flag is set.

Example: A LATEIK entry is made in procedure IKDELAY logic block NEWLATER for target pair HI, HK, TD, which has a score given by the expression

$$S_{\text{LATE3,LATE2}} = w_3 + w_2 + \text{Max}_{\substack{j \in J \\ m \in M}} S_{j,m}^{(12)}$$

where

$$\begin{aligned} S_{\text{LATE3,LATE2}} &= 16 \\ w_3 &= 10 \\ w_2 &= 1 \\ j &= 0 \\ m &= 1 \\ S_{0,1}^{(12)} &= 5 \end{aligned}$$

The score of 16 exceeds all previous scores so a LIST entry HN(23) is made for this case and the MAXIMER flag is set.

LISTOUT (GENLIST Logic Block)

If a LIST printout is requested, a new batch of LIST entries is printed out.

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BOTTOMCK (GENLIST Logic Block)

If the LIST buffer in core is almost full, it is necessary to make room for potential future LIST entries by removing earlier entries from the LIST buffer and storing them outside core. The top portion of the LIST entries is written out, the remaining LIST entries in the LIST buffer are moved up to the top portion, and the indices are reset. Thus, each target pair can possess two LIST entry numbers, one being a true or absolute LIST entry number, which starts from the first target pair considered in the program, and a relative LIST entry number, which identifies the target pair when it is located in the LIST buffer.

If all mutual decision times for the target pair have been considered, the next target pair is determined by procedure NEXTHIHK.

NEXTHIHK (Procedure)

This procedure determines the next target pair to be considered and has been previously described.

Example: The next target pair is HI, HK(2,3). However, this target pair is rejected by logic block IFHKPRIM as Target 3 is a primary target and cannot be assigned to Path 2. Since this is the last target pair to be considered, the DONE flag is set in BUMPFI, and control is transferred to MAIN PROGRAM logic block ASSTGEN.

ASSTGEN (MAIN PROGRAM Logic Block)

ASSTGEN controls the generation of the Acquisition Scope Selection table (ASST), which yields the optimum target scheduling for Path 1 and Path 2.

GENASST (Procedure)

GENASST reconstructs the optimum sequence of LIST entries from the LIST to form the LISTX, which has the same format as the LIST. The ASST tape is then formed from the LISTX tape. GENASST calls the procedure READLIST, which enters target and predecessor pair LIST entries into core for the formulation of the LISTX.

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AREYOUIT (GENASST Logic Block)

The LIST buffer is searched for the LIST entry HN that has the maximum score. This entry will be the largest LIST entry number for which the MAXIMER flag is set. If such an entry does not exist in the LIST buffer, procedure READLIST is called to read more LIST entries into the LIST buffer, and the process is repeated until such an optimum LIST entry is found.

Example: The LIST entry for which the maximum score is obtained is HN(23).

EUREKA (GENASST Logic Block)

The maximum score LIST entry is entered in the LISTX, in this case HN(23).

ROBLSO (GENASST Logic Block)

The LIST buffer is searched for the optimal predecessor pair LIST entry, which is specified by the optimal target pair LIST entry. If it is not in the LIST buffer, procedure READLIST is called to read more LIST entries into the LIST buffer. Since each target pair LIST entry always contains the LIST entry of the predecessor pair, the determination of the optimum predecessor pair LIST entry is no problem. This LIST entry is then read into the LISTX.

Example: The LIST entry of the optimal predecessor pair is HM(12).

ATTOP (GENASST Logic Block)

If all predecessor pair LIST entries for the maximum score paths have not been entered into LISTX, the process initiated by EUREKA is continued. If all LISTX entries have been made, the LISTX is then time ordered and the target groups are sequentially renumbered.

Example: The LISTX consists of LIST entries HN(12) and HN(23) and is presented in Table 3-34.

READLIST (Procedure)

READLIST reads more LIST entries from the LIST tape into the LIST buffer. This procedure is required because there is not sufficient room in the LIST buffer to store all of the LIST entries. Because some LIST

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Table 3-34. Example Time Ordered LISTX

LISTX Entry Number HN	Start of Scope Target View Time		Total Score SUMSCOR	Predecessor LIST Entry Number PREDNUM	MAXIMER Flag	Mutual Decision Time TDECIS
	Path 1 TSTART1	Path 2 TSTARTK				
12	TFIRST <sub>0</sub>	TFIRST <sub>1</sub>	5	0	1	TD <sub>2</sub>
23	TFIRST <sub>3</sub>	TLATE <sub>2</sub>	16	12	1	TD <sub>2</sub>

COTRIME Target Entry Number	Group Number		ASCOT Target Entry Number		Number of LIST Entries for Target Pair and Specified Decision Time LISTCNT	Target Weight	
	Path 1	Path 2	Path 1	Path 2		Path 1	Path 2
0	1	1	0	1	1	2	3
3	2	1	3	2	2	10	1
COTPI	COTPK	GROUPNO	ASCOTI	ASCOTK		WEIGHTI	WEIGHTK*

\*This column is not generated in the LISTX, but is presented to aid in the understanding of the algorithm.

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entries are in the LIST buffer and the remainder are not, it facilitates matters to assign to each LIST entry a buffer entry number in addition to its actual entry number. These two entries are related by the parameters LISTO and LISTDROP. LISTO represents the number of entries written out of core, and LISTDROP represents the number of entries written out each time a write out of the LIST is required.

LISTXOUT (GENASST Logic Block)

The LISTX is printed out if requested.

NOLISTX (GENASST Logic Block)

Individual ASST entries are formed from the LISTX entries, and all pseudo target LISTX entries are eliminated since they are no longer required.

ORDERAST (GENASST Logic Block)

The ASST entries are time ordered.

Example: The time ordered ASST entries are presented in Table 3-35. Scope 1 views Target 0 at the earliest possible on time  $TFIRST_0$  and then views the primary Target 3 at the earliest possible on time  $TFIRST_3$ . Scope 2 views Target 1 at the earliest possible on time  $TFIRST_1$  and then views Target 2 at the delayed time  $TLATE_2$ .

ASSTOUT (GENASST Logic Block)

The ASST is printed out if requested.

NOASST (GENASST Logic Block)

The ASST tape is written; the format has been previously illustrated in Table 3-28.

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Table 3-35. Acquisition Scope Selection Table (ASST)

ASST Entry Number	COTPRIME Entry Number	ASCOT ENTRY Number	Target Group Number	Target Path 0:2* 1:1*	Target Weight	Scope View Start Time	Group Decision Time
HN	GCOTENT	GASCOT	GGROUPNO	GPATH	GWGT	GTSTART	GTDECIS
0	0	0	1	1	2	TFIRST <sub>0</sub>	TD <sub>2</sub>
1	1	1	1	0	3	TFIRST <sub>1</sub>	TD <sub>2</sub>
2	3	3	1	0	10	TFIRST <sub>3</sub>	TD <sub>2</sub>
3	2	2	1	1	1	TLATE <sub>2</sub>	TD <sub>2</sub>

\* 0 denotes Path 2

\* 1 denotes Path 1

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TWASSP2

TWASSP2

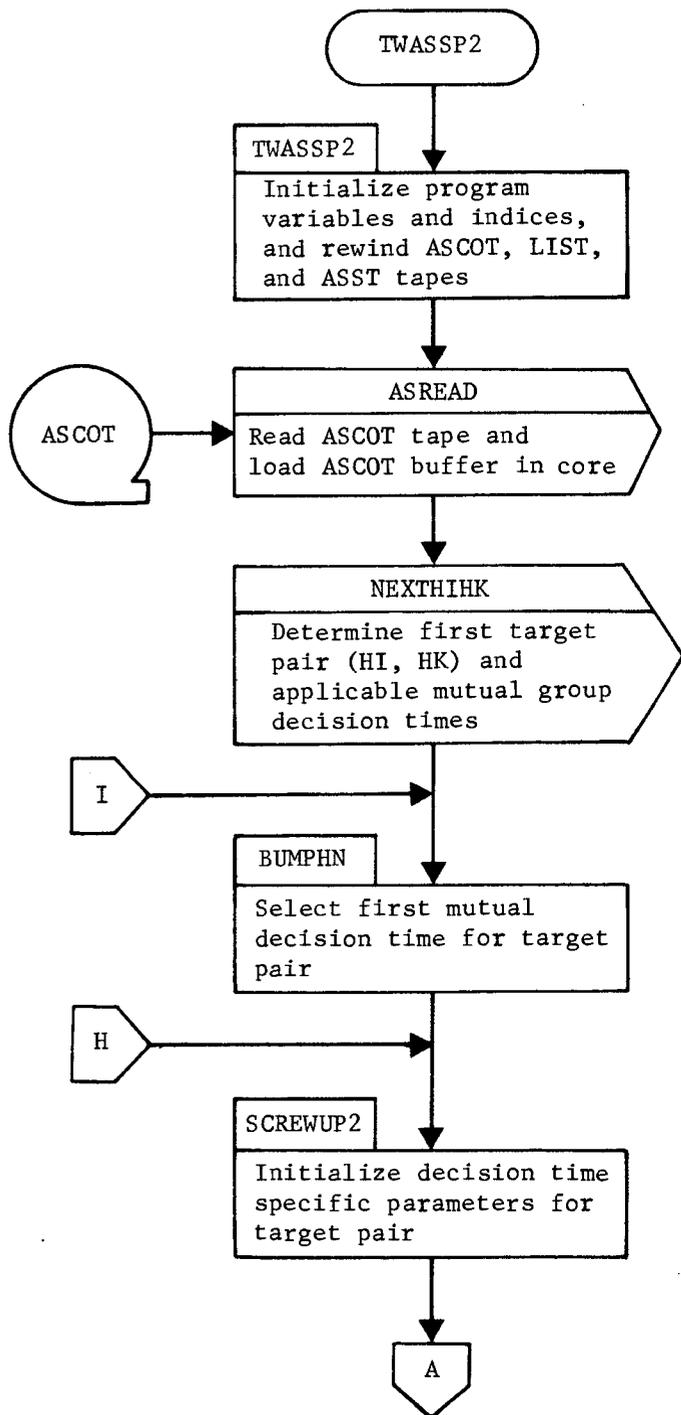


Figure 3-18. TWASSP2 Flow Chart

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TWASSP2

TWASSP2

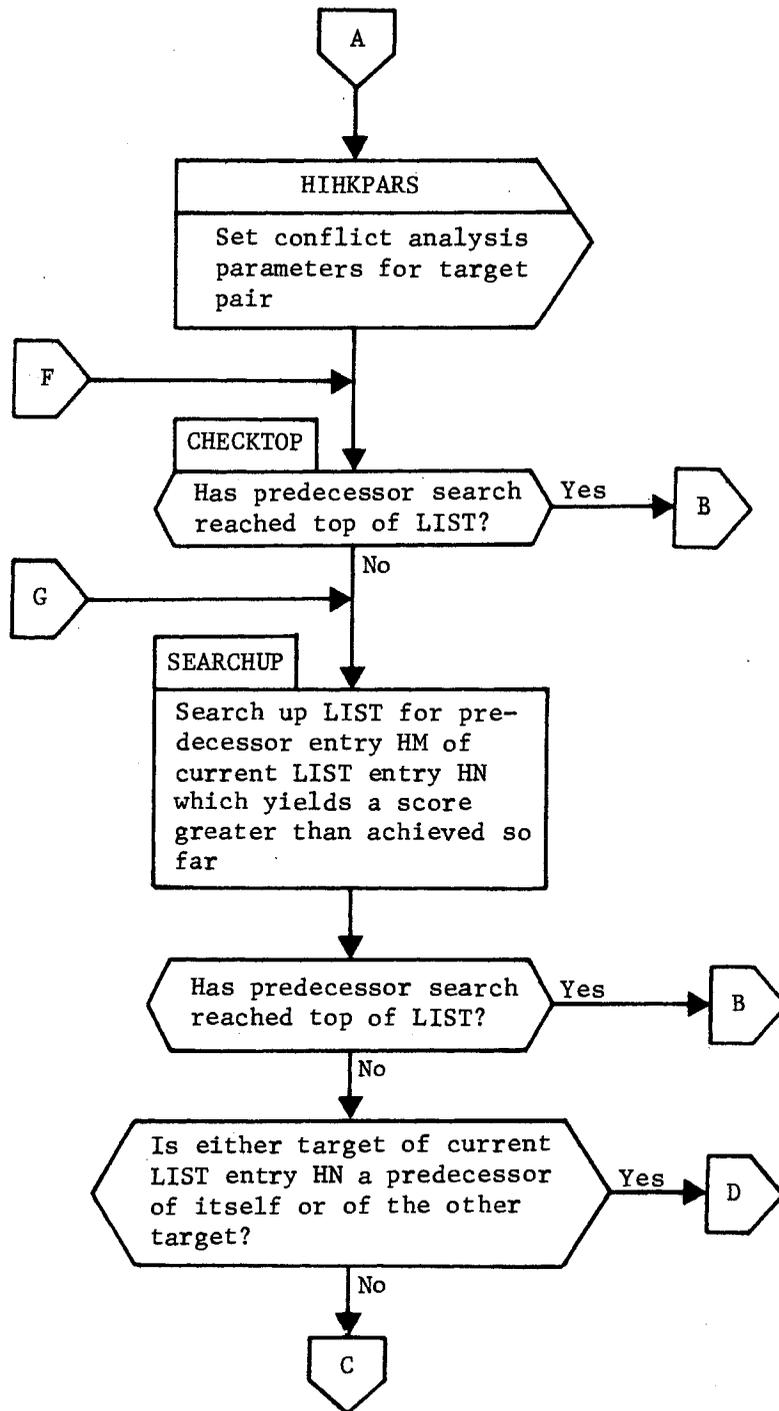


Figure 3-18. TWASSP2 Flow Chart (Continued)

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TWASSP2

TWASSP2

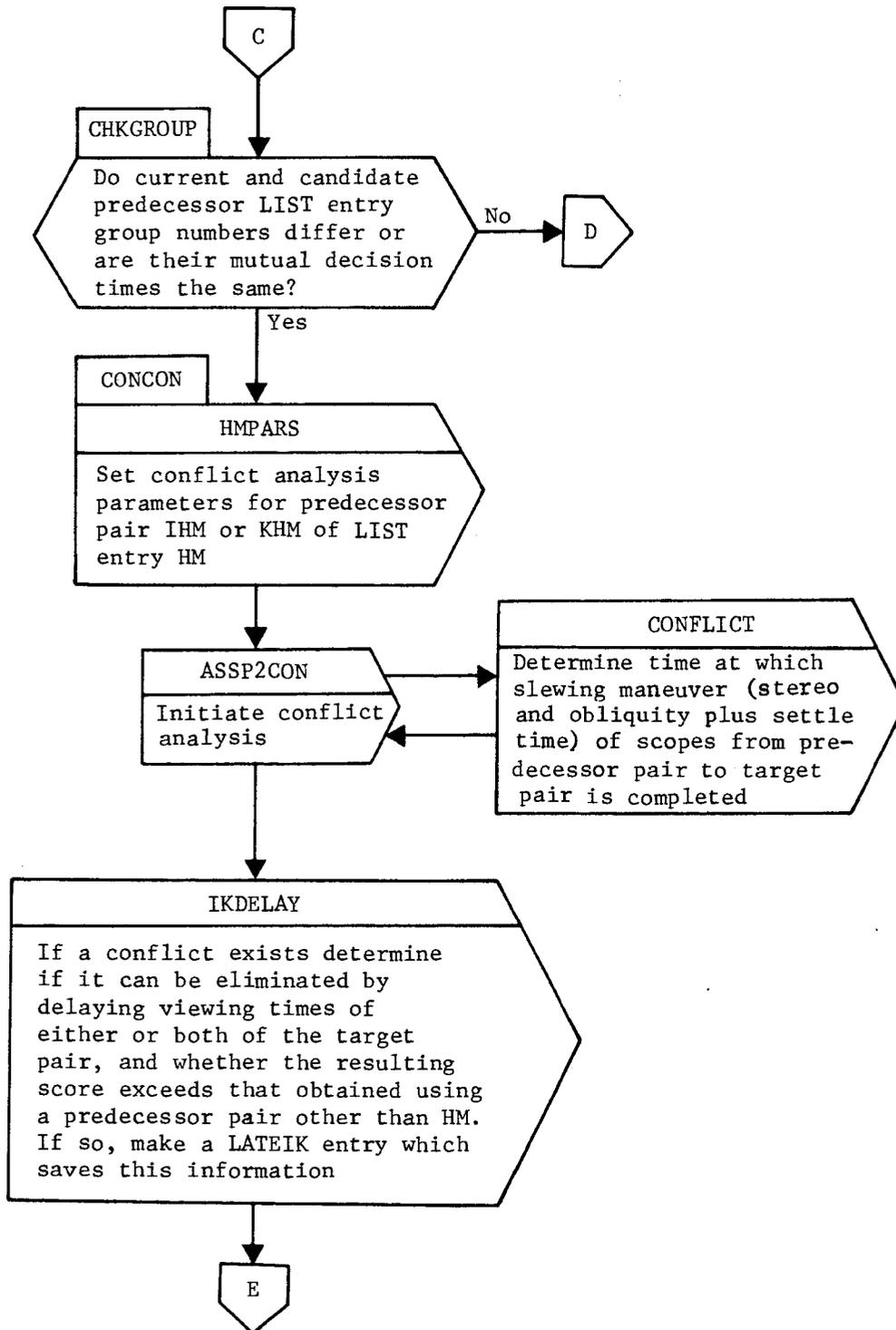


Figure 3-18. TWASSP2 Flow Chart (Continued)

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TWASSP2

TWASSP2

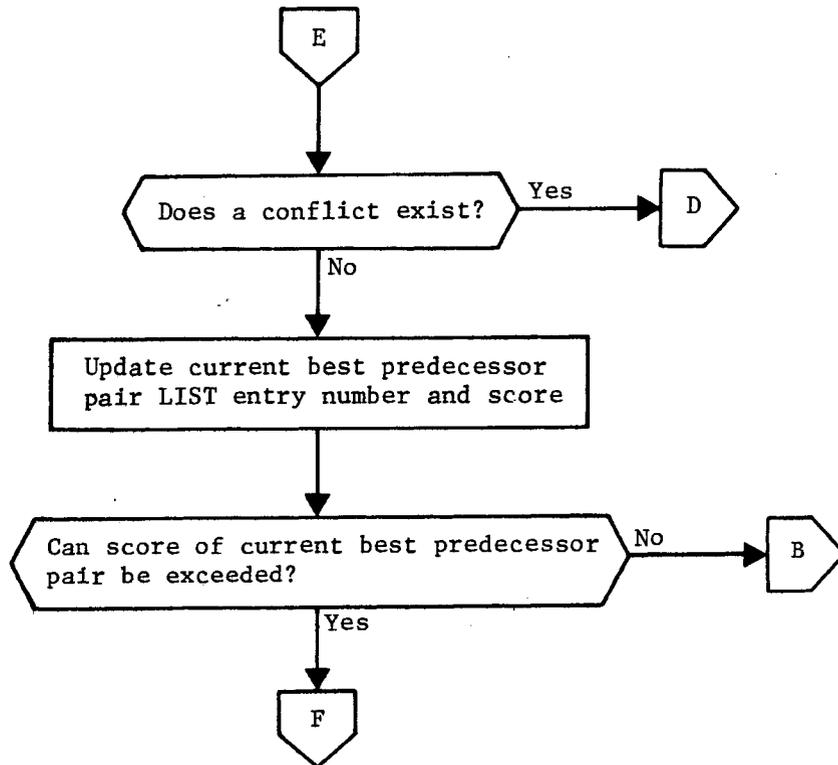


Figure 3-18. TWASSP2 Flow Chart (Continued)

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TWASSP2

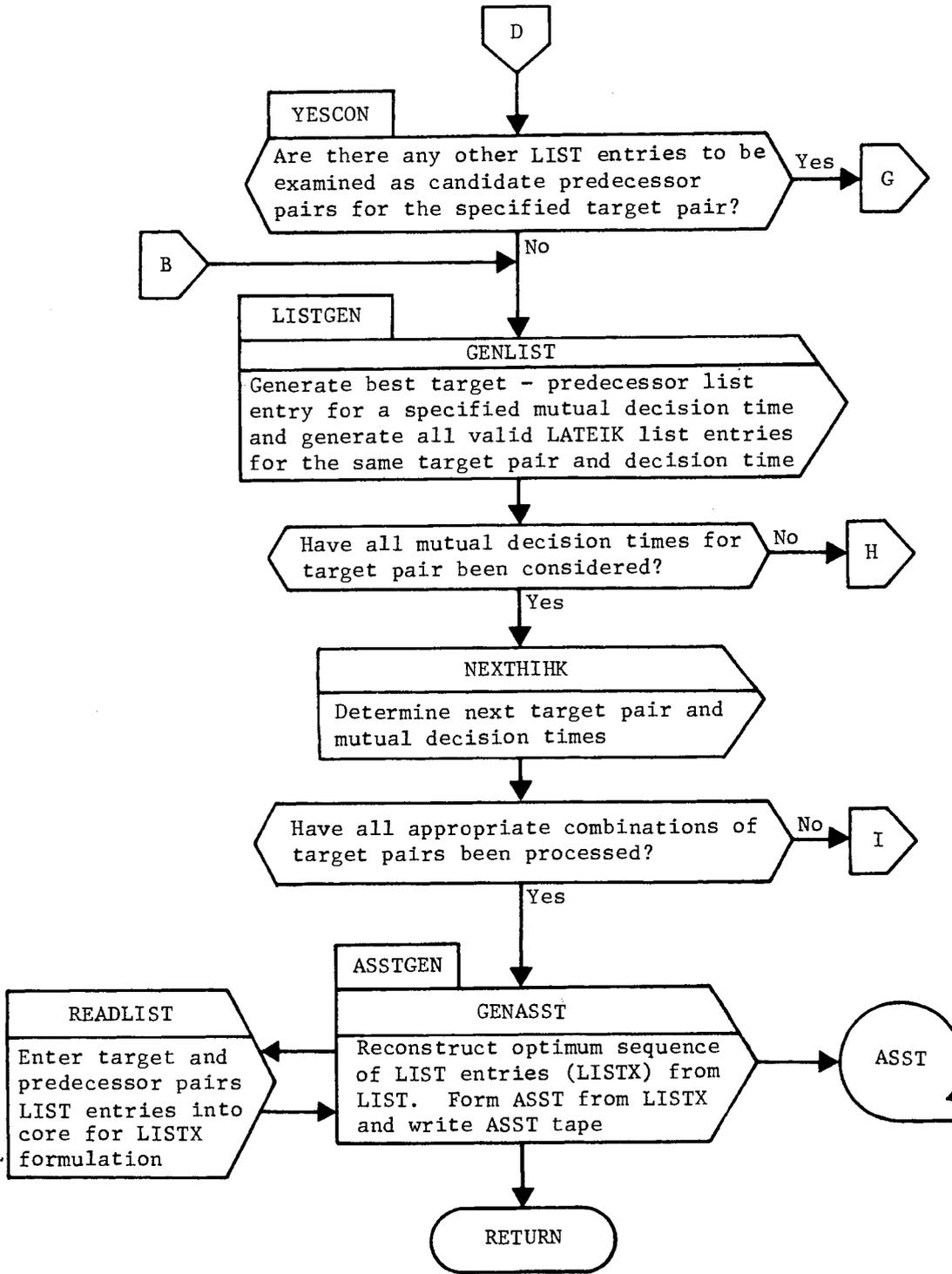


Figure 3-18. TWASSP2 Flow Chart (Continued)

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NEXTHIHK

NEXTHIHK

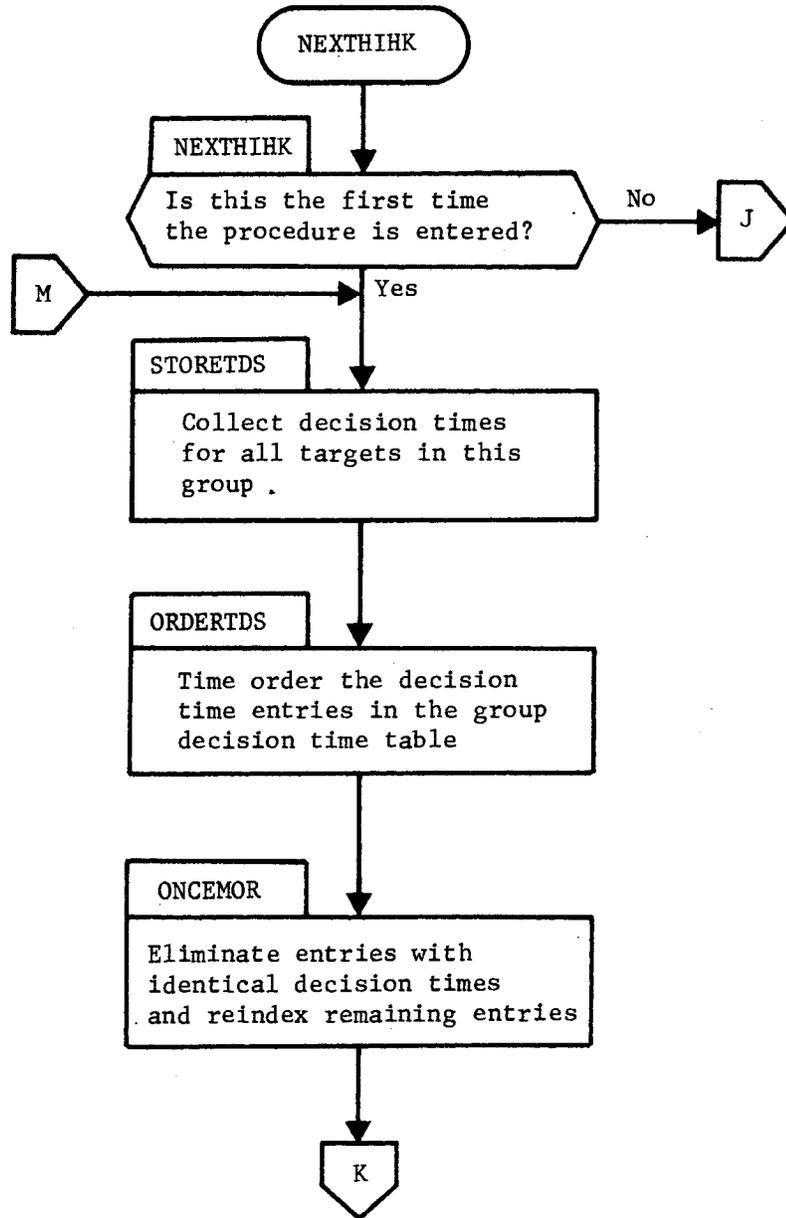


Figure 3-18. TWASSP2 Flow Chart (Continued)

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NEXTHIHK

NEXTHIHK

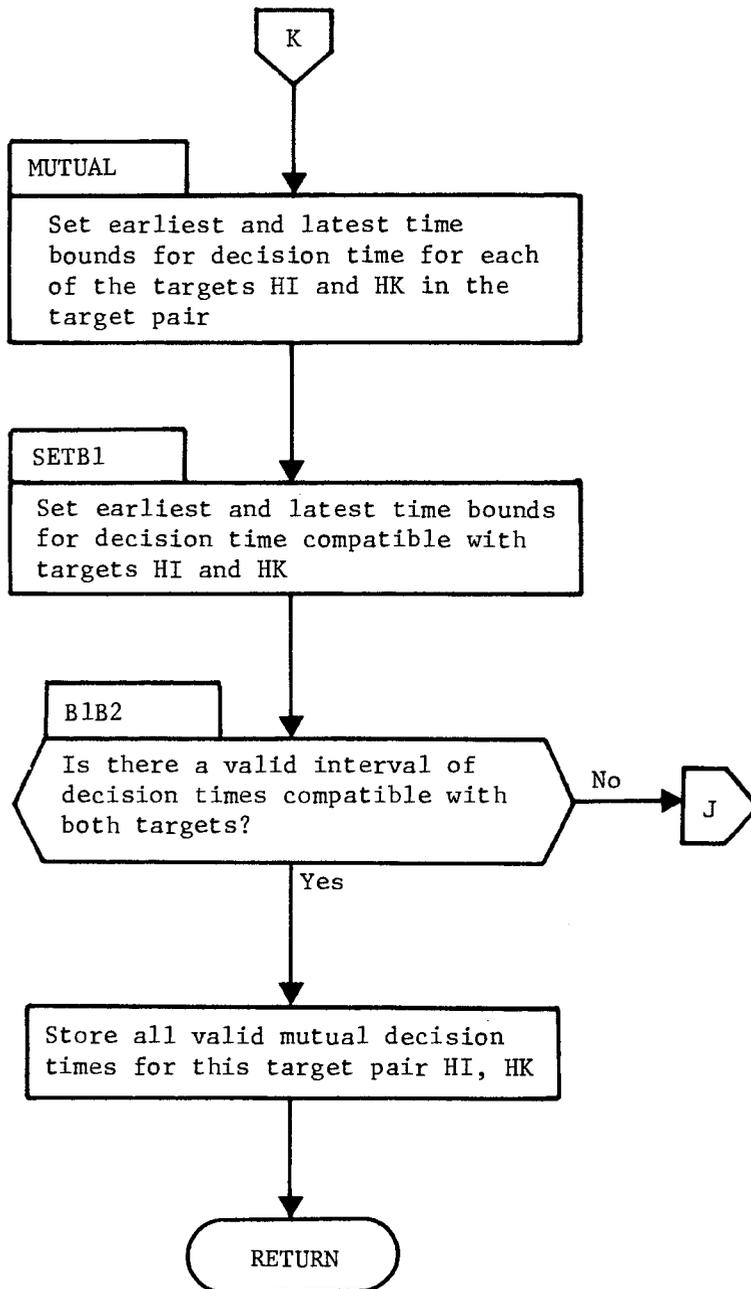


Figure 3-18. TWASSP2 Flow Chart (Continued)

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NEXTHIHK

NEXTHIHK

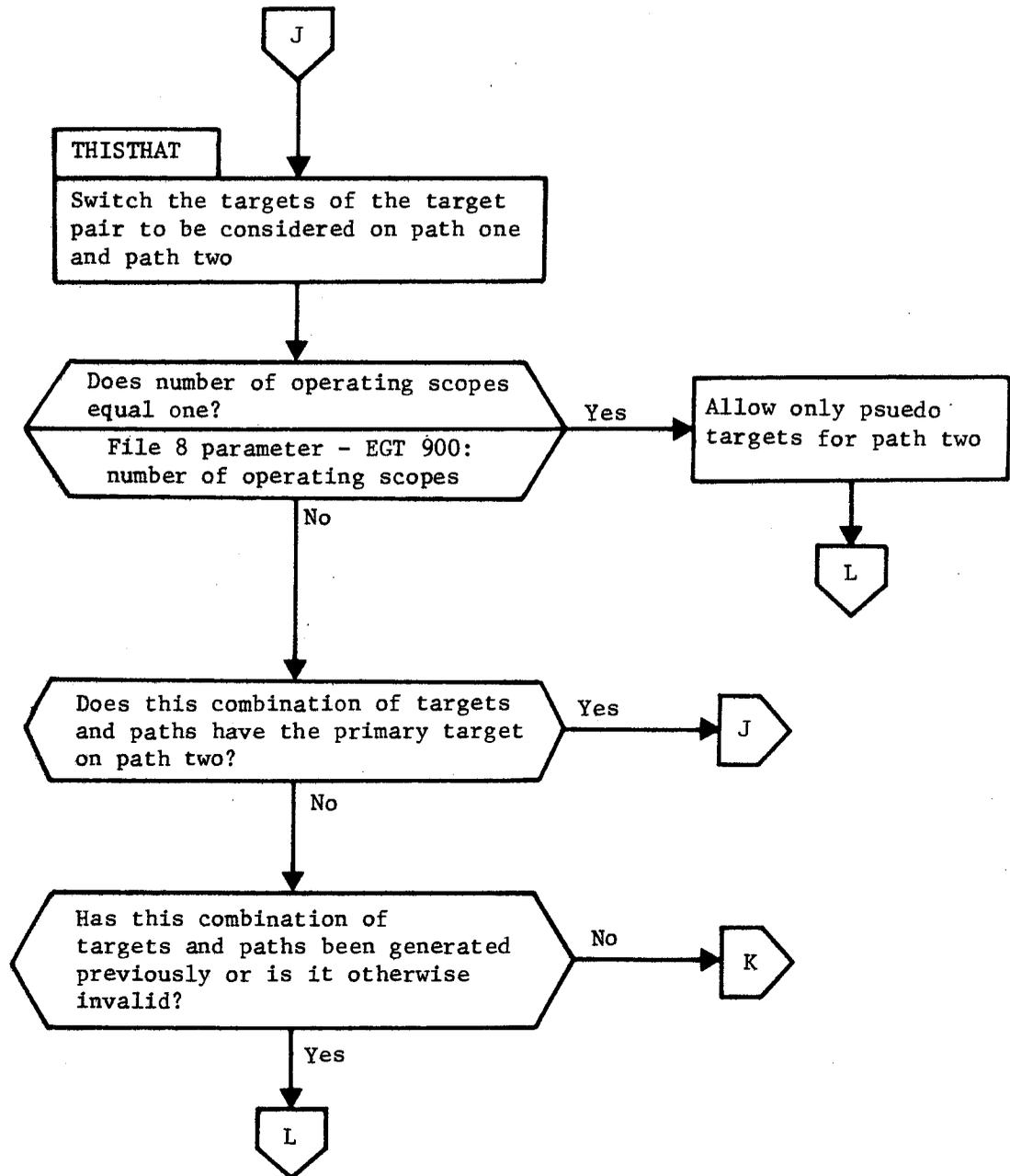


Figure 3-18. TWASSP2 Flow Chart (Continued)

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NEXTHIHK

NEXTHIHK

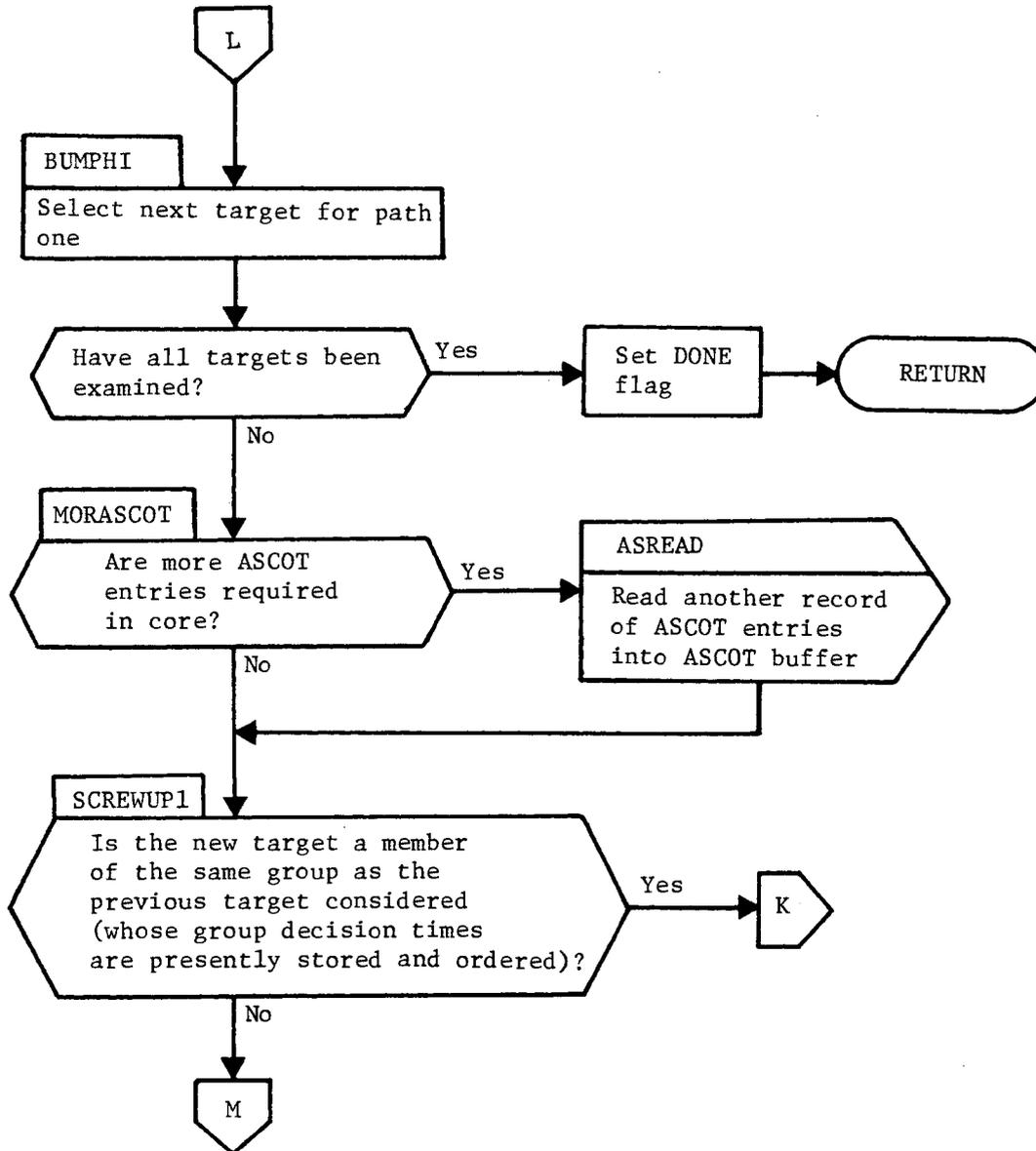


Figure 3-18. TWASSP2 Flow Chart (Continued)

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HIHKPARS

HIHKPARS

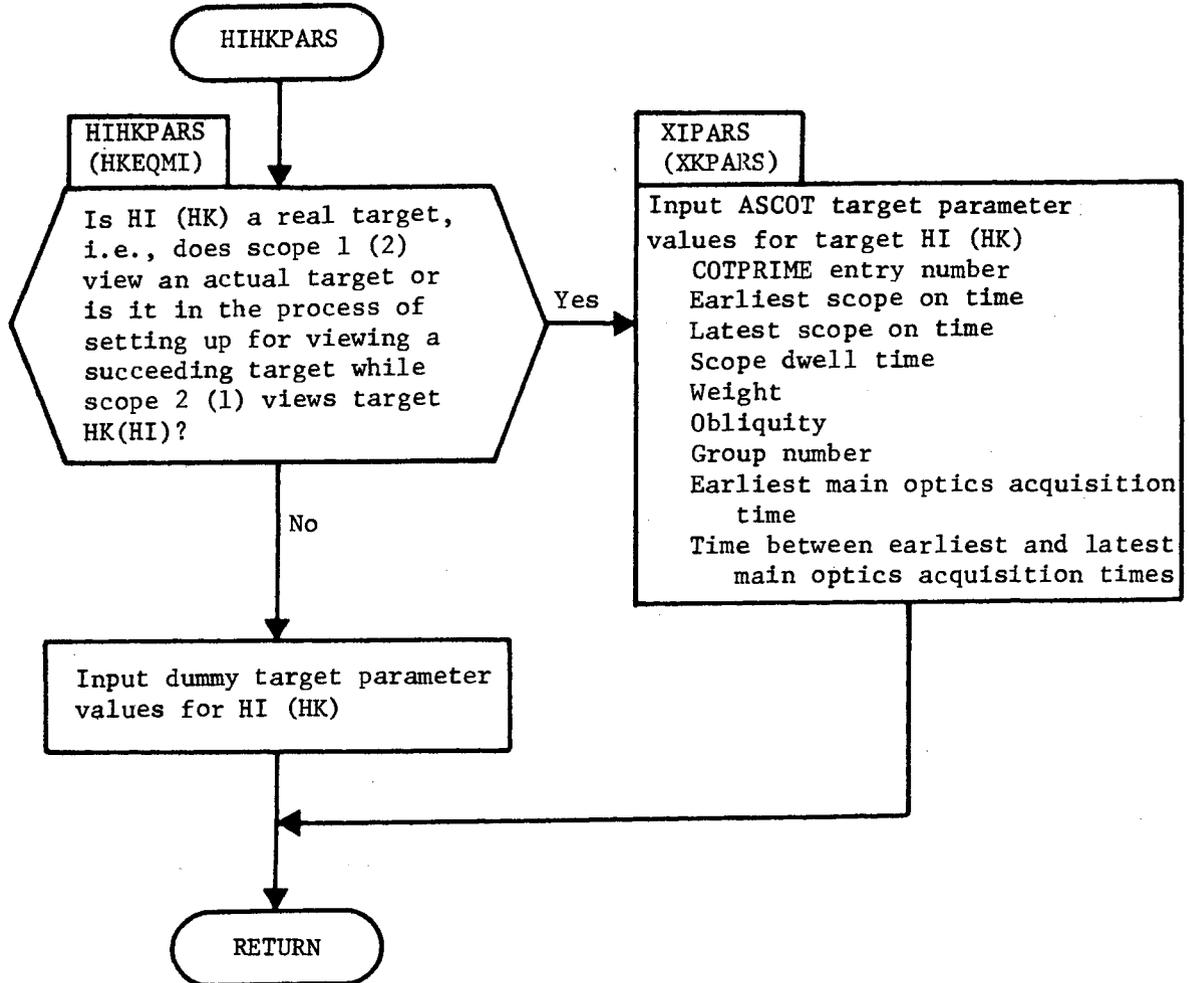


Figure 3-18. TWASSP2 Flow Chart (Continued)

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HMPARS

HMPARS

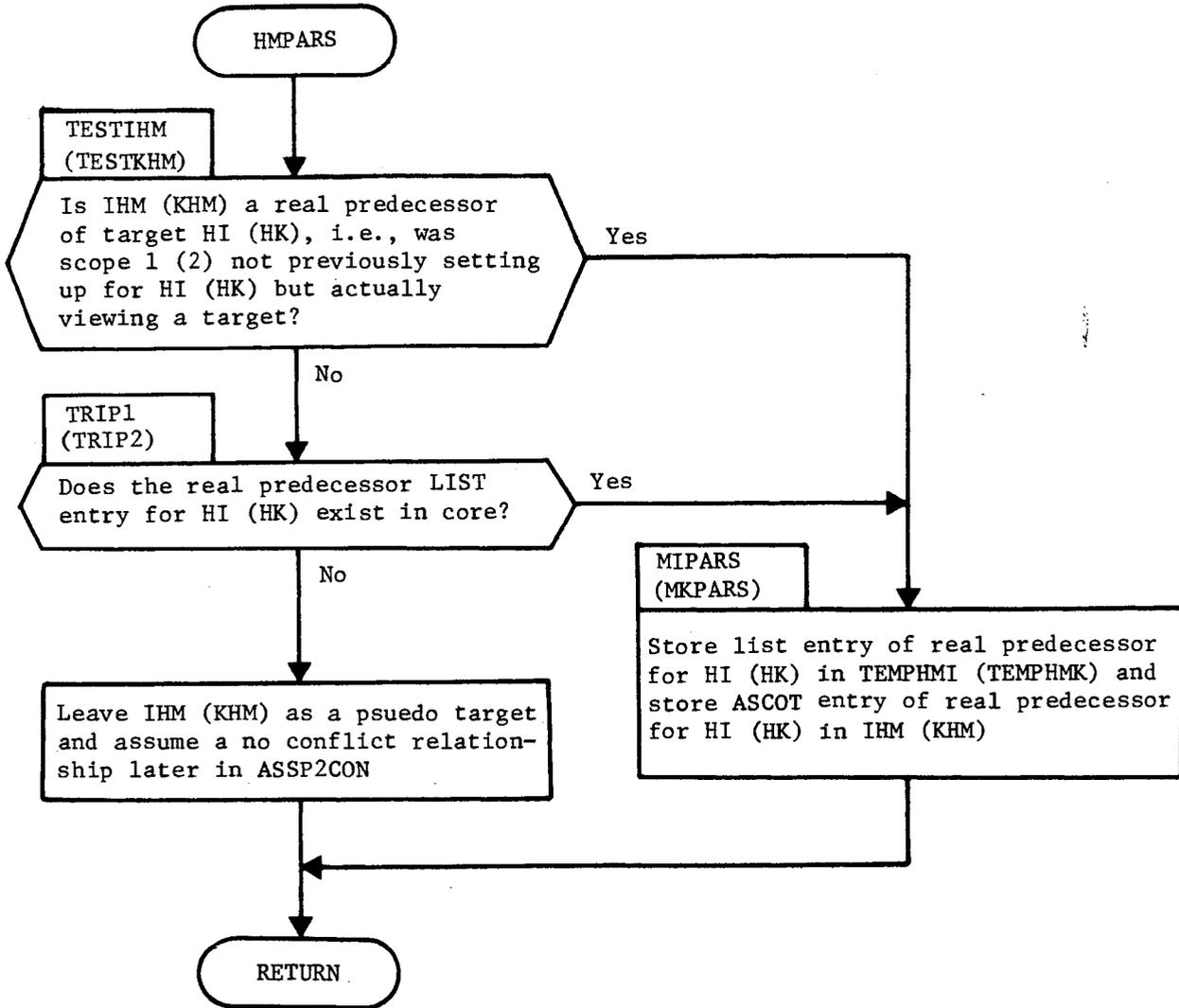


Figure 3-18. TWASSP2 Flow Chart (Continued)

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GENLIST

GENLIST

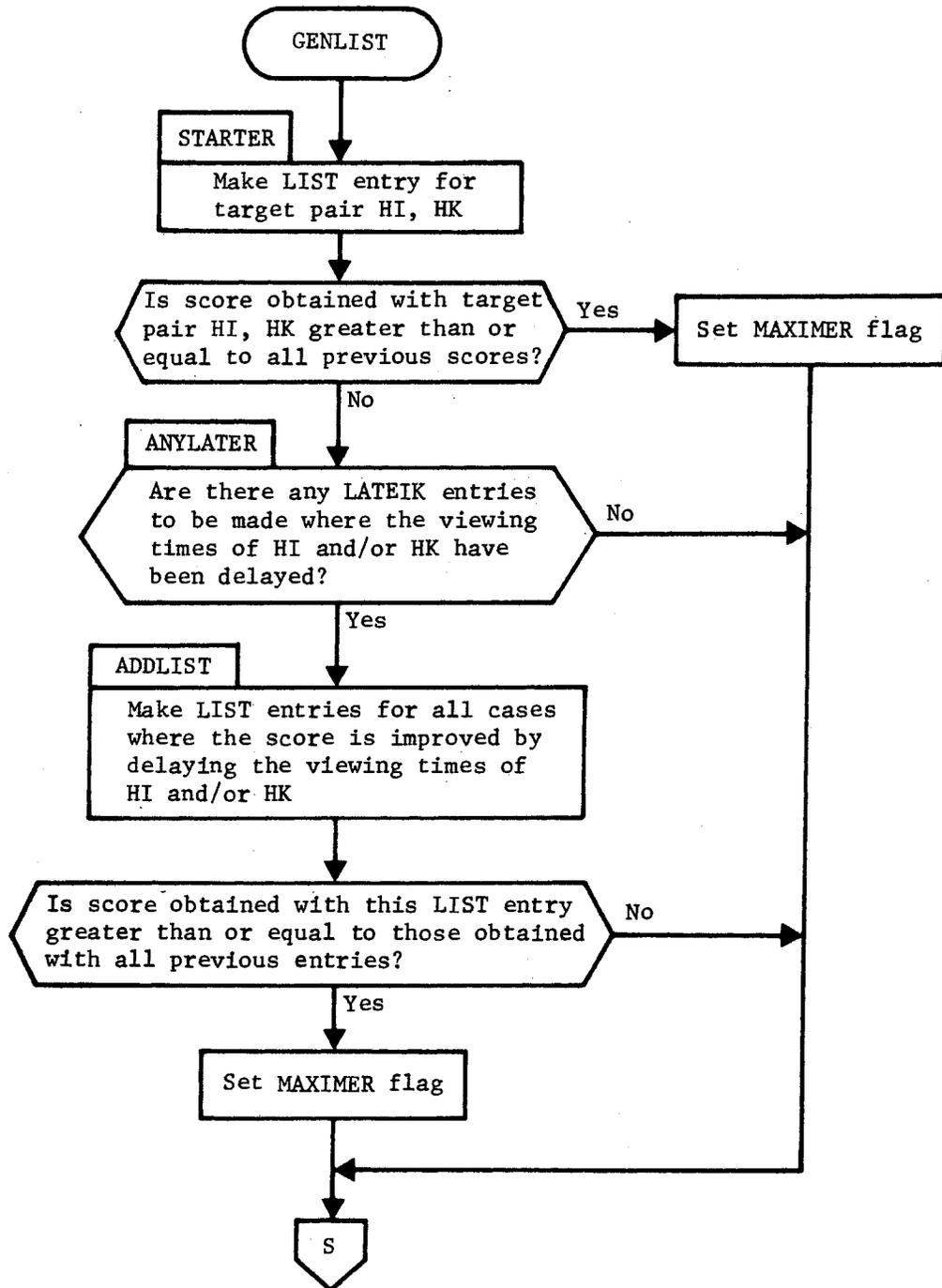


Figure 3-18. TWASSP2 Flow Chart (Continued)

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GENLIST

GENLIST

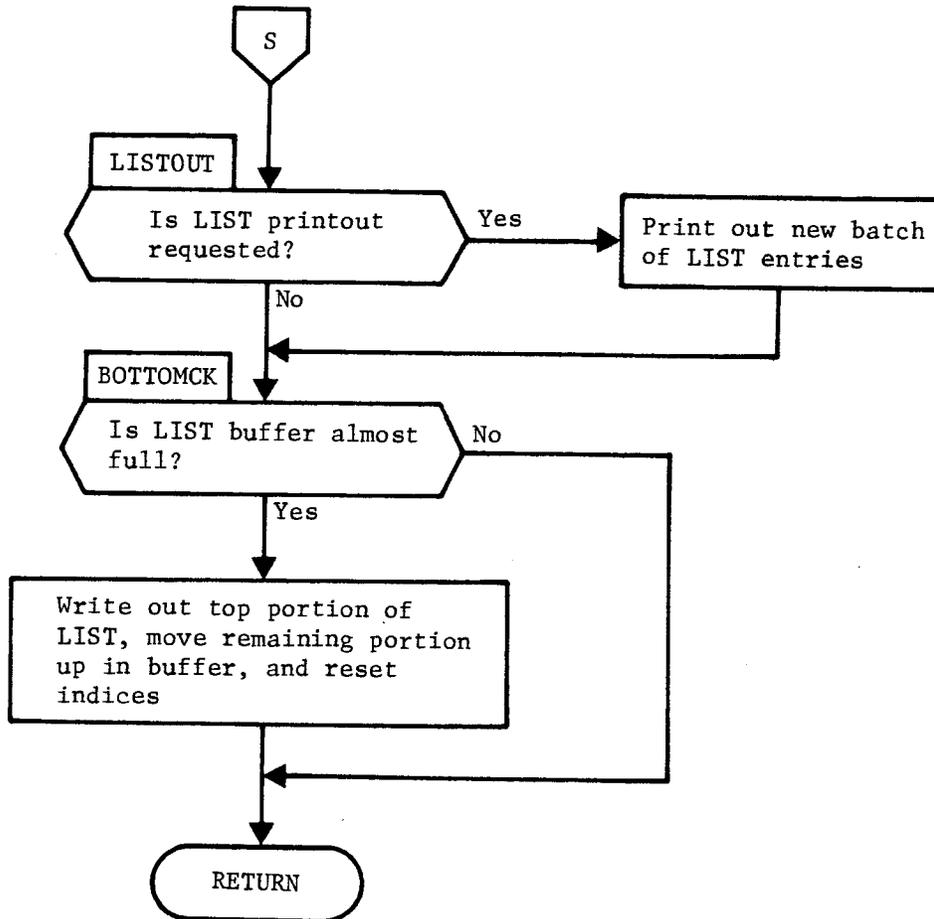


Figure 3-18. TWASSP2 Flow Chart (Continued)

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CONFLICT

CONFLICT

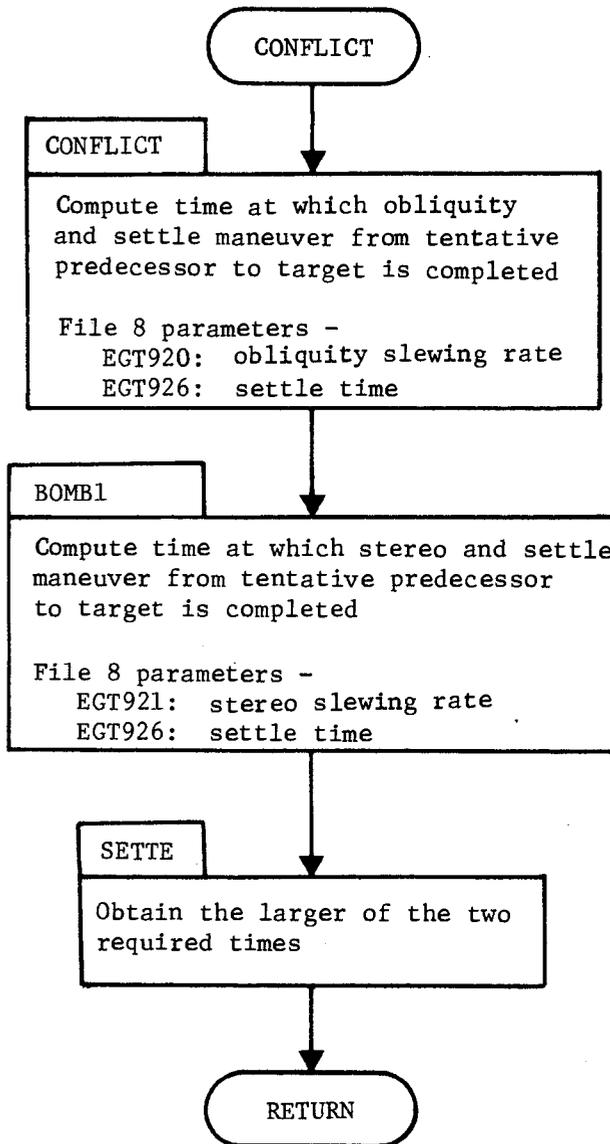


Figure 3-18. TWASSP2 Flow Chart (Continued)

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IKDELAY

IKDELAY

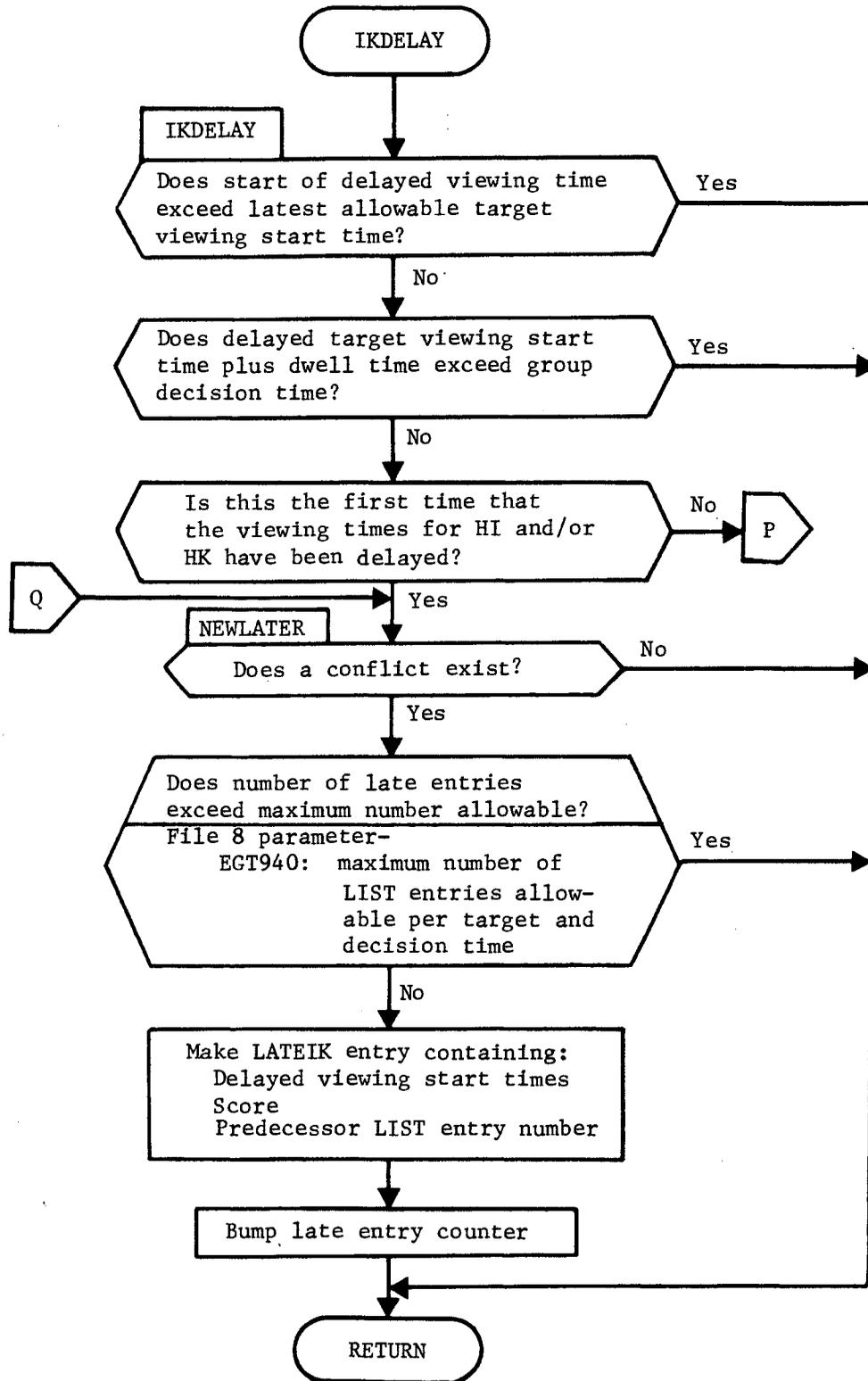


Figure 3-18. TWASSP2 Flow Chart (Continued)

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IKDELAY

IKDELAY

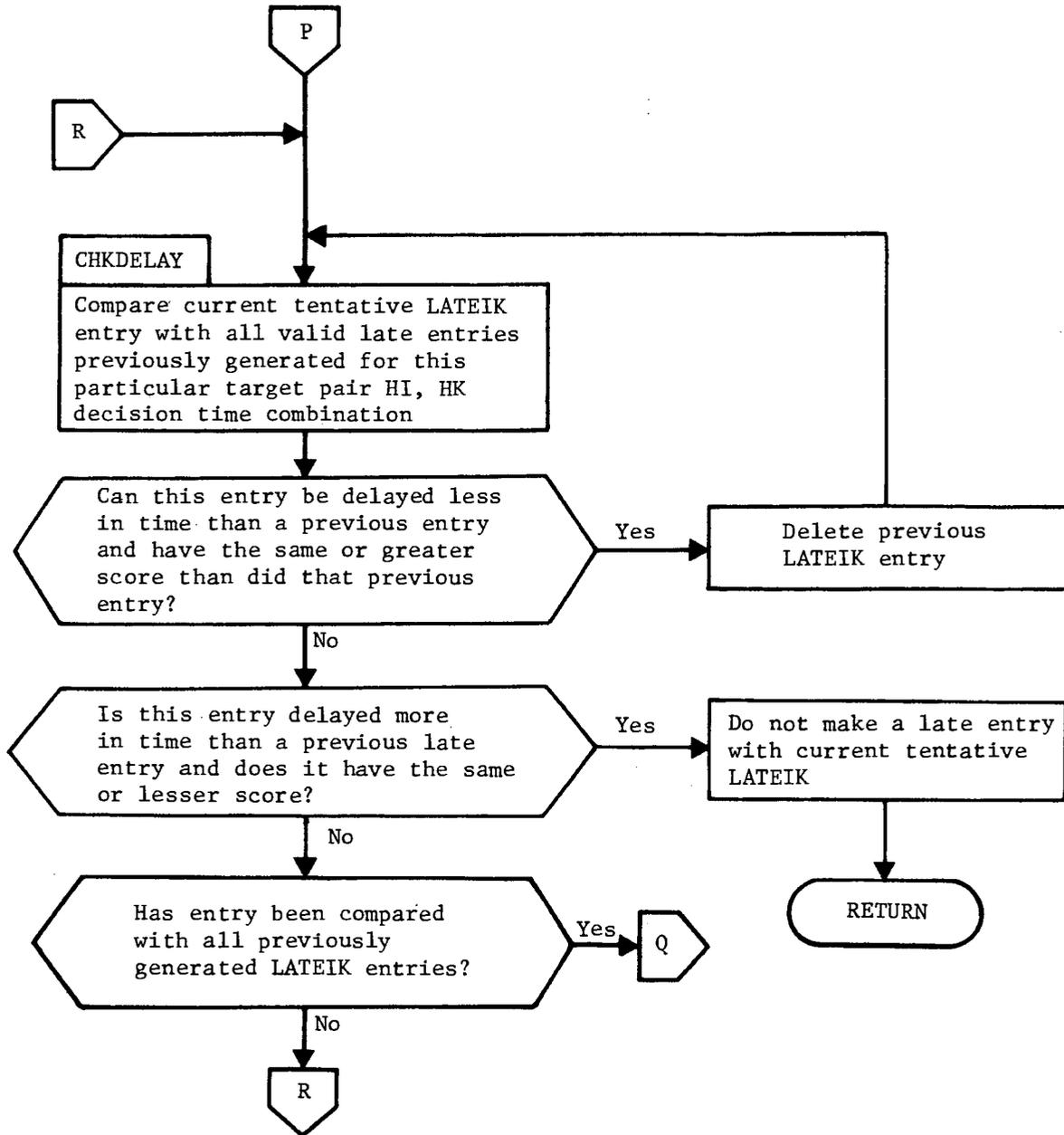


Figure 3-18. TWASSP2 Flow Chart (Continued)

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GENASST

GENASST

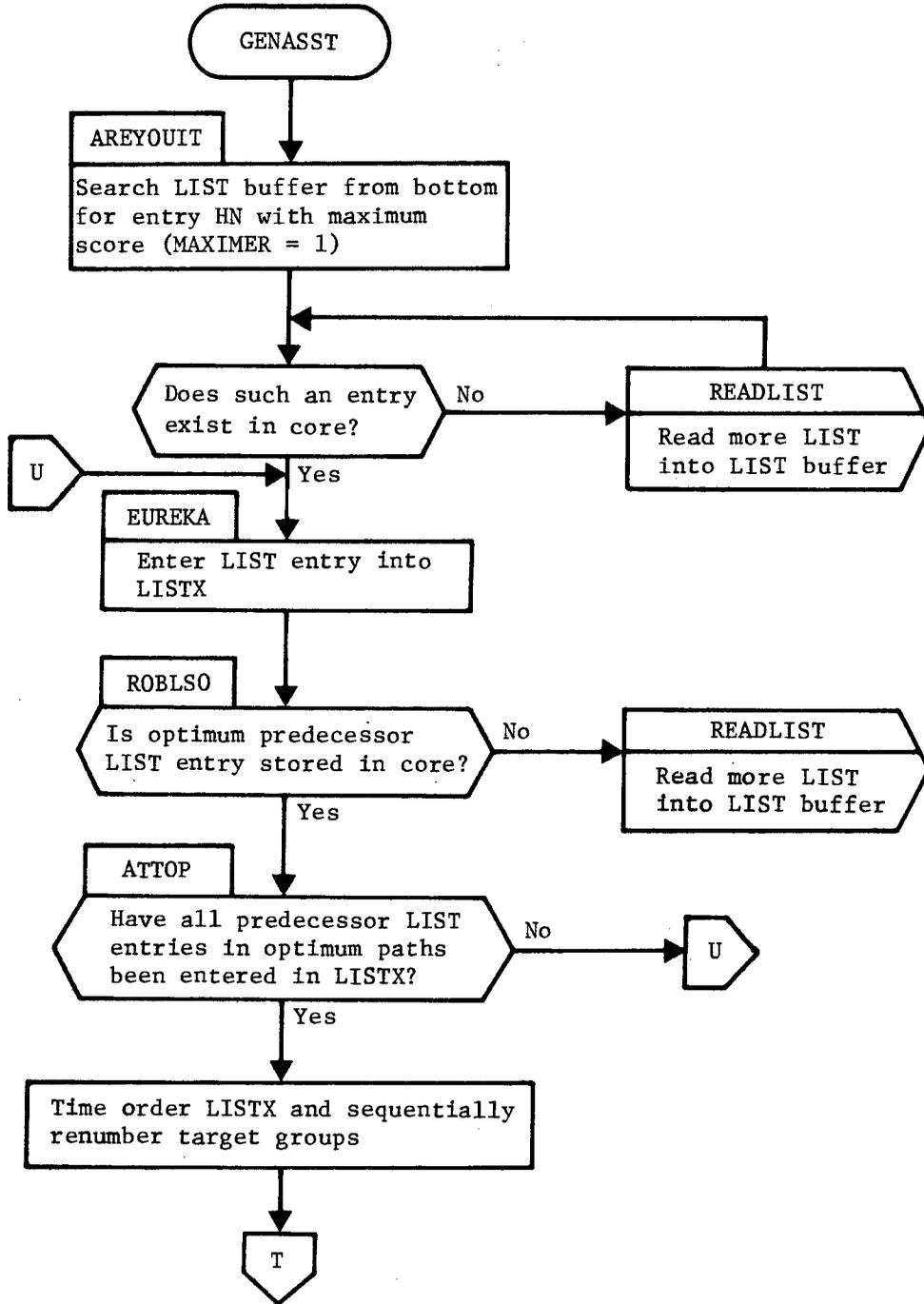


Figure 3-18. TWASSP2 Flow Chart (Continued)

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GENASST

GENASST

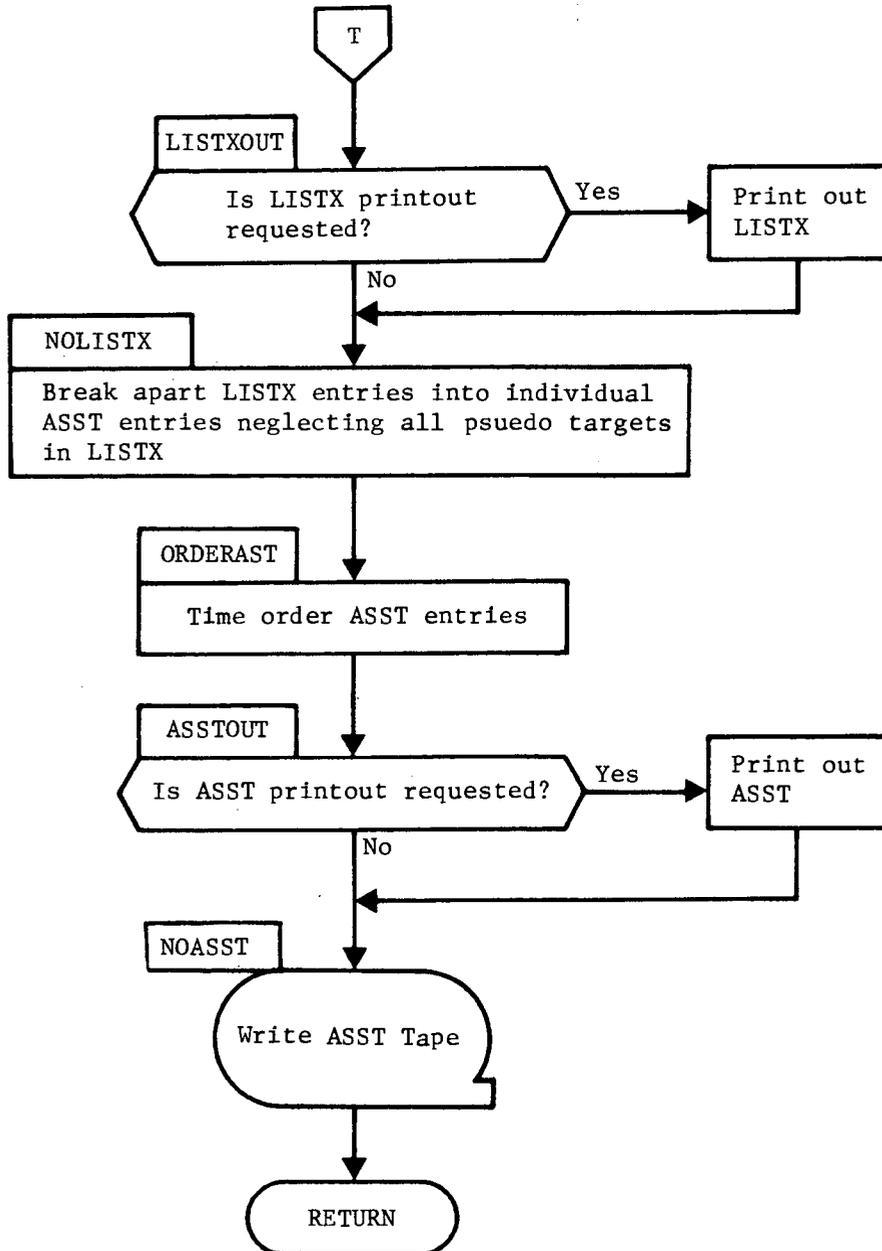


Figure 3-18. TWASSP2 Flow Chart (Continued)

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### 3.12 TWOUT

#### 3.12.1 Purpose

The subfunction TWOUT is the basic output routine for TWONDER. The inputs to this routine are the COTPRIME, the MOST and the ASST. The following basic types of output are available for listing:

- . Main Optics Strategy
- . ATS Strategy
- . Results of expected score calculation per target
- . Rev summaries of the above three items.

Computations are required in TWOUT for the required output parameters. Since only the essential information pertaining to target selection is contained in the MOST and ASST, the detailed characteristics of the selected targets, photographic sequences, ATS viewing, target worth, and expected score per target group are computed.

#### 3.12.2 Input

The following input tables are required by TWOUT:

- a. COTPRIME (see Section 3.6.3)
- b. MOST (see Section 3.9.3)
- c. ASST (see Section 3.11.3)
- d. THINGS (see Section 3.2.3)
- e. ALSO (see Section 3.2.3)

The File 7 and File 8 parameters used by TWOUT, and located in table THINGS, are shown in Table 3-36.

Input arrays located in table ALSO are depicted in Table 3-37.

#### 3.12.3 Output

Samples of the listable outputs provided by the subfunction TWOUT are provided in Table 3-38. In addition to these listable outputs the table PATHDATA is passed via tape to TWPLOTT1 with the information required for plotting of the Main Optics and ATS strategies. The content of this table is shown in Table 3-39.

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Table 3-36. File 7 and File 8 Parameters Used in TWOUT Located in Table THINGS

File 7 and 8 Location	Form of Data	Nominal Value	Units	Definition	Interface Table Usage		
					Internal Symbol	JOVIAL Definition	Internal Units
SEV001	I	1.	n.d.	Mission number	MISSNO	I 48 U	n.d.
EGT134	I	1.	n.d.	Output control flag 1: target selection output and plots on Tape 8 2: target selection output and plots online 4: Intermediate Data Tables on Tape 8 8: Intermediate Data Tables online 16: ASST 32: LISTX 64: LIST 128: ASCOT 256: MOST 512: ALMOST 1024: MOCOT 2048: COTPRIME Output requests are summable	OUTFLAG	I 48 U 230 0	n.d.
EGT900	I	2.	n.d.	Number of scopes in use 0=none, 1=one scope, 2=two scopes	NUMSCOP	I 48 U 56 0	n.d.

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Table 3-36. File 7 and File 8 Parameters Used in TWOUT Located in Table THINGS (Continued)

File 7 and 8 Location	Form of Data	Nominal Value	Units	Definition	- Interface Table Usage		
					Internal Symbol	JOVIAL Definition	Internal Units
EGT911	FP	6.	sec	Dwell time for primary	TDWELLP	F 55 0	sec
EGT912	FP	6.	sec	Dwell time for activity alternates	TDWELLA	F 52 0	
EGT913	FP	6.	sec	Dwell time for visual inspection targets	TDWELLV	F 53.0	sec
EGT922	FP	0.05	n.d.	Probability of activity	PROBA	F 2 0	n.d.
EGT923	FP	0.	n.d.	Probability of falsely reporting a target active	PROBFA	F 10 0	n.d.
EGT924	FP	1.	n.d.	Probability of recognizing activity	PROBREC	F 19 0	n.d.
EGT931	FP	1.	n.d.	Probability that a target will be unclouded	PROBV	F 319 0	n.d.
EGT938	I	0	n.d.	Main optics weight flag 0: use inactive weight 1: use expected weight	MOEX	B	n.d.
EGT939	I	1.	n.d.	Group-by-group expected score print flag 0: don't print 1: do print	PRNTEWFG	B 269 47	n.d.

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Table 3-37. File 8 Parameters Used in TWOUT Located in Table ALSO

File 8 Location	Form of Data	Nominal Value	Units	Definition	Interface Table Usage		
					Internal Symbol	JOVIAL Definition	Internal Units
EGT150 to EGT159	FP	-	sec	Photographic time as a function of photographic mode (forward stereo)	DELTAT1	10 F ARRAY	sec
EGT160 to EGT169	FP	-	sec	Photographic time as a function of photographic mode (aft stereo)	DELTAT2	10 F ARRAY	sec
EGT170 to EGT179	FP	-	deg	Delta stereo angle as a function of photographic mode	DELTAS	10 F ARRAY	rad
EGT180 to EGT229	FP	-	n.d.	Pitch weighting factor as a function of pitch weighting	PWF	10 5 F ARRAY	n.d.
EGT300 to EGT399	FP	-	n.d.	Photographic mode weighting table. Score multiplication factor as a function of mode requested and mode selected	MMULT	10 10 F ARRAY	n.d.

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Table 3-38. TWOUT Output

TWONDER Selection Summary

OUTPUT FOR THE TWONDER PROGRAM

VEHICLE 9999	RUN NUMBER SAMPLE	REV NUMBER	10
REVS 10 THRU 10	NUMBER OF ACTIVE SCOPES	2	

MAIN OPTICS SELECTION FOR REV NUMBER 10

IP D	ALT SHD M	CC	ESS	AP	DPA	STF	BMF	MF	PA	SVT	PWF	TGT	ID	WF	RR	SCC	LATITUDE	LONGITUDE	VIF		
1	20	11	150	-50	3	US	1	15	0	0	0	15	20	2	99F1234AB	30	90	400	45.000	-120.0000	0
S.ANG SLNTRNG VEH.ALT TIME ON TIME OFF OBLIQ STEREO M CONVANG WEIGHT																					
18.32 125.93 105.62 80420.20 80421.00 -12.78 20.50 3 15.00 999999999.9																					

MAIN OPTICS SUMMARY (TOTALS)

NUMBER OF TARGETS	12	WEIGHTS	9999999999.
MANDATORY PRIMARIES	4	BENCH MARKS	3

ACQUISITION SCOPE SELECTION FOR REV NUMBER 10

IP D	ALT	SHD	M	CC	ESS	AP	DPA	STF	BMF	MF	PA	SVT	PWF	TGT	ID	WF	RR	SCC	LATITUDE	LONGITUDE	VIF
20	11	150	-50	3	US	1	15	0	0	0	15	20	2	99F1234AB	30	90	400	45.000	-120.0000	0	
S.ANG SLNTRNG VEH.ALT TIME ON TIME OFF OBLIQ STEREO VERT.ANG WEIGHT DEC.TIME PT GR.NO. SN																					
18.32 150.06 106.13 80406.70 80408.50 -13.27 37.35 41.83 999999999.9 80412.36 1 0 2																					

ACQUISITION SCOPE SUMMARY (TOTALS)

PATH 1 TARGETS	26	WEIGHTS	9999999999.
PATH 2 TARGETS	28	SCAN TARGETS	2
ATS TARGETS	54	MANDATORY ATS	5
VISUAL INTELLIGENCE TARGETS	3	PRIMARY TARGETS	12

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Table 3-38. TWOUT Output (Continued)

VEHICLE 9999	RUN NUMBER	SAMPLE	PAGE NUMBER
REVS 6 THRU 6	NUMBER OF ACTIVE SCOPES	2	18
EXPECTED WEIGHT INFORMATION FOR REV NUMBER 6			
GROUP NO.	PRIMARIES	ALTERNATES	VITS
1	1	2	2
	PRIMARY WEIGHT	TOTAL GROUP WEIGHT	VIT WEIGHT
	162530194.7	155243009.0	88229120.0
VEHICLE 9999	RUN NUMBER	SAMPLE	PAGE NUMBER
REVS 6 THRU 6	NUMBER OF ACTIVE SCOPES	2	20
EXPECTED WEIGHT SUMMARY (TOTALS) FOR REV NUMBER 6			
TOTAL NUMBERS OF TARGETS	TOTAL WEIGHTS		
PRIMARY 27 ALTERNATE 23 VIT 11	PRIMARY 9616228682 TOT GROUP	9761144936 VIT	1114907725

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Table 3-38a. Target Card Data Key

<u>Item</u>	<u>Description</u>
IP	Priority (inactive)
D	Target diameter (ft x 10 <sup>-1</sup> )
ALT	Target altitude (ft x 10 <sup>-2</sup> )
SHD	Shade factor
M	Photo mode weighting function
CC	Country code
ESS	Exposure setting sequence
AP	Priority (active)
DPA	Desired pitch angle ( <u>+</u> deg)
STF	Scan target flag
BMF	Benchmark flag
MF	Mandatory flag
PA	Probability of activity (%)
SVT	Specified ATS view time (sec x 10 <sup>-1</sup> )
PWF	Pitch weighting function
TGT ID	Target identifier
WF	Weather factor
RR	Resolution requirement (in.)
SCC	Special category code
LATITUDE	Target latitude (deg, + = north)
LONGITUDE	Target longitude (deg, + = west)
VIF	Visual intelligence flag

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Table 3-38b. Main Optics Selection Key

<u>Item</u>	<u>Description</u>
S.ANG	Sun elevation
SLNTRNG	Slant range (n.mi.)
VEH.ATL	Vehicle altitude (n.mi.)
TIME ON	Time "ON" (system time, sec)
OBLIQ	Obliquity (deg)
STEREO	Stereo angle (deg)
M	Mode
CONVANG	Stereo convergence angle
WEIGHT	Operation weight

Table 3-38c. ATS Selection Key

<u>Item</u>	<u>Description</u>
S.ANG	Sun elevation angle (deg)
SLNTRNG	Slant range (n.mi.)
VEH.ALT	Vehicle altitude (n.mi.)
TIME ON	Time "ON" (system time, sec)
TIME OFF	Time "OFF" (system time, sec)
OBLIQ	Obliquity (deg)
STEREO	Stereo angle (deg)
VERT.ANG	Average angle from vertical (deg)
WEIGHT	Operation weight
DEC.TIME	Decision time (system time, sec)
PT	Primary target flag
GR.NO.	Group identifier
SN	Scope number

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Table 3-39. Table PATHDATA

Symbol	JOVIAL Declaration			Definition
PLTTON	F	0	00	Beginning of main optics photo sequence or ATS tracking sequence in system time
PLTTOFF	F	1	00	End of main optics photo sequence or ATS tracking sequence in system time
PLTIDL	H	8	2 00	Left 8 characters of target ID
PLTIDR	H	2	3 00	Right 2 characters of target ID
PLTGRNO	I	14 U	4 00	Group number if ATS selection
PLTITEM	I	2 U	4 46	Type selection: 0=M0, 1=ATS1 2=ATS2
PLTDLT1	I	4 U	5 0	Time duration. 1st half stereo sequence if M0
PLTDLT2	I	4 U	5 4	Time duration, 2nd half stereo sequence if M0
PLTDECT	F	5	0	Group decision time (system) if ATS
PLTOBLQ	F	6	0	Target obliquity from COTPRIME table

#### 3.12.4 Method

The subfunction TWOUT combines the data available in the input tables (COTPRIME, MOST, and ASST) and performs the computations necessary to provide the listable output. Flow charts for TWOUT and the key procedures used by TWOUT are provided in Figure 3-19. Essentially, three types of computation are performed by this subfunction. These are:

- a. Computation of Main Optics Strategy output parameters
- b. Computation of ATS Strategy output parameters
- c. Computation of expected score per target group

These computations are performed by the procedures OUTMO, OUTSC and EXWGTSC described in Sections 3.12.4.1 through 3.12.4.3.

##### 3.12.4.1 OUTMO

The first line of the Main Optics output (as shown in Table 3-38) includes target specific parameters obtained directly from the COTPRIME table. Parameters defining Main Optics photographic activity are given on the

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second line. These parameters are determined from the information available in the COTPRIME and MOST tables. The MOST table contains only the information necessary to define (not fully describe) the Main Optics Strategy. The following items are stored in the MOST for each target which is part of the strategy: the COTPRIME entry number of the selected target, the photographic mode, and the time of completion of the photographic sequence for the target. Given the photographic finish time MOT2, the photographic start time is calculated from the equation

$$PT = (\Delta t_1 + \Delta t_2) + \Delta \Sigma (t_3 - t_1) / (A-B)$$

The parameters  $\Delta t_1$ ,  $\Delta t_2$ , and  $\Delta \Sigma$  are determined as a function of photographic mode from File 8 input parameters defined by EGT150 through EGT179. The difference  $(t_3 - t_1)$  is the elapsed time from first acquisition to last acquisition. These parameters are obtained from the COTPRIME table for the particular target being considered. The quantity  $(A-B)$  is the total change in stereo angle from first acquisition to last acquisition. These parameters are defined by the File 7 parameters SEV063 and SEV065. The stereo angle ( $\Sigma$ ), obliquity ( $\Omega$ ), and slant range are then determined at the midsequence time  $t$ :

$$t = (MOT1 + MOT2)/2$$

$$\Sigma = (t - t_1) (A - B)/(t_3 - t_1) - A$$

$$\Omega = (t - t_1) (\Omega_3 - \Omega_1)/(t_3 - t_1) + \Omega_1$$

$$SR = SR (tca) / \cos (\Sigma)$$

where

$\Omega_1$  = obliquity at first acquisition time

$\Omega_3$  = obliquity at last acquisition time

$SR(tca)$  = slant range at time of closest approach

These parameters are obtained from the COTPRIME.

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The remaining parameters on the second line of the Main Optics outputs are obtained directly from the input tables with the exception of target weight. The target weight is calculated by the method described in Sections 3.7 and 3.8.

#### 3.12.4.2 OUTSC

The ATS output is determined from the data available in the COTPRIME and ASST tables. Since dwell time is available in the COTPRIME and target worth is available in the ASST, the only calculations required are for the determination of stereo angle ( $\Sigma$ ), obliquity ( $\Omega$ ), and slant range (SR). These parameters are determined at an average time ( $t$ ) by the method described in Section 3.12.4.1.

#### 3.12.4.3 EXWGTSC

Procedure EXWGTSC computes the expected score of each target group generated and stored in the ASST by the ATS target selection algorithm. EXWGTSC sums the expected scores of all target groups in each rev to determine the expected score of each rev.

A target group as output by TWONDER consists of a primary target, alternate targets and/or visual intelligence targets. EXWGTSC does not include visual intelligence targets in the computation of expected score; therefore, for the purposes of EXWGTSC a target group consists only of the primary target and it's alternates.

The probability that a target  $j$  is reported by a crew member as being active is

$$P_{A(j)} = P\{RA\}_{(j)} = P_{A(j)} P_V P_R + (1 - P_{A(j)}) P_V P_F$$

where  $P_{A(j)}$  = Probability of activity of target  $j$

$P_V$  = Probability of visibility (EXWGTSC employs the same value of  $P_V$  for all targets)

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$P_R$  = Probability of recognition of activity (EXWGTSC employs the same value of  $P_R$  for all targets)

$P_F$  = Probability of false alarm, that is, reporting an inactive target active (EXWGTSC employs the same value of  $P_F$  for all targets)

The probability that the target  $j$  is reported inactive is

$$\rho_{I(j)} = P \{RI\}(j) = P_{A(j)} P_V (1-P_R) + (1-P_{A(j)}) P_V (1-P_F)$$

The expected worth of a target  $j$  if reported active is

$$\bar{W}_{A(j)} = E(W/RA)(j) = (W_{A(j)} P_{A(j)} P_V P_R + W_{I(j)} (1-P_{A(j)}) P_V P_F) / \rho_{A(j)}$$

The expected worth of target  $j$  if reported inactive is

$$\bar{W}_{I(j)} = E(W/RI)(j) = (W_{A(j)} P_{A(j)} P_V (1-P_R) + W_{I(j)} (1-P_{A(j)}) P_V (1-P_F)) / \rho_{I(j)}$$

where  $W_{A(j)}$  = the basic active worth of target  $j$

$W_{I(j)}$  = the basic inactive worth of target  $j$ .

The expected score of a target group is computed as follows:

1. The quantities  $\bar{W}_A$ ,  $\rho_A$  and  $\bar{W}_I$ ,  $\rho_I$  are computed for each target.
2. For each  $\bar{W}$  (regardless of subscript A or I) and corresponding  $\rho$  the quantity  $w$  is computed

$$w = \bar{W} \times \rho \prod_M (1 - \rho_{(m)}) \prod_N (1 - P_V)$$

where  $M$  is the set of targets in the group such that either  $\bar{W}_A > \bar{W}$  (then  $\rho_{(m)} = \rho_A$ ) or  $\bar{W}_I > \bar{W}$  (then  $\rho_{(m)} = \rho_I$ )

$N$  is the set of targets in the group such that  $\bar{W}_A > \bar{W}$  and  $\bar{W}_I > \bar{W}$ .

3. The expected score of the target group is computed as the sum of the  $w$ 's.

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$P_V$ , the probability of visibility, is specified through File 8 parameter EGT937.  $P_R$ , the probability of recognition, is specified through File 8 parameter EGT924.  $P_F$ , the probability of false alarm, is specified through File 8 parameter EGT923.

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TWOUT

TWOUT

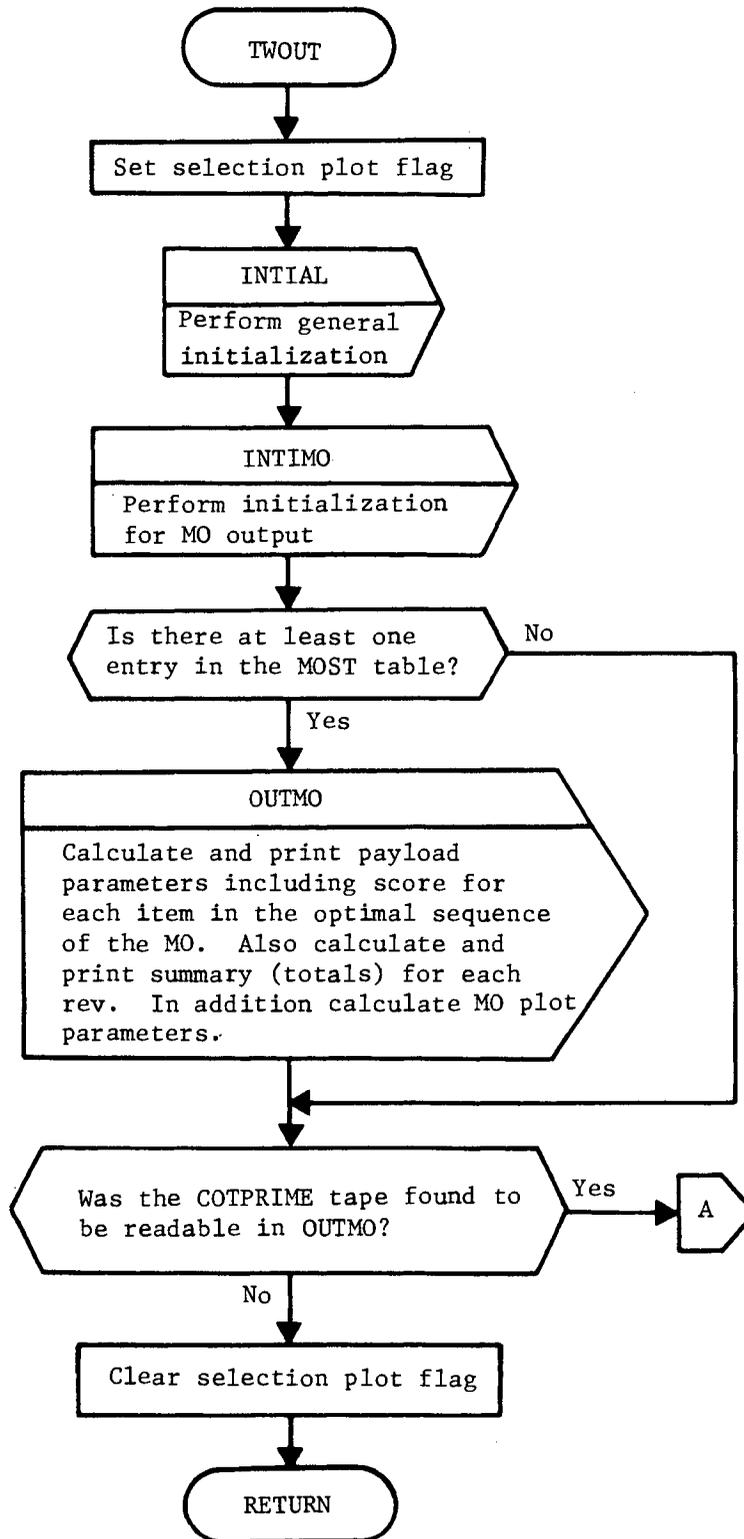


Figure 3-19. TWOUT Flow Chart

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TWOUT

TWOUT

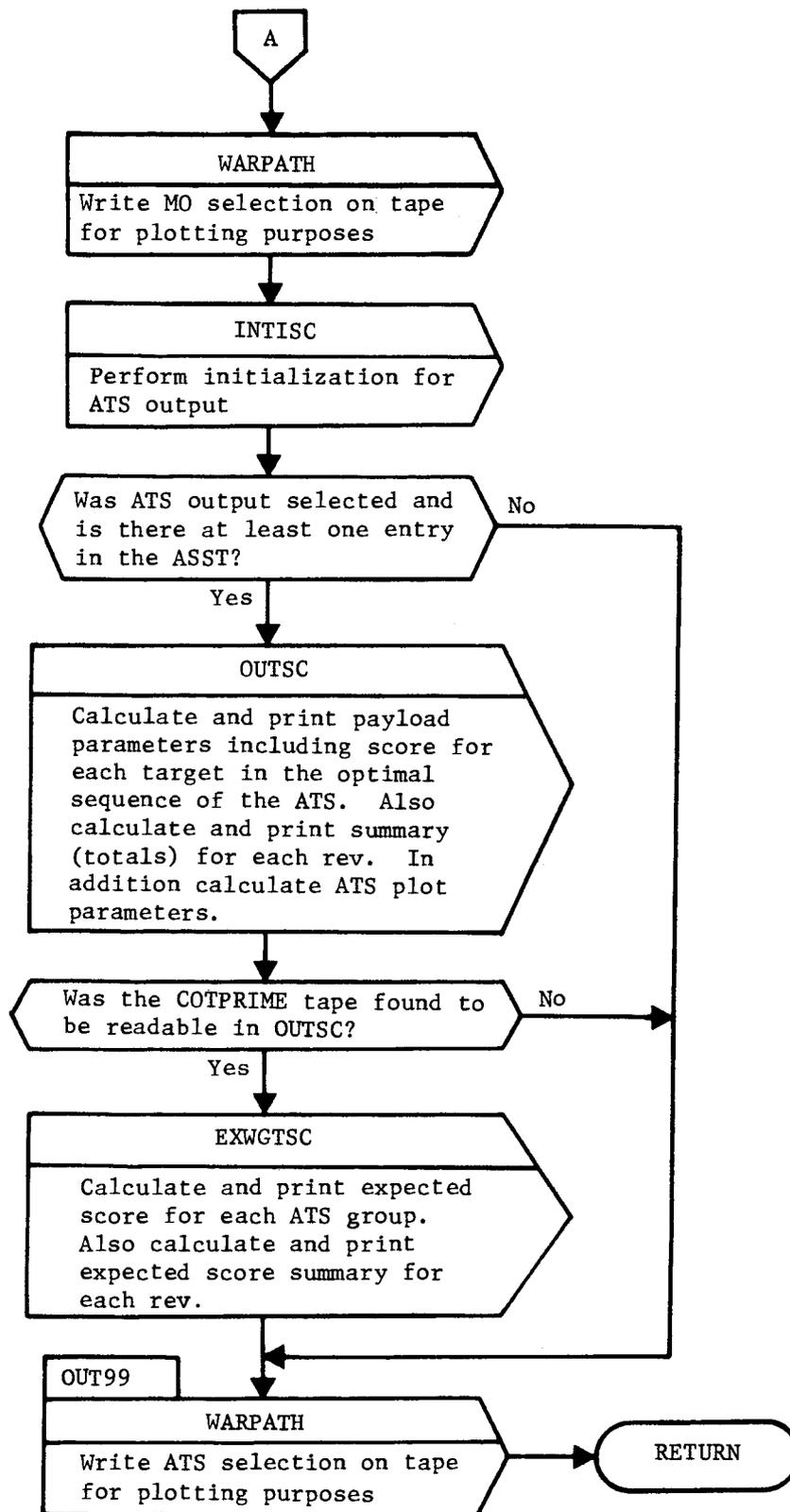


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTMO

OUTMO

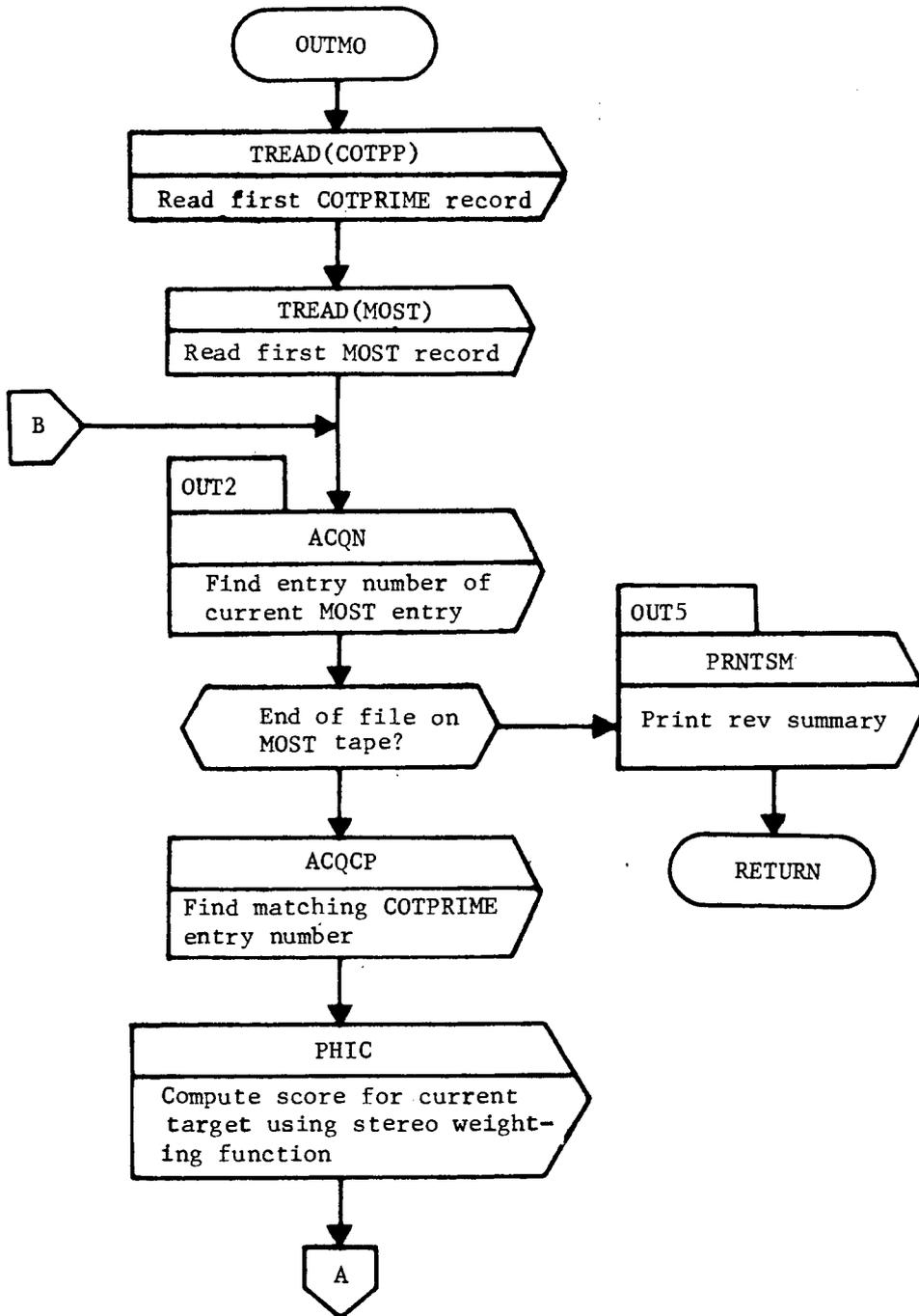


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTMO

OUTMO

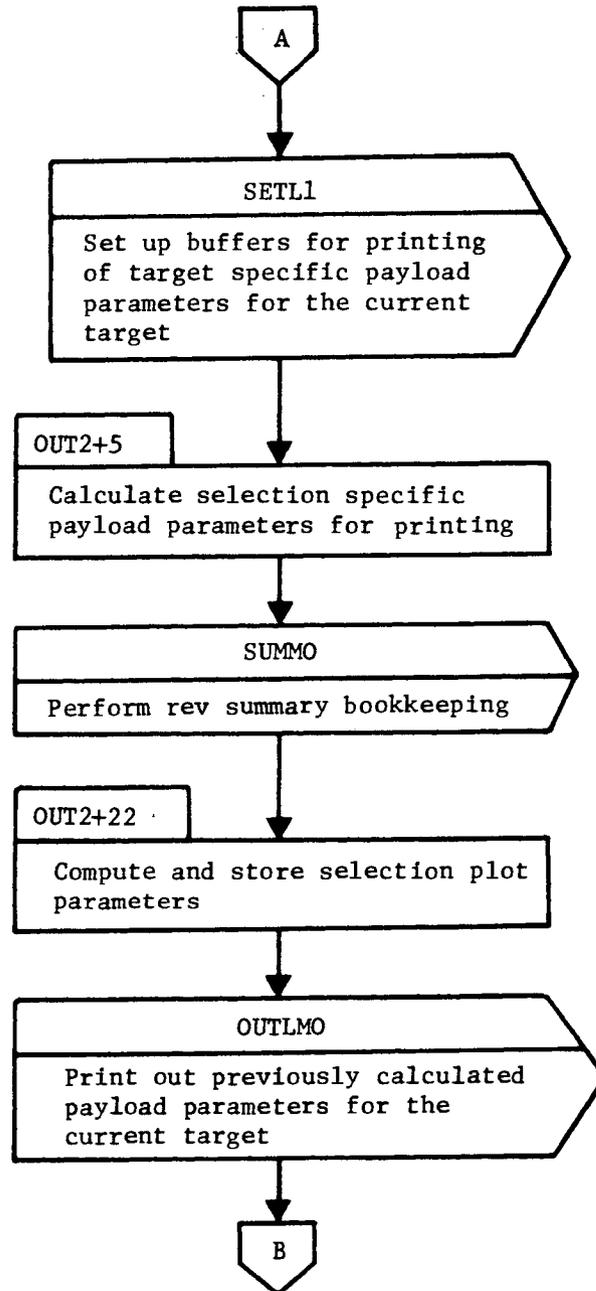


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTLMO

OUTLMO

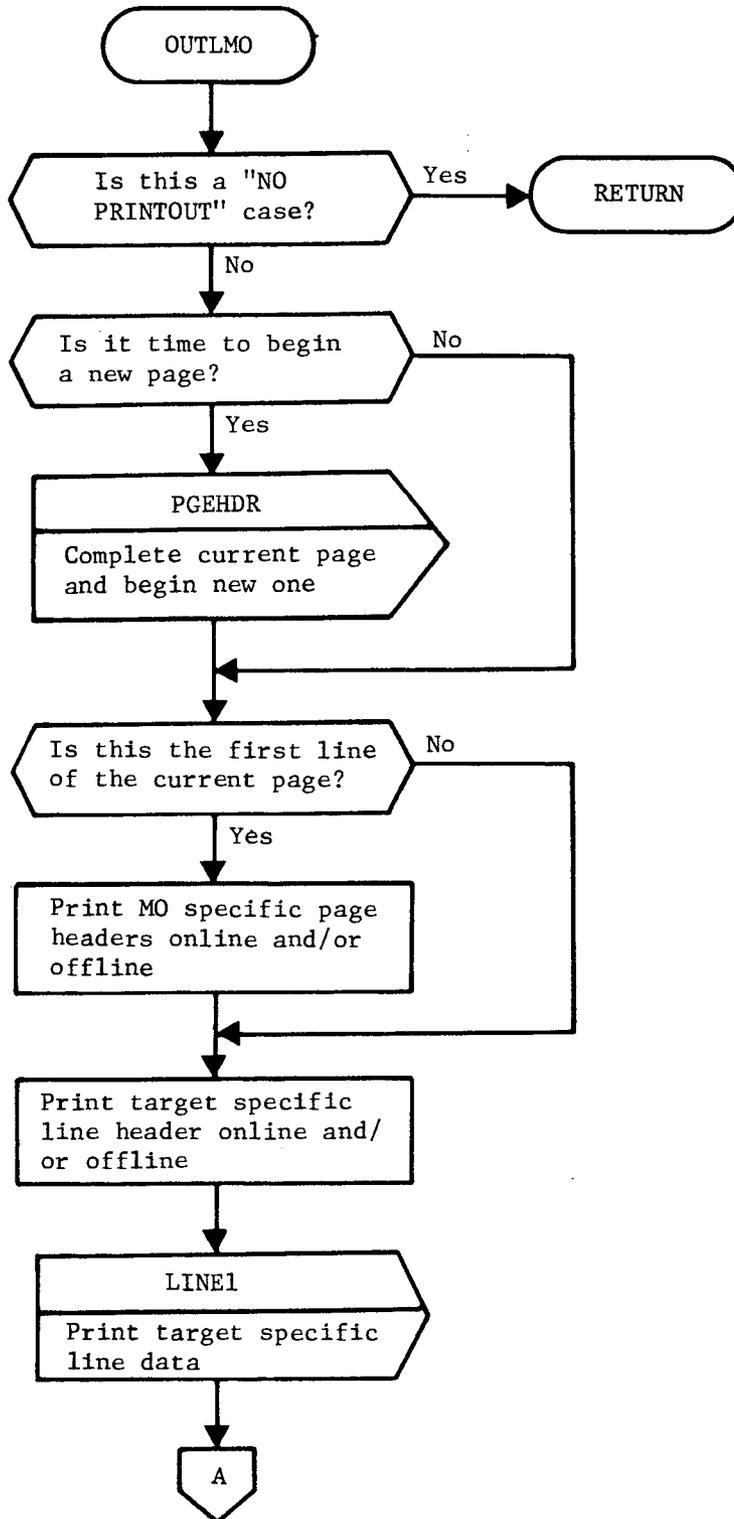


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTLMO

OUTLMO

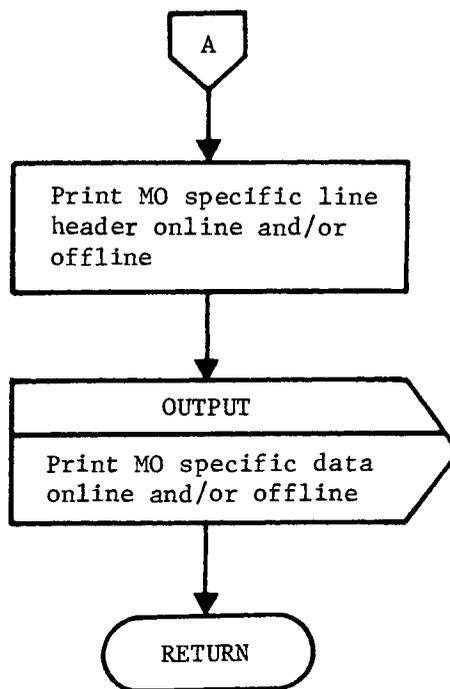


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTSC

OUTSC

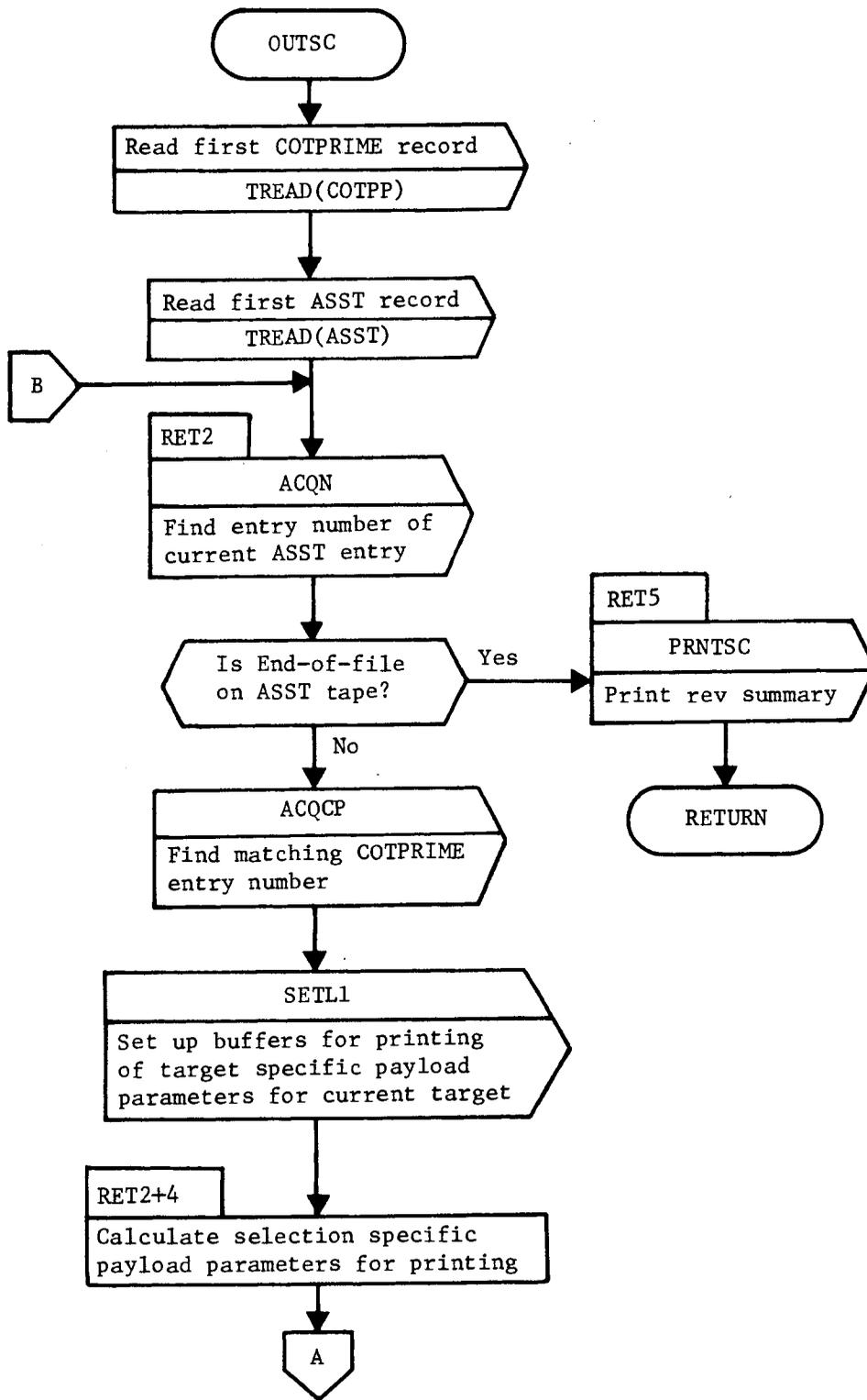


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTSC

OUTSC

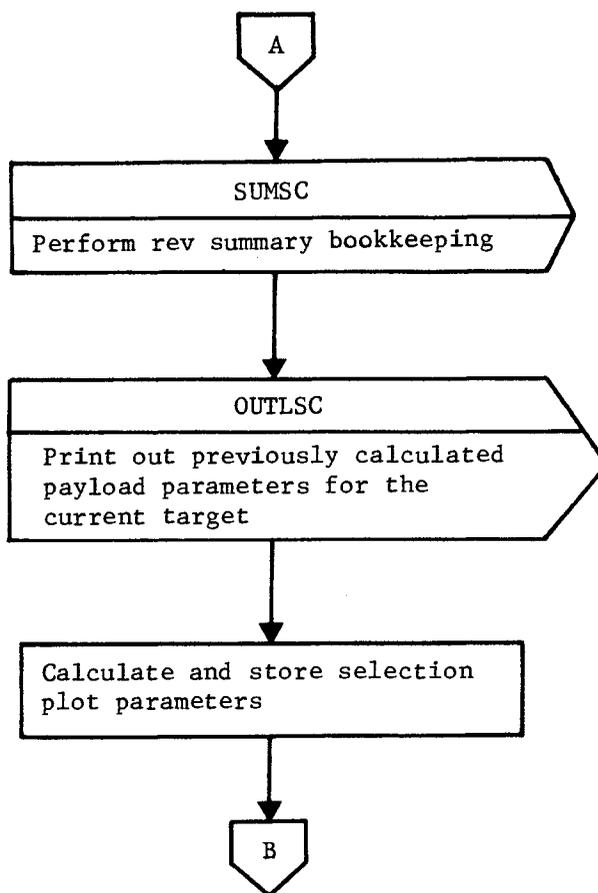


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTLSC

OUTLSC

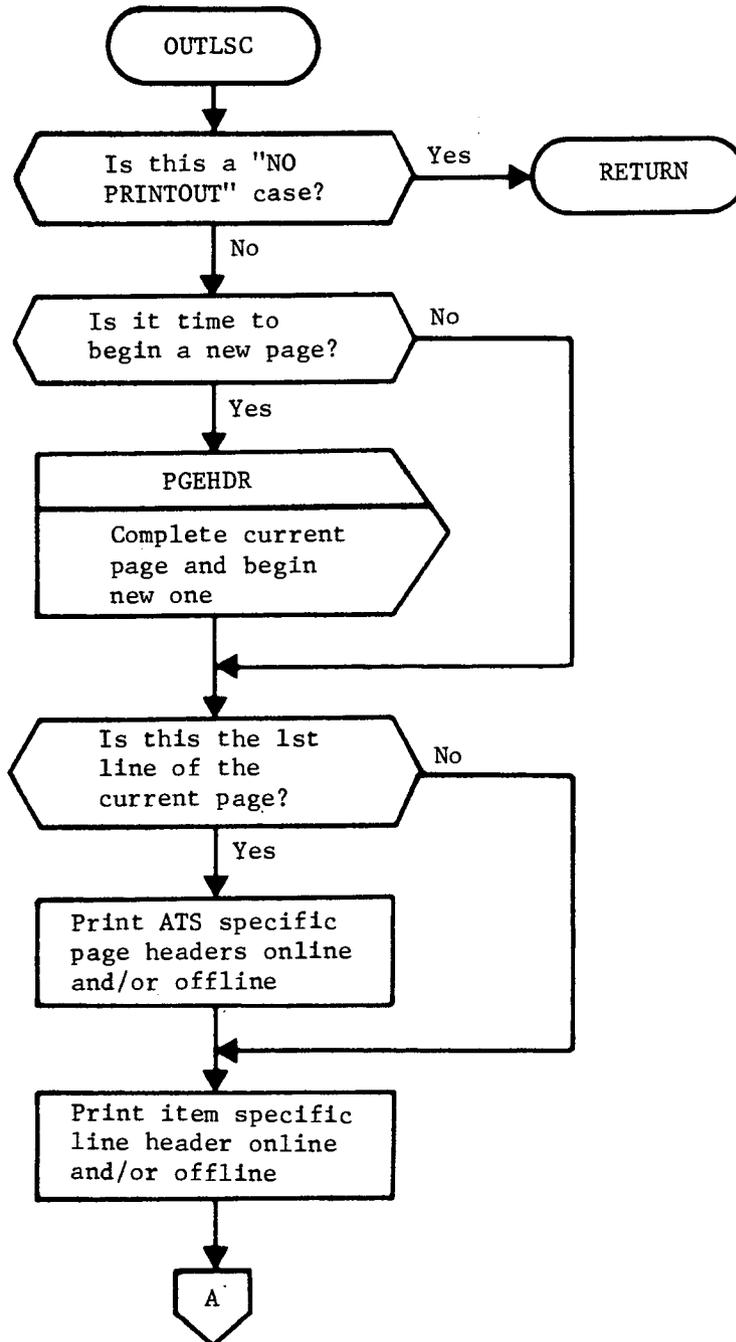


Figure 3-19. TWOUT Flow Chart (Continued)

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OUTLSC

OUTLSC

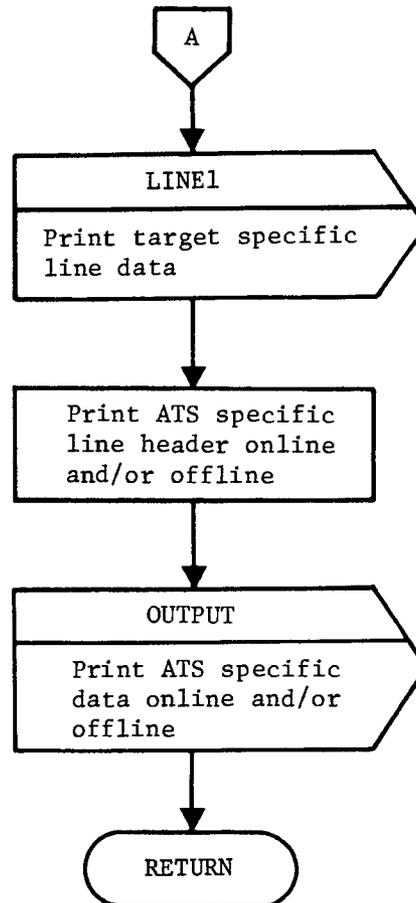


Figure 3-19. TWOUT Flow Chart (Continued)

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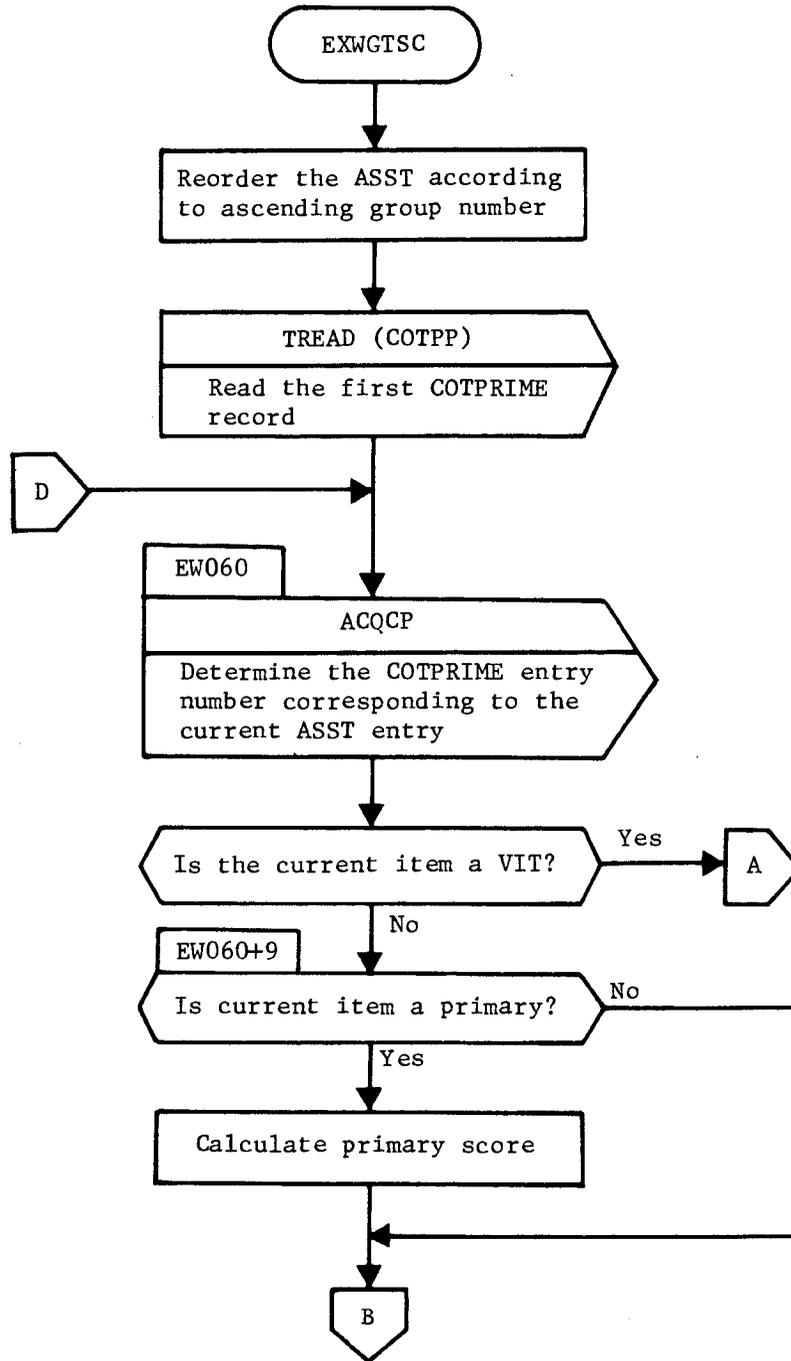


Figure 3-19. TWOUT Flow Chart (Continued)

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EXWGTS

EXWGTS

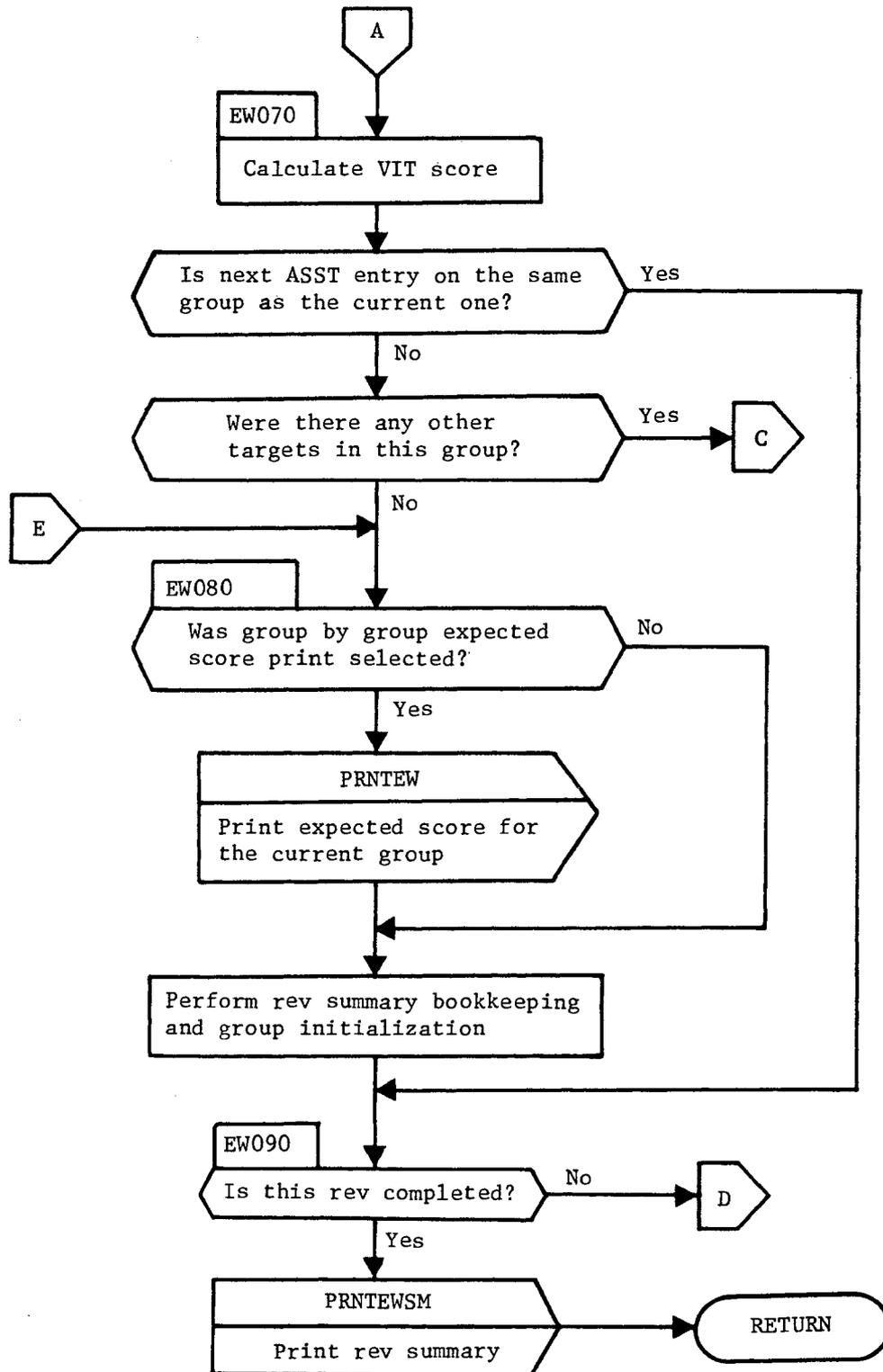


FIGURE 3-19. TWOUT Flow Chart (Continued)

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EXWGTSC

EXWGTSC

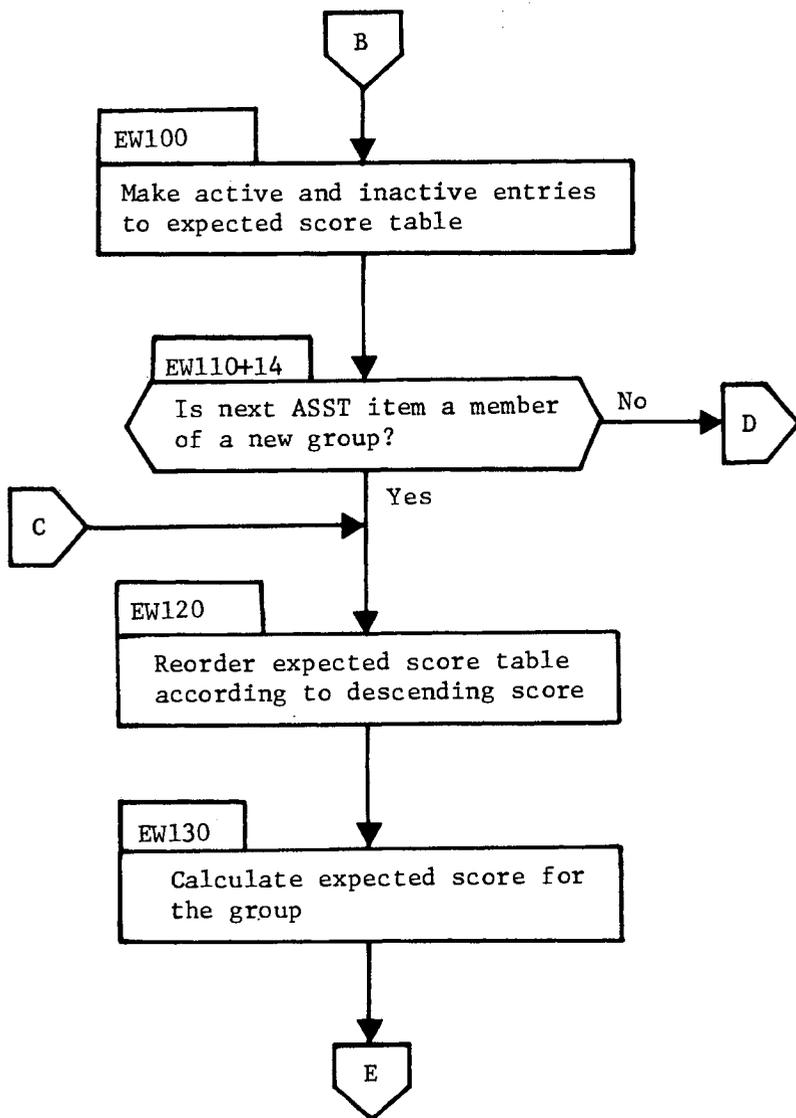


Figure 3-19. TWOUT Flow Chart (Continued)

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### 3.13 TWPLOT1

#### 3.13.1 Purpose

TWPLOT1 produces a time-obliquity swath plot of all targets on the acquisition tape. On option, the targets selected for main optics photography and ATS viewing are superimposed on the plot.

#### 3.13.2 Input

The following inputs are required by TWPLOT1

- a. Acquisition tape (See Section 3.3.3)
- b. PATHDATA (see Section 3.12.3)
- c. THINGS (see Section 3.2.3)

The table THINGS parameters that control TWPLOT1 output options are input through the File 8 parameters used by TWPLOT1 and located in table THINGS as depicted in Table 3-40.

#### 3.13.3 Output

The output of TWPLOT1 is a time obliquity swath plot as shown in Table 3-41.

A hierarchy of characters is employed to resolve conflicts in printing requirements. This hierarchy is shown in Table 3-42. The character having a lower rank will be printed if a conflict occurs.

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Table 3-40. File 8 Parameters Used in TWPLOTL Located in Table THINGS

Reset File Definition				Interface Table Usage			
File Location	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
EGTL10	I	2	n.d.	Flags for TWPLOTL control in successor function mode 0: Do not generate PLOT 1: Generate ACQ plot 2: Generate selection plot 4: Plot (+) and (-) for forward and aft stereo times Above options summable	TRWPLOT	I 48 U 314 0	n.d.

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Table 3-40. File 8 Parameters Used in TWPL0T1 Located in Table THINGS (Continued)

Reset File Definition				Interface Table Usage			
File 8 Location	Form of Data	Nominal Value	Units	Definition	Internal Symbol	JOVIAL Definition	Internal Units
EGT134	I	1	n.d.	Output control flag 1: Target selection output and plots on Tape 8 2: Target selection output and plots online 4: Intermediate Data Tables on Tape 8 8: Intermediate Data Tables on- line 16: ASST 32: LISTX 64: LIST 128: ASCOT 256: MOST 512: ALMOST 1024: MOCOT 2048: COTPRIME Output requests are summable	OUTFLAG	I 48 U 239 0	n.d.

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Table 3-41. Acquisition and Target Selection Plot

TIME	SCALE FACTOR	1.600	PRG/COL	0	10.0	20.0	30.0	45.0	4EV NO.	6
21260	40.0	20.0	20.0							
21261										
21262										
21263										
21264										
21265										
21266										
21267										
21268										
21269										
21270										
21271										
21272										
21273										
21274										
21275										
21276										
21277										
21278										
21279										
21280										
GM 2										
21282										
21283										
21284										
21285										
21286										
21287										
21288										
21289										
21290										
21291										
21292										
21293										
21294										
21295										
21296										
21297										
21298										
21299										
21300										
GM 3										
21302										
21303										
21304										
21305										
21306										
21307										
21308										
21309										
21310										
21311										
21312										
21313										
21314										
GM 4										

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Table 3-42. Hierarchy of Characters in TWPL0T1

Rank	Character	Octal Representation	Rank	Character	Octal Representation
0-4	SPARES		23	E	0(65)
5	<	0(72)	24	F	0(66)
6	>	0(57)	25	G	0(67)
7	(	0(34)	26	H	0(70)
8	)	0(74)	27	I	0(71)
9	0	0(12)	28	J	0(41)
10	1	0(01)	29	R	0(51)
11	2	0(02)	30	M	0(44)
12	3	0(03)	31	L	0(43)
13	4	0(04)	32	N	0(45)
14	5	0(05)	33	X	0(27)
15	6	0(06)	34	Y	0(30)
16	7	0(07)	35	Z	0(31)
17	8	0(10)	36	+	0(60)
18	9	0(11)	37	-	0(40)
19	A	0(61)	38	>	0(57)
20	B	0(62)	39	<	0(72)
21	C	0(63)	40	.	0(73)
22	D	0(64)	41	↓	0(56)
			43	*	0(54)
			42	BLANK (and all others)	0(20)

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#### 3.13.4 Method

The flow charts for TWPLOTL and the key procedures employed by this subfunction are provided in Figure 3-20. The key procedures are described in the following paragraphs.

##### 3.13.4.1 TPLOTS

Generation of the swath plot is accomplished by the procedure TPLOTS. An image of two pages of the plot is maintained in core. This image is initially filled with blanks by the procedures PAGESET1 and PAGESET2. If the largest allowable plot obliquity is other than the nominal 45°, an appropriate scale change is then made. Two hundred entries are read into core from the acquisition tape. Acquisition entries are then examined until the first target in the rev span of interest is found. When a selection plot is requested, a target selected by the main optics target selection algorithm or the ATS target selection algorithm is flagged so that selection symbols may be affixed to the target. Forward, vertical, and aft acquisition times are converted to page row numbers and obliquity is converted to page column number. If the row number of the forward acquisition time indicates that a new page must be started, control is passed to PGEWRITE which produces the selection plot and writes the completed page on the list tape. Control is passed to TSTORE which plots the most significant digit of the target inactive priority in the vertical time row. The characters "+" and "-" are plotted in the forward and aft rows if requested. TSTORE also writes each target ID in the right hand margin of the page in the vertical acquisition row.

The successive acquisition entries are then processed as described above until all targets in the rev span of interest have been processed. Control is then returned to TWONDER2.

##### 3.13.4.2 TSTORE

The procedure TSTORE initially determines if the current target vertical acquisition row is the same as the last one. If not, a check is made to determine if the ID's of targets in the earlier row have been stored in the right margin of the page and stores them if not. If the number of targets in the last row is greater than 2, the three right most

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characters of each ID are stored. If the number of targets exceeds the maximum number of 3 character fragments, which is seven, the number of targets is stored in the left hand margin overriding the system time print. The "+", the most significant digit of priority, and the "-" are stored in the appropriate column and rows by the procedure PLACE and control is returned to TPLOTS. If the current target vertical acquisition row is the same as the last one, PLACE stores the "+", the most significant digit of priority, and the "-". The target ID and obliquity are stored in a special ID buffer with the other target(s) in the same row; only the seven highest priority targets are retained if there are more than seven targets in the row. Control is then returned to TPLOTS. The procedure SYSTIME is used as necessary to store a running count of system time in the left hand margin.

#### 3.13.4.3 PGEWRITE

If the selection plot is not desired, the acquisition plot is immediately written online and/or offline and control is returned to TPLOTS. If the selection plot is desired, each ATS selection is processed as follows: the group decision time of each selection is indicated by overriding the system time in the left margin with the group number and printing a set of "\*"s across the plot page at five column intervals. PLACE is used to store the "\*"s and will not allow them to be stored if a more important character already occupies the intended space. Path number and a running count of the duration of the scope dwell time are stored in the appropriate obliquity column enclosed in parentheses.

After all ATS selections for the page have been processed, the main optics selection is processed as follows: a running count for the forward photographic sequence is stored in the appropriate obliquity column followed by blanks representing the dead time and a running count for the aft photographic sequence. The entire sequence is enclosed in carets.

After all main optics selections have been processed, the completed plot page is written online and/or offline and control is returned to TPLOTS.

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#### 3.13.4.4 Utility Subroutines

The following utility subroutines are used by TWPLLOT1.

- PLACE        A procedure which compares a character to be stored in the plot page image buffer with the character (including BLANK) already present according to the hierarchy of characters in TWPLLOT1. The new character overrides the old one only if it is found to be more important in the hierarchy scheme.
- PAGESET1    A procedure which stores all blanks in the first page image buffer. PAGESET1 is used by TPLOTS.
- PAGESET2    A procedure which stores all blanks in the second page image buffer. PAGESET2 is used by TPLOTS and PGESHIFT.
- PAGEHDR     A procedure which stores page headers to begin pages and stores page trailers to complete pages. PAGEHDR is used by TPLOTS.
- PGESHIFT    A procedure which shifts the second page image buffer into the first one. PGESHIFT is used by TPLOTS.
- SYSTIME     A procedure which stores system time in seconds modulo 86,400 (one day) in the left hand margin of the plot page image buffer. SYSTIME is used by TPLOTS and TSTORE.
- TSHIFT      A procedure which stores target ID and obliquity column in a buffer in order of obliquity. If the buffer is full (7 entries) the incoming entry will bump the entry of lowest rank from the buffer if the new entry is of higher rank. TSHIFT is used by TSTORE.
- FATR        A procedure which converts forward, vertical and aft acquisition times from machine time to system time. FATR is used by TPLOTS.
- TIMR        A procedure which converts forward, vertical and aft acquisition time (system) to page row numbers. TIMR also converts obliquity to page column number. TIMR is used by TPLOTS.
- TWTIMR     A procedure which computes the duration of photographic sequences. TWTIMR also converts selection obliquities to column numbers. TWTIMR is used by PGEWRITE.
- TWFATR      A procedure which computes the starting row of a photographic sequence from system start time. TWFATR is used by PGEWRITE.

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TWPLOT1

TWPLOT1

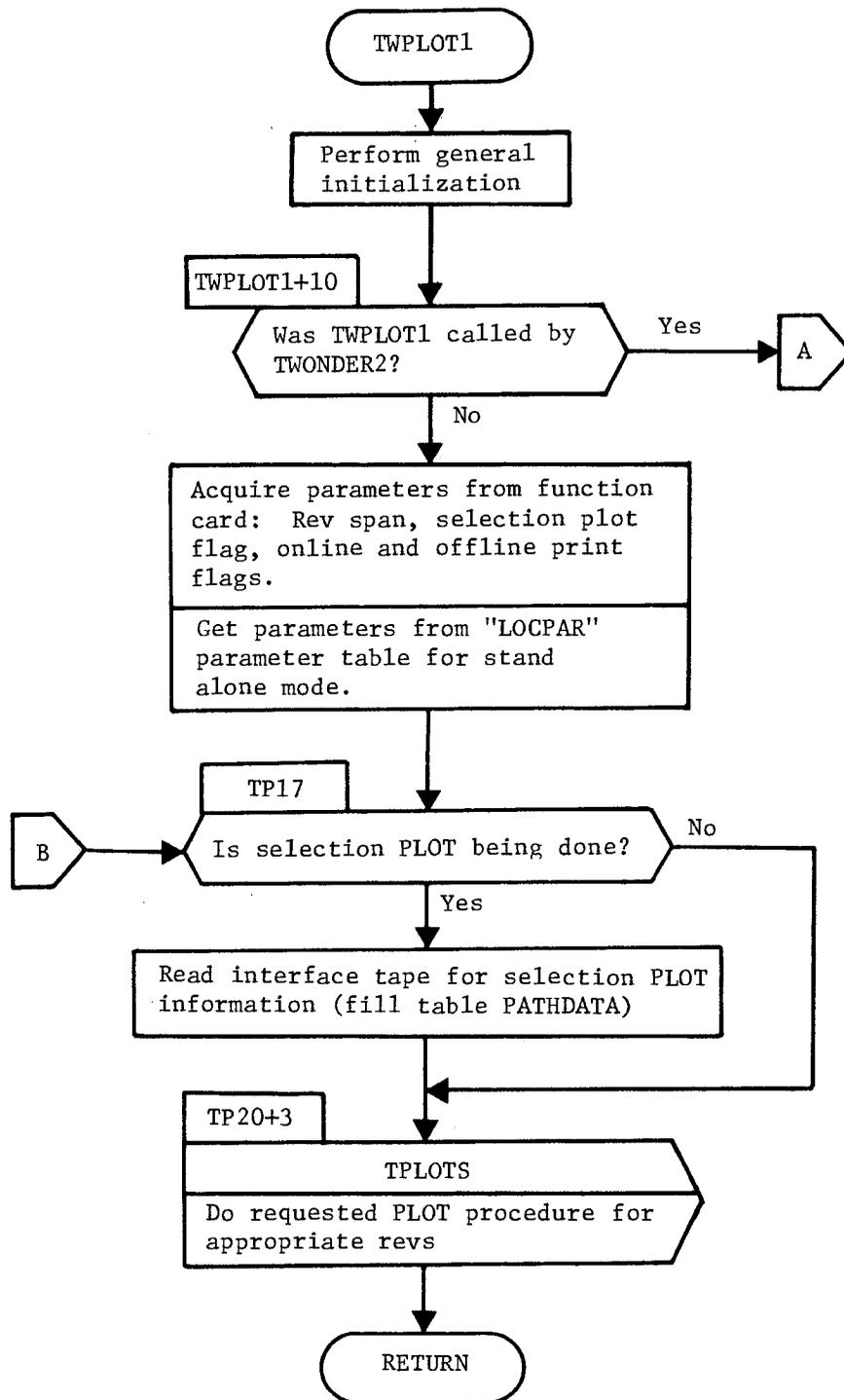


Figure 3-20. TWPLOT1 Flow Chart

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TWPLOT1

TWPLOT1

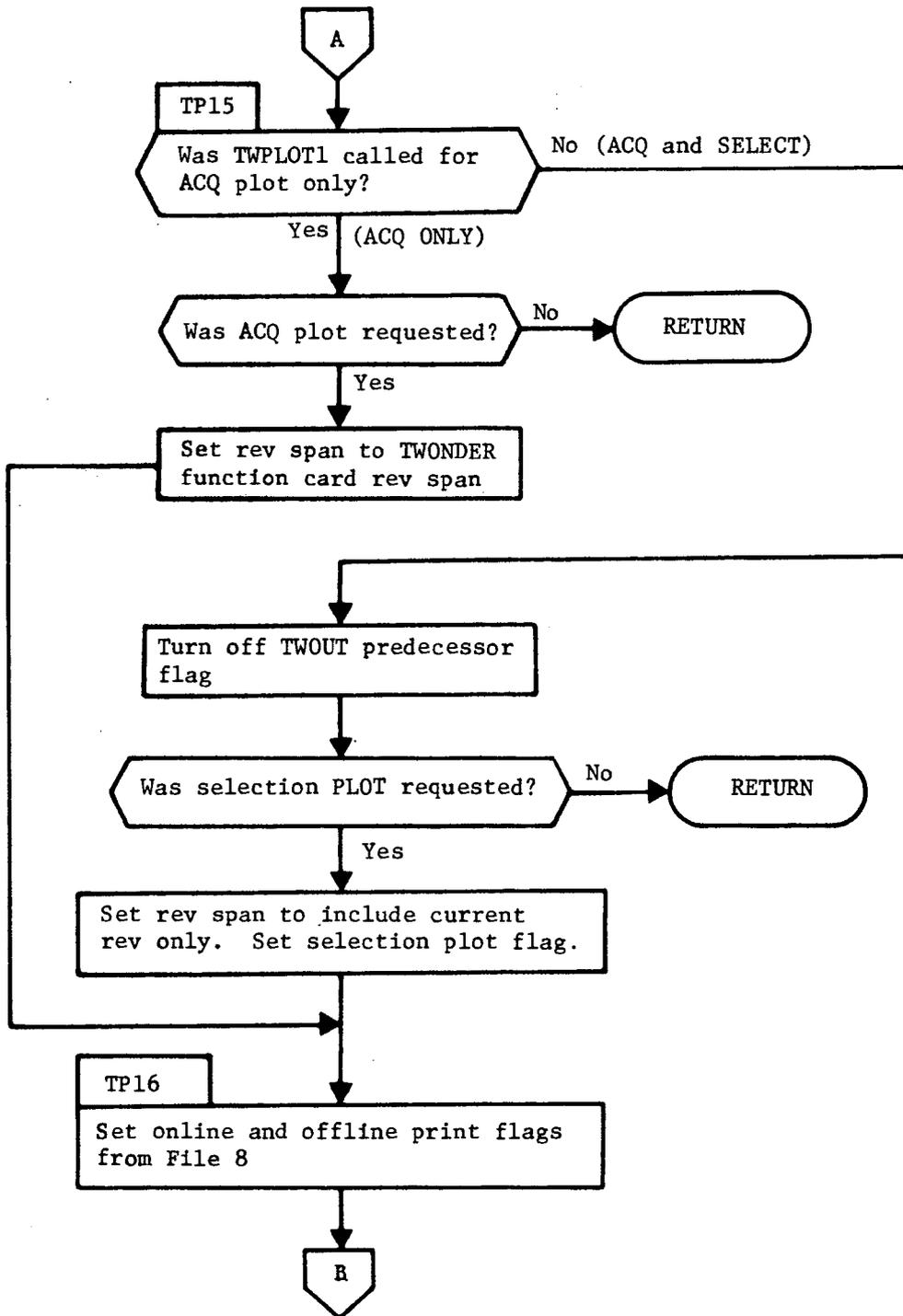


Figure 3-20. TWPLOT1 Flow Chart (Continued)

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TPLOTS

TPLOTS

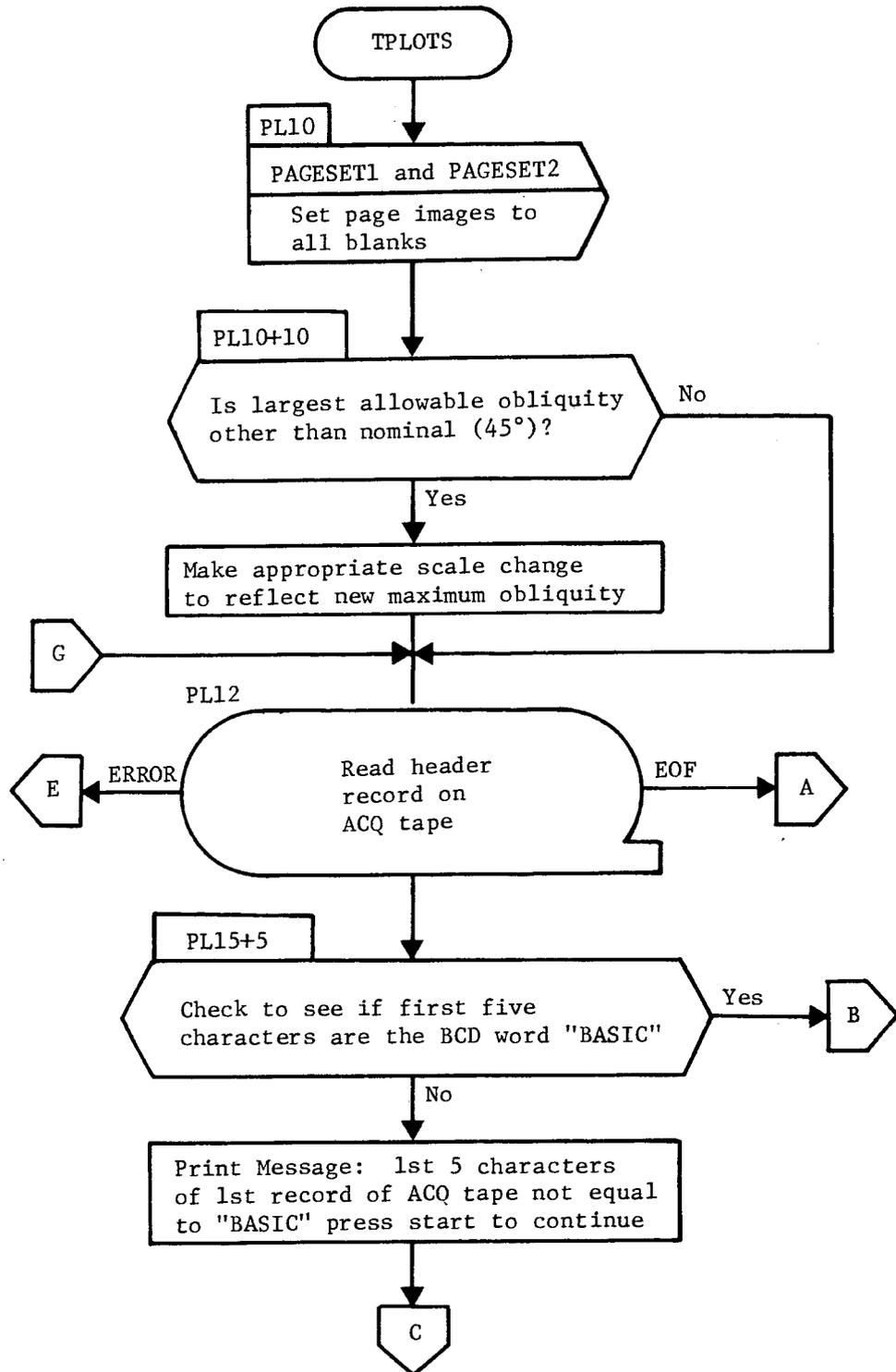


Figure 3-20. TWPLOTT Flow Chart (Continued)

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TPLOTS

TPLOTS

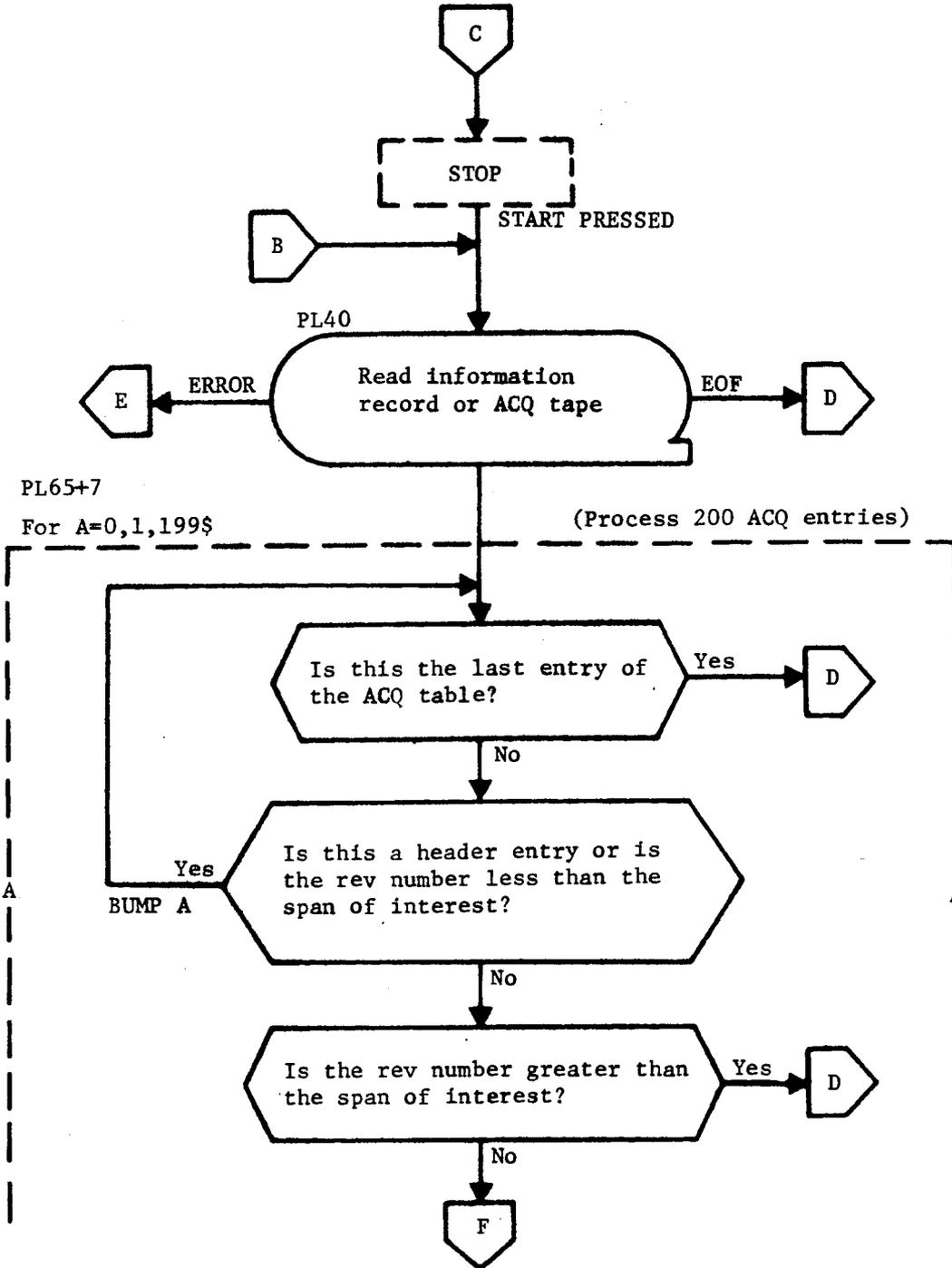


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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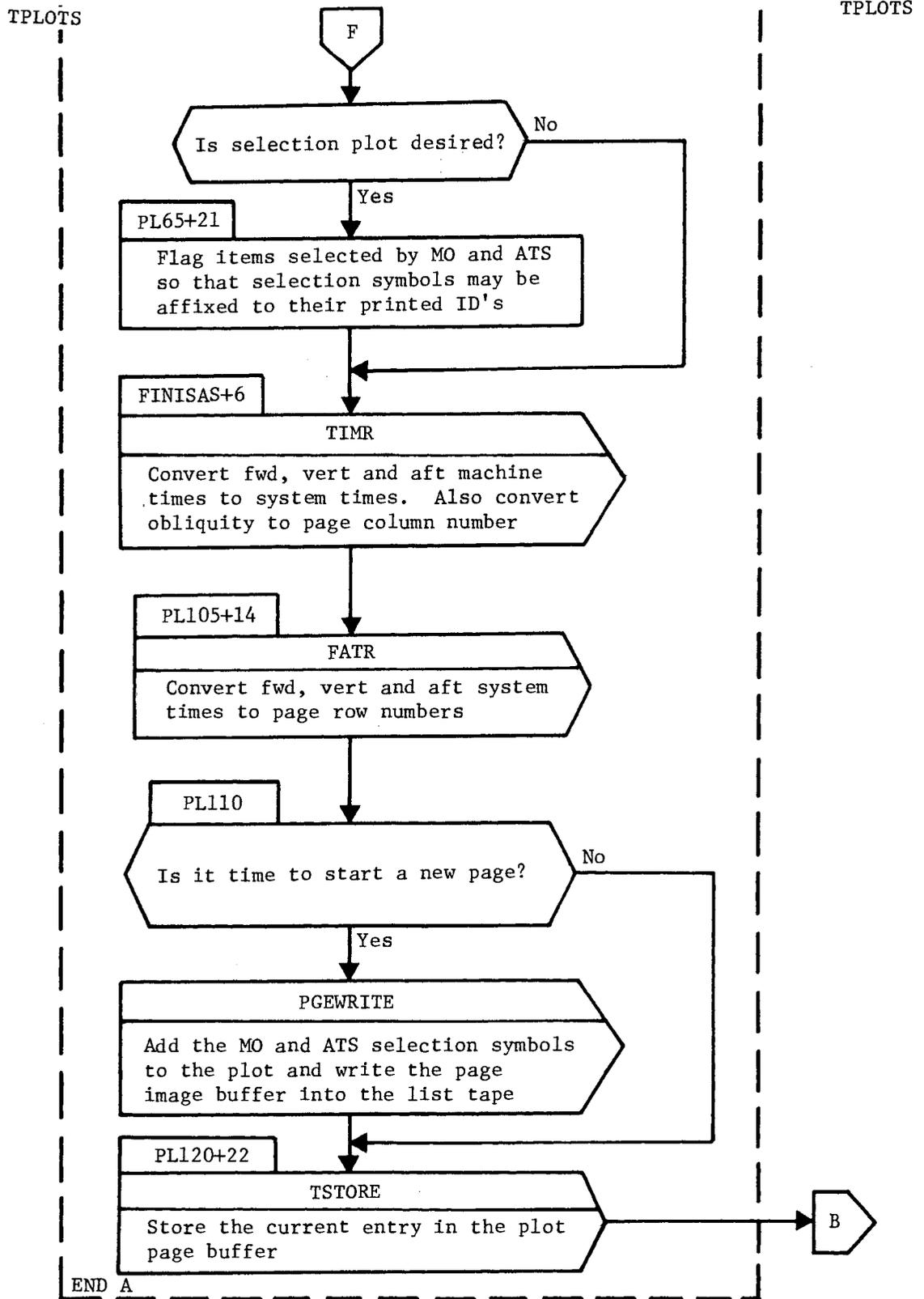


Figure 3-20. TWPLOT1 Flow Chart (Continued)

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TPLOTS

TPLOTS

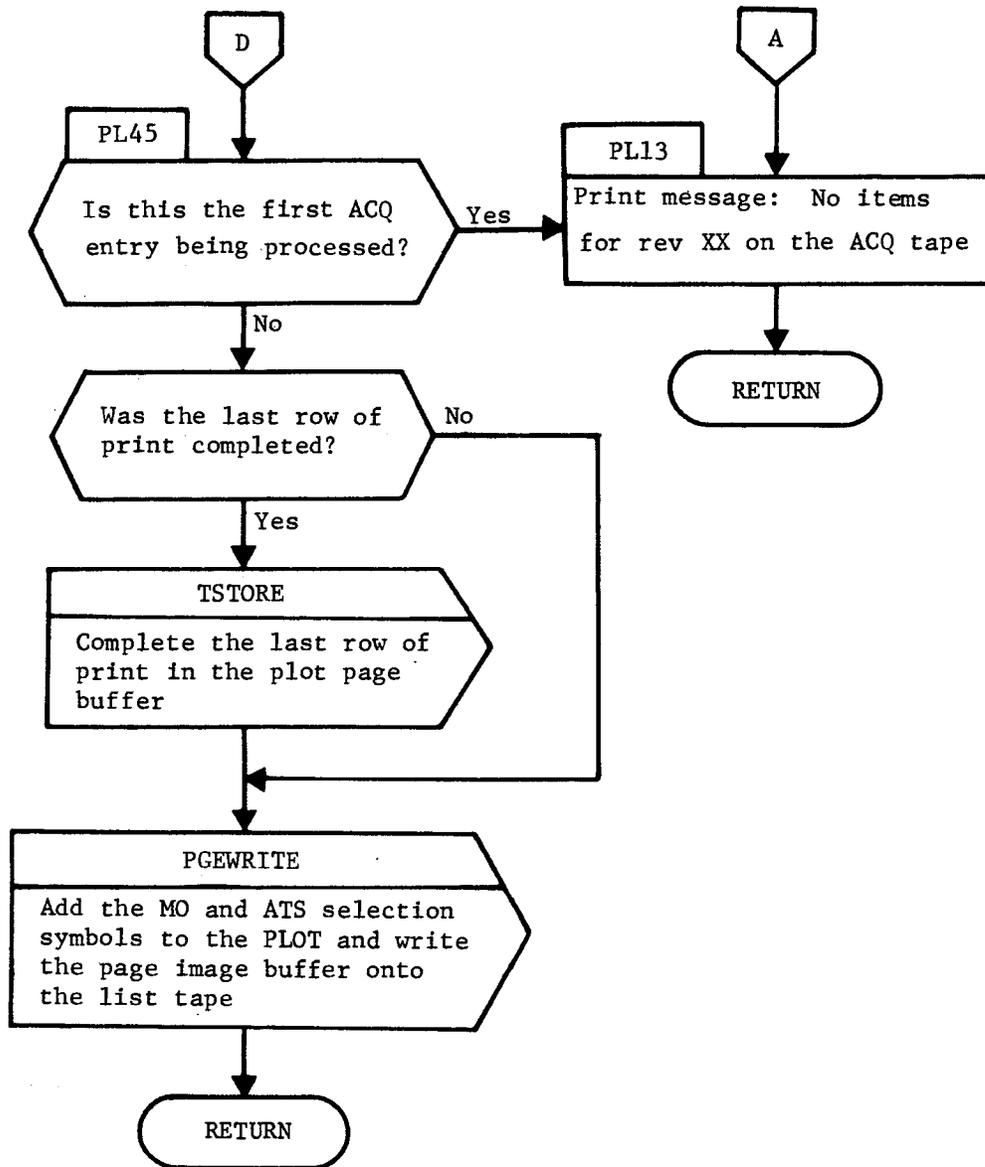


Figure 3-20. TWPLOTT Flow Chart (Continued)

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TLOTS

TLOTS

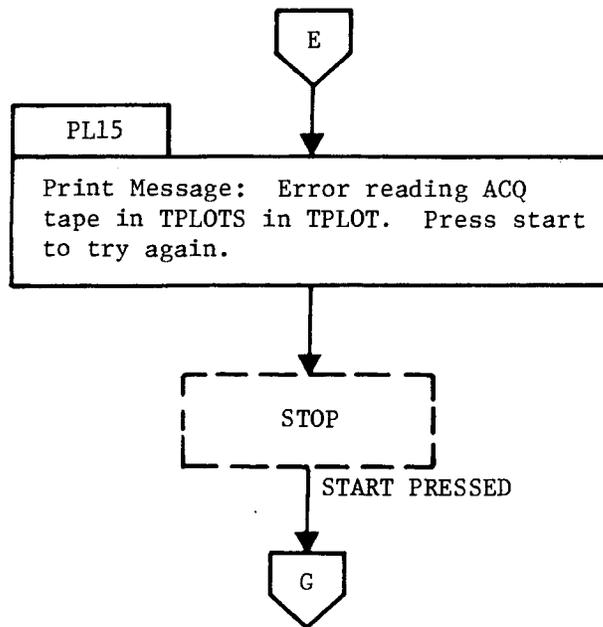


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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TSTORE

TSTORE

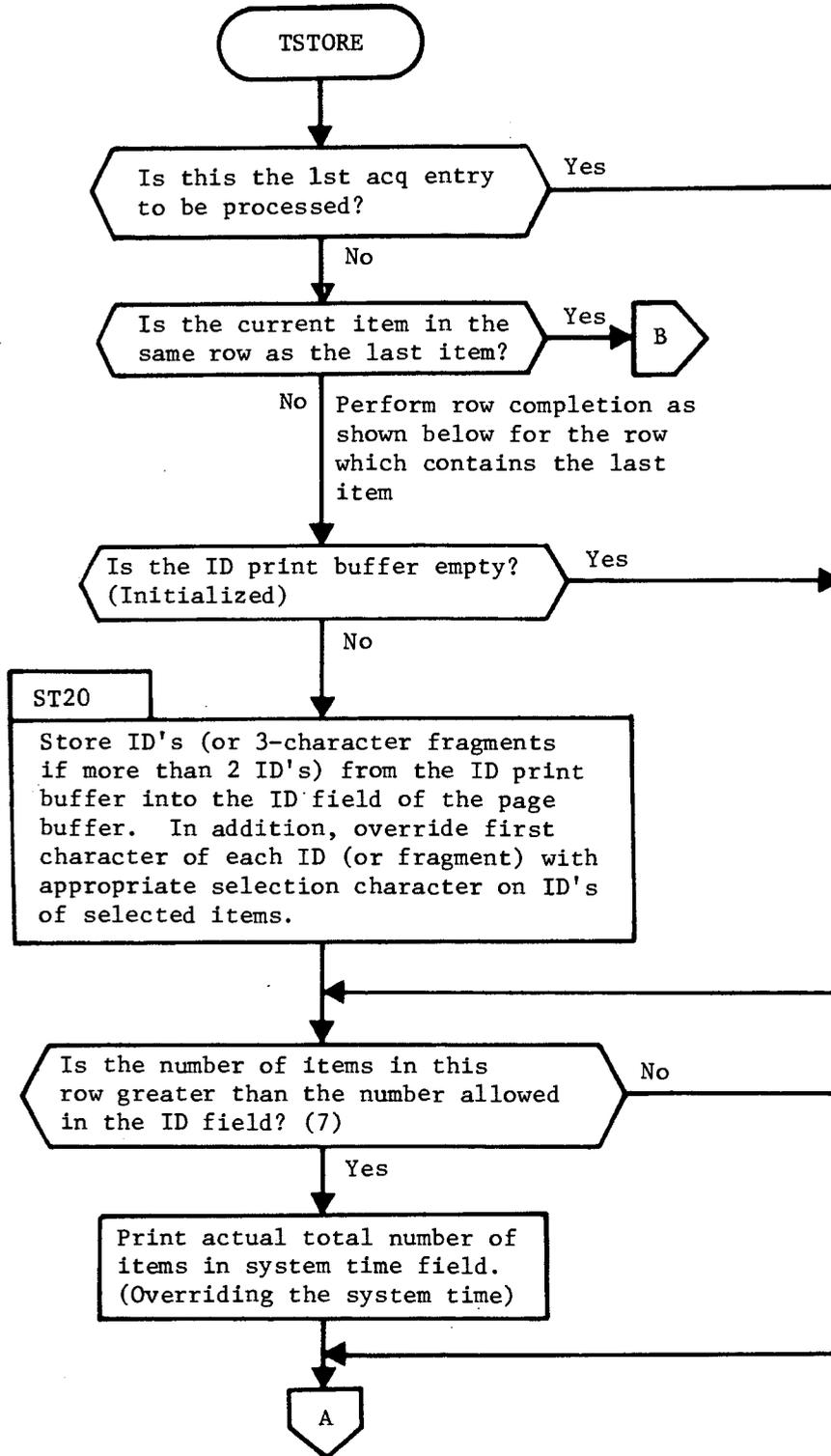


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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TSTORE

T'SOTRE

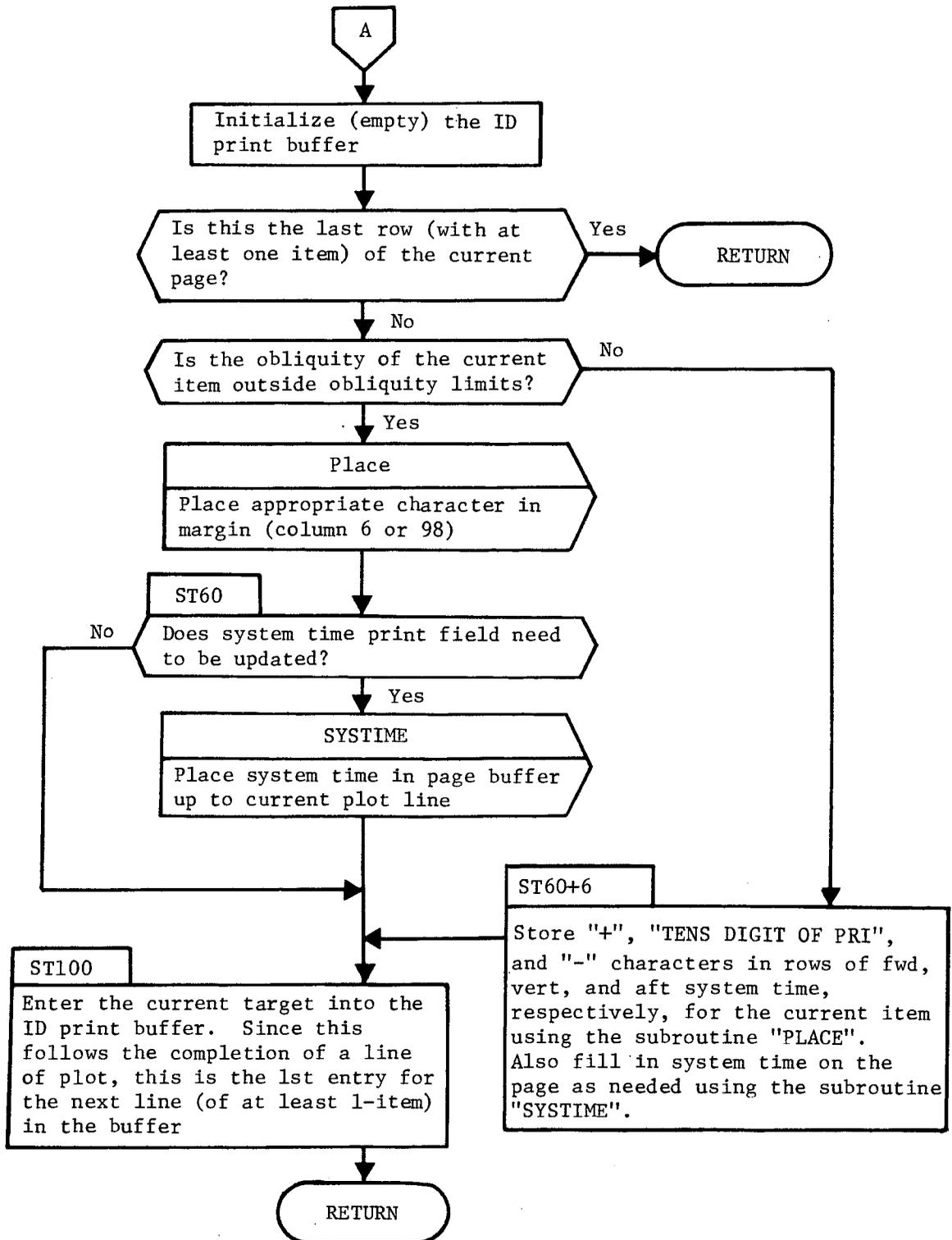


Figure 3-20. TWPLOTI Flow Chart (Continued)

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TSTORE

TSTORE

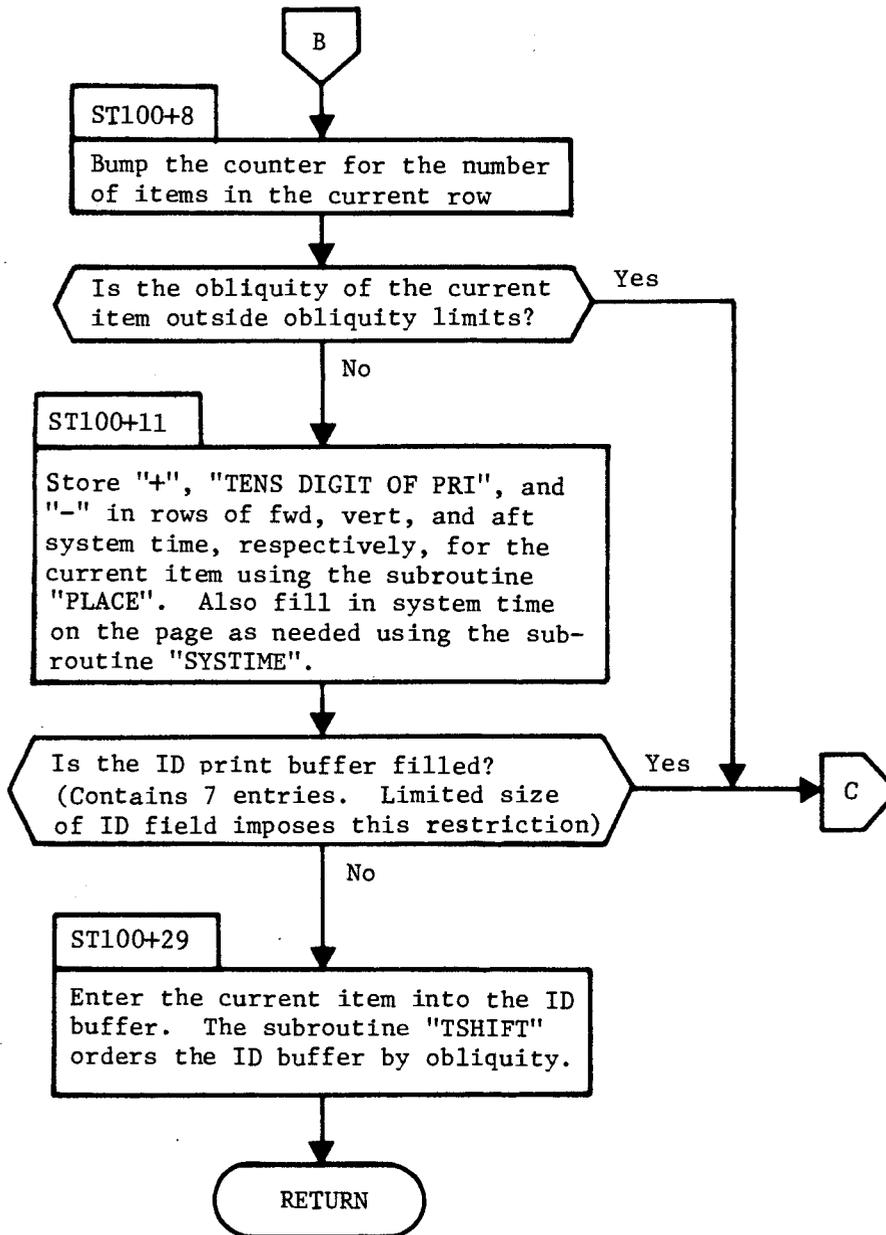


Figure 3-20. TWPLOTT1 Flow Chart (Continued)

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TSTORE

TSTORE

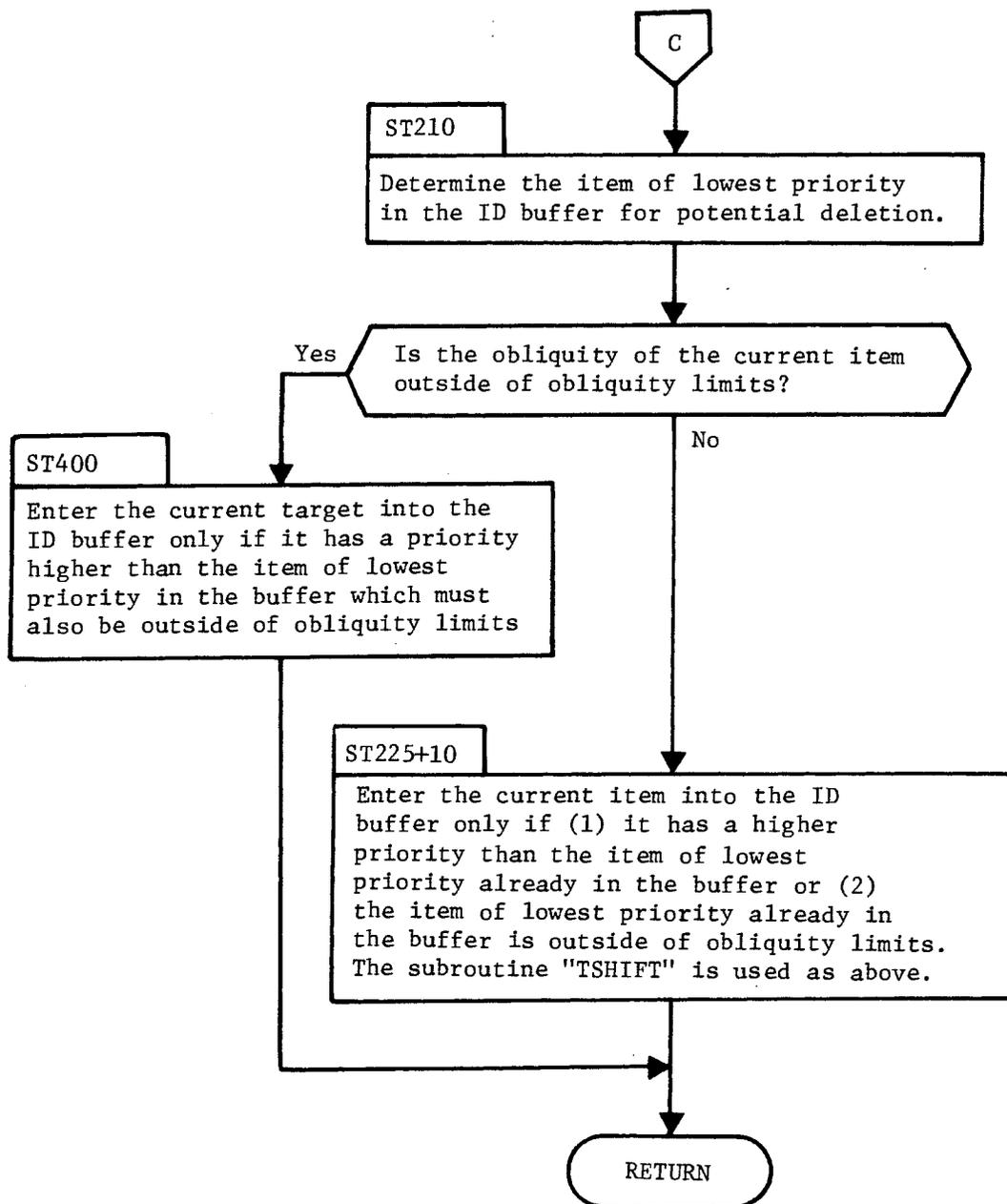


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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PLACE

PLACE

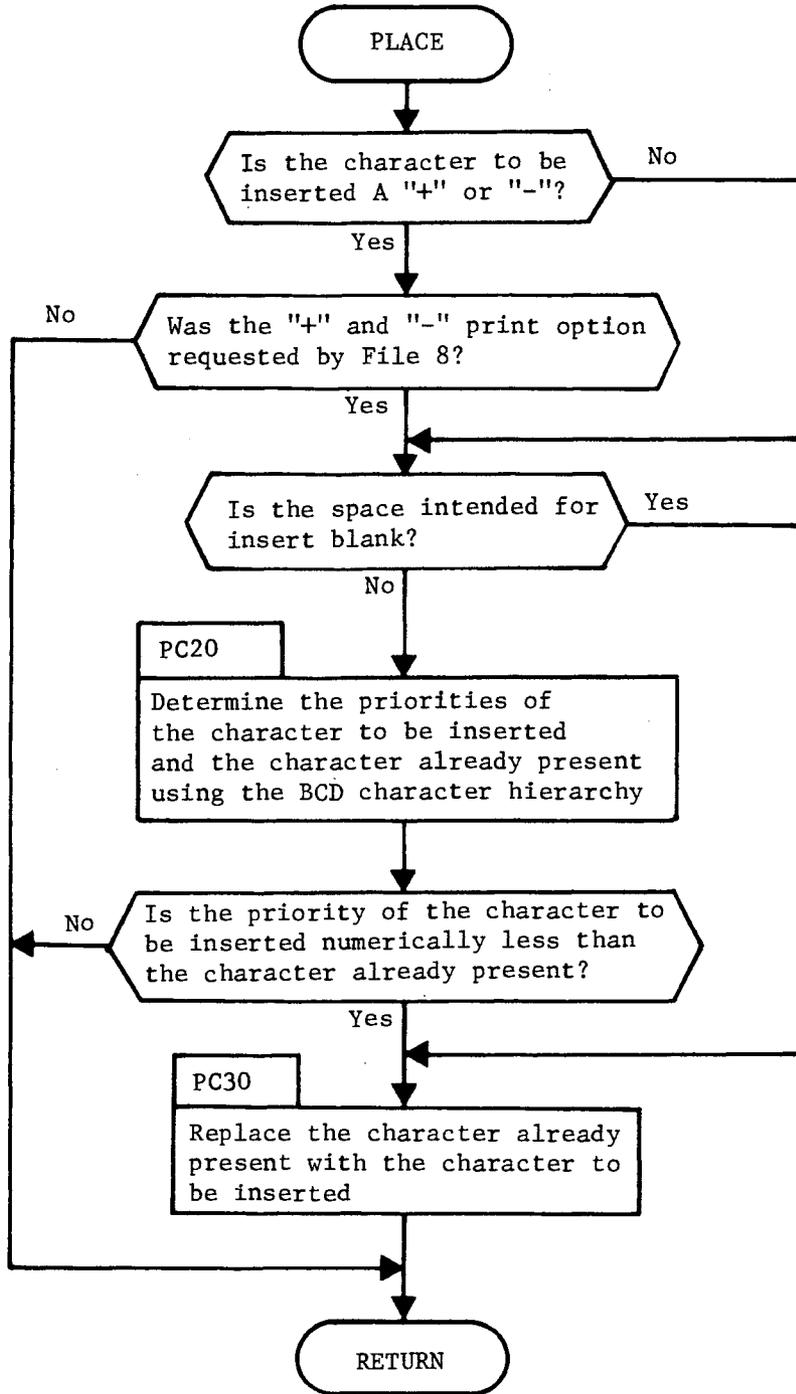


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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PGEWRITE

PGEWRITE

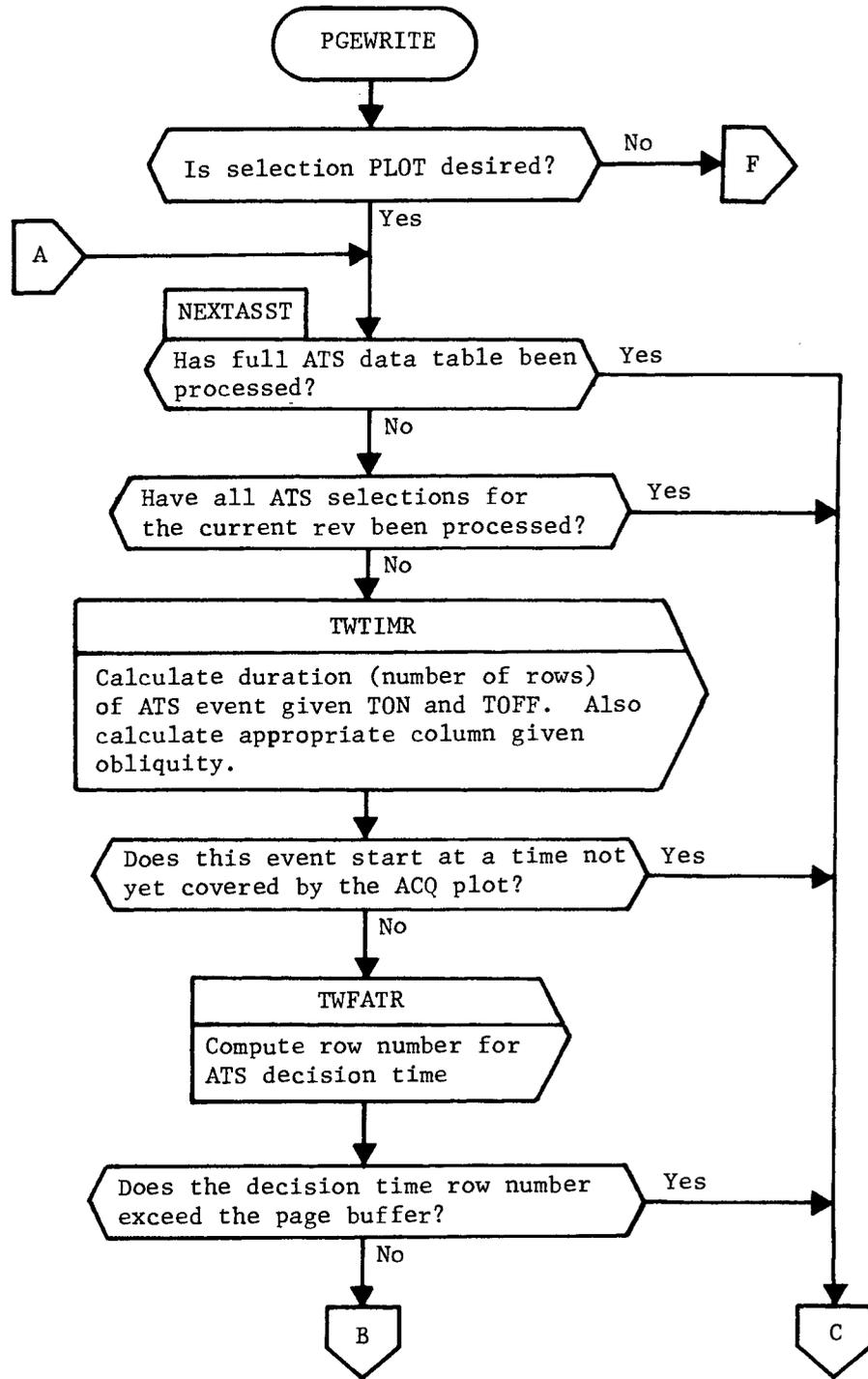


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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PGEWRITE

PGEWRITE

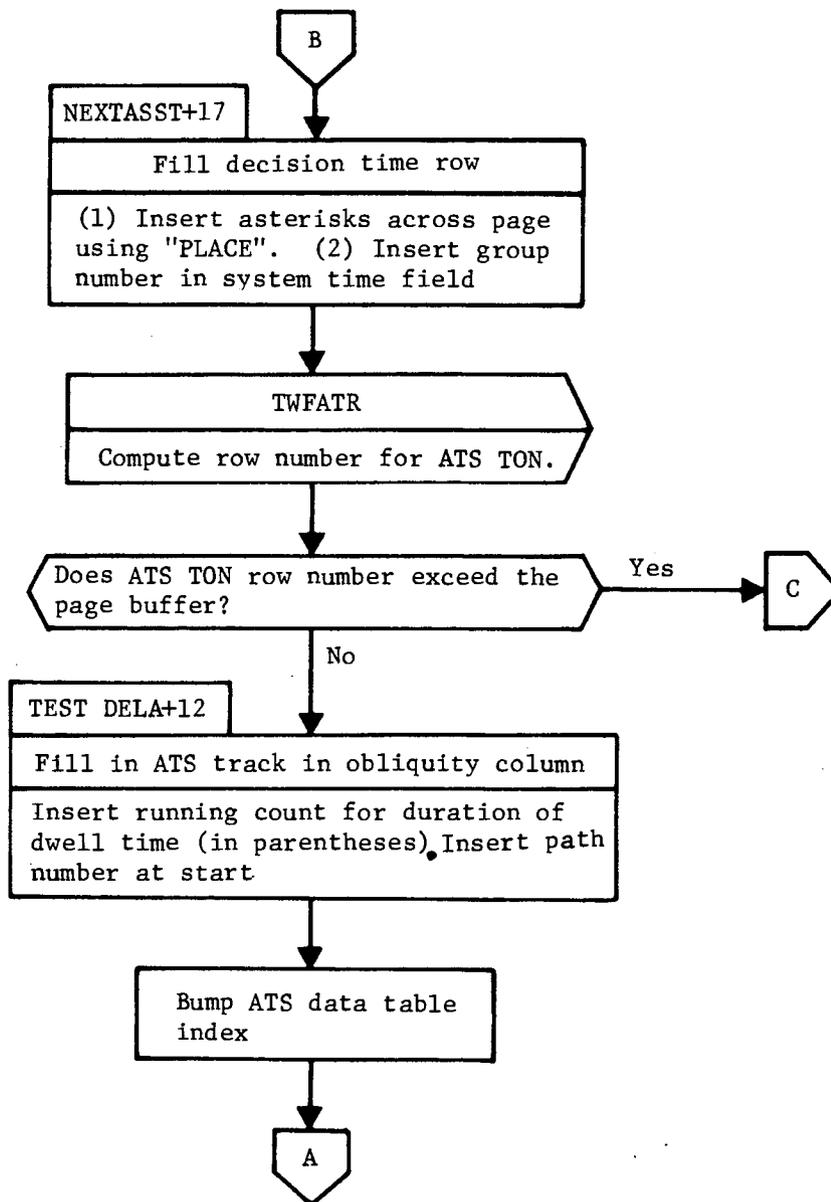


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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PGEWRITE

PGEWRITE

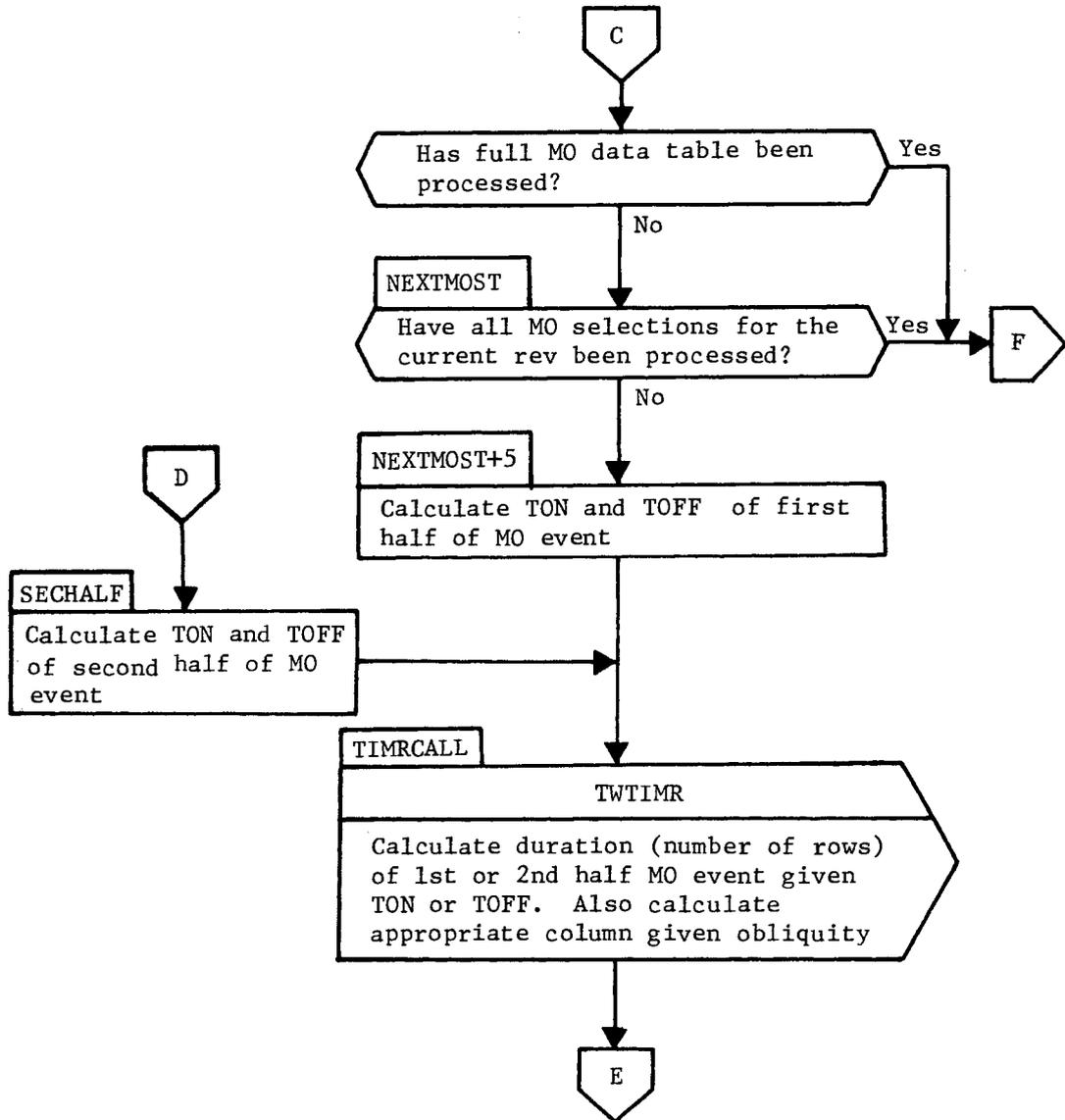


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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PGEWRITE

PGEWRITE

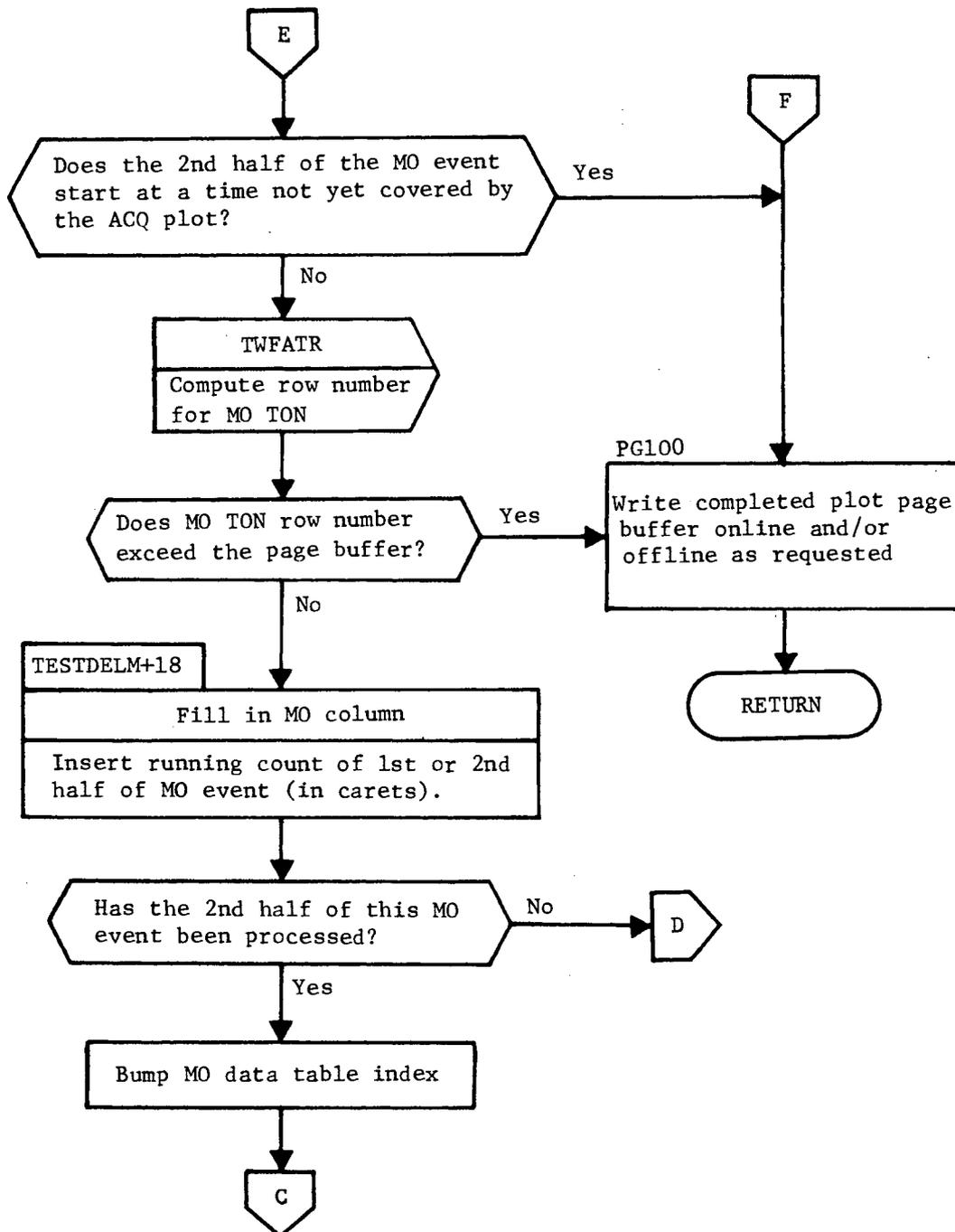


Figure 3-20. TWPL0T1 Flow Chart (Continued)

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REFERENCES

1. "Users Manual for TWONDER (Revised)," DM 38-0071, 24 June 1968.
2. "Study Results Report," DM 36-0067, 1 December 1967.

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