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LANDSAT-D FLIGHT SEGMENT OPERATIONS MANUAL

APPENDIX B
OBC SOFTWARE OPERATIONS

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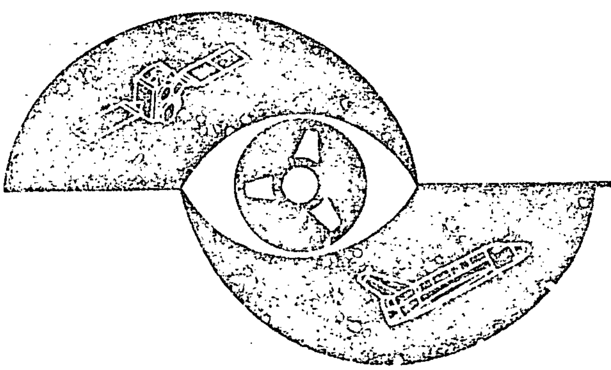

SPACE SYSTEMS DIVISION

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Appendix B
31 December 1981

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LANDSAT-D
FLIGHT SEGMENT
OPERATIONS MANUAL

APPENDIX B

OBC SOFTWARE OPERATIONS

Prepared for
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Appendix B
31 December 1981

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B.1 INTRODUCTION

B.1 INTRODUCTION

The operation and control of Landsat-D is highly dependent on the operation of the spacecraft On Board Computer (OBC). Landsat-D contains two NASA Standard Spacecraft Computers (NSSC-1) and 65536 words of memory. A hardware and interface description of the OBC and memory is provided in Section 6.0 of Volume I of this manual. Appendix B provides a description of the OBC software. This description is based on:

1. SVS-9953 Landsat-D Flight Software Requirements Specification, Revision A, dated March 1, 1981

2. SVS-10130 Landsat-D Flight Software Computer Program Design Specification, data August 1981

3. S-700-56 MMS OBC Flight Executive Technical Description, Revision B, dated February 1980

The OBC software is divided into two areas, the Flight Executive and the Applications processors. The Flight Executive controls the timing and execution of all the OBC software and calls upon the applications processors for specific software tasks. There are 23 applications processors that perform various spacecraft functions. Both the applications processors and the flight executive use one or more of 67 system tables to obtain variables, constants and software flags. Output from the software for monitoring operation is via 49 OBC Telemetry Reports subcommutated in the spacecraft telemetry.

B.2 PURPOSE

B.2 PURPOSE

B.2 PURPOSE

The purpose of this appendix is to:

1. Provide an operational description of the Landsat-D Flight Segment Software.

2. Provide the basis for monitoring and control of the OBC.

3. Present detailed flow diagrams of the software showing System Table input and Telemetry output.

4. Provide a means of understanding the interactions of the -Systems Tables and the various processors in all software modes of operations.

5. Show the origin of telemetry points presented in the OBC telemetry.

In general, this appendix is to provide information about the flight software as it is used to control the various spacecraft oeprations and interpret the operational OBC Telemetry. For detailed Program Design Listing see SVS-10130 Landsat-D Flight Segment Software Computer Program Design Specification.

B.3.0 GENERAL DESCRIPTION

Section B.3.X.X of this appendix is divided into 24 subsections (the X below) each dealing with a particular processor of the software. These are further divided to provide:

B.3.X.1 Processor Function Description
B.3.X.2 Processor Operation
B.3.X.3 Software Constraints
B.3.X.4 Processor System Tables
B.3.X.5 Processor Telemetry
B.3.X.6 Procesor Flow Charts

The System Tables of Sections B.3.X.4 are formatted as follows:

ENTRY	Position in Table Offset from Table starting point
NAME	Identification as given by software
TLM	* Denotes parameter is available in OBC Telemetry
TYPE	C = Constant, V = Variable, F = Flag
USING SUBROUTINE	Software processor/subroutine that uses parameter

B.3 SOFTWARE PROCESSOR DESCRIPTION

B.3.0 GENERAL DESCRIPTION

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- B.3.X.1 Processor Function Description
- B.3.X.2 Processor Operation
- B.3.X.3 Software Constraints
- B.3.X.4 Processor System Tables
- B.3.X.5 Processor Telemetry
- B.3.X.6 Processor Flow Charts

The System Tables of Sections B.3.X.4 are formatted as follows:

ENTRY	Position in Table Offset from Table starting point
NAME	Identification as given by software
TLM	* Denotes parameter is available in OBC Telemetry
TYPE	C = Constant, V = Variable, F = Flag
USING SUBROUTINE	Software processor/subroutine that uses parameter

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DESCRIPTION	Describes Item; provides other information to describe parameter

The Telemetry of Sections B.3.X.5 is formatted as follows:

ENTRY NUMBER	Location of TLM point in Report Word # = Entry # + 1
NAME	As designated by software
GENERATING SUBROUTINE	Processor subroutine which calculates or sets software telemetry point
DESCRIPTION/COMMENT	Explains telemetry point and provides other details of TLM points use and meaning

In the Flow Charts of Section B.3.X.6 a coding is provided to identify System Table entries and TLM points. This coding which underscores the particular parameters is as follows:

- - -	TELEMETRY POINT
....	SYSTEM TABLE ENTRY
———	TELEMETRY POINT & SYSTEM TABLE ENTRY

B.3.1 FLIGHT EXECUTIVE (FLTEXEC)

B.3.1 FLIGHT EXECUTIVE (FLTEXEC)

B.3.1.1 Flight Executive (FLTEXEC) Processor Description

The MMS Flight Executive includes several processors and other related decks in addition to the Flight Executive Proper. The total system consists of the following decks:

FLTEXEC
XREQ
UNIQUE
SCMDBUF
STCMDS
CDHTST
PROCESSORS
COMMON

The logical parts of the executive are discussed separately in the subsections which follow.

B.3.1.1.1 Flight Executive Proper

The MMS Flight Executive consists mainly of interrupt handlers - one section for each allowable interrupt. In addition, there is section BUFFER, which contains various storage areas whose absolute addresses must be known on the ground; section PRCTL, which contains routines for starting, restarting, and terminating processors and checking for processors requested for execution; section SUBRTN, which contains subroutines used by several other decks; and section ERROR, which reports any illegal interrupts which may occur. These sections are combined into a single deck, FLTEXEC, except for the interrupt handler for interrupts 12 and 8, which forms a separate deck, XREQ. Finally, there is a deck UNIQUE, which contains all the coding which may need to be changed in making mission-unique modification to the system.

The interrupt handlers are the following:

Interrupt 0--INIT
Interrupt 5--CLOCK
Interrupt 6--TMSYNC
Interrupt 9--REMOTE
Interrupt 11-DUMPEND
Interrupt 12 and 8--XREQ
Interrupt 15--WRERROR
EXIT Interrupt--SVC

In general, symbols (labels) begin with the initial letter of the section in which they are defined. There are a few exceptions; the symbols INTRPTn and

CSDEVn (the interrupt areas at the start of the fixed bank and the cycle-steal areas at the end of the fixed bank) are defined in section BUFFER. Symbols in section SUBRTN begin with the letter J, and symbols in deck COMMON begin with the letter Q, except for the Data Reference Table, DATAREF, and the labels (names of data items) attached to entries within it. No conventions are followed with the latter, and no conventions apply to decks SCMDBUF, STCMDS, CDHTST, and PROCESSORS.

Interrupt 5, CLOCK, the 16-millisecond clock interrupt, is the main driver for the OBC, It controls and schedules all periodic activities (except telemetry). Other interrupts occur more or less asynchronously, and perform their functions without reference to other OBC activities.

In the Flight Executive proper, constants and storage areas are generally defined at the end of the section which uses them, and their symbols begin with the initial letter of the section name. Data areas which may need to be changed in making mission-unique modifications to the system are grouped into deck UNIQUE, however, and their symobls begin with the letter U.

The data areas for the Flight Executive proper occupy the fixed bank of the OBC, which is reserved for this use. To implement this, all decks of the Flight Executive (FLTEXEC, XREQ, and UNIQUE) assign an absolute origin to location counter C. In deck FLTEXEC there are several AORG directives, all in section BUFFER. In decks XREQ and UNIQUE the AORG directives immediately follow the title lines at the start of the deck. If the data areas become too large to fit in the fixed bank, the telemetry buffers (in section BUFFER of deck FLTXEC) can be moved to another bank.

Location counter 1, under which instructions are assembled, is relocatable in all decks. This allows all the instructions in a complete OBC memory load to occupy a contiguous block of core, with the Flight Executive at the start, so that memory checking can be carried out properly.

B.3.1.1.2 Stored Command Buffers

Deck SCMDBUF contains the stored command buffers used by the Absolute and Relative Time Command Processors and by the C&DH Test Processor. In release 4, the buffers as assembled contain test data to reduce the need for memory loads. There are several sets of commands for testing the Absolute Time Command Processor and some predefined blocks of commands and relative time sequences to be used with them. There is also a set of commands which can be used with the C&DH Test Processor to send commands continuously at maximum hardware speed. A number of procs are provided to simplify the job of setting up additional test data as needed. Details can be found in the program listing.

The stored command buffers are assigned absolute addresses so that they can be placed on bank boundaries. Only the first AORG needs to be changed to move the buffers to a different bank - all other AORGs are relative to the first (which sets the origin SCMDBUF1). The sizes of the buffers can be changed by changing the EQUs which define certain symbols. SCMDLEN controls the length of the main buffer, giving the number of commands (not words) the buffer will hold. SPREBUFL specifies the number of predefined blocks for which space will be reserved; the number of words reserved will be 32 times this number. The size of the buffer for relative time sequences is defined by a simple RES directive, following the directive which defines the symbol for the buffer, RTSBUF. In release 4 of the Flight Executive, this RES has been coded to use all of bank 1 which is not used for other stored command buffers. If the length of the other buffers is changed, the size of RTSBUF will be automatically adjusted to correspond. If the stored command buffers are moved to a bank other than bank 1, however, this RES directive must also be changed.

B.3.1.1.3 System Processors

Seven system processors are included in the Flight Executive. The processors are as follows:

ATCP
RTCP
CDHTST
MEMCK
MONTOR
CMDTST
FAILCK
MEMTST

ATCP (the Absolute Time Command Processor) and RTCP (the Relative Time Command Processor) are combined into a single deck, STCMDS. These processors together provide the main MMS stored command processing capability. CDHTST is the C&D Test Processor and forms a deck by itself, because it will not be included in the flight system. The remaining processors are combined into a single deck, PROCESSORS. MEMCK performs the memory check described in Section B.3.21. MONTOR monitors up to 20 words of memory and transmits their contents to the ground through the OBC contribution to telemetry as described in Section B.3.22. CMDTST checks the spacecraft command hardware as described in Section B.3.20. FAILCK sends the failure detection signal as described in Section B.3.14. MEMTST can be used to test the memory hardware for one or more banks by storing and reading worst case bit patterns in each word.

B.3.1.1.4 Deck Common

Deck COMMON contains the COMMON area for communication among processors. It also has the status buffer, parameter tables for processors (which can be loaded from the ground and are included in the COMMON area), and the Data Reference Table (DATAREF) used in getting data from telemetry or getting computer data.

The deck also defines the end of the memory area occupied by instructions, which processor MEMCK uses in setting up the boundaries of the area it checks. Deck COMMON must therefore be the last deck in the loader run which creates the core image for the OBC.

B.3.1.2 Flight Executive (FLTEXEC) Processor Operation

See MMS OBC Flight Executive Technical Description S-700-56 Rev. B for operation details.

B.3.1.3 Flight Executive (FLTEXEC) Software Constraints

See MMS OBC Flight Executive Technical Description S-700-56 Rev. B for software constraints.

B.3.1.4 Flight Executive (FLTEXEC) System Tables

Table #0 - UCDADDR - List of Addresses for Getting Computer Data.

List of 16 bit address words, one word for each 8 bit of computer data wanted by OBC. Addresses are sent in bursts of cycle-steal I/O (DMA) at intervals controlled by Executive Scheduler Table, #2. The following format of address words is used:

18 16 12	11 10	9 1
RIU #	Data Type	Channel # (out of RIU)

Data Type:
0=conditioned analog
1=serial digital
2=active analog
3=bilevel

Table #1 - UCADDRNO - Number of Addresses to be Sent for Getting Computer Data

One word entry which specifies the number of addresses to be sent for getting computer data.

Table #2 - USCHED - Scheduler Table

This table schedules the periodic flight executives activities. It is processed by the clock interrupt (interrupt #5) which occurs every 16 msecs. On each interrupt the executive examines the table entry to determine what action should be taken. After the entry is processed, the table pointer is incremented. When the end of the table is reached, the pointer returns to the start and long period processing is performed (Table #3). The length of the table is 64 entries, therefore, one cycle through the table is 1.024 sec (i.e. 64 x 16 msec).

Each table entry consists of one 18 bit word with the following format:

18	17	16	1
0	1/0	Specification of Action	

Specification of Action:

- =0 no action
- ≤15 executive snap action whose number is given
- ≥16 request execution of an application processor (the number here is the relative location of the PCT for the processor)

Bit 17:

- =1 get a burst of computer data

Table #3 - ULPROC - Table of Long-Period Application Processors

Processors that require execution periods longer than the 1.024s provided by table USCHED are scheduled by using the long-period processing table. The execution intervals must be multiples of the length of table USCHED.

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Each table entry consists of 4 words:

	Bits 18 — 1
Word #1	Counter
#2	# USCHED Cycles Before Long-Period Processor Called
#3	Initial Count
#4	Processor Control Table Number

Table #4 - USNAPTBL - Table of Snap Actions

Snap actions are relatively short processors that are executed within the 16 ms clock interrupt routine and will delay whatever other processor is going on. The normal starting and terminating time of a processor (500 - 550 msec) is not required when using snap actions. The relative location of each snap action in this table is inserted in Table USCHED, #2. A maximum of 15 snap actions can be defined and location 0 must not be used.

Table #5 - ULPSNAP - Table of Long Period SNAP ACTIONS

Long period snap actions are scheduled in the same way as long-period processors and are controlled by this table. The format of each table entry is identical to that used for long-period processors, except that the last word of each entry gives the absolute address of the snap action.

Table #6 - UTRPLOC - Table of Buffer Locations for Reports in the OBC Contribution to Telemetry

The OBC can contribute up to a maximum of 26 words to each minor frame of telemetry. The first word (word 35 of the minor frame) gives the report number, and the remaining words give the data being reported. The first word is sent directly by the frame sync interrupt, while the remaining words go by means of a cycle-steal operation, initiated by the frame sync interrupt. Each processor stores data in a buffer in its own data area. The frame interrupt moves this data from the processors buffer to the buffer from which it will be transmitted. The address of the data in the processor's buffer is contained in this table, Ø6.

Table Ø7 - UTRPTIDS - Table to Control the Cycle of Reports in the OBC Contribution to Telemetry

This table gives the cycle of reports to be sent out in the telemetry stream. Each entry word gives the report Ø to be sent down in telemetry word Ø35.

Table Ø10 - UPCT - Table of Processor Control Table

The flight executive controls the execution of the processors through the use of Processor Control Tables (PCT). Each processor has its own PCT which is used to start or restart the processor. The order of the PCT's stored in the OBC memory determines the IDØ assigned to each processor.

The format of each PCT consists of 16 words, 18 bits long:

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Table B.3.1-1. Processor Control Table Format

1=system initialized since last execution (bit 1)
1=initialize on next new start (bit 2)
1=inhibited from sending commands (bit 3)
1=execution interrupted; restart next time (bit 4)

Word	18	17	16–9	8	7	6	5	4	3	2	1
0	1/0		COUNTER					1/0	1/0	1/0	1/0
1	WORD IN WHICH REQUEST BIT IS LOCATED										
2	MASK TO TURN ON REQUEST BIT										
3	0	MAX RESTARTS		0	0	0	0	0	0	0	0
4	SAVE ACC										
5	SAVE EA										
6	SAVE X										
7	LSR MASK TO RESTART										
8	PAGE, D, OV, AND C REGISTERS TO RESTART										
9	STORAGE LIMITS REGISTER TO RESTART										
10	RESTART ADDRESS										
11	UNASSIGNED										
12	LSR MASK FOR NEW START										
13	PAGE, D, OV, AND C REGISTERS FOR NEW START										
14	STORAGE LIMITS REGISTER FOR NEW START										
15	ENTRY ADDRESS FOR NEW START										

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Table #11 - Processor Priority Table

The relative priority of each processor is specified by its location in this table. The lower the entry number in the table, the higher the priority. Each processor has a single entry in UPPT which gives the location of the PCT in Table #10.

Each time a processor is requested during the 16 ms interrupt, its priority is compared to that of the processor currently executing. If the latter is lower in priority, it is cut off and the information needed for restart is stored in UPCT. After the newly started processor is executed, the previous processor is resumed as long as there is no higher priority processor waiting to be executed.

Table #12 - DATAREF - Data Reference Table

This table contains a list of data which processors can retrieve by name using library procs (macros). The table contains one entry for each data item referenced by any processor:

```
18   8                              1
+-------------------------------------+
|       Address of Data Item          |
+-------------------------------------+
         |
         |____data item may be: 1. minor frame telemetry data
                                2. subcom data
                                3. data obtained directly by computer
```

The table must be changed when the addresses of the data items change; i.e. may change when telemetry format is changed.

Table #13 - QMEMCK - Parameters for Processor MEMCK

Details of this table are in Section B.3.21.

Table #14 - QLIMITS - Limits for Memory to be Checked by MEMCK

Details of this table are in Section B.3.21.

Table #15 - QMONITOR - List of Memory Locations to be Monitored by Processor MONTOR

This processor will monitor a maximum of 18 words of memory and report their contents through the OBC contribution to telemetry, report #40-42. The addresses of the words to be monitored are listed in this table. See Section B.3.14.

Table #16 - FAILCMDS - List of Failure Detection Signal Cmds to be Sent by Processor FAILCK

Processor FAILCK periodically sends pulse commands (if QOKSW=0) to several parts of MMS hardware to prove it is functioning.

Each command must be received at 1.024s $\pm$100 ms intervals but there is no requirement as to the relative timing of different commands sent to different parts of the hardware. One command is sent from this table each time the processor FAILCK is executed. FAILCK must, therefore, be executed several times during the 1.024s interval in order to send all the commands in the table. At present the processor sends 3 commands, one to each of the 3 major hardware modules: Command and Data Handling, Attitude Control System, and Power. See Section B.3.14.

Table #17 - FLCMDEND - End of Table Test for Sending Failure Detection Signals

If the number of commands in Table #16 is changed in orbit, the 1 word entry in Table #17 must be loaded with a value equal to 2 less than twice the number of cmds. See Section B.3.14.

Table #18 - QOKSW - Hardware Failure Switch

This table consists of 1 entry whose value is set to 1 by the processors CMDTST and MEMCK when they find errors and is initialized to 0 by section INIT in deck FLTEXEC. When QOKSW=1, processor FAILCK will stop sending the failure detection signal.

Table #19 - QSCMD - Parameter for C&DH Test Processor

Not used after launch

Table #20 - QCMDINHL - List Used to Selectively Inhibit Sending of Absolute Timed Cmds

The Absolute Time Command Processor sends commands from the stored command buffer when the 18 low order bits of the time tag equal the 18 low order bits of the OBC clock. In the 9 high-order bits of the time tag, bits 22-25 can be used to inhibit sending a command if certain unpredictable conditions exist at the time the command is scheduled to be sent. Bits 22-25 of the time tag are used as an index to pick up a word listed in Table #20. If this word=0, then sending of the command is inhibited.

Table #21 - TMPARAM - Check TLM Input

The flight executive will check telemetry as it is read in to ensure its accuracy. Checking is done during the frame sync interrupt and is controlled by 5 parameters listed in this table.

Entry #1	TMWORD	= 0, check will be skipped = 1-127, word # of telemetry to be checked
#2	TMMASK	- mask to be applied to telemetry word
#3	TMVALUE	- value which should equal the masked word
#4	TMBUB	= 0, erroneous frames won't be stored < 0, address of a set of 128 word buffers where bad frames are to be stored
#5	TMBUFNO	- number of buffers in the set

Table ∅22 - MEMBANKS - List of Banks to be Tested

The processor MEMTST can be used to test memory hardware for one or more logical banks of 4096 words by storing and reading a set of 72 worst case bit patterns in each word. This list of banks to be tested is found in Table ∅22.

Table ∅23 - MEMBANKL - Number of Banks in List

1 word entry giving the number of banks to be tested by MEMTST.

B.3.2 GYRO DATA (GYROD)

B.3.2 GYROD

B.3.2 GYRO DATA (GYROD)

B.3.2.1 Gyro Data (GYROD) Processor Description

The Gyro Data Acquisition Module (GYROD) is a priority level 1 task scheduled for execution every 64 ms by the flight executive. GYROD has a processor number of 1. The input gyro data used by GYROD is contained in the computer data buffer. The objective is to process the gyro data and output actuator control commands in a minimum time. This objective is achieved by scheduling GYROD on the Executive Select Table (EST) entry immediately following the acquisition of computer data. Therefore, the GYROD EST entries are 2, 6, 10, 14, etc.

During its 4 msec execution time, GYROD performs functions related to the acquisition and processing of gyro data. These functions include accessing the raw gyro data and formatting it for numerical processing; prefiltering the gyro data to remove the effects of high frequency vehicle motion; and outputting the raw gyro data to the Payload Correction Data (PCD) formatter. The subroutines that comprise GYROD are:

1. GYROCNTRL - GYROD Control Component
2. GYROFMT - Gyro Data Formatter
3. GYROFLTR - Gyro Data Prefilter
4. GYROPCD - Gyro Payload Correction Data Processing

B.3.2.2 Gyro Data (GYROD) Processor Operation

B.3.2.2.1 GYROCNTRL

The GYROD control component sequences the processing of the gyro data. It calls the GYROFMT and GYROFLTR subroutines. GYROD also calls subroutine GYROPCD if the system table entry GPCDFLG equals 1. This entry value indicates that the spacecraft is in ACS mode 4 with the Thematic Mapper (TM) on. A software flowchart of the overall GYROD processor is shown in Section B.3.2.6.

B.3.2.2.2 GYROFMT

GYROFMT samples the raw gyro data from both channels of each of the 3 gyros every 64 ms. Each channel generates a 24-bit word. Every word is read into the OBC in 3 8-bit bytes and reformatted into 2 18-bit words. An example of a 24-bit word, obtained from 1 channel of 1 axis, that has been reformatted appears below:

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bit 18	11	10	3	2	1
Sign of most significant bits of X gyro Channel #1		8 middle bits of X gyro		1	8

18	12	11	1
8 least significant bits of X gyro	1	not used	

B.3.2.2.3 GYROFLTR

GYROFLTR detects and compensates for the effects of gyro data word overflow. If 2 conditions are met, it will also filter the data to remove the effect of vehicle angular motion outside the normal control loop bandwidth. These conditions are: the prefilter must not be disabled by the system table flag FLTROFF and, the spacecraft not be in orbit adjust mode 7. Only one of the redundant data channels of each gyro is filtered.

B.3.2.2.4 GYROPCD

GYROPCD formats the raw gyro data into two serial magnitude command buffers, PCDH%BUF and PCDL%BOF, and then requests the flight executive to issue them to the PCD formatter. These commands will be issued by the flight executive 10 msec after the GYROD interrupt (i.e. EST entries 2,6,10,14,etc.). The data consists of 3 8-bit words obtained from each gyro channel in use. (That is a total of 9 gyro 8-bit words.) Since a serial magnitude command consists of 16 bits, 5 serial magnitude commands are required. GYROPCD is enabled/disabled by the system table flag GPCDFLG. The ground sets this flag to 1 in order to enable GYROPCD only if the ACS is in mode 4 with the TM [illegible]

B.3.2.3 <u>Gyro Data (GYROD) Software Constraints</u>

1. The gyro prefilter is operational only when MODE=4 and ICAL=3. The ground must set the system table word FLTROFF to 1 or 0 to indicate whether or not the prefilter is to be enabled.

2. The GYROPCD subroutine is executed only when MODE=4 and the TM is ON. The ground must set the system table word GPCDFLG to 1 or 0 to indicate whether or not this routine is to be executed.

B.3.2.4 <u>Gyro Data (GYROD) System Tables</u>

GYROD uses the data items found in system table #24 called GYRODPAR. For system table load format see DFCB Volume III CMD.

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Entry	Name	TLM	Type	Using Subroutine	Description
GYROD System Table #24 - GYRODPAR					
0	GPCDFLG			GYROCNTRL	Payload correction data processing enable/disable flag. The raw gyro data is output to the PCD MUX only if MODE=4 and TM is on. 0 = disable GYROPCD subroutine 1 = enable GYROPCD subroutine
1	FLTROFF		F	GYROFLTR	Gyro Prefilter enable/disable flag. The prefilter is enabled only when MODE=4 and ICAL=3. 0 = disable prefilter 1 = enable prefilter
5	NGL		C	GYROFLTR	Gyro accumulator overflow test limit; value is 0100000.
6	GPA1		C	GYROFLTR	Gyro prefilter coefficient; value is 0320000.
7	NGSP1		C	GYROFLTR	Gyrod parameter equal to (NGS+1); value is 0.839E+07.
9	NGSK1		C	GYROFLTR	Gyrod parameter equal to (NGS+1)/(2*GPB1); value is 0.447E+08.
11	NGSK2		C	GYROFLTR	(NGS+1)/(2*GPB1**2); value is 0.477E+09.
13	NGSK3		C	GYROFLTR	-[NGS/(2*GPB1)]; value is -0.447E+08
15	NGSK4		C	GYROFLTR	-[NGS/(2*GPB1**2)]; value is -0.477E+09.

Entry	Name	TLM	Type	Using Subroutine	Description
17	NGSK5		C	GYROFLTR	1/(2*GPB1); value is 0.533E+01
19	NGSK6		C	GYROFLTR	1/(2*GPB1**2); value is 0.569E+02
21	NGSK7		C	GYROFLTR	GPB1*GPB1; value is 0.879E-02
23	NGSK8		C	GYROFLTR	-NGS; value is -0.839E+07
25	NGTEMP			GYROFLTR	Gyrod temporary storage locations

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B.3.2.5 Gyro Data (GYROD) Telemetry Reports

GRYOD can be monitored by OBC TLM Report #1 whose mnemonic is ASC01. The report occurs in TLM minor frames 8, 40, 72 and 104. The telemetered parameters appear in columns 109-126. Column 35 contains the report # (i.e. #1).

OBC TLM Report #1 - ACS01

ENTRY #	NAME	GENERATING SUBROUTINE	DESCRIPTION	
6	DNGX	GYROFLTR	(roll)	• Raw gyro difference data from GYROFLTR of the gyro data acquisition processor GYROD.
9	DNGY	GYROFLTR	(pitch)	• DNGX, Y, Z is not filtered or compensated for misalignment or bias errors
12	DNGZ	GYROFLTR	(yaw)	• The GYROD Processor is called each .064 sec and inputs the contents of the 6 ITP 24 bit gyro data registers and stores the data in NGX1, NGX2, NGY1, NGY2, NGZ2. DNGX, Y, Z are then the difference between successive readings of the selected channels: NGX1 or NGX2, NGY1 or NGY2, NGZ1 or NGZ2.
15	NGXF	GYROFLTR	(roll)	• Total gyro angular data input each 0.64 sec from the ITP. (The 3 selected channels only?
18	NGYF	GYROFLTR	(pitch)	• The data is filtered by the 2 stage filter of GYROFLTR unless: MODE = 7, or THRUST = 1, or MODE = 1, or THRUST = 0; but the data is not compensated for mis-alignment or bias errors.
21	NGZF	GYROFLTR	(yaw)	• NG (X,Y,Z)F are the product of GYROFLTR of the GYROD processor. (SCP) then inputs these data to calculate the gyro difference data. (GYDIF(I)=NG(I)F=NG(I)H, where NG(I)F is the past reading of NG(I)F and I = X,Y,Z. The SCP is called each .256 sec and if MODE = 4. The ACS is called each .512 sec under these conditions (GYOIF(I) is calculated every other calling of the SCP.

B.3.2.6 Gyro Data (GYROD) Flow Charts

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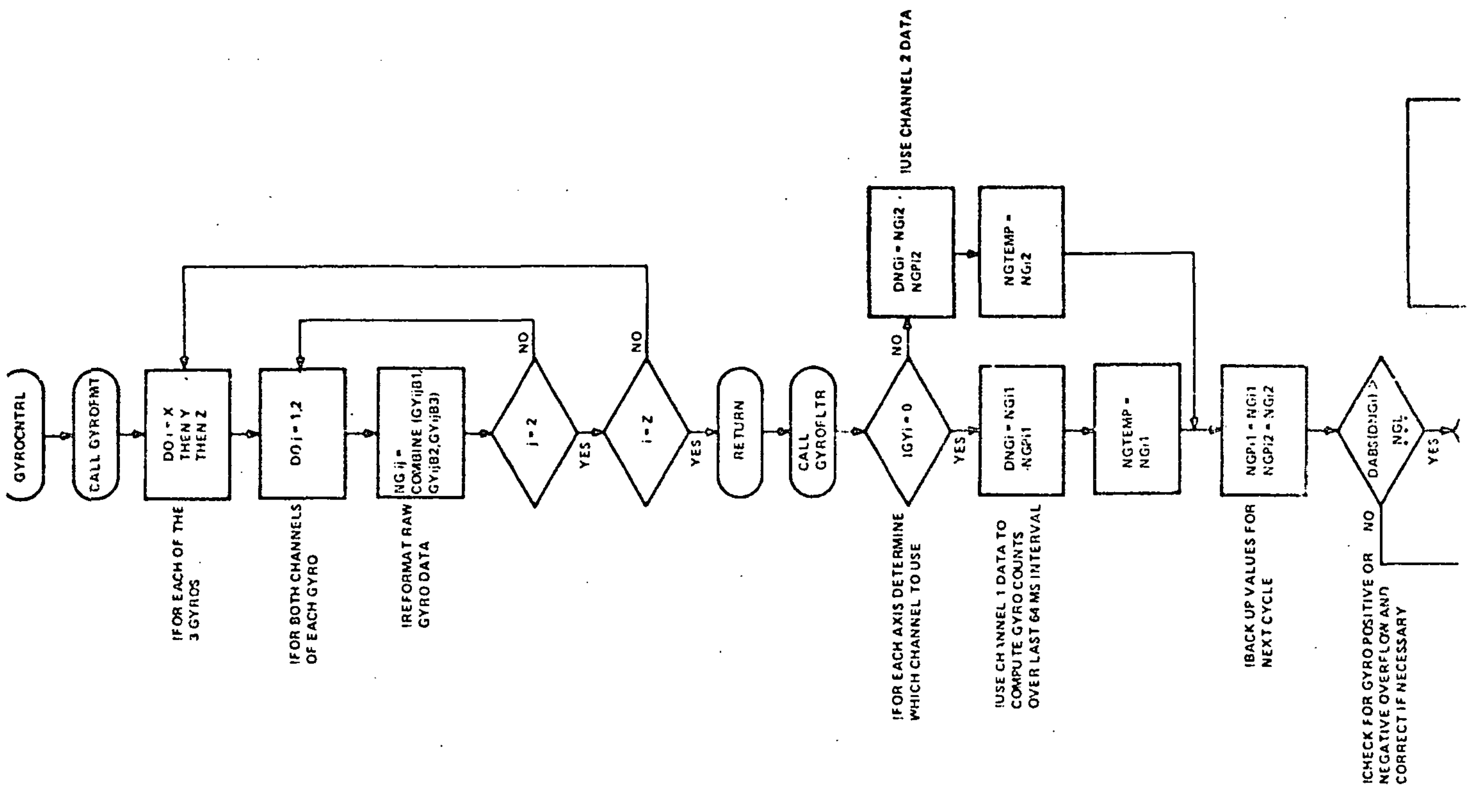

FOLDOUT FRAME

2 FOLDOUT FRAME

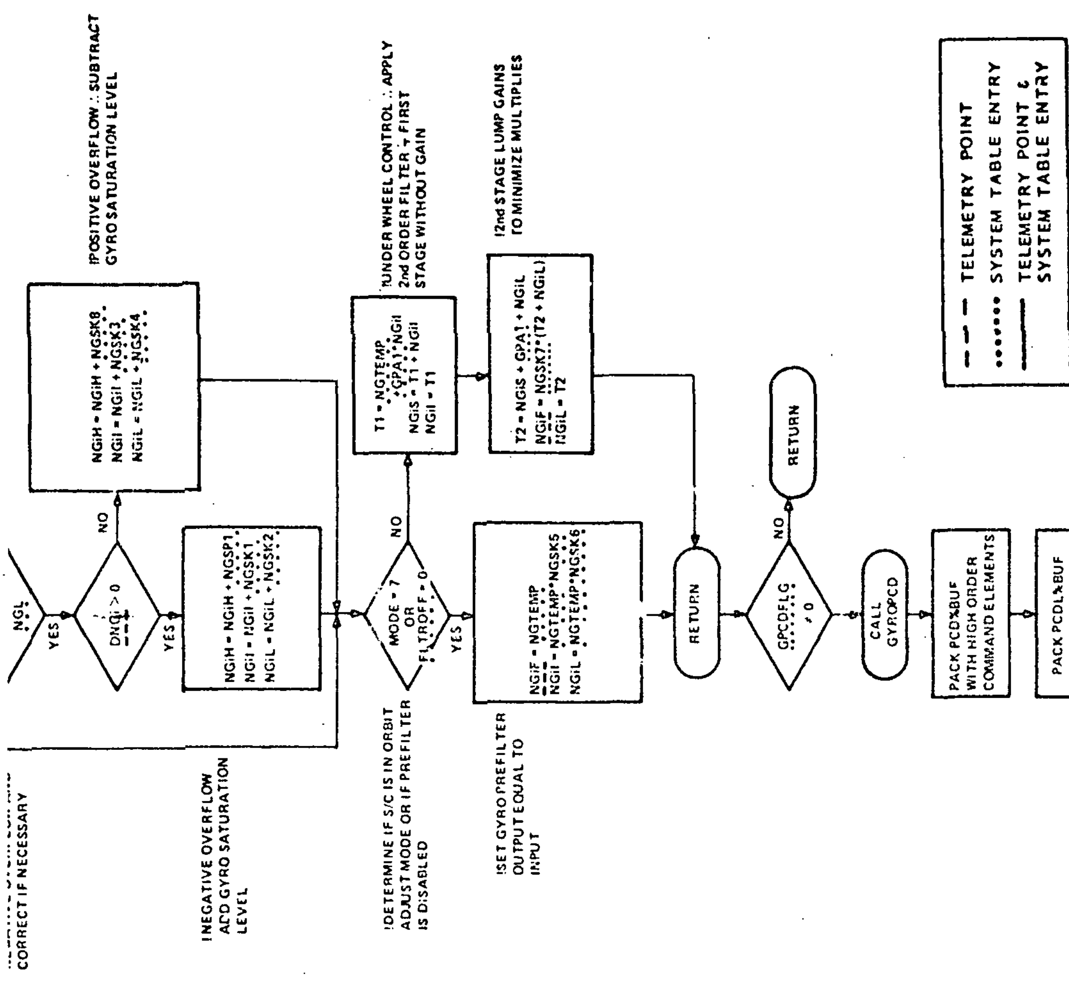

Figure B.3.2-1 GYROD Flow Chart

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B.3.3 SEPARATION DETECTION (SDTECT)

B.3.3 SEPARATION DETECTION (SDTECT)

B.3.3.1 Separation Detection (SDTECT) Processor Description

The separation of the spacecraft from the Delta launch vehicle is detected by the routine SDTECT, flowcharted in Section B.3.3.6. The spacecraft is attached to the Delta by 3 bolts. After launch, the Delta explodes these bolts to free the spacecraft. The separation is sensed by 2 magnetic switches, A and B. SDTECT will activate the Gyro Prefilter and Spacecraft Control Processor when either switch is found closed. Once separation has been detected (both switches closed) on 3 consecutive execution cycles, SDTECT will activate the Solar Array Deploy Processor and deactivate itself. It will output this separation time in the SOLARD's TLM report. Prior to deactivation, SDTECT is executed once every 1.024 sec. It has a processor number and priority number of 5.

B.3.3.2 Separation Detection (SDTECT) Processor Operation

See Section B.3.3.6 for detailed processor operation.

B.3.3.3 Separation Detection (SDTECT) Software Constraints

None

B.3.3.4 Separation Detection (SDTECT) System Tables

None

B.3.3.5 Separation Detection (SDTECT) Telemetry Reports

The time at which spacecraft separation is detected for 3 consecutive times, SDSEPTME, is output in SOLARD's, TLM which has the mneumonic SDPLOY01. This telemetry appears in OBC TLM report #36, minor frame #1.

B.3.3.6 Separation Detection (SDTECT) Flow Charts

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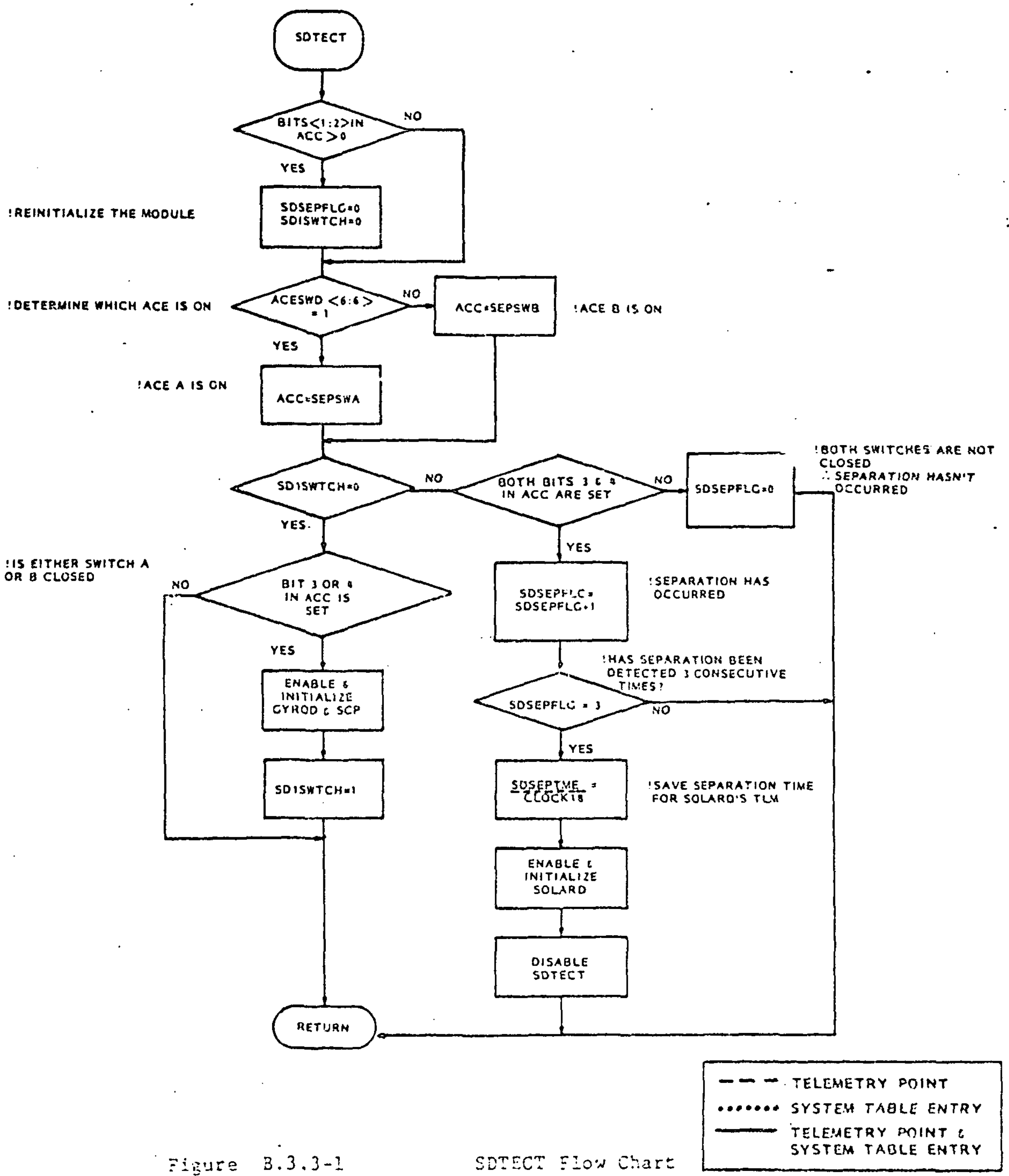

Figure B.3.3-1 SDTECT Flow Chart

B.3.4 SOLAR ARRAY DEPLOYMENT (SOLARD)

B.3.4 SOLAR ARRAY DEPLOYMENT (SOLARD)

B.3.4.1 Solar Array Deployment (SOLARD) Processor Description

SOLARD is activated by the Spacecraft Separation Detect Module SDTECT when it detects separation three consecutive times. It is then executed once every 5.12 sec before it is deactivated. SOLARD's processor number and priority are both 3.

The function of the Solar Array Deploy Module "SOLARD" is to deploy the Solar Array (SA) panel. SOLARD accomplishes this function by determining which side of the Spacecraft Condition and Control Unit (SC&CU) is on. Once the on side has been determined, the appropriate commands will be sent to the SC&CU to arm the deploy circuitry and pyro bus. Both sets of pyros will be fired. Commands will then be sent to safe the deploy circuitry and pyro bus. Commands will also be sent to the Power Distribution Unit (PDU) to configure the PDU and to extend (deploy) the SA panel. SOLARD will deactivate itself, once it has deployed the panel or when SOLARD is unable to complete an event in the deployment sequence.

SOLARD is comprised of the following 9 subroutines:

1. SOLARD - SOLARD Main Routine
2. SDSCCU - Configure SC&CU
3. SDARMCIR - Arm Deploy Circuitry and Pyros
4. SDFRPYRO - Fire Pyros
5. SDCONPDU - Configure the PDU
6. SDEPLOY - Deploy Solar Array
7. SDELAY - 100 Millisecond Delay
8. SDMRUB - Manipulate PDU Remote Unit Bits
9. PDUXSTRAP - Perform Cross-Strapping of PDU and RIU

B.3.4.2 Solar Array Deployment (SOLARD) Processor Operation

B.3.4.2.1 SOLARD

Once it is activated by SDTECT, SOLARD will be scheduled for execution every 1.024 sec. The flowchart shown in Section B.3.4.6 describes this routine. If it is requested, processing will commence with the initialization of the module and the recording of spacecraft separation time (SDSEPTME) in SOLARD's telemetry report. Otherwise, processing commences with the calling of the subroutine associated with the current value of SOLARD's function flag (SDFUNCT). SDFUNCT will not be altered by the subroutine if it the subroutine has more processing to perform. SDFUNCT will be incremented by one if the subroutine successfully performs its function. SDFUNCT will be set to five by SDEPLOY if the SA panel is successfully deployed or by any subroutine which is unable to perform its function.

The execution cycle counter (EXCYCNTR) will be decremented by one upon returning to SOLARD. If EXCYCNTR is greater than zero, the module will be exited as a time delay, which is a multiple of the module's execution cycle (1.024 seconds). No processor will be performed until the delay has timed out (EXCYCNTR=0). If EXCYCNTR is less than or equal to zero, the subroutine associated with the value of SDFUNCT will be executed.

The forementioned sequence of events will continue until SDFUNCT is equated to five. At this time, processing will terminate with the recording of the termination time (SOLARD's exit time) in SOLARD's telemetry report and the inhibiting of the module from further execution.

B.3.4.2.2 SDSCCU

SDSCCU, flowcharted in Section B.3.4.6, determines the configuration of the SC&CU. It must configure the SC&CU if it has not been preconfigured. Configuring consists of selecting RIU #4A and side A of the SC&CU or selecting RIU #4B and side B of the SC&CU.

SDSCCU will be executed a maximum of three times. If on the first pass (execution of SDSCCU) the SC&CU has been configured, SCUSIDE1 will be equated to a value which is indicative of the side of the SC&CU which is on. A return to SOLARD will then be made whereby SDARMCIR will be executed. If the SC&CU is not configured, an attempt to select RIU #4A and SC&CU side A will be made. On the second pass, if the SC&CU was not successfully configured, an attempt to select RIU #4B and side B of the SC&CU will be made. Deployment of the solar array will be aborted on the third pass if both attempts at configuring the SC&CU failed. If either attempt at configuring the SC&CU proved successful SCUSIDE1 will be equated as previously stated and SDARMCIR executed. Note, once an attempt to configure the SC&CU is made, the next execution of SDSCCU will be delayed by a minimum of 1.024 seconds.

B.3.4.2.3 SDARMCIR

The function of SDARMCIR is to arm the deploy circuitry and enable the pyro bus. SDARMCIR, flowcharted in Section B.3.4.6, accomplishes this by sending a series of commands, some of which are separated by a 100 millisecond delay. A maximum of two attempts at performing the arming and enabling function, utilizing different configurations of the SC&CU, will be made. If either attempt is successful, SDFUNCT will be equated to two. A return to SOLARD will be made whereby SDFRPYRO will be executed. If neither attempt proves successful, SDARMCIR will abort the deployment of the SA. Following each attempt, SDARMCIR initiates a 1.024 second delay and returns control to SOLARD.

B.3.4.2.4 SDFRPYRO

SDFRPYRO's function is to fire both sets of pyros, safe the deploy circuitry and disable the pyro bus. These tasks are accomplished by sending a series of five commands to the SC&CU shown in Section B.3.4.6. A 5.12 second delay is initiated between the FIRE SET 1 and FIRE SET 2 commands. The delay is initiated by SDFRPYRO but implemented by SOLARD. The other three commands have 100 msec, delays between them. SDFUNCT will be equated to three after sending the fifth command. A return to SOLARD is made whereby SDCONPDU is executed.

B.3.4.2.5 SDCONPDU

SDCONPDU, flowcharted in Section B.3.4.6, prepares the PDU to extend the SA. Sending Set #1 of the PDU commands accomplishes this task. Before sending the commands, SDCONPDU must determine which RIU (#6A or #6B) is to be used. SDMRUB is then called and the remote unit bit in all PDU pulse commands set accordingly. A major frame delay, implemented by SOLARD, is then initiated by SDCONPDU. Once the delay has timed out, bits in telemetry point TPDU01W2 ~~will~~ be examined to determine if the commands are accepted. If they are, SDFUNCT will be equated to four. A return to SOLARD is made and SDEPLOY executed.

If the commands are not accepted, the PDU will be reconfigured. Reconfiguring consists of calling the subroutine PDUXSTRAP which calls the executive to send the command to switch either the PDU side or PDU RIU #6. Set #1 is again sent to the PDU. If the commands are accepted, SDFUNCT will be equated to four and SDEPLOY executed.

The design of subroutines SDCONPDU and SDEPLOY assumes that Set #1 and Set #2 of the PDU commands do not and will not contain commands which are a function of the PDU side (PDUSIDE2). Hence, one does not need to know which side of the PDU is on in order to send either set of commands.

B.3.4.2.6 SDEPLOY

SDEPLOY, flowcharted in Section B.3.4.6, deploys (extend) the SA and then terminates its deployment. Deployment is accomplished by sending command CMDB (8) to the PDU and initiating a 20 minute delay. The delay is implemented by SOLARD. Once the delay is over, SDEPLOY terminates the deployment by sending Set #2 of the PDU pulse commands to the PDU. A bit in telemetry point TPDU01W1 is examined to determine the status of the SA. If the SA deployed, SDFUNCT will be equated to five. A return to SOLARD will be made whereby module processing will be terminated.

If the SA did not deploy, the PDU will be reconfigured as described in SDCONPDU. Control will be passed to SDCONPDU to once again prepare the PDU to extend the SA. If SDCONPDU performs its function successfully, SDEPLOY will be called and a second attempt made to extend the SA. Module processing will be terminated regardless of the outcome of the second attempt.

B.3.4.2.7 SDELAY

SDELAY, flowcharted in Section B.3.4.6, implements 100 millisecond delays which are requested by SDARMCIR and SDFRPYRO. SDELAY performs this task by acquiring the scheduler table pointer CSCHEDP and storing it in SDSCHEDP. The Executive increments CSCHEDP by one every 16 milliseconds. SDELAY continuously samples CSCHEDP and compares it to SDSCHEDP. A return to SDARMCIR will be made once the difference between the two values equals or exceeds six.

B.3.4.2.8 SDMRUB

SDMRUB, flowcharted in Section B.3.4.6, is referenced by SDCONPDU and SDEPLOY. SDMRUB's function is to manipulate the remote unit bit in all PDU pulse commands as specified by an argument. Remote unit bits will be cleared if the argument equals zero, set if equal to one or inverted if equal to two. Commands CMDB (1) thru CMDB (4) will be readily manipulated as they are PDU pulse commands. Set #1 and Set #2 of the PDU pulse commands will be scanned for pulse commands as the present composition of the sets are known but is subject to change. Processing ends with a return to the calling subroutine.

B.3.4.2.9 PDUXSTRAP

PDUXSTRAP, flowcharted in Section B.3.4.6, is called by the subroutines SDCONPDU and SDEPLOY to reconfigure the PDU. Reconfiguring consists of sending either commands CMDB(3) or (4) to switch PDU sides or commands (1) and (2) and selecting the other RIU. The other RIU is selected by calling SDMRUB to invert the remote unit bit in all PDU pulse commands.

B.3.4.3 Solar Array Deployment (SOLARD) Software Constraints

None

B.3.4.4 Solar Array Deployment (SOLARD) System Tables

The SOLARD processor uses the data items found in system table #69 which is called SDSYSTAB. For system table load format, see DFCB Vol III CMD.

Entry	Name	TLM	Type	Using Subroutine	Description
SOLARD System Table #69 - SDSYSTAB					
0	MFRMTIME		C	SDCONPDU	A one major frame delay is implemented by SOLARD after SDCONPDU sends command (5) to select the SA hinge. The value of MFRMTIME equals the number SOLARD executions in 1 major frame (i.e. 16).
1	DPDLTIME		C	SDEPLOY	20 minute delay (i.e. 236*5) is implemented by SOLARD after SDEPLOY sends command (8) to the PDU to deploy the SA.
2	LENSET1		C	SDMRUB	Number of PDU commands in Set #1; it is initialized to 1. Set #1 consists of CMDB (5).
3	LENSET2		C	SDMRUB	Number of PDU command in set #2; it is initialized to 3. SET #2 consists of CMDB (9), (10) and (11).
4	SDSYSTAB		C	SDMRUB SDCONPDU	MSH of PDU CMDB (5) in set #1; its value is 76.
20	SDSYSTAB		C	SDCONPDU	LSH of PDU CMDB (5) in set #1; its value is 19.
36	SDSYSTAB		C	SDMRUB SDEPLOY	MSH of PDU CMDB (9) in set #2; its value is 12.
37	SDSYSTAB		C	SDMRUB SDEPLOY	MSH of PDU CMDB (10) in set #2; its value is 76.
38	SDSYSTAB		C	SDMRUB SDEPLOY	MSH of PDU CMDB (11) in set #2; its value is 76.

Entry	Name	TLM	Type	Using Subroutine	Description
52	SDSYSTAB		C	SDEPLOY	LSH of PDU CMDB (9) in set #2; its value is 0200036.
53	SDSYTAB		C	SDEPLOY	LSH of PDU CMDB (10) in set #2; its value is 59.
54	SDSYSTAB		C	SDEPLOY	LSH of PDU CMDB (11) in set #2; its value is 52.
68	DFSTOP		F	SDEPLOY	Stop flag for reconfiguring the RIU/PDU; value equals 0.
69	DFSTOP		F	SDEPLOY	Stop flag for reconfiguring the RIU/PDU; value equals 1.
70	DFSTOP		F	SDEPLOY	Stop flag for reconfiguring the RIU/PDU; value equals 1.

B.3.4.5 Solar Array Deployment (SOLARD) Telemetry Reports

The SOLARD processor can be monitored by the OBC TLM Report #36 whose mnemonic is SDEPLOY 01. This report appears in columns 91-95 and 108-127 of minor frame #1. Column 35 contains the report # (i.e., #36).

Entry #	Name	Generating Subroutine	Description/Comment
OBC TLM Report #36 - SDEPLOY 01			
0	SDSEPTME	SDTECT	Time that separation was detected 3 consecutive times
3	SDTEMP	SOLARD	Solard exit time
6	SCUSIDE1	SDSCCU	Indicates which side of SC&CU is on 0=A on, 1=B on
7	PDUSIDE2	PDUXSTRAP	Indicates which side of PDU is on 0=A on, 1=B on
*8	ARMLOOP1	SDARMCIR	# unsuccessful attempts to arm deploy circuitry and pyros
9	PDULOOP2	SDCONPDU	# unsuccessful attempts to configure PDU
*10	DEPLOOP3	SDEPLOY	# unsuccessful attempts to deploy solar array panel
11	PDUXLOOP	PDUXSTRAP	# attempts at configuring the PDU/RIU

* TLM alarm: ARMLOOP1=2
DELOOP3=2

B.3.4.6 Solar Array Deployment (SOLARD) Flow Charts

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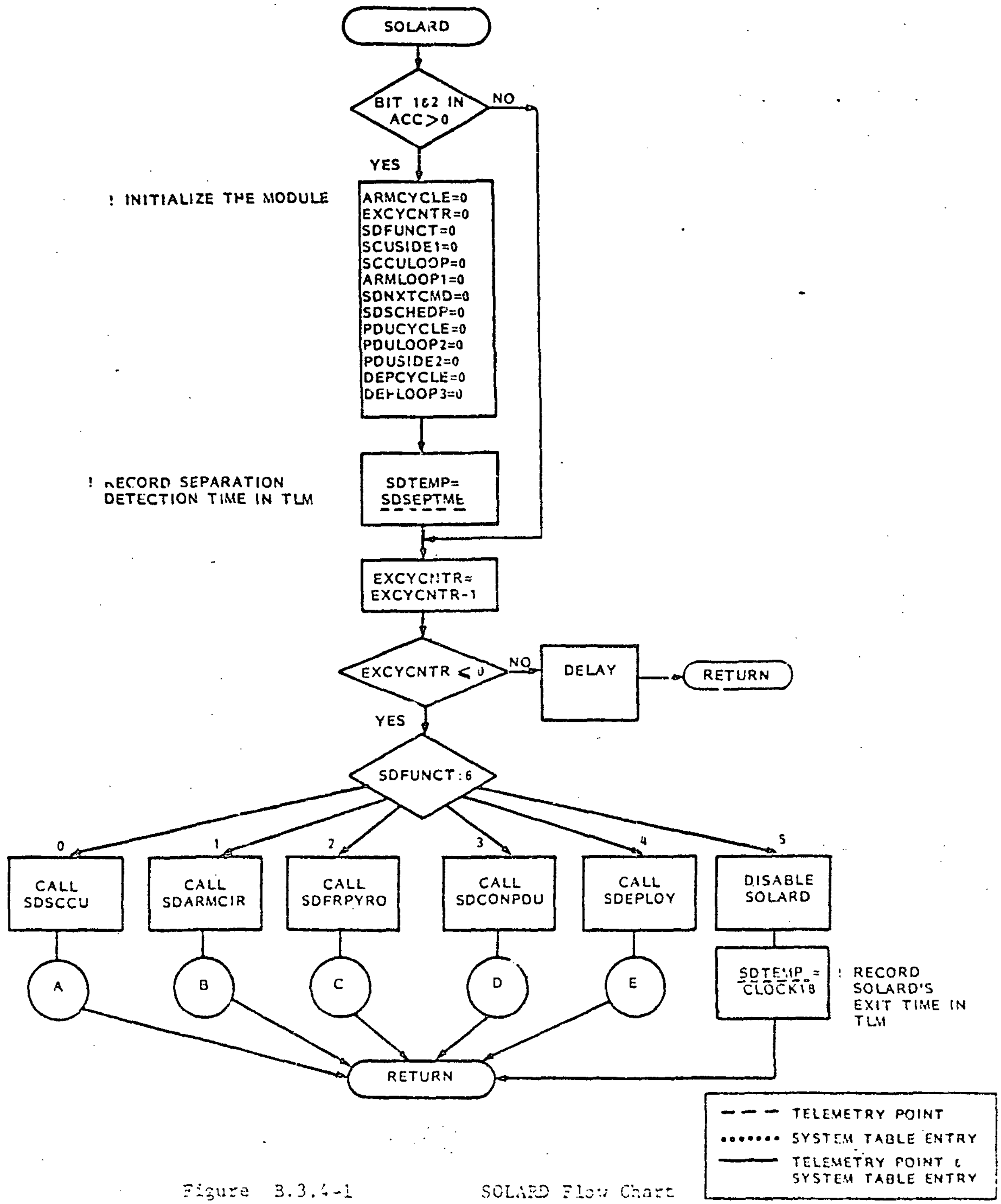

Figure B.3.4-1 SOLARD Flow Chart

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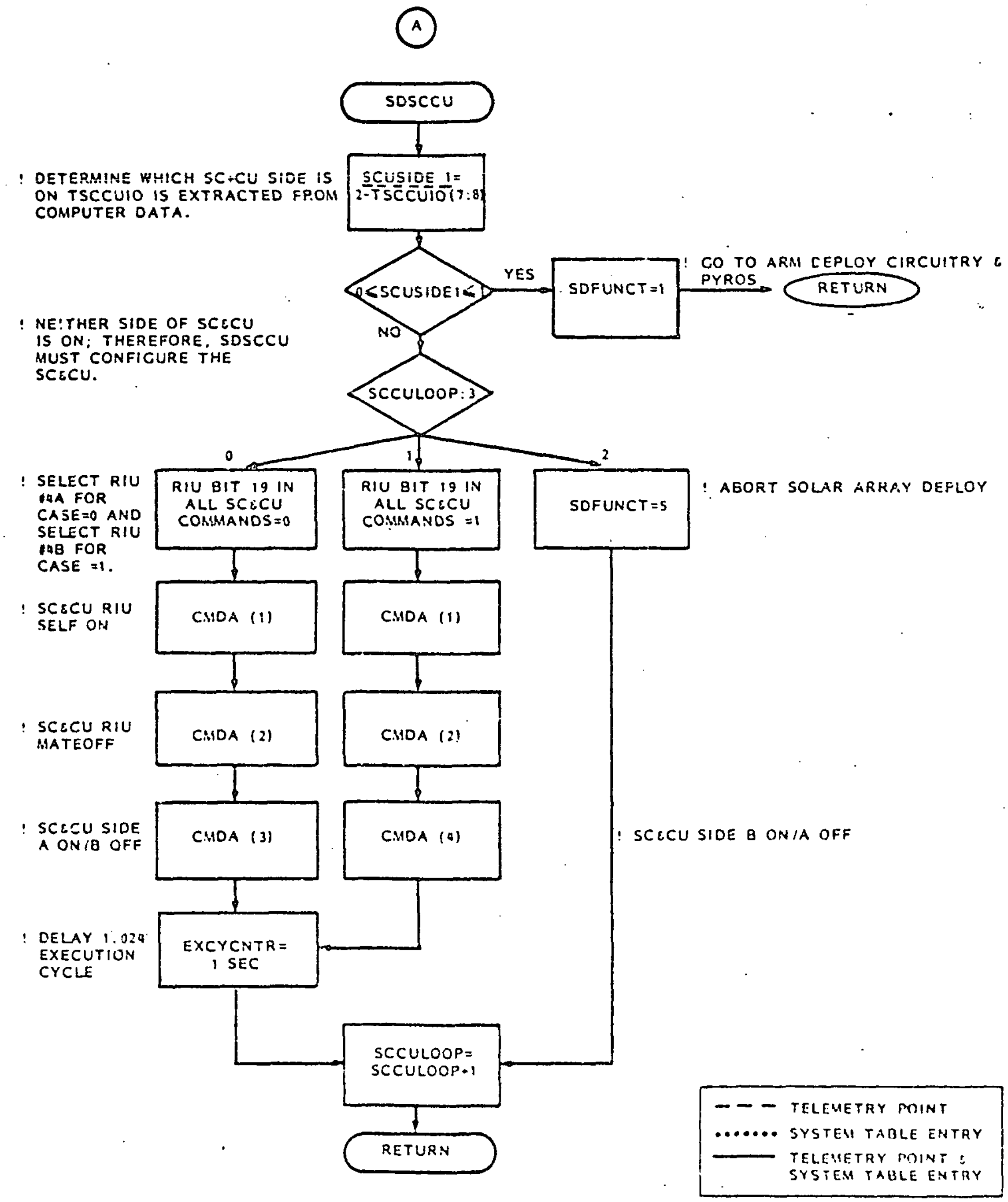

Figure B.3.4-2 SDSCCU Flow Chart

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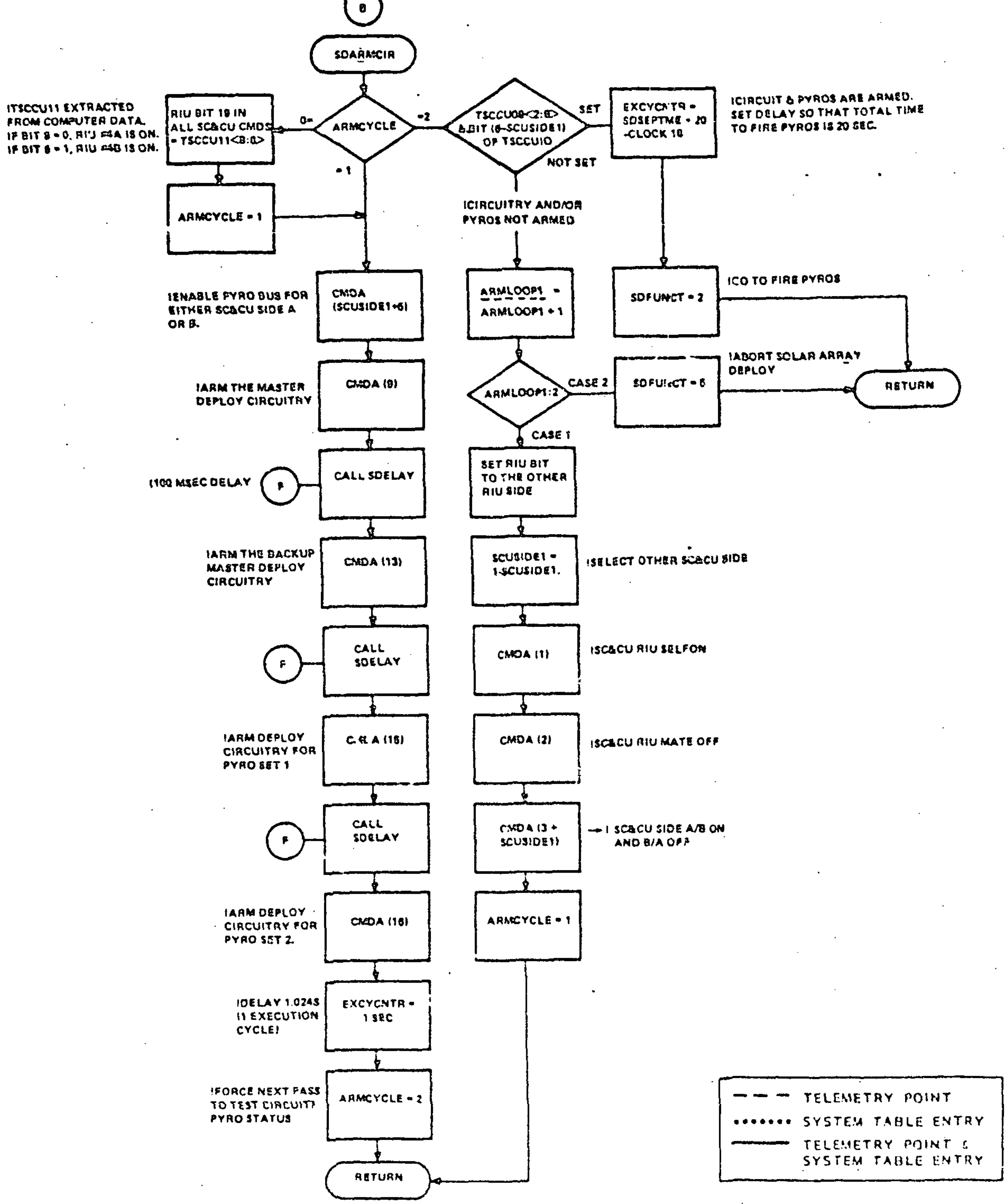

Figure B.3.4-3 SDARMCIR Flow Chart

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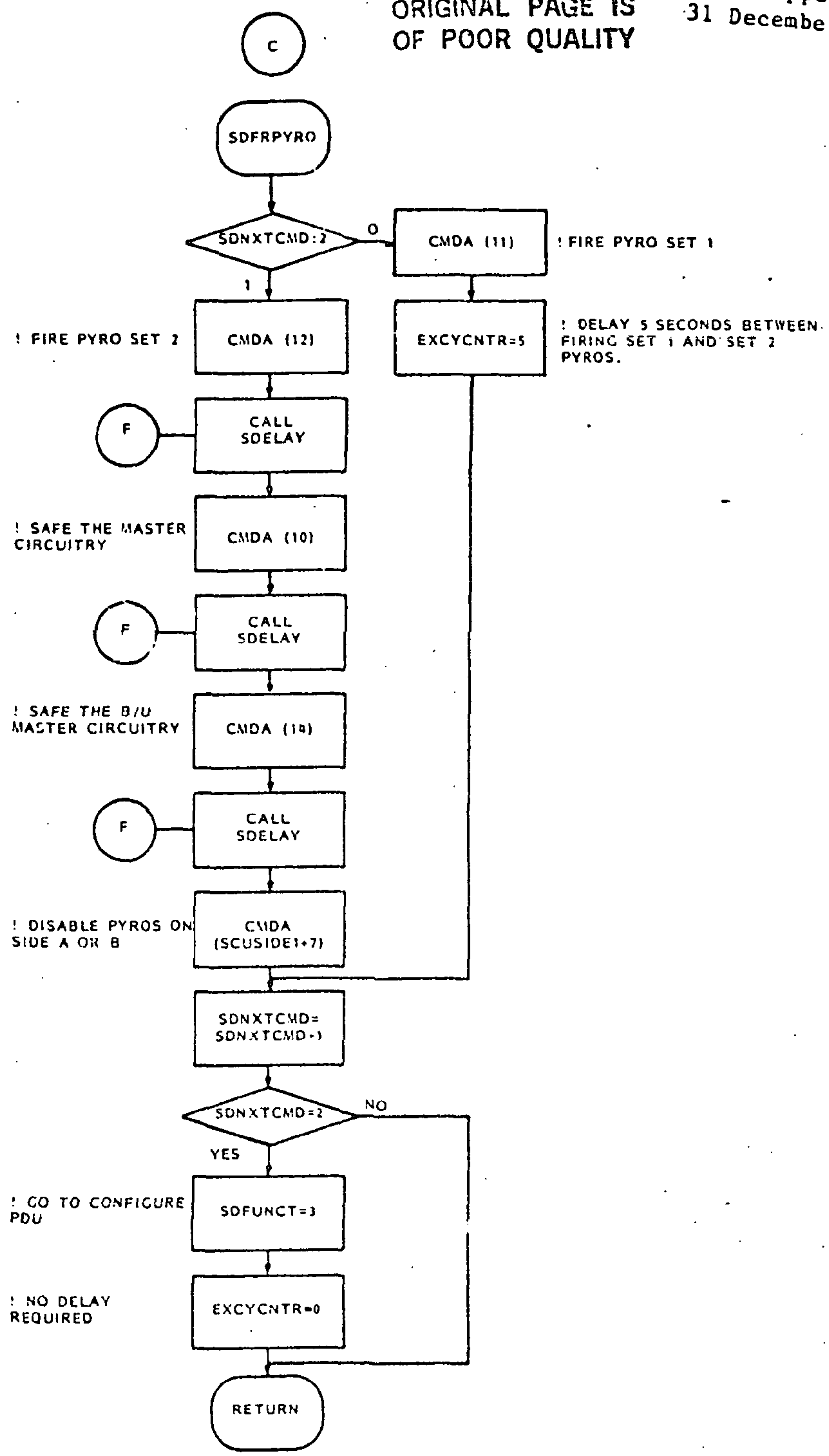

Figure B.3.4-4. SDFRPYRO Flow Chart

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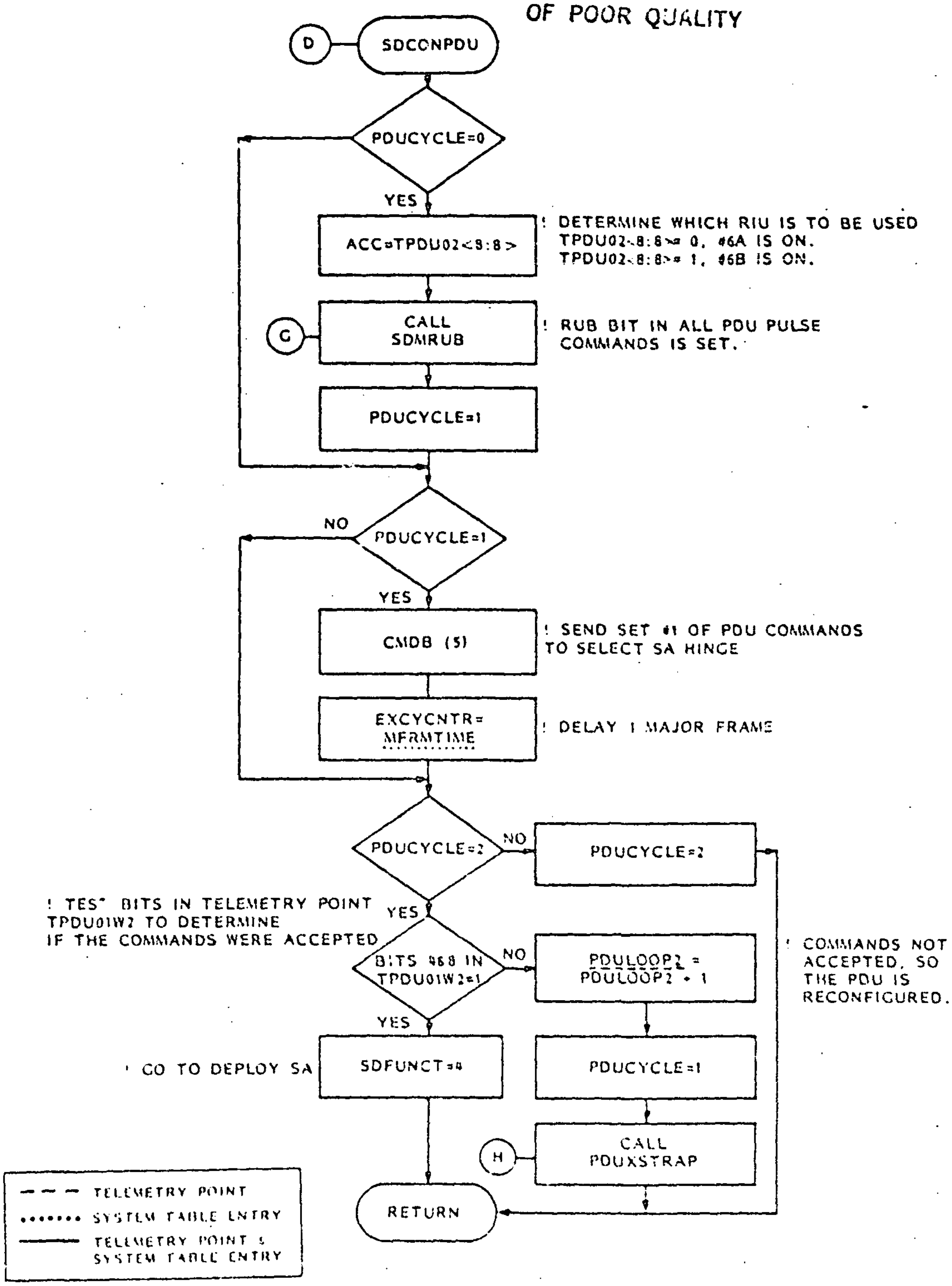

Figure 3.3.-5 SDCONPDU Flow Chart

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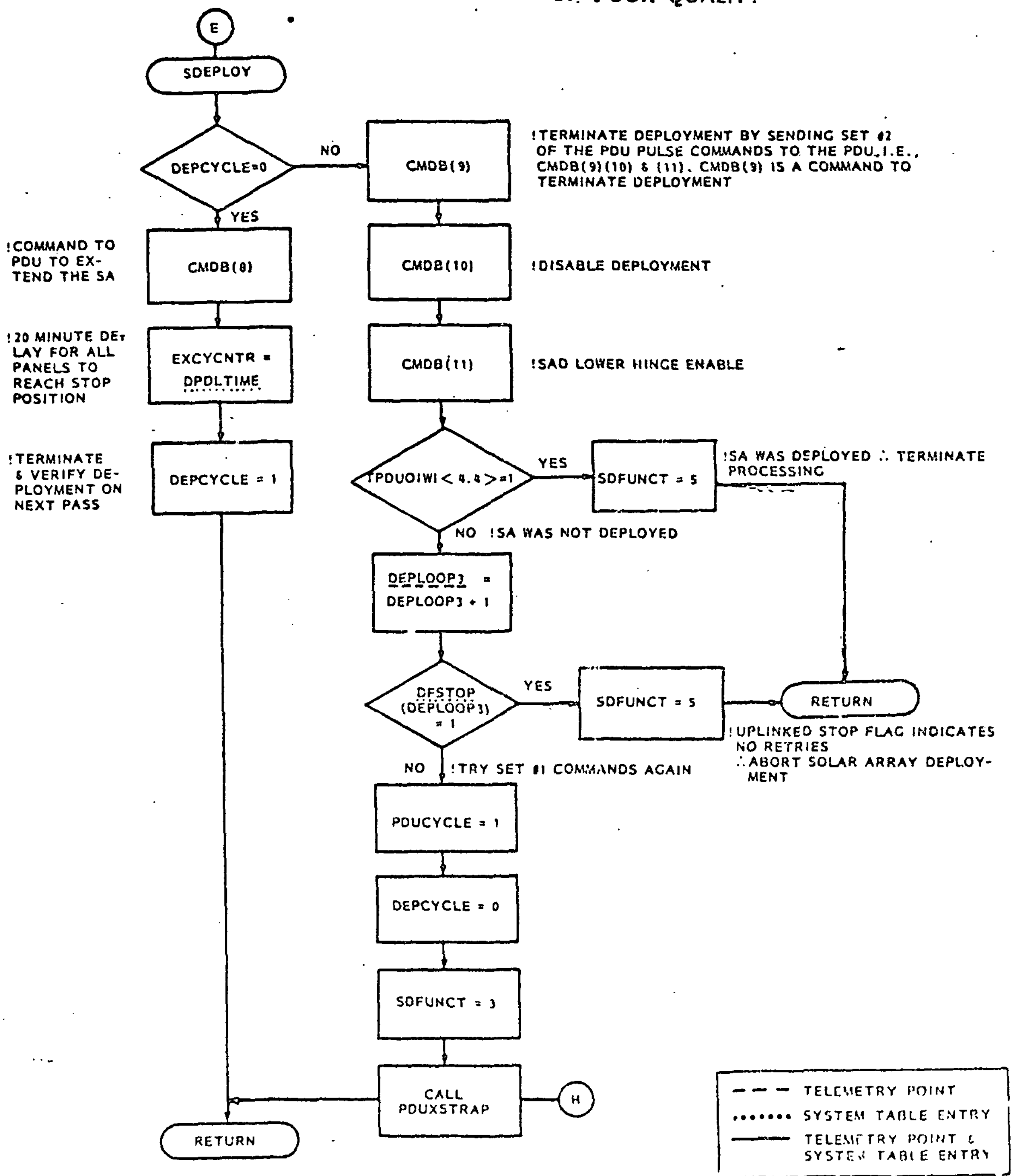

Figure B.3.4-6 SDPLOY Flow Chart

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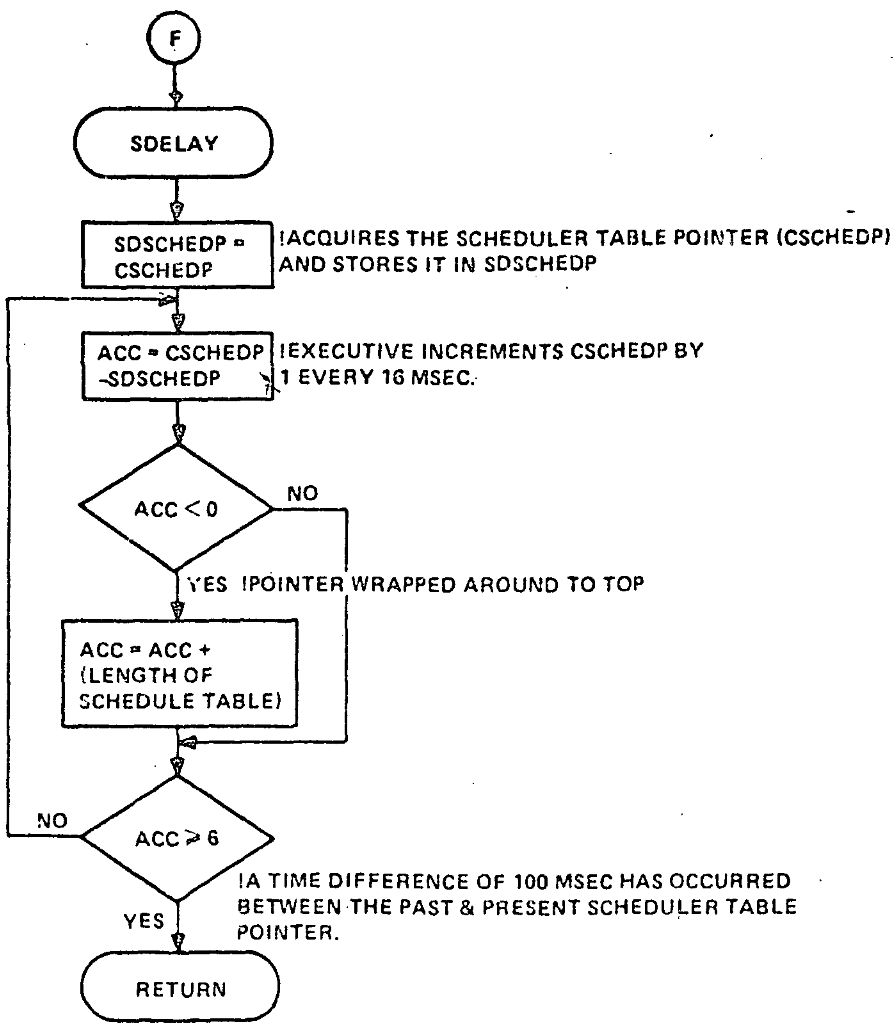

Figure B.3.4-7. SDELAY Flow Chart

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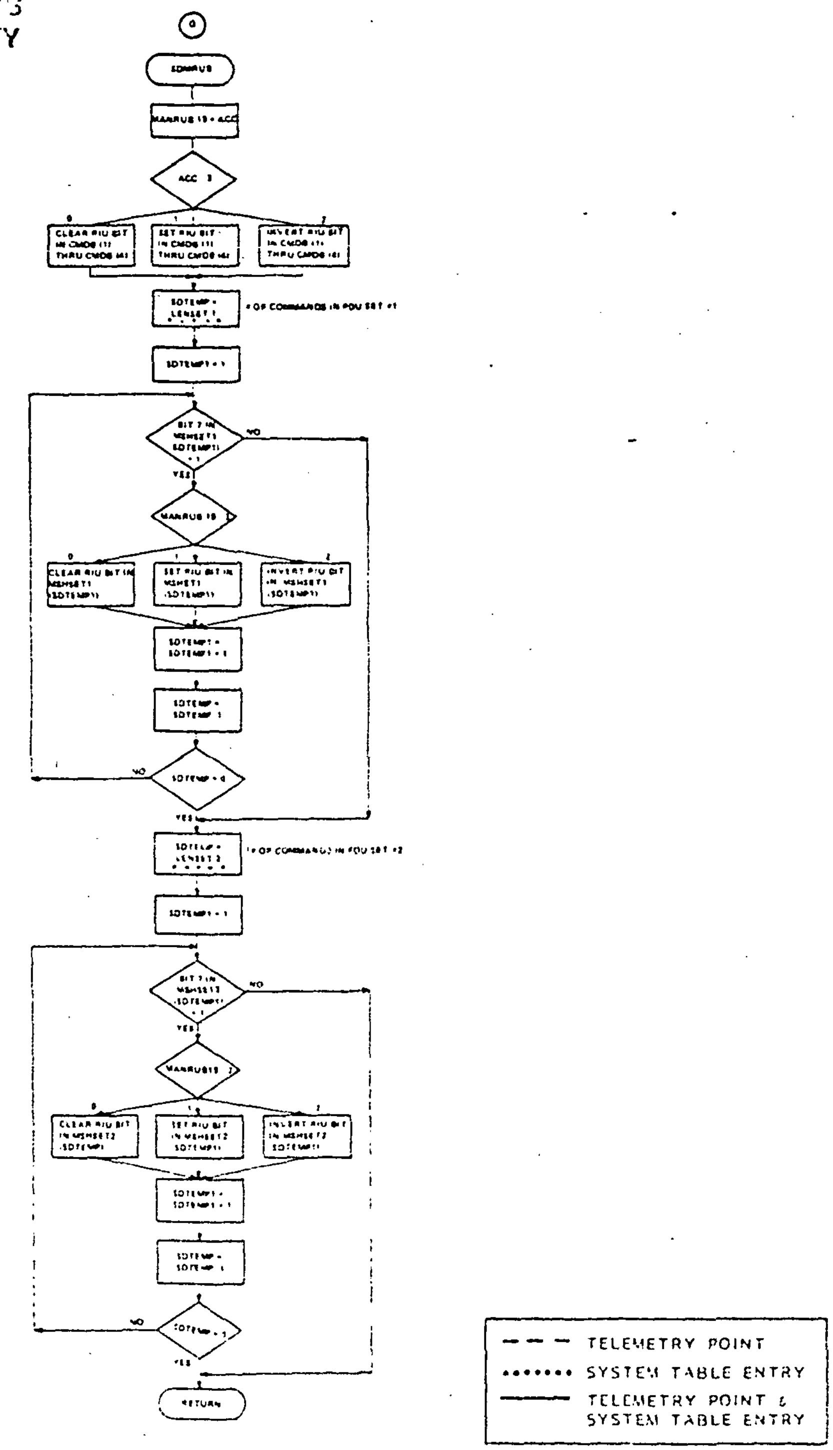

Figure B.3.4-8. SDMRUB Flow Chart

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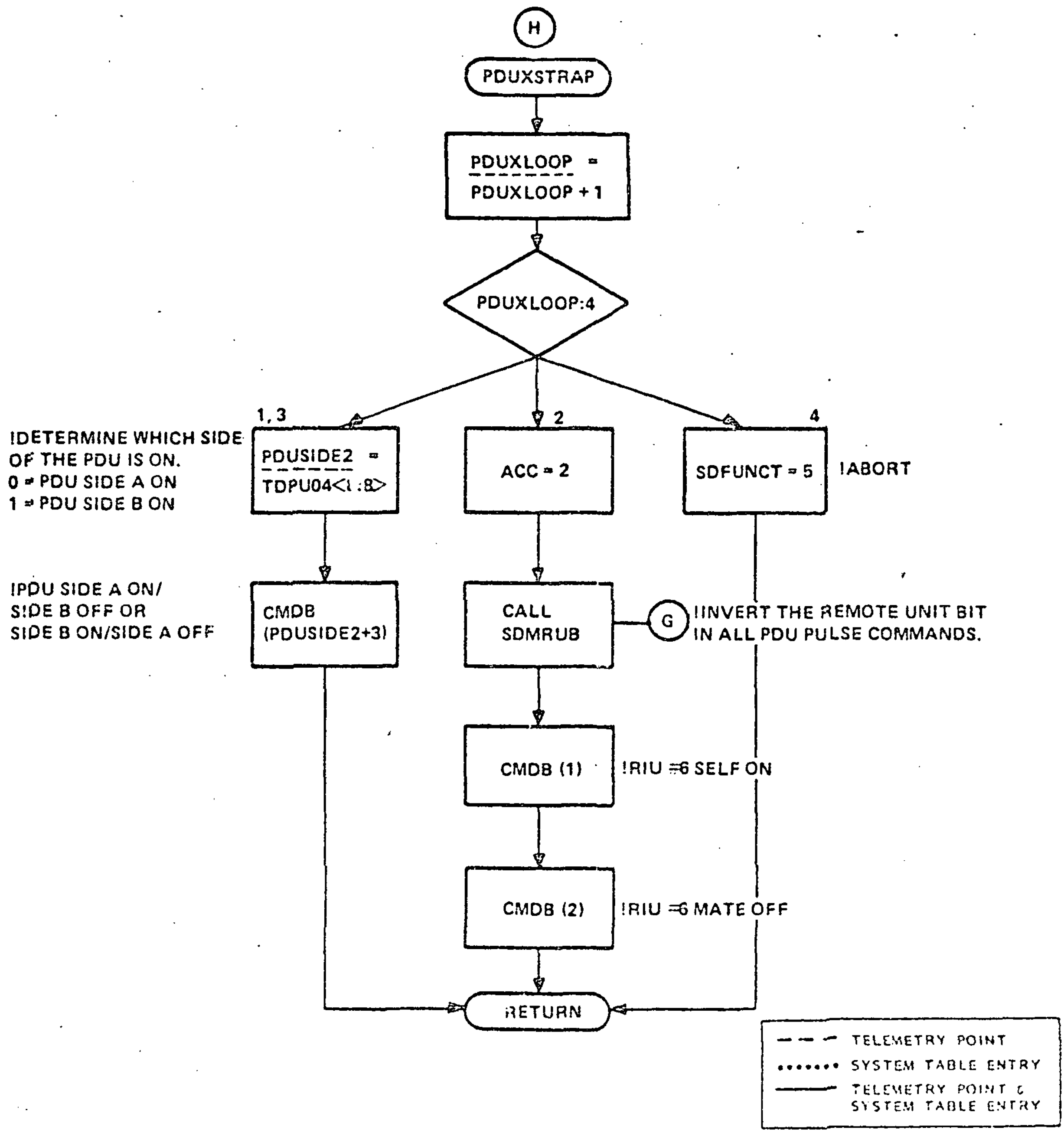

Figure B.3.4-9. PDUXSTRAP Flow Chart

B.3.5 GPS DATA ACQUISITION (TDA)

B.3.5 GPS DATA ACQUISITION (TDA)

B.3.5.1 GPS Data Acquisition (TDA) Processor Description

The function of the GPS Data Acquisition Processor is the acquisition and storage of GPS file 7 data for processing by the GPS Flight Segment Ephemeris Coefficient Update Processor (GCUP).

This processor is a foreground processor and is normally executed every 0.128 seconds, or 8 times every cycle of the Flight Executive Schedoler Table. This is the time of one GPS minor frame of data at the 8 kbps telemetry rate. However, when the telemetry rate is 1 kbps, this processor is executed every 1.024 seconds.

The GPS Data Acquisition Processor consists of 4 subroutines and a control function TACQ. These subroutines are listed in Table B.3.5-1 and are diagrammed in Figure B.3.5-1.

Tests are performed to determine if the GPS data buffer is free and if GPS file 7 data is available. The status of the GPS data buffer is set by a flag (GALFLAG4) in the GPS Ephemeris Coefficient Updata Processor (GCUP). The availability of GPS file 7 data is checked by unpacking the data ready bit in the GPS bilevel word (GPSBILVL). If the GPS data buffer is free (checked in TACQ) and if GPS file 7 data is available (checked in GADAQ), the processor will store a GPS minor frame of data. The form of GPS file 7 is shown in Table B.3.5-2.

If either of these tests is unsatisfied, the current file 7 data set will be bypassed by execution of the resync process.

The GPS Data Acquisition Processor utilizes no system table and generates no telemetry reports.

Detailed processor description by subroutine is presented in Section B.3.5.3 and detailed flow charts presented in Section B.3.5.6.

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Table B.3.5-1. GPS Data Acquisition (TDA)

GPS Data Acquisition (TDA)

Number:	4
Type:	Foreground
Priority:	4
Period:	Nominally 0.128 sec Possibly 1.024 sec (1 kbs telemetry rate)
Function:	Acquisition and storage of GPS file 7 data for utilization by the GCUP processor

Subroutines:

GACOLD	Cold start initialization
GASYNC	Resync
GADAQ	GPS data acquisition
GABUFFR	Store minor frame into buffer

Procs:

PREQ	Calculate constant to allow exec data to be referenced by applications processor
DATABLK	Get block of data from main telemetry
PCTL (UGCUP,REQ,INIT)	Request executive to execute GCUP processor with initialization
PCTL (UGCUP,REQ)	Request executive to execute the GCUP processor

System Tables: None

Telemetry Reports: None

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Table B.3.5-2. GPS File 7 Data

NAVIGATION BEST ESTIMATE

	Bits	Units
Sync $(EDE20)_{16}$	20	NA
File ID = 7	4	None
Frame ID = 1	8	None
Checksum	16	NA
T_{R1}(TCG)	48	μsec
Time (GPS)	48	sec
X ECEF Position	48	meter
Y ECEF Position	48	meter
Z ECEF Position	48	meter
X ECEF Velocity	32	meter/sec
Y ECEF Velocity	32	meter/sec
Z ECEF Velocity	32	meter/sec
UTC Clock Bias (b)	32	meter
UTC Clock Bias Rate ($\dot{b}$)	32	meter/sec
Drag Constant ($C_o A/2m$)	32	$meter^2/kg$
Position Variance	32	$meter^2$
Velocity Variance	32	$(meter/sec)^2$
Clock Bias Variance	32	$meter^2$
Clock Bias Rate Variance	32	$(meter/sec)^2$
Coded Data	32	
No. of Valid time marks	16	
Six time marks at 48 bits each	288	
Total	944	

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This is done in subroutine GASYNC.

If the tests are passed, the subroutine GADAQ is executed and the file 7 data minor frame is stored in buffer. The GPS minor frame of data consists of 12 words in Mission Format or 5 words in Engineering Format. When 120 data words have been stored, a request is made for the execution of the GPS FS Ephemeris Coefficient Update Processor (GCUP). This is accomplished in the subroutine GADAQ, after checking to see if the number of stored words (GALVOFST) is greater than or equal to GALVMXWD (number of stored words at which point the buffer is full). When GALVOFST $\geq$GALVMXWD, GADAQ requests the Flight Executive to schedule the execution of GCUP, and resets appropriate flags to prepare for acquisition of new data.

B.3.5.2 GPS Data Acquisition (TDA) Processor Operation

The TDA Processor consists of the control function TACQ, and the four subroutines as previously listed. A detailed description of the control function and the subroutines is presented in Sections B.3.5.2.1 through B.3.5.2.5.

B.3.5.2.1 Control Function TACQ

TACQ is the control function which unpacks the data ready bit of the GPS bilevel word and determines if the resync process is in effect (GALFLAG4 <> 0). The resync processor (GASYNC) is called whenever errors occur during data acquisition. Data is ignored until the "data ready" bit becomes zero, at which time the resync process terminates (GAGFLAG4=0). For the next execution of TDA after resync, the input will be the first set of data for a new file. If no resync is in progress, the routine GADAQ is called to perform the data acquisition process.

B.3.5.2.2 GACOLD Subroutine

GACOLD is the routine which initializes variables when a "cold start" condition exists (bit 1 and 2 of the ACCUMULATOR is set when the module TDA is called). These variables are flags and counters, to define buffer ready status, (GAGFLAG3), resync status (GALFLAG4), and cold start flag, and initializes counters for data dropout and buffer not free.

B.3.5.2.3 GASYNC Subroutine

GASYNC is the resync processor which allows the Telemetry Data Acquisition Processor to ignore any questionable input GPS file 7 data. GASYNC assumes that the data ready flag contained in the GPS bilevel word is set when data is available and is reset (zero) when data stops. GASYNC checks the data ready flag (GALVDRDY) and if it is set (ready), the resync process continues. If data is not ready, the resync flag is reset and the resync process is discontinued.

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B.3.5.2.4 GADAQ Subroutine

GADAQ first checks to make sure the data ready flag is set (GALVDRDY <> 0). For the first GPS file 7 minor frame data, this process checks the GPS input data word 3 and makes sure the input if file 7 data and the sync words 1 and 2 are legal. If either of these checks fail, the resync process is initiated by setting the flag GALFLAG4. If these checks pass, GADAQ tests the buffer ready flag (GAGFLAG3). If reset (zero), this flag indicates that the background program (GCUP) which uses the GPS data, is finished with the buffer and new data may begin filling the buffer. If GAGFLAG3 is set (non-zero), the previous file 7 data has not been processed by the background program and the current file 7 data will be considered lost and the resync flag will be set. If new data is to be acquired, the routine GABUFFR will be called to store the GPS file 7 minor frame data. If the buffer is not yet filled, control will return to TDA. If the buffer is full, the buffer ready flag is set (GAGFLAG3=1) and certain variables are reset for the next GPS file 7 data.

B.3.5.2.5 GABUFFR Subroutine

The routine which stores the data from each minor frame into the buffer (GAGBGBUF) is known as GABUFFR. This routine extracts the telemetry format from TMSTAT1 of the telemetry data stream. If the data is in Mission Format, the first 12 GPS file 7 words are stored into the buffer. Otherwise, the first 5 GPS file 7 words are stored. After the proper number of words are stored, the buffer pointer is adjusted for the next set of GPS file 7 data.

B.3.5.3 <u>GPS Data Acquisition (TDA) Software Constraints</u>

TBD

B.3.5.4 <u>GPS Data Acquisition (TDA) System Tables</u>

None

B.3.5.5 <u>GPS Data Acquisition (TDA) Telemetry</u>

None

B.3.5.6 <u>GPS Data Acquisition (TDA) Flow Charts</u>

See Figures B.3.5-2 thru B.3.5-5.

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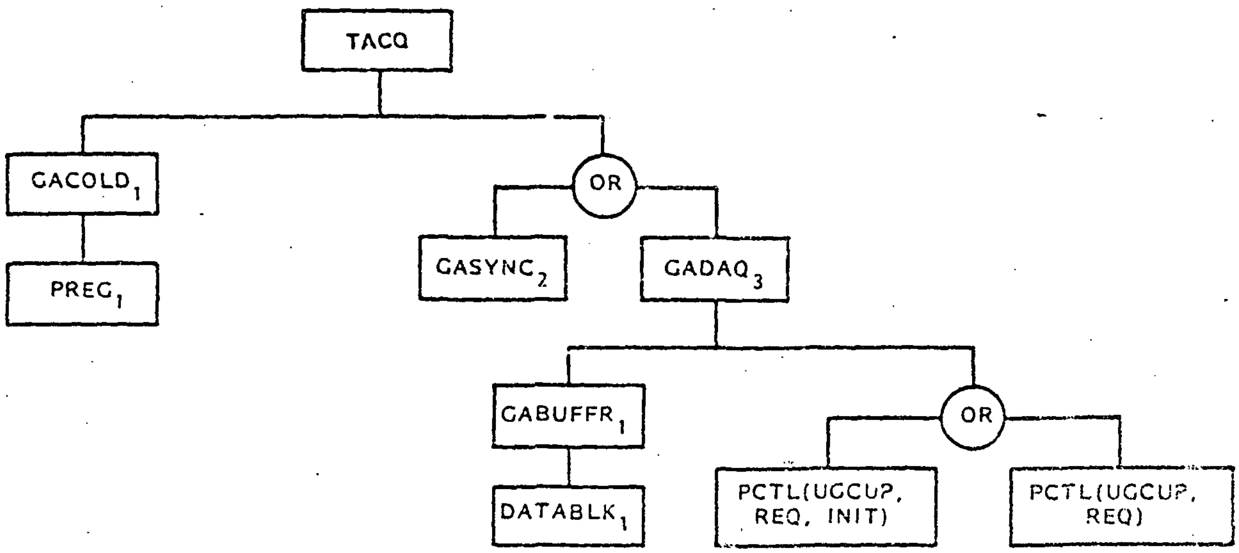

Figure B.3.5-1. TDA Top Level Diagram

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TELEMETRY DATA ACQUISITION

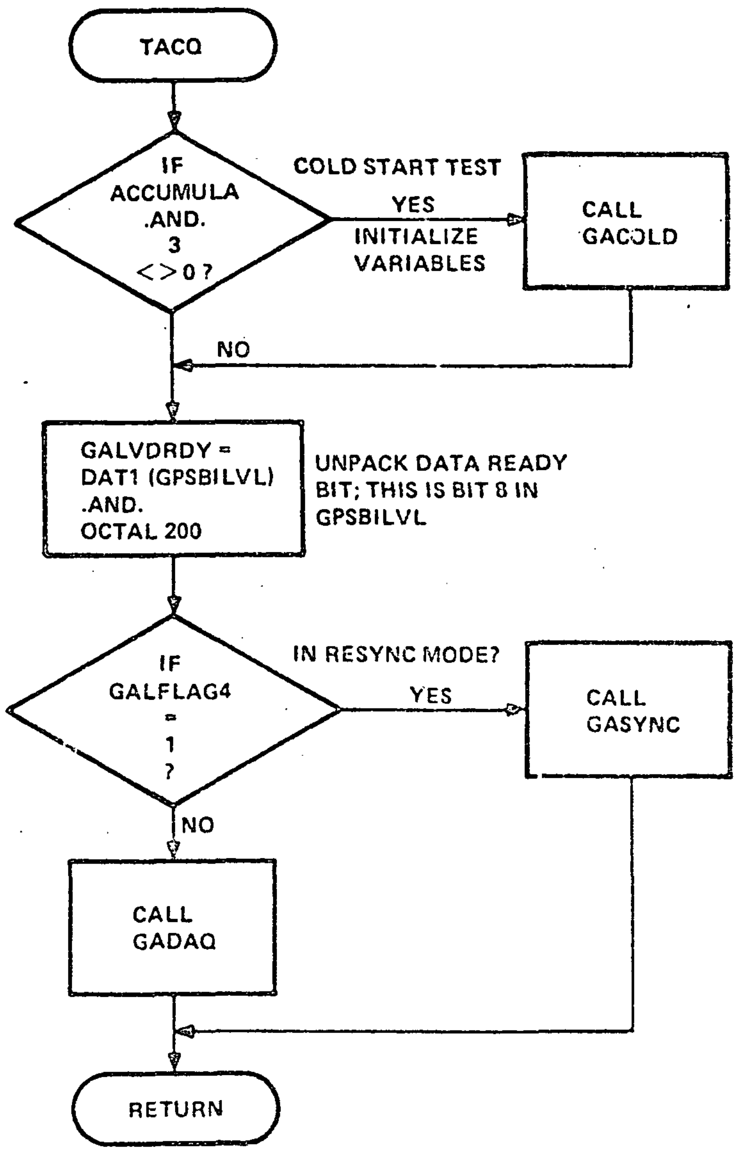

Figure B.3.5-2. TACQ Flow Chart

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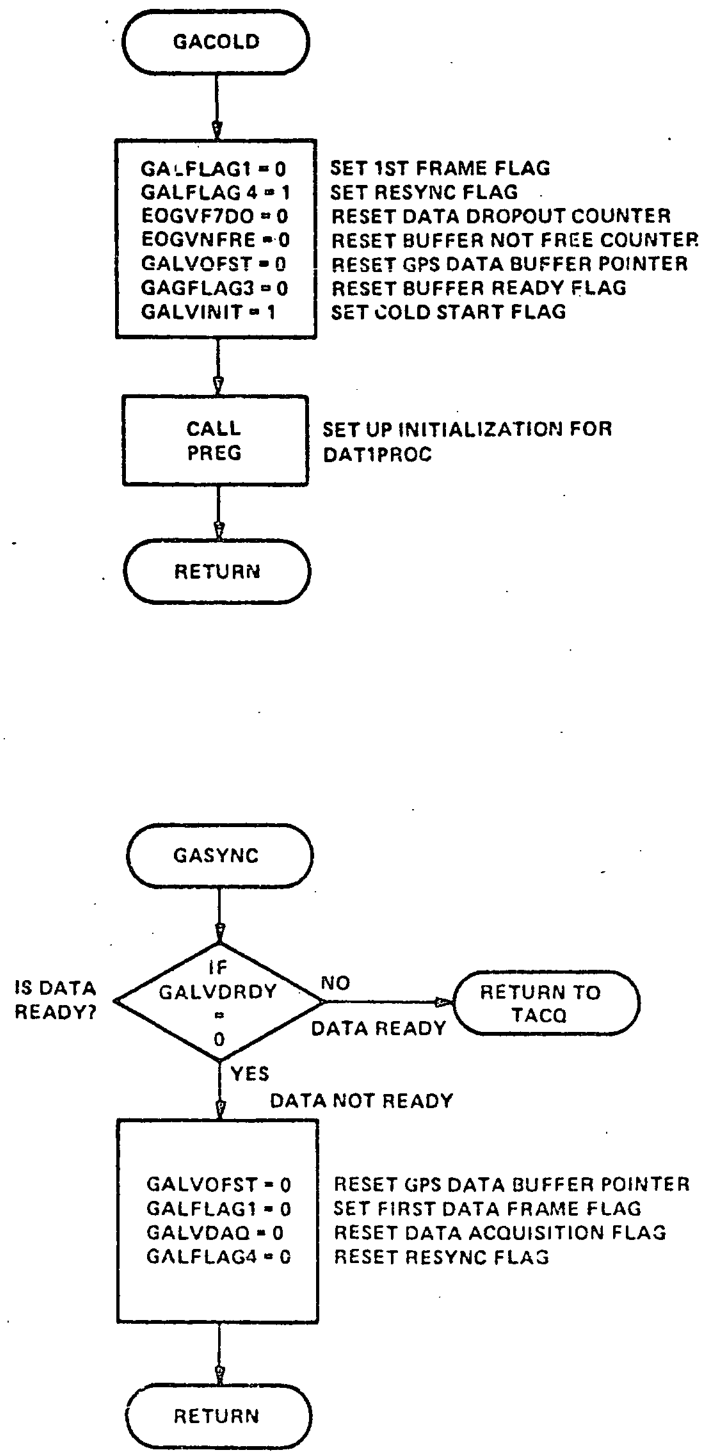

FIGURE B.3.5-3 GACOLD,GASYNC Flow Chart

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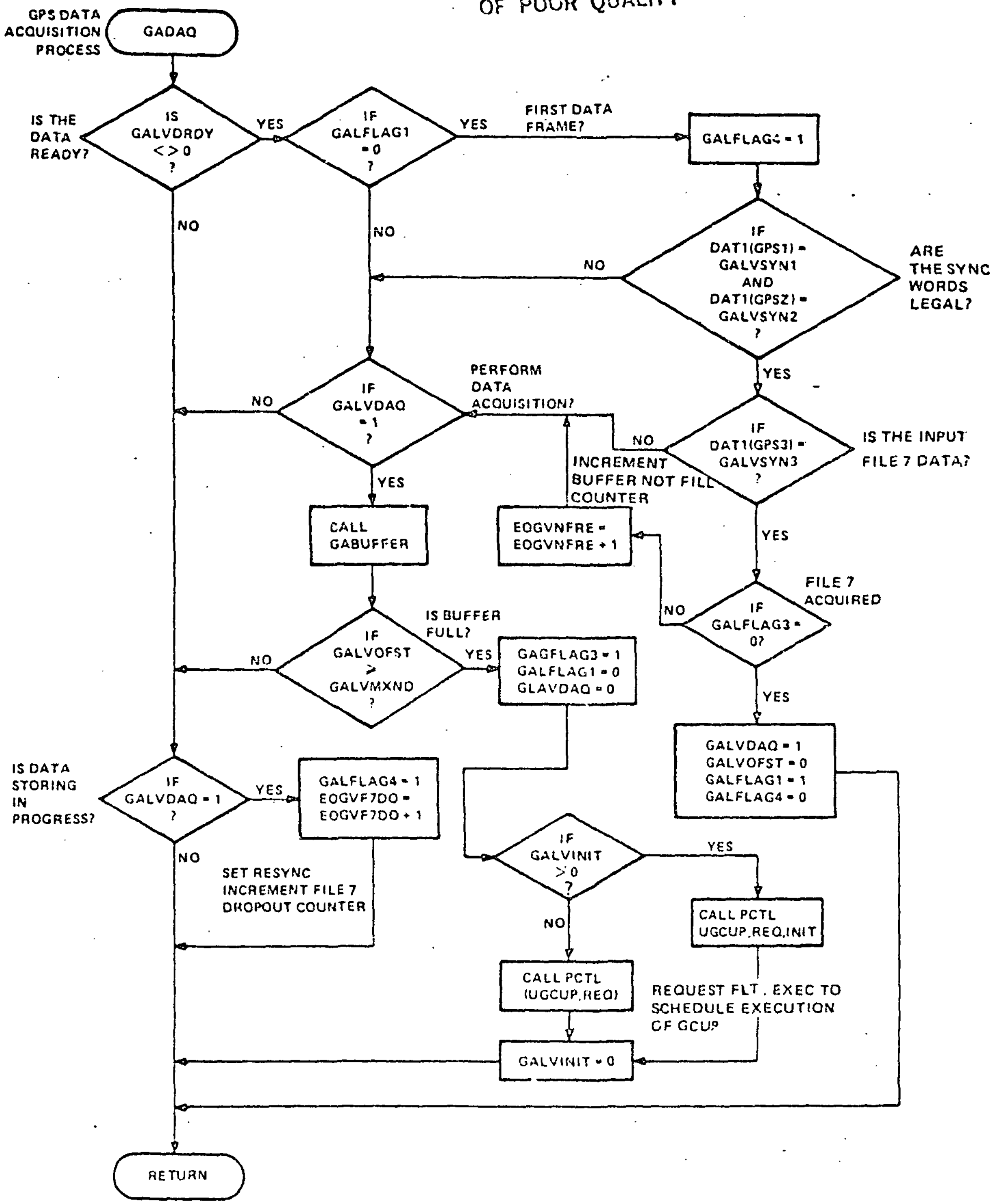

FIGURE B.3.5-4 GADAQ Flow Chart

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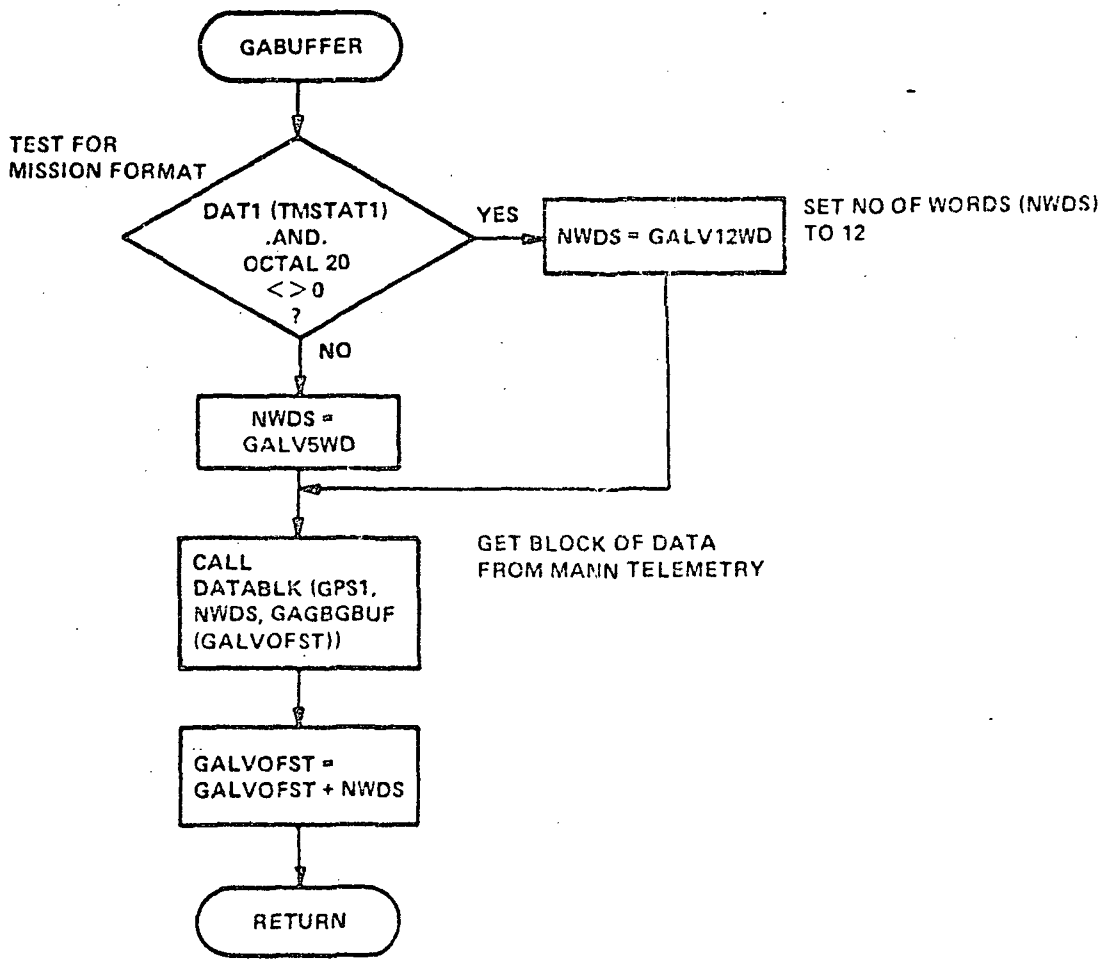

FIGURE B.3.5-5 GABUFFER Flow Chart

B.3.6 GPS FS EPHEMERIS COEFFICIENT UPDATE (GCUP)

B.3.6 GCUP

B.3.6 GPS FS EPHEMERIS COEFFICIENT UPDATE (GCUP)

B.3.6.1 GPS FS Ephemeris Coefficient Update (GCUP) Processor Description

The function of the GPS FS Ephemeris Coefficient Update (GCUP) processor is the computation of extrapolator coefficients for use by the Ephemeris Computation (EPHEM) processor for the generation of GPS-based Landsat-D FS position and velocity.

This processor is a background processor and is executed nominally once every 6 seconds. The GPS FS Ephemeris Coefficient Update (GCUP) processor is scheduled by the Flight Executive upon request by the GPS Data Acquisition (TDA) processor. This occurs when GPS file 7 data is available (120 words stored in the GPS data buffer).

The GCUP processor consists of 10 subroutines as delineated in Table B.3.6-1, and diagrammed in Figure B.3.6-1. Additionally, the processor has a control function GCUP.

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Table B.3.6-1. GPS FS Ephemeris Coefficient Update (GCUP)

GPS FS Ephemeris Coefficient Updata (GCUP)

Number:	15
Type:	Background
Priority:	12
Period:	6 seconds
Function:	Computes extrapolator coefficients for utilization by EPHEM Processor to generate LS-D FS Ephemeris; activated by TDA Processor

Subroutines:

GUCOLD	Cold start initialization
GUTEST	Perform GPS Data Checksum Test
GUDAT	Convert and transform data
GUFCON	Perform GPS Input Data Conversion
GUFTF	Convert GPS Floating to NSSC 1 Fixed Format
GUGDCT	Transform GPSP and V from ECEF to EC
GUCOEFF	Calculate coefficients
GUINIT	Perform GPS Initialization
GUPROCGP	Process grid point values
GUECC	Extrapolator coefficients computation

System Tables:

#	Mneumonic	Type	# Words	Description
63	GPERMIT	Constant	4	GPS Limit Parameters
64	GMAJOR	Variable	8	GPS Coordinate Transformation Major Parameters
65	GMINOR	Variable	14	GPS Coordinate Transformation Minor Parameters

Telemetry Reports: None

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When new GPS file 7 data is available to be processed, the control function, GCUP, first checks to see if the processor has to be initialized, and if so, requests the subroutine GUCOLD, which resets error counters. A checksum test is then performed by the subroutine GUTEST and if satisfied, the subroutine GUDAT is called which converts the data from GPS to NSSC format (subroutines GUFCON and GUFTF). If the data is successfully converted, GUDAT tests position and velocity variance errors against input maximum permissible values (System Table 63), and if these checks are satisfied, calls the subroutine GUGDCT. This subroutine converts the GPS position and velocity vectors from ECEF coordinates to Earth Centered Inertial (ECI) coordinates. If any of the checks referred to above are not satisfied, the processing is terminated, control is returned to the Flight Executive, and the complete GPS buffer (GAGBGBUF) is not utilized.

After the data is converted, assuming checks on the data quality have been satisfied, the subroutine GUCOEFF is called to calculate GPS extrapolator coefficients. If extrapolator coefficient initialization has to be performed, the subroutine GUINIT is called to initialize (by GUCOEFF), and then GUPROCGP is called to process the grid points. This subroutine essentially removes the oldest grid point data and replaces it with a new set of data. The subroutine GUECC is then called to generate new extrapolator coefficients and a "new coefficients ready" flag is set. This flag is checked by the Ephemeris Computation (EPHEM) processor, and hence, setting GUGFLGUP=2, allows EPHEM to request new coefficients. Processor control is returned to the control function GCUP, which in turn returns control at this point to the Flight Executive.

The GPS FS Ephemeris Coefficient Update (GCUP) processor utilizes Flight Segment Software System Tables #63-65.

B.3.6.2 GPS FS Ephemeris Coefficient Update (GCUP) Processor Operation

This processor consists of the control function GCUP and the ten subroutines as delineated in Section B.3.6.1. The control function is described in the preceding section. Sections B.3.6.2.1 through B.3.6.2.10 describe the subroutines.

B.3.6.2.1 GUCOLD Subroutine

The GUCOLD Subroutine, cold start initialization, initializes or resets various GCUP error counters to zero, and additionally sets the previous GPS time (GULWTGPP) equal to zero. The GCUP error counters reset to zero, are:

1. Variance error counter (EOGVARER)

2. Checksum error counter (EOGVCSEC)

3. Difference error counter (EOGVDERR)

4. EGPS time error counter (EOGVGTER)

5. Shift error counter (EOGVSHER)

After execution of this subroutine processor control is returned to the GCUP control function.

B.3.6.2.2 GUTEST Subroutine

GUTEST performs the GPS data checksum test. Every two 8-bit GPS words are combined to make a 16-bit word and these values are added to the running sum. The record checksum (words 5 and 6 in GPS file 7) are not added. After the calculated checksum is formed, this value is tested equal to the record checksum. If these checksums are different, an error flag (GULFCSER) is set, the running checksum error counter (EOGVCSEC) is incremented, and control returns to the module GCUP.

B.3.6.2.3 GUDAT Subroutine

GDAT is the routine which manipulates the input GPS data. The GPS data conversion routine (GUFCON) is called to convert the data from floating point to fixed point format and if the conversion is good, the position and velocity error variances are checked within limits. If the variances are good, GUDAT calls the routine GUGDCT to perform the transformation of position and velocity from the ECEF to the ECI coordinate system. Any errors will cause the flag (GULFLGER) to be set and control returned to the GCUP control function.

B.3.6.2.4 GUFCON Subroutine

GUFCON is the routine which performs the GPS file 7 data conversion. GPS time is converted from 48 bits to a triple precision fixed point number. The general purpose routine (GUFTF) is called to convert the double precision 48-bit floating point X/Y/Z position components, the 32-bit single precision floating point X/Y/Z velocity components, and the 32-bit single precision floating point position and velocity variances to scaled double precision fixed point values. If there are any shift erors from GUFTF, the error counter (EOGVSHER) is incremented by 1 except for variances. In the case of variance shift errors, the error counter EOGVARER is incremented by 1.

In the case of either error, however, processing is terminated and control returns to the GCUP control function.

B.3.6.2.5 GUFTF Subroutine

GUFTF is the conversion routine which will accept a single or double precision floating point GPS value and, making use of the scale factor supplied, will convert this value to a double precision fixed point value.

After the output words have been formed, the exponent and the input scale factor argument come into play. This input scale factor represents the required number of integer bits.

GUFTF checks to make sure the number of bits to shift is not a negative value. This is an error condition which causes the flag GUFLFLGER to be set, terminate GUFTF processing, increment the shift error counter, and return control to the GCUP control function.

B.3.6.2.6 GUGDCT Subroutine

GUGDCT transforms the time, position, and velocity data from the GPS coordinate system (Earth-Centered Earthed-Fixed) to the attitude control coordinate system (Earth-Centered Inertial "true of date"). GUGDCT converts the GPS time to spacecraft time and uses this spacecraft time in the calculation for the R.A. of Greenwich. The sine and cosine of the R.A. of Greenwich are found using the double precision sine and cosine routines. The transformed position and velocity components are finally calculated using the uplinked elements of coordinate transformation matrix, which accounts for the components of pole wander.

B.3.6.2.7 GUCOEFF Subroutine

GUCOEFF checks to see if the initialization is required. If it is, GUINIT is called to initialize the grid point values and GUPROCGP is called to process and update the grid point values. If initialization is complete, GUCOEFF tests the input time to make sure a new data set is available. The grid point processor (GUPROCGP) is executed and finally the new extrapolator coefficients are computed in the routine GUECC.

B.3.6.2.8 GUINIT Subroutine

GUINIT is an initializing routine which is called only on the first pass of the module GCUP. The primary purpose is to set the initial times which are used in the grid point processing component GUPROCGP. The initial process flag (EOGVINIT) is set to 2 and the queue buffer pointer for grid values is set to 1.

B.3.6.2.9 GUPROCGP Subroutines

The routine GUPROCGP is called whenever valid data is present. This is the grid point processor which determines the times and grid point values to be used in order to maintain the range of grid spacing needed to extrapolate the GPS data using a modified Hermite 2 point extrapolator polynomial.

B.3.6.2.10 GUECC Subroutine

GUECC initially updates the 2nd grid point time and then performs the extrapolator coefficient computation using a modified Hermite 2 point extrapolator polynomial. The coefficients calculated in this routine are then used by the Ephemeris Computation Module (EPHEM). The flag GUGFLGUP is set to 2 to notify EPHEM that new coefficients are ready.

B.3.6.3 GPS FS Ephemeris Coefficient Update (GCUP) Software Constraints

Execution of the GCUP processor is achieved by request from the TDA processor and the setting of the new GPS data ready flag (GAGFLAG3 <> 0) in TDA Processor. This processor makes many checks on data quality. Failure of any of these checks would negate generation of extrapolator coefficients for the data set and would result in loss of the complete 120 words in the GPS buffer (GAGBGBUF).

B.3.6.4 GPS FS Ephemeris Coefficient Update (GCUP) System Tables

System Table #63, GPERMIT-GPS Limit Parameters, consists of 3 parameters providing limits for checks on GPS data quality and permissible limit on time difference for new GPS data set. These parameters are norminally constant.

System Table #64, GMATOR-GPS Coordinate Transformation Major Parameters, consists of 4 parameters utilized in the transformation of GPS ephemeris data from ECEF coordinates to Earth Centered Inertial coordinates. These parameters, utilized in the GUGDCT subroutine, are periodically updated.

System Table #65, GMINOR-GPS Coordinate Transformation Minor Parameters, consists of 6 parameters and a table reload flag. The 6 parameters, periodically updated, although with varying required update frequencies, are utilized in the GUGDCT subroutine in the conversion of GPS data from ECEF coordinates to ECI coordinates.

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #63 - GPERMIT (GPS Limit Parameters)					
0000	E1GWPVAR		C	GUDAT	Limit on GPS positional error variance
0001	E1GWTDIF		C	GUCOEFF	Maximum time difference for new GPS data set
0003	E1GWVVAR		C	GUDAT	Limit on GPS velocity error variance

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #64 - GMAJOR (GPS Coordinate Transformation Major Parameters)					
0000	E1GWDH		V	GUGDCT	Nutation correction to R.A. of Greenwich
0002	E1GWDT		V	GUGDCT	Difference between ephemeris time and universal time corrected for polar motion
0004	E1GWP		V	GUGDCT	Angular coordinates of instanteous North pole relative to adaptive North pole
0006	E1GWQ		V	GUGDCT	Angular coordinates of instantous North pole relative to adaptive North pole

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #65 - GMINOR (GPS Coordinate Transformation Minor Parameters)					
0000	E1GVCW		V	GUECC	Constant used in GPS coefficient computation
0001	E1GWCTO		V	GUGDCT	Constant used in converting from GPS to spacecraft time
0004	E1GWEEK		V	GUGDCT	Time interval between GPS time resets
0006	E1GWRAGO		V	GUGDCT	Initial value of Greenwich Right Ascension
0008	E1GWTRAG		V	GUGDCT	Epoch time for E1GWRAGO computation
0011	E1GWWE		V	GUGDCT	Earth's mean sidereal rotation rate
* 0013	GMINOR+13		F	GCUP	Table reload flag

* NOTE: This entry in the process of being moved to the top of the table

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B.3.6.5 GPS FS Ephemeris Coefficient Update (GCUP) Telemetry

None

B.3.6.6 GPS FS Ephemeris Coefficient Update (GCUP) Flow Charts

See Figures B.3.6-2 thru B.3.6-11.

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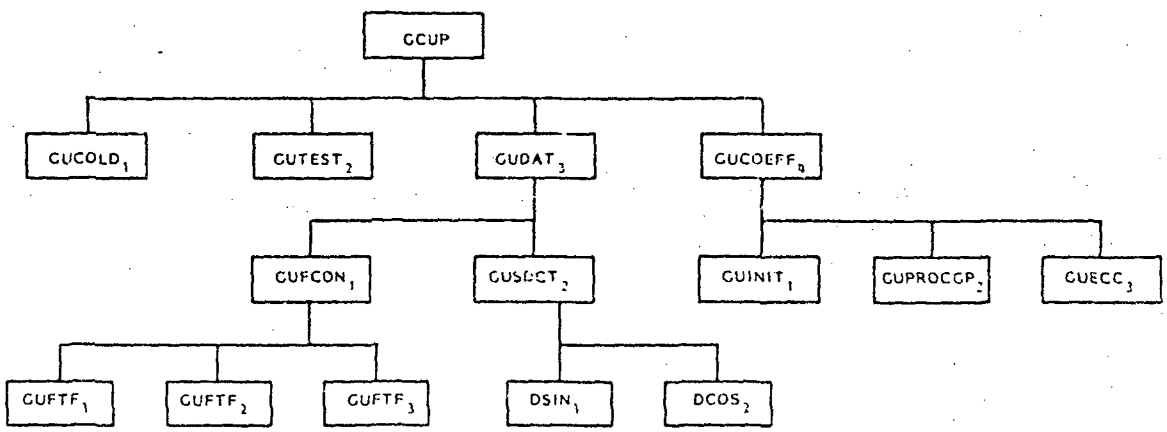

Figure B.3.6-1. GCUP Top Level Diagram

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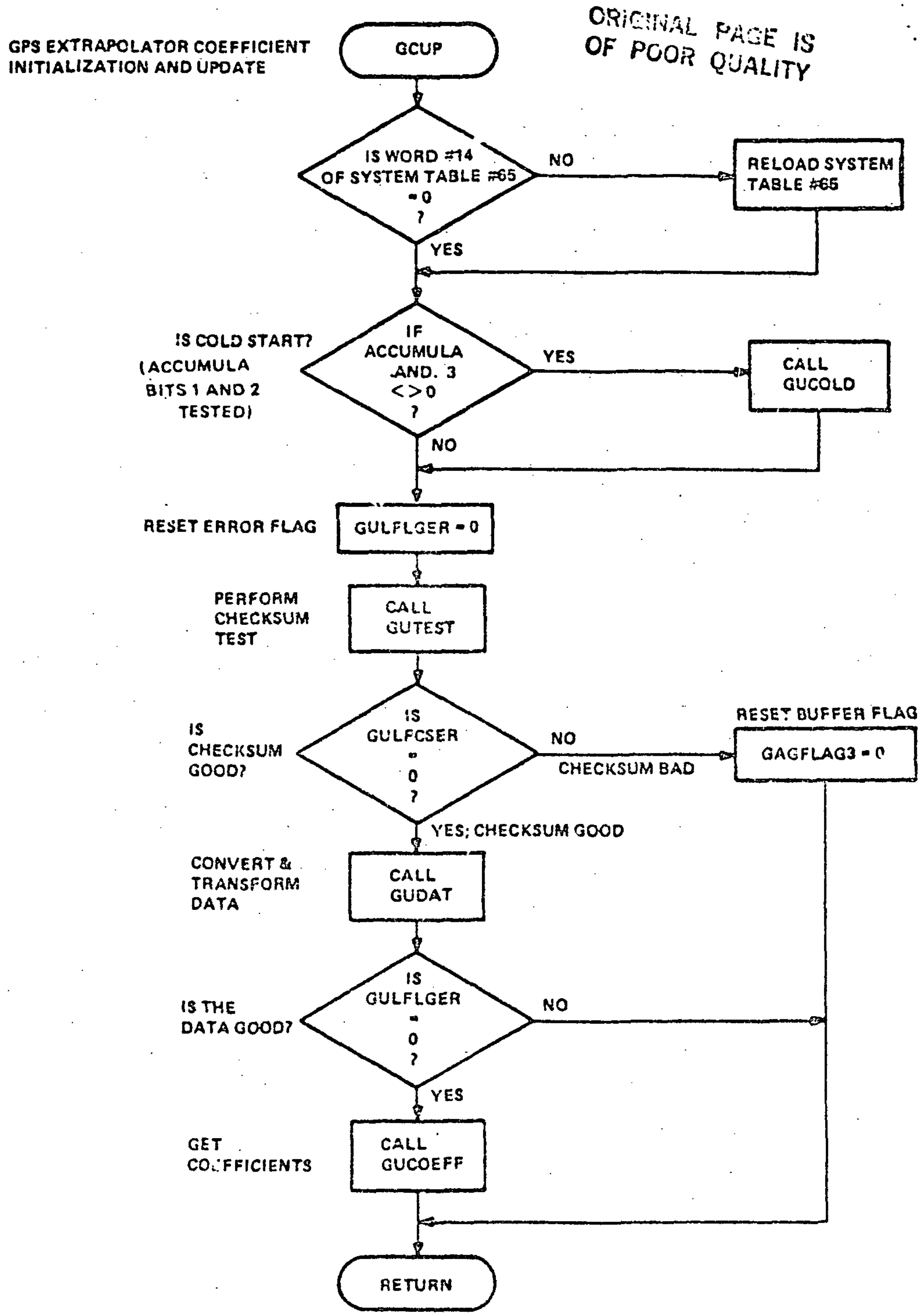

Figure B.3.6-2. GCUP Flow Chart

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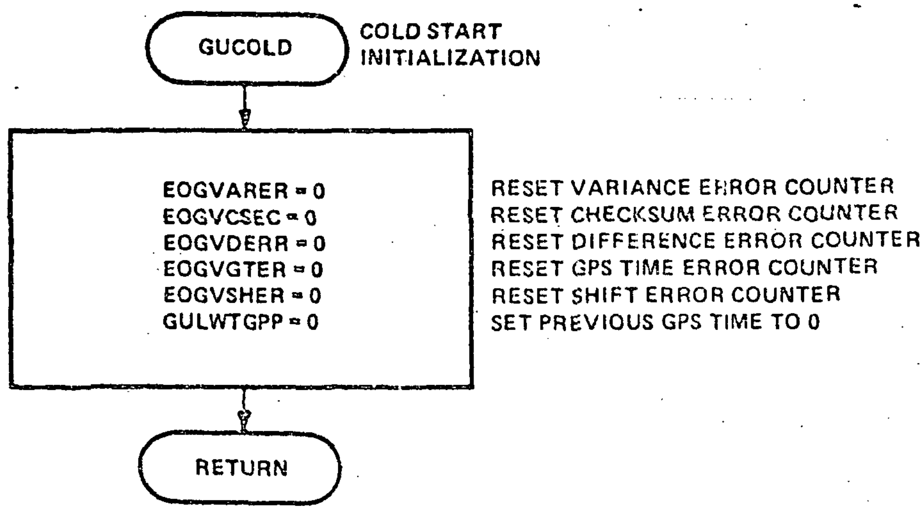

Figure B.3.6-3. GUCOLD Flow Chart

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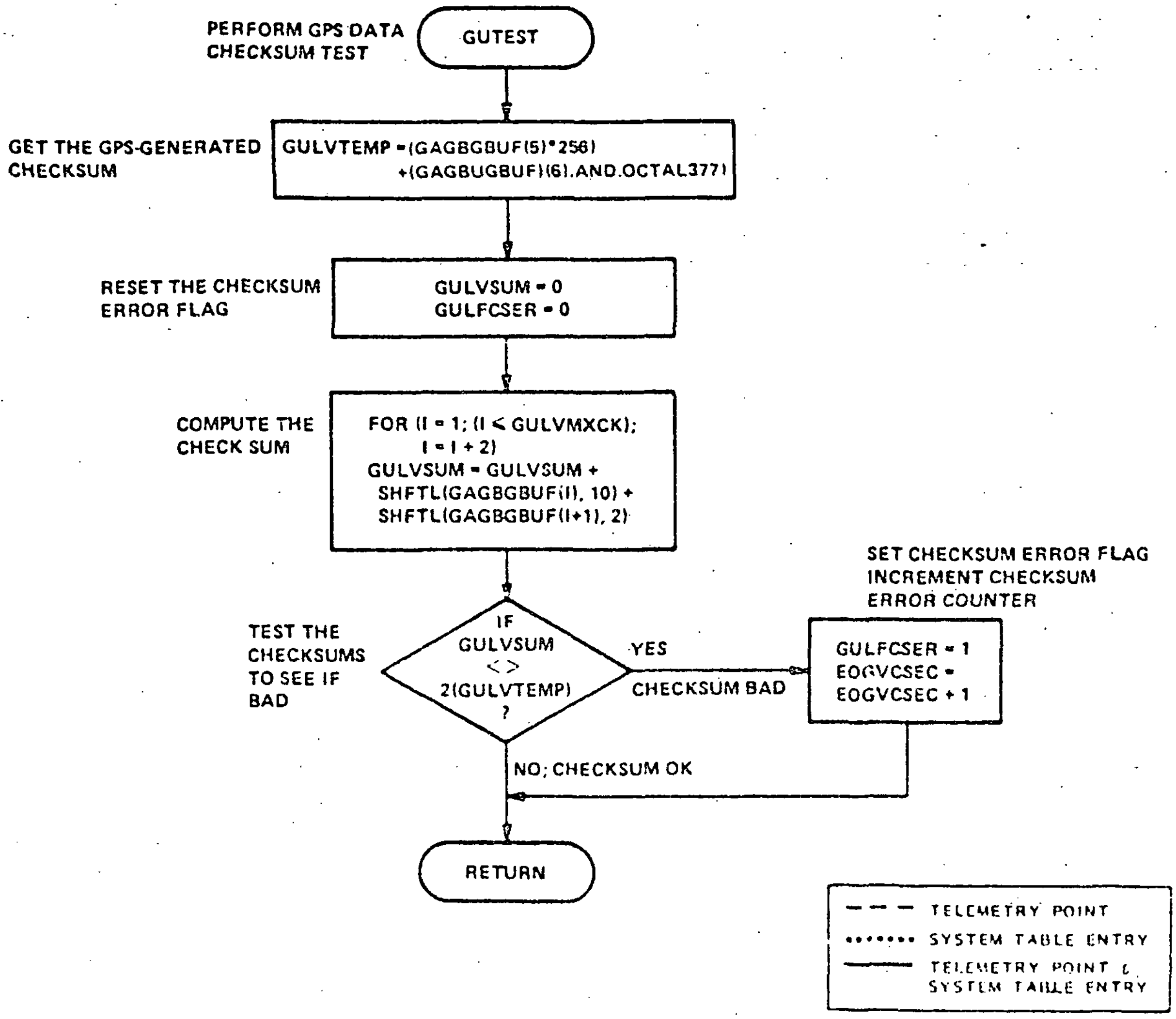

Figure B.3.6-4. GUTEST Flow Chart

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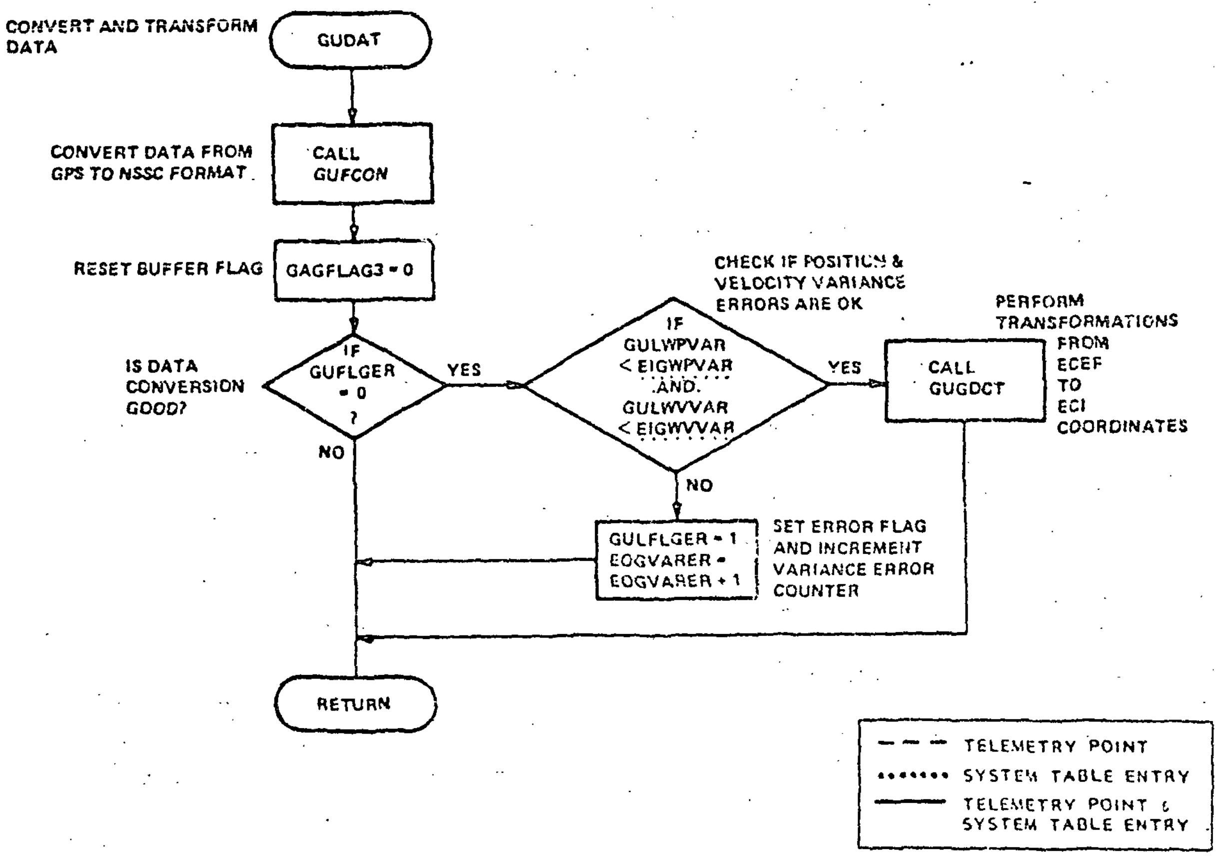

Figure B.3.6-5. GUDAT Flow Chart

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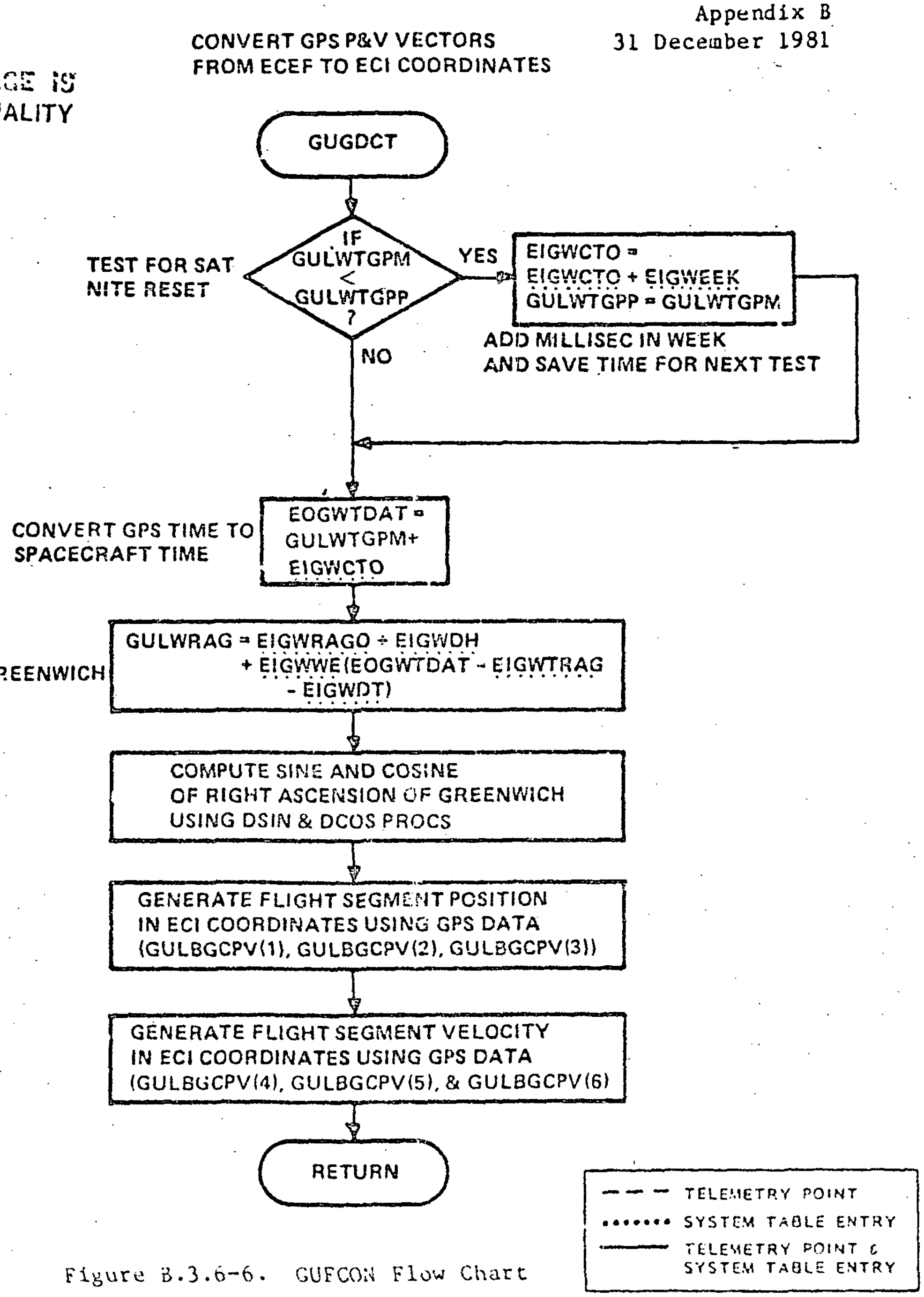

Figure B.3.6-6. GUFCON Flow Chart

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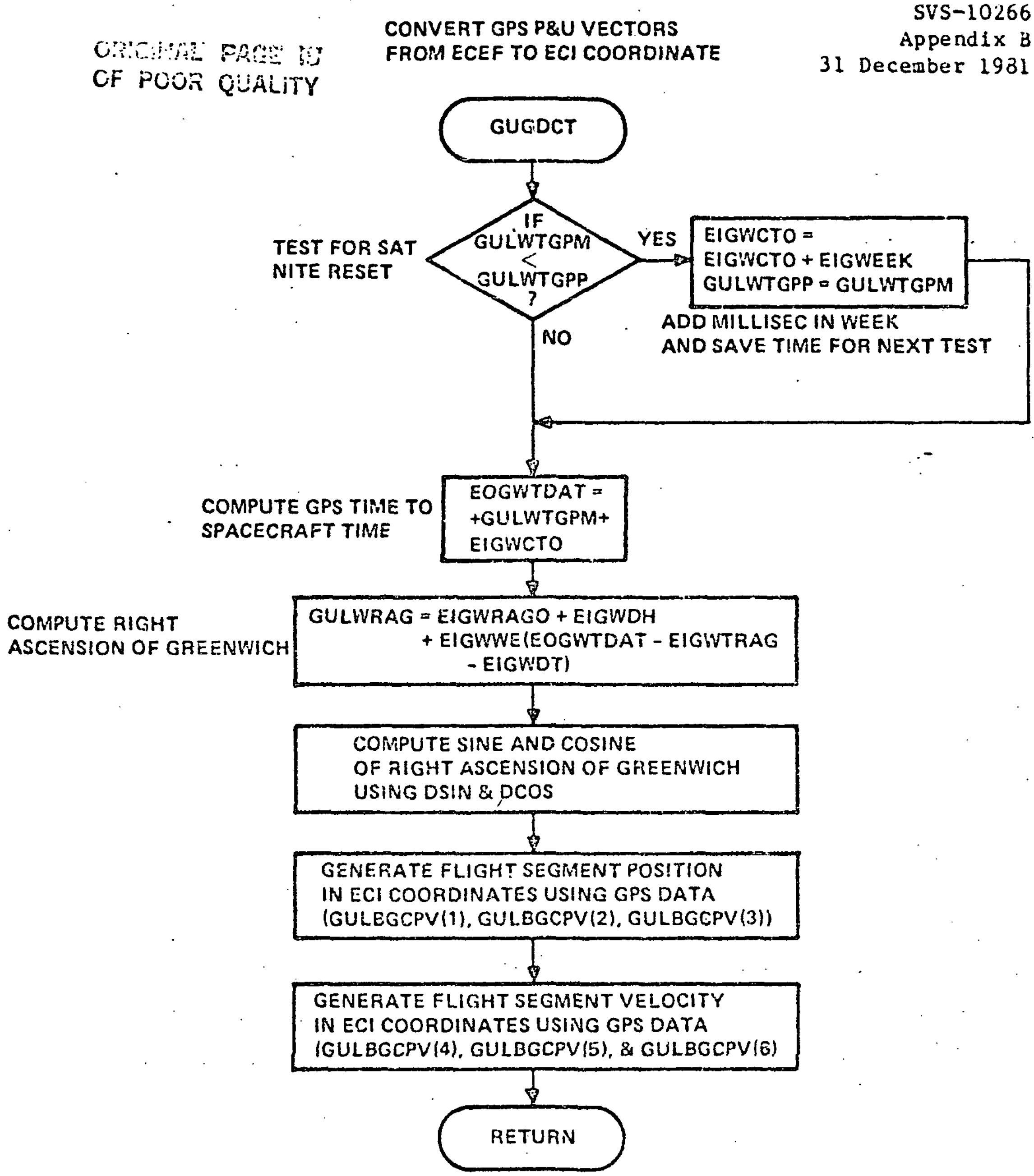

Figure B.3.6-7. GUGDCT Flow Chart

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CALCULATE COEFFICIENTS

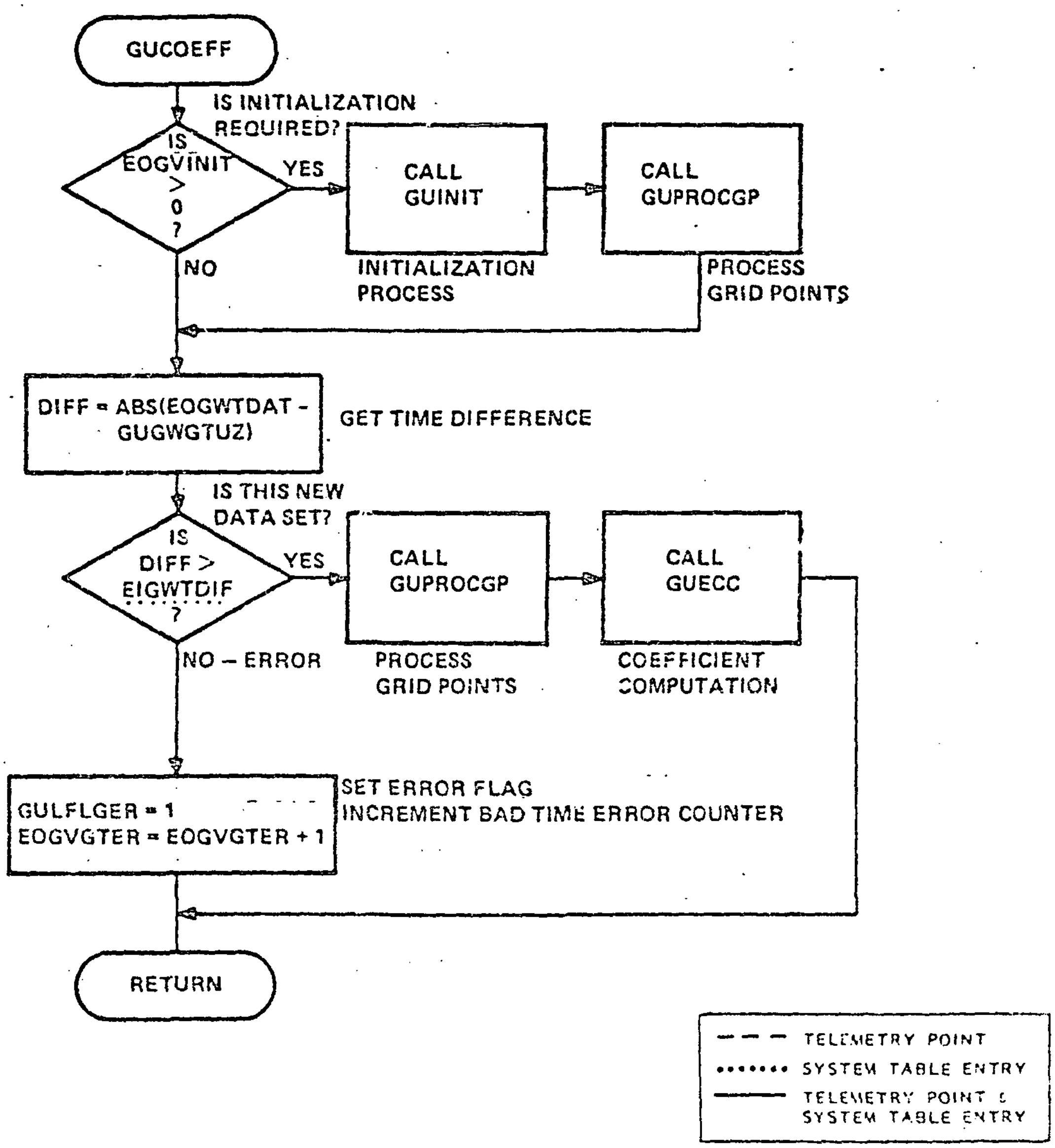

Figure B.3.6-8. GUCOEFF Flow Chart

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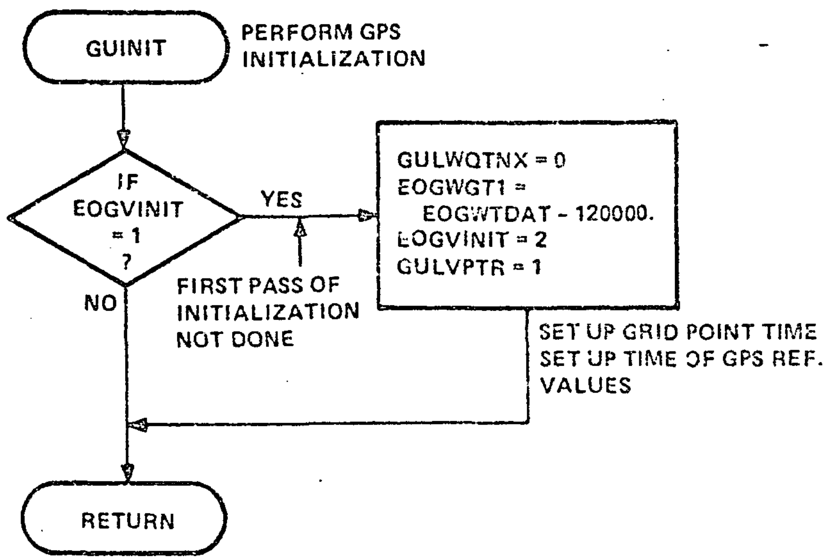

Figure B.3.6-9. GUINIT Flow Chart

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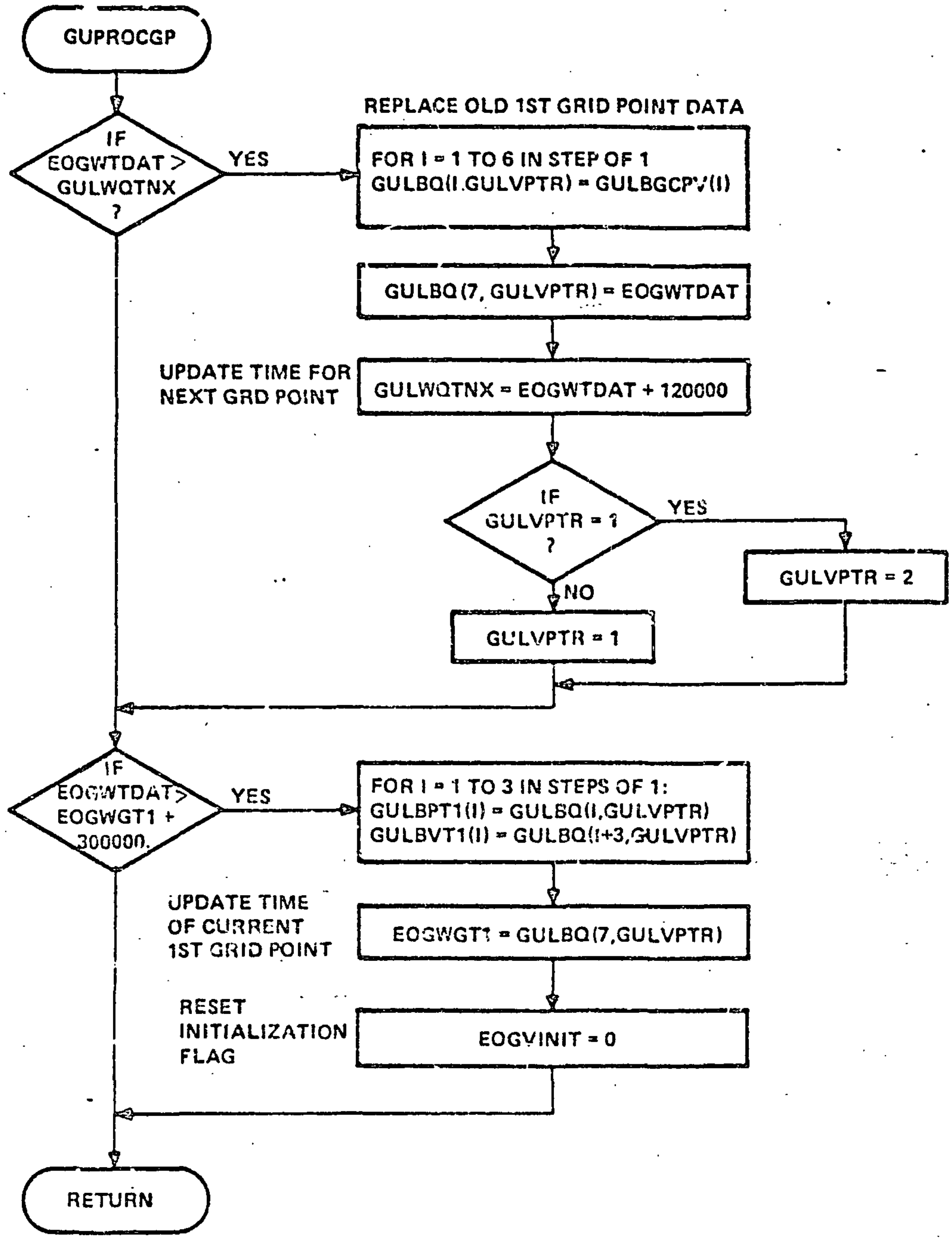

Figure B.3.6-10. GUPROCGP Flow Chart

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GUECC EXTRAPOLATOR COEFFICIENT COMPUTATION

UPDATE SECOND GRID POINT TIME

GUGWGTU2 = EOGWTDAT
GULWGTU = GUGWGTU2-EOGWGTI
GUGWGTUR = $\frac{1}{\text{GULWGTU}}$
CULWKC4 = [(GULWGTU)(EIGVCW)]^4

COMPUTE SECOND GRID POINT EPHEMERIS

FOR I = 1 TO 3 IN STEPS OF 1:
GULBPT2 = GULBGCPV(I)
GULBVT2 = GULBGCPV(I+3)

COMPUTE NEW EXTRAPOLATOR COEFFICIENTS

FOR I = 1 TO 3 IN STEPS OF 1:

GUGBGCU(I,5) = (GULWKC4)(GULBPT2(I))
GUGBGCU(I,4) = 2[GULBPT1(I)-GULBPT2(I)]
- GULWGTU(GULBVT1(I)+GULBVT1(I))
- 2 GUGBGCU(I,5)

GUGBGCU(I,3) = 3[GULBPT2(I)-GULBPT1(I)]
+GULWGTU[2(GULBVT1(I)
+GULBVT2(I)]
+GULGBGCU(I,5)

GUGBGCU(I,2) = GULWGTU(GULBVT1(I))
GUGBGCU(I,1) = GULBPT1(I)
GUGBGCU(I,9) = 4(GUGBGCU(I,5))(GULWGTUR)
GUGBGCU(I,8) = 3(GUGBGCU(I,4))(GULWGTUR)
GUGBGCU(I,7) = 2(GUGBGCU(I,3))(GULWGTUR)
GUGBGCU(I,6) = (GUGBGCU(I,2))(GULWGTUR)

SET THE NEW COEFFICIENTS READY FLAG FOR EPHEMERIS COMPUTATION

GUGFLGUP=2

RETURN

— — — TELEMETRY POINT
••••••• SYSTEM TABLE ENTRY
———— TELEMETRY POINT & SYSTEM TABLE ENTRY

Figure B.3.6-11. GUECC Flow Chart

B.3.7 SPACECRAFT CONTROL PROCESSOR (SCP)

B.3.7 SPACECRAFT CONTROL PROCESSOR (SCP)

B.3.7.1 Spacecraft Control Processor (SCP) Processor Description

The SDTECT processor enables SCP once SDTECT detects that one of the two separation detection switches (A or B) is closed. SCP, whose processor # and priority # equal 5, is then executed every 256 msec.

SCP initiates and controls the execution of the three subprocessors, APCM, EPHEM and ACS:

	Execution Frequency	Processor #	Priority #
APCM	- 256 ms	7	5
EPHM	- 512 ms	6	5
ACS	- 512 ms (normal) 256 ms (orbit adjust)	8	5

SCP uses computer data and the processed gyro data output by GYROD. GYROD is scheduled for execution by the Executive Scheduler Table (EST) every 64 ms on entry slot numbers 2, 6, 10, 14, etc. Therefore, SCP is scheduled immediately after GYROD, on entry slot numbers 3, 19, 35 and 51.

Other SCP functions include the calculation and resetting of flight software time, the collection of a common computer data sample for use by APCM, EPHEM, and ACS, the formatting and commanded output of payload correction data, and the collection and formatting of a computed data buffer for use by the Update Filter. The 11 subroutines that comprise the SCP processor are shown below:

- SCP - SCP Main Routine
- COMPDSAV - Computer Data Save Processing
- GYCMPFD - Gyro Difference Processing
- PCD - Payload Correction Data Processing
- PCDF8 - PCD 8-bit CMD Formatting Processing
- PCDF32 - PCD 32-bit CMD Formatting Processing
- FSTIME - Flight Software Time Update Processing
- DPUDCODE - DPU Time Dividing Processing
- DPUCONVT - DPU Time Conversion Processing
- TFRESET - DPU/FST Synchronization Processing
- MVUFDATA - Update Filter Data Save Processing

B.3.7.2 Spacecraft Control Processor (SCP) Processor Operation

B.3.7.2.1 SCP Main Routine

The flowchart shown in Section B.3.7.6 describes the detailed software operation of SCP. Each time SCP is executed it calls COMPDSAVE and APCM. The current minor frame and executive scheduler table slot number determines which of the other subprocessors and subroutines will be activated during each cycle:

1. If the present operation is in the normal mode (i.e., MODE = 4 and ICAL = 3), then the ground must set the system table input PCDFLAG to 0. PCD is then called to format and output PCD data.

2. If the present minor frame number is 3, 35, 67 or 99, SCP loads a bit pattern into word TREPORTS to indicate that TLM reports from APCM, EPHEM and TDRS are needed and should be formatted and stored into the TLM buffer.

3. If the present executive slot number is 3 or 35, SCP calls FSTIME, EPHEM and ACS. ACS is also called if MODE = 7. After ACS is executed, SCP calls the flight executive to retrieve the primary and redundant converted resolver pulses from TDRS's RIU #9A or #9B and put the data into the computer data. The ground must indicate which RIU is to be used by setting the system table input RPERIU. SCP will then call MVUFDATA if the Update Filter (UFLTR) has requested data.

B.3.7.2.2 COMPDSAV/GYCMPFD

These routines are described by the flowchart shown in Section B.3.7.6. COMPDSAV is called by SCP to save a common sample of computer data in buffer SCDBUF to be used by the subprocessors EPHEM, ACS and APCM. This is necessary since the computer data stored in UCDBUF is updated every 64 msecs for GYROD. If ACS is to be called during the present SCP cycle, then the filtered and unfiltered gyro data from GYROD processor is differenced by COMPDSAV and GYCMPFD, respectively. COMPDSAV computes the difference between the past and present filtered gyro data for each of the three (3) axis currently in use. The output data GYDIF is used by ACS. GYCMPFD computes 6 gyro differences from the raw data formatted by GYROD (i.e. two (2) channels per each of the three (3) gyros). Its output WGD is used by the subroutine GYROFD (Gyro Failure Detection).

If UFLTR requests data, then COMPDSAV will save a subset of the computer data found in UCDBUF and store it in the UFLTR buffer, UFCDBUF.

B.3.7.2.3 PCD

If the spacecraft is in normal operating mode, this routine, flowcharted in Section B.3.7.6, is executed every 256 msec. It performs one of nine actions depending on the current minor frame number. It may format data using either the PCDF8 or PCDF32 formatting routine. Or it may request that commands be added to the low priority executive command stack. These commands will then be sent to the PCD formatter to output attitude, ephemeris, TM TLM or gyro drift data in subcom word F2 of the PCD Format.

B.3.7.2.3.1 PCDF8. The PCD 8 bit data formatting routine, flowcharted in Section B.3.7.6, is used to format TM data and TLM spare data that has been stripped out of the realtime TLM format or computer data by the OBC. Consecutive 8 bit words located in the input buffer are packed into one 16 bit command in the output buffer.

B.3.7.2.3.2 PCDF32. The PCD 32 bit formatting routine, flowcharted in Section B.3.7.6, formats attitude, ephemeris and gyro drift data. This routine formats 32 bit double precision words into 2 16 bit commands. The 32 bit words have been compressed from 36 bit OBC double precision words by dropping the second sign bit and the three (3) least significant bits.

B.3.7.2.4 FSTIME/DPUDCODE/DPUCONVT/TFRESET

The FSTIME routine, flowcharted in Section B.3.7.6, is called by SCP to update the Flight Software Time (TF) by 512 msecs, only if the present executive slot number is 3 or 35. If minor frames 0 - 7 are in the minor frame buffer, subroutine DPUDCODE (see Section B.3.7.6) is called to unpack and validate the DPU time code words from the subcommutator buffer. Any errors detected are accumulated in word FSDCDSTS. For example, if an error is detected when decoding the number of hundreds of days, bit 12 of FSDCDSTS (written FSDCDSTS<12:12>) is set to 1. The ground will be notified of any decoding error by two words, DPUDCERR and FSDPUSTS, found in telemetry report number 11. DPUDCERR is the number of DPU decode errors and FSDPUSTS<1:1> = 1 is a flag to signal a decode error has occurred.

If the BCD digits are valid, subroutine DPUCONVT (Section B.3.7.6) is called to convert the decoded digits into a triple precision word, TDPU, which represents the total number of msecs. The time of the last computer data read is then calculated in the routine FSTIME by the formula

TDPU = TDPU + 36 + 8192 *(2**-TMRATE)

where

TMRATE = 3 for TLM rate 8kbps
= 0 for TLM rate 1kbps

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For a 8kbps TLM rate, this equation becomes:

TDPU = TDPU + 36 + 1024

which is illustrated in the following timeline:

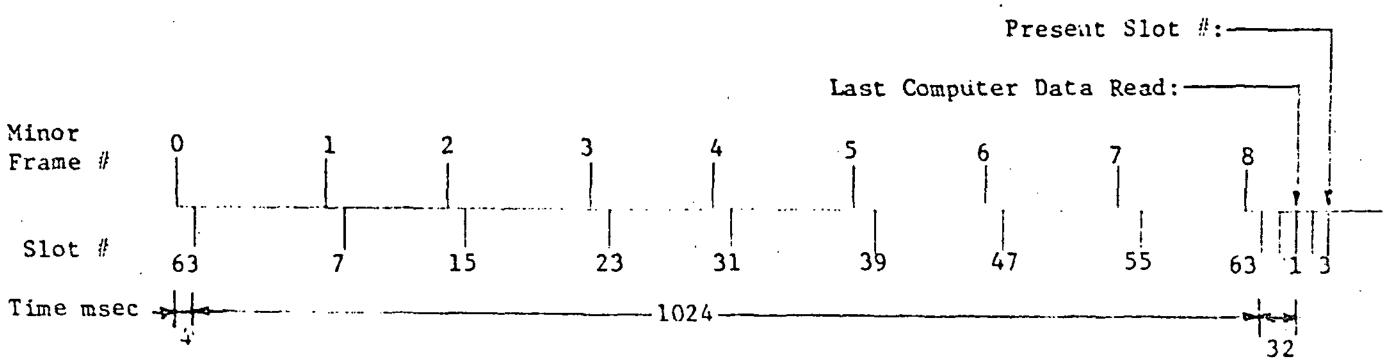


Figure B.3.7-1. Timeline to Calculate Last Computer Data Read

The difference, TDELTA, between this DPU time and the present TF time is then calculated and sent down in the TLM stream. It is then tested to determine whether or not it lies within the limits, TMIN and TFOX. If it does, then TF is automatically reset to the DPU time. A counter, TFRESET, and a status bit, FSDPUSTS<3:3>, are updated to reflect the action and put in TLM along with the TF.

If TDELTA is greater than the upper limit, TFOX, the ground is notified by telemetry status word FSDPUSTS<2:2>. The ground must then decide whether or not to allow the large time difference to be resynched by setting the system table entry USEDPU to a 1 or 0, respectively.

If TDELTA is less than TMIN, the time difference is insignificant and TF is not reset to DPU time.

B.3.7.2.5 MVUFDATA

This routine, flowcharted in Section B.3.7.6,, is called by SCP if UFLTR requests data from SCP. SCP contains a list of 24 addresses that corresponds to the data items located in the buffer for UFLTR (i.e., UFCDBUF). The subroutine COMPDSAVE moves 16 of these words into UFCDFUB. The remaining words are placed into the buffer by MVUFDATA. The SCP list of addresses includes the following 24 words:

1. Raw star tracker data (12 words) - moved by COMPDSAVE
2. Euler parameters (8) - moved by MVUFDATA
3. Magnetometer Data (3) moved by MVUFDATA
4. Magnetic torquer commands (3) moved by MVUFDATA
5. Angular Rates (3) moved by MVUFDATA
6. Flight Software Time (3) moved by MVUFDATA
7. Orbit Position Data (4) moved by MVUFDATA
8. FSS Data (4) - moved by COMPDSAVE

B.3.7.3 <u>Spacecraft Control Processor (SCP) Software Constraints</u>

The ground must set the system table word PCDFLG to 0 when the PCD subroutine is to be executed (i.e, when MODE=4 and ICAL=3).

B.3.7.4 <u>Spacecraft Control Processor (SCP) System Tables</u>

The SCP processor uses the data items found in system table number 25 which is called SCPCTLTB. For system table load format, see DFCB Volume III CMD.

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #25 (SCPCTLTB)					
0	PCDFLAG		F	SCP	SCP will format and write PCD data if MODE=4 and ICAL=3 0=format & write PCD data 1=don't process PCD subroutine
1	RPERIU		C	SCP	WBCS RIU - nominal RIU #9A. This RIU is used to obtain the converted primary redundant resolver pulse data which is to be put in the computer data. Switched to RIU #9B if #9A no longer functions properly
2	USEDPU		F	FSTIME	Ground must monitor TDELTA in OBC TLM report #11 and decide if it will accept the large TDELTA 0=don't reset TF 1=large TDELTA can reset TF
4	TFOX		C	FSTIME	Upper bound on TDELTA for unconditional TF resets
7	TMIN		C	FSTIME	Lower bound on TDELTA for unconditional TF resets. If TDELTA is below this limit TF is not reset.

B.3.7.5 Spacecraft Control Processor (SCP) Telemetry Reports

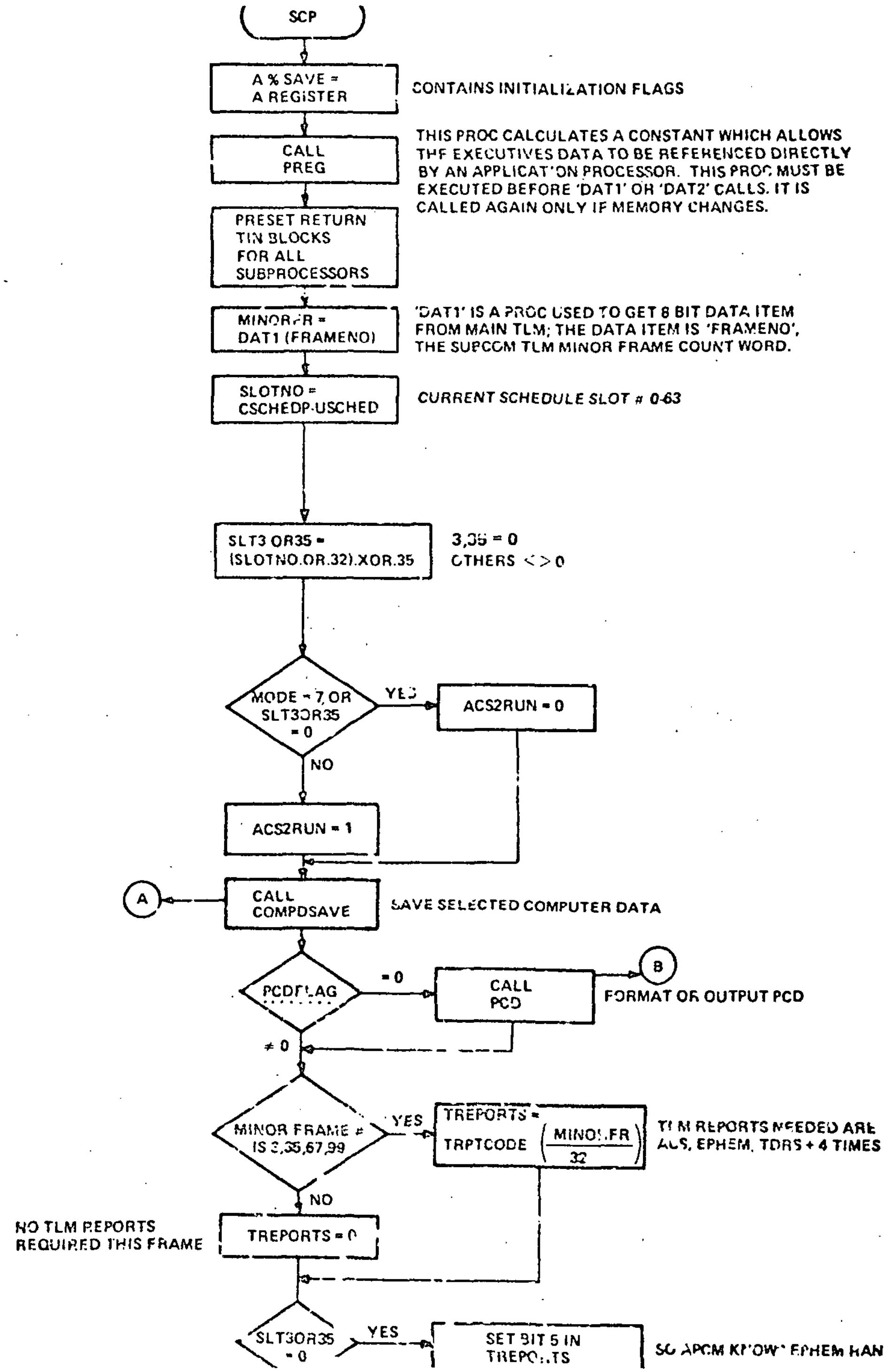
The status of the SCP execution is contained in OBC TLM Report number 11 whose mnemonic is ACS 11. The report occurs in TLM minor frames 30, 62, 94, and 126. The first word (word 0) is output in column 35 and gives the report number. The remaining words are output in columns 91-95 and 108-127.

A telemetry alarm, FSDPUSTS<1:1> = 1, will occur if an error is found when decoding the DPU time. Another alarm, FSDPUSTS<2:2>=1, will occur if the difference, TDELTA, of the present TF and the DPU of the most recent computer data read is greater than the maximum limit, TFOX.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #11 - ACS 11			
1	TF	FSTIME or FSRESET	Flight Software Time - it is updated every 512 msec when executive slot number is 3 or 35. It is reset to DPU time when minor frame 7 is in the minor frame buffer if TDELTA is within the limits TMIN and TFOX or if the ground allows the update.
7	TDELTA	FSTIME	Difference between TF and DPU time
13	DPUDCERR	FSTIME	Counter of the number of DPU decode errors
14	FSDPUSTS	FSTIME or FSRESET	Flight software time computation status word: FSDPUSTS<1:1> - DPU decode error * FSDPUSTS<2:2> - Large TDELTA * FSDPUSTS<3:3> - TF reset to TDPU 0 = NO, 1 = YES
15	TFRESET	FSRESET	Counter that indicates the number times that TF has been reset to TDPU

*TLM ALARM

B.3.7.6 Spacecraft Control Processor (SCP) Flow Charts



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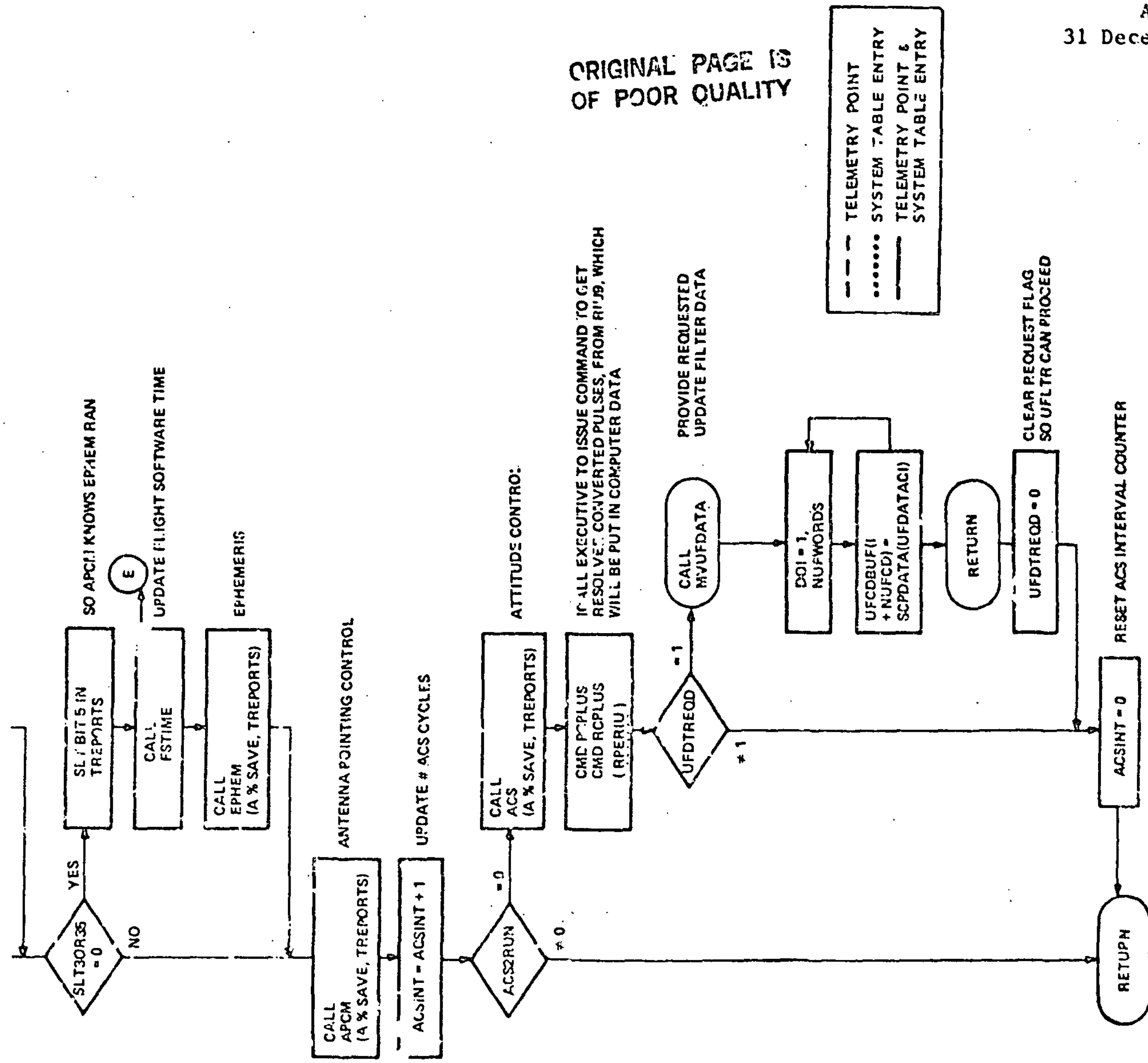

Figure B.3.7-1 SCP & MVUDATA Flow Chart

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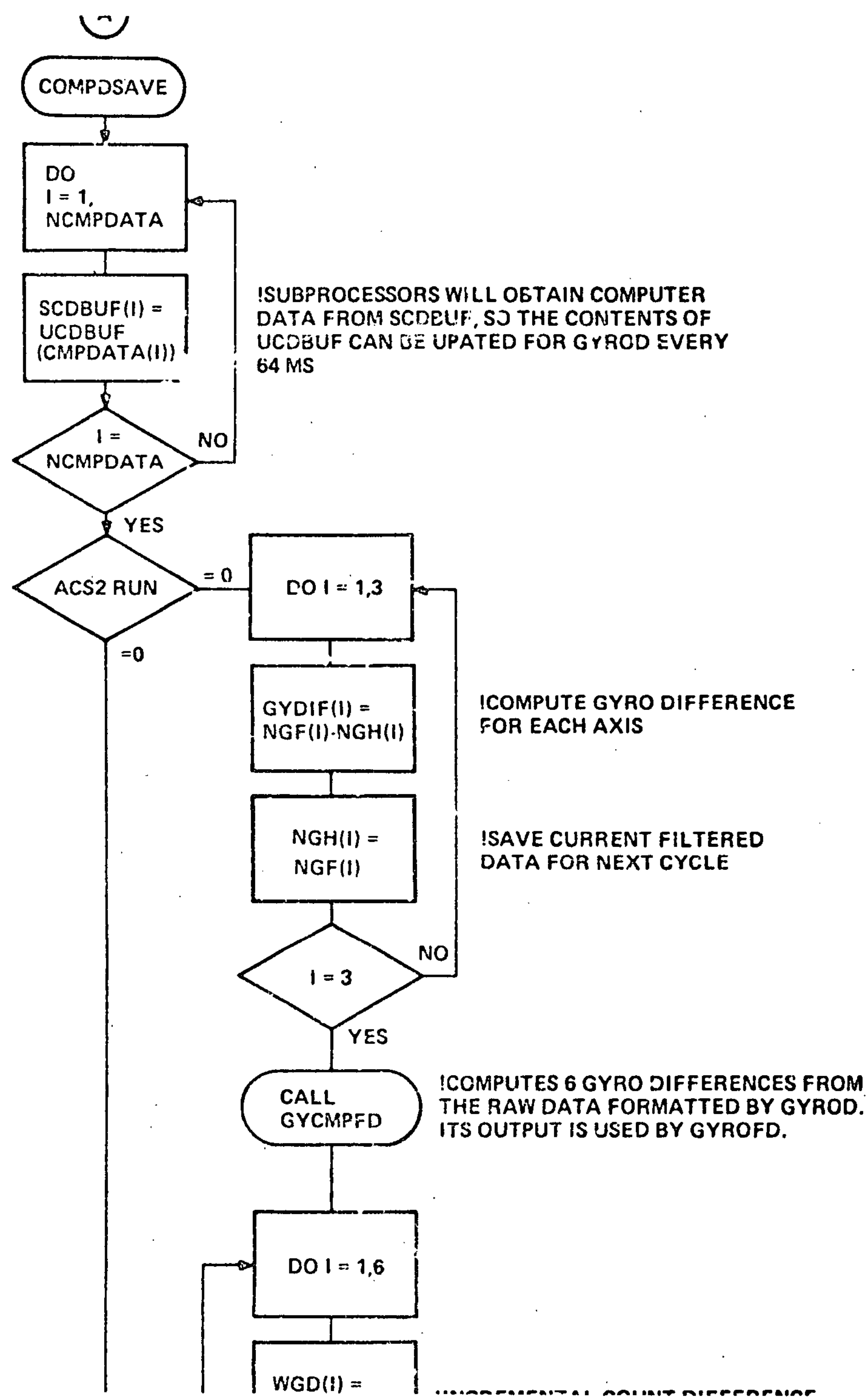

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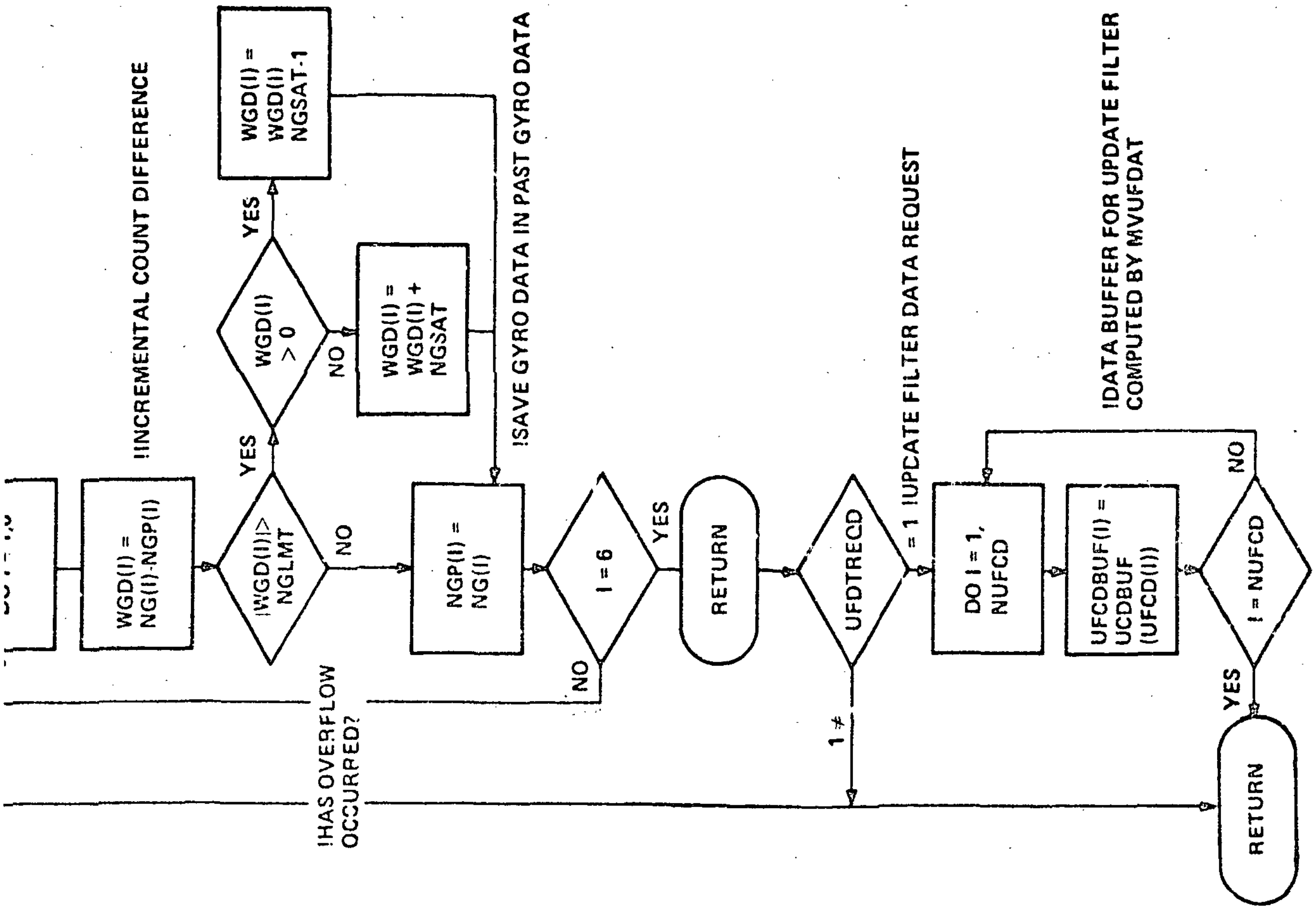

Figure B.3.7-2 CMPDSAV & GYCMPFD Flow Chart

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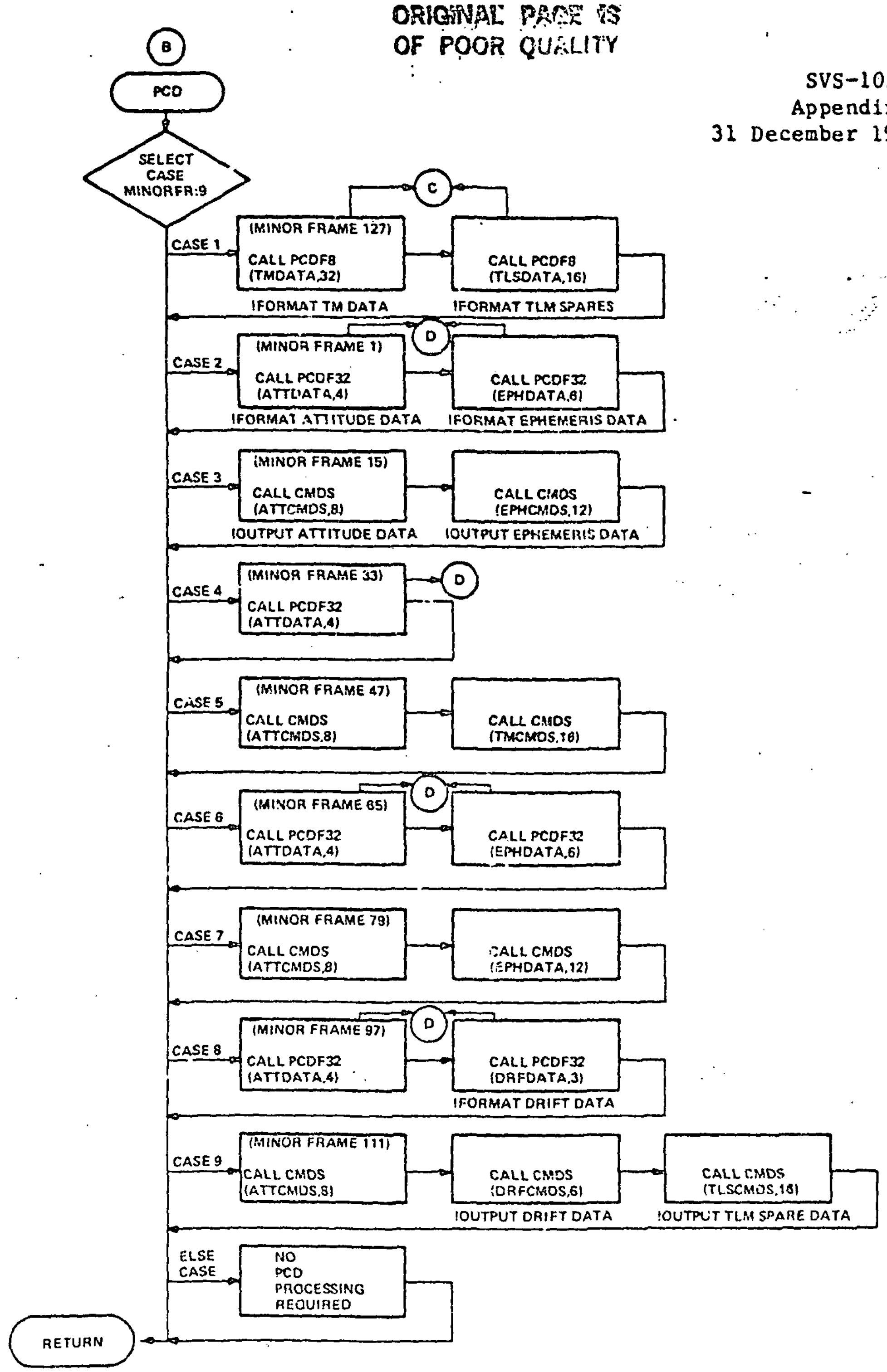

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Figure B.3.7-3. PCD Flow Chart

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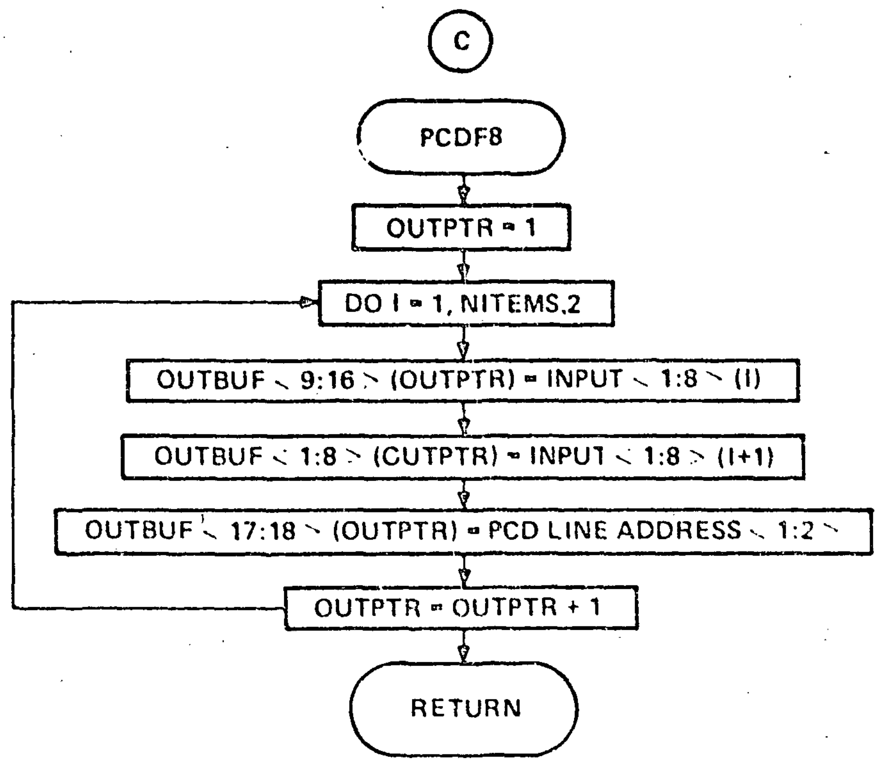

Figure B.3.7-4. PCDF8 Flow Chart

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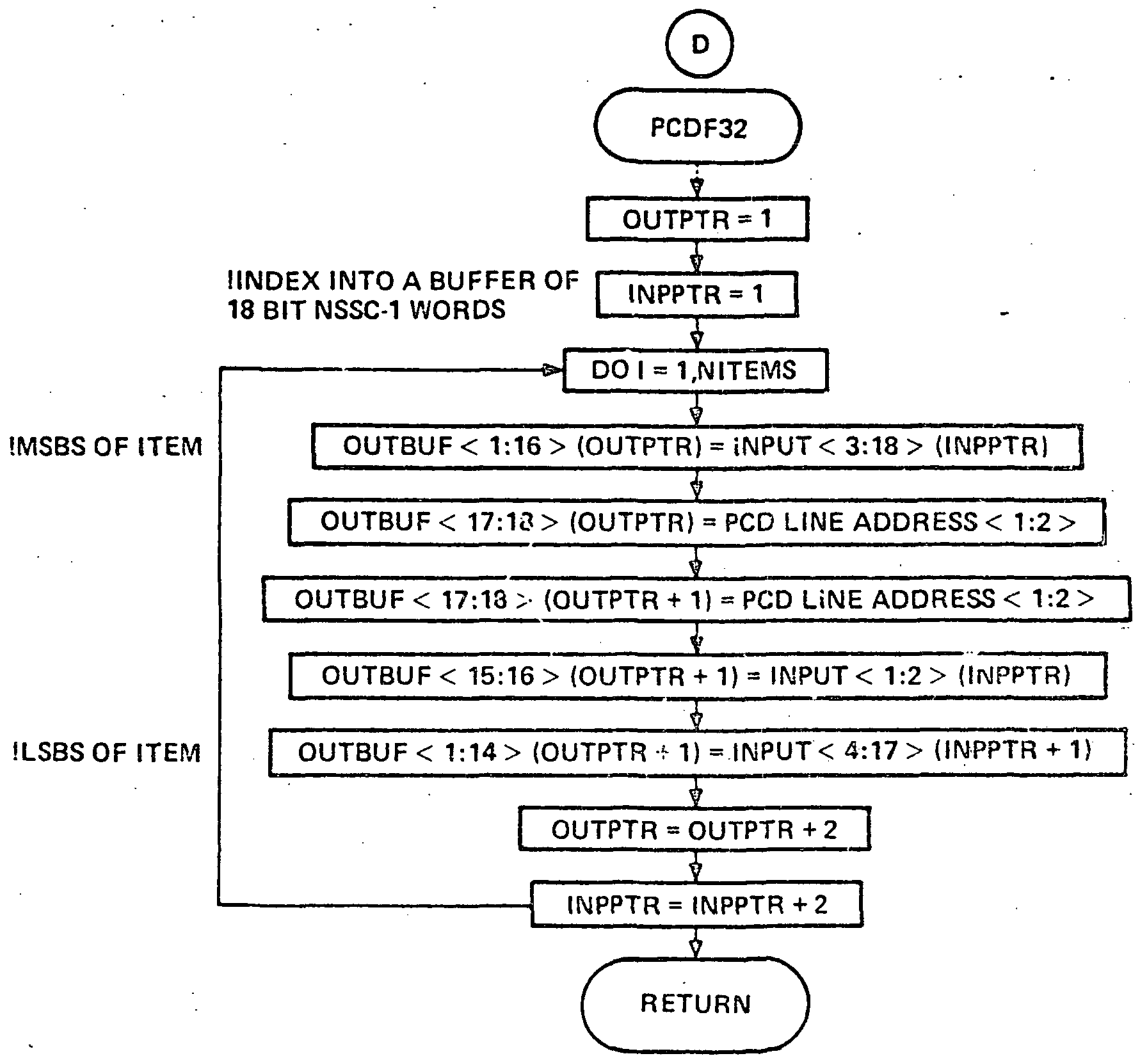

Figure B.3.7-5. PCDF32 Flow Chart

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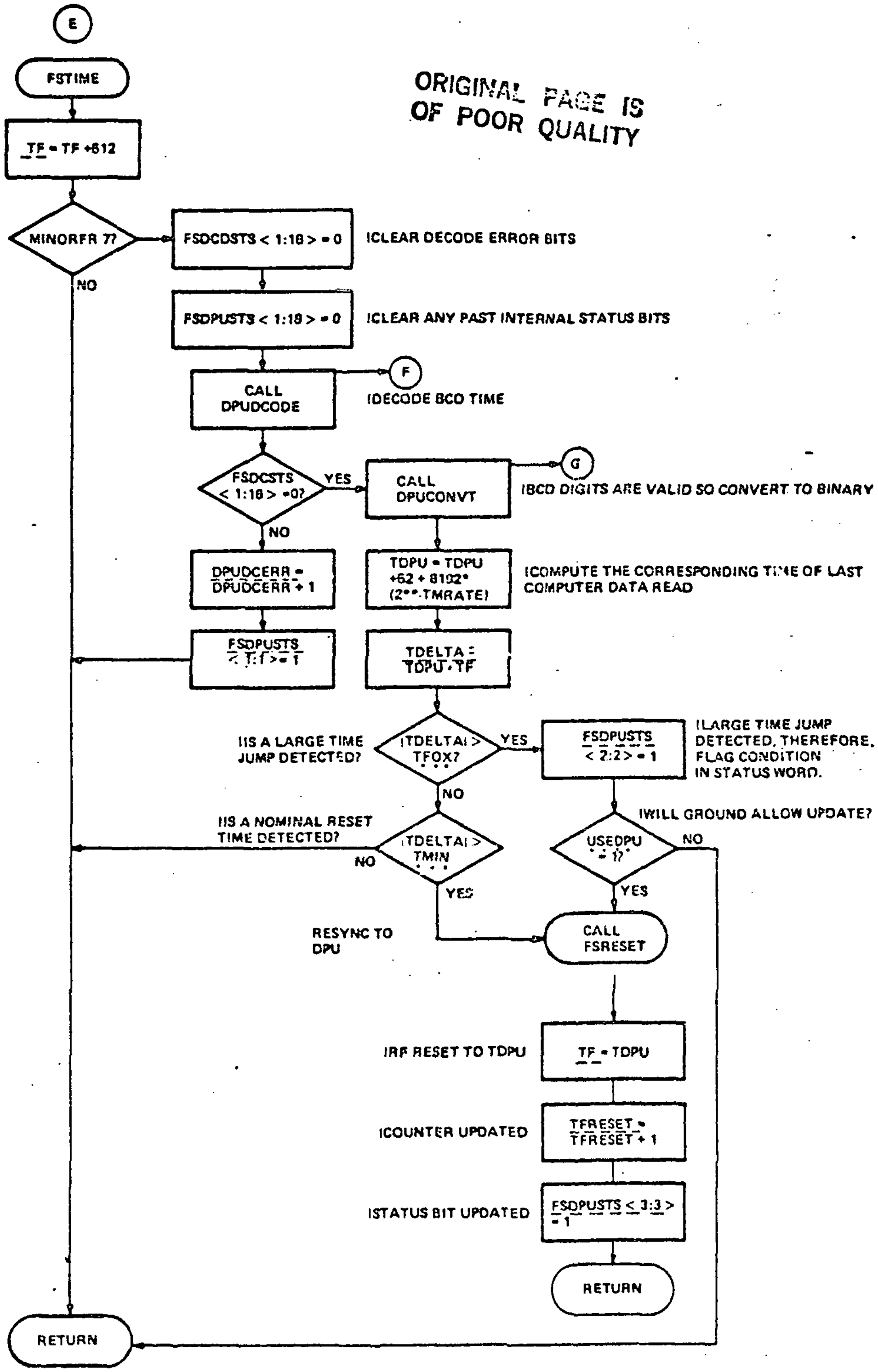

Figure B.3.7-6. FSTIME Flow Chart

— — —	TELEMETRY POINT
•••••••	SYSTEM TABLE ENTRY
———	TELEMETRY POINT & SYSTEM TABLE ENTRY

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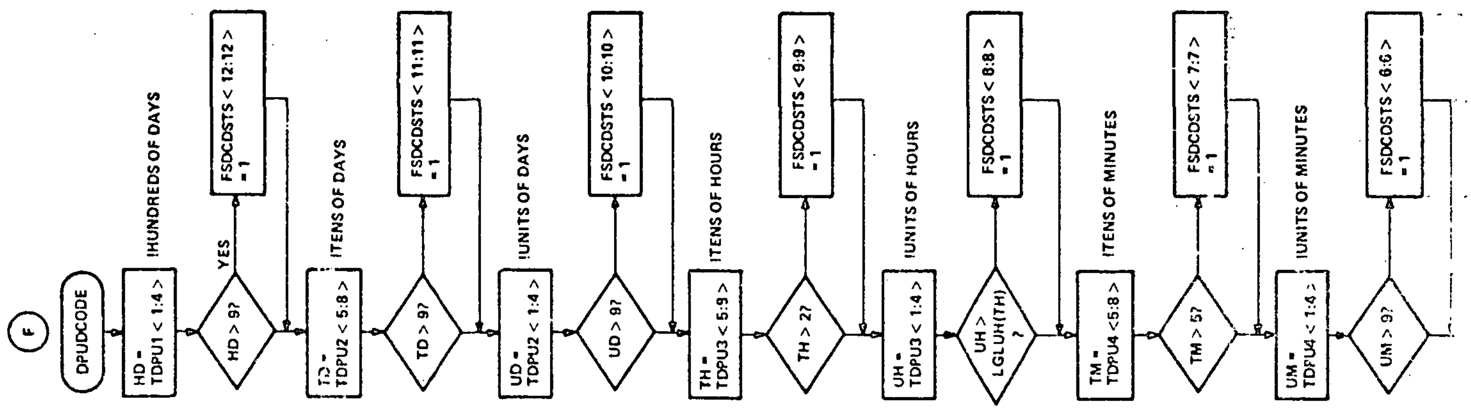

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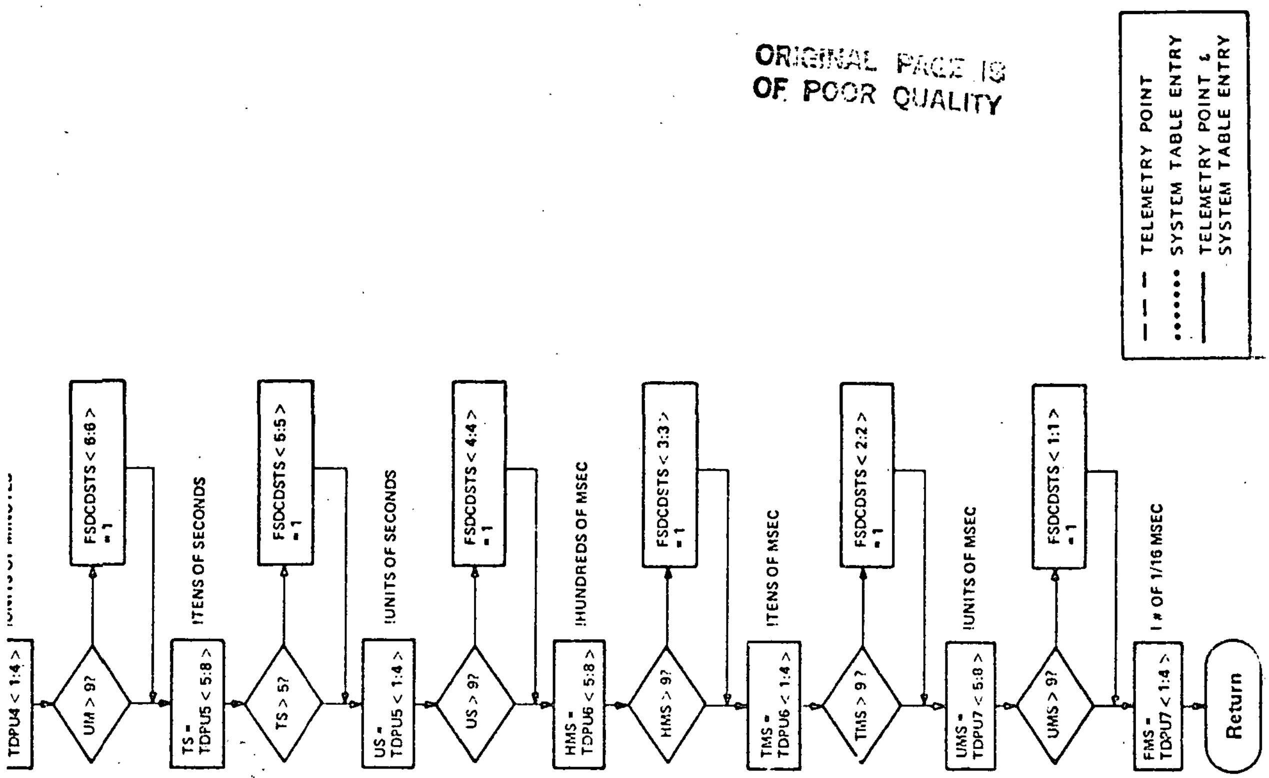

Figure B.3.7-7 DPUDCODE Flow Chart

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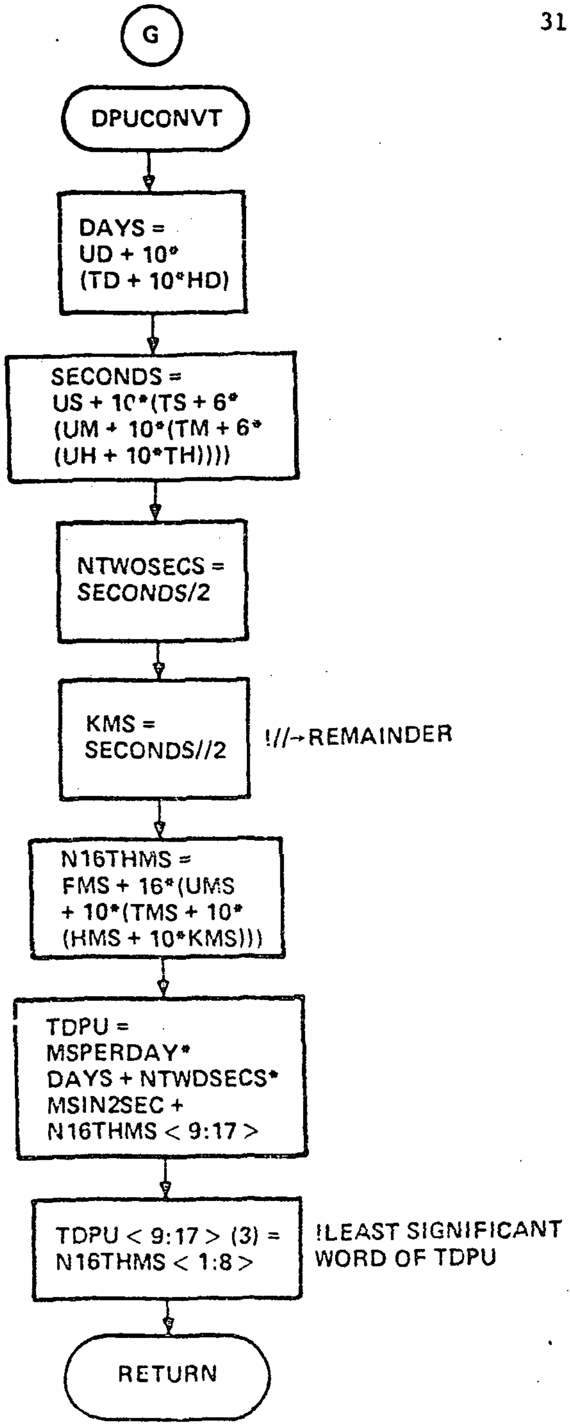

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Figure B.3.7-8. DPUCONVT Flow Chart

B.3.8 EPHEMERIS COMPUTATION (EPHEM)

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B.3.8 EPHEMERIS COMPUTATION (EPHEM)

B.3.8.1 Ephemeris Computation (EPHEM) Processor Description

The Ephemeris Computation (EPHEM) processor determines the Landsat-D Flight Segment position and velocity and TDRS East and/or West position, as desired. Polynominal interpolation or extrapolation techniques are used to compute the desired ephemeris at the specified time points. EPHEM determines FS position and velocity using coefficients generated in the UCUP processor. These coefficients are based on uplinked OBC parameters and/or GPS receiver data. The data source(s) to be used are specified by the Ground Segment. TDRS East and/or West ephemeris is computed utilizing coefficients generated by the TCUP processor which is based on uplinked OBC parameters. The EPHEM processor then generates OBC Telemetry Reports 13 through 19 which present ephemeris data. These are discussed in detail in Section B.3.8.5.

The Ephemeris Computation (EPHEM) processor is a foreground processor called by the Spacecraft Control Processor (SCP), and is nominally executed every 0.512 seconds, or twice every computer major cycle. The SCP calls the EPHEM processor every other time it is executed. EPHEM has a priority of 5.

The EPHEM processor consists of 8 subroutines and a control function, EPHEM. These subroutines are delineated in Table B.3.8-1 and discussed in detail in Section B.3.8.2, with detailed flowcharts presented in Section B.3.8.6. The processor is diagramed in Figure B.3.8-1.

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Table B.3.8-1. Ephemeris Computation (EPHEM)

Number:	6
Type:	Foreground
Priority:	5
Period:	0.512 seconds
Function:	Determination, at a given point in time, of Flight Segment position and velocity (from uplinked OBC parameters and/or GPS data) and position of both Tracking and Data Relay (TDRS) Satellites scheduled by SCP.

Subroutines:

ECCOLD	Cold start initialization
ECFSBLD	Testing and processing uplinked FS coefficients
ECFCALC	Computation of position and velocity for flight segment from uplinked data
ECGPBLD	Rebuild of GPS extrapolator coefficients
ECGCALC	Computation of GPS FS ephemeris
ECTDBLD	Testing and processing of TDRS coefficients
ECTCALC	Computation of TDRS position components
ECTELEM	Format data and output to telemetry

System Tables:

#	Mneumonic	Type	# Words	Description
31	EPERMIT	Variable	5	Processing Permitted Flags
32	EPARAM	Constant	13	Ephemeris Parameters

Telemetry Reports: OBC Reports 13 through 19

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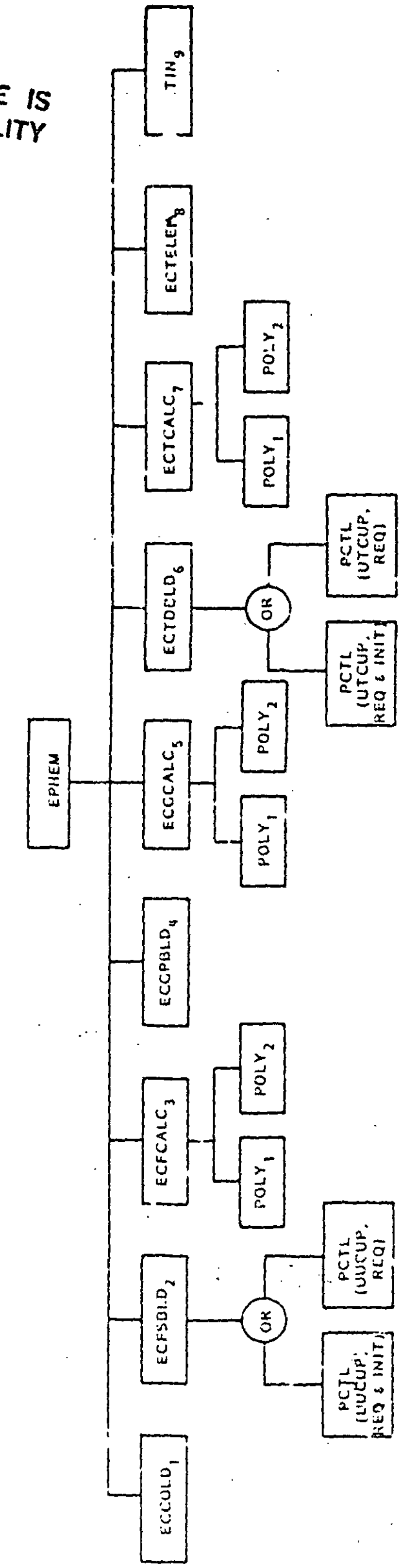

Figure B.3.8-1. EPHEM Top Level Diagram

B.3.8.2 Ephemeris Computation (EPHEM) Processor Operation

B.3.8.2.1 EPHEM

The EPHEM control function first checks to see if the processor has to be initialized, and if so, calls the subroutine ECCOLD. It then checks whether FS ephemeris processing from uplinked OBC parameters, FS ephemeris processing from GPS data, and TDRS ephemeris processing from uplinked OBC parameters are permitted. If processing is permitted for the particular ephemeris, two routines are called by EPHEM. One routine is used to rebuild the coefficients table with new values and the other routine performs the calculations which determine the final ephemeris components. The two routines for the uplinked FS ephemeris are ECFSBLD and ECFCALC, for GPS FS ephemeris are ECGPBLD and ECGCALC, and finally for uplinked TDRS FS ephemerides are ECTDBLD and ECTCALC. If the check fails for the particular ephemeris, EPHEM ignores the calls to the routines mentioned above. The final process to be performed is to output the Telemetry data by calling ECTELEM.

B.3.8.2.2 ECCOLD

ECCOLD sets flags regarding coefficient sources (UCUP, TCUP, and GCUP) and sets upper grid times to zero for both the Flight Segment and TDRS, and returns to the control function.

B.3.8.2.3 ECFSBLD

ECFSBLD checks for new uplinked FS OBC parameters. If spacecraft time exceeds the new data start time, ECFSBLD sets the flag FUGFLGUP=2 to tell the background module (UCUP) to move this data to the working area. ECFSBLD also requests the execution of the background rpocessor UCUP. ECFSBLD replaces old interpolator coefficients with new from the slow loop module UCUP. In order to perform this task, the following two conditions must be met - the software time must exceed the fit intervale upper time limit and new coefficients must be available (flag FUGFLGUP=3). These new coefficients replace the old coefficients and th fit interval is advanced by the grid inteval time. Finally, the new coefficients ready flag (FUGFLGUP) is set to 4 for the slow loop module UCUP.

B.3.8.2.4 ECFCALC

ECFCALC computes the position and velocity components for the uplinked FS ephemeris. The normalized time is computed and this time, along with the interpolator coefficients (old or new), are used in the four point Hermite polynominal interpolation algorithm to obtain the final FS ephemeris components.

B.3.8.2.5 ECGPBLD

ECGPBLD replaces old extrapolator coefficients with new from the background module GCUP. This replacement only occurs if the new coefficients ready flag GUGFLGUP=2. These new coefficients replace the old coefficients and the fit interval is advanced. Finally, the new coefficients ready flag (GUGFLGUP) is set to 3 for the background module GCUP.

B.3.8.2.6 ECGCALC

ECGCALC computes the position and velocity components for the GPS FS ephemeris. The normalized time is computed and used along with the extrapolator coefficients (old or new) to calculate the GPS ephemeris components.

B.3.8.2.7 ECTDBLD

ECTDBLD checks for new uplinked TDRS E.C. data. If spacecraft time exceeds the new data start time, ECTDBLKD sets the flag TUGFLGUP=2 to tell the background module (TCUP) to move this data to the working area. ECTDBLD also requests the execution of the background processor TCUP. ECTDBLD replaces old interpolator coefficients with new from the slow loop module TCUP. This replacement procedure is bypassed if the following two conditions are not met - the software time must exceed the fit interval upper time limit and new coefficients must be available (flag TUGFLGUP=3). If the above conditions are met, the old coefficients are replaced by the new and the fit interval is advanced by the grid interval time. Finally, the new coefficients ready flag TUGFLGUP is set to 4 for the slow loop module TCUP.

B.3.8.2.8 ECTCALC

ECTCALC computes the TDRS position components for TDRS East and TDRS West ephemerides. If TDRS East processing is required, the East normalized fit time is calculated and this time, along with the East interpolator coefficients (old or new) are used in the four point Hermite polynomial interpolation algorithm to obtain the final TDRS position components. The same process is followed to obtain the TDRS West position components.

B.3.8.2.9 ECTELEM

ECTELEM formats the output for the Landsat-D Computer Generated Telemetry reports. There are seven separate Ephemeris reports which are issued during certain minor frames of the Landsat-D flight software processing cycle.

Four routines are used for formatting these telemetry reports. The first routine (MOVINIT) will initialize for the loading of a report buffer. MOVSPREC will unpack and move single precision fixed point values into 3 OBC telemetry words. MOVDPREC will unpack and move double precision values into 4 OBC telemetry words. MOVBYTE will move an 8 bit value to 1 OBC telemetry word. The PROC 'MOVELO' moves the low order 3 bits of word 2 and the high order ibts of word 3 of the triple precision time word into the 5th OBC telemetry word after MOVDPREC has moved the first 2 words.

B.3.8.3 Ephemeris Computation (EPHEM) Software Constraints

EPHEM will do no processing of a particular ephemeris unless at least one of the slow loop background modules for the three types of data (uplinked FS, GPS FS, and uplinked TDRS) has computed one set of coefficients.

B.3.8.4 Ephemeris Computation (EPHEM) Systems Tables

The EPHEM processor uses the data items found in system table number 31 and 32. Table 31 contains the ephemeris computation parameters (EPARAM) consisting of 13 words. These parameters are used in setting time biases and grid intervals for the ephemeris computations. Table 32 contains the 5 ephemeris processing permitted flags (EPERMIT) that establish which ephemeris processing is permitted.

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #31 - EPARAM (Epehmeris Parameters)					
0000	E1GVNGMX		C	ECGPBLD	Max # of consecutive ephemeris calculation computation before GPS data available again
0001	E1GWDTE		C	ECTCALC	Bias for current TDRS East time from current FS time
0003	E1GWDTW		C	ECTCALC	Same as 0001 but for TDRS West
0005	E1GWTG		C	ECFSBLD	Ephemeris grid interval
0007	E1GWTGR		C	ECFCALC	Reciprocal if E1GWIG
0009	E1GWTTG		C	ECTDBLD	TDRS ephemeris grid interval
0011	E1GWTTGR		C	ECTCALC	Reciprocal of E1GWTTGE

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #32 - EPERMIT (Ephemeris Processing Permitted Flags)					
0000	E1GVEAST		F	ECTCALC	TDRS East ephemeris processing permitted?
0001	E1GVFFS		F	EPHEM	Uplinked FS ephemeris processing permitted?
0002	E1GVGFS		F	EPHEM	GFS ephemeris procuring permitted?
0003	E1GVTFS		F	EPHEM	TDRS ephemeris processing permitting?
0004	E1GVWEST		F	ECTCALC	TDRS West ephemeris processing permitted?

B.3.8.5 Ephemeris Computation (EPHEM) Telemetry

OBC Telemetry Reports 13-19 present the ephemeris data and associated ephemeris parameters. Each telemetry report is 25 words (8 bit) long and may contain single word (18 bit), double word (36 bit word, of which 32 bits are used), triple word (54 bit word of which 40 bits are used), or byte (8 bit) data items. The first 3 reports (TLM reports 13-15) will be output 4 times per major frame. The last 4 reports (TLM reports 16-19) will be output once per major frame as shown below:

Report # (Word 35)	Minor Frame Number	Name
13	16,48,80,112	EPHEM 01
14	17,49,81,113	EPHEM 02
15	18,50,82,114	EPHEM 03
16	58	EPHEM 04
17	59	EPHEM 05
18	60	EPHEM 06
19	61	EPHEM 07

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #13			
0000	EOGBRF	ECFCALC	ECI X axis component of FS position computed using uplinked data
0004	EOGBRF	ESFCALC	ECI Y axis component of FS position computed using uplinked data
0008	EOGBRF	ECFCALC	ECI Z axis component of FS position computed using uplinked data
0012	EOGBVF	ECFCALC	ECI X axis component of FS velocity computed using uplinked data
0016	EOGBVF	ECFCALC	ECI Y axis component of FS velocity computed using uplinked data
0020	EOGBVF	ECFCALC	ECI Z axis component of FS velocity computed using uplinked data

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #14			
0000	EOGBRFG	ECGCALC	ECI X axis component of FS position computed using GPS data
0004	EOGBRFG	ECGCALC	ECI Y axis component of FS position computed using GPS data
0008	EOGBRFG	ECGCALC	ECI Z axis component of FS position computed using GPS data
0012	EOGBVFG	ECGCALC	ECI X axis component of FS velocity computed using GPS data
0016	EOGBVEG	ECGCALC	ECI Y axis component of FS velocity computed using GPS data
0020	EOGBVFG	ECGCALC	ECI Z axis component of FS velocity computed using GPS data

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Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #15			
0000	EOGVCSEC	ECTELEM	GPS running consecutive checksum error count. Initialized to 0
0003	EOGVSHER	ECTELEM	GPS running conversion error counter Initialized to 0
0006	EOGVARER	ECTELEM	Running GPS variance error count Initialized to 0
0009	EOGVGTER	ECTELEM	No new GPS time running counter
0012	EOGVDERR	Undefined	GPS running consecutive data error count. Initialized to 0
0015	EOGVF7DO	ECTELEM	Count of GPS data lost because file 7 data not ready Initialized to 0
0018	EOGVNFRE	ECTELEM	Count of GPS files lost due to buffer not free Initialize to 0
0021	EOGVLOST	ECGPBLD	Count of nubmer of times the E.C. module was executed since last good GPS

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OBC TLM Report #16

Entry Number	Name	Generating Subroutine	Description/Comment
0000	EOGVFALM	ECTELEM	Residual count exceeded counter for FS uplinked data Initialized to 0
0003	EOGVTALM	ECTELEM	Total TDRS ephemerides fit interval exceeded counter Initialized to 0
0006	EOGWPU	ECFCALC	Uplinked FS ephemeris normalized time
0010	EOGWPG	ECGCALC	GPS ephemeris normalized time
0014	EOGWPT	ECTCALC	TDRS ephemerides normalized time

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #17			
0000	EOGBPTDE	ECTCALC	ECI X axis component of TDRS-E position
0004	EOGBPTDE	ECTCALC	ECI Y axis component of TDRS-E position
0008	EOGBPTDE	ECTCALC	ECI Z axis component of TDRS-E position
0012	EOGBPTDW	ECTCALC	ECI X axis component of TDRS-W position
0016	EOGBPTDW	ECTCALC	ECI Y axis component of TDRS-W position
0020	EOGBPTDW	ECTCALC	ECI Z axis component of TDRS-W position

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #18			
0000	EOGWTT3	ECCOLD	Upper time limit for uplinked FS ephemeris interpolator Initialized to 0
0005	EOGWTT3	ECTDBLD ECCOLD	TDRS interpolator coefficients upper time limit Initialized to 0
0010	EOGWTTE	ECTCALC	TDRS East time of current data
0015	EOGWTTW	ECTCALC	TDRS West time of current data.
0020	EOGVNT	ECTELM	Uplinked FS Ephemeris residual counter

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #19			
0000	EOGWGT1	ECTELEM	Time of current first grid point for GPS interpolation
0005	EOGWGT2	ECTTELEM	Time of most recent GPS data (GUGWGTU2 for use in E.C.)
0010	EOGWTDAT	ECTELEM	Converted GFS to spacecraft time time
0015	EOGVINIT	ECTELEM	GPS coefficient update program initialization indicator (1,2,0) Initializated to 1
0016	EOGVMXTM	ECGPBLD	Max time without data

B.3.8.6 Ephemeris Computation (EPHEM) Flow Charts

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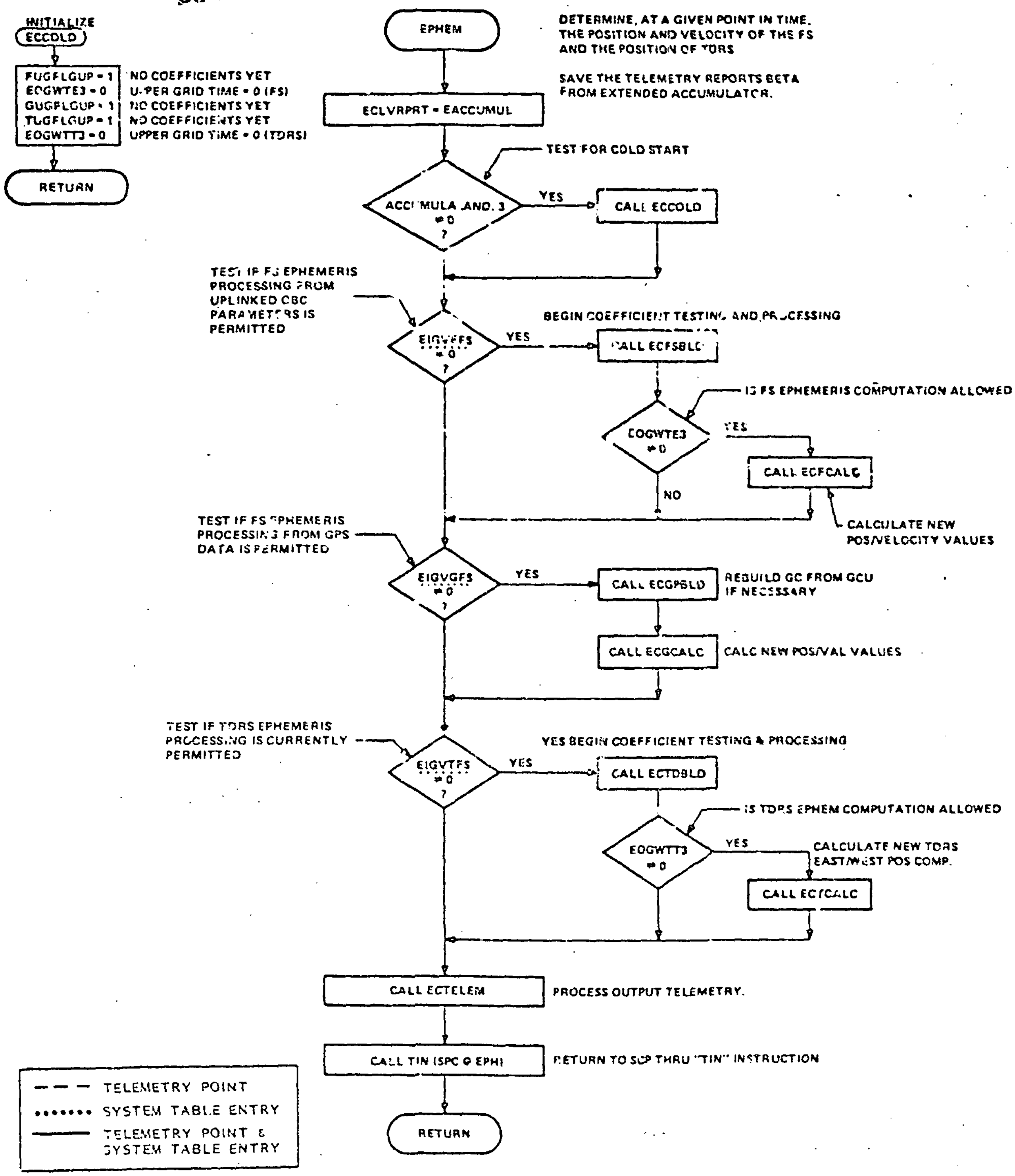

Figure B.3.8-2. EPHEM,ECCOLD Flow Charts

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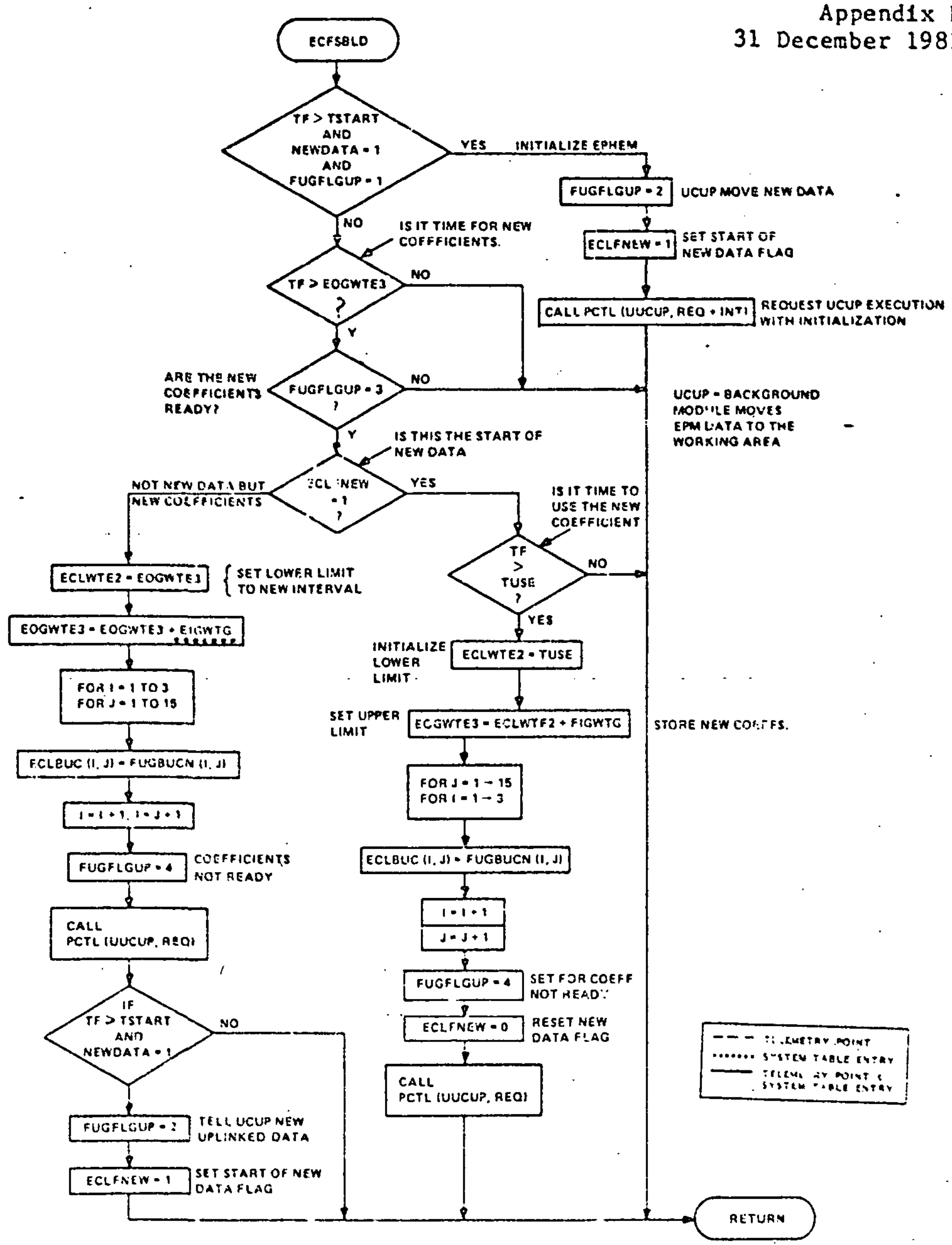

Figure B.3.8-3. ECFSBLD Flow Chart

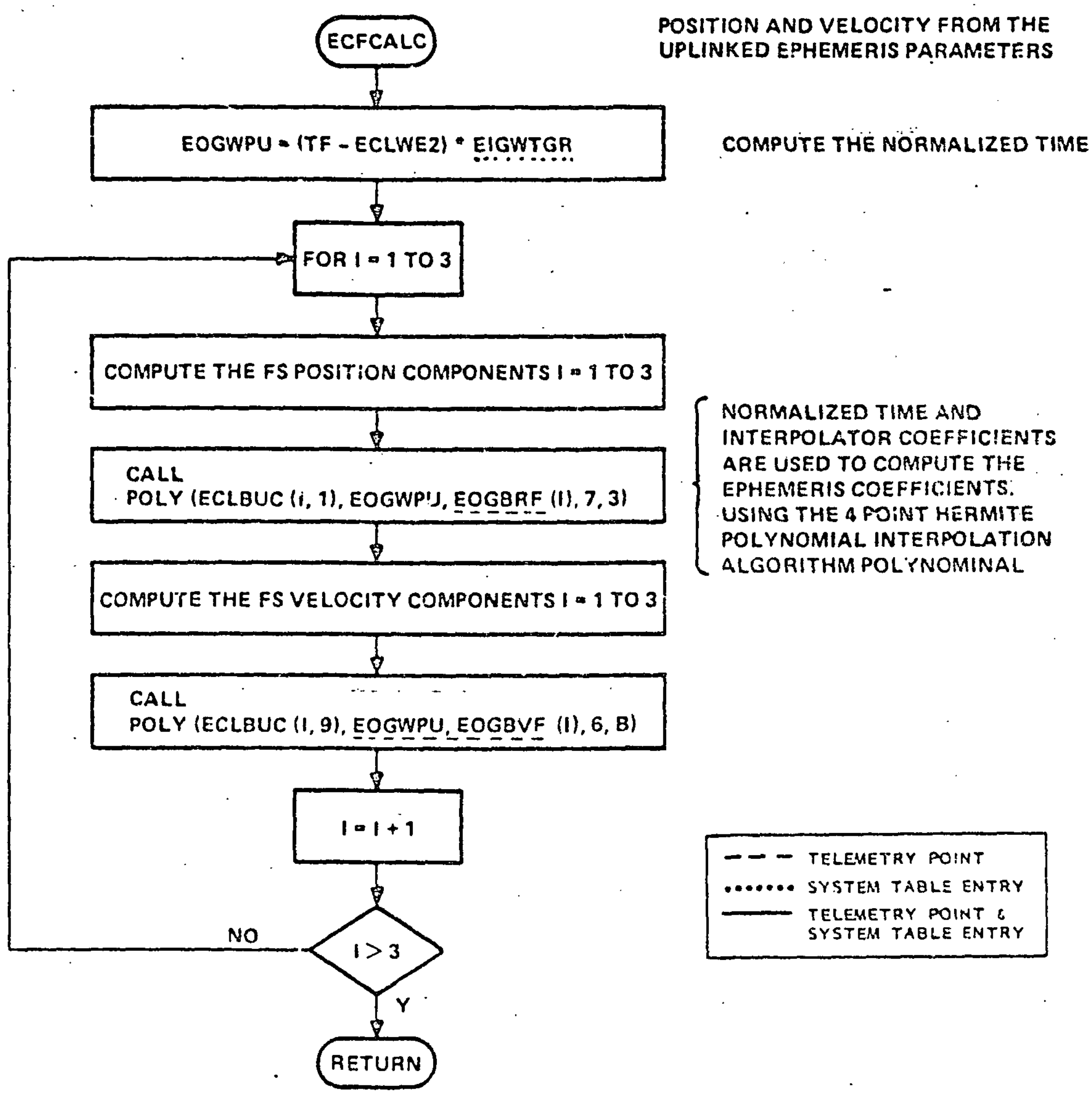

Figure B.3.8-4. ECFCALC Flow Chart

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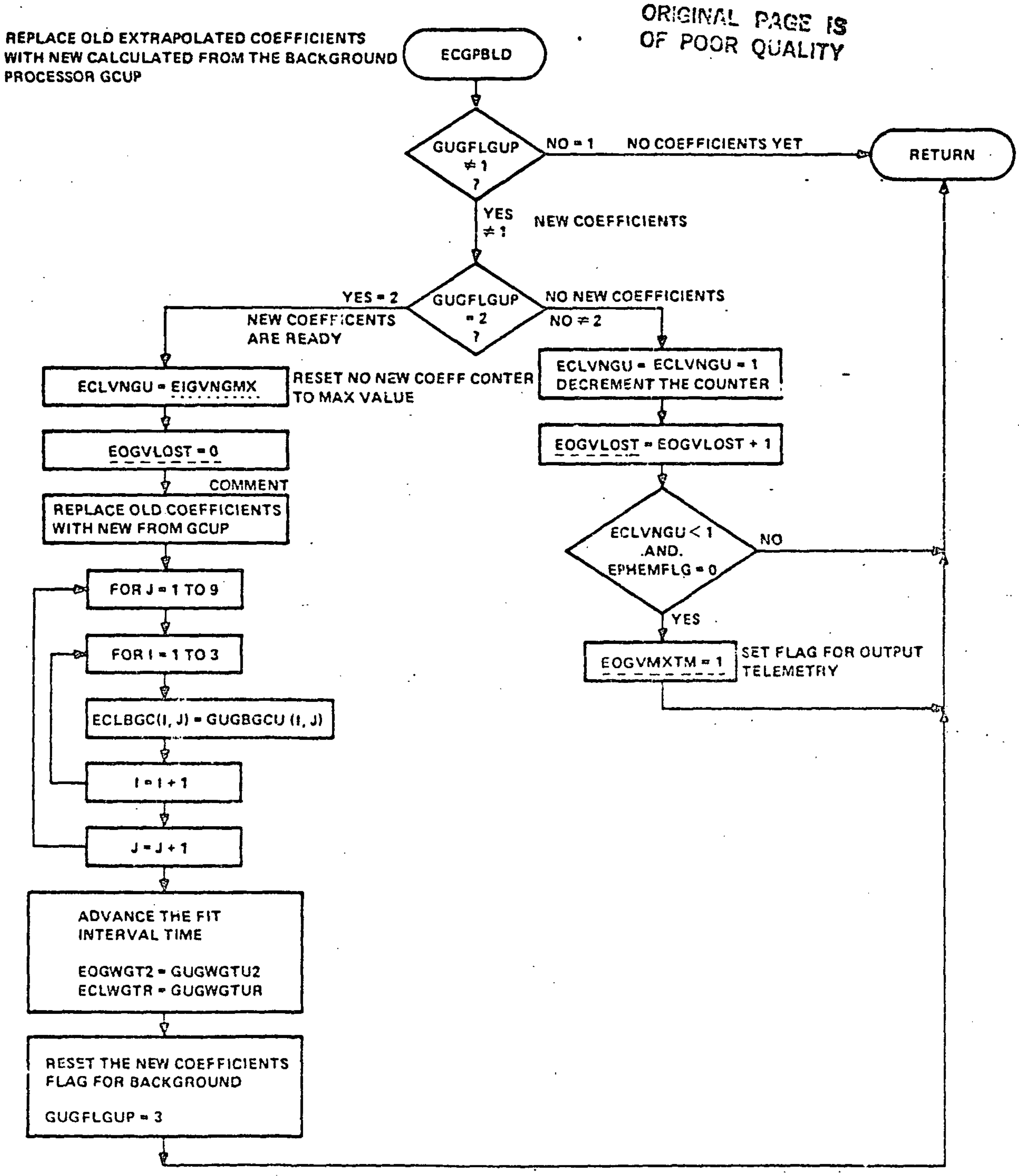

Figure B.3.8-5. ECGPBLD Flow Chart

— — —	TELEMETRY POINT
•••••••	SYSTEM TABLE ENTRY
———	TELEMETRY POINT & SYSTEM TABLE ENTRY

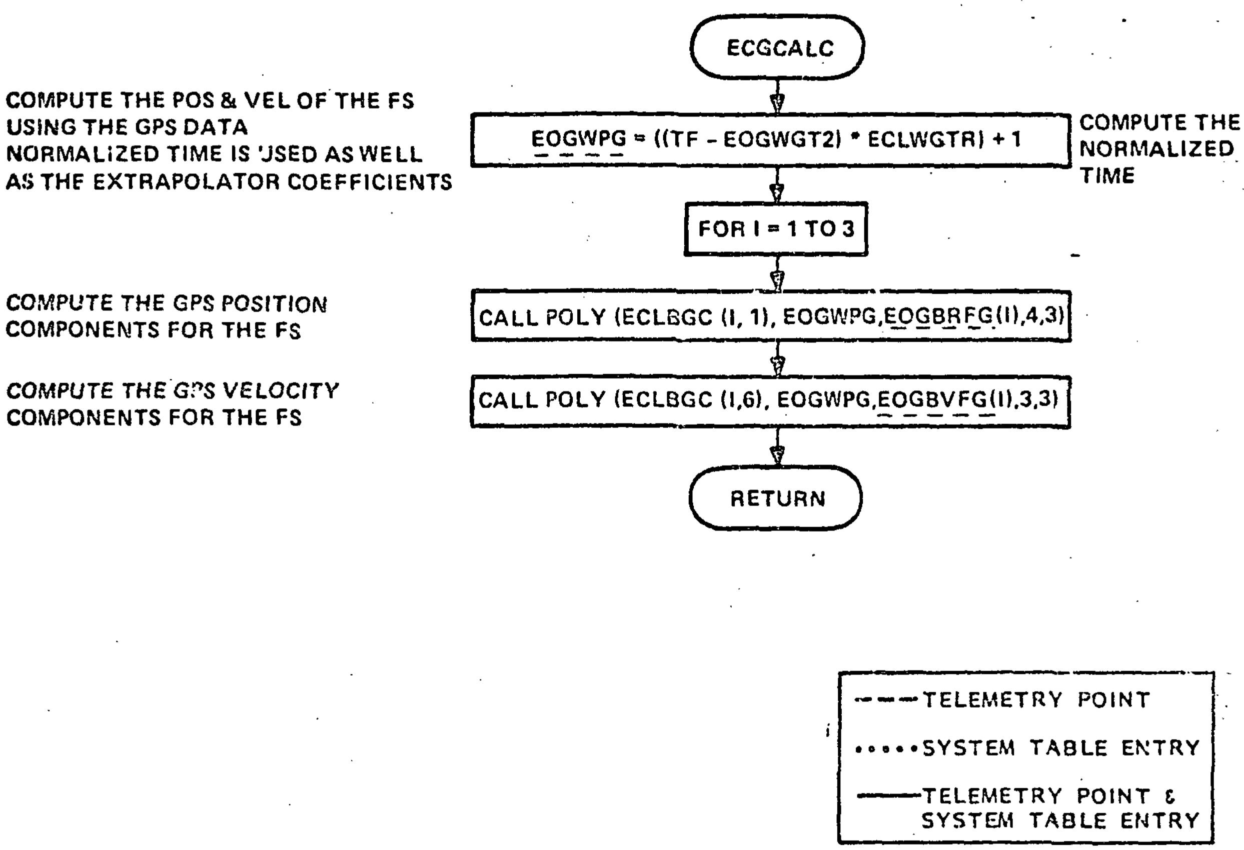

Figure B.3.8-6. ECGCALC Flow Chart

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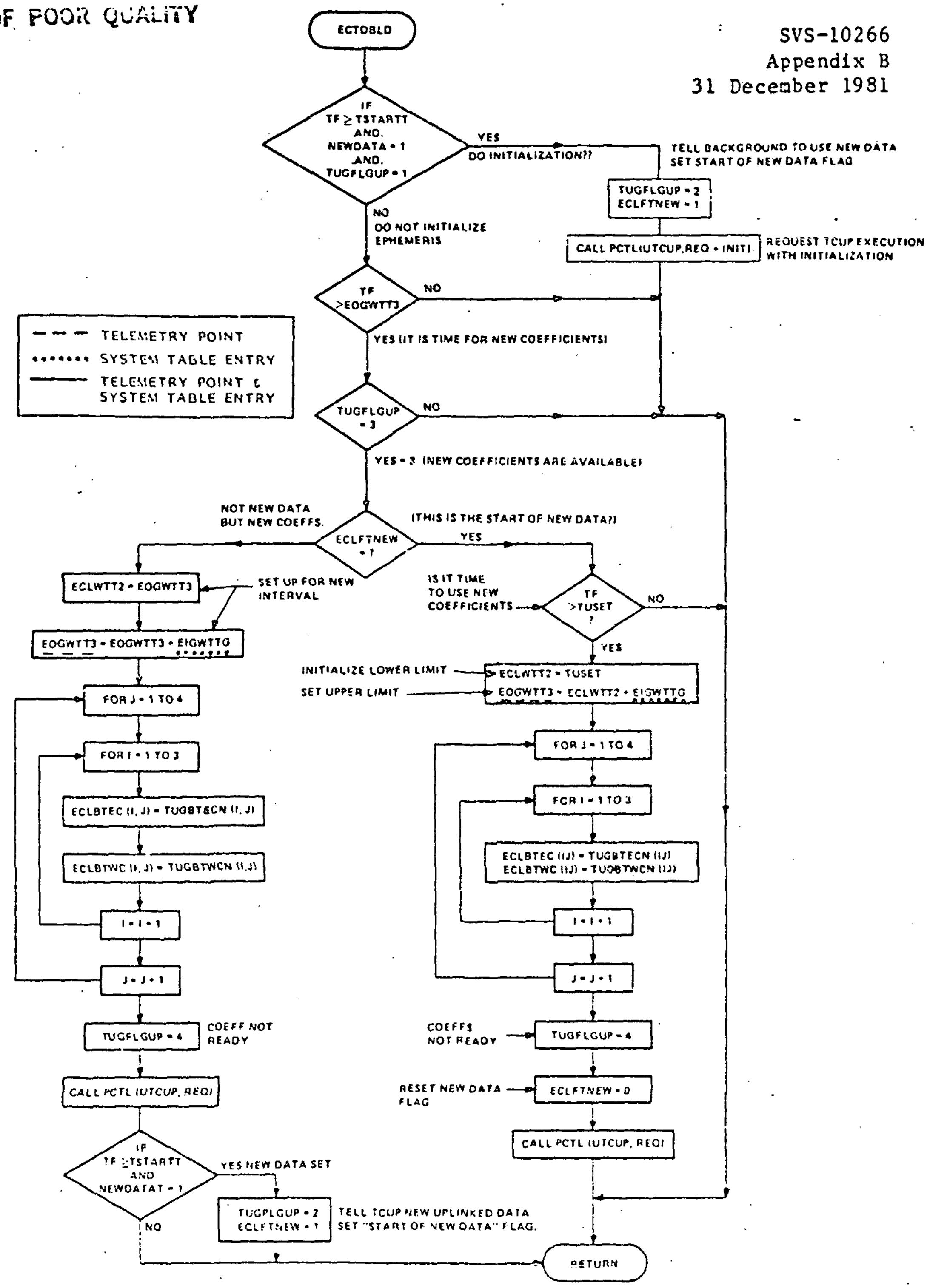

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Figure B.3.8-7. ECTDBLD Flow Chart

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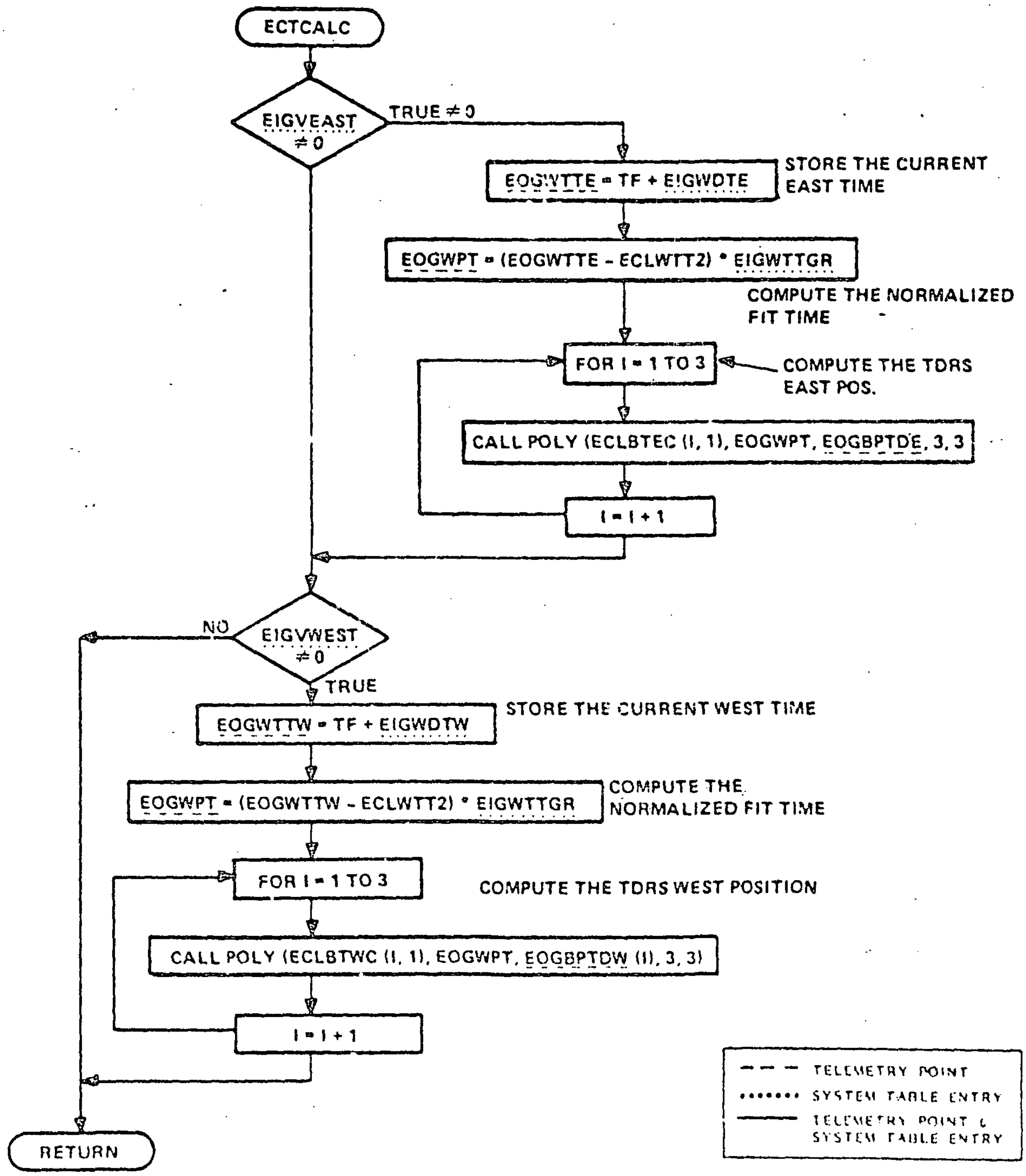

Figure B.3.8-8. ECTCALC Flow Chart

B.3.9 UPLINKED FS EPHEMERIS COEFFICIENT UPDATE (UCUP)

B.3.9 UPLINKED FS EPHEMERIS COEFFICIENT UPDATE (UCUP)

B.3.9.1 Uplinked FS Ephemeris Coefficient Update (UCUP Processor Description

The function of the Uplinked FS Ephemeris Coefficient Update (UCUP) processor is the processing of uplinked Flight Segment OBC parameters, and computation of interpolator coefficients for utilization by the Ephemeris Computation (EPHEM) processor.

UCUP is a long period, or background, processor nominally executed every 614.4 seconds. The execution of this processor is requested by the Ephemeris Computation (EPHEM) processor. When a new set of OBC parameters is uplinked, the UCUP processor moves the data into a working buffer. These uplinked OBC parameters, prepared by the Orbit Computation Group (OCG), and uplinked nominally every 24 hours, consist of Fourier power series coefficients for each component of Landsat-D position and velocity, together with position residuals at a nominal grid point spacing of 10 minutes. The format of the OBC parameter tape is shown in Figure 10-9 and 10-10 of GES-10140, "Landsat-D GS to OCG ICD, 26 March 1981.

The UCUP processor consists of 5 subroutines as delineated in Table B.3.9-1 and the UCUP control function. This processor subroutine flow is diagrammed in Figure B.3.9-1.

When the UCUP processor is called by EPHEM, UCUP first checks to see if the processor has to be initialized, and if so, requests the subroutine FUCOLD, which resets the residual exceeded counter to zero. If it is time to use new data, indicated by the flag FUFLUP=2 set in EPHEM, UCUP moves the new data to the working buffer, and initializes the vector table of position and velocity components in FUIVT. If FUGFLUP≠2, indicating that UCUP is not using new data, the vector table is updated utilizing the subroutine FUUVT. In either case, position and velocity components of Landsat-D FS are generated for four grid points (4 times values 10 minutes apart nominally) using the uplinked Fourier coefficients and the position residuals. This is accomplished in the subroutine FUFPS.

The subroutine FUCIC then generates interpolator coefficients for a four point Hermite polynomial fit, for utilization by EPHEM in generating Landsat-D FS ephemeris. UCUP then resets the flag FUGFLGUP=3 indicating that new coefficients are ready, and returns control to the Flight Executive.

The Uplinked FS Ephemeris Coefficient Update (UCUP) Processor utilizes Flight Segment Software System Table #33. This system table, UDATA-FS Ephemeris Computation Data, consists of time values to indicate when new data is to be used, coefficients of Fourier power series for FS position and velocity components, and position residuals. Details of this system table are presented in Section B.3.9.4.

This processor generates no telemetry reports.

Table B.3.9-1. Uplinked FS Ephemeris Coefficient Update (UCUP)

Number:	17
Type:	Background
Priority:	15
Period:	614.4 seconds
Function:	Processing of new set of uplinked FS OBC data and computation of new set of interpolator coefficients for utilization by the EPHEM processor for generation of FS position and velocity. Requested by EPHEM processor.

Subroutines:

FUCOLD	Cold start initialization
FUIVT	Initiation of vector table
FUUVT	Update of vector table
FUFPS	Computation of FS ephemeris using Fourier power series
FUCIC	Computation of FS interpolator coefficients

System Tables:

#	Mneumonic	Type	# Words	Description
33	UCUP	Variable	1059	Uplinked FS Ephemeris Computation Data

Telemetry Reports: None

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B.3.9.2 Uplinked FS Ephemeris Coefficient Update (UCUP) Processor Operation

The UCUP processor consists of the UCUP control function and subroutines as indicated in Section B.3.9.1. The control function is described in Section B.3.9.1. Sections B.3.9.2.1 through B.3.9.2.5 describe the subroutines.

B.3.9.2.1 FUCOLD Subroutine

FUCOLD is the routine which initializes a counter when a "cold start" condition exists (bit 1 and 2 of the ACCUMULATOR is set when the module UCUP is called).

B.3.9.2.2 FUIVT Subroutine

FUIVT is the routine which initializes the vector table of fit points and associated position and velocity components. Three fit point times, starting at the initial time of the uplinked FS ephemeris residuals, are used to find the components at the fit point times by calling the Fourier power series routine FUFPS. The corresponding uplinked residual values are added to the position vectors. The next fit point time is computed and the residual counter (EOGVNT) is incremented by 3 for use in the routine FUUVT.

B.3.9.2.3 FUUVT Subroutine

FUUVT updates the vector table for uplinked FS ephemeris processing. This routine does essentially the same processing as the routine FUIVT except only the most recent grid time is worked on. Initially the vectors are moved to make room for the new fit point time. The Fourier power series routine FUFPS is called by FUUVT to calculate the values for slot 4 of the vector table. FUUVT checks that the residual counter does not exceed the maximum allowed residual count uplinked from ground and adds the corresponding residual values to the position components. The residual counter is incremented by 1 for the next pass. If the maximum residual count is exceeded, no residual values are added and an error counter (EOGVFALM) is incremented. In either case, the next fit point time is computed and control is returned to the control function (UCUP).

B.3.9.2.4 FUCIC

FUCIC is the routine which calculates the coefficients for a 4 point Hermite interpolator polynomial using the data from the prior components FUIVT and FUUVT.

B.3.9.2.5 FUFPS

FUFPS evaluates the Fourier power series for a coordinate (position or velocity component) at the current fit point time. There are two arguments in the calling sequence to this routine - the location where the result is to be stored and the column index of the array of uplinked coefficients for the Fourier power series equation. This array consists of 6 sets (3 position and 3 velocity) of 42 coefficients each. The remaining values used by FUFPS are fit point time dependent and are therefore used from their respective local storage areas.

B.3.9.3 Uplinked FS Ephemeris Coefficient Update (UCUP) Software Constraints

Execution of the UCUP processor occurs when called by the EPHEM processor. This processor requires periodic uploading of OBC parameters for execution.

B.3.9.4 Uplinked FS Ephemeris Coefficient Update (UCUP) System Tables

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #33 - UDATA (Uplinked FS Ephemeris Computation Data)					
0000	NEWDATA		F	UCUP, ECFSBLD (EPHEM processor)	Uplinked data ready flag
0001	TSTART		V	ECFSBLD (EPHEM processor)	Time to initiate transition to new E.C. data set
0004	TUSE	ECFSBLD		(EPEHM processor)	Time to utilize new E.C. data set in EPHEM
0007	EIGWT1ST		V	FURVT, UCUP	Time of first uplniked FS ephemeris residual
0009	EIGBNTMX		V	FUUVT	Maximum number of valid position residuals
0010	EIGVNT		V	FUIVT, FUUVT	Uplinked FS ephemeris residual number
0011	EIGWWFS		V	FUUVT, FUIVT	Fundamental frequency
0013	EIGW2ND		V	FUIVT, FUUVT	Secondary frequency
0015-0518	EIGBA		V	FUFPS	Coefficients of Fourier power series for position of velocity
0519-1058	EIGBRES		V	FUIVT,	FS position residuals at fit points

B.3.9.5 Uplinked FS Ephemeris Coefficient Update (UCUP) Telemetry

None

B.3.9.6 Uplinked FS Ephemeris Coefficient Update (UCUP) Flow Charts

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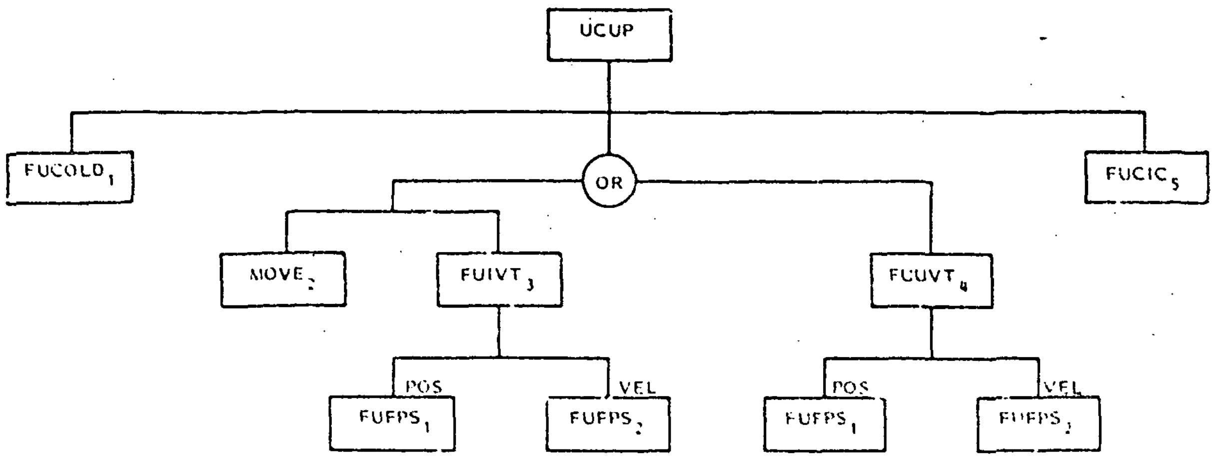

Figure B.3.9-1. UCUP Top Level Diagram

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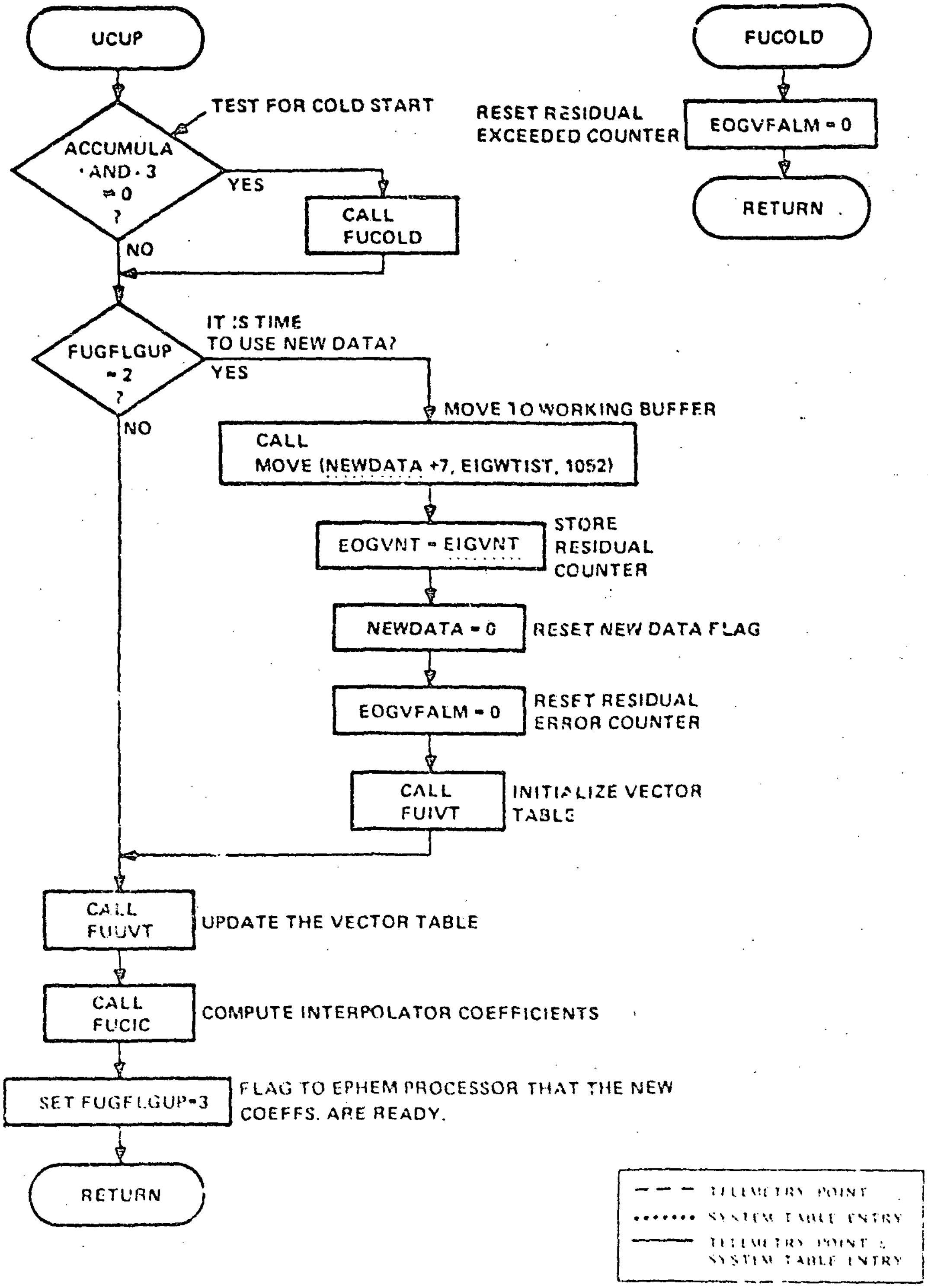

Figure B.3.9-2. UCUP, FUCOLD Flow Chart

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EIGWT1ST = TIME OF 1ST UPLINKED FS EPHEM RESIDUAL

EIGWWFS = FUNDAMENTAL FREQUENCY

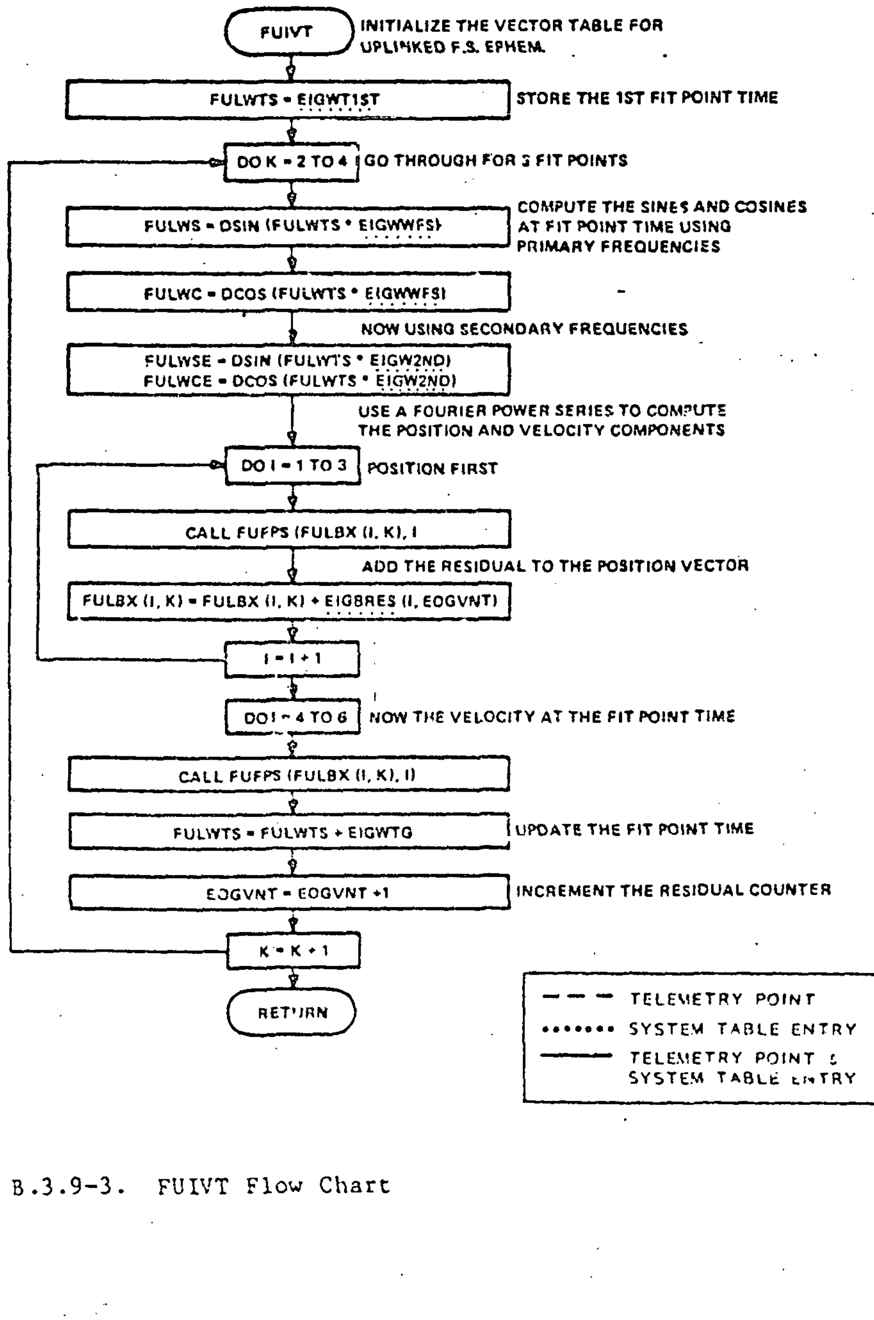

Figure B.3.9-3. FUIVT Flow Chart

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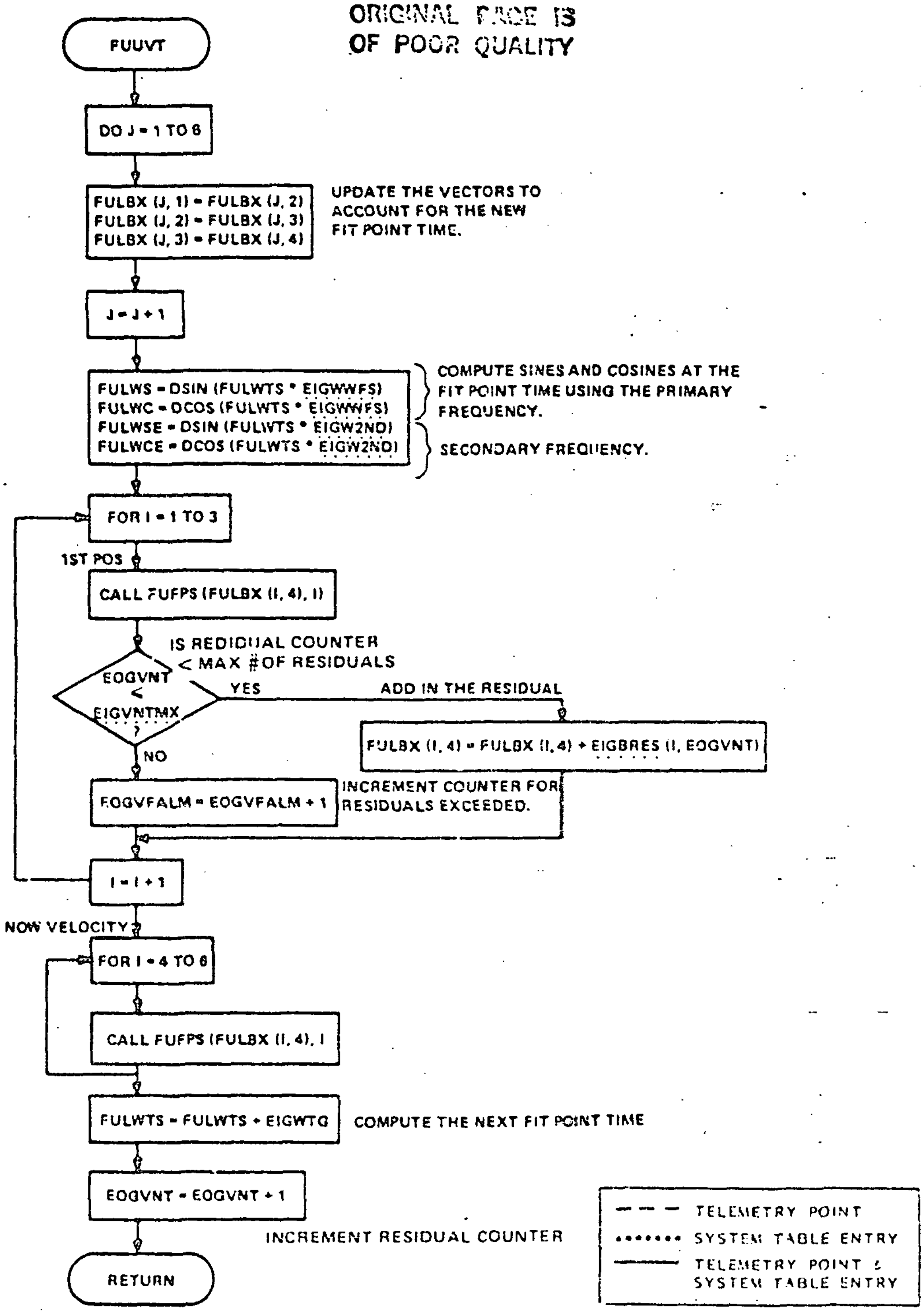

FIGURE B.3.9-4 FUUVT Flow Chart

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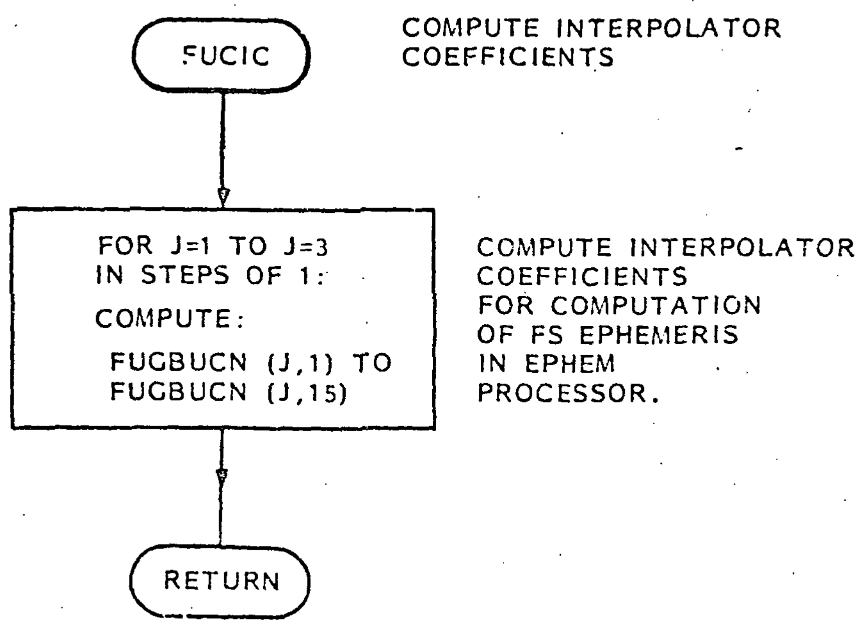

Figure B.3.9-5. FUCIC Flow Chart

B.3.10 TDRS EPHEMERIS COEFFICIENT UPDATE (TCUP)

B.3.10 TDRS EPHEMERIS COEFFICIENT UPDATE (TCUP)

B.3.10.1 TDRS Ephemeris Coefficient Update (TCUP) Processor Description

The function of the TDRS Ephemeris Coefficient Update (TCUP) processor is the processing of uplinked OBC parameters to generate interpolator coefficients required for the computation of TDRS-East and TDRS-West position by the Ephemeris Computation (EPHEM) processor. The TCUP processor computes interpolater coefficients for both TDRS-East and TDRS-West position. These coefficients are used by the EPHEM processor to generate position of TDRS-East and/or TDRS-West.

TCUP is a long period, or background, processor nominally executed every 614.4 seconds. The execution of this processor is requested by the Ephemeris Computation (EPHEM) processor. When a new set of TDRS OBC parameters is uplinked and it is time to use this new data, the TCUP processor moves the new data into a working buffer. These uplinked data, prepared by the Orbit Computation Group (OCG) and uplinked nominally once every 24 hours, consists of Fourier power series coefficients for each component of position for both TDRS-East and/or TDRS-West satellites. The OBC parameter tape format is shown in Figures 10-11 and 10-12 in GES-10140, "Landsat-D GS to OCG ICD" March 26, 1981.

The TCUP processor consists of 5 subroutines as delineated in Table B.3.10-1 and the TCUP control function. The processor subroutine flow is diagrammed in Figure B.3.10-1.

When the TCUP processor is requested to be executed by the Ephemeris Computation (EPHEM) processor and TCUP processing initiated, TCUP first checks to see if the processor has to be initialized, and if so, requests the subroutine TUCOLD, which resets the fit time exceeded counter to zero. If it is time to use new uplinked data, indicated by the flag TUGFLGUP=2 set in EPHEM, TCUP moves the data to a working buffer, resets the new data flag, the time exceeded counter and initializes the vector table of TDRS-East and /or West position components by executing the subroutine TUIVT. If TUGFLGUP≠2, indicating that TCUP is not using new data, the vector table is updated by executing the subroutine TUUVT. In either case, position components for TDRS-East and/or West are generated for four fit point times using the uplinked Fourier coefficients, uplinked in System Table #34. This is accomplished by executing subroutine TUFPS.

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The subroutine TUCIC then generates interpolator coefficients for a four point Hermite polynomial fit, for utilization by EPHEM in generating TDRS ephemeris. TCUP then resets the flag TUGFLGUP=3 indicating that new coefficients are ready, and returns control to the Flight Executive.

The TDRS Ephemeris Coefficient Update (TCUP) processor utilizes Flight Segment Software System Table #34. This system table, TDATA-TDRS Ephemeris Computation Data, consists of time values to indicate utilization time for the new data, and Fourier power series coefficients for TDRS-East and/or West position components. Details of this system table are presented in Section B.3.10.4.

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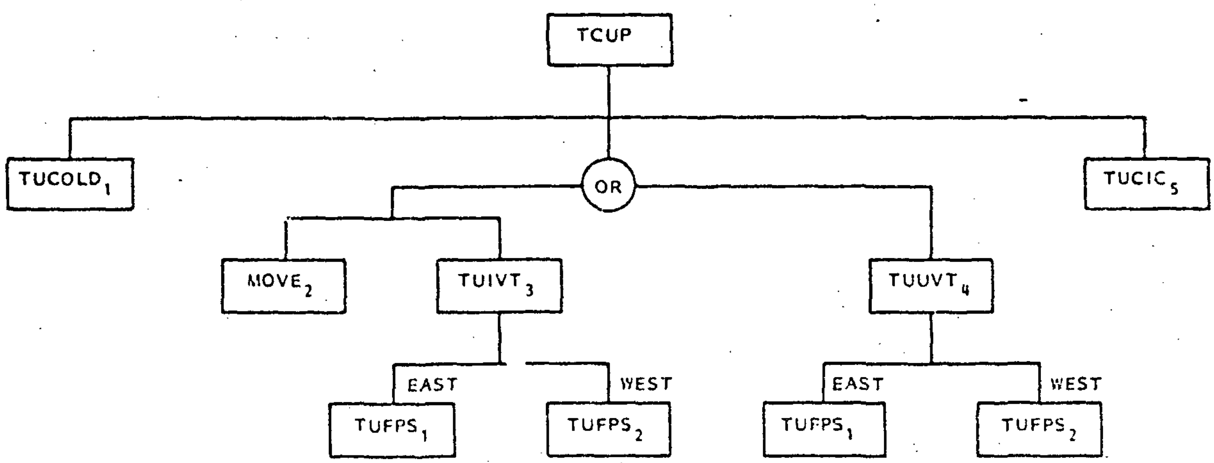

Figure B.3.10-1. TCUP Top Level Diagram

Table B.3.10-1. TDRS Ephemeris Coefficient Update (TCUP)

Number:	18
Type:	Background
Priority:	16
Period:	614.4 seconds
Function:	Processing of new set of TDRS ephemeris data and computation of new set of interpolator coefficients for utilization by the EPHEM processor for generation of TDRS East and West positions. Requested by the EPHEM processor.

Subroutines:

TUCOLD	Cold start initialization
TUIVT	Initiation of vector table
TUUVT	Update of vector table
TUFPS	Computation of TDRS ephemeris using Fourier power series
TUCIC	Computation of TDRS interpolator coefficients

System Tables:

#	Mneumonic	Type	# Words	Description
34	TCUP	Variable	111	TDRS Ephemeris Computation Data

Telemetry Reports: None

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B.3.10.2 TDRS Ephemeris Coefficient Update (TCUP) Processor Operation

The TCUP processor consists of the TCUP control function and the 5 subroutines as delineated in Section B.3.10.1. The control function is detailed in this section.

Sections B.3.10.2.1 through B.3.10.2.5 give the details of the subroutine operation.

B.3.10.2.1 TUCOLD Subroutine

TUCOLD is the routine which initializes a counter when a "cold start" condition exists (bit 1 or 2 of the ACCUMULATOR is set when the module TCUP is called).

B.3.10.2.2 TUIVT Subroutine

TUIVT is the routine which initializes the vector table of fit points and associated position components for East and West ephemerides. Three fit point times, starting at the initial time of the TDRS ephemeris fit interval, are used to find the components at the fit point times by calling the Fourier power series routine TUFPS. The next fit point time is also computed for use in the routine TUUVT. If this is the very first uplinked data set (cold start), grid times TT2 and TT3 are stored for use by the module EPHEM.

B.3.10.2.3 TUUVT Subroutine

TUUVT updates the vector table for TDRS ephemeris processing. This routine does essentially the same processing as the routine TUIVT except only the most recent grid time is worked on. Initially the vectors are moved to make room for the new fit point time. This new fit point time is TULWTS and the Fourier power series routine (TUFPS) is called by TUUVT to calculate the values for slot 4 of the vector table. FUUVT checks that the new fit point time does not exceed the last time for the TDRS ephemeris fit interval. If the last time is exceeded, the time exceeded counter (EOGVTALM) is incremented. Error or not, the next fit point time is computed and control is returned to the control function TCUP.

B.3.10.2.4 TUCIC Subroutine

TUCIC is the routine which calculates the coefficients from a 4 point Hermite interpolator polynomial using the data from the prior routines TUIVt and TUUVT.

B.3.10.2.5 TUFPS Subroutine

TUFPS evaluates the Fourier power series for a coordinate (East or West position component) at the current fit point time. There are three arguments in the calling sequence to TUFPS - the location where the result is to be stored, the column index of the array of coefficients for the Fourier power series equation, and a direction indicator (1=East, 2=West). The coefficients for the Fourier power series consists of 3 sets of 8 coefficients for East and 3 sets of 8 coefficients for West. The remaining values used by TUFPS are fit point time dependent and are therefore used from their respective local storage areas.

B.3.10.3 TDRS Ephemeris Coefficient Update (TCUP) Software Constraints

Normally, a new set of OBC parameters must be uplinked before the end of the valid time interval for current data set.

B.3.10.4 TDRS Ephemeris Coefficient Update (TCUP) System Tables

Entry	Name	TLM	Type	Using Subroutine	Description

System Table #34 - TDATA (TDRS Ephemeris Computation Data)

Entry	Name	TLM	Type	Using Subroutine	Description
0000	NEWDATAT		F	TCUP, ECTDBLD	Uplinked TDRS data ready flag
0001	TSTARTT		V	ECTDBLD (EPHEM processor)	Time to initiate transition to new TDRS uplinked data set
0004	TUSET		V	ECTDBLD (EPHEM processor)	ime to use the new TDRS data
0007	EIGWTT1		V	TUIVT, TCUP	Time of first TDRS fit interval
0009	EIGWTTL		V	TUUVT	Time of last TDRS fit interval
0011	EIGWWTE		V	TUIVT, TUUVT	Fundamental frequency for TDRS-E fourier power series
0013	EIGWWTW		V	TUIVT, TUUVT	Fundamental frequence for TDRS-W fourier power series
0015-0060**	EIGBBE		V	TUFPS	Fourier power seies coefficient for TDRS-E position
0061-0110**	EIGBBW		V	TUFPS	Fourier power series coefficients for TDRS-W position

** These are double precision coefficients; 24 for EIGBBE and 24 for EIGBBW

B.3.10.5 TDRS Ephemeris Coefficient Update (TCUP) Telemetry

The TCUP processor generates no telemetry reports.

B.3.10.6 TDRS Ephemeris Coefficient Update (TCUP) Flow Charts

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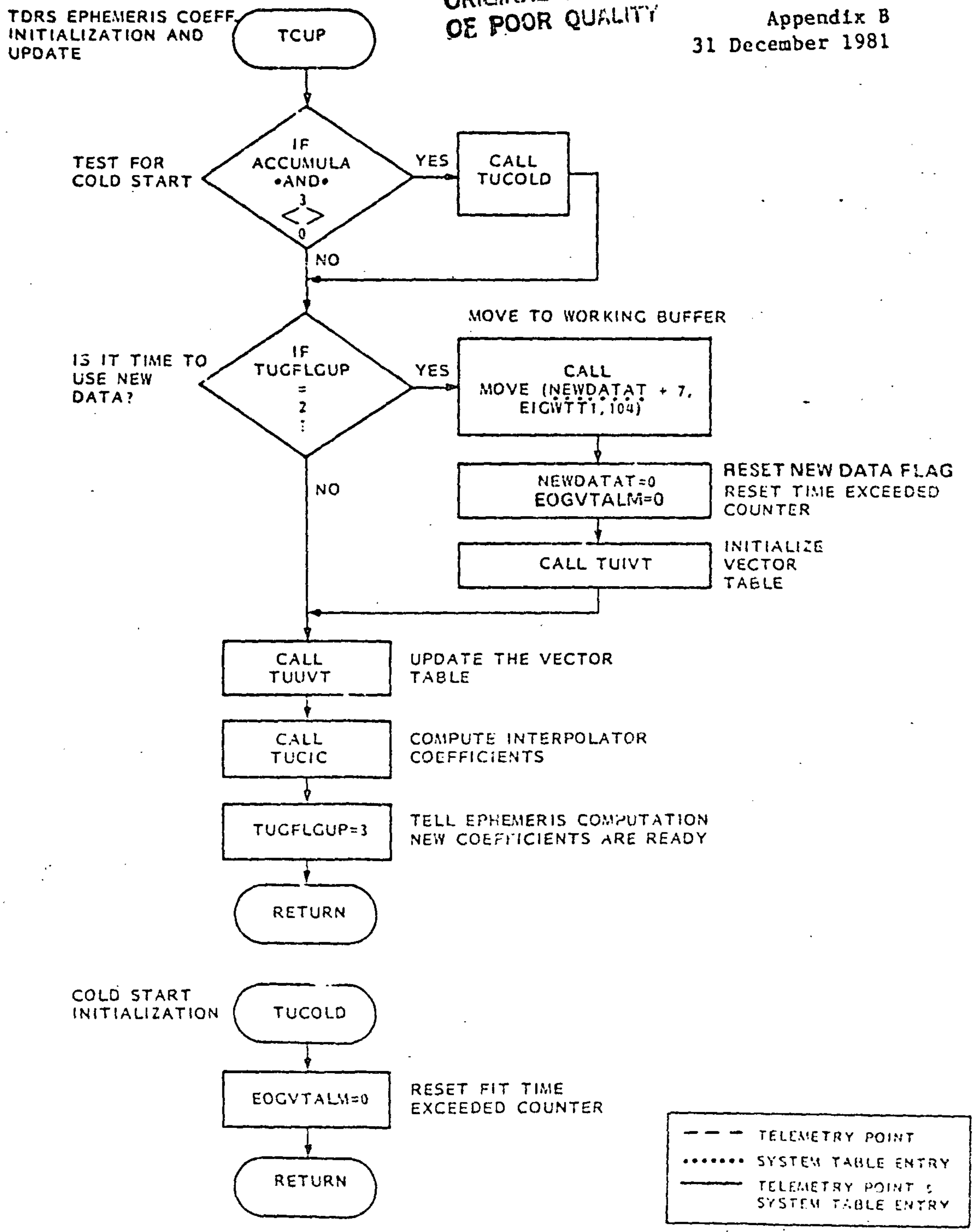

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Figure B.3.10-2. TCUP Flow Chart

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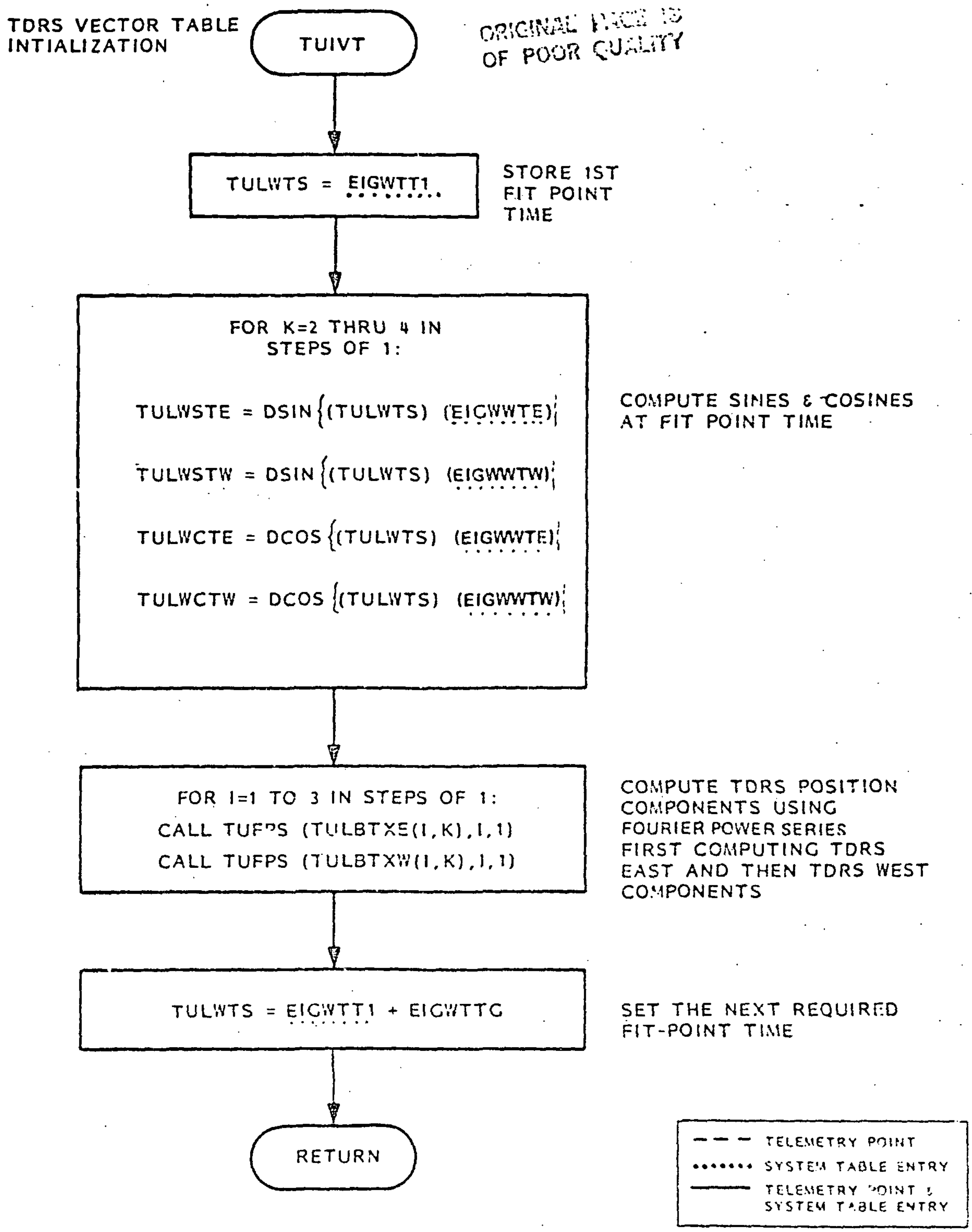

FIGURE B. 3.10-3 TUIVT Flow Chart

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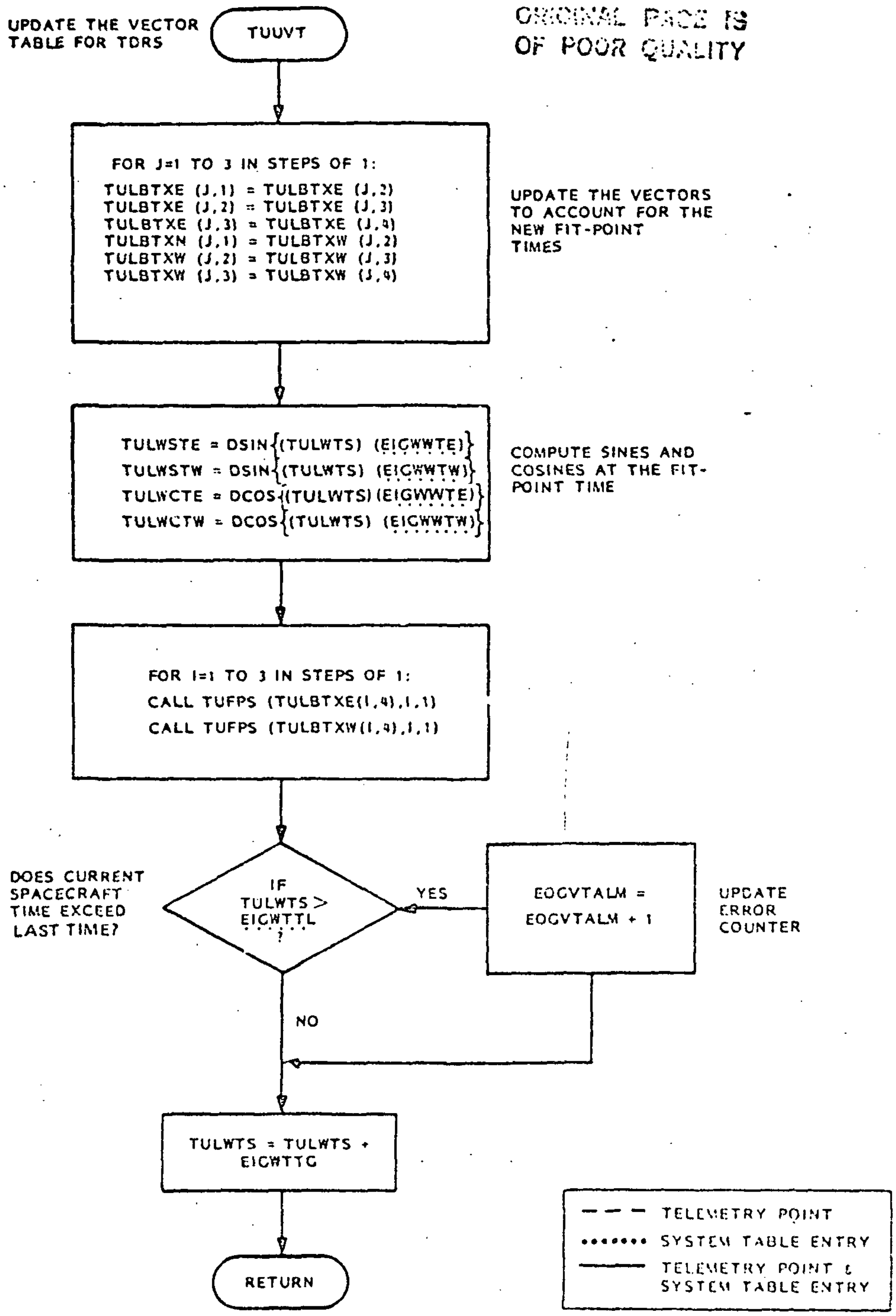

FIGURE B.3.10-4 TUUVT Flow Chart

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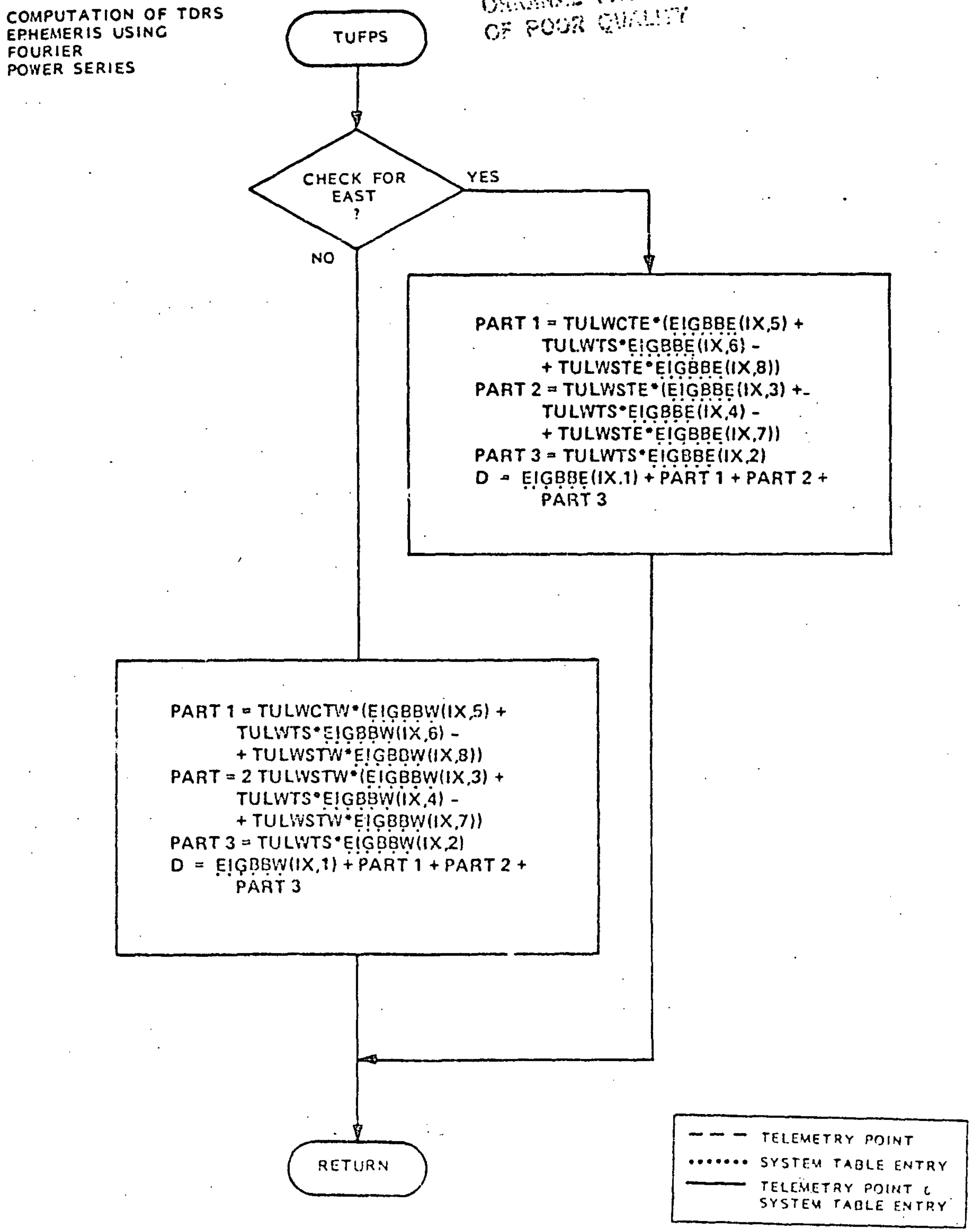

FIGURE B.3.10-5 TUFPS Flow Chart

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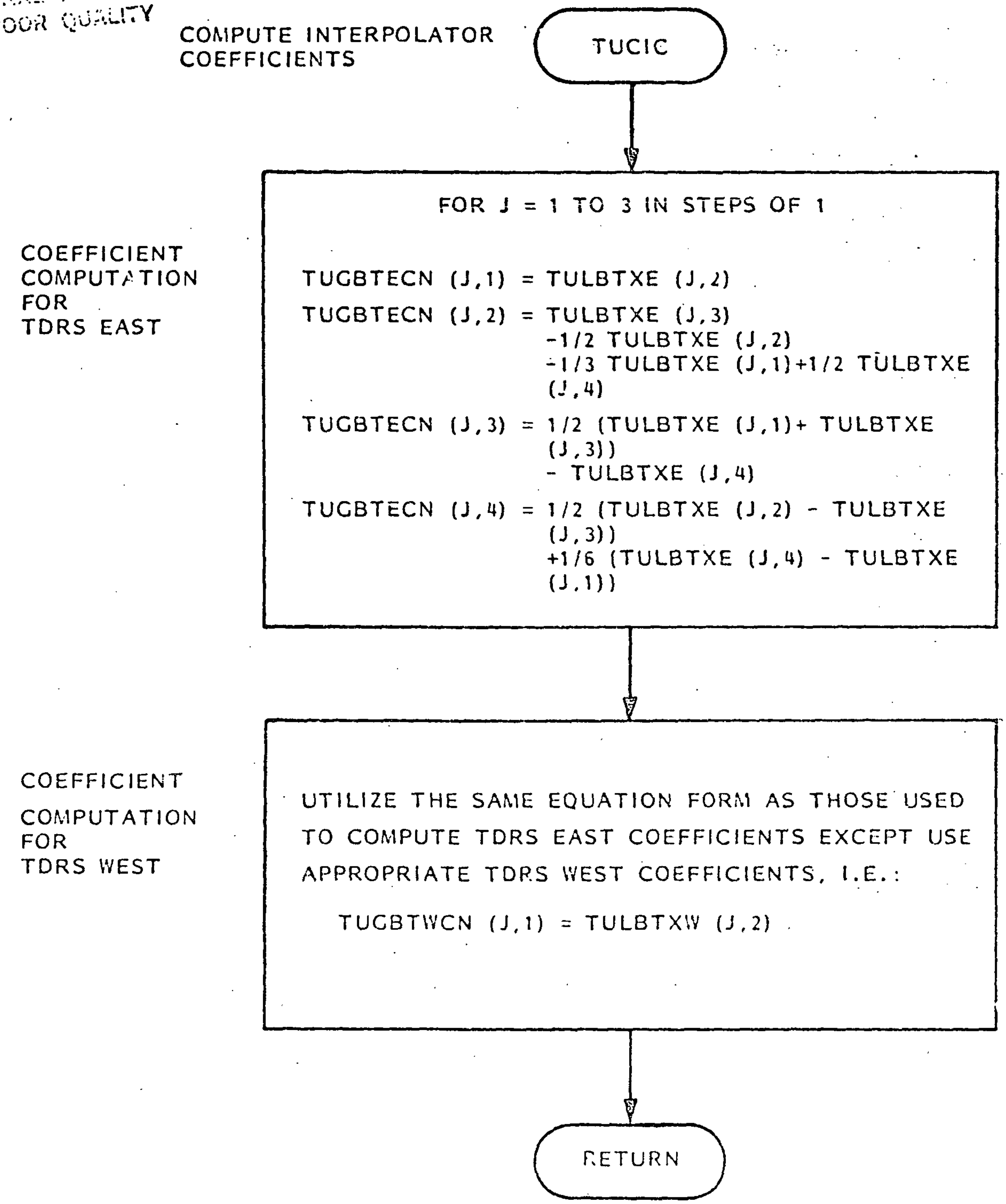

FIGURE B.3.10-6 TUCIC Flow Chart

B.3.11 TDRS ANTENNA POINTING MODULE (APCM)

B.3.11 APCM

B.3.11 TDRS ANTENNA POINTING MODULE (APCM)

B.3.11.1 TDRS Antenna Pointing Module (APCM) Processor Description

The function of the TDRS Antenna Pointing Module (APCM) processor is to command the orientation of the TDRS Antenna. This processor provides control capability for the TDRS Antenna to function in the Autotrack, Program Track, and Slew mode. Additionally, the processor has the capability to command and control the TDRS antenna to function in the Backup Search mode. Finally, the APCM processor provides failure detection and correction capability.

The APCM processor is a foreground processor executed nominally every 0.256 seconds. Execution is requested by the Spacecraft Control Processor (SCP), and the APCM processor has a priority of 5. This processor consists of 16 subroutines and a control function APCM as delineated in Table B.3.11-1.

The TDRS Antenna Pointing Module (APCM) Processor is structured as a series of nested subroutines. The APCM control function has the capability of calling nine of the processor subroutines.
All other processor subroutines are called by one of these nine.

The APCM processor utilizes System Tables 26 and 27. These system tables provide the capability for uplinking Antenna commands and also TDRS Antenna system parameters. These parameters include alignments, switching threshholds, and failure threshhold levels.

Additionally, the TDRS Antenna Pointing Module (APCM) Processor outputs four telemetry reports. These reports - OBC Telemetry Reports 20 through 23 - are output four times per major frame.

Table B.3.11-1. TDRS Antenna Pointing Module (APCM)

Number:	7
Type:	Foreground
Priority:	5
Period:	0.256 seconds
Function:	Command the orientation of the TDRS Antenna, utilizing Program Track, Autotrack, Backup Search, and Slew operation.

Subroutines:

APINT	Antenna pointing initialization
PREFLTR	Retrieve and filter ATR data
GRSDATA	Retrieve, convert gimbal angles, and compute azimuth gain correction factor
APRQEST	Validate and update antenna pointing request commands
VERIFY	Validate antenna pointing request commands
UPDATE	Sets antenna pointing/control flags
MODEINT	Initialize variables required by current pointing mode
MODESWI	Check to see if time to exit current pointing mode
PROTRAK	Program track error computation
TAROUND	Turnaround maneuver computation
TRAKERR	Tracking error computation
BUSERCH	TDRS backup search
SLEW	Open loop antenna drive at specified rate
AUTOTRK	Antenna drive command computation based on autotrack receiver tracking errors
NEWSTEP	Antenna step command computation
SENCMDS	Step command sending

System Tables:

#	Mneumonic	Type	# Words	Description
26	[illegible] QUEUE	Variable	up to	Antenna Commands
27	ANTPARM	Variable	11	Antenna Parameter

Telemetry Reports: OBC Reports 20 through 23

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B.3.11.2 TDRS Antenna Pointing Module (APCM) Processor Operation

When program control is passed to APCM by the S/C Control Processor (SCP), the EA register will be saved and APCM will check to see if it has been instructed to initialize itself. If it has, the appropriate variables will be set to their initial values. Regardless of whether APCM is instructed to initialize itself or not, program control is then unconditionally transferred to PREFLTR to process the Autotrack Receiver (ATR) outputs. This consists of retrieval of the ATR outputs and filtering of the mode switching data, using a simple digital lag filter. Additionally, compensated tracking errors are computed.

The next thing to be done is dependent on whether it is the start of an antenna pointing control cycle or not. If not, program control will be returned to the Spacecraft Control Processor (SCP) immediately, and no further execution of the TDRS Antenna Pointing Module (APCM) Processor will occur. If it is the start of an antenna pointing control cycle, the subroutines GRSDATA and APRQEST will be called sequentially. The measured antenna pointing angles (Gimbal Resolver outputs) will be converted to degrees in the subroutine GRSDATA, and the antenna pointing request commands (if any) will be acted upon in APRQEST, respectively.

The processor then executes mode dependent processes. The mode dependent processing is dependent on both the current and past pointing modes. The APCM processor, using either MODEINT or MODESWI subroutines, causes the current antenna pointing mode to be either initialized, exited, or continued, dependent on whether the current and past pointing modes are different or the same. Processor operation will then be transferred to either PROTRAK, AUTOTRK, BUSERCH, or SLEW, as specified by the current pointing mode. These routines, in association with the respective subroutines and procs, that they call, will perform, respectively, the program track processing, autotrack processing, backup search mode processing, and slew processing. This mode dependent processing will then be concluded by implementing the software gimbal stops when necessary, and sending the antenna drive commands for the current control cycle to the Gimbal Drive Electronics (GDE). These procedures will be performed by the subroutine SENCMDS.

The TDRS Antenna Pointing Module (APCM) Processor control function then calls the subroutine APCSFDC. This subroutine performs the failure detection and correction function.

Finally, the APCM control function checks to determine whether the APCM telemetry buffer is to be updated. If it is time to update the buffer, control will be transferred to TLMFMT. If it is not time to update the telemetry buffer, the APCM Processor will be exited and control will be returned to the Spacecraft Control Processor (SCP).

The following presents a summary description of the processor subroutines. For more detail, see the flow charts in Section B.3.11.6.

B.3.11.2.1 Autotrack Receiver Prefilter (PREFLTR) Operation

The function of the PREFLTR subroutine to prefilter the ATR outputs. PREFLTR begins by retrieving the selected ATR outputs and converting them from counts to volts. The results will then be filtered using a simple digital lag filter. PREFLTR will then compute the compensated tracking error signals (the difference between the ATR tracking errors and their corresponding calibrated reference values), and filter them using a quadratic digital lag filter. This is done in the subroutine FLTR2. This subroutine is called by the APCM control function every execution of the APCM processor (every 256 milliseconds).

B.3.11.2.2 Gimbal Resolver Serial Data (GRSDATA) Subroutine Operation

This subroutine is called by APCM to convert the measured pointing angles to degrees. GRSDATA begins by extracting the azimuth and elevation data from the appropriate bits of the selected resolver data, and converting them by multiplying by the appropriate counts to degrees conversion factor. The subroutine then converts the data from TRW coordinates to Landsat-D coordinates and applies appropriate gain correction factors.

B.3.11.2.3 Antenna Pointing Request Commands (APRQEST) Subroutine Operation

This subroutine and the subroutines it calls (VERIFY and UPDATE) have the capability to update the antenna pointing control flags and /or the control data. APRQEST, when called by the APCM control function, will first test to see if there are any real time antenna pointing request commands to be acted upon. If the test is successful, program control passes, in turn, to VERIFY to validate the requests and to UPDATE to set the appropriate control flags and/or data as specified by the request commands. If one or more of the request codes are invalid, this fact will be reported to the ground through the antenna pointing contribution to telemetry by VERIFY and none of the requests will be honored. Regardless whether or not the requests are honored, the real-time request command queue and queue counter will be reinitialized.

APRQEST will then test, in turn, the stored command queue counter to see if there are any stored request commands to be acted upon, and the stored command enable flag to see if stored command processing is allowed. If both checks are affirmative, program control will be trnasferred to VERIFY and UPDATE to process the stored request commands in a similar fashion to that done for the real time commands.

B.3.11.2.4 Request Command Verification (VERIFY) Subroutine Operation

This subroutine is called by APRQEST to validate the antenna pointing request commands and their associated operands. If an invalid command is encountered, the appropriate status bit will be set and the updating of the control flags/data will be inhibited.

B.3.11.2.5 Antenna Pointing Control Flag/Data Update (UPDATE) Subroutine Operation

This subroutine is called by APRQEST to update the antenna pointing control information. UPDATE subroutine simple sets the pointing control flags and/or data as specified by the contents of QUEADD, unless the queue pointer is zero. If the queue pointer is zero, control to returned to APRQEST.

B.3.11.2.6 Mode Initialization (MODEINT) Subroutine Operation

This subroutine is called by the APCM control function when the current and past pointing modes are different. Thefunction to be performed by the MODEINT subroutine is controlled by the current pointing mode. If the current pointing mode is set to either backup search or slew, then the variables unique to either of these respective modes will be initialized. No initialization is required for either the program track or autotrack modes except for the initial initialization.

B.3.11.2.7 Mode Switching (MODESWI) Subroutine Operation

This subroutine is called by APCM control function when the current and past pointing modes are the same. Its function is to check if it is time to exit the current pointing mode. MODESWI first computes the size of the mode switching error signals. The next thing to be done is dependent on the current pointing mode, APMODE.

If APMODE is set to program track and automatic mode switching is enabled, a check will be made to see if the program track to autotrack mode switching criteria have been met. APMODE will be set to auto track if it has.

If APMODE is set to backup search, a check will be made to see if the backup search to autotrack mode switching criteria has been met, and, if it has, APMODE will be set to autotrack and automatic mode switching will be inhibited. If not, MODESWI will then check to see if the maximum scan range has been exceeded. APMODE will be set to program track if this is the case.

If APMODE is set to autotrack, MODESWI will check to see if the autotrack to program track switching criteria has been met. APMODE will be set to program track when and if the mode switching criteria are met.

B.3.11.2.8 Program Track (PROTRAK) Subroutine Operation

The Program Track (PROTRAK) subroutine is called by the APCM control function when the current mode is set to Program Track. PROTRAK operation is controlled by the variable EXTRN. When EXTRN is zero, the Normal Program Track processing will be performed; that is, tracking errors will be computed using LANDSAT-D and TDRS ephemerides. When EXTRN is not zero, the tracking errors will be computed by subtracting the measured pointing angles from the desired pointing angles. In either case, the antenna will be driven at the appropriate rate to null the tracking errors. Additionally, if the calibrate enable switch, CALENA, is other than zero, the calibrated bias values will be updated.

B.3.11.2.9 Antenna Turnaround Maneuver (TAROUND) Subroutine Operation

This subroutine is called by the PROTRAK subroutine when an antenna turnaround has been commanded. TAROUND first transfers control to ZENITH subroutine to compute the zenith angle in the orbital frame. TAROUND then checks to see if it is time to start the turnaround maneuver. If it is time to start the turnaround maneuver, the tracking errors will be computed by subtracting the measured pointing angles from the externally commanded pointing angles and PROTRAK will be signaled that an antenna turnaround is in progress by the setting of EXTRN to a value of 1. If it is not time, the tracking errors for the continous track mode will be computed (This will be done in the subroutine TRAKERR).

B.3.11.2.10 Tracking Error Computation (TRAKERR) Subroutine Operation

This subroutine is called by PROTRAK when an antenna turnaround has not been commanded and by TAROUND when an antenna turnaround has been commanded. TRAKERR performs three functions:

(1) computes the errors for the continuous program track mode
(2) corrects the azimuth tracking error for the geometric gain associated with gimbal lock; and
(3) sets up the limits on the computed elevation drive rate.

B.3.11.2.11 Backup Search (BUSERCH) Subroutine Operation

This subroutine is entered when the current pointing mode is set to backup search. The desired pointing angles are first computed. The subroutine then proceeds to compute the pointing errors in a four step process. First, the desired pointing angles will be computed. Then, the scan increment angles will be added to the desired pointing angles. Third, the tracking errors will be computed by subtracting the measured pointing angles from the angles computed in Step two. The azimuth tracking error will then be compensated. The subroutine then checks to see if the current scan axis limit has been reached. If so, the scan range and scan direction for the other gimbal axis will be updated.

B.3.11.2.12 Slew Maneuver (SLEW) Subroutine Operation

The SLEW subroutine has the function to drive the antenna open loop at the specified rates for the specified amount of time. This subroutine is entered when the current pointing mode is set to slew. The drive rates for the current control cycle will be set to the commanded slew rates. SLEW then checks to see if the end of the slew maneuver has been reached. If so, the current pointing mode will be set to program track.

B.3.11.2.13 Autotrack (AUTOTRK) Subroutine Operation

The Autotrack (AUTOTRK) subroutine is entered when the current pointing mode is set to autotrack. AUTOTRK converts the tracking errors from volts to radians, compensates the azimuth tracking error for the gain associated with gimbal lock, and sets the limit on the elevation drive rate.

B.3.11.2.14 Antenna Step Commands Computation (NEWSTEP) Subroutine Operation

This subroutine is called by either PROTRAK, TAROUND, AUTOTRK, or BUSERCH subroutines. Its function is to compute the antenna step commands for the closed loop control modes, using the tracking errors. This subroutine then limits these commandsto the maximum steps per control cycle. This is dependent on the current pointing mode.

B.3.11.2.15 Send Step Commands to the GDE (SENCMDS) Subroutine Operation

This subroutine is called upon completion of the mode dependent processing. Its function is to appropriately format the commands and call the executive to queue the commands. Before doing this, however, this subroutine checks for step command size change, and limits this. Also, software gimbal stops are implemented.

B.3.11.2.16 Antenna Pointing Telemetry Formatter (TLMFMT) subroutine Operation

This subroutine formats the APCM parameters that appear in the telemetry reports. See Section B.3.11.5 for more detail.

B.3.11.3 TDRS Antenna Pointing Module (APCM) Software Constraints

TBD

B.3.11.4 TDRS Antenna Pointing Module (APCM) System Tables

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Entry	Name	TLM	Type	Using Subroutine	Description
System Table #26 - ANTIQUE (Antenna Pointing Real Time Commands)					
0000	I%COUNT		V	APRQEST	Number of commands to be acted upon
0001-0009	I%QUEUE		V	APRQEST	Antenna pointing commands. Up to 8 commands can be uplinked. Possible commands are listed here.

Basic Format of Antenna Commands

Fixed Code	Request Code*	Operand**
0111 11111	XXXXX	XXXX

X X X X X X X X X X X X X X X X X X   Additional operands

*Request codes are right justified from 1 (000001) to 12 (01100)

**Operands for any command may not be required (see commands #2 & 3), or may require additional operands (see command #9)

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Req. Code	Operand	Description
1(00001)	0000 Inhibit 0001 Program track 0010 Backup search 0011 Slew	Change antenna pointing mode or inhibit
2(00010)	not used	Enable advance turnaround maneuver
3(00011)	not used	Reset antenna pointing status info
4(00100)	0000 Enable 0001 Inhibit	Control stored request command processing
5(00101)	0000 Enable 0001 Inhibit	Control automatic mode switching
6(00110)	0000 Enable 0001 Inhibit	Control autotrack receiver reference calibration
7(00111)	0000 East 0001 West	Control TDRS to be used
8(01000)	0000 Compute 0001 Use uplink	Program track pointing angle source
9(01001)	not used Additional operands: (1) New slew time:	Update slew timer Number of counts, where each count equals 0.512 seconds
10(01010)	not used Additional operands: (1) Azimuth slew rate (2) Elevation slew rate	Update slew rates Azimuth slew rate and elevation slew rate are both in 2's complement
11(01011)	not used Additional operands (1) Azimuth pointing	Update external pointing commands Bits 1-9: fractional

Req. Code	Operand	Description
	angle (2) Elevation pointing angle	position Bits 10-18: integer position
12(01100)	0000 Disallow 0001 Allow	Large slew allow/disallow

Additional Remarks

1. Pointing request commands achieved by system table uplink consisting of entry #0000 and command sequence entry #0000 indicates number of command words. For example, command #11, Update ext. ptng commands consists of 3 commands.

2. Table #27 changes are single buffered; hence any changes in Table #27 should be preceeded by an inhibit of APM until table is verified. This is accomplished by Table #26 utilization with Req. Code #1.

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Entry	Name	TLM	Type	Using Subroutine	Description
System Table #27 - ANTPARM (Antenna Pointing Parameters)					
0000	INITSW		C	APCM	Ground initialization bits
0001	IERATR	*	F	APINT	ATR selection index
0002	IRESLV	*	F	APINT	Gimbal resolver data source
0003	FDCGDEE		F	APCS DETECTION	Elevation GDE, FDC and Azimuth GDE-FDC
0004	FDCGDEA		F	APCS DETECTION	Enabled flag
0005	TABCMD	*	V	TRAKERR	Azimuth bias command
0006	TEBCMD	*	V	TRAKERR	Elevation bias command
0007	KUCHNL		F	APCSFDC	KU TWTA channel select
0008	LAMA1	*	C	MODESWI	Program track to autotrack switching thresholds
0009	LAME1	*	C	MODESWI	
0010	LAMS1	*	C	MODESWI	
0011	LAMA2	*	C	MODESWI	Autotrack to program track switching thresholds
0012	LAME2	*	C	MODESWI	
0013	LAMS2	*	C	MODESWI	
0014	LAMS3	*	C	MODESWI	Backup switch to autotrack switching threshold
0015	ELIM		C	AUTOTRK, TRAKERR	Elevation high rate limit antenna advance angle
0017	ANTADV	*	C	PROTRAK	Turnaround initiation criterion

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Entry	Name	TLM	Type	Using Subroutine	Description
0018	ELBIAS	*	C	TAROUND	Turnaround completion
0019	ALPHA		C	PROTRAK	criterion
0021		*	C	DIRNANB	Euler parameters to
0023	EPAE(I)	*	C		correct for antenna
0025	I=1,4	*	C		alignment errors
0027		*	C		
0028	MAXCNT		C	APCSFDC	FDC parameters (limits)
0029	TELMIN		C	APCSFDC	
0030	TELMAX		C	APCSFDC	
0031	TAZMIN1		C	APCSFDC	
0032	TAZMAX1		C	APCSFDC	
0033	TAXMIN2		C	APCSFDC	
0034	TAZMAX2		C	APCSFDC	
0035	EFPASS		C	APCSFDC	
0036	AFPASS		C	APCSFDC	

B.3.11.5 TDRS Antenna Pointing Module (APCM) Telemetry

Entry Number	Name	Generating Subroutine	Description/Comment
<u>OBC TLM Report #20</u>			
0000	EANA	PREFLTR	ATR azimuth error signal
0001	EANE	PREFLTR	ATR elevation error signal
0002	ESTS	PREFILTER	ATR signal strength in volts
0003	EABSC	PROTRAK	Calibrated air azimuth signal bias
0004	EEBSC	PROTRAK	Calibrated ATR elevation signal bias
0005	ESSBC	PROTRAK	Calibrated ATR signal strength bias
0006	THANA	GRSDATA	TDRS antenna azimuth angle
0008	THANE	GRSDATA	TDRS elevation angle
0010	THAZ	BUSERCH	Desired TDRS antenna azimuth
0012	THEL	BUSERCH	Desired TDRS antenna elevation
0014	E2PANA	PROTRAK, TRAKERR, BUSERCH, AUTOTRK	TDRS antenna azimuth tracking TDRS antenna azimuth tracking error
0016	E2PANE	BUSERCH, AUTRK	TDRS antenna elevation tracking error
0018	DASCAN	MODEINT, BUSERCH	TDRS antenna azimuth scan range delta
0019	DESCAN	MODEINT, BUSERCH	TDRS antenna elevation scan range delta
0020	ZENANG	PROTAAK, TAROUND	Zenith angle
0022	NCSLEW	MODEINT,SLEW	TDRS antenna slew timer

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #21			
0000	NASTEP	APCM PROTRAK, SLEW, SENCMDS	TDRS antenna azimuth gimbal drive step cmd
0001	NESTEP	APCM, PROTRAK, SLEW	TDRS antenna elevation gimbal drive step cmd
0002	IS	MODEINT, BUSERCH	Scan axis indicator: = 0, azimuth scan = 1, elevation scan
0003	IAD	MODEINT, BUSERCH	Azimuth scan direction flag
0004	IED	MODEINT, BUSERCH	Elevation scan direction flag
0005	ACPMODE	APINT, UPDATE, MODESWI, SLEW, APCS DETECTION	TDRS antenna pointing mode flag
0006	EXTRN	UPDATE, PROTRAK, TAROUND	Index for selecting the gimbal angles
0007	ADVTRN	Update, PROTRAK	Advance antenna turnaround flag
0008	INTDRS	UPDATE,	Index for selecting TDRS East or West: = 0, TDRS East = 1, TDRS West
0009	CALENA	UPDATE	ATR reference calibration flag: = 0, Enabled = 1, Inhibited

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Entry Number	Name	Generating Subroutine	Description/Comment
0010	AUTOSW	UPDATE, MODEINT, MODESWI	Automatic mode switching flag: = 0, Enabled = 1, Inhibited
0011	IERATR	APINT	Index for ATR receiver select
0012	IRESLV	APINT	Index for selecting the resolver outputs: = 0, Use primary = 1, Use redundant
0014	NRACMD	UPDATE	Azimuth slew rate cmd
0015	NRECMD	UPDATE	Elevation slew rate cmd
0016	NSTCMD	UPDATE	Slew timer
0018	FEANA	MODESWI, PROTRAK	Filtered azimuth error signal
0019	FEANE	MODESWI, PROTRAK	Filtered elevation error signal
0020	FESTS	PREFLTR	Filtered strength error signal signal
0021	LARGE	UPDATE	Large slew indicator
0022	GANA		Gain compensation constant
0023	GAME		Gain compensation constant
0024	ANTAD	PROTRAK	Antenna advance angle

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #22			
0000	EPAE1	TLMFMT	Euler parms to correct for antenna alignment errors
0002	EPAE2	TLMFMT	Same
0004	#EPAE2	TLMFMT	Same
0006	EPAE4	TLMFMT	Same
0008	THACMD	UPDATE	Ext. commanded azimuth gimbal angle
0010	THECMD	UPDATE	Ext. commanded elevation gimbal angle
0012	BANA	APINT, PROTRAK NEWSTEP	Limited azimuth error signal integral
0014	BANE	APINT, PROTRAK, NEWSTEP	Limited elevation error signal integral
0016	YANA	APINT, PROTRAK, NEWSTEP	Limited azimuth error signal double integral
0018	YANE	APINT, PROTRAK, NEWSTEP	Limited elevation error signal double integral
0024	OMEGA	BUSERCH	Backup search conversion criteria

Entry Number	Name	Generating Subroutine	Description/Comment
<u>OBC TLM Report #23</u>			
0000	ELBIAS	TAROUND	Turnaround initiation criterion
0001	LAMA1	MODESWI	Program track to autotrakck MODE SWITCHING THRESHOLDS
0002	LAME1	MODESWI	Same
0003	LAMS1	MODESWI	Same
0004	LAMA2	MODESWI	Autotrack to program track SWITCHING THRESHOLDS
0005	LAME2	MODESWI	Same
0006	LAMS2	MODESWI	Same
0007	LAMS3	MODESWI	Backup search to autotrack mode switching threshold
0008	DMAX	MODESWI, BUSERCH	Backup search scan RADIUS
0009	DELTA	MODEINT, BUSERCH	Backup search scan range increment
0010	TABCMD	TRAKERR	Azimuth RESOLVER BIAS CMD
0012	TEBCMD	TRAKERR	Elevation RESOLVER BIAS CMD
0014	STALIM	MODEINT, TAROUND, TRAKERR, AUTOTRK	Max. steps in a control CYCLE
0015	STELIM	MODEINT, TAROUND, TRAKERR, AUTOTRK	Max steps in a control cycle

Entry Number	Name	Generating Subroutine	Description/Comment
0016	SCPENA	UPDATE	Stored command processing enable flag: = 0, Enabled = 1, Disabled
0017	GPA		Azimuth rate computation constants
0018	GIA		Azimuth rate computation constants
0019	GDA		Azimuth rate computation constants
0020	GPE		Elevation rate computation constants
0021	GIE		Elevation rate computation constants
0022	GDE		Elevation rate computation constants

B.3.11.6 TDRS Antenna Pointing Module (APCM) Flow Charts

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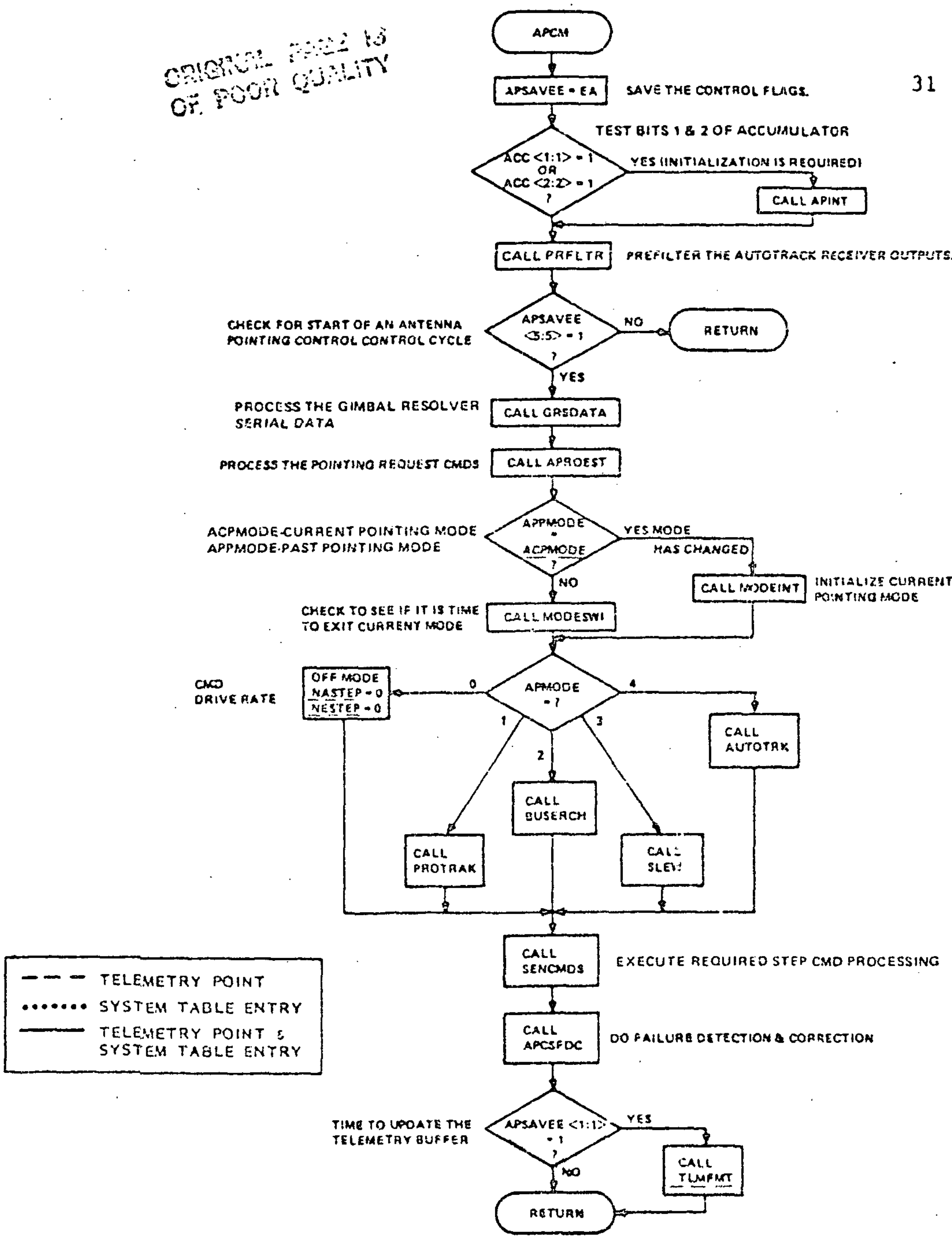

Figure B.3.11-1. APCM Flow Chart

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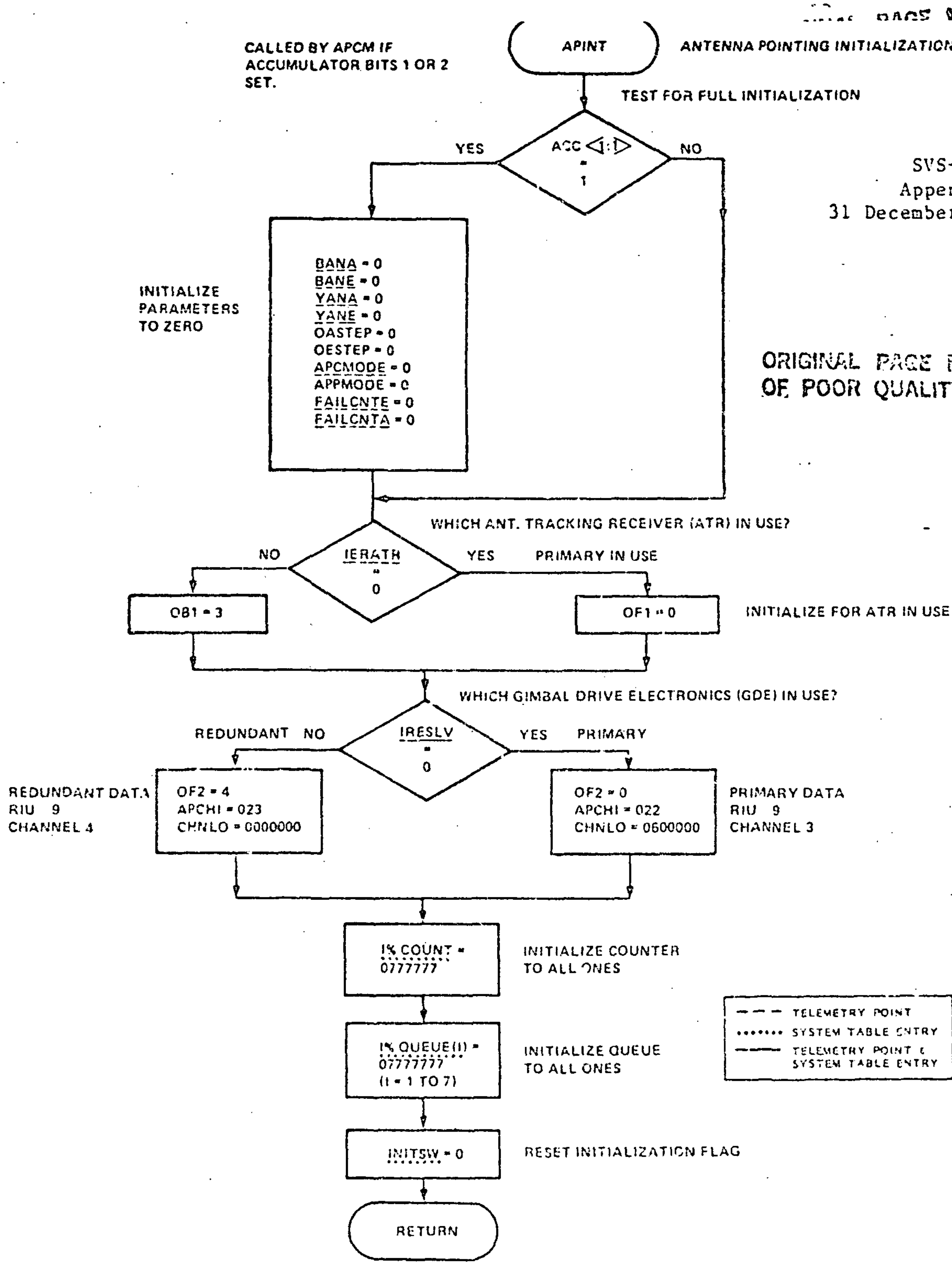

Figure B.3.11-2. APINT Flow Chart

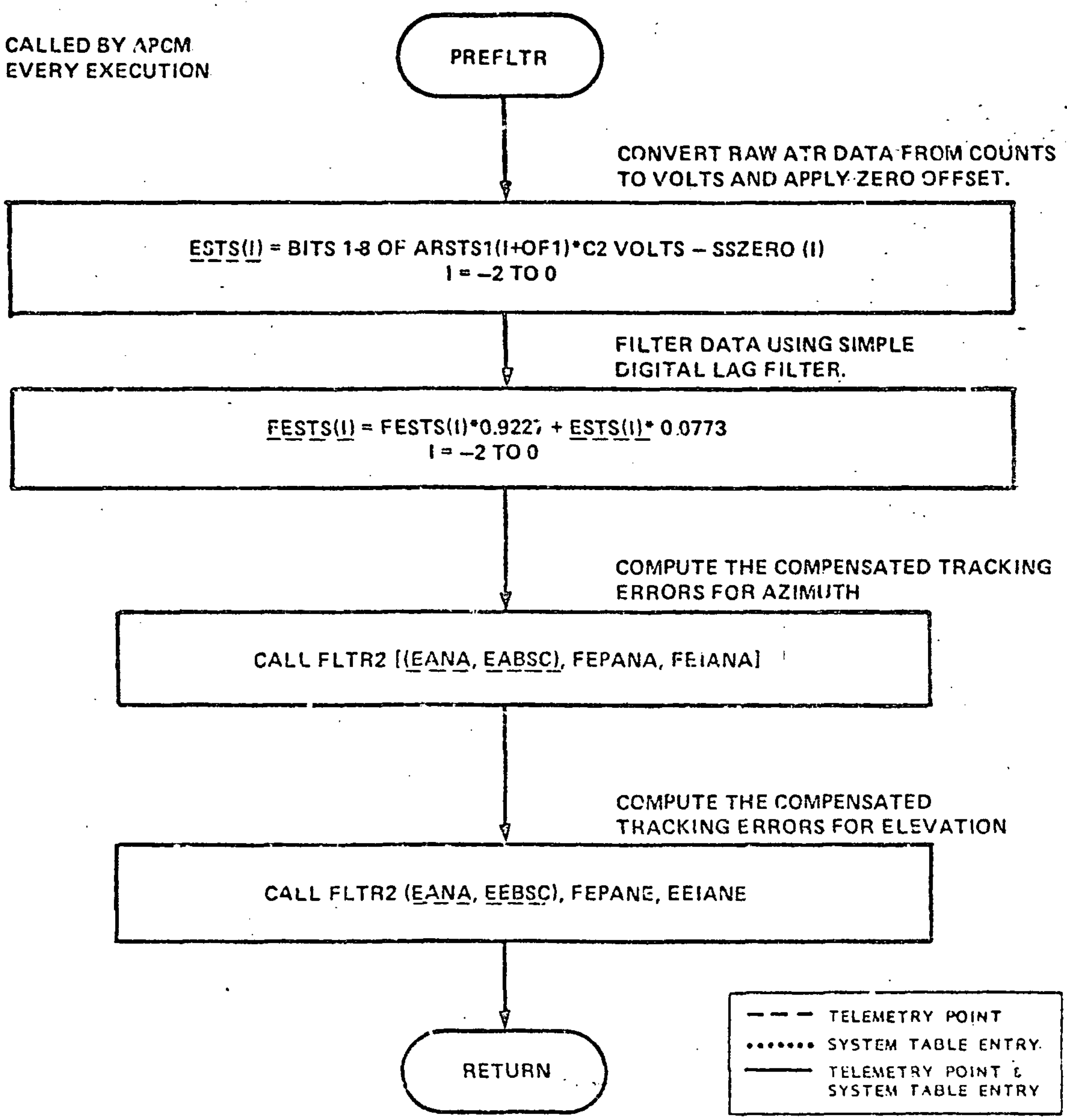

Figure B.3.11-3. PREFLTR Flow Chart

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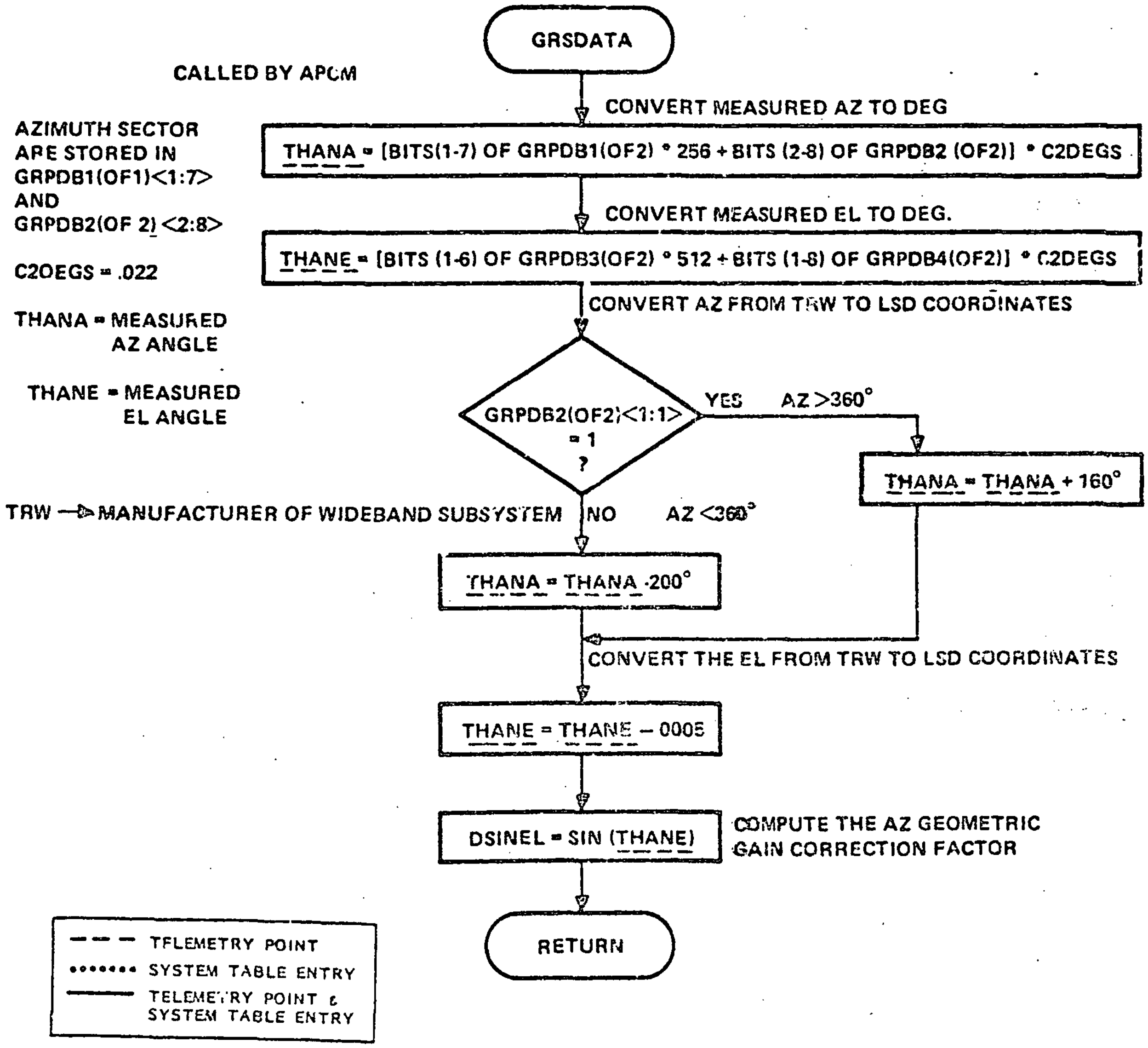

Figure B.3.11-4. GRSDATA Flow Chart

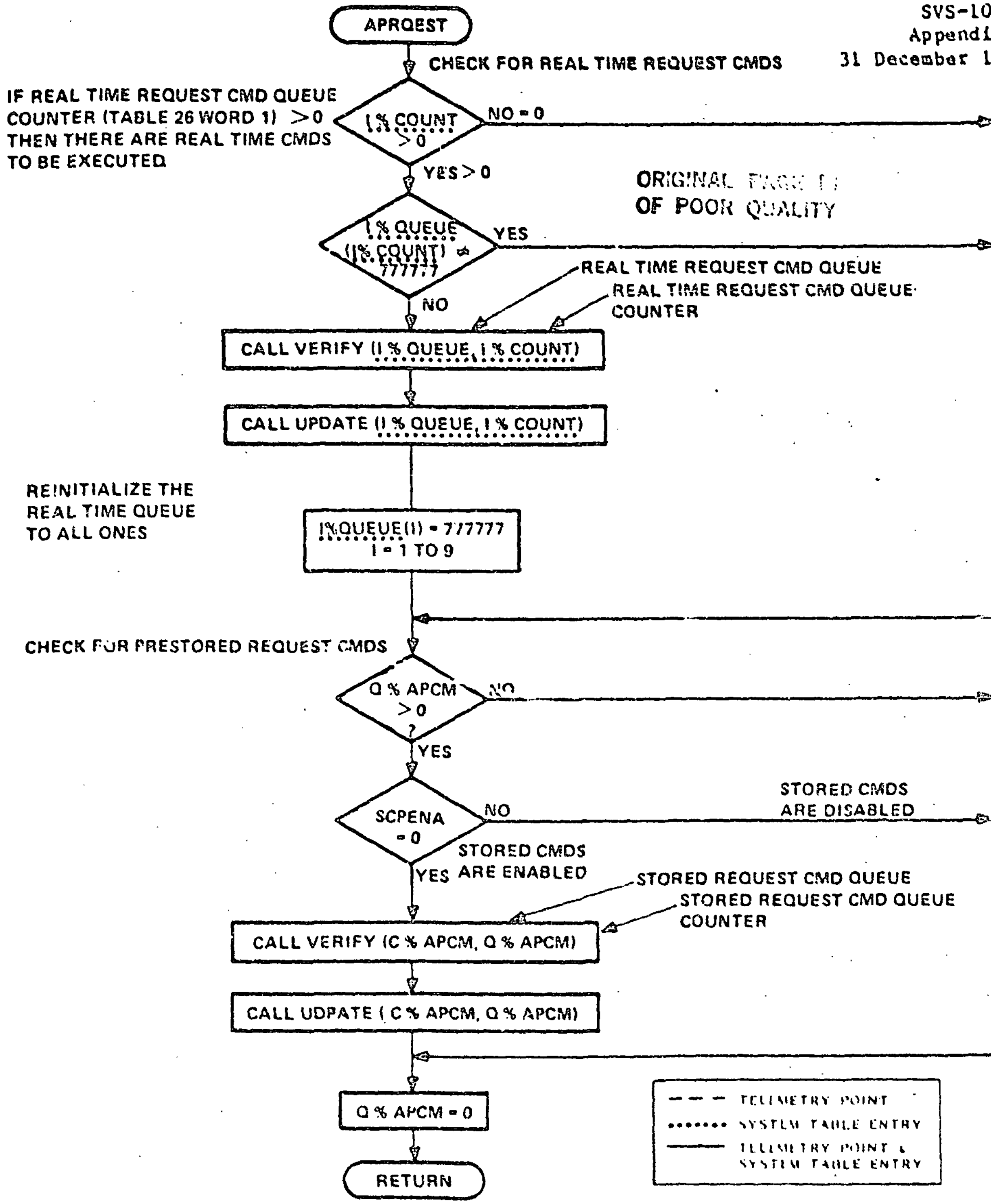

Figure B.3.11-5. APRQEST Flow Chart

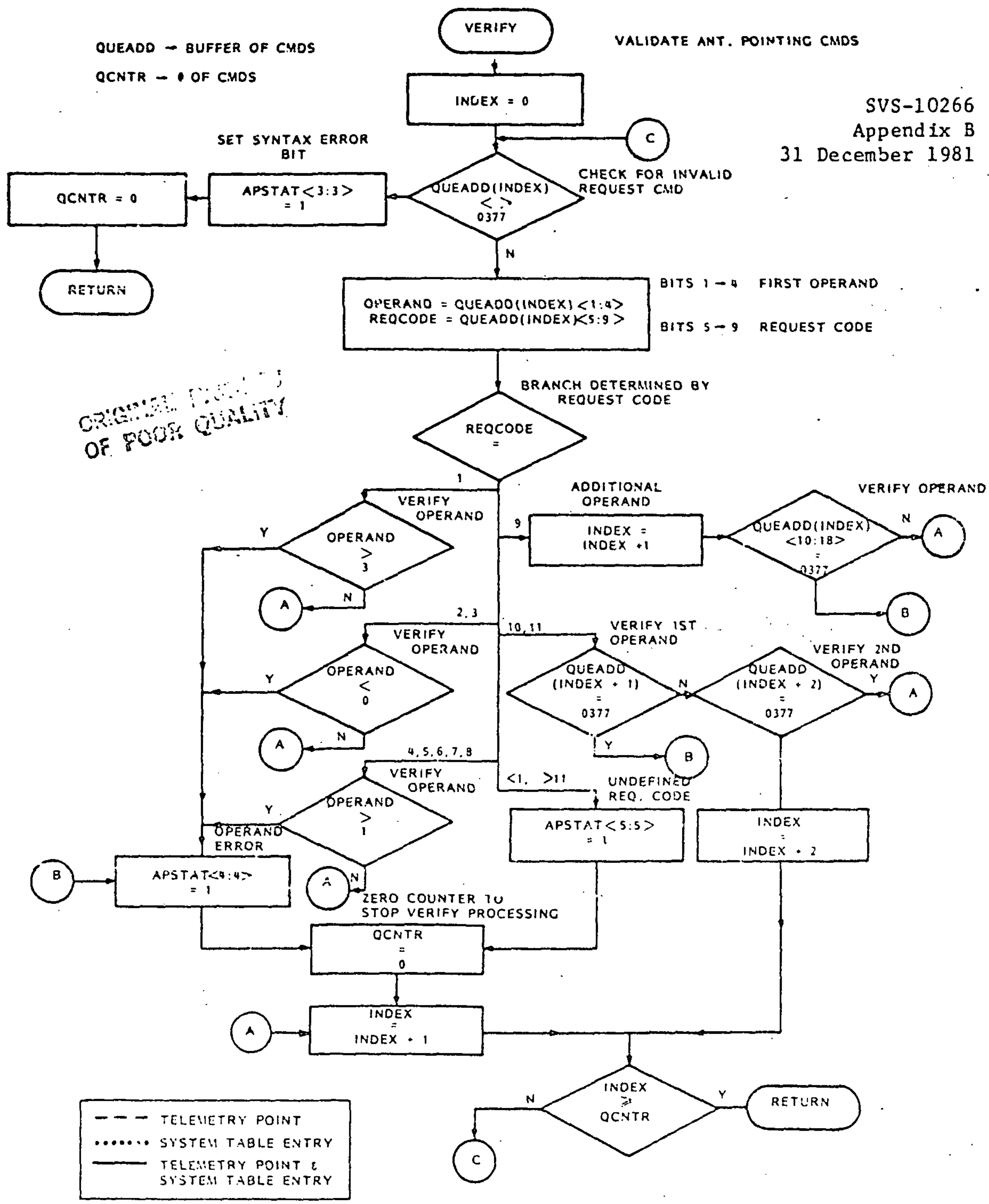

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Figure B.3.11-6. VERIFY Flow Chart

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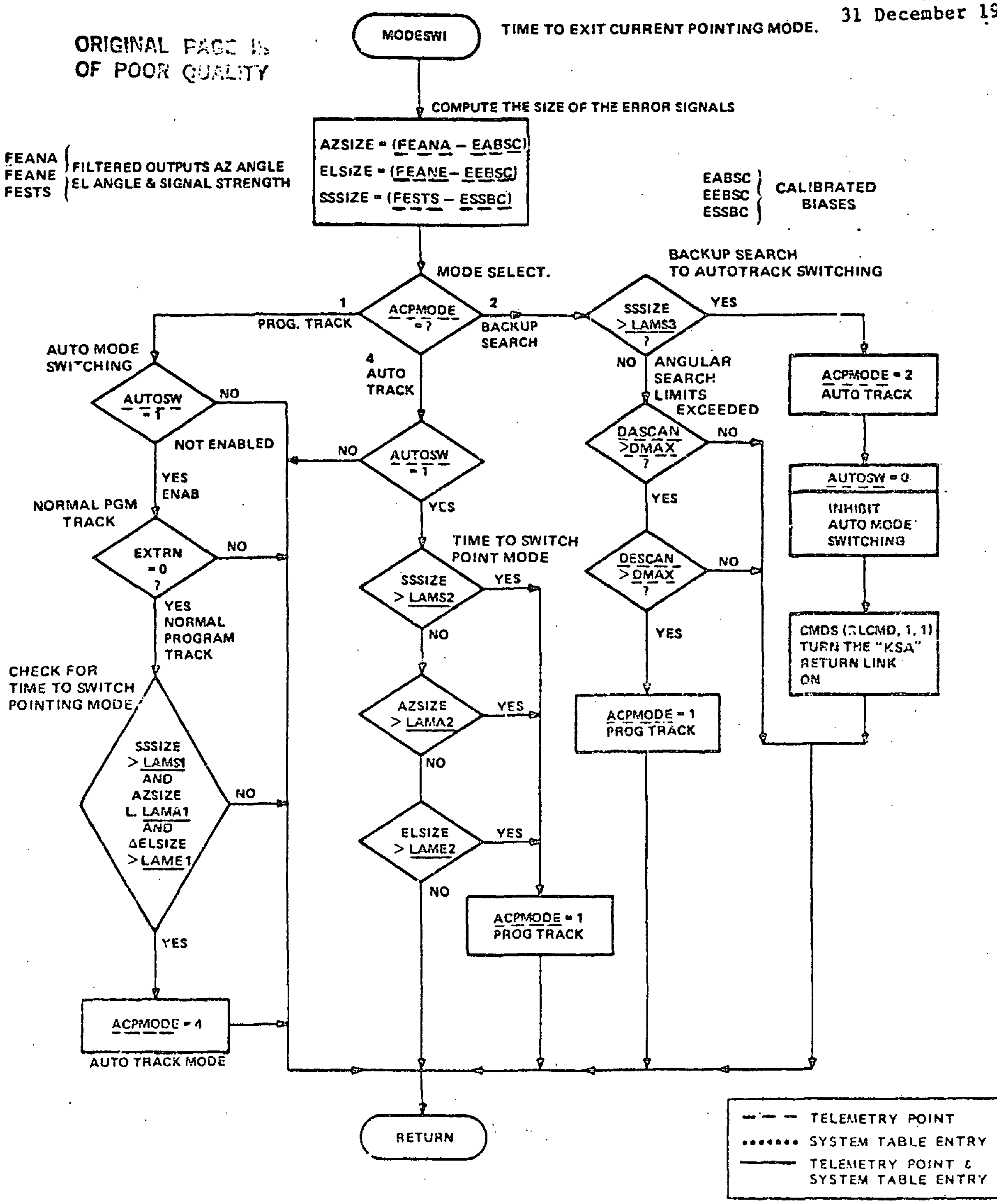

Figure B.3.11-7. MODESWI Flow Chart

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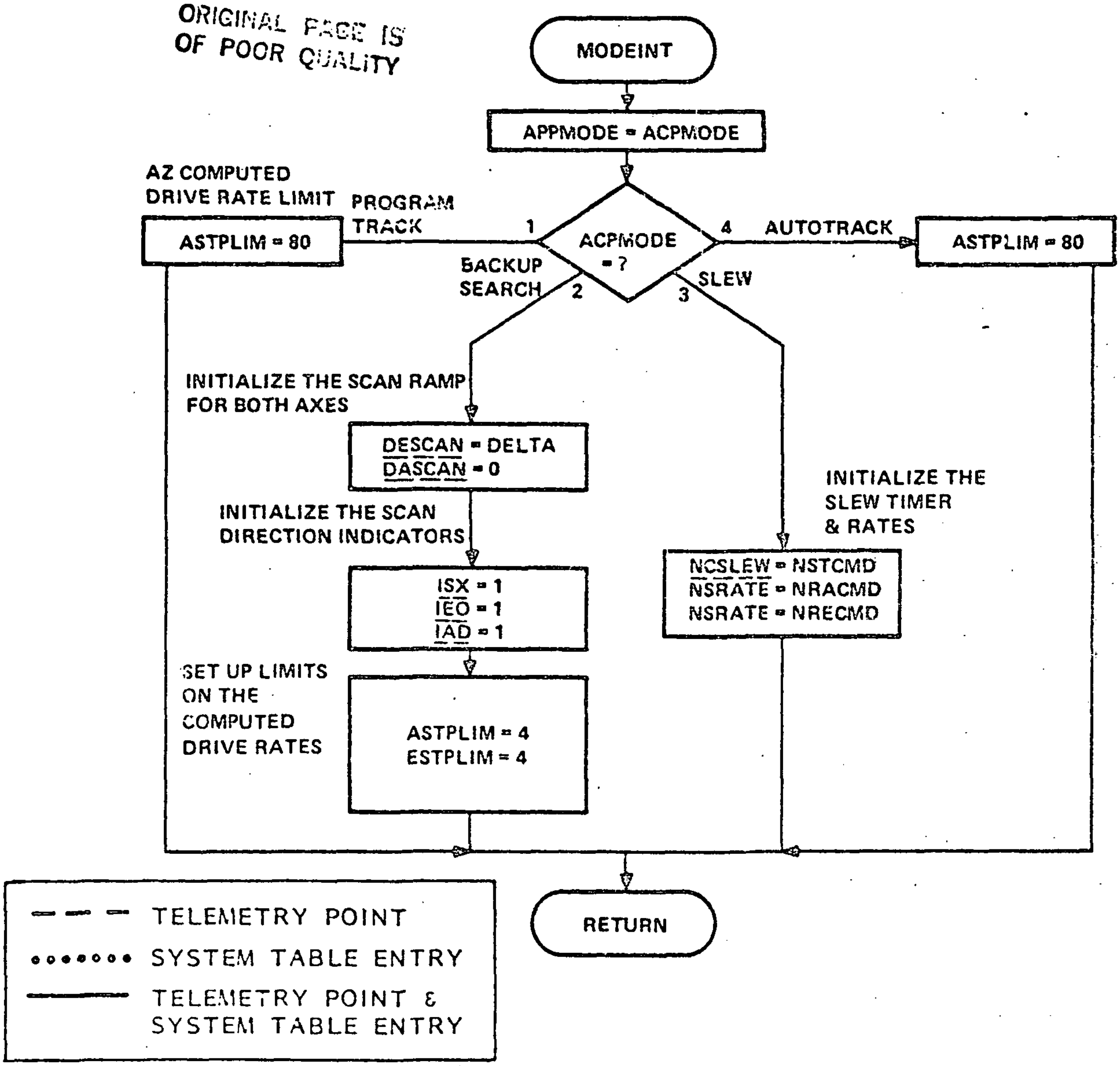

Figure B.3.11-8. MODEINT Flow Chart

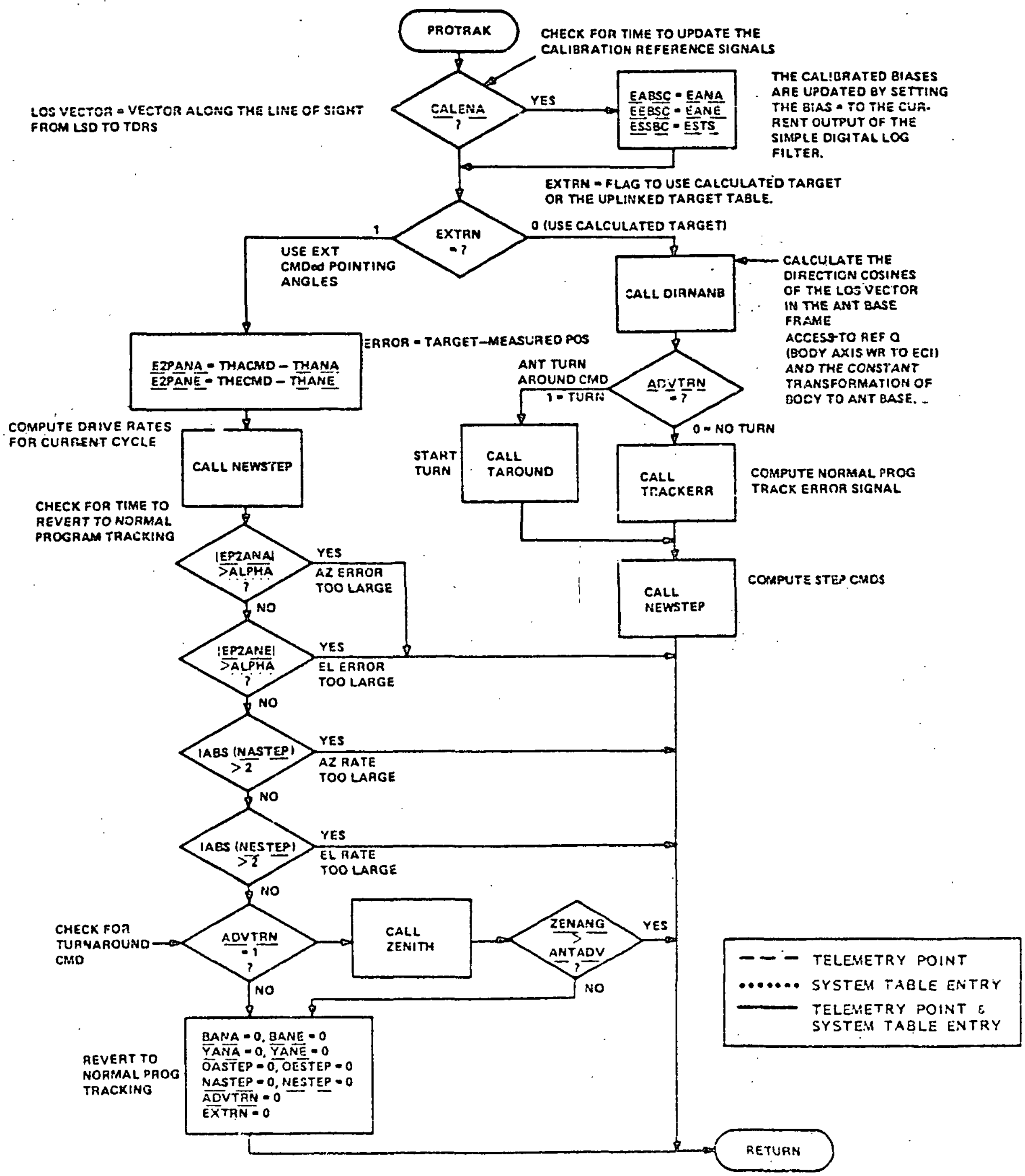

Figure 3.3.11-9. PROTRAK Flow Chart

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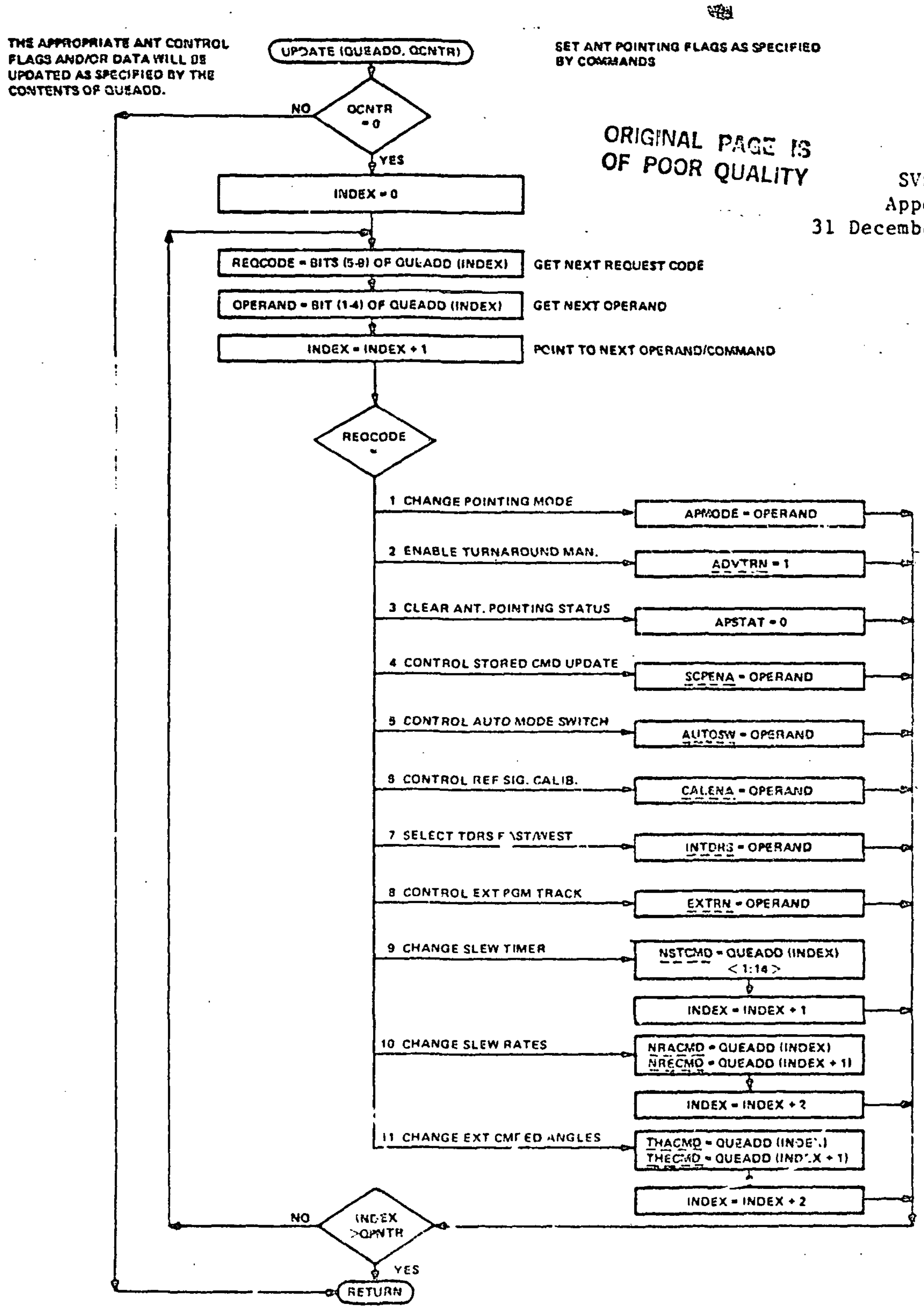

Figure B.3.11-10. UPDATE (QUEADD, QCNTR) Flow Chart

— — —	TELEMETRY POINT
•••••••	SYSTEM TABLE ENTRY
———	TELEMETRY POINT & SYSTEM TABLE ENTRY

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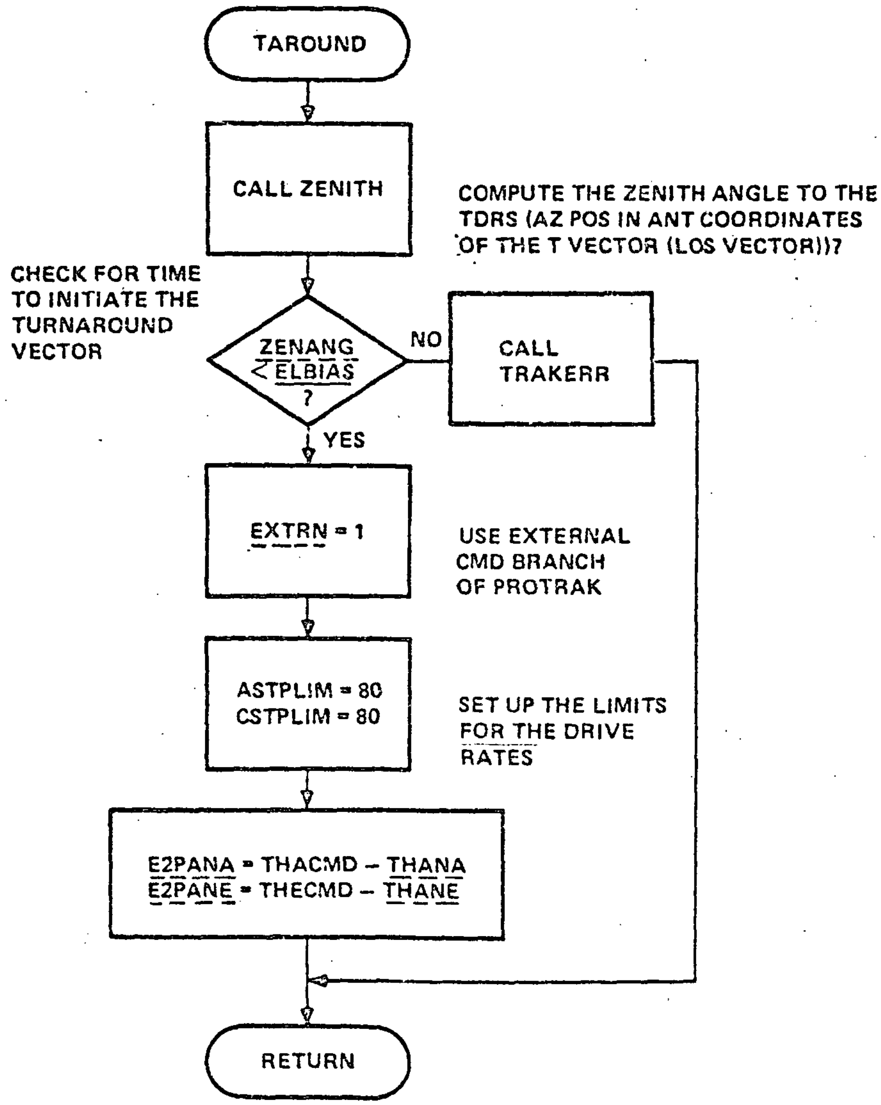

Figure B.3.11-11. TAROUND Flow Chart

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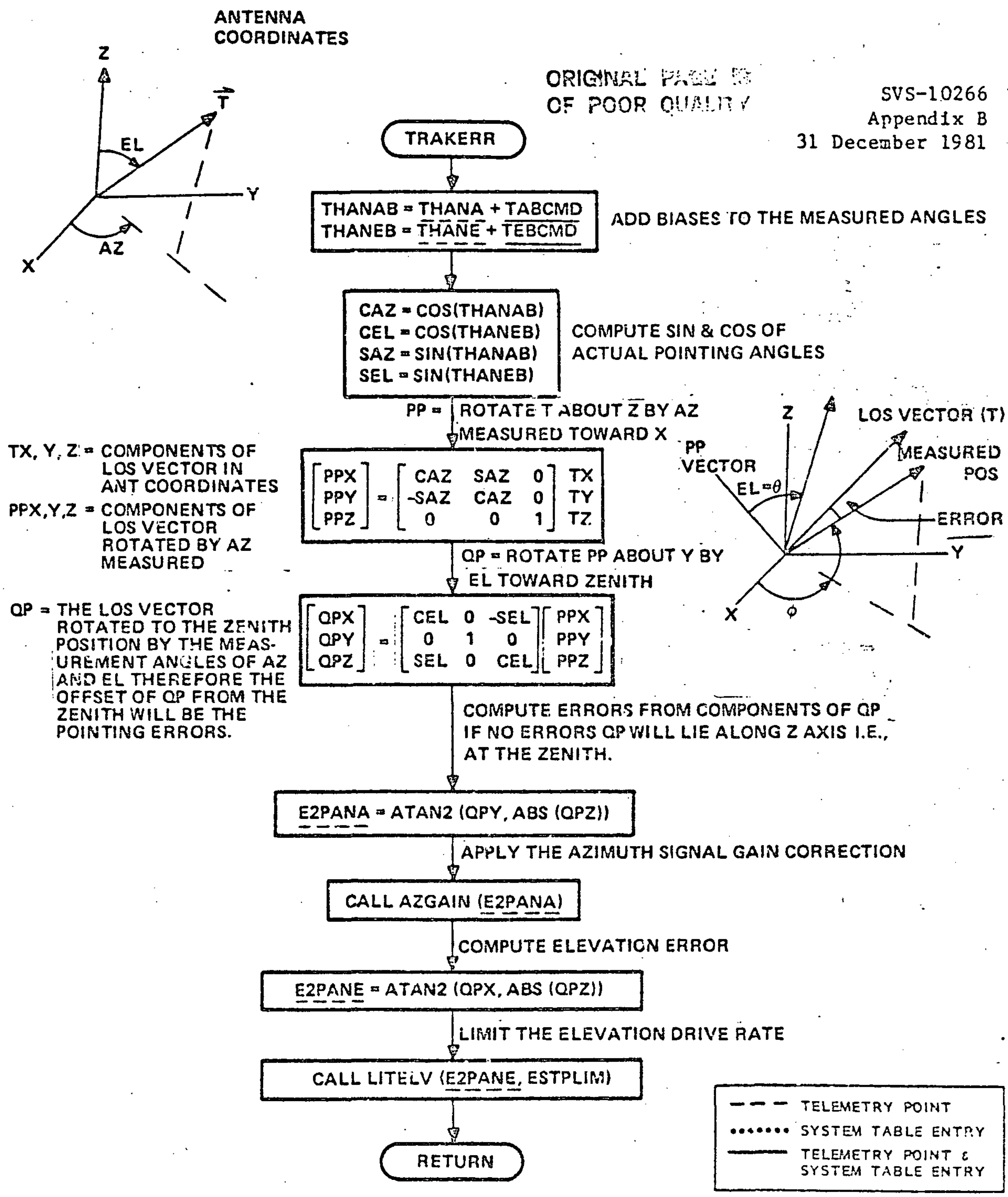

Figure B.3.11-12. TRAKERR Flow Chart

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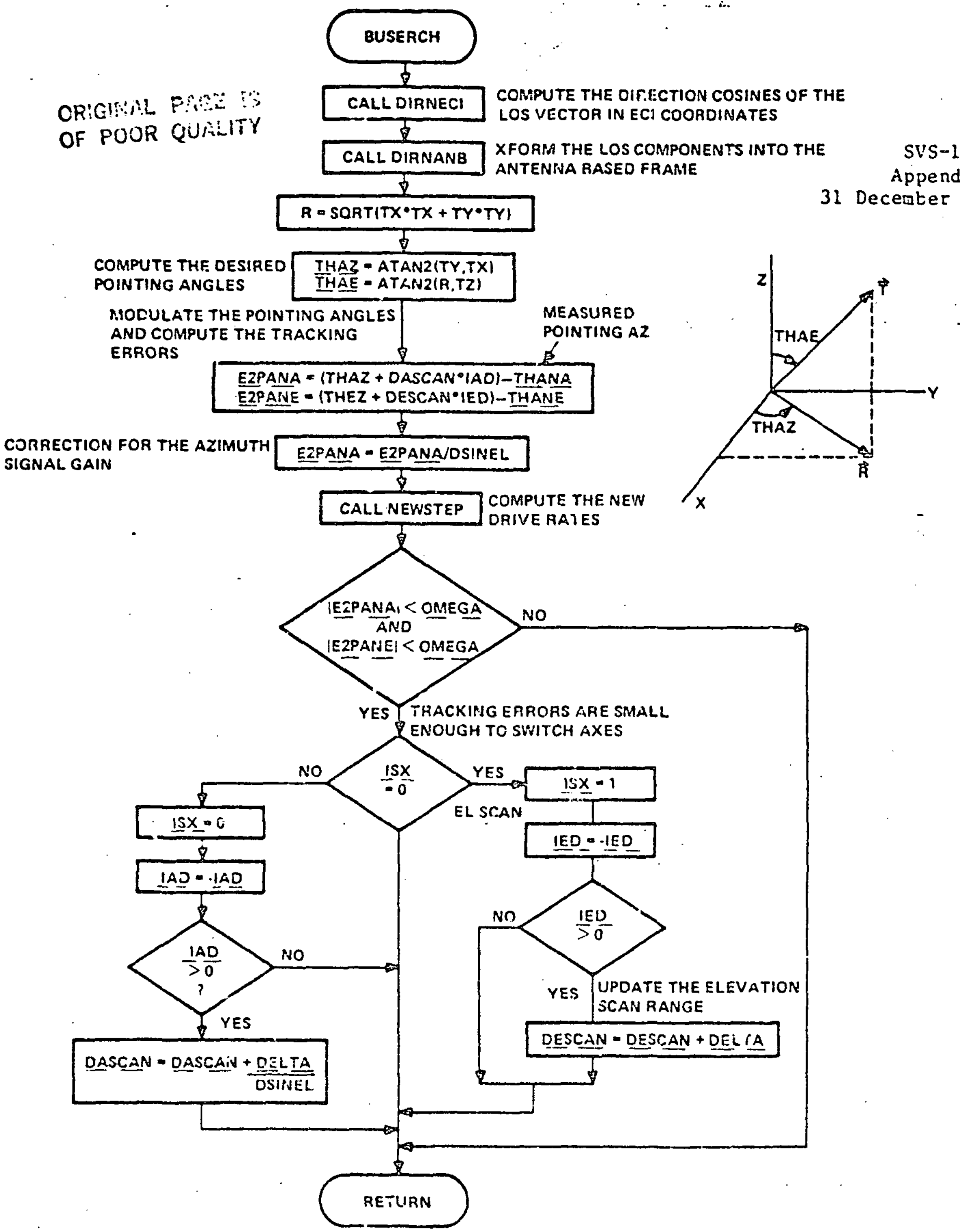

Figure B.3.11-13. BUSERCH Flow Chart

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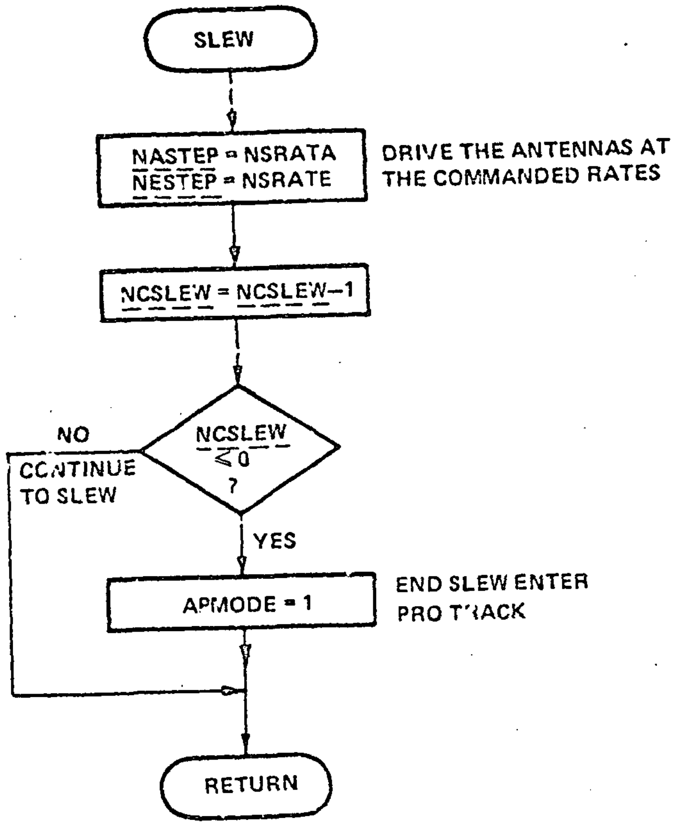

Figure 3.3.11-14. SLEW Flow Chart

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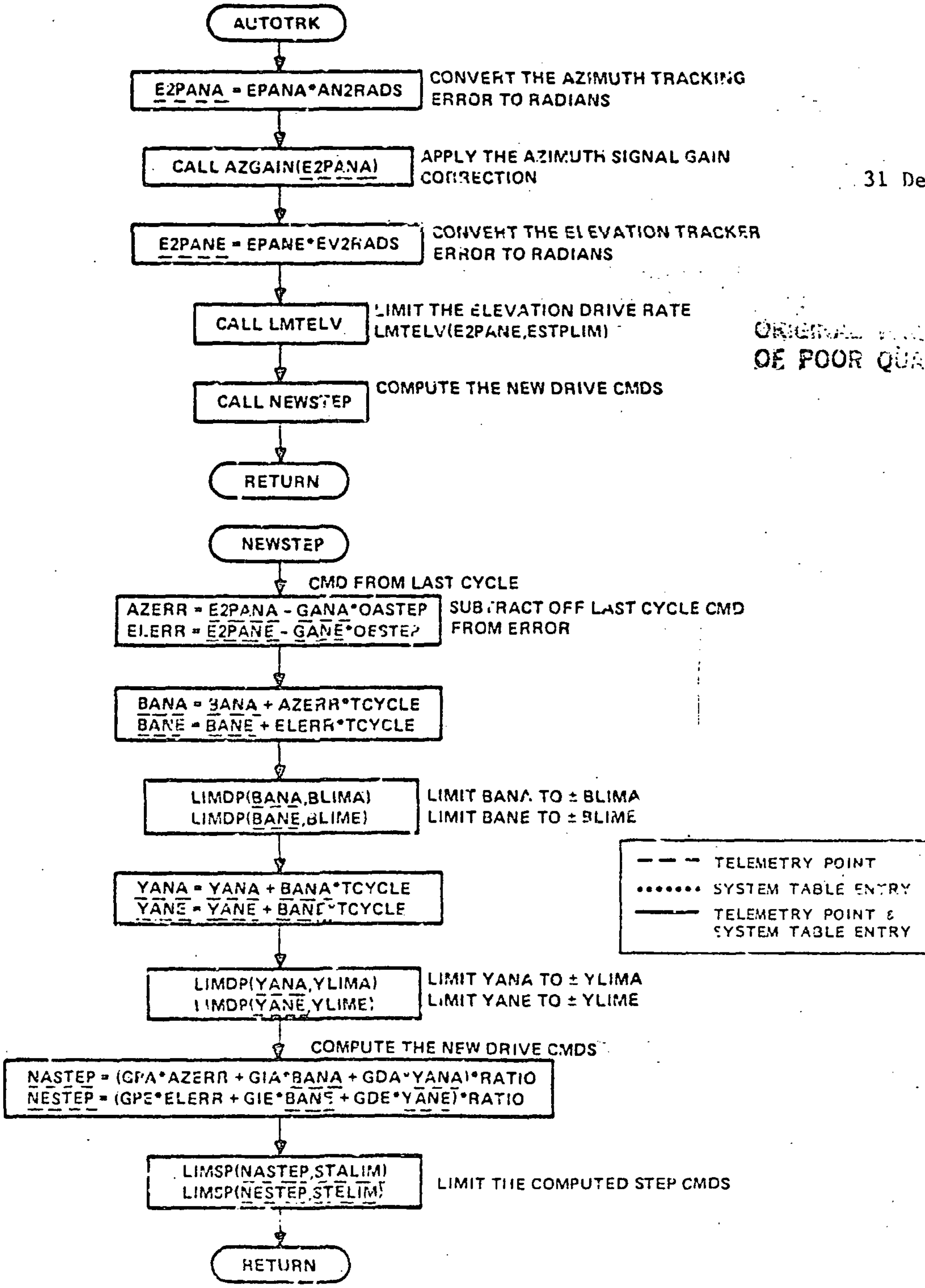

Figure B.3.11-13. AUTOTRK, NEWSTEP Flow Chart

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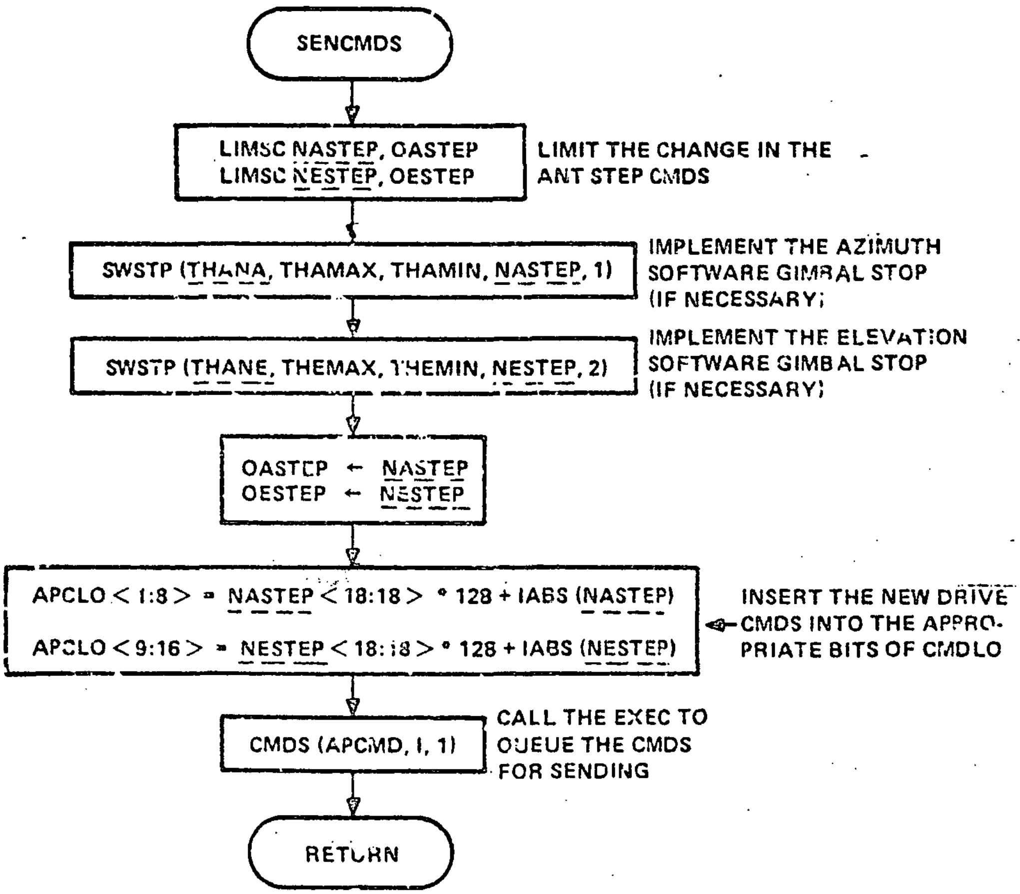

Figure B.3.11-16. SENCMDS Flow Chart

B.3.12 APPTITUDE CONTROL (ACS)

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B.3.12 ATTITUDE CONTROL (ACS)

B.3.12.1 Attitude Control (ACS) Processor Description

The function of the ACS processor is to maintain three axis stabilized earth pointing of the Landsat-D Flight Segment. To accomplish this spacecraft control errors are determined and used to calculate wheel drive and thruster commands. The commands are calculated such that the produced torques will drive the errors to zero. The control error is derived from the sum of position error plus rate error. The rate error is derived directly from filtered gyro data input from the Gyro Data Processor (GYROD). The position error is determined from the equation QE=INV(QREF)QT. The target quaternion QT is defined as the rotation from the ECI coordinate system to the desired spacecraft attitude. The reference quaternion Q(Ref) is defined as the rotation from the ECI system to the spacecraft system as estimated by integrating gyro rate data over time segments. Then INV(QREF)QT is the rotation from the estimated attitude to ECI then from ECI to the desired attitude, or from the estimated attitude to the desired attitude. The spacecraft position errors are then calculated directly from QE.

Earth pointing requires the Landsat-D spacecraft +Z axis oriented towards the earth center and the +X axis in the direction of the spacecraft velocity vector. To correctly determine the desired attitude the ACS processor must "know" the orbital position of the spacecraft. Each cycle the EPHEM processor provides to the ACS processor the F.S. ECI position and velocity vectors, $\underline{R}$ and $\underline{V}$. The ACS processor then builds the target quaternion QT by aligning the spacecraft +Z axis along $-\underline{R}$ and the +X axis along $+\underline{V}$. In support of the EPHEM processor the ground must calculate and uplink 2 data files. One file is the 6 sets of 42 coefficients of the Fourier power series ephemeris representation. The other file is a set of F.S. position vector residuals at the Fourier power series evaluation times. The UCUP processor then uses these two files to calculate 6 sets of interpolator coefficients for each 10 minute "grid" interval between the Fourier power series evaluation times. The EPHEM processor then uses the interpolation coefficients to calculate the components of $\underline{R}$ and $\underline{V}$ at the ACS cycle interval, .512 sec if MODE $\leq$4 or .256 sec if MODE=7.

The reference quaternion represents a position which is propagated using gyro data. To initialize the reference requires some direct measurement. On Landsat-D the initialization is accomplished by measuring the Earth vector and the Sun vector in in body coordinates and then using the calculated Earth and Sun vectors from the EPHEM and SOLAR EPHEM processors to determine the transformation from the ECI system to the body system.

Gyro data is subject to systematic errors which cause the reference quaternion to drift from the actual spacecraft attitude. To compensate for these systematic errors periodic corrections of the reference quaternion using direct measurements are required. On Landsat-D these periodic corrections are implemented by the Update Filter processor. The direct measurements used are star positions. The Update Filter uses the ground uplinked star catalog to identify starts which are being tracked by the FHST's. When "guide stars" are identified their measured position errors are used to update the reference quaternion and the gyro bias vector.

To avoid reaction wheel speed saturation some method of generating "dumping torques" must be employed. The primary mode for "dumping" reaction wheel momentum on Landsat-D is to generate torques using the magnetic torquers. Wheel speed and Magnitometer data are used to generate the proper torquer bar commands. The capability does exist to use thrusters but their use for "dumping" wheel momentum is not planned.

Figure B.3.12-1 shows the ACS processor top level block diagram, and Figure B.3.12-2 shows the OBC ACS software and interface with executive.

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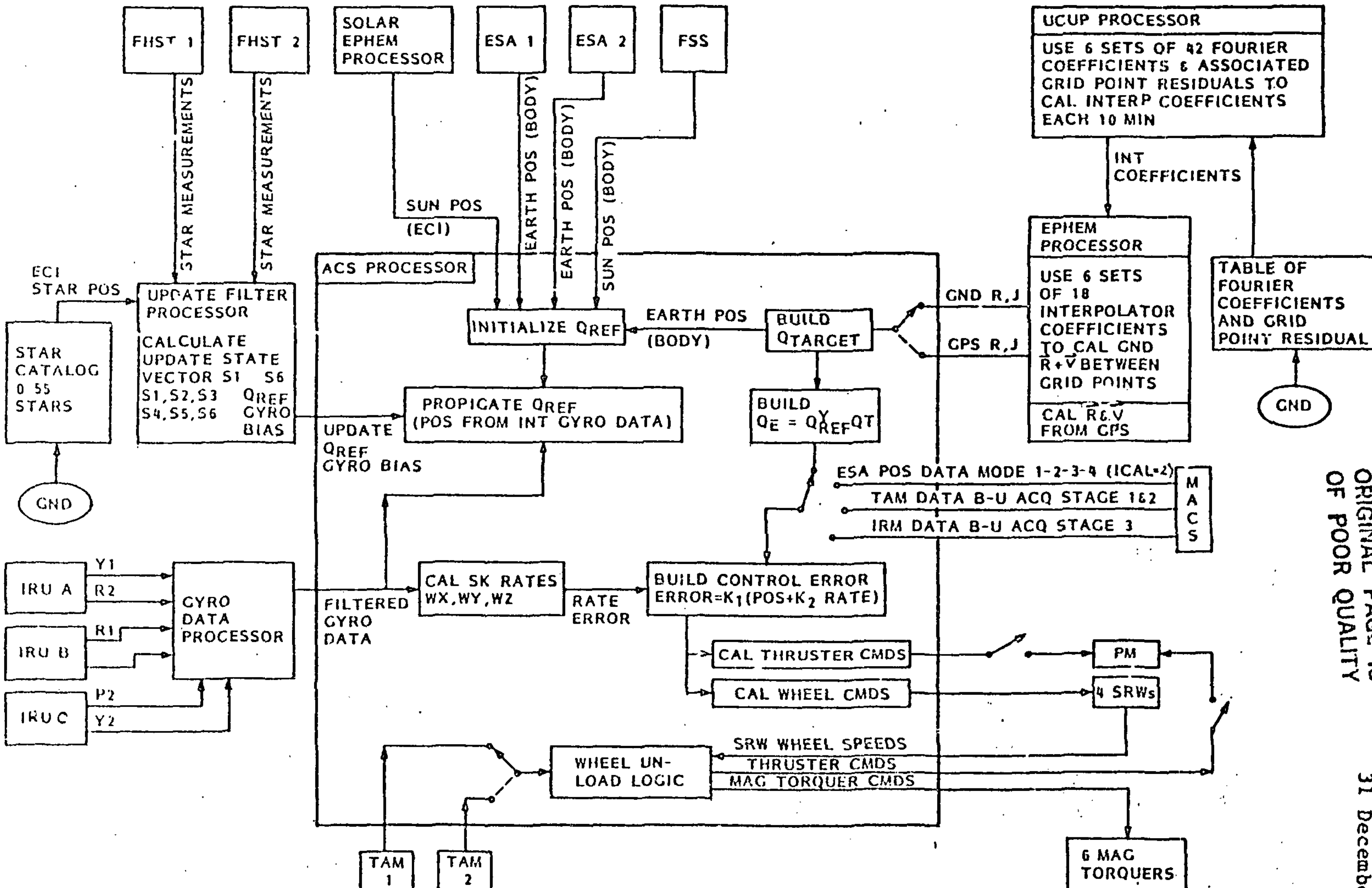
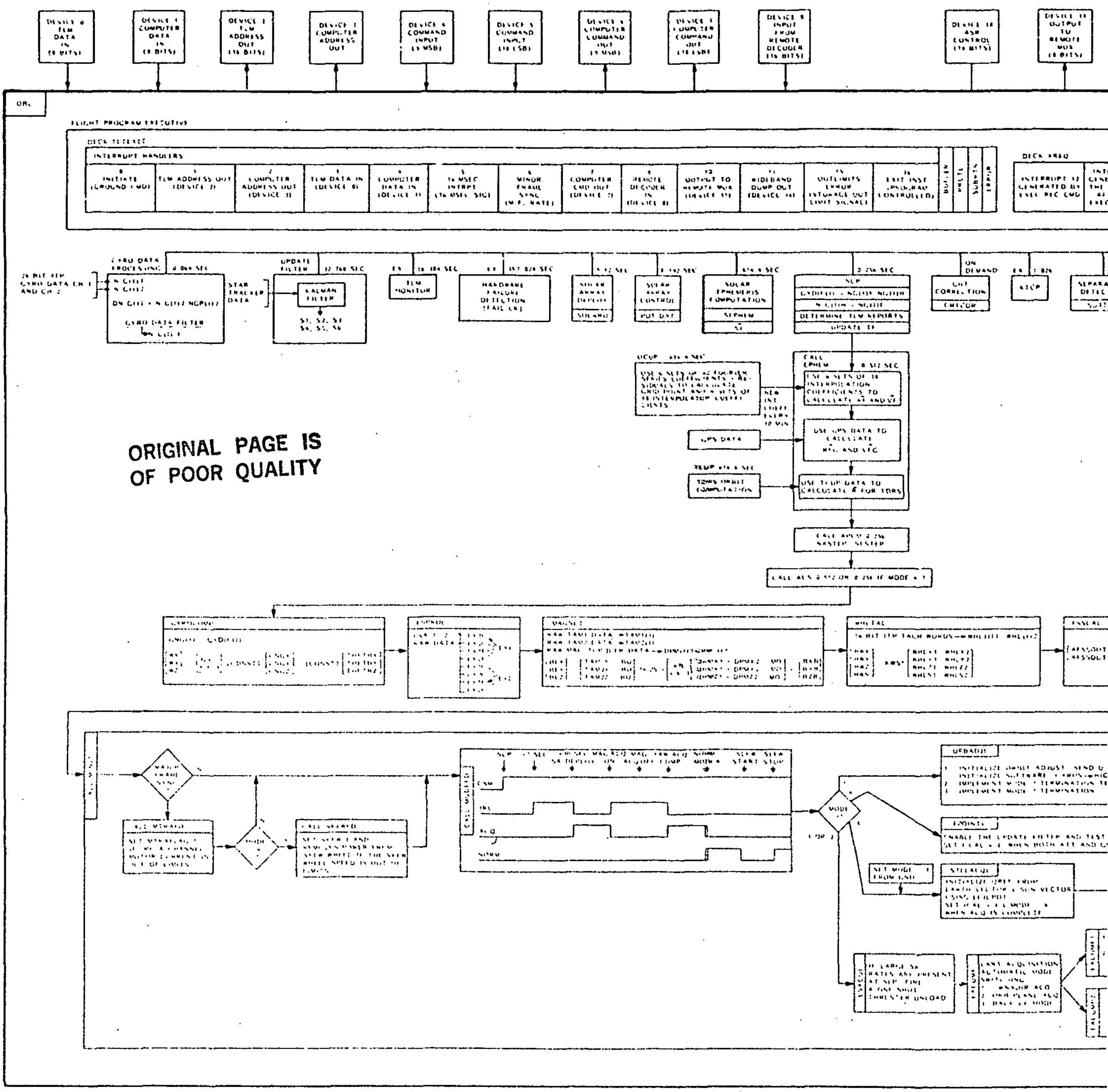


Figure B.3.12-1. ACS Top Level Diagram



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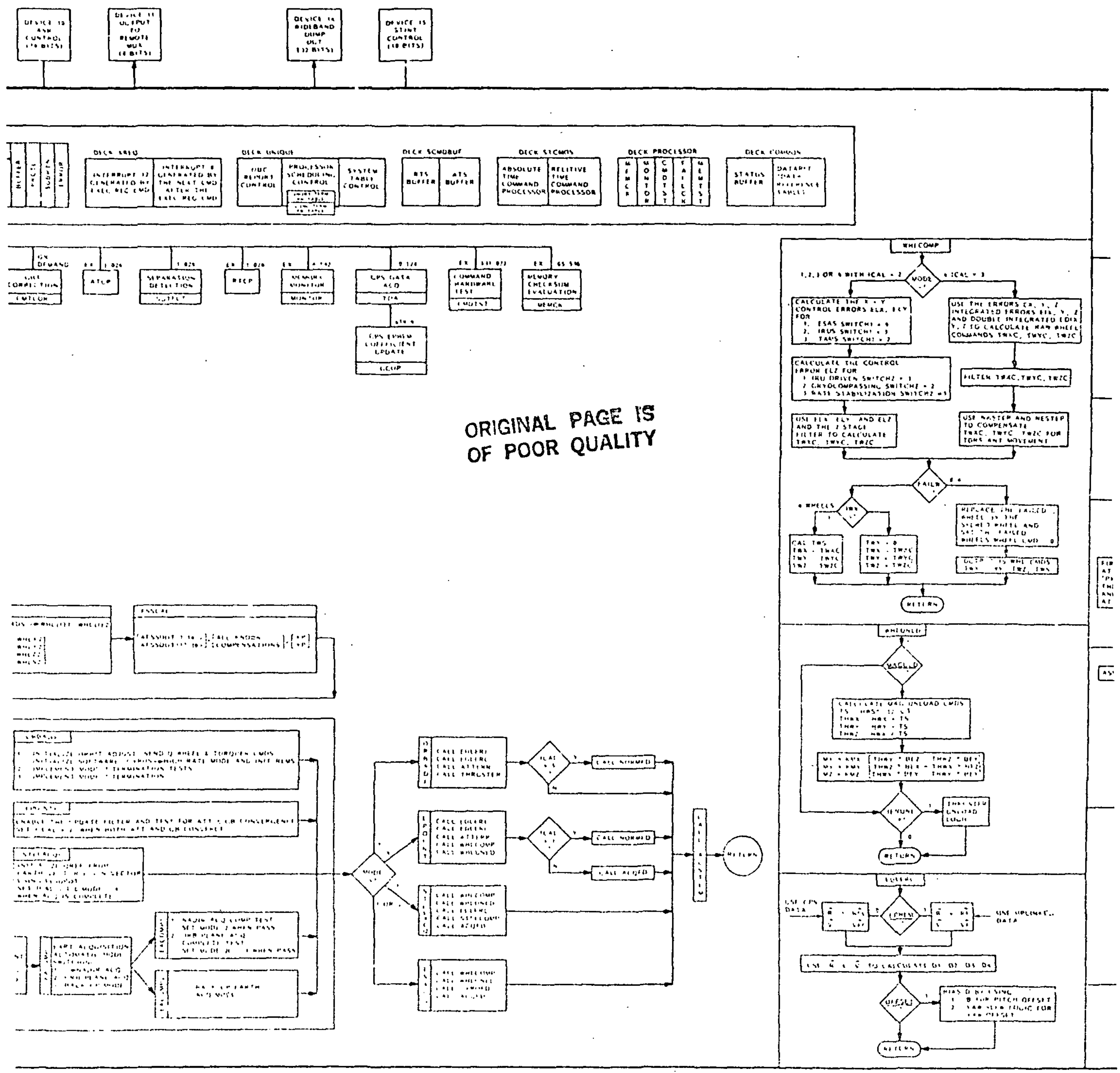

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Figure B.3.12-2. OBC

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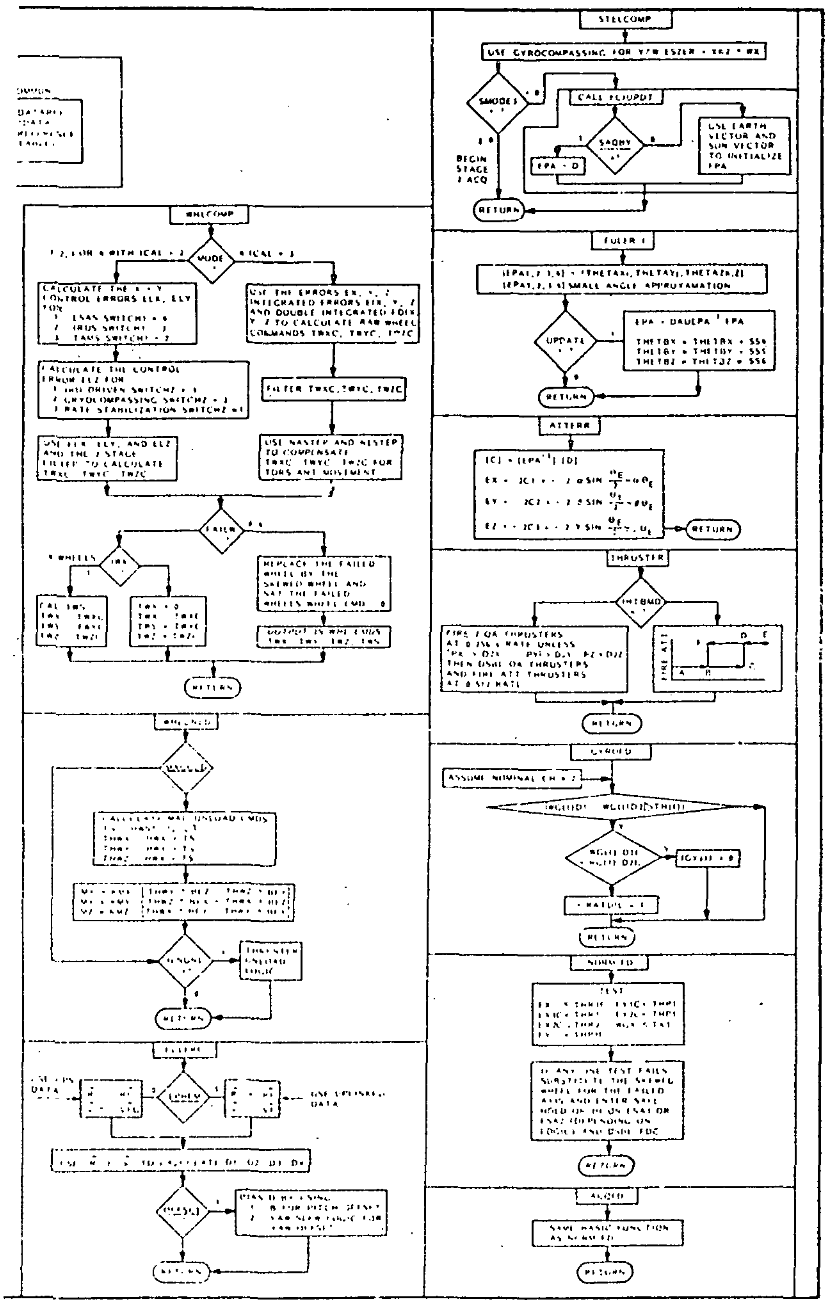

Figure B.3.12-2. OBC ACS Software Diagram

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Table 3.12-1. List of ACS Subroutines

1st Level	2nd Level	Other Levels
GYROCOMP	MTRAFD	ENAQTHR
ESPROC	SKEWFD	DISAQTHR
MAGNET	MODEFD	EACOMP1
WHLTAC	ORBADJI	EACOMP2
FSSCAL	EPOINTI	CROSS
MINIT	STELACQI	EULER
ESACQ	ESACQI	XFORM
STELACQ	EACOMP	ECIUPD
EPOINT	EULERC	CRATT
ORBADJ	EULERI	NORMFDB
ACSTLM	ATTERR	NORMFDC
	WHLCOMP	ACQFDA
	WHLUNLD	ACQFDB
	STELCOMP	ACQFDC
	THRUSTER	ACQFDD
	NORMFD	ACQFDP
	ACQFD	ACQFDU
	GRYOFD	ACQFDLL
		ACQFDS
		RIUSWTCH
		SAFEHOLD 1-1
		SAFEHOLD 1-2
		SAFEHOLD 1-3
		SAFEHOLD 1-4
		SAFEHOLD 1-5
		SAFEHOLD 1-6
		SAFEHOLD 1-7
		SAFEHOLD 1-8
		SAFEHOLD 2-1
		SAFEHOLD 2-2
		SAFEHOLD 2-3
		SAFEHOLD 2-4
		GYROFD1
		GYROFD2

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Table 3.12-2. ACS Subroutine Nesting

```
ACS PROCESSOR
      GYROCOMP
      ESPROC
          ENAQTHR
          DISAQTHR
      MAGNET
      WHLTAC
      FSSCAL
      MINIT
          MTRAFD
          SKEWFD
          MODEFD
          ORBADJI
          EPOINTI
          STELACQI
          ESACQI
          EACOMP
              EACOMP1
              EACOMP2
      ESACQ
          WHLCOMP
              WHLACQ
          WHLUNLD
          GYROFD
              GYROFD1
              GYROFD2
          ACQFD
              ACQFD SET
      STELACQ
          WHLCOMP
              WHLACQ
          WHLUNLD
          EULERC
              CROSS
              EULER
              XFORM
          STELCOMP
              ECIUPD
                  XFORM
                  CRATT
                  EULER
          ACQFD
```

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Table 3.12-2. ACS Subroutine Nesting

```
        ACQFD SET
EPOINT
    EULERI
    EULERC
        CROSS
        EULER
        XFORM
    ATTERR
    WHLCOMP
        WHLACQ
    WHLUNLD
    NORMFD
        NORMFD SET
    ACQFD
        ACQFD SET
ORBADJ
    EULERI
    EULERC
        CROSS
        EULER
        XFORM
    ATTERR
    THRUSTER
    NORMFD
        NORMFD SET
ACSTLM
```

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Table B.3.12-3. ACQFD Set

- ACQFD
  - ACQFDA
    - SAFEHOLD 1-1
    - SAFEHOLD 1-2
    - SAFEHOLD 1-3
    - SAFEHOLD 1-4
  - ACQFDB
    - SAFEHOLD 2-1
    - SAFEHOLD 2-2
    - SAFEHOLD 2-3
    - SAFEHOLD 2-4
  - ACQFDC
    - ACQFDLL
      - SAFEHOLD 1-1
      - SAFEHOLD 1-4
  - ACQFDD
    - SAFEHOLD 1-5
    - SAFEHOLD 1-6
    - SAFEHOLD 1-7
    - SAFEHOLD 1-8
  - RIUSWTCH
  - ACQFDP
    - ACQFDS
      - SAFEHOLD 1-3
    - SAFEHOLD 1-1
    - SAFEHOLD 1-3
  - ACQFDU

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Table B.3.12-4. NORMFD Set

```
NORMFD
   SAFEHOLD 1-1
   SAFEHOLD 1-3
   NORMFDB
      SAFEHOLD 1-1
      SAFEHOLD 1-4
      SAFEHOLD 1-5
      SAFEHOLD 1-7
      SAFEHOLD 2-1
      SAFEHOLD 2-4
      RIUSWITCH
   NORMFDC
      SAFEHOLD 1-2
      SAFEHOLD 1-8
      SAFEHOLD 2-2
      RIUSWTCH
```

B.3.12.1.1 1st Level Subroutines

GYROCOMP

GYROCOMP inputs filtered gyro difference data, CNCX,Y,Z, from the Gryo Data Processor and calculates the spacecraft rates WX, WY and WZ. Missalignment errors are compensated for by the 3x3 GS matrix. Scale factors are accounted for by the high or low rate parameters GSFLX,Y,Z or GSFHX,Y,Z. The gyro bias compensations THETBX,Y,Z are subtracted after the gyro to body transformation (GS) and, therefore, refer to body axes, not gyro axes. THETBX,Y,Z are updated each 32 sec by the update filter.

ESPROC

ESPROC inputs coarse and fine earth sensor data and stores it in locations EX1C, EX2C, EX1F, EX2F, EY1C, EY2C, EY1F, EY2F. Then depending on MODE, the data quality, and the value of the ground commanded selection flag (ESASEL) one of the four X inputs is transferred to the earth sensor control error EXE, and one of the four Y inputs is transferred to EYE.

MAGNET

Magnet inputs magnitometer data from both TAM 1 and TAM 2 and calculates the earth magnetic field vector components BEX, BEY and BEZ using one of the two inputs depending on the ground commandable flag SELMAG. Magnetic torquer disturbances are compensated for using the torquer inputs DPMX1, DPMX2, DPMY1, DPMY2, DPMZ1, DPMZ2.

WHLTAC

WHLTAC inputs raw reaction wheel speed data from the 4, 16 bit ITP wheel speed registers and coverts the data to wheel momentum HWX, HWY, HYZ, HYS.

FSSCAL

FSSCAL inputs raw FSS data and calculates XP and YP by compensating the raw data for all known errors. XP and YP are sun position errors with respect to FSS axes.

MINIT

MINIT calls MTRAFD and SKEWFD once per major frame. Then each minor frame calls MODEFD. The MODE flag is then checked and if:

MODE=1 or 2	MINIT calls ESACQI and EACOMP
MODE=3	MINIT calls STELACQI
MODE=4	MINIT calls EPOINTI
MODE=7	MINIT calls ORBADJI

ESACQ

If MODE=1 or 2 ESACQ is called to call in order WHLCOMP, WHLUNLD, GYROFD, and ACQFD.

STELACQ

If MODE=3 STELACQ is called to call in order WHLCOMP, WHLUNLD, EULERC, STELCOMP, and ACQFD.

EPOINT

If MODE=4 EPOINT is called to call in order EULERI, EULERC, ATTERR, WHLCOMP, WHLUNLD, and then NORMFD if ICAL=3 else EPOINT calls ACQFD.

ORBADJ

If MODE=7 ORBADJI is called to call in order EULERI, EULERC, ATTERR, THRUSTER, and then NORMFD if ICAL=3 else ORBADJ by passes NORMFD.

ACSTLM

ACSTLM controls the formatting and the timing of the attitude telemetry report. (OBC reports #1 to 12)

B.3.12.1.2 2nd Level Subroutines

MTRAFD

MTRAFD sets flag MTRAFLAG=1 if the Channel A motor current is out of limits.

SKEWFD

For the 4-wheel control case only; SKEWFD will turn off the power to the skewed wheel and set flag SKEW=1 if the wheel momentum HWS is out of limits for 3 consecutive readings.

MODEFD

MODEFD controls the activation and deactivation of GYROFD, NORMFD and ACQFD.

GYROFD is enabled for the 23 sec period from separation +7 sec to separation +30 sec. Then if magnetic acquisition is entered GYROFD is enabled until yaw acquisition is complete.

ACQFD is enabled at separation +30 sec and disab d when the Normal mode 4 operation is begun. (Normal Mode 4 --> [illegible] 3). If, however, magnetic acquisition is entered ACQFD is disabled until Y acquisition is complete.

NORMFD is enabled when the normal mode 4 operati is begun and remains enabled except during slews.

ORBADJI

ORBADJI has 3 bias functions:

1. Initialize the orbit adjust by initializing the O.A. software parameters, sending wheel commands and torquer commands equal to 0 and enabling the REMs.

2. Implement the MODE 7 termination tests.

3. Implement the MODE 7 termination by setting MODE to 4 and disabling the REMs.

EPOINTI

EPOINTI has 2 basic functions:

1. Upon initial entry, EPOINTI initializes the error registers to zero.

2. EPOINTI administers the stage 2 acquisition termination tests, attitude convergence and gryo bias convergence.

STELACQI

STELACQI has 2 basic functions:

1. On the first entry STELACQI initialize stage 1 acquisition.

2. STELACQI implements the termination of stage 1 acquisition and passes control automatically to stage 2 acquisition by setting MODE=4 and MODE4I=1. The ground must, however, enable the update filters.

ESACQI

ESACQI implements a "one shot" thruster unload in the event large rates are imported to the Landsat-D flight segment upon separation. At separation +30 sec this capability is permanently disabled.

EACOMP

EACOMP controls the logic which selects the normal earth acquisition mode or the backup mode. If the earth sensor data is invalid (ESASTA=0) EACOMP will implement magnetic tracking until the magnetic reference is reached the EACOMP will transfer control to Inertial hold until the attitude is favorable for a reacquisition attempt. Once the first revolution is complete software parameters must be reinitialized from the ground to reenter magnetic tracking.

EULERC

EULERC uses the spacecraft velocity vector $\underline{V}$ and position vector $\underline{R}$ to build the attitude target quaternion D. The target frame is oriented such that the S/C +Z axis is aligned along $-\underline{R}$ and the S/C +X axis is aligned along $+\underline{V}$. $\underline{R}$ and $\underline{V}$ are calculated from either G.P.S. data processor or the Ephem processor depending on the ground commanded flag EPHEM. Offset pointing is implemented by ground setting OFFSET to 1, and the euler offset parameters B in the case of a pitch offset, or the yaw slew parameters in the case of a yaw offset.

EULERI

EULERI uses the result of GYROCOMP, THETAX,Y,Z, to build a small angle approximation to the quaternion which represents the spacecraft rotation during the preceeding cycle, QD. The reference quaternion is then propigated by: Q(Ref) = Q   Q(Ref).

ATTERR

ATTERR first calculates the error quaternion C by: C = (EPA**-1)*D. Then the attitude errors are calculated from the error quaternion C by:

$$EX = -2\ C1 = -2\ \alpha\ \mathrm{Sin}\ (\theta E/2) \cong -\theta EX$$

$$EY = -2\ C2 = -2\ \alpha\ \mathrm{Sin}\ (\theta E/2) \cong -\theta EY$$

$$EZ = -2\ C3 = -2\ \alpha\ \mathrm{Sin}\ (\theta E/2) \cong -\theta EZ$$

WHLCOMP

The basic function of WHLCOMP is to use position error data and rate error data to calculate wheel commands TWX, TWY, TWZ and TWS.

If MODE=1, 2 or 3 or MODE=4 with ICAL=2 the X and Y control errors ELX and ELY are calculated from IRU rates WX, WY and WZ and earth sensor data, or IRU integrated data, or tam data depending on whether SWITCH1=4, or 3, or 2. The Z control error ELZ is calculated from IRU driven yaw error, gyrocompassing, or simple rate stabilization depending on whether SWITCHZ=3, or 2, or 1. The intermediate wheel commands TWXC, TWYC and TWZC are then calculated from ELX, ELY and ELZ using a 2-stage filter.

If MODE=4 with ICAL=3 the intermediate wheel commands TWXC, TWYC and TWZC are derived from the spacecraft rates WX, WY and WZ calculated in GYROCOMP; the outputs of the ATTERR subroutine EX, EY, EZ; and the integrals EIX, EIY, EIZ and double integrals EDIX, EDIY, EDIZ of the errors EX, EY, EZ. TWXC, TWYC and TWZC are then compensated for TDRS antenna movement using NASTEP and NESTEP.

The Failed wheel branch of WHLCOMP is executed independent of MODE. If the X, Y or Z wheel is failed (FAILW≠4) the failed wheel is replaced by the skewed wheel and the failed wheel wheel command is set to Ø. If all wheels are OK (FAILW=4) the final wheel commands depend on 3 or 4 wheel control IW4=0 or 1. In all cases the final output of WHLCOMP are the wheel commands TWX, TWY, TWZ, TWS.

WHLUNLD

The basic function of WHLUNLD is to calculate and send commands to the magnetic torquers (if MAGULD=1) and the thrusters (if IENUNL=1) to create torques opposite in direction to the wheel momentum vector. The outputs are the magnetic torquer commands MX, MY, MZ and the 1x6 thruster command array IACCMD.

STELCOMP

STELCOMP controls the timing of stage 1 acquisition by calling ECIUPD once each 120 cycles (~61.4 sec).

THRUSTER

THRUSTER implements the orbit adjust mode.

If the back-up mode is commanded by ground setting ITHBMD=1 then each .256 sec 2 orbit adjust 5 lb. thrusters are fired until termination as defined in ORBADJI. If any attitude errors exceed their limits (2 degrees in all axes) the orbit adjust thrusters are disabled and the .2 lb. attitude thrusters are used until the attitude errors are brought within lmits.

If the normal mode is commanded (ITHBMD=Ø) all 4 orbit adjust thrusters are fixed each .256 sec cycle except for certain defined cycles where either thruster Ø4 or Ø1 is off pulsed to compensate for the center of mass to center of thrust offset caused toques. Figure B.3.12-7 shows the hysterisis firing for pitch and yaw attitude thrusting. In the range A-B the open loop firing pattern is executed. In the range B-C, the O.A. thrusters are fired not using the open loop table but rather using the commands to the attitude thrusters to determine the off-pulsing pattern (attitude thruster override). In range D-E-F, the O.A. thrusters are all disabled in favor of attitude thrusting.

NORMFD

NORMFD implements the top level logic of the normal mode Failure Detection and Correction logic. If EX >THR1F or EX1C >THRA1 or EX2C >THRA2 then NORMFD B is called. If EY >THP1F or EY1C >THP1 or EY2C >THP2 then NORMFDC is called. Lastly the yaw FDC is implemented by testing WBX. If WBX is greater than TX1 then either safehold 1-1 or safehold 1-3 is called depending on the state of the IRU Channel A current (MTRAFLAG).

ACQFD

ACQFD implements the top level logic of the acquisition mode Failure Detection and Correction logic. If both earth sensors have earth presence ACQFDC is called. If just ESA1 or ESA2 has earth presence then ACQFDA or ACQFDB is called. If neither ESA has earth presence ACQFDD is called if ACQRIU=3, if ACQRIU and 3 then RIUSWTCH is called. In all cases ACQFDP and ACQFDA are called.

GYROFD, GYROFD1, GYROFD2

GYROFD calls GYROFD1 to compare the X axis inputs from Channel 1 and Channel 2 and the Y axis inputs from Channels 1 and 2. Then GYROFD calls GYROFD2 to compare the Z axis inputs from Channels 1 and 2. If any inputs disagree the smaller value is assumed to be correct. The logic assumes operation using Channel 2 and if the Channel 1 input is lower a switch to Channel 1 is made for the corresponding failed axis, if the Channel 2 input is lower no action is taken except to set the corresponding dilemma flag.

B.3.12.1.3 Other Levels

ENAQTHR

ENAQTHR enables thrusters for a "1 shot" momentum unload. (Called only by ESACQI)

DISAQTHR

DISAQTHR disables thruster unloading. (Called only by ESACQI).

CROSS

CROSS is a math subroutine used to calculate the cross product of 2 vectors.

EULER EULER is a math subroutine used to calculate the 4 element quaternion given the rotation matrix.

XFORM

XFORM is a math subroutine used to transfer a vector from one coordinate system to another when the transformation is specified by a quaternion.

ECIUPD

In the normal mode (SAQBU=Ø) ECIUPD calculates the initial value of the reference quaternion using the Earth and Sun vectors measured in both Body and ECI axes. In the back-up mode the reference quaternion is initialized simply by setting the reference quaternion equal to the target quaternion.

CRATT

CRATT is called by ECIUPD to calculate the transformation matrix from the ECI coordinate system to the body system using the Earth vector and the Sun vector each measured with respect to both systems.

NORMFDB

There are 7 possible cases for X axis failures using the three parameters EX, EX1C, and EX2C. (Case 8 is all three OK which is not a failure.) NORMFDB calls one of the Safehold subroutines or RIUSWTCH depending on the failure case and the status of the Channel A motor current. (MTRAFLAG)

NORMFDC

There are 7 possible cases for Y axis failures using the three parameters EY, EY1C, EY2C. NORMFDC calls one of the safehold subroutines or RIUSWITCH depending on the failure case, the state of ACQRIU and the state of EVES1.

ACQFDA

ACQFDA calls safehold 1-1, 1-2, 1-3, or 1-4 depending on the status of MTRAFLAG, EY1C, and EX1C.

ACQFDB

ACQFDB calls safehold 2-1, 2-2, 2-3, or 2-4 depending on the status of MTRAFLAG, EY2C, and EX2C.

ACQFDC

ACQFDC calls safehold 1-2 or ACQFDLL depending on the status of EY1C and EY2C.

ACQFDD

ACQFDD calls safehold 1-5, 1-6, 1-7, or 1-8 depending on the status of MTRAFLAG, WGYD1, and WGXD1.

ACQFDP

ACQFDP calls ACQFDS if yaw FDC is disabled and MODE=1 or 2. Otherwise, if WGX02 is out of limits ACQFDP calls either safehold 1-1 or 1-3 depending on the status of MTRAFLAG.

ACQFDU

If MODE=1 or 2 and SWITCH1=1, 2 or 3 ACQFDU commands the ACEB SHE position input to ES/GYC if SWITCH1P=1, 2 or 3 or to Inertial hold if SWITCH1P=4.

ACQFDS

ACQFDS checks the Z rate by comparing WBDZ1 and WBDZ2. If WBDZ only is out of limits safehold 1-3 is called. If both are out of limits then ACQFDS will set IGYZ=0 and ZRATDIL=1 if /WBDZ2/</WGDZ1/; otherwise ZRATDIL is set to 2.

ACQFDLL

ACQFDLL calls safehold 1, 1 or 1-4 depending on the status of EX1C, EX2C, and MTRAFLAG.

SAFEHOLD 1-1 --> 2-4: The following table illustrates the functions of the 12 safehold subroutines.

Table B.3.12-5. Safehold Routines

Safehold #	Earth Pointing or Sun Pointing	ACE SHE A or B	IRU Rate Select	SHE Position Select	SRW CMDED OFF
1-1	EP	A	R1,P1,Y2	ESA1,GYC	Skew
1-2	EP	A	R1,P1,Y1	ESA1,GYC	Roll
1-3	EP	A	R1,P1,Y1	ESA1,GYC	Pitch
1-4	EP	A	R1,P1,Y1	ESA1,GYC	Yaw
1-5	IH	A	R1,P1,Y1	IRU R1,P1,Y1	Skew
1-6	IH	A	R1,P1,Y1	IRU R1,P1,Y1	Roll
1-7	IH	A	R1,P1,Y1	IRU R1,P1,Y1	Pitch
1-8	IH	A	R1,P1,Y1	IR2 R1,P1,Y2	Yaw
2-1	EP	B	R1,P1,Y1	ESA2 GYC	Roll
2-2	EP	B	R1,P1,Y1	ESA2 GYC	Pitch
2-3	EP	B	R1,P1,Y1	ESA2 GYC	Yaw
2-4	EP	B	R1,P1,Y1	ESA2 GYC	Skew

B.3.12.2 Attitude Control (ACS) Processor Operation

B.3.12.2.1 Mode I (Earth Acquisition Nadir Only)

1. Sensors:

   Roll and pitch position: ESA 2 coarse inputs EX2C and EY2C. If the ESA 2 data is out of limits (EVES2 <EVES2OK), then the ESA 1 coarse inputs EX1C and EY1C are used.

   If, at any time prior to MODE=3, both ESA data inputs are out of limits (EVES2 <EVES2OK and EVES1 <EVES1OK), the software will delay 5 cycles (~2.5 sec) and then default to the back-up acquisition mode (see Section B.3.12.2.3). If during the 5 cycle delay data from either earth sensor becomes valid the delay counter is reset and the normal acquisition mode will resume.

   The pitch orbit rate bias is disabled (SWTCHY=1).

   Yaw position: Simple rate stabilization. (ELZ = KRLZ * WZ).

   The control system will drive the control error ELZ and hence the rate WZ to 0.

   Roll, pitch and yaw rates: IRU (R2,P2,Y2)

2. Actuators: 4 SRWs with magnetic torquers for unloading momentum.

   Thrusters will be disabled except for the first 30 seconds after separation when they will be enabled to execute a "one shot" thruster unload, in the event the launch vehicle imparts large rates to the F.S. The system momentums SYSMOX, SYSPL, SYSMOZ are calculated and compared to the threshold HTHX1, HTHY1, HTHZ1. If the first comparison shows low system momentum, thrusters will not fire and JTHSW will be set to 1 and remain 1 disabling the thrusters permanently. (The thrusters can then be reenabled only by ground command.) If, however, the first comparison shows high system momentum thrusters will fire until one of the following two conditions are met:

   a. All three components of the system momentum are brought within limits.

b. The 30 second time limit is reached. If the 30 second time limit is reached JTHSW will remain Ø, flagging possible residual momentum. If the system momentum is all unloaded JTHSW will be Ø during the time thrusters are firing and then be set to 1 after all three components of momentum pass the comparison test.

3. Operation: The ACS software is initialized to mode 1 (MODE=1) at launch. Nadir acquisition will commence 6 cycles (~3 sec) after separation. The launch vehicle is expected to release the FS such that the spacecraft Z axis is within 3 degrees of the nadir vector, and the acquisitions of local vertical is expected to take roughly 5 minutes. Nadir acquisition (mode 1) is completed when the Z axis is earth pointing within 9.7 deg, both roll and pitch rates are less than 1 deg/sec and the yaw rate is less than 0.57 deg/sec. The yaw orientation is arbitrary since it is not controlled, but if no one-shot thrusting is required the S/C X axis orientation is expected to be within 3 degrees of the F.S. velocity direction. Assuming that either one or the other ESA is always yielding valid data the flight software will then set MODE=2 and control will then automatically pass to mode 2. The above mode 1 terminataion conditions define the initial conditions for mode 2.

B.3.12.2.2 Mode 2 (Earth Acquisition, Orbit Plane)

1. Sensors:

Roll and pitch position: ESA 2 coarse inputs EX2C and EY2C. The ESA switching logic defined in Section B.3.12.2.1 for mode 1 is also used in mode 2.

The pitch orbit rate bias is enabled. (SWTCHY=2)

Yaw position: gyrocompassing

The control system uses the ESA outputs to maintain the S/C Z axis pointing along the nadir vector. As the spacecraft orbits the earth it will be forced to rotate about some axis to maintain nadir pointing. If the S/C X axis is in the direction of the orbital velocity, this rotation will be pure pitch. If, however, the X axis is not in the direction of the velocity vector, maintaining local vertical pointing requires a roll and a pitch maneuver. These maneuvers will be repeated each cycle yielding a roll and a pitch rate. The size of the X maneuver is proportional to the yaw error and opposite in direction. The yaw axis position error is, therefore, negatively proportional to the roll rate. (See Table B.3.12-6.)
Roll, pitch, yaw rates: IRU (R2,P2,Y2).

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2. Actuators: 4 SRWs with magnetic torquers for unloading momentum.

3. Operation: Mode 2 will continue local vertical acquisition to within 2.9 degrees with roll and yaw rates less than .02 deg/sec and pitch rate less than .057 deg/sec. In addition mode 2 will align the spacecraft X axis along the velocity direction. When these orbit plane acquisition conditions are met the software will set MODE2C=1. The ground operations team will then manually initiate stage 1 steller acquisition by uplinking MODE=3 and MODE3I=1. Once this is done stage 1 and stage 2 steller acquisition will automatically be executed and telemetry will report MODE=4 and ICAL=2. The quaterions derived from gyro and star data are not used to derive the control error until the ground uplinks ICAL=3. See Section 3.4.2.2.4.

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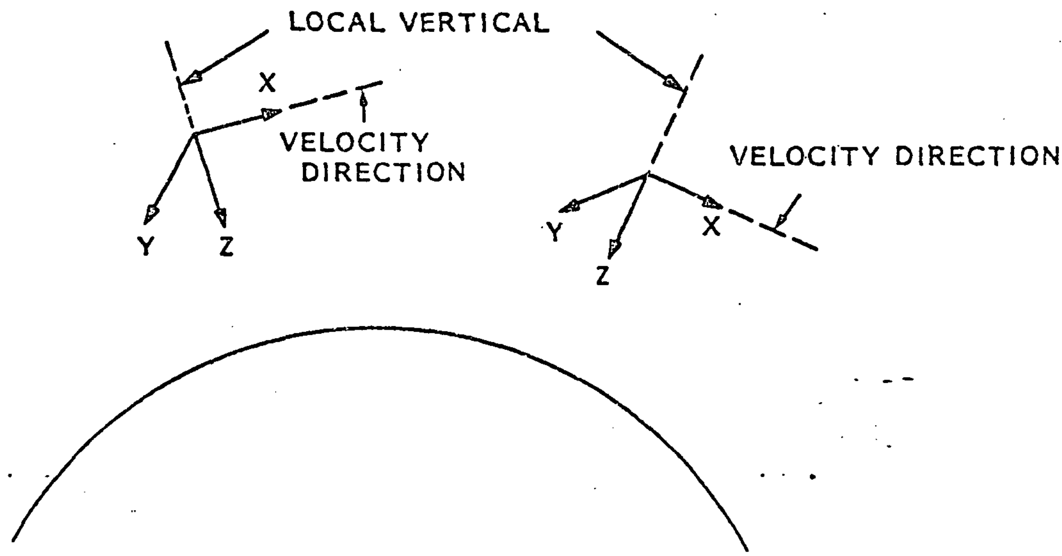
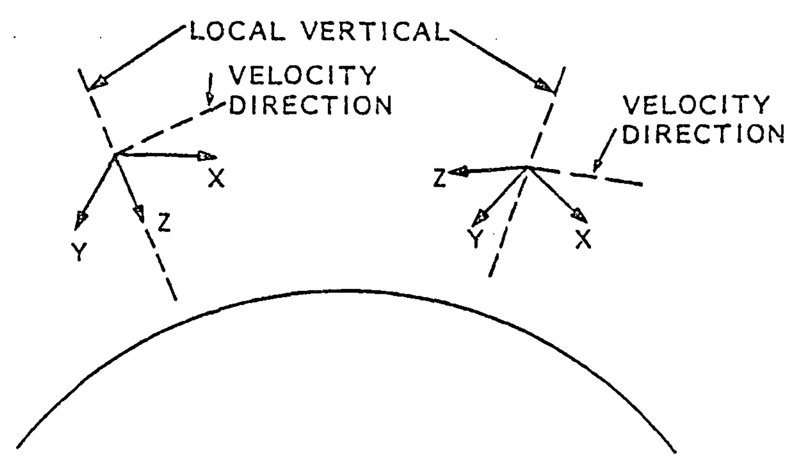


CASE 1: THE X AXIS IS PROPERLY ALIGNED ALONG THE VELOCITY DIRECTION AND THE Z AXIS HOLDS LOCAL VERTICAL AS THE S/C ROTATES ABOUT Y AT THE ORBIT RATES.



CASE 2: THE X AXIS DOES NOT LIE IN THE ORBIT PLANE SO THE ORBIT RATE ABOUT Y CAUSES THE Z AXIS TO LEAVE THE LOCAL VERTICAL

Figure B.3.12-3 Mode 2 Orientation

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B.3.12.2.3 Back-Up Earth Acquisition Mode

If at separation the earth pointing errors are >30 deg. it is probable that the earth is not in the field of view of either earth sensor. If this situation occurs the back-up earth acquisition mode will protect the payload instruments from the sun. This is accomplished by pointing the +Z axis along the earth's magnetic field vector and tracking the magnetic field until the field vector points in the direction of the earth sun line away from the sun. At this point the inertial hold mode is entered.

Stage 1: Magnetic field tracking from separation to the magnetic reference. (0 <TACS <TMTST1). See Figure B.3.12-4.

1. Sensors:

   Roll and pitch position: Magnetometers

   The control system drives the spacecraft such that the X and Y components of the field vectors in body coordinates are zero. Figure B.3.12-5 shows the field vector B in body coordinates. BX and BY are used to derive the control errors ELX and ELY. ELX = KRLX*WX $\pm$KPRX BEY/BMAG. Where $\pm$ is determined by the value of SWTCH1, the direction to the magnetic field. From Figure B.3.12-5 one can see that a rotation about X is required to drive BY to Ø.

   The pitch orbit rate bias is disabled. (SWTCHY=1)

   Yaw position: Simple rate stabilization

   Roll, pitch, yaw rates: IRU (R2,P2,Y2)

2. Actuators: 4 SRWs with both magnetic and thruster unloading disabled.

3. Operation: Stage 1 is entered if at any time prior to TACS = TMTST1 both earth sensors fail to produce valid data. TACS is the ACS time which is initialized to Ø at separation and TMTST1 is a constant defining the time when the spacecraft reaches the magnetic reference.

   Magnetic field tracking is the control mode until TACS = TMTST1 at which time control automatically passes to stage 2.

Stage 2: At the magnetic reference. TACS = TMTST1

When the spacecraft reaches the magnetic reference the inertial hold mode is entered due to the following automatic software changes.

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a.	SWTCH1 --> 3	Use IRUs for roll and pitch positions
b.	SWTCH2 --> 1	Disable the pitch position bias
c.	SWTCHY --> 1	Disable the pitch orbit rate bias
d.	MAGULD --> 1	Enable magnetic unloading
e.	SWTCHZ --> 1	Use simple rate stabilization for yaw position
f.	BXG = BEY/BMAG EYG = BEX/BMAG	Initialize the IRU integrated position registers to the current value of the Y X field components (normalized).

Stage 3: Inertial hold from the magnetic reference to the point at which reacquisition is attempted. TMTST1 <TACS <TMTST2.

1. Sensors:

Roll and pitch position: IRU integrated position registers EXG and EYG. The pitch orbit rate and position biases are disabled.

Yaw position: Simple rate stabilization.

Roll, pitch, yaw rates: IRU

Actuators: 4 SRWs with magnetic unloading enabled.

Stage 4: Reacquisition attempt. (TACS ≥TMTST2)

When TACS ≥ TMTST2 the S/C attitude should . favorable for a reacquisition attempt. At time TACS ≥ TMTST2 the spacecraft intersects the imaginary line which connec the centers of the earth and sun. At this time, if ESASTA >0 (earth sensors OK), TMTSTA is reset to Ø (TAMs not in use) and earth acquisition is reattempted using earth sensors.

If magnetic tracking is to be reenabled after exit from umbra of the 1st revolution, the following parameters must be reset.

MODE = 1 ESACNT = 0 IRUSTA = 0 TMTSTA = 0 MODE2C = 0	reset automatically by software
TMTST1 & TMTST2	to the appropriate values defining the magnetic reference point

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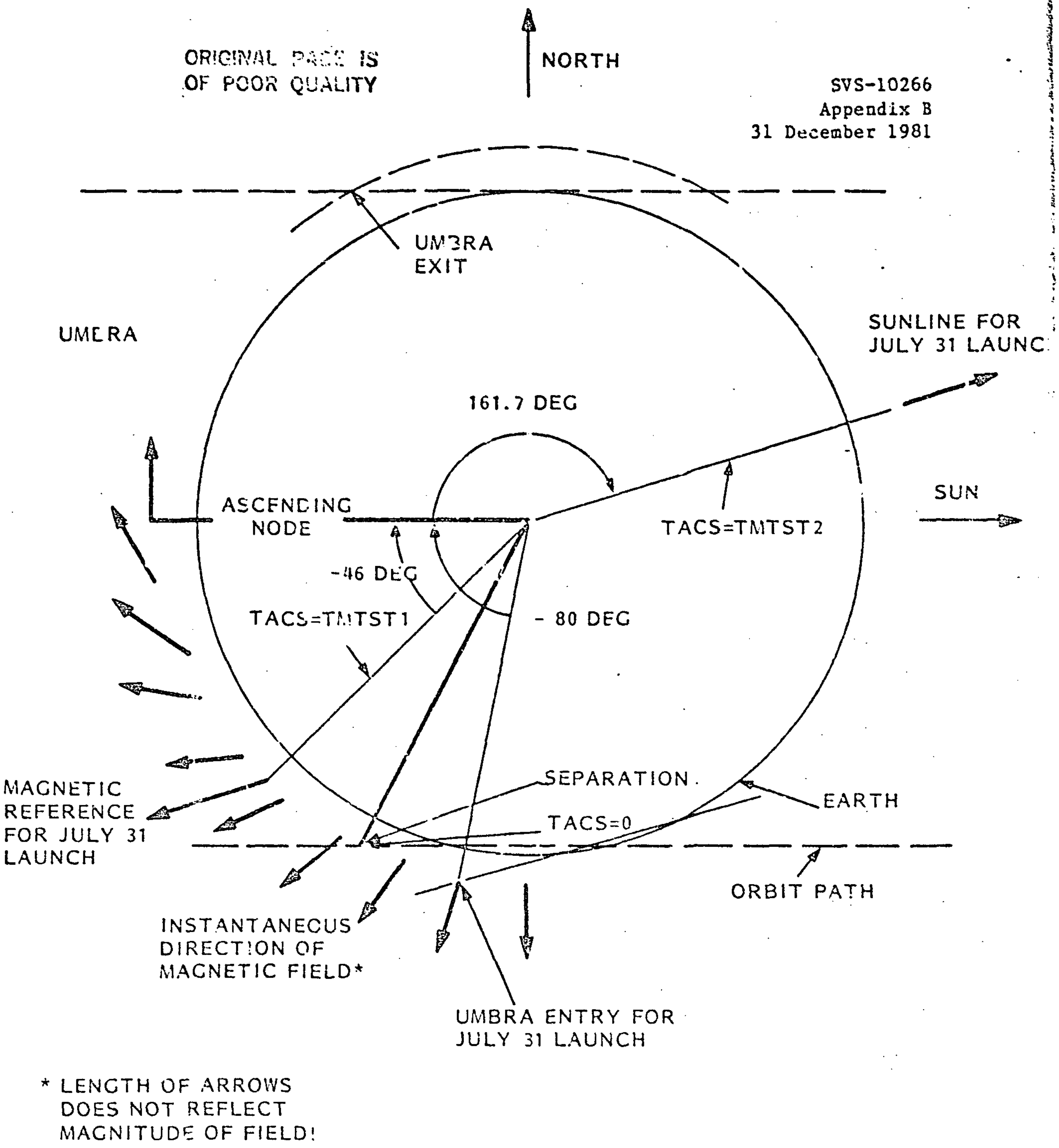

Figure B.3.12-4. Magnetic Field Acquisition Maneuver

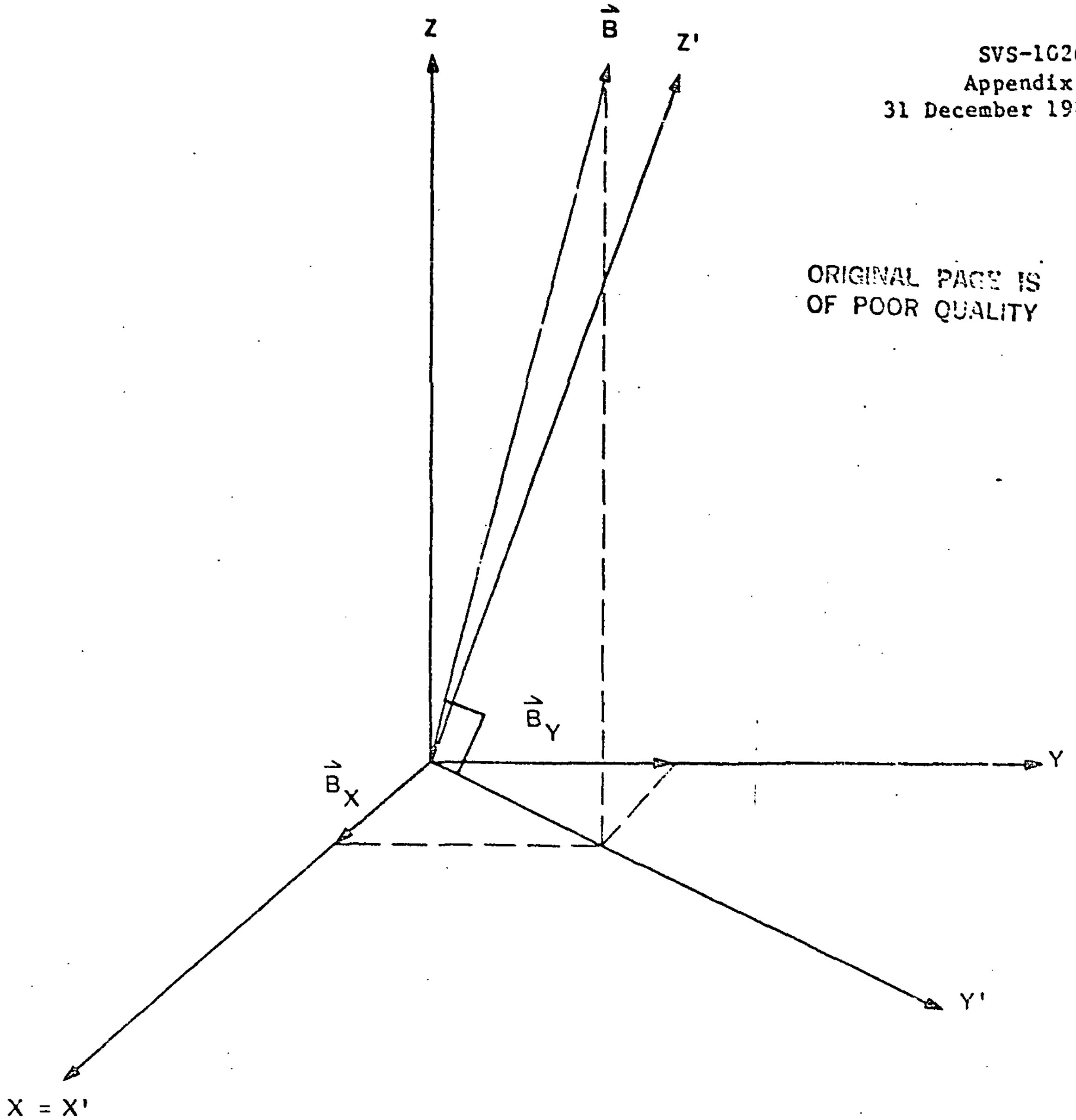

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Figure 3 shows that rotating the S/C axes about X is required to drive BY to Ø. Note that the Y axis is perpendicular to B.

Figure B.3.12-5. Earth Magnetic Field Vector

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Table B.3.12-6. Switch Status

State	1	2	3	4
SWTCH1	-Yaw to Earth Mag. Field	+Yaw to Earth Mag. Field	IRU data for Roll & Pitch Position	ESA data for Roll & Pitch Position
SWTCHY	Pitch Orbit rate bias Disable	Pitch Orbit rate bias Enable		
SWTCH Z	Yaw = Simple Rate Stabilization	Yaw = Gyrocompassing		

1. Simple Rate Stabilization for Yaw Pos Error: ELZ = KRLZ * WZ

2. Gyrocompassing for Yaw Pos Error:

$$ELZ = KRLZ * WZ - KZ * KRLZ * KPRZ * WX$$

3. Pitch Pos Bias: In the IRU accumulated error EYG use:

$$EYG = EYG + (WY - OME) * .512$$

instead of

$$EYG = EYG + WY * .512$$

4. Pitch Orbit Rate Bias:

For ESA use: use ELY = KRLY * (EYE * KPRY + WY - OME)
instead of ELY = KRLY * (EYE * KPRY + WY)

For IRU use: use ELY = KRLY * WY - OME + KPRY * EYG)
instead of ELY = KRLY * (WY + KPRY * EYG)

B.3.12.2.4 Mode 3 (Steller Acquisition Stage 1)

1. Sensors:

   Roll and pitch position: ESA 2 as in mode 1 and 2.
   Yaw position: Gyrocompassing
   Roll, pitch and yaw rate: IRU (R2,P2,Y2)

2. Actuators; 4 SRWs with magnetic unloading enabled and thruster unloading disabled.

3. Operation: The ground initiates the transfer to mode 3 by commanding MODE = 3 and MODE3I = 1.

   When MODE is commanded to 3 EULERC begins to be called to calculate the target quaternion D1, D2, D3, D4. Since the Landsat-D mission is earth pointing the target orientation is dependent upon F.S. orbital position; EULERC is then called each .512 sec to recalculate the desired pointing quaternion. The EPHEM processor provides to the EULERC module the flight segment position vector P and velocity vector V. The position and velocity vectors are calculated in the following manner. The background processor UCUP uses 6 sets of 42 ground uplinked fourier series coefficients to calculate the position and velocity vectors at 10 minute intervals. To each "grid point" position vector is added a position residual vector (3 components). The 252 fourier coefficients must be updated once per day. The length of the residual table depends on the time between table uplinks. UCUP uses the fourier series coefficients and the residuals to calculate a unique set of 45 intepolator coefficients to be used for each 10 minute intervals between grid points. Eight coefficients are needed for each component of position and seven coefficients for each component of velocity. The foreground processor EPHEM then uses the interpolator coefficients to calculate the F.S. position and velocity vectors at .512 second intervals. EULERC then uses the P and V vectors to build the target reference frame. The target +Z axis is aligned along -P and the target +X axis along +V. See Figure B.3.12-6.

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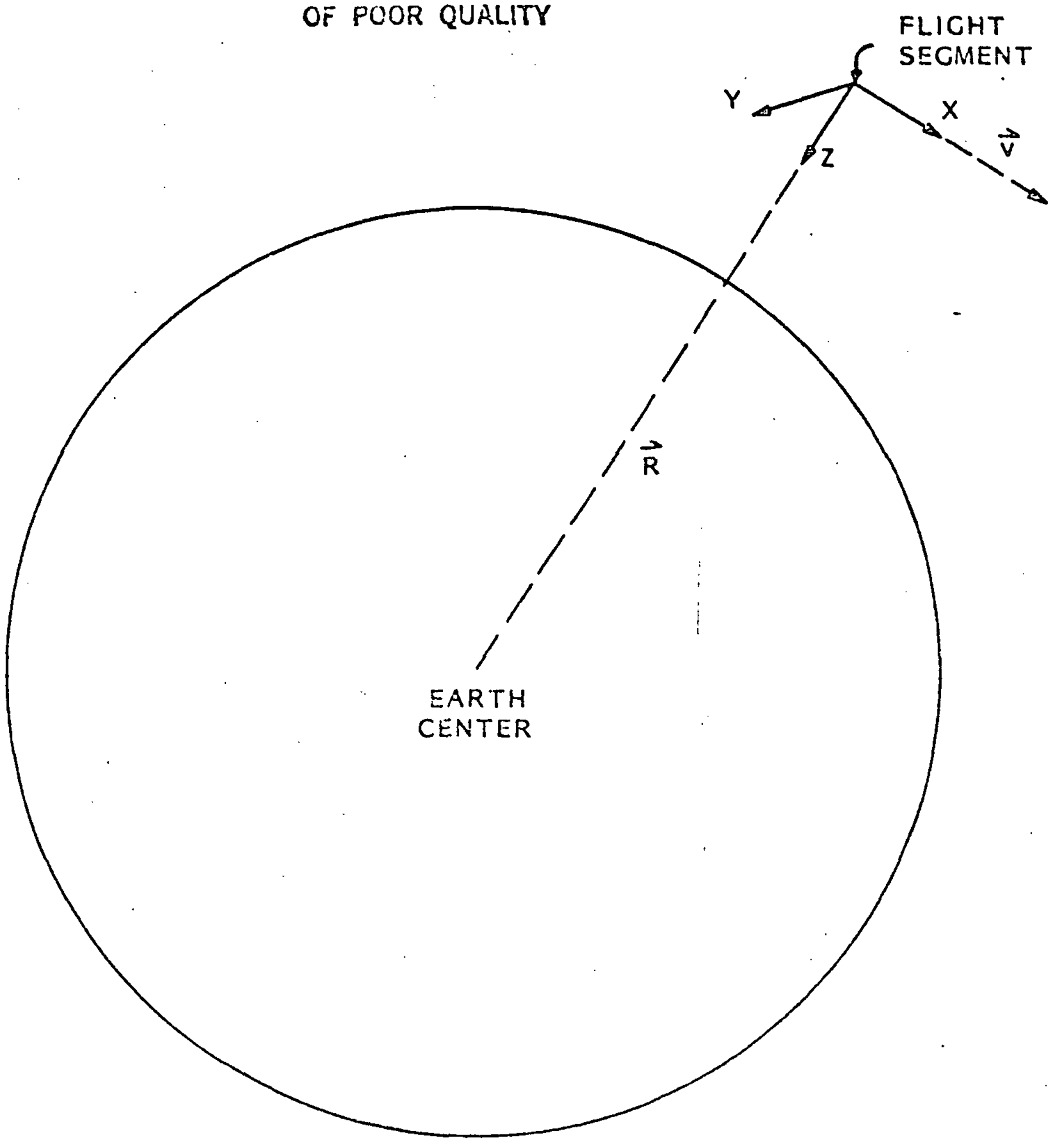

Figure B.3.12-6. Landsat-D Target Orientation

Stage 1 steller acquisition is performed by the module ECIUPD which is called by STELCOMP during mode 3. The option exists to use either the normal mode or the backup mode. The choice is implemented by the ground setting of the flag SAQBU (1 --> back-up mode; Ø --> normal mode).

Normal Mode:

In the normal mode the reference quaternion EPA 1,2,3,4 is initialized using the earth and sun vectors. The earth and sun vectors are each calculated in the ECI system (EI and SI) and the body system (ES and SV). The relationship between ECI and body coordinates is then derived from the components of these four three-component vectors. The earth vector in body coordinates (ES) is calculated from the earth pointing errors EXE and EYE with the approximation ESZ = 1/(SQRT(1+EXE*EXE+EYE*EYE)) used for the Z-component. The sun vector in body coordinates is calculated from the FSS inputs XP + YP with the approximation SZ = 1/(SQRT(1+XP*XP+YP*YP)). These components are then transformed to body coordinates by the XF matrix to yield the SV vector since XP and YP are measured with respect to the FSS coordinates. The ECI sun vector, SI, is input from the solar ephemeris module. The ECI earth vector, EI, is calculated from the ephemeris inputs as the unit vector opposite in direction to the FS positive vector EI=-R/lRl. The ECI earth vector and the ECI sun vector are then used to determine if the spacecraft geometry is correct by performing 2 tests.

a. EI SI $\leq$Cos 45 deg.;

b. EI_z $\geq$SIN 75 deg.

If these tests pass CRATT is called to use the components of EI,SI,ES and SV to calculate the transformation matrix CVI from ECI to body coordinates. EULER is then called to build the reference quaternion EPA1, EPA2, EPA3, EPA4 from the matrix CVI. The flag ECIATT is then set to 1 flagging the initialization of the reference quaternion. When ECIATT $\geq$1, STELACQI will set MODE=4, MODE4I=1, SMODE3=1 and ICAL=1 and control will pass automatically to mode 4. Stage 2 acquisition must then be initiated from the ground by enabling the update filter.

Back-up Mode:

The back-up mode is entered when the ground commands SAQBU=1. In this mode the reference quaternion is set equal to the target quaternion, EPA(I) = D(I). The normalized earth vector ESX and ESY are limited to

<2 X 10 EXP-5 and used as the update vector components SS1 and SS2 for the first reference update. SS3 is set to EZER. The bias vector SS4,SS5,SS6 is set to 0,0,0. The flags VEC and UPDATE are set to 1 and ECIATT --> 2. STELCOMP will then transfer control to mode 4 by setting MODE=4, MODE4I=1, SMODE3=1 and ICAL=1. The first update then executed by EULER I will use the SS1,2,3,4,5,6 value set by the back-up mode of ECIUPD.

B.3.12.2.5 Mode 4 - Earth Pointing Mode

As soon as MODE=4 EULERI and ATTERR are called to propigate the reference quaternion from gyro data and calculate the attitude error by computing the error quaternion C1, C2, C3, C4 as the rotation from the reference position EPA to th target position D. Updates to the reference quaternion are performed in EULER I if UPDATE=1.

B.3.12.2.5.1 Stage 2 Acquisition (MODE=4, ICAL=1).

1. Sensors:

   Roll and pitch position: ESA 2 data as in modes 1, 2 and 3
   Yaw position: gyrocompassing
   Roll, pitch, yaw rates: IRU (R2,P2,Y2)

2. Actuators: 4 SRWs with magnetic unloading enabled and thruster unloading disabled.

3. Operation: Stage 2 acquisition (MODE=4, ICAL=1) controls the spacecraft using earth sensors and gyrocompassing as in mode 3, while the update filter is called to use star tracker data to update the reference quaternion and the gyro bias vector. Updates are nominally performed each 32 sec by the update filter. Each .512 seconds the module EPOINTI tests for attitude and gyro bias convergence. When both tests pass ICAL is set to 2, as a flag, to tell the ground it is OK to use the error quaternion to generate the control errors. The ground then initiates normal mode 4 operation by setting ICAL=3.

B.3.12.2.5.2 Normal Mode 4 Operation (MODE=4, ICAL=3).

1. Sensors:

   Roll, pitch, yaw positions: R, P and Y positions are determined by using gyro data to propigate the reference quaternion, then generating the error quaternion as the rotation from body axis to the target axis. The position errors are then derived from the error quaternion by the module ATTERR. The control errors are then derived from the position and rate errors.

   Roll, pitch and yaw rates: IRU (R2,P2,Y2)

2. Actuators: 4 SRWs with magnetic unloading enabled and thruster unloading disabled. (3 wheels for maneuvers)

3. Operation: Normal mode 4 operation is entered by ground setting ICAL=3. At that time the normal mode 4 control law is used. GYROCOMP inputs gyro data and calculates the change in spacecraft position since the last cycle (.512 sec), THETAX, THETAZ, THETAZ, and the average rate, WX, WY and WZ, during that time. EULERI then uses THETAX,Y,Z to propigate the reference quaternion, EPA1,2,3,4. EULERC uses the F.S. position P and velocity V to calculate the target quaternion D1,2,3,4. ATTERR then calculates the error quaternion C1,2,3,4 from D1,2,3,4 and EPA1,2,3,4; and the error EX,EY,EZ from C1,2,3,4. WHLCOMP then uses EX,EY,EZ and WX,WY,WZ to derive the control errors and subsequent wheel commands, TWX,TWY,TWZ,TWS. The update filter continues to update the reference quaternion EPA1,2,3,4 and the gyro bias vector THETBX,Y,Z each 32 seconds using star tracker data. See Section B.3.12.2.5.3 for update filter operation.

Offset Pointing:

Offset pointing is implemented in EULERC by setting OFFSET=1 from the ground.

Yaw offset only: If the desired offset is a yaw maneuver only the ground need only uplink three parameters; IYSLEW=1 to enable the yaw slew, NYSLEW=# of cycles which defines the length of the slew, and IYSLEW=±1 defining the direction of the slew. The system table parameters EYSLEW3 and EYSLEW4 are then used to generate a yaw bias on the target quaternion which is incremented each cycle for the number of cycles uplinked in the parameter NYSLEW. When the slew is complete the offset will remain constant. To return to the nominal target, one must uplink NYSLEW, IYSLEW and JYSLEW with JYSLEW defining the opposite direction. (Note that IYSLEW is reset to 0 by EULERC.) For a yaw slew only the system table parameters B1, B2, B3, B4 should be set to 0,0,0,1.

General Offset:

Any offset can be commanded by using the B1, B2, B3, B4 parameters which represent the rotation from the nominal target to the desired offset. As soon as the offset is commanded (OFFSET=1) the control system will "see" the entire slew as an error and perform an eigen axis maneuve to drive the error to 0.

B.3.12.2.5.3. The ACS uses the Update Filter to update the reference quarternion and gyro bias vector. See Section B.3.17.

B.3.12.2.6 Mode 7 (Orbit Adjust)

1. Sensors:

   Roll, pitch, yaw positions: Integrated gyro data as in the mode 4 normal operations case.

   Roll, pitch, yaw rates: IRU (R2,P2,Y2) (high rate mode)

2. Actuators: Thrusters with the RWAs disabled (WHLCOMP and WHLUNLD are not called if MODE=7).

3. Operation:

   a. Initialization: Mode 7 is initiated by ground command only by setting MODE=7 and MODE7I=1. Upon these commands the gyros are automatically commanded to the high rate, (.8 sec/count); the torquer commands are zeroed, MX=MY=MZ=0; the appropriate REMs are enabled, (depending on the state of the flags ITHBMD (normal or backup mode) and BKUPREM (Rems A/C or B/D for backup mode)); and the parameters NOAPLS, OAPCH and OAYAW are set to Ø. The latch valves, however, are not automatically commanded. Prior to initiating the maneuver by commanding MODE=7 the following must be done:

      (1) Set MODE7I=1 --> initialize the orbit adjust

      (2) Set ITHBMD = Ø --> Normal Orbit Adjust mode
                       1 --> Backup Orbit Adjust mode

      (3) Set BKUPREM = Ø --> (For use in backup mode only)
                      = 1 --> Rems (B/D) (if in backup mode)

      (4) Set EXEBIAS and EYEBIAS if any maneuver has been performed. The EXE and EYE ESA errors must be biased to maintain the integrity of the 10 deg. termination test.

      (5) Perform any necessary maneuvers using three wheels.

      (6) Set up for any return yaw maneuver subsequent to the Orbit Adjust.

         (a) IYSLEWCMD = 1 Enable part Orbit Adjust maneuver

(b) NYSLEWCMD = number of cycles for SLEW

(c) JYSLEWCMD >+1 direction of SLEW

(7) Set NORBADJ = number of Orbit Adjust Pulses desired.

b. Termination: An orbit adjust maneuver may be terminated in any one of the following ways:

(1) NOPALS >NORBAOJ - Orbit Adjust will nominally terminate because the desired number of Orbit Adjust pulses has been executed. NOAPLS counts the number of Orbit Adjust pulses. NORBADJ is the uplinked desied number of pulses.

(2) TACS >TOAMX - The maximum time of 600 sec has been exceeded.

(3) SAPOS - TSAC1 >TSAM - The solar array position is out of limits (>10 deg. off nominal). For certain Orbit Adjust maneuvers TSAM may be set higher.

(4) SCFLAGS=3 The solar array potentiometer is bad.

(5) EXE-EXEBIAS >ESMX (10°) 10° termination test
or
EYE-EYEBIAS >ESMX (10°)

(6) The orbit adjust may be terminated by ground command by sending the following sequence.

(a) Disable REMS A,B,C,D

(b) Set MODE=4

(c) Set MODE4I=1

(d) Set IU4=0

(e) SS2=ISEV

(f) SS1=SS3=SS4=SS5=SS6=0

(g) IENUNL=1 - Enable thruster unloading

(h) MAGULD=1 - Enable magnetic unload

(i) Command gyros to low rate (This must also be done for cases 1,2,3 and 4 also.)

c. Normal mode: The control errors PX, PY and PZ are generated from gyro data using position error and rate error and smoothed for three samples. In the normal mode, all 4 orbit adjust thrusters are used with the features of off pulsing, #1 and #4 in a given pattern defined by the open loop firing pattern table to compensate for torque generated because the center of thrust is not coincident with the center of mass. If the orbit adjust thruster #1 is off pulsed the -yaw attitude thruster is pulsed for 280 msec. If the orbit adjust thruster #4 is off pulsed the +pitch attitude thruster is pulsed for 280 msec.

If either pitch or yaw errors exceed 1 deg., the open loop firing pattern table is abandoned. Off pulsing of the O.A. thrusters is then controlled by the attitude thrusting commands. For example, if a yaw attitude pulse is required, then O.A. #1 is automatically off-pulsed.

If the errors continue to grow in spite of the off pulsing the software will disable the orbit adjust thrusters and begin using the attitude thrusters only. When the errors become within the hysterisys limits, Orbit Adjust thrusting will resume. Pitch and yaw attitude thrusting with the Orbit Adjust thrusters disabled is indicated when the errors are >3 deg. and is terminated when the errors are <1 deg. Orbit Adjust thrusting may be interrupted for as little as .256 sec. See Figure B.3.12-7. If the roll errors magnitude reaches D3Y (~1 deg), the orbit adjust thrusters will be disabled and attitude thrusters used until the roll error magnitude drops below D3Y at which time Orbit Adjust thrusting is resumed.

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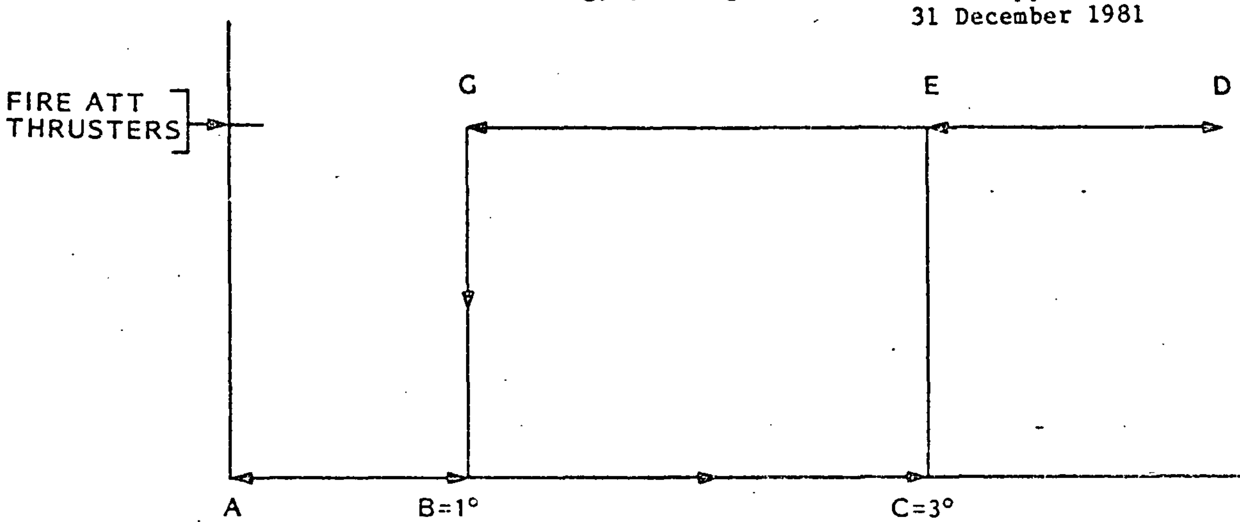

Figure B.3.12-7. Mode 7 Thruster Hysteresis

A->B Normal open loop firing pattern for off pulsing #1 and #4.

B->C Allow ACS thruster commands to override individual thrusters. (For +Z and -Y errors only.)

D-E-G Disable orbit adjust thrusters and use attitude control thrusters. (For $\pm$Z and $\pm$Y, not $\pm$roll)

G-A Reenable orbit adjust thrusters and discontinue the use of attitude thrusters except for the normal open loop off pulsing cycles.

The parameters IHTY and IHTZ are set to 1 at point C and reset to Ø at point G. The parameter DISPAS flags the first pass with orbit adjust thrusters OFF. The parameter ENAPAS flags the first pass with orbit adjust thrusters ON.

d. Backup Orbit Adjust Mode: In the backup mode only two orbit adjust thrusters are fired each cycle, either REM, A/C or REMS B/D depending on the status of the flag BKUPREM (1-->use B/D, 0-->use A/C). If the magnitude of any of the control errors $\pm$Pitch, $\pm$Yaw, and $\pm$roll is greater than D2(D2=2 deg.), then the orbit adjust thrusters are disabled and attitude thrusting takes place until all $\pm$pitch and $\pm$yaw and $\pm$roll errors are less than D2 Orbit Adjust thrusting then resumes.

e. Pulse Counting and Termination: The pulse counting and termination test is the same for both normal and backup modes. The length of the maneuver is specified by the ground by uplinking to the parameter NORBADJ the total number of milliseconds of thruster firing desired. If an OA thruster is commanded to fire during a particular thruster module cycle its dedicated counter is incremented by 256, unless an attitude pulse on that axis had been commanded the previous cycle. In the latter case the attitude thrusing will spill over into the current cycle. Since attitude pulses ae 280 msec and an OA thruster cannot fire if the corresponding attitude thruster is firing the OA thruster will come on 24 msec into the current cycle and fire for 232 msec. Therefore, in the case where the corresponding attitude thruster was firing and burning the previous cycle the dedicated OA counter is incremented by only 232. At the end of each cycle all 4 dedicated OA counters are added and stored in NOAPLS.

NOAPLS=NOMS1+NOMS2+NOMS3+NOMS4, and the termination condition, NOAPLS $\geq$NORBADJ, is measured in milliseconds. It should be noted that typically the normal mode will increment NOAPLS by 1024 each cycle (if no off pulsing) while the backup mode will increment NOAPLS by 512. In addition milliseconds of attitude pulsing are counted in resistors NACS1, NACS2, NACS3, NACS4, NACS5, and NACS6.

B.3.12.3 Attitude Control (ACS) Software Constraints

TBD

B.3.12.4 Attitude Control (ACS) System Tables

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #50 (ACS Mode Control Parameters)					
0	MODE	*	F		• ACS mode of operation • Bit definition =1-->Earth Acq (Nadir only) =2-->Earth Acq (Orbit plane) =3-->Stellar Acq =4-->Earth Pointing =7-->Orbit Adjust
2	MODE1I	*	C	ESACQI	• Earth acquisition initialize flag • Bit definition (0:DIS, 1:ENA) • Set to Ø in ESACQI after initialization of mode 1 thus preventing reinitialization • Reset to 1 by ground only
3	MODE3I	*	C	STELACQI	• Stellar acquisition • Initialize flag • Bit definition (0:Dis, 1:ENA) • Commanded, by ground only, to 1 in order to pass control from mode 2 to 3. (Ground must also command MODE=3)
4	MODE4I	*	F	EPOINTI	• Earth pointing initialize flag • Bit definition (0:DIS, 1:ENA) • Set in STELACQ upon completion of STAG1 Acq • Used in EPOINTI to enable the Update Filter and implement STAG2 Acq
5	MODE7I		F	ORBADJI	• Orbit adjust initialize flag • Bit Definition (0:DIS, 1:ENA)

Entry	Name	TLM	Type	Using Subroutine	Description
					• Set by ground to 1 to enable entry into the mode initialization branch of ORBADJI. To enter mode 7 the ground must also command MODE=7 • Reset to Ø by ORBADJI. -
6	ICAL	*	C	QWHLCOMP	• Acquisition/earth pointing flag • Set to Ø by STELACQI on initialization of mode 3 • Set to 1 by STELACQI on completion of STAGE 1 acq. • Set to 2 by EPOINTI on completion of STAGE 2 acq. • Set to 3 by Ground command to enable the normal branch of WHLCOMP • Used by WHLCOMP
					initialize flag
7	HTHX1		C	ESACQI	• System momentum threshold
8	HTHY1		C	ESACQI	• Used in ESACQI to determine whether a "one shot" thruster unload is required at separation
9	HTHZ1		C	ESACQI	
10	FIX		C	ESACQI	• Roll, pitch and yaw moments of inertia
11	FIY		C	ESACQI	• Used in ESACQI and in the thruster unload branch of WHLUNLD to calculate system momentum.
12	FIX		C	ESACQI	
15	IYSLEW		F	EULERC	• Yaw slew enable (=1)/disable (=0) flag

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Entry	Name	TLM	Type	Using Subroutine	Description
					• Used in the offset pointing branch of EULERC to enable a yaw slew
14			F	EULERC	• Yaw slew cycle counter • Used in the offset pointing branch of EULERC to control the slew time
13	IYSLEW		V	EULERC	• Yaw slew direction (*/-1) • Used in the offset pointing branch of EULERC to define the solarity of the yaw rate bias
16	TIMDLY		C	EACOMP	• Time delay before EAQ enabled • Used in EACOMP to implement a 6 cycle delay before entering the acq logic of EACOMP
17	ELVTH		C	EACOM1	• Acq. pos. threshold 1 • Used in the FACOM1 mode 1 completion test • Mode 1 completion test: /FXE/<ELVTH and /EYE/<ELVTH /WX/<WTH1;/WY/<WTH1; and /WZ/<WTH
18	ELVTH1		C	EACOMP1	• Acq. pos. threshold 2 • Used in the EACOMP1 mode 2 completion test • Mode 2 completion test: /EXE/<ELVTH1 and /EYE/<ELVTH1 /WX/<WTH2;/WY/<WTH; and /WZ/<WTH2
19	WTH		C	EACOMP1	• Acq. rate threshold 1,2, and 3
20	WTH1		C	EACOMP1	• Used in EACOMP1 for mode 1 and 2 completion tests. See entries 17 and 18 above.

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Entry	Name	TLM	Type	Using Subroutine	Description
21	WTH2		C	EACOMP1	
22	WO		C	EULERC	• Orbital angular rate • Used in EULERC to set up the commanded spacecraft rates WCX, Y, Z Nominally WCX=WCZ=0; WCY=WO
23	SMODE3	*		STELACQ	• Steller acq submode flag • Set in STELACQI • Used in STELACQ • Ø-->ECI reference is not yet initialized, the mode is still Stage 1 acquisition. Stage 1 acquisition calls SCIUPD to initialize the reference quaternion using derived earth and sun vectors • 1-->The reference quaternion has been initialized by ECIUPD and Stage 2 has begun. Stage 2 acquisition is attitude convergence using the UPDATE FILTER processor
24	SMODE4	*	C		• Earth pointing submode • Set to 1 = earth pointing • Not used
25	TMTST1		C	EACOMP	• Time between separation and magnetic reference not to be less than 180 sec • Used in EACOMP to lock out further use of the TAMS for magnetic field tracking after the S/C has passsed the magnetic reference.

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Entry	Name	TLM	Type	Using Subroutine	Description
					(Used for Back-up acq. mode)
26	TMTST2		C	EACOMP	• Time bet separation and earth acq. opportunity if magnetometer acq. was used at STP. • Used by EACOMP to reenable earth sensor data processing for acquisition. Used when the initial attempt to use earth sensors fails and magnetic tracking mode is entered.
27	POLRTY		C	EACOMP2	• Yaw direction to mag. field (0:+YAW, 1:-YAW) • Used in EACOMP2 to set the yaw axis orientation during back-up earth acquisition.
28	ESCNTT		C	EACOMP2	• Consecutive earth sensor errors during earth acquisition • Used by EACOMP2 as the number of cycles to delay upon invalid earth sensor data before switching to magnitometers.
29	PA11		C	EPOINTI	• Earth pointing position error/gyro bias convergence threshold
30	PA22		C	EPOINTI	• Used in EPOINI to implement the Stage 2 Acq. Completion Test

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Entry	Name	TLM	Type	Using Subroutine	Description
31	MAGREF		C	EACOMP	• Magnetic reference flag 0=NOT AT Magnetic reference 1=AT or past reference • Used in EACOMP to allow the the gyro registers to be initialized to values determined by the magnetic field components. The test of MAGREF is only performed if TACS<TMTST1, i.e. 1st rev only.
32	MODEP		F	MODEFD	• Past value of MODE • MODE is transferred to MODEP as the last function preformed by the ACS processor before return to the SCP.

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #51 (Gyro Data Compensation Parameters)					
0	GC11		C	GYROCOMP	• Gyro axes to body axes transformation matrix.
2	GC12		C		• Used in GYROCOMP to transform raw filtered gyro data from gyro to S/C body coordinates.
4	GC13		C		
6	GC21		C		
8	GC22		C		
10	GC23		C		
12	GC31		C		
14	GC32		C		
16	GC33		C		
18	GSFHX		C	GYROCOMP	• Gyro X,Y,Z; high, low scale factor.
20	GSFHY		C		• Used in GYROCOMP to convert counts to RADIANS.
22	GSFHZ		C		• The use of the high or low rate scale factor is determined by bit CHNL of SENSTA.
24	GSFLX		C		
26	GSFLY		C		
28	GSFLZ		C		
30	THETBX		V	GYROCOMP	• Roll, pitch, yaw gyro rate bias.
32	THETBY				• Used in GYROCOMP
34	THETBZ				• Calculated by the update filter or uplinked from the ground.
36	IGYX		C	GYROCOMP	• X,Y,Z gyro selection flag 0=gyro 1 1=gyro 2
37	IGYY				
38	IGYZ				

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #52 (Uplinked Euler Parameters)					
0	OFFSET	*	F	EULERC	• Offset pointing flag • 1-->enter the offset pointing branch of EULERC. • Set to 1 by ground command or by ORBADJI if IYSLWCMD=1 • Set to Ø by ground only
1	EPHEMFLG	*	F	EULERC	• Ephemeris source flag • Used in EULERC • Set by ground command only • 0-->GPS; 1--> ground data
2 4 6 8	B1 B2 B3 B4			EULERC	• Offset pointing euler parameter set • Used by EULERC in the offset pointing branch to build the offset target
10 12	EYSLEW3 EYSLEW4			EULERC	• Third and fourth Euler parameters describing the yaw slew • Used in the offset pointing branch of EULERC. EYSLEW1,2,3,4 are used to transform the offset pointing parameters B1,2,3,4 into the temporary outer parameters EQ. EQ is then used to obtain the offset pointing enter parameters D1,2,3,4. • EYSLEW1 and EYSLEW2 are always jØ-->only yaw slews
14	YRTBSNOM		C	EULERC	• Nominal yaw slew rate • Used by the offset pointing branch of EULERC to control the slew rate.

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #53 (Magnetometer Parameters)					
0	SELMAG	*	F	MAGNET	• Magnetometer select flag (1=MAG. 1, 2=MAG. 2) • Used in MAGNET
1	KBXX		C	MAGNET	• Coefficients used in the compensation of the input for the effects of the magnetic torquer bars • Used in MAGNET
2	KBXY		C		
3	KBXZ		C		
4	KBYX		C		
5	KBYY		C		
6	KBYZ		C		
7	KBZX		C		
8	KBZY		C		
9	KBZZ		C		
10	BXB		V	MAGNET	• Components of three-axis magnetic fld bias vector - roll component • Used in MAGNET
11	BYB		V		
12	BZB		V		
13	BO		C	MAGNET	• Magnetometer zero offset compensation • Used in MAGNET
14	MO		C	MAGNET	• Torquer bar dipole moment zero offset compensation • Used in MAGNET
15	KMS		C	MAGNET	• Magnetometer scale factor • Used in magnet
OBC System Table #54 (Wheel Tach Parameters)					
0	KWS		C	WHLTAC	• Tach counts to momentum conv factor • Used in WHLTAC

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #55 (FSS Calibration Coefficients)					
0	A11		C	FSSCAL	• Fine Sun Sensor calibration coefficients X axis. • Used in FSSCAL to calibrate XP.
1	A12		C		
2	A13		C		
3	A14		C		
4	A15		C		
5	A16		C		
6	A17		C		
7	A18		C		
8	A19		C		
9	A21		C	FSSCAL	• Fine Sun Sensor calibration coefficients Y axis. • Used in FSSCAL to calibrate YP.
10	A22		C		
11	A23		C		
12	A24		C		
13	A25		C		
14	A26		C		
15	A27		C		
16	A28		C		
17	A29		C		

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #56 (Earth Sensor Parameters)					
0	ESASEL	*	V	ESPROC	• ESA selection flag (1:UNIT 1, <>1: UNIT2) • Used in ESPROC to use either ESA1 or ESA2 as the first choice for the ESA data-source.
1	KXC1		C	ESPROC	• Coarse/fine ESA 1/2 Roll/Pitch gain constants. • Used in ESPROC
2	KYC1		C		
3	KXF1		C		
4	KYF1		C		
5	KXC2		C		
6	KYC2		C		
7	KXF2		C		
8	KYF2		C		
9	BXC1		C	ESPROC	• Coarse/fine ESA 1/2 Roll/pitch OFFSETS. • Used in ESPROC
10	BYC1		C		
11	BXF1		C		
12	BYF1		C		
13	BXC2		C		
14	BYC2		C		
15	BYF2		C		
16	BYF2		C		
17	EVES1OK		C	ESPROC	• ESA 1,2 data validity threshold • Used in ESPROC • If ESASEL=1 then the ESA 1 data (EVES1) is compared to EVES1OK. If then EVES1 >EVES1OK then the ESA1 data is used. IF the above test fails then attempt is made to use data from ESA2.
18	EVES2OK		C		

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Entry	Name	TLM	Type	Using Subroutine	Description
19	EPES1		C	WHLACQ	• Euler parameters which describe the ESA 1, 2 mounting errors • Transferred to ECTM1, 2,3,4 (either EPES1 (1,2,3,4) EPES2 (1,2,3,4) depending on the value of ESASTA) in ESPROC. Then ECTM1,2,3,4 is used by WHLACG if ESA data is being used to drive the acq. control errors.
21	EPES1		C		
23	EPES1		C		
25	EPES1		C		
27	EPES2		C		
29	EPES2		C		
31	EPES2		C		
33	EPES2		C		

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Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #57 (Wheel Command Parameters)					
0	IW4		V	WHLCOMP	• 4 wheel control flag • 1=4 wheels; Ø=3 wheels • Used in WHLCOMP
1	A1X		C	WHLCOMP	• Roll, pitch, yaw filter-coefficients • Used in WHLCOMP to filter the raw wheel drive commands for mode 4 use only. (with ICAL=3)
2	A1Y		C		
3	A1Z		C		
4	A2X		C		
5	A2Y		C		
6	A2Z		C		
7	AF1X		C	WHLACQ	• Roll, pitch, yaw filter coefficients for acq. modes 1,2,3 and 4 with ICAL<3. • Used in WHLACQ
8	AF1Y		C		
9	AF1Z		C		
10	AF2X		C		
11	AF2Y		C		
12	AF2Z		C		
13	B1X		C	WHLCOMP	• Roll, pitch, yaw filter coefficients • Used in WHLCOMP to filter the raw wheel drive commands for mode 4, ICAL=3.
14	B1Y		C		
15	B1Z		C		
16	BF1X		C	WHLACQ	• Roll, pitch, yaw filter coefficients for acq. modes 1,2,3 and 4 with ICAL<3. • Used in WHLACQ
17	BF1Y		C		
18	BF1Z		C		
35	EL		C	WHLACQ	• Positive earth acq. error limit. • Used in the 2 stage filter of WHLACQ
36	ELM		C	WHLACQ	• Negative earth acq. error limit • Used in the 2 stage filter of WHLACQ

Entry	Name	TLM	Type	Using Subroutine	Description
37 39 41	EXL EYL EZL		C C C	WHLCOMP	• Attitude error limits roll, pitch and yaw • Used in WHLCOMP (normal mode 4 branch
43 44	FLMT FLMTM		C C	WHLACQ	• Positive & negative earth acq. filter limit>SV • Used in the 2 stage filter of WHLACQ
45 46 47	IDXL IDYL IDZL		C C C	WHLCOMP	• Axial attitude error data double integral limits - roll, pitch, yaw • Used in WHLCOMP (normal mode 4 branch)
48 49 50	IXL IYL IZL		C C C	WHLCOMP	• Attitude error integral limits - roll, pitch, yaw • Used in the normal mode 4 branch of WHLCOMP
51 52 53 54 55 56	KDIX KDIY KDIZ KIX KIY KIZ		C C C C C C	WHLCOMP	• Double integral gains; roll, pitch, yaw • Used in the normal mode 4 branch of WHLCOMP • Axial integral gains; roll, pitch and yaw • Used in the normal mode 4 branch of WHLCOMP
57 58 59	KPRX KPRY KPRZ		C C C	WHLACQ	• Roll, pitch and yaw earth acquisition position error gains • Used in WHLACQ
60 61 62	KPX KPY KPZ		C C C	WHLCOMP	• Roll, pitch and yaw position error gains. • Used in the normal mode 4 4 branch of WHLCOMP

Entry	Name	TLM	Type	Using Subroutine	Description
63 64	KRLX KRLY		C C	WHLACQ	• Roll and pitch earth acq. rate error gains • Used in WHLACQ
65	KRLZ		C	WHLACQ	• Yaw earth acq. rate error • Used in WHLACQ
66 67 68	KRY KRY KRZ		C C C		• Rate error gains for roll, pitch and yaw • Used in the normal mode 4 branch of WHLCOMP
70	KZ		C	WHLACQ	• Yaw gyro compassing error gain • Used in WHLACQ for the yaw error determination if SWITCHZ=2
71 72	PLMT PLMTM		C C	WHLCOMP	• Positive and negative filter output limits • Used in the normal mode 4 branch of WHLCOMP
73	SKP		C	WHLCOMP	• Skewed wheel rate gain • Used in the 4-wheel control branch of WHLCOMP
74 75	SVLMT SVLMTM		C C	WHLCOMP	• Positive and negative 4-wheel controller limit 1 • Used in the 4-wheel control branch of WHLCOMP for the determination of the skewed wheel command
76 77	SWLMT SWLMTM		C C	WHLCOMP	• Positive and negative 4-wheel controller limit 2 • Used in the 4-wheel control branch of WHLCOMP for the determination of the skewed wheel command

Entry	Name	TLM	Type	Using Subroutine	Description
78	W4CMD			WHLCOMP	• Commanded skewed wheel momentum • Used in the 4-wheel control branch of WHLCOMP
79	ACEAORB		C		• ACE enabled for RW/MT cmds (0:A, 1:B)
80 81	WHLMT WHLMTM		C C	WHLCOMP	• Positive and negative final wheel command limit • Used in the normal mode-4 branch of WHLCOMP
82 83 84	WYL WXL WZL		C C C	WHLCOMP	• Pitch, roll and yaw rate error limits • Used in the normal mode-4 branch of WHLCOMP
87	K1P99S8		C	WHLCOMP	• Twice the normal raw wheel command limit • Used to limit TW(X,Y,Z)C prior to the filter in the normal mode 4 branch of WHLCOMP
89	K1P99S2		C		
91 92	K61P11 KM64P60		C C	WHLCOMP	• TDRS antenna conversion factors • Used in the normal mode 4 branch of WHLCOMP to convert DELTNA,E to P1,2,3
93	KP0012		C	WHLCOMP	• TDRS counts to acceleration scale factor 3 • Used in WHLCOMP (Mode-4 normal operations)
94	KP458S8		C	WHLCOMP	• TDRS antenna compensation elevation limit

Entry	Name	TLM	Type	Using Subroutine	Description
					• Used in the normal mode-4 branch of WHLCOMP
95	SKI		C	WHLCOMP	• Skewed wheel controller gain • Used in the 4-wheel command branch of WHLCOMP
96	WHLMTD		C		
98	WHLMTA		C	WHLCOMP	• Final wheel command limit (Pos and Neg) • Used in WHLCOMP to limit TW(X,Y,Z)C after the TDRS compensations have been added
99	WHLMTAM		C	WHLCOMP	

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #58 (Thruster Command Parameters)					
0	IHTBMD	*	F	THRUSTER & ORBADJI	• Backup orbit adjust mode • Controlled by ground command only • Used by THRUSTER and ORBADJI to choose normal or backup O.A. mode
1	BKUPREM		F	THRUSTER	• Back up O/A REM flag • Used in THRUSTER to choose REMs A/C or B/D if the Back-Up O.A. mode is chosen
2	PMEFLG		C		• O/A PME RIU A/B flag (0:RIU A, 1:RIU B) • Used in proc CMDSPM
3	BIASX		F	THRUSTER	• Roll position error bias • Used in THRUSTER in the calculation of the O.A. control error TTX
4	BIASY	*	F	THRUSTER	• Pitch, yaw position error bias • BIASY,Z are used in the calculation of TTY,Z and are nominally = Ø. If OAPCH >.03 RAD or OAYAW <-.03 RAD BIASY or Z is incremented by .00873 RAD. Tests on OAPCH, YAW are preforms in mode 7 by THRUSTER once per minute. If OAPCH or OAYAW is out of limits the open loop firing pattern is altered as well as
5	BIASZ	*	F		

Entry	Name	TLM	Type	Using Subroutine	Description
					the bias changed. BIASY and BIASZ can be reset to Ø by ground command only.
6	HTKP		C	THRUSTER	• Orbit adjust control error position and rate gains-
7	HTKR		C	THRUSTER	• Used in THRUSTER in the calculation of TTX,Y,Z
8	OAFL1		C		• O.A. attitude error gain 1,2 Used in THRUSTER in the calculation of OAPCH and OAYAW
9	OAFL2		C		
10	IOPEN	*	C	ORBADJI & THRUSTER	• Large center of thrust-center of mass offset flag • Used in ORBADJI and THRUSTER • Set by ground command only
11	MHTLIM		C	THRUSTER	• Firing pattern change counter threshold • Used in THRUSTER to control the timing of the firing pattern change test
12	OALMT		C	THRUSTER	• O.A. pitch and yaw error limit • Used in the firing pattern test of THRUSTER as the limits to which OAPCH and OAYAW are compared to
13	MOALMT		C	THRUSTER	
14	FPBLD		F	ORBADJI	• Rebuild thruster firing pattern (1:ENA, 0:DIS) • Used in ORBADJI to rebuild the thruster firing pattern in the event it had been change by the firing pattern loop of THRUSTER

Entry	Name	TLM	Type	Using Subroutine	Description
					o Set by ground only
15	BIAS873		C		o Pitch/yaw bias adjustment o BIAS873 is the amount by which BIASY or/and BIASZ are changed each loop of the firing pattern change logic
16 17	BIASM017 BIASM017		C C		o Positive and negative pitch bias adjustment
18 19 20 21	NLMTS MLMTS D1Y D1Z		C C C C	THRUSTER	o Pitch and yaw firing pattern index limit o Used in the firing pattern change logic of THRUSTER
				THRUSTER	o Negative pitch/yaw hysteresis switch threshold
				THRUSTER	o Used in THRUSTER for the normal O.A. mode only
22 23 24	D2X D2Y D2Z		C C C	THRUSTER	o Low thrust roll, pitch, yaw error limit o Used in THRUSTER when back-up O.A. commanded or when the high thruster are disabled
25 26 27	D3X D3Y D3Z		C C C	THRUSTER	o Positive roll, pitch, yaw hysteresis switch threshold o Used in THRESHOLD for the normal O.A. mode only
28 29 30	OACX OACY OACZ		C C C	THRUSTER	o Roll, pitch, and yaw back-up O.A. mode control error gains o Used THRUSTER for backup O.A. mode only

Entry	Name	TLM	Type	Using Subroutine	Description
31	NCOUNT		C	THRUSTER	• Open loop firing pattern array index limit • Used in THRUSTER
32	ORBADJ		V	ORBADJI	• Orbit adjust mode commanded pulse count • Used in the O.A. termination test in ORBADJI
33	TSAM		C	ORBADJI	• Solar array position error limit • Used in the O.A. termination test in ORBADJI
34	TOAMX		C	ORBADJI	• Orbit adjust time limit • Used in the O.A. termination test in ORBADJI
35	ESMX		C	ORBADJI	• Orbit adjust roll/pitch ESA error limit • Used in the O.A. termination test in ORBADJI • Used as the test limit for the compensated earth sensor errors EXE-EXEBIAS and EYE-EYEBIAS
36	IYSLWCMD		V	ORBADJI	• Yaw slew enable flag (0:DIS, 1:ENA) • Used in ORBADJI to enable the offset processing branch of EULERC
37	NYSLWCMD		V	ORBADJI	• Yaw slew counter initial value • Used in ORBADJI to transfer an initial value of the slew time to NYSLEW. (NYSLEW = initial value of the slew counter in EULERC)

Entry	Name	TLM	Type	Using Subroutine	Description
38	JYSLWCMD		V	ORBADJI	• Yaw slew direction (+1:+YAW, -1:-YAW) • Used in ORBADJI to transfer the slew direction to JYSLEW. (JYSLEW is the direction of the slew used in EULERC.
39	TSAK		C		• Solar array noon position
40	EXEBIAS		C	ORBADJI	• Roll and pitch earth sensor bias • Used in the O.A. termination test in ORBADJI
41	EYEBIAS		C	ORBADJI	
42	ISEV		C	ORBADJI	• State vector SS2 reset value • Used in ORBADJI

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #59 (Momentum Unloading Parameters)					
0	MAGULD	*	F	WHLUNLD	• Magnetic unloading enabled flag • Set by EACOMP or ORBADJI (on reentry to MODE 4) • Used by WHLUNLD • Ø=DSBL 1=ENAB • Nominally MAGULD=1
1	IENUNL	*	C	WHLUNLD	• Thruster unloading enable flag • Used in WHLUNLD. If=0 the thruster unload branch will be bypassed • Set=1 in ESACQI if a one time unload is desired at separation
2	INIUNL	*	C	WHLUNLD	• Thruster unloading initialization flag • Used in WHLUNLD (1=initialize thruster unloading)
3	IMOMUN	*	C	WHLUNLD	• Momentum unload select flag • 1--> unload system momentum ≠1--> unload wheel momentum • Set in ESACQI • Used in WHLUNLD
4	FAILW	*	C	WHLCOMP	• Failed wheel flag • Used in WHLCOMP by the failed wheel logic • Set by ground command only • =1--> Roll wheel failed =2--> Pitch wheel failed =3--> Yaw wheel failed =4--> All wheels are OK

Entry	Name	TLM	Type	Using Subroutine	Description
5 6 7	KMX KMY KMZ		C C C	WHLUNLD	• Magnetic unloading gains roll, pitch, yaw • Used in WHLUNLD
8-13	TRQLVL		V	WHLUNLD	• Thruster torque array R1, P1, Y1, R2, P2, Y2 • Used by WHLUNLD to determine the available thrust for each thrusters
14 15	ITPOS ITNEG		C C	WHLUNLD	• Positive and negative torque level index • Used in WHLUNLD
16	UNLDTM		C	WHLUNLD	• Unloading delay timer • Used in WHLUNLD
17	TIMINC		C	WHLUNLD	• Delay timer increment • Used in WHLUNLD

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #60 (Stellar Acquisition Parameters)					
0	XKZ		C	STELCOMP	• Yaw gryo-compassing gain • Used in STELCOMP for steller acq. gyro compassing
1 2 3	YGFA1 YGFA2 YGFB1		C C C	STELCOMP	• Yaw gyrocompassing Filter 1,2,3 • Used in STELCOMP for steller acq. gyro compassing
4	SAQBU		C	ECIUPD	• Stellar acq. backup flag (0:NORMAL, 1:BACKUP) • Used in ECIUPD to implement either the normal or backup mode of steller acq. • Normal mode used measured values, of the earth and sun vectors to derive an initial value for the reference quaternion • Backup mode uses uplinked as the initial values for the reference quaternion

SVS-10266
Appendix B
31 December 1981

B.3.12.5 Attitude Control (ACS) Telemetry

The following is a tabulation of telemetry parameters available from the ACS Processor via OBC Telemetry Reports 1 through 12. The report tabulation contains:

Entry Number	-	location of TLM point in report (this is offset from report entry point)
Name	-	As designated by software
Generating Subroutine	-	Processor subroutine which calculates or sets software telemetry point.
Description/Comment	-	Explains telemetry point provides other details of TLM points use and meaning.

For more detailed information such as scale, units, length and value of TLM point see SVS-10130 Landsat-D Flight Segment Computer Program Design Specification.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report 1 (ACS 01)			
0 2 4	THETAX THETAY THETAZ	GYROCOMP	o Angular increments of the spacecraft X, Y, and Z axes since the last measurement processed by the ACS processor. (.256 sec if MODE = 7; .512 sec if MODE = 4) o THETAX,Y,Z are calculated from filtered gyro data with compensations for misalignment and bias errors included.
6 9 12	DNGX DNGY DNGZ	GYROD	o Raw gyro difference data from GYROFLTR of the gyro data acquisition processor GYROD. o DNGX,Y,Z is not filtered or compensated for misalignment or bias errors. o The GYROD processor is called each .064 sec and inputs the contents of the 6 ITP 24 bit gyro data registers and stores the data in NGX1, NGX2, NGY1, NGY2, NGZ2, NGZ2. DNGX,Y,Z are then the difference between successive readings of the selected channels; NGX1 or NGX2, NGY1 or NGY2, NGZ1 or NGZ2.
15 18 21	NGXF NGYF NGZF	GYROFLTR	o Total gyro angular data input each .064 sec from the ITP. (The 3 selected channels only) o The data is filtered by the 2 stage filter of GYROFLTR unless: MODE = 7, or THRUST = 1, or MODE = 1 and SMODE1 = 0; but the data is not compensated for misalignment or bias errors. o NG(X,Y,Z)F are the product of GYROFLTR of the GYROD processor. The spacecraft control processor

Entry Number	Name	Generating Subroutine	Description/Comment
			(SCP) then inputs these data to calculate the gyro difference data. (GYDIF(I)=NG(I)F=NG(I)H, where NG(I)F is the past reading of NG(I)F and I = X,Y,Z. The SCP processor is called each .256 sec and if MODE=4, the ACS processor is called each .512 sec. Under these conditions (GYOIF(I)) is calculated every other calling of the SCP.
OBC TLM Report 2 (ACS 02)			
0 1 2	WGX WGY WGZ	GYROCOMP	• Angular displacement of the spacecraft X,Y,Z axes compensated for misalignment but not bias errors. • WGX,Y,Z is the result of an intermittent calculation in GYROCOMP.
3 4 5	WX WY WZ	GYROCOMP	• X,Y,Z components of the spacecraft angular velocity vector. • WX,Y,Z are the final result of GYROCOMP calculated from filtered gyro data and compensated for misalignment and bias errors.
6 8 10	EX EY EZ	ATTERR	• X,Y,Z component of the attitude error vector calculated from filtered gyro data with misalignment compensation and bias errors included. • EX,Y,Z are calculated from the error quaternion components C1, C2 C3 using the small angle approximation EX=-2*C1=-2* *SIN(θ/2)≅ θ

Entry Number	Name	Generating Subroutine	Description/Comment
			EX,Y,Z are then the angles from the mission frame to the body axes.
12 15 18 21	EPA1 EPA2 EPA3 EPA4	EULER I	• Euler parameters which represent the rotation from ECI to the spacecraft body axis as determined by propagating filtered gyro data. (Reference Quaternion)
24	NHT	THRUSTER	• NHT is the open loop command array index for orbit adjust thruster firing. • NHT is initialized to 0 in ORBADJI, incremented and reset in THRUSTER.
<u>OBC TLM Report 3 (ACS 03)</u>			
0 2 4 6	EPD1 EPD2 EPD3 EPD4	EULERC	• Euler parameters which represent the rotation from ECI coordinates to the desired pointing target. (Target Quaternion or Mission Reference Frame) • The earth pointing target is dependent on orbit position. EULERC uses the flight segment position and velocity vectors calculated by the EPHEM processor to build the target D1,D2,D3,D4. EULERC aligns the target +Z axis along -<u>R</u> and the target X axis along the X-component of <u>V</u> where <u>R</u> and <u>V</u> are the F.S. position and velocity vectors.
8 11 14 17	EPC1 EPC2 EPC3 EPC4	ATTERR	• Euler parameters which represent the rotation from the vehicle axes to the target axes. (ERROR QUATERNION)

Entry Number	Name	Generating Subroutine	Description/Comment
20 22	EIX EIY	WHLCOMP	• X and Y components of the integrated attitude error calculated from filtered, compensated gyro data. • EIX,Y are developed in WHLCOMP using data from the present and past cycles to smooth the wheel commands.
24	IACCMD	THRUSTER	• 1 X 6 Thruster command array • Bit definition 1 = ON, 0 = OFF Bit 1 +Roll Bit 2 -Roll Bit 3 +Pitch Bit 4 -Pitch Bit 5 +Yaw Bit 6 -Yaw • If the ACS is in the orbit adjust mode (MODE = 7) and no attitude thrusting is called for, then Bits 3,4,5,6 of IACCMD imply: 0000--->pulse all 4 Orbit Adjust thrusters 0010--->off pulse Orbit Adjust thruster #1 for +Y torque 0100--->off pulse Orbit Adjust thruster #4 for -P torque
<u>OBC TLM Report 4 (ACS 04)</u>			
0	EIZ	WHLCOMP	• Z component of the attitude error single integral • See OBC TLM Report 3 (20-22)
2 4 6	EDIX EDIY EDIZ	WHLCOMP	• X,Y,Z components of the double integrated attitude errors calculated from filtered, compensated gyro data.

Entry Number	Name	Generating Subroutine	Description/Comment
			• EDIX,Y,Z are developed in WHLCOMP to smooth the wheel commands by considering errors from the past and past-past cycles.
8 10 12	TWX TWY TWZ	WHLCOMP	• TWX,Y,Z are the wheel commands output by WHLCOMP • If MODE = 4 the wheel commands are driven by filtered compensated gyro data and smoothed by a double integral "smoother" which operates on the error signals EX,Y,Z • If MODE = 1,2,3 or 4 with ICAL<3 the wheel commands are driven by earth sensor signals for roll and pitch with gyro compassing for yaw. • Magnitometers and/or gyros may drive TWX,Y,Z during backup acquisition mode.
14 15 16	WEX WEY WEZ	WHLCOMP	• Spacecraft angular rate errors. WEX = WX - WXC where WX is the measured rate and WXC is the commanded rate.
17 18 19	TTX TTY TTZ	THRUSTER	• Roll, pitch and yaw total error (Pos + Rate) • Calculated in Mode 7 by THRUSTER
20 22	BIASY BIAZ	THRUSTER	• Pitch and yaw position error biases used only for Mode 7
24	SKEW	SKEWFD	• SKEW wheel out of limits flag. • If the skew wheel is out of limits FDC is then disabled.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report 5 (ACS 05)			
0	NOAPLS	THRUSTER	• Orbit adjust time counter (counts milliseconds of thruster firing) • Initialized to 0 and then tested each cycle as a mode 7 termination condition by ORBADJI. • Incremented by THRUSTER and records the total number of thruster milliseconds of firing.
2 3 4 5 6 7 8 9	EX1C EY1C EX2C EY2C EX1F EY1F EX2F EY2F	ESPROC	• Coarse and fine earth sensor error signals compensated for known offsets • EX1C etc are the product of ESPROC used to calculate EXE and EYE
11 12	DELTNA DELTNE	WHLCOMP	• TDRS antenna azimuth and elevation acceleration • DELTHA,E are calculated by WHLCOMP and used to calculate roll, pitch, and yaw torques P1, P2 and P3 which are added to the wheel commands when MODE=4 and ICAL=3.
13 14 15	ITHUNLX ITHUNLY ITHUNLZ	WHLUNLD	• X,Y, and Z pulse counters for thruster unloading • Used in WHLUNLD
16 18	XP YP	FSSCAL	• FSS roll and pitch errors compensated for all known sensor errors • XP and YP are calculated in FSSCAL

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Entry Number	Name	Generating Subroutine	Description/Comment
20 21	TWS	WHLCOMP	• Skew wheel command
23	TAMSTA	EACOMP	• Three Axis Magnitometers in use Flag. • Set in EACOMP if Magnetic tracking (Stage 1 of Back-up Earth - Acquisition Mode) is entered and reset to Ø when Magnetic tracking is shut off. (Stage 2)
24	MTRAFLAG	MTRAFD	• Channel A motor current out of limits flag. • The Channel A motor current is checked once per Major frame if out of limits MTRAFLAG is set to 1. • Used in ACQFD and NORMFD to present the use of gyro axis Y1 if channel A is suspect.
<u>OBC TLM Report 6 (ACS 06)</u>			
0 1 2	SYSMOX SYSPL SYSMOZ	ESACQI	• System momentum X, Y + orbit rate, Z • Calculated in ESACQI during modes 1 and 2 to allow a 1 time thruster unload of momentum which may be imparted to the vehicle upon separation
5 7 9	ELX1L ELY1L ELZ1L	WHLACQ	• Limited roll, pitch, yaw wheel commands once filtered • Calculated in WHLACQ when MODE = 1,2,3 or 4 with ICAL<3.
6 8 10	TWXC TWYC TWZC	WHLCOMP	• Roll, pitch, yaw wheel commands filtered twice • TW(X,Y,Z)C are equal to TW(X,Y,Z) if the commands are unchanged

Entry Number	Name	Generating Subroutine	Description/Comment
			by the failed wheel logic of WHLCOMP
11	FDC1PR	MODEFD	• Yaw and Pitch/Roll FDC enable flag
12	FDC1Y		• Set in MODEFD and used in NORMFD and ACQFD to control the automatic enabling and disabling of the FDC logic.
13	FDC1PRF		• Yaw and Pitch/Roll FDC fail flag
14	FDC1YF		• Set by ground command to disable FDC • Set by the RTS which commands safe hold after an FDC failure • If either flag is set to 1 the corresponding FDC logic can only be reenabled from the ground.
15	FDC2PR	GYROMSFD	• Yaw and Pitch/Roll Gyro FDC enable flags
16	FDC2Y		• Set in GYROMSFD and used in MODEFD to control the use of GYROFD or ACQFD if MODE = 1.
17	FDC2PRF	GYROFD	• Yaw and Pitch/Roll Gyro FDC fail flags
18	FDC2YF		• Used in GYROFD to bypass processing after the first failure • Set in GYROFD upon a first failure
19	XRATDIL	GYROFD	• Roll IRU rate dilemma flag • Set to 1 if the R1 and R2 gyros do not agree and R1 is the higher of the two.

Entry Number	Name	Generating Subroutine	Description/Comment
20	YRATDIL	GYROFD	• Pitch IRU rate dilemma flag • Set to 1 if the P1 and P2 gyros do not agree and P1 is the higher of the two.
22 23	FSTATE1 FSTATE2	NORMFD	• Pitch and Roll failure State for Normal FDC • FSTATE1 and FSTATE2 each define one normal state 000 or 1 of 7 possible failure states. See Section TBD, Normal Mode FDC.
24	SAFE.ST	FDC Safehold Interlock Module (Name TBD)	• Safehold FDC initialization flag • Initialized to (TBD) then reset to (TBD) after the 1st execution of the module
<u>OBC TLM Report 7 (ACS 07)</u>			
0 1 2	P1 P2 P3	WHLCOMP	• Spacecraft axes components of the TDRS antenna pointing commands DELTNA and DELTNE • P1,2,3 are calculated in WHLCOMP for MODE = 4 only. These torques are then added to the wheel commands TW(X,Y,Z)C.
3 4 5	WXC WYC WZC	EULERC	• X,Y,Z components of the commanded vehicle rate vector. Calculated in EULERC the nominal values are: WXC = 0, WYC = W0, WZC = 0 • If offset pointing is commanded W(X,Y,Z)C take new values calculated in the offset pointing branch of EULERC • Used in WHLCOMP during normal mode 4 operation only

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Entry Number	Name	Generating Subroutine	Description/Comment
6 7 8	PX PY PZ	THRUSTER	• Roll, pitch and yaw orbit adjust mode attitude error control signals • PX,Y,Z are dependent on position and rate error • PX,Y,Z undergo 3 sample smoothing and are compensated by the biases BIAS(X,Y,Z)
11	TACS	MINIT ORBADJI	• ACS/Orbit Adjust time counter • TACS is incremented each ACS cycle in MINIT • TACS is reset to Ø on entry to MODE 7 by ORBADJI.
13 15 17 19 21 23	WGDX1 WGDX2 WGDY1 WGDY2 WGDZ1 WGDZ2	GYROFD	• Gyro X1,X2,Y1,Y2,Z1,Z2 rates • Used in GYROFD in the tests which compare gyro outputs
OBC TLM Report 8 (ACS 08)			
0	MODE		• ACS mode of operation 1 = NADIR ACQ 2 = ORBIT PLANE ACQ 3 = STELLAR ACQ 4 = EARTH POINTING 7 = ORBIT ADJUST
1	XPOSDIL	ACQFD	• Roll position dilemma flag • Set to 1 when the ESA's do not agree and EX2C is out of limits and EX1C is in limits. Safehold 1-1 or 1-0 will be entered. • Set to 2 when the ESA's are both out of limits and don't agree. No safehold will be entered.

Entry Number	Name	Generating Subroutine	Description/Comment
2	YPOSDIL	ACQFD	• Pitch position dilemma flag • Set to 1 if the ESA's do not agree and ESA2 is out of lmits but ESA 1 is OK. Safehold 1-2 will be entered. • Set to 2 if the ESA's do not agree and both ESA's are out of limits.
3	SMODE3	STELACQI	• Stellar acq submode flag • Used in STELACQ 0 = ECI reference is not yet initialized, the mode is still stage 1 . 1 = The reference quaternion has been initialized by ECIUPD and Stage 2 has begun. Stage 1 acquisition calls ECIUPD to initialize the reference quaternion using derived earth and sun vector. Stage 2 acquisition is attitude convergence using the UPDATE FILTER processor
4	SMODE4	EPOINT	• Earth pointing submode flag set to 1 = Earth Pointing
5	ESACNT	EACOMP2	• ESA acquisition failure counter • ESACNT counts the 5 cylce delay before entry to magnetic tracking if neither earth sensor has earth presence during the 1st rev.
6	MAGULD	EACOMP	• Magnetic unloading enabled flag • Set by EACOMP or ORBADJI (on reentry to MODE 4) • Used by WHLUNLD • 0 = DSBL 1 = ENAB Nominally MAGULD = 1

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Entry Number	Name	Generating Subroutine	Description/Comment
7	FLTROFF	GROUND	• Prefilter ON/OFF control flag • Set by ground only • Used in GYROFLTR of the GYROD processor to disable the IRU prefilter • 1 = bypass IRU prefilter
8	ESASTA	ESPROC	• ESA signal status • ESASTA flags which ESA data (1 flags ESA1 and 2 flags ESA2) is used to generate the earth sensor control errors EXE and EYE
9	MODE4I	STELACQI	• Earth pointing initialize flag • Set in STELACQI upon completion of Stage 1 acquisition
10 11	TIMUNLX TIMUNLY	WHLUNLD	• X,Y,Z unload timer • When thruster unloading is enabled, TIMUNLX,Y,Z count milliseconds between X, Y and Z thruster pulses. Thrusting is controlled to occur once each UNLDTM seconds. (Delay ≈120 sec).
12	MODE3I		• MODE 3 initialization flag • Upon the successful completion of orbit plane acquisition (MODE 2) the ground must command MODE = 3 and MODE3I = 1 to allow control to pass to mode 3. Control will then pass automatically through STAGE1 acquisition to MODE 4. Therefore the attitude sensors must all be operating properly before the ground proceeds to mode 3.

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Entry Number	Name	Generating Subroutine	Description/Comment
13	ECIATT	ECIUPD	• Stage 1 complete flag • Used by STELACQI >0 = control has passed to Stage 2 acquisition =1 = normal ECI initialization (earth and sun vector) =2 = backup ECI initialization (used ground commanded values)
14	MODE1I	ESACQI	• Mode 1 initialization flag • Set to 0 in ESACQI after the initialization of MODE 1 thus preventing reinitialization. To reinitialize after the 1st rev the ground must set MODE = 1 and MODE1I = 1 as well as reevaluate TMTST1 and TMTST2.
15	EPHEMFLG	GROUND	• Ephemeris source flag 0 = GPS 1 = Ground Data • Used in EULERC
16	FAILW	GROUND	• Failed wheel flag • Used in WHLCOMP by the failed wheel logic • Set by ground command only =1 = roll wheel failed =2 = pitch wheel failed =3 = yaw wheel failed =4 = all wheels are OK
17	ICAL		• Acquisition/earth pointing flag • Set to 0 by STELACQI on initialization of mode 3 • Set to 1 by STELACQI on completion of Stage 1 acquisition • Set to 2 by EPOINTI on completion of Stage 2 acquisition • Set to 3 by ground command to enable the normal branch of WHLCOMP

Entry Number	Name	Generating Subroutine	Description/Comment
			• Used by WHLCOMP
18 19	NGXOVFL NGYOVFL		• Roll/Pitch Gyro overflow processing counter
20	TIMUNLZ		• When thruster unloading is enabled, TIMUNLX,Y,Z count milliseconds between X,Y,Z pulses. Thrusting is controlled to occur each UNLDTM seconds. (Delay ~120 sec).
21	SUNPRS	FSSCAL	• Sun presence in FSS FOV flag 0 = No Sun 1 = Sun • Used by ECIUPD
22	IRUSTA	EACOMP1	• IRU Initialization flag • Reset to Ø in EACOMP 1 to flag IRUs not in use • Set to 1
23	JTHSW		• Thruster switch timer initialization flag • Used to enable thrusters for a one shot firing to kill initial rates which may be acquired upon separation • Set to 0 by mode 1 initialization. If there are no thruster firings JTHSW will remain 0. If firings do occur at separation JTHSW will be set to 1 and remain equal to 1. The thrusters will fire a number of times specified by DHUNLD and then shut off independent of spacecraft rates.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report 9 (ACS 09)			
0	IENUNL	ESACQI	• Thruster unloading enable flag • Used in WHLUNLD. If = 0 the thruster unload branch will be bypassed • Set = 1 in ESACQI if a one time unload is desired at separation
1	INIUNL		• Thruster unloading initialization flag 1 = Enable <>1 = Disable • Used in WHLUNLD to initialize the thruster unload branch
3	MODE2C	EACOMP1/2	• Mode 2 complete flag • Set to 1 in EACOMP1 when mode 2 tests pass • Set to 0 in EACOMP1 if mode 2 tests fail • Set to 0 in EACOMP2 if EACOMP2 is entered
4	IHTBMD	GROUND	• Backup orbit adjust mode flag • Controlled by ground command • Used by THRUSTER and ORBADJI to choose normal or backup orbit adjust mode
5	DISPAS	THRUSTER	• First pass flag for orbit adjust thruster OFF 1 = 1st thruster off pass 0 = Not 1st thruster off pass • Initialized in ORBADJI
6	ENAPAS	THRUSTER	• First pass flag for orbit adjust thruster ON 1 = 1st thruster ON pass 0 = Not 1st thruster ON pass

Entry Number	Name	Generating Subroutine	Description/Comment
7 8	IHTY IHTZ	THRUSTER	• Computed hysteresis flags for pitch and yaw • IHTY,Z flag high pitch, yaw errors when MODE = 7
10 11 12	IGYX IGYY IGYZ	GYROFDC	• X,Y,Z gyro channel selection flags • Used in GYROCOMP • Set by ground command or gyro failure detection correction
13	SENSTA	SCP	• Gyro high - low rate flag • Used by GYROCOMP • Set by the status of the gyro
14	OFFSET	ORBADJI	• Offset pointing flag • 1 = enter the offset pointing branch of EULERC • Set to 1 by ground command or by ORBADJI if IYSLWCMD = 1 • Set to 0 by ground only
16	ESASEL	FDC	• ESA select flag • Select ESA1 or ESA2 as the first choice for the EXE and EYE data source • Used by ESPROC • Set by ground command or FDC
17 18 19	ELX ELY ELZ	WHLACQ	• Roll, Pitch, Yaw limited error signal • Used in WHLACQ for acquisition mode control error
23	IMOMUN	ESACQI	• Momentum unload select flag 1 = unload system momentum ≠1 = unload wheel momentum • Used by WHLUNLD
24	MAGREF	EACOMP	• Magnetic field reference flag • Initialized to 0 MAGREF is set to

Entry Number	Name	Generating Subroutine	Description/Comment
			1 when the spacecraft 1st reaches the magnetic reference and then remains 1.
25	ITHSW	ESACQI	• Thruster controller for earth acquisition switch • Thrusters will be disabled for a one shot unload if ITHSW=1
OBC TLM Report 10 (ACS 10)			
0 2 4	THETBX THETBY THETBZ	GROUND or UFLTR	• X,Y,Z components of the gyro bias vector • Calculated by the update filter or uplinked from the ground • Used in GYROCOMP. THETBX,Y,Z correspond to spacecraft axes, not gyro axes
6 7 8 9	HWX HWY HWZ HWS	WHLTAC	• SRW X,Y,Z skew momentum
10 11 12	MX MY MZ	WHLUNLD	• Magnetic torquer commands to unload SRW's
13 14 15	BX BY BZ	MAGNET	• X,Y,Z components of Earth's magnetic field vector computer in body axes
16	SELMAG	GROUND	• Magnetometer select flag 1 = TAM 1 2 = TAM 2 • Used in MAGNET
17 18 19	DHUNLD1 DHUNLD2 DHUNLD3	WHLUNLD ESACQI	• Roll-Pitch-Yaw momentum to be removed by thrusters • Set to either C2Po or SYSMOX,

Entry Number	Name	Generating Subroutine	Description/Comment
			SYSPL, SYSMOZ during the 1 shot unload enable period. Set to C2PO after the allowable time time for the one shot has elapsed
20 21 22	EXG EYG EZG	EACOMP WHLACQ	• Roll-Pitch-Yaw IRU position registers • Initialized by EACOMP when the spacecraft reaches the magnetic reference to the magnetic field errors. • Used in WHLACQ if IRUs are in use. If IRUs are not in use these Registers will not be updated.
23 24	EXM EYM	WHLACQ	• Roll-Pitch magnitometer position signal
<u>OBC TLM Report 11 (ACS 11)</u>			
See SCP Section B.3.7.5			
15	SWTCH1	EACOMP	• Sensor selection for roll-pitch position control for acquisition modes • Set in EACOMP, EACOMP1 or EACOMP2 and used in WHLACQ
16	SWTCHY	EACOMP	• Pitch orbrate bias enable for acquisition modes • 1=DSBL 2=ENAB • Set in EACOMP, EACOMP1 or EACOMP2 and used in WHLACQ
17	SWTCHZ	EACOMP	• Yaw position selection for acquisition modes • 1=Single rate stabilization 2=Gyrocompassing 3=IRU

Entry Number	Name	Generating Subroutine	Description/Comment
			• Set in EACOMP, EACOMP1 or EACOMP2 and used in WHLACQ
18	SYSMOY	ESACQI	• Pitch system momentum • Used in the calculation of thruster unload commands if a one shot unload is executed
19	ITPFAIL	FDCITP Hangup Protection Module (Name TBD)	• ACE ITP failure flag • ITPFAIL is initialized to 0 then incremented if an ITP hang up is detected. When ITPFAIL=5 Send safehold 1-1 and disable FDC.
20	SHFAIL	Safehold Interlock Module (Name TBD)	• Safehold Mode failure flag • Initialized to 0 then incremented when either macs is in safehold • Disables FDC when SHFAIL=3
21	ITPIST	FDC ITP hangup Protection Module (Name TBD)	• IPT FDC initialization flag
<u>OBC TLM Report 12 (ACS 12)</u>			
0,6,12,18 2,8,14,20 4,10,16,22	CNGX CNGY CNGZ	GYROCOMP	• Gyro data filtered by GYROD but not compensated for misalignment or bias errors • Sample time is from previous major frame +36,548,1060 and 1572 msec
<u>ACS Report 13 (OBC #13)</u>			
0	TACSSP	GYROMSFD	• 2 separation switch times • Incremented in GYROMSFD TACSSP

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Entry Number	Name	Generating Subroutine	Description/Comment
			is used in MODEFD to time separation plus 30 sec at which time the one shot unload capability is disabled and Acq FDC replaces gyro FDC.
1	SDSEPFLG	SDTECT	• Two separation switches open flag • Set in SDTECT when both separation switches are open • Used in GYROMSFD to start the TALSSP counter
2	SDFUNCT	SOLARD	• Solar array deploy complete flag • Used in MODEFD, Acquisition FDC cannot be enabled until the solar array is deployed
3	ACQIST	ACQFD	• Acquisition FDC Pitch-Roll initialization flag • Used in ACQFD to reset the gyro selection flags to R2-P2-Y2 • Initialized to 0 then set to 1 on the first pass through ACQFD
4	FDCEP	ACQFD	• Acquisition mode earth presence failure state flag • State definitions 0=Both ESAs have earth presence 1=ESA1 does not have earth presence 2=ESA2 does not have earth presence 3=Neither ESAs have earth presence

Entry Number	Name	Generating Subroutine	Description/Comment
5	EPCNT	ACQFD	• Acquisition mode earth presence failure state counter • EPCNT implements the 5 cycle delay which assures a failure is present for 5 cycles before action is taken.
6	ACQRIU	RIUSWTCH	• RIU switching flag • Used to flag whether both RIUs have or have not been used and therefore dissallow or allow an RIU switch as a result of FDC. (Either Acq. FDC or Normal FDC)
7	PFDCEP	ACQFD	• The previous value of the Acquisition mode earth presence failure state flag
8	FPITCH	ACQFDC	• ESA1 or 2 pitch failure state • Used in Acquisition mode FDC only • State definitions 0=No Failures 1=ESA1 pitch failure 2=ESA2 pitch failure 3=ESA1 and ESA2 pitch failures
9	FPCNT	ACQFDC	• ESA1 and ESA2 pitch failure state counter • Used in Acquisition mode only • Implements a 5 cycle delay before FDC action is taken
10	PFPITCH	ACQFDC	• Past value of FPITCH
11	FROLL	ACQFDLL	• ESA1 and 2 roll failure state flag • Used in Acquisition mode only • State definition

Entry Number	Name	Generating Subroutine	Description/Comment
			0=No failure 1=ESA1 roll failure 2=ESA2 roll failure 3=ESA1 and 2 roll failure
12	FRCNT	ACQFDLL	o ESA1 and ESA2 roll failure state counter o Used in Acquisition mode only o Implements a 5 cycle delay before FDC action is taken
13	PFROLL2	ACQFDLL	o Past value of FROLL
14	ACQFD1	ACQFDP	o Acquisition FDC yaw initialization flag o Used to reset the gyro flag IGYZ=1 to use the Y2 gyro o Set to 0 by ground initialization then reset to 1 on the first module execution
15	WGXK1	NORMFD	o Roll rate failure counter o Used in the Normal mode yaw FDC to implement a 5 cycle delay before any FDC action is taken.
16	WGZK1	ACQFDS	o Yaw rate failure counter o Used in the acquisition mode yaw FDC to implement a 5 cycle delay before any FDC action is taken
17	SWTCH1M	MODEFD	o Past history of SWTCH1 o Used in the mode switching logic for mode=1 or 2 to determine if IRUs or TAM 5 have ever been used
18	MODE2CM	MODEFD	0 Past history of MODE2C o Used in the mode switching logic for mode=1 or 2 to determine if MODE2C has ever been set to 1

Entry Number	Name	Generating Subroutine	Description/Comment
19 20	FDCNT(1) FDCNT(2)	NORMFD	• Normal mode FDC pitch/roll failure state counter. (1=Pitch/2=Roll) • FDCNT(1) or (2) implements a 5 cycle delay before any FDC action is taken
21 22	PFSTATE(1) PFSTATE(2)	NORMFD	• Past value of FSTATE(1), FSTATE(2)
23	CTR120	SKEWFD	• SKEW wheel FDC 120 second counter • When IW4 is commanded from 0 (3 wheel controller) to 1 (4 wheel controller) CTR120 counts from 1 to 8 to implement a 120 second delay before the skew wheel test is preferred. This is to allow the skew wheel to reach its commanded speed.
24	SKOUTCNT	SKEWFD	• Skew wheel FDC failure counter • SKOUTCNT implements the requirement that the skew wheel test fail 3 successive times before any FDC action is taken

B.3.12.6 Attitude Control (ACS) Flow Charts

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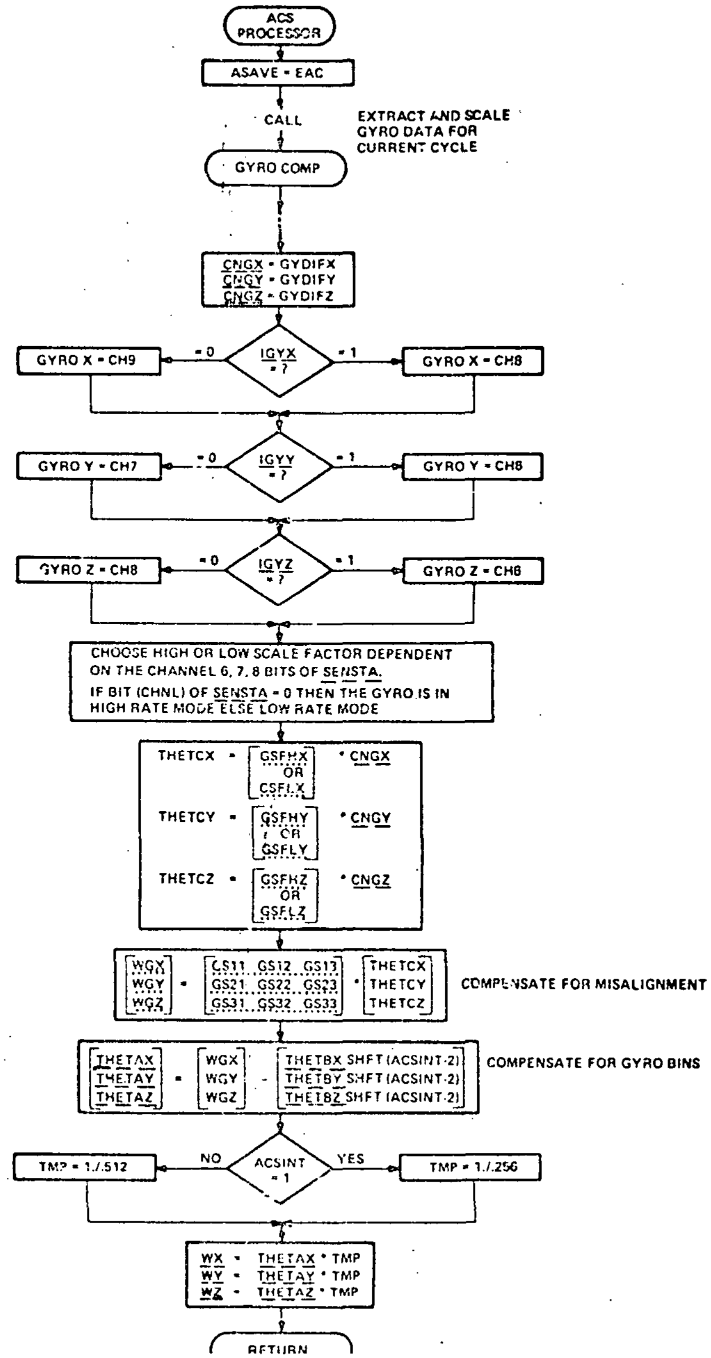

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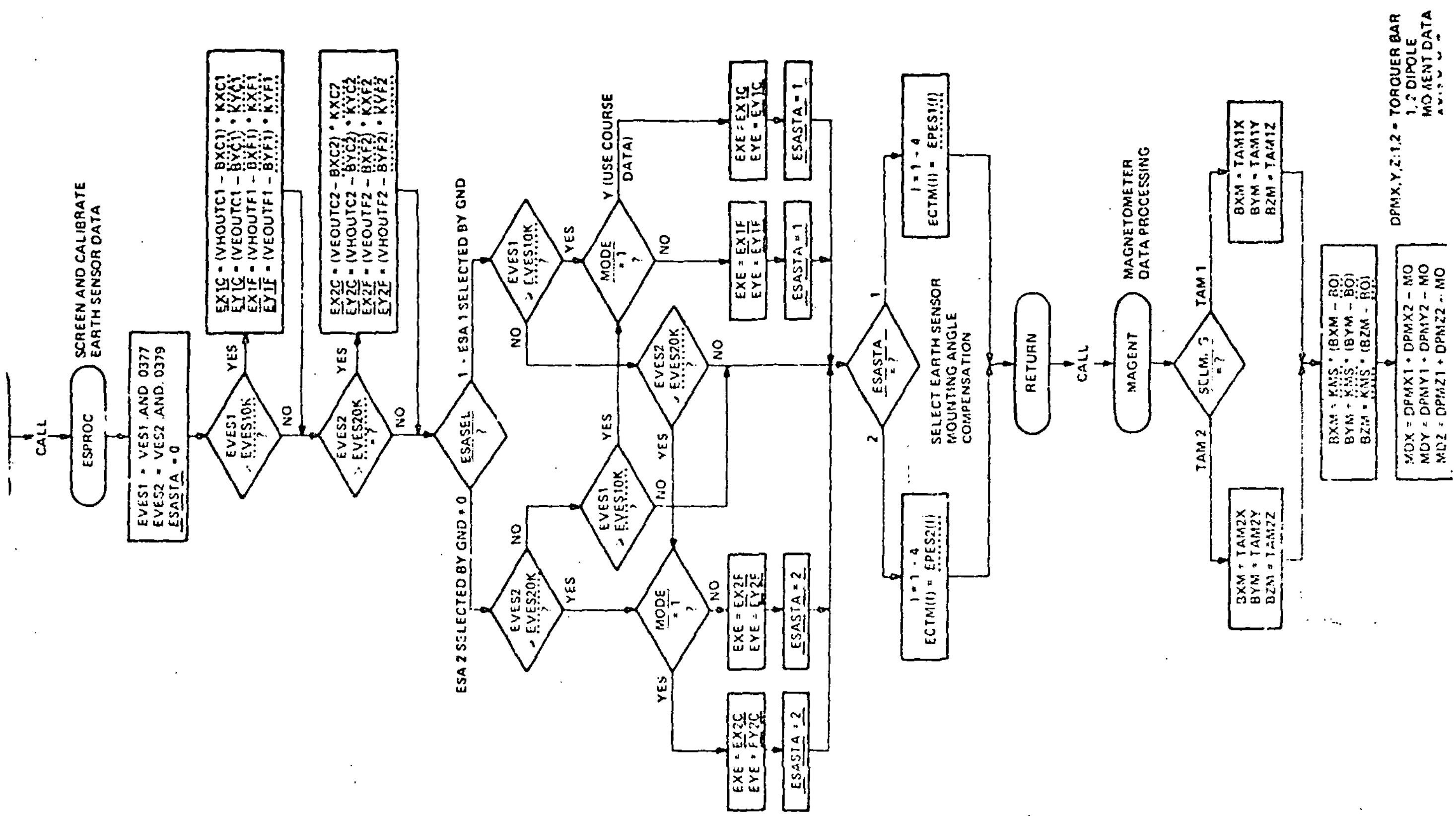

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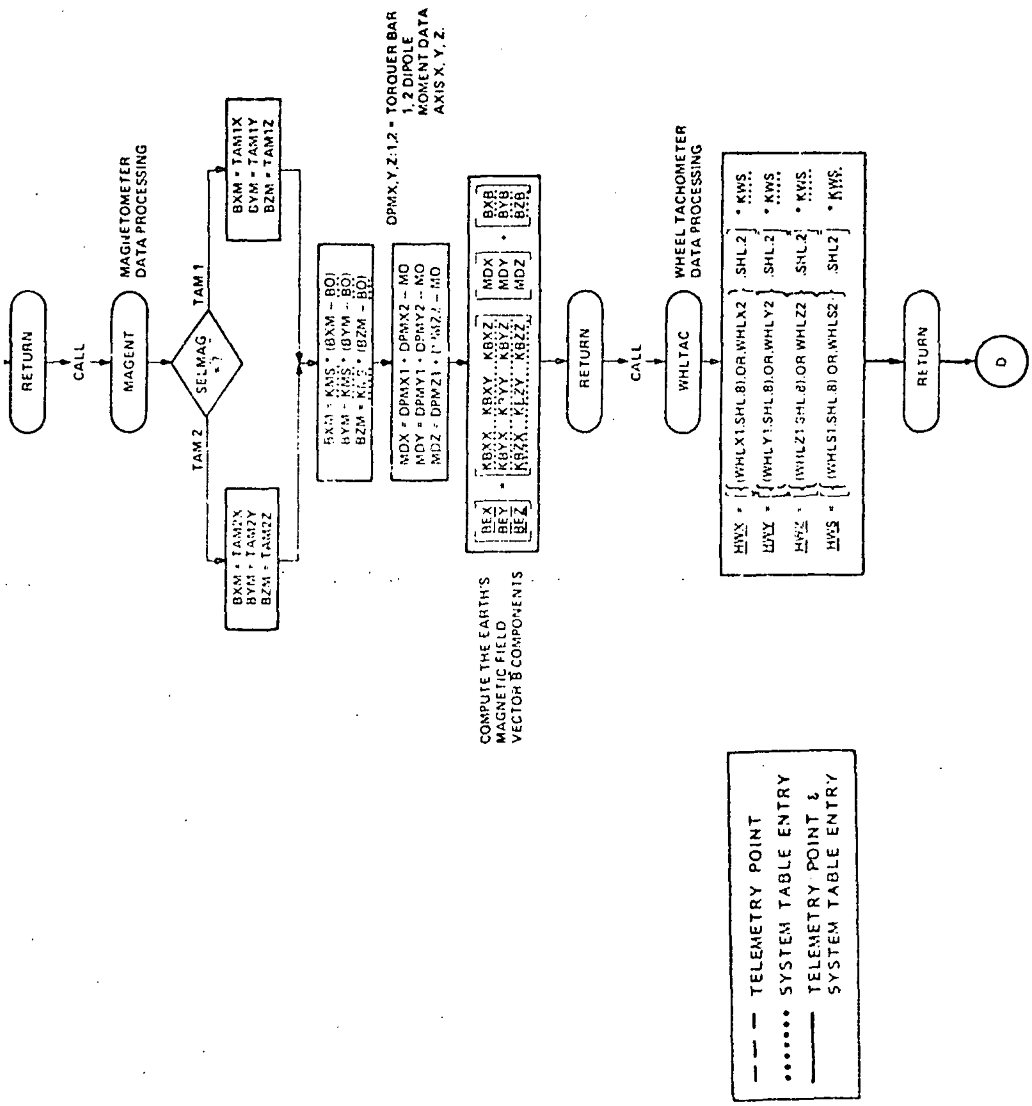

Figure B.3.12-8. ACS Processor Flow Chart

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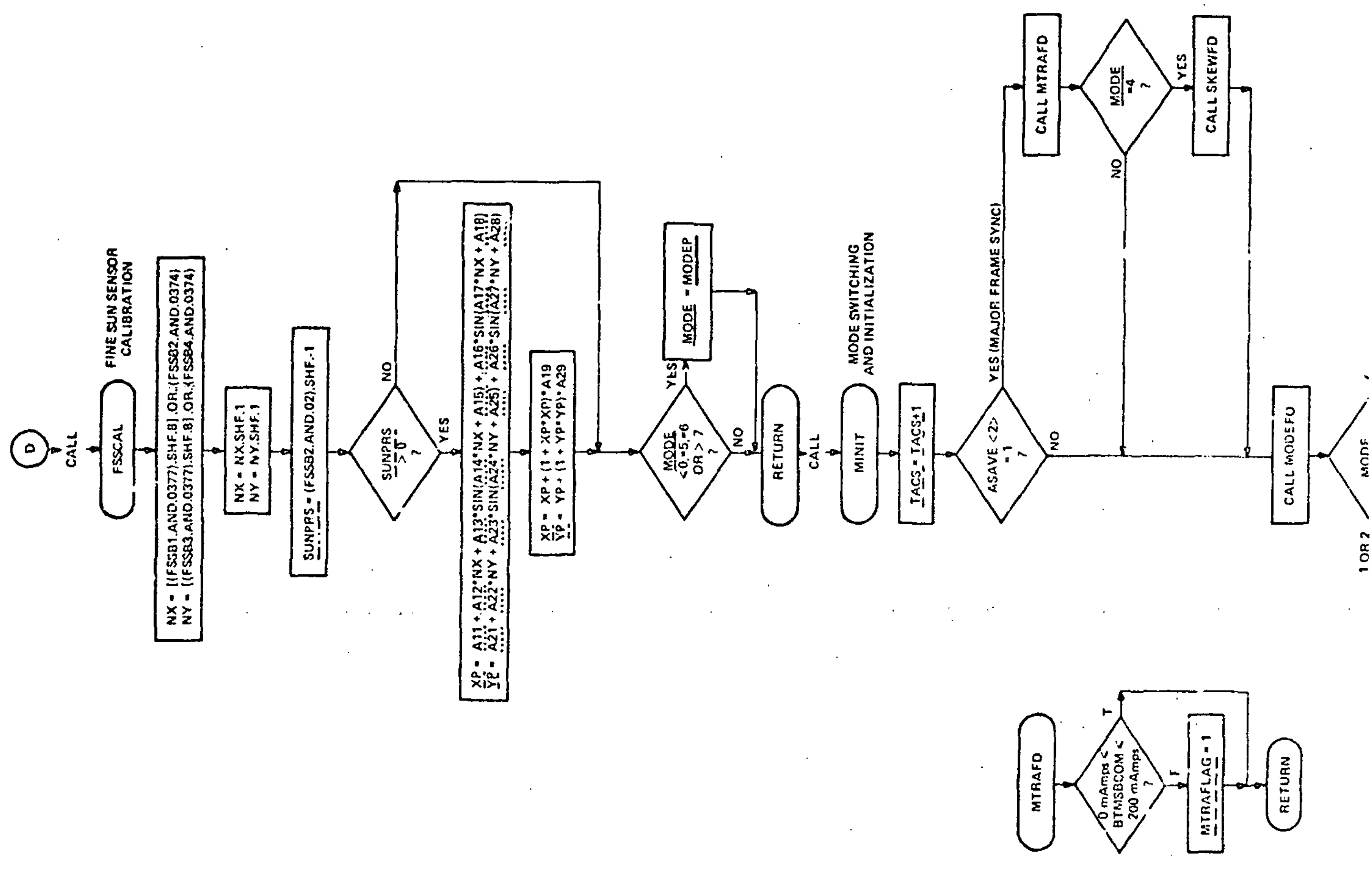

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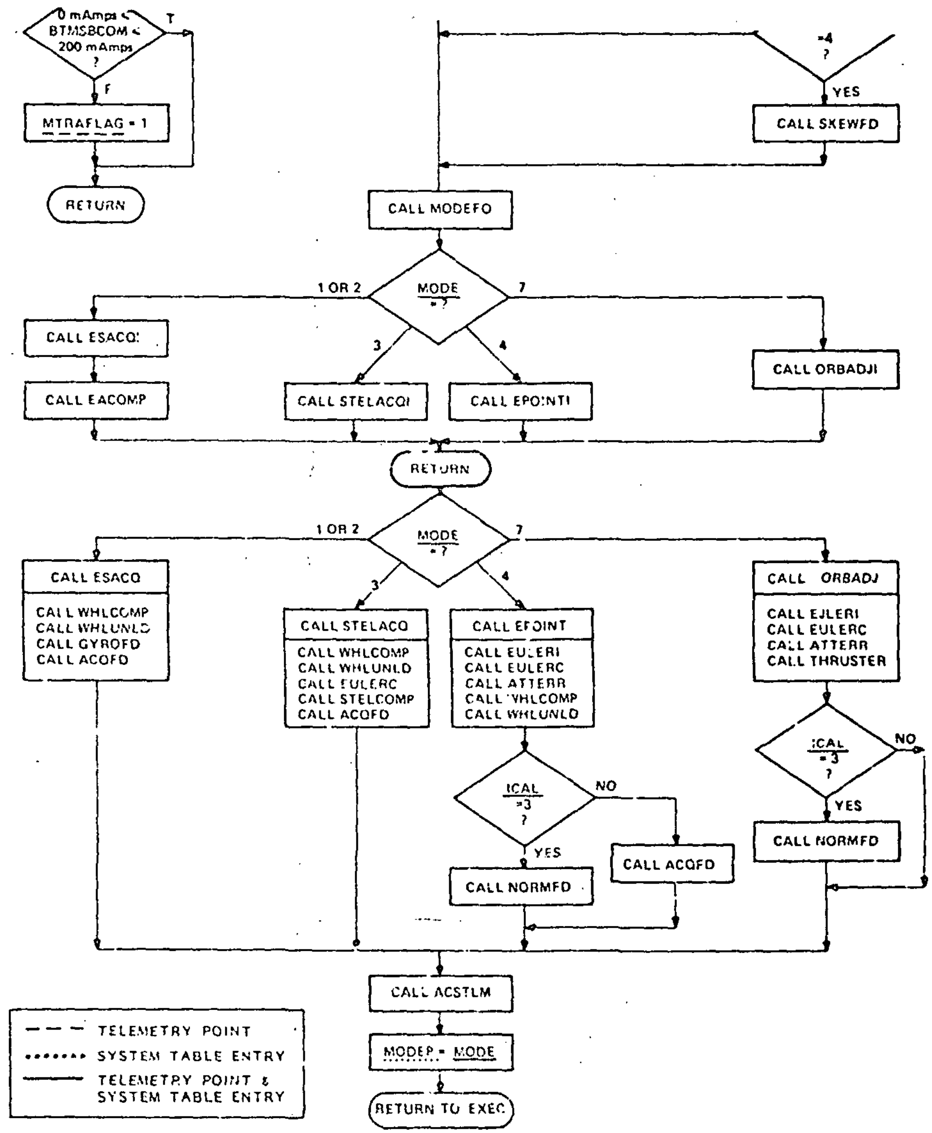

FIGURE B.3.12-8 ACS Processor Flow Chart (continued)

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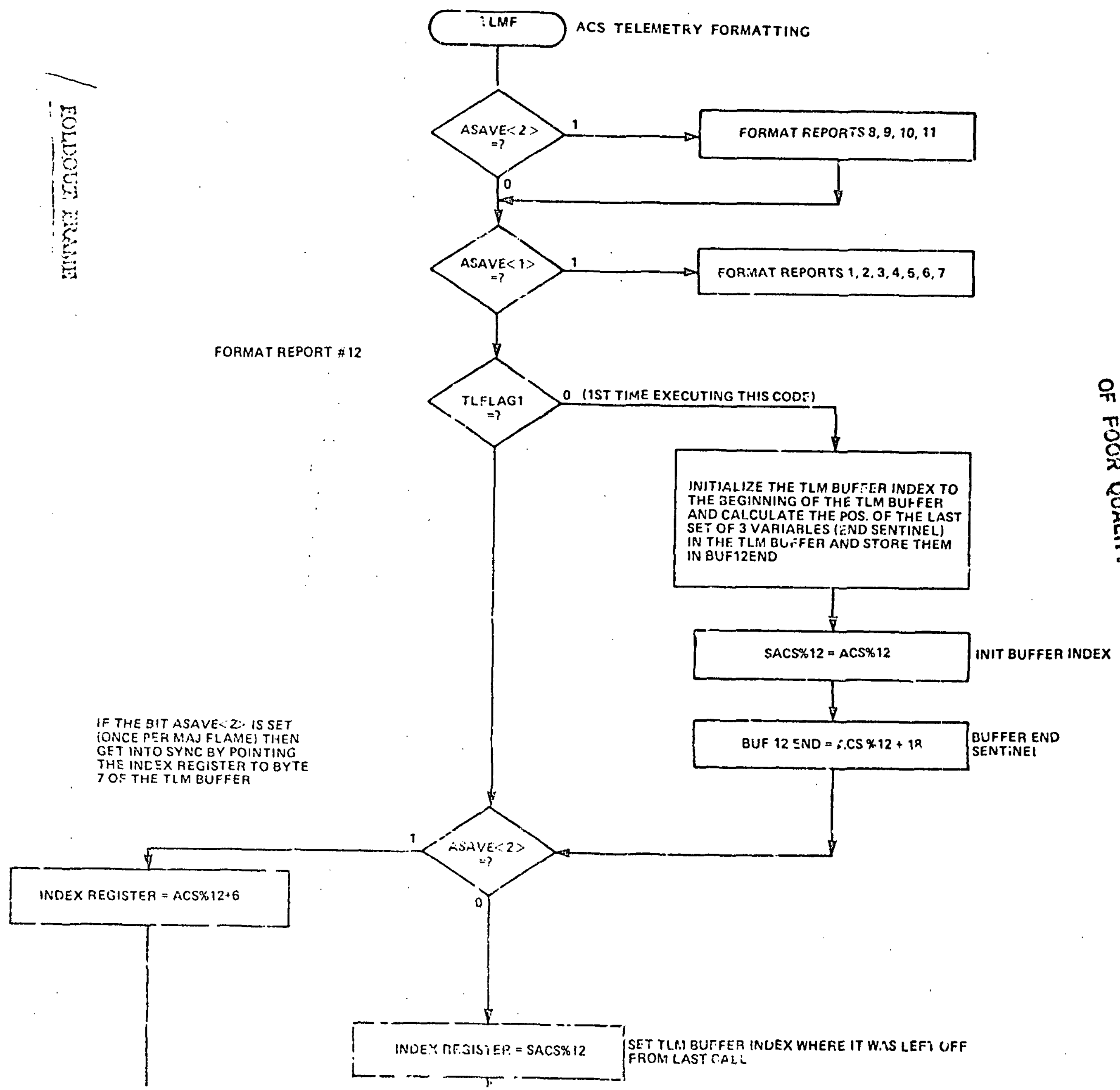

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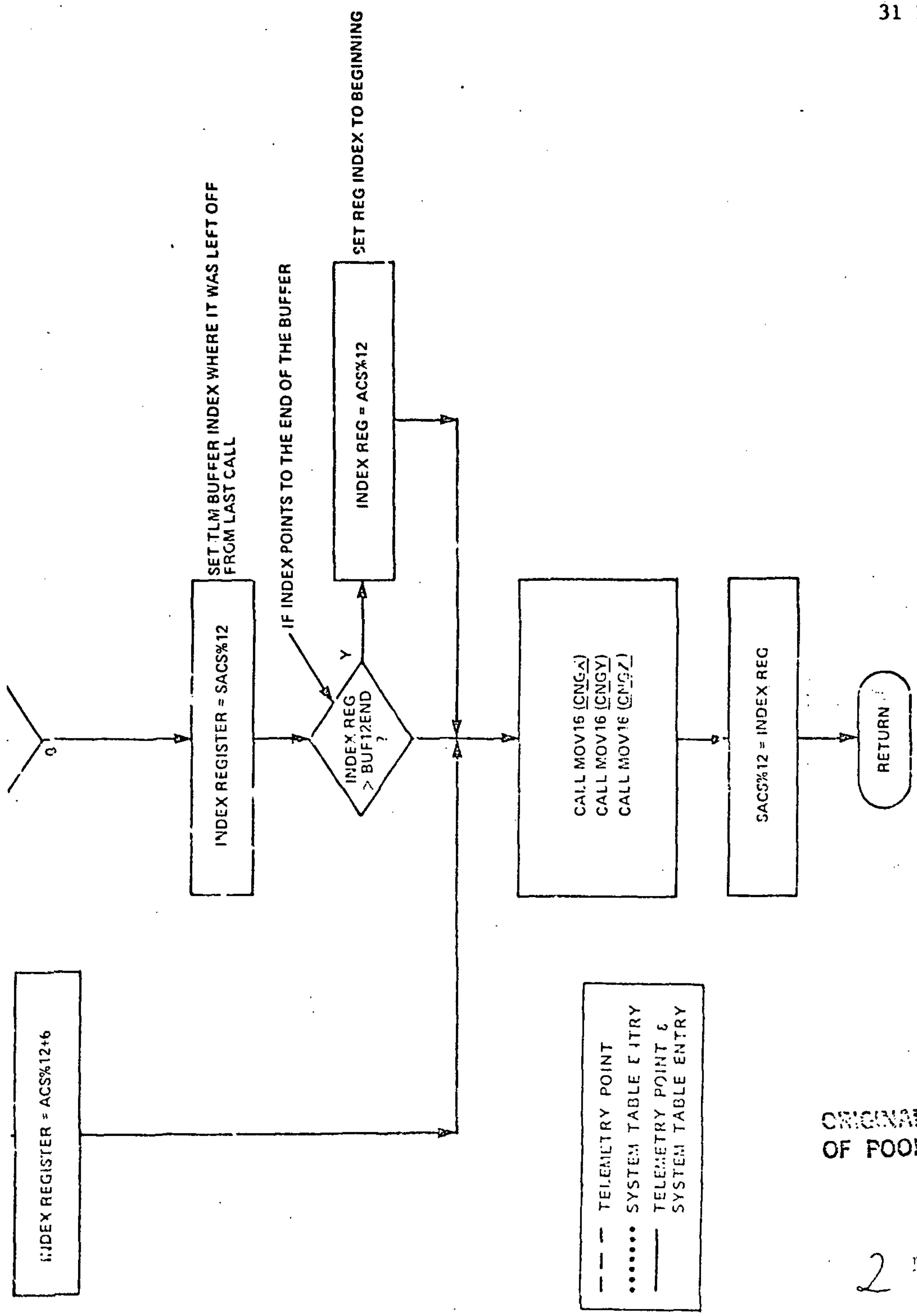

Figure B.3.12-9. ACSTLM Flow Chart

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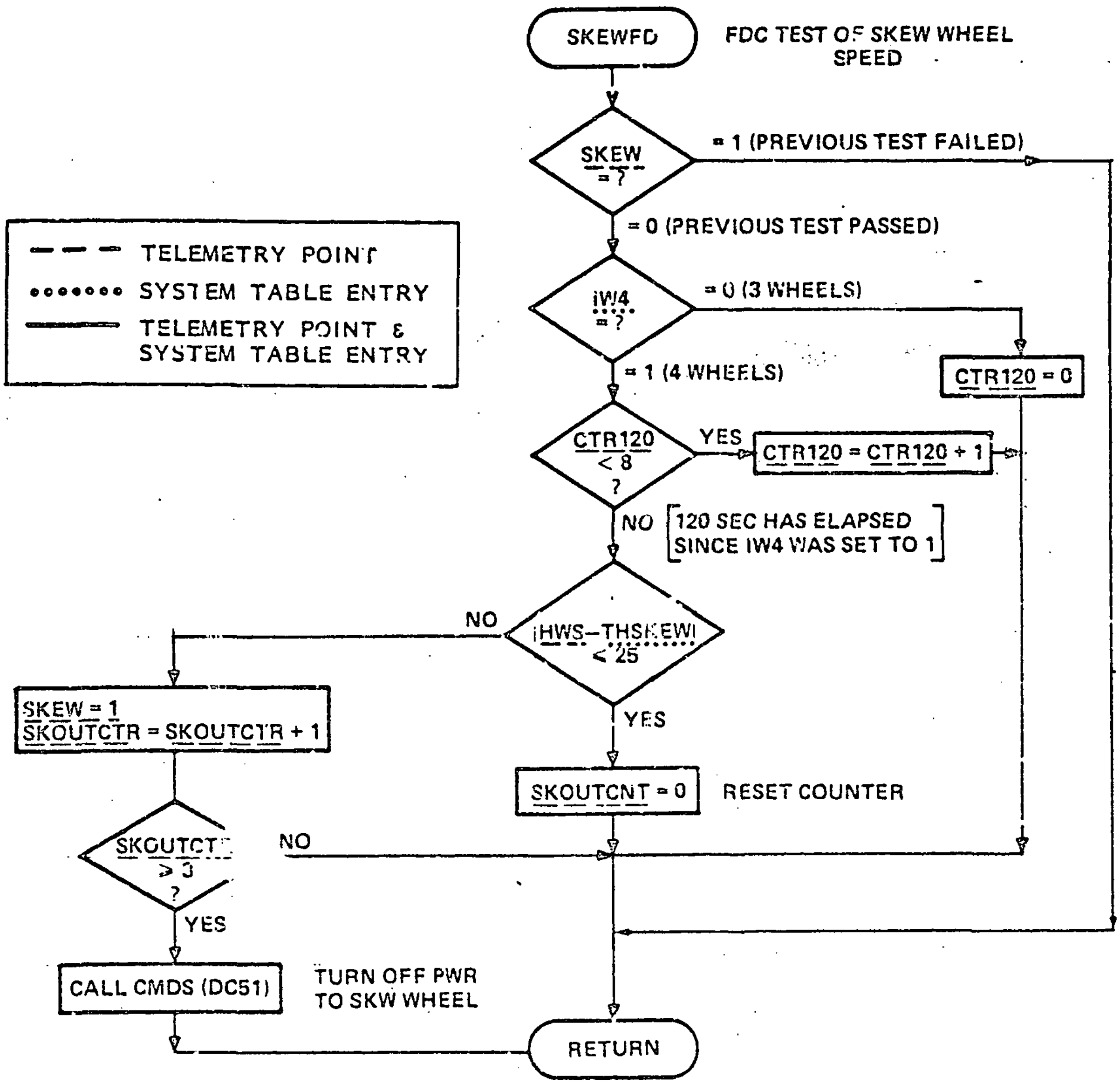

Figure B.3.12-10. SKEWFD Flow Chart

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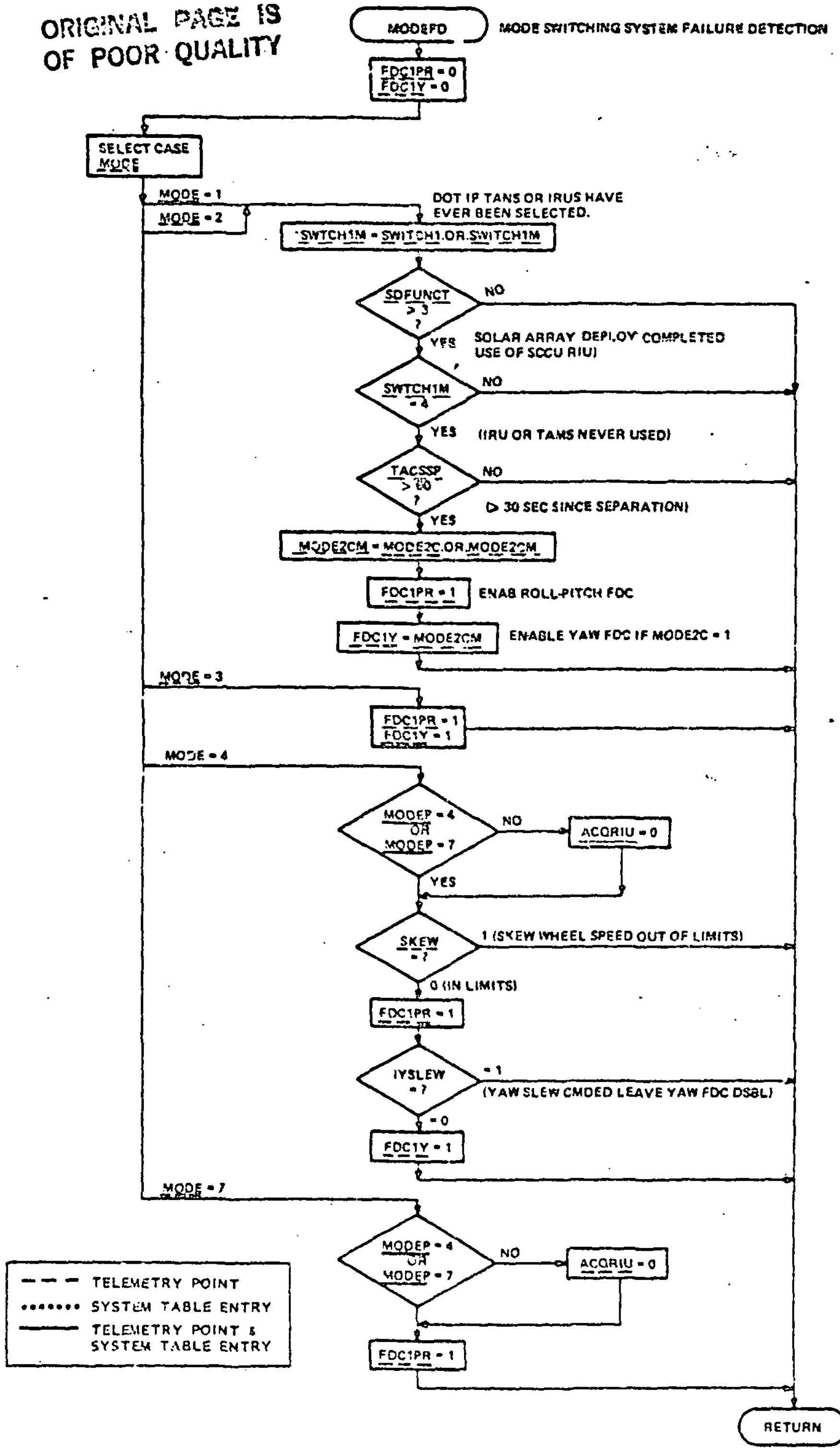

Figure B.3.12-11. MODEFD Flow Chart

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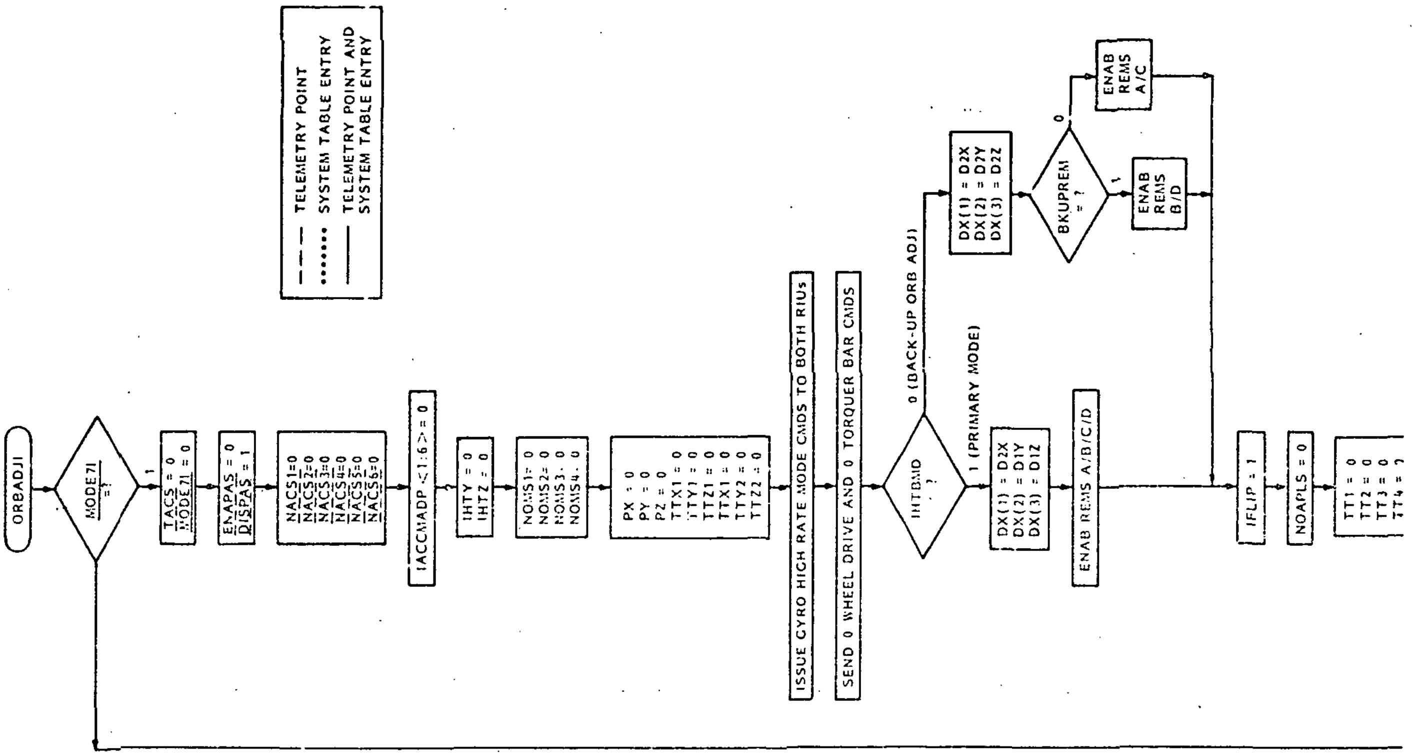

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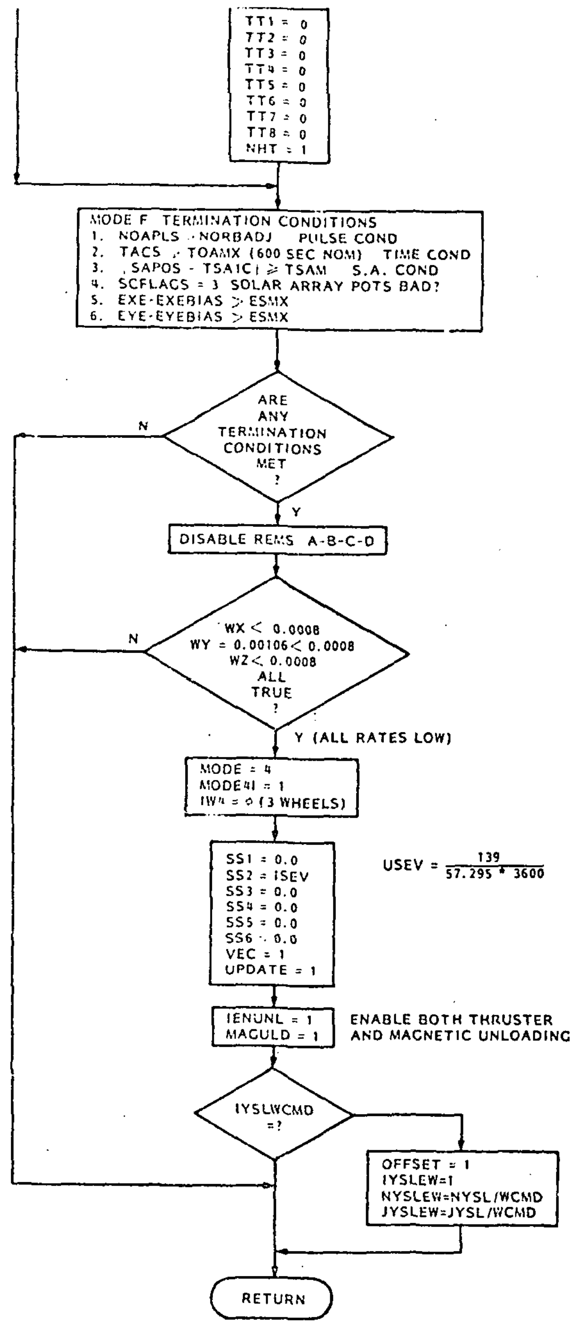

Figure B.3.12-12. ORBADJI Flow Chart

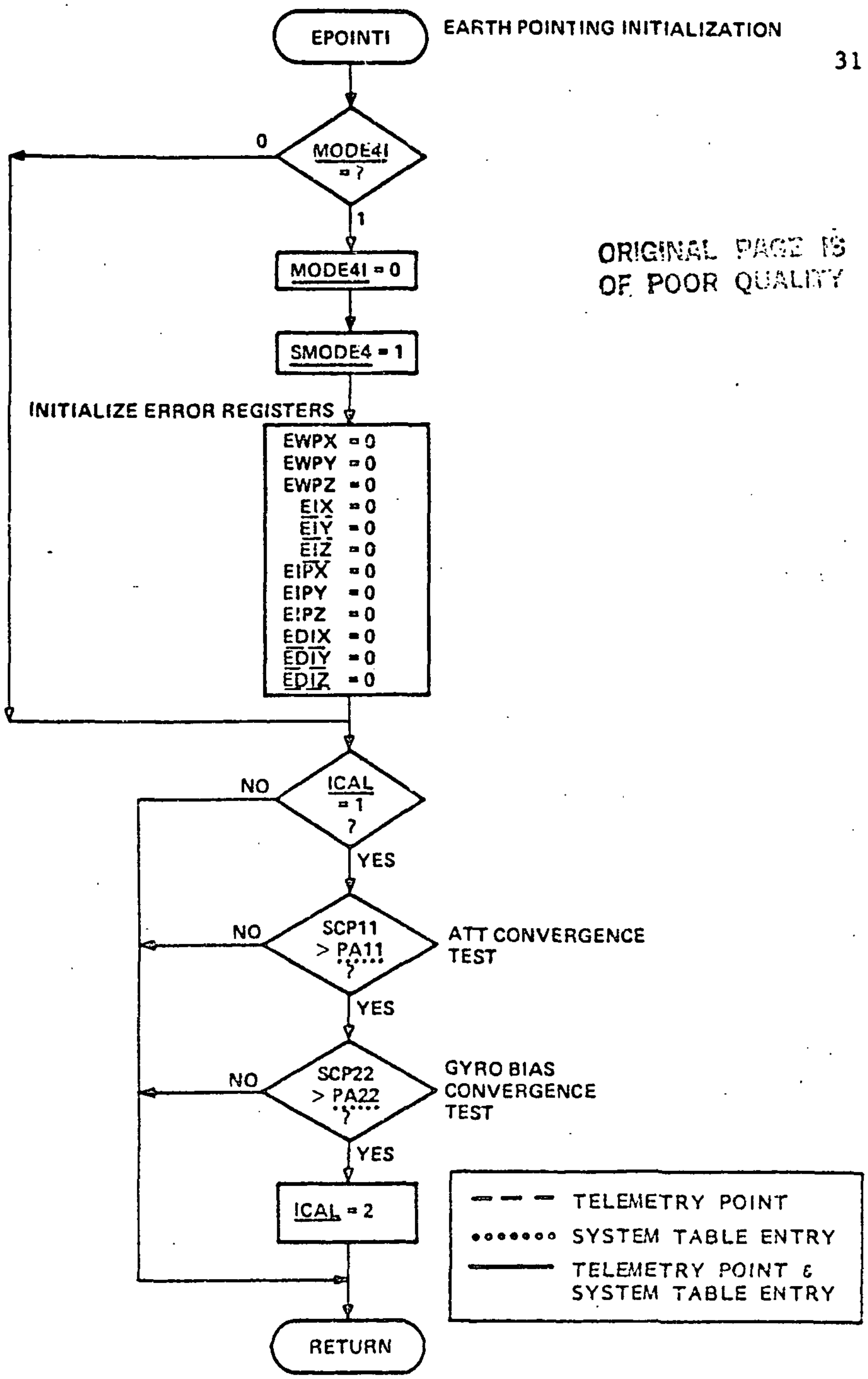

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Figure B.3.12-13. EPOINTI Flow Chart

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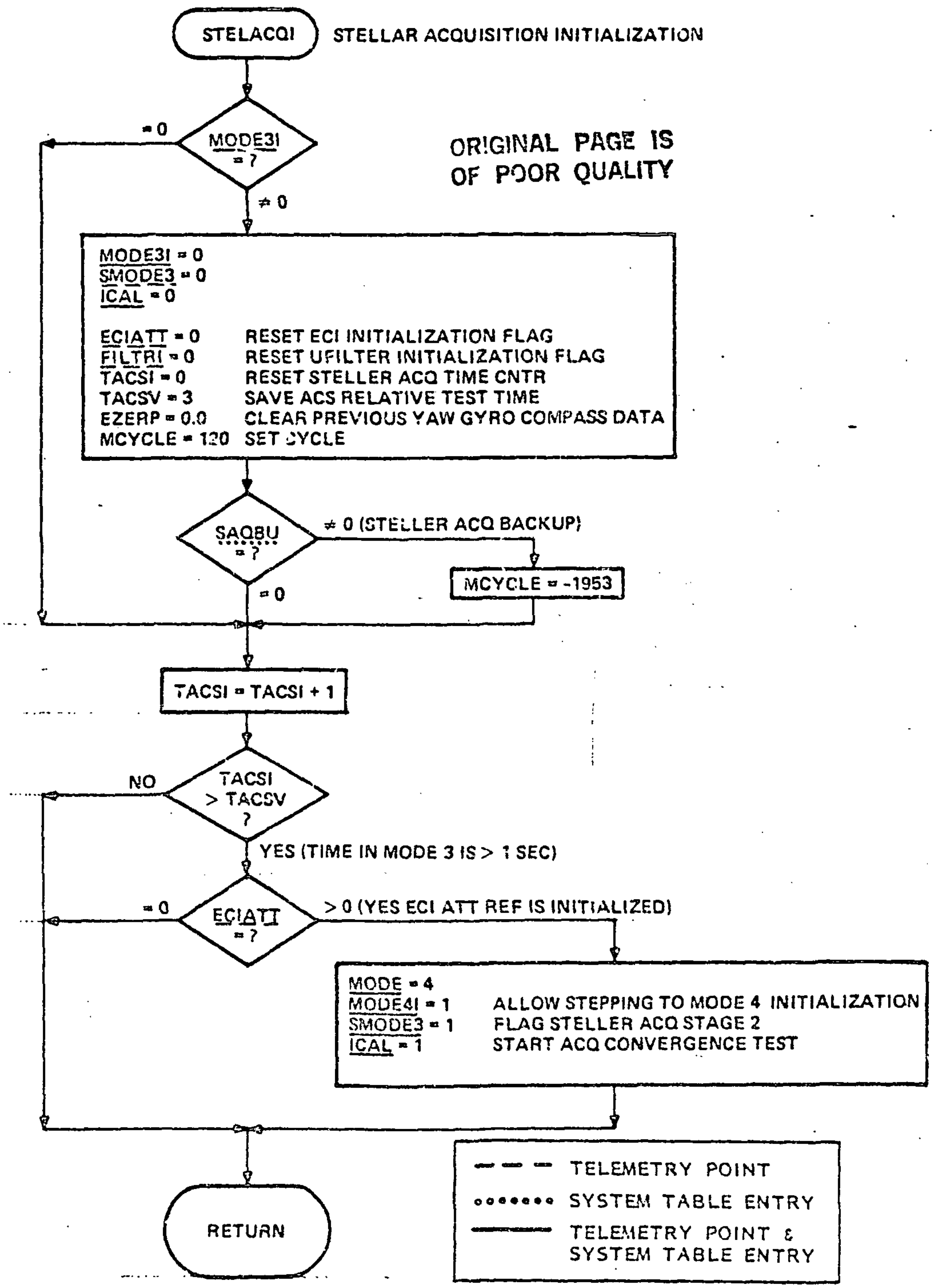

Figure B.3.12-14. STELACQI Flow Chart

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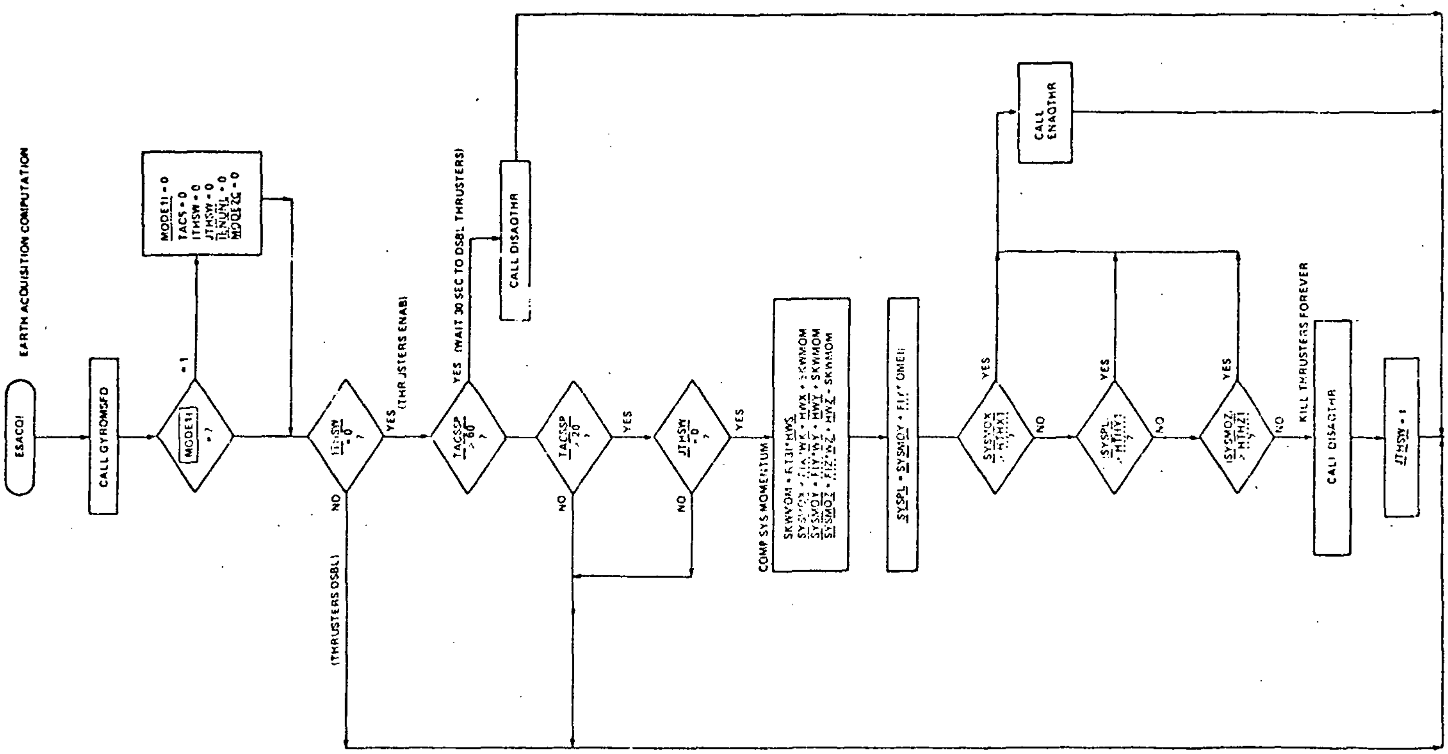

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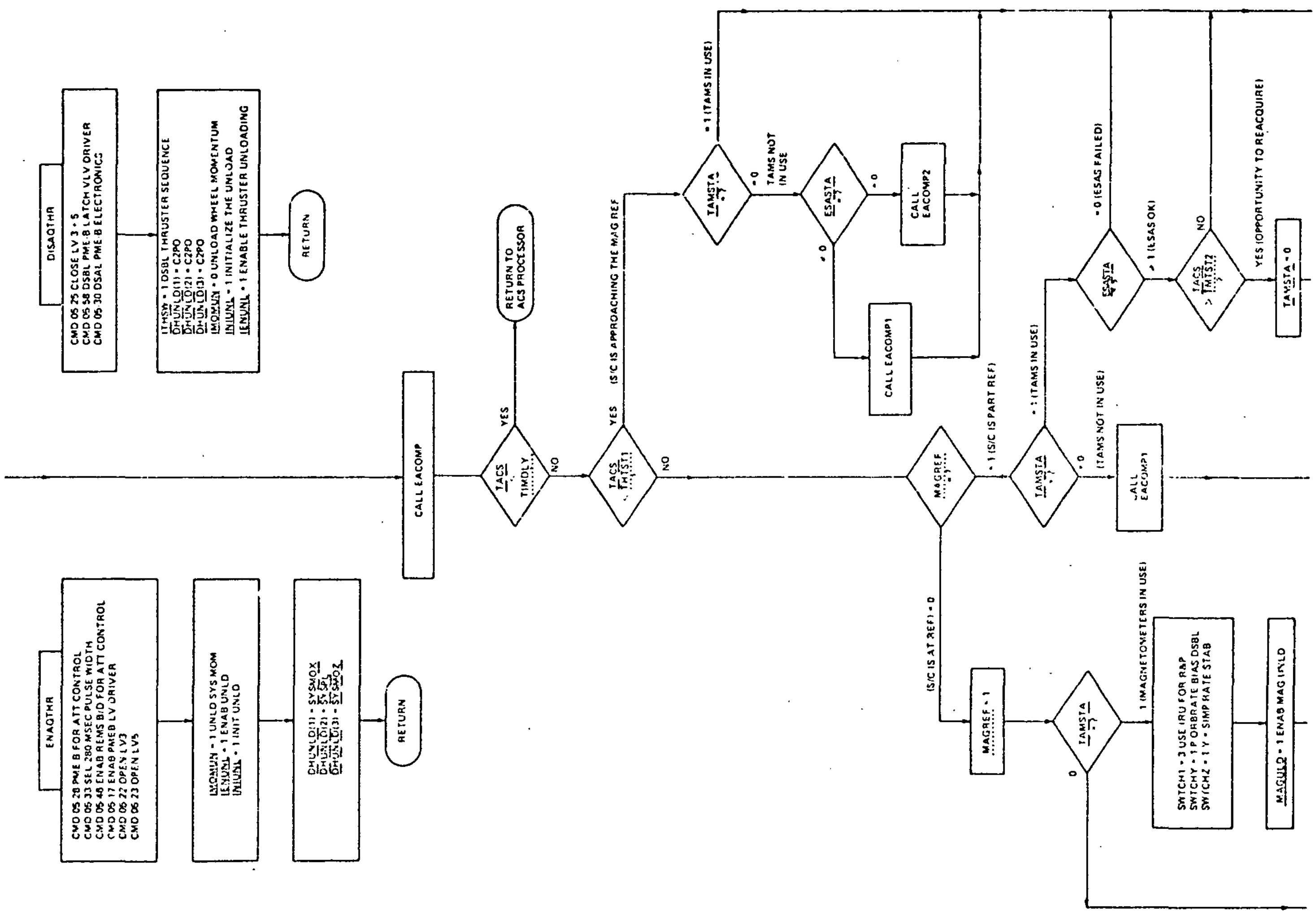

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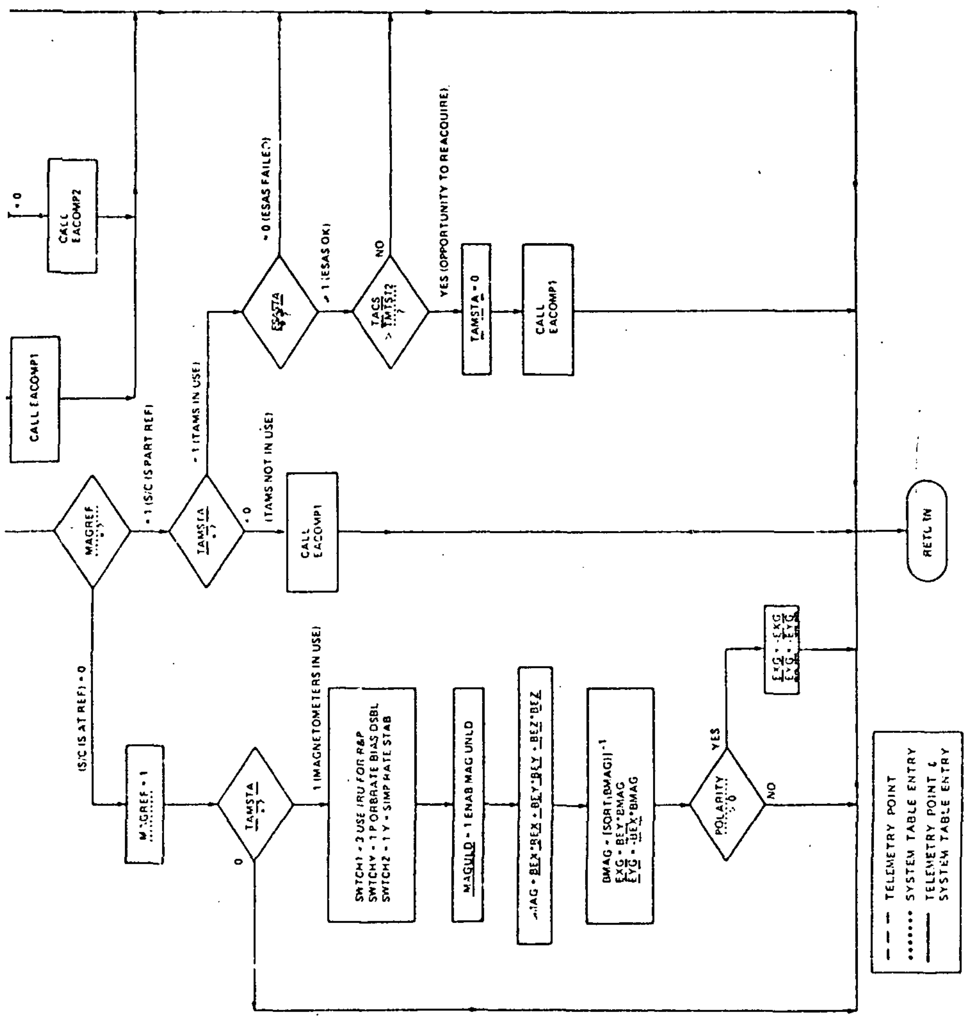

Figure B.3.12-15. ESACQI Flow Chart

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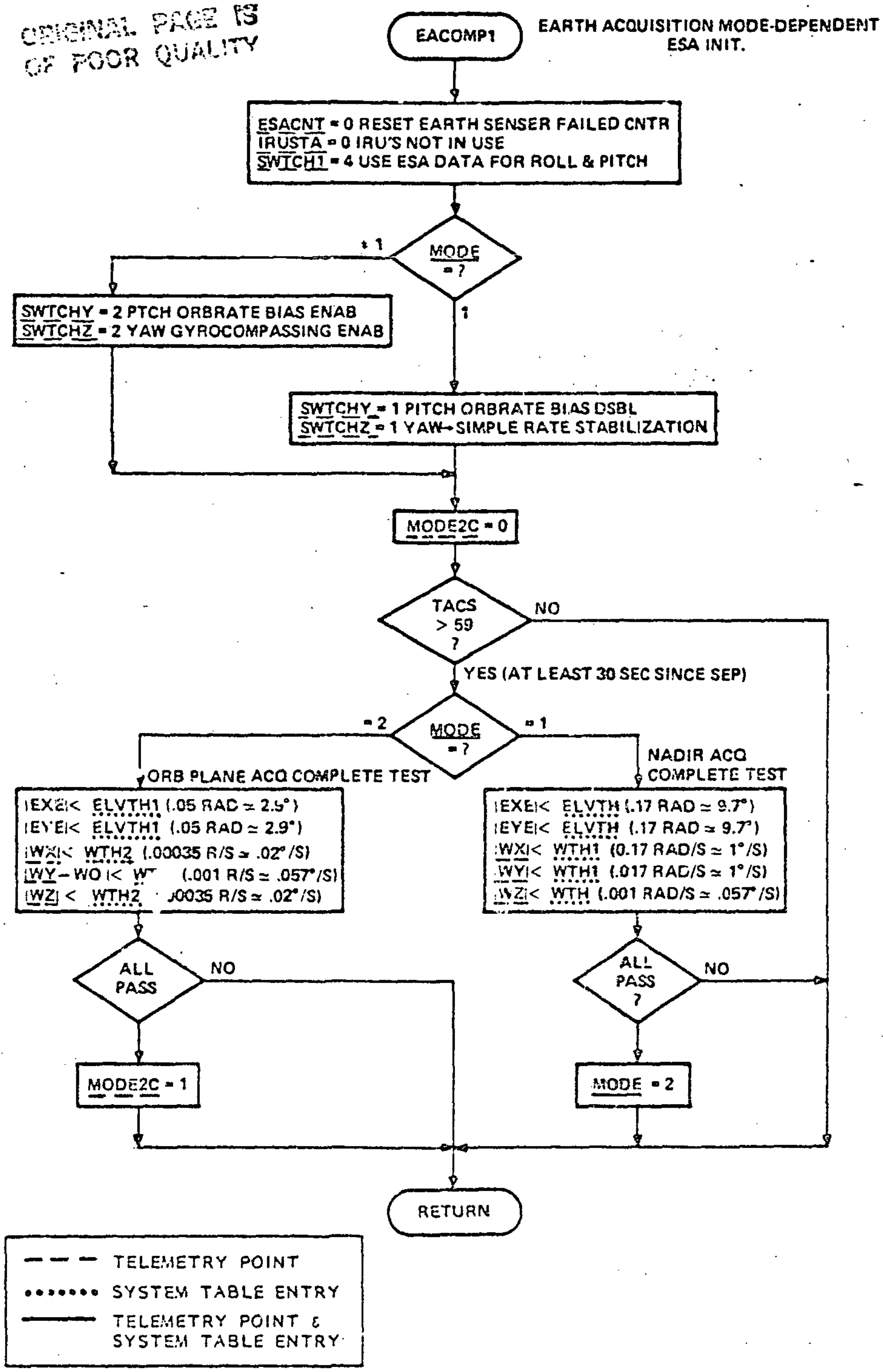

Figure B.3.12-16. EACOMP1 Flow Chart

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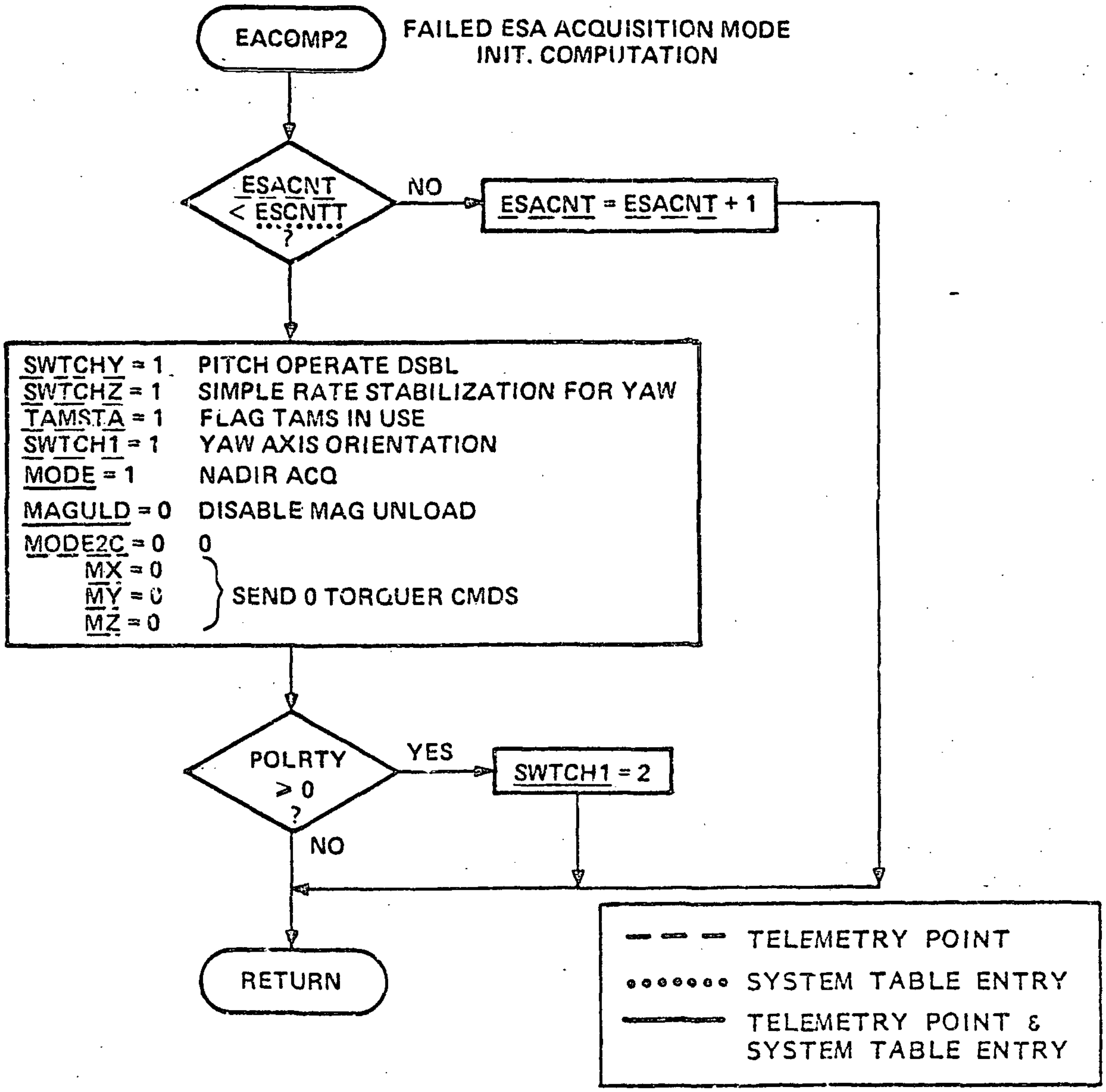
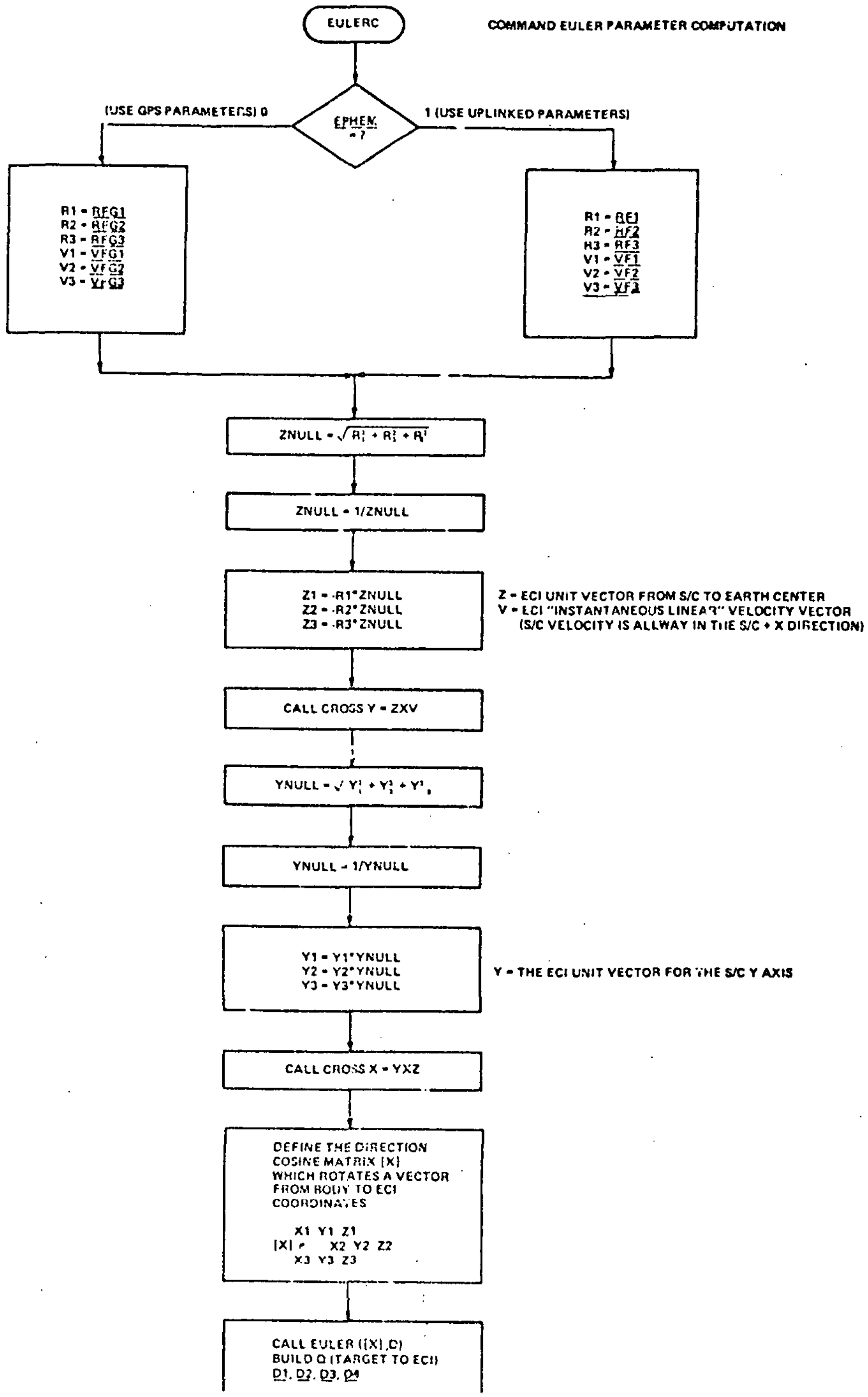


Figure B.3.12-17. EACOMP2 Flow Chart



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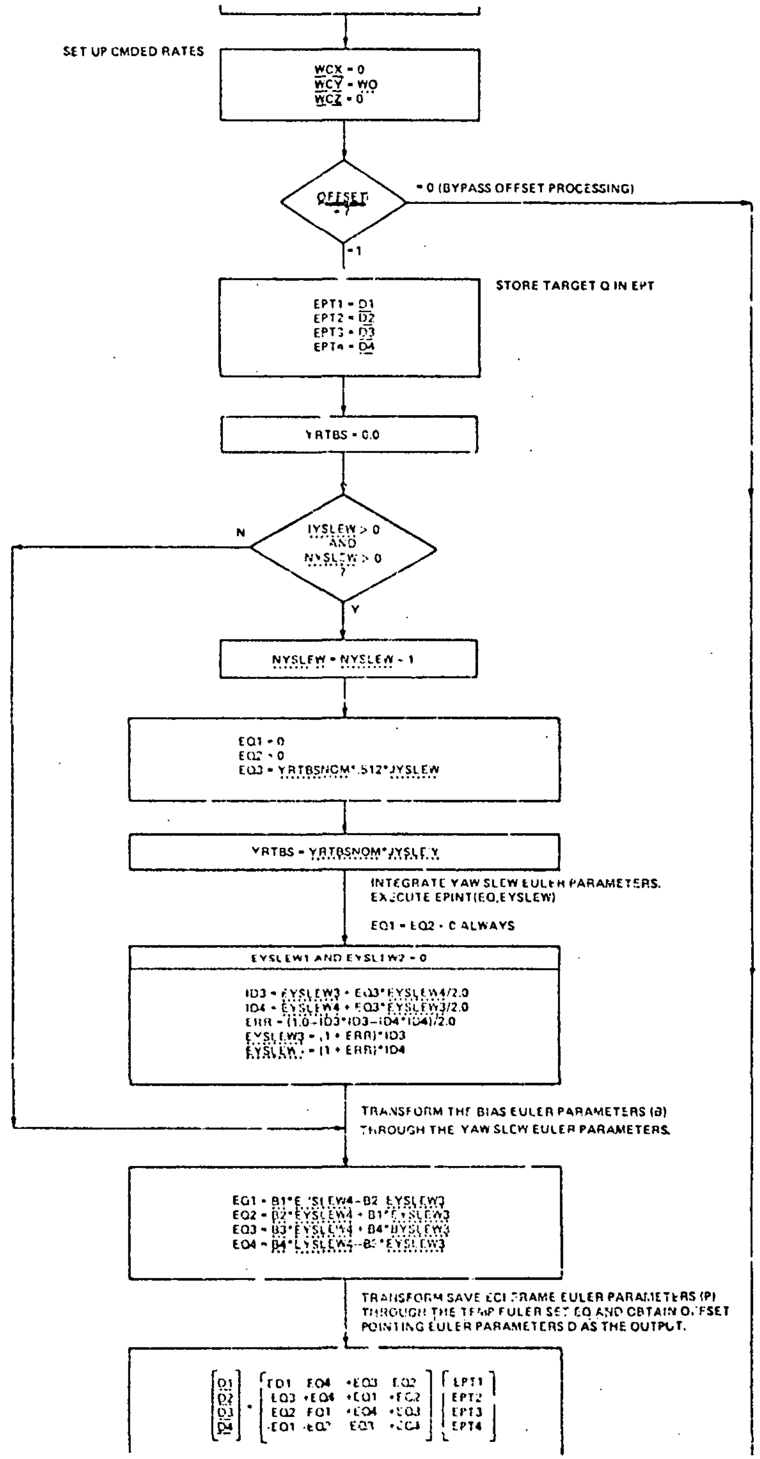

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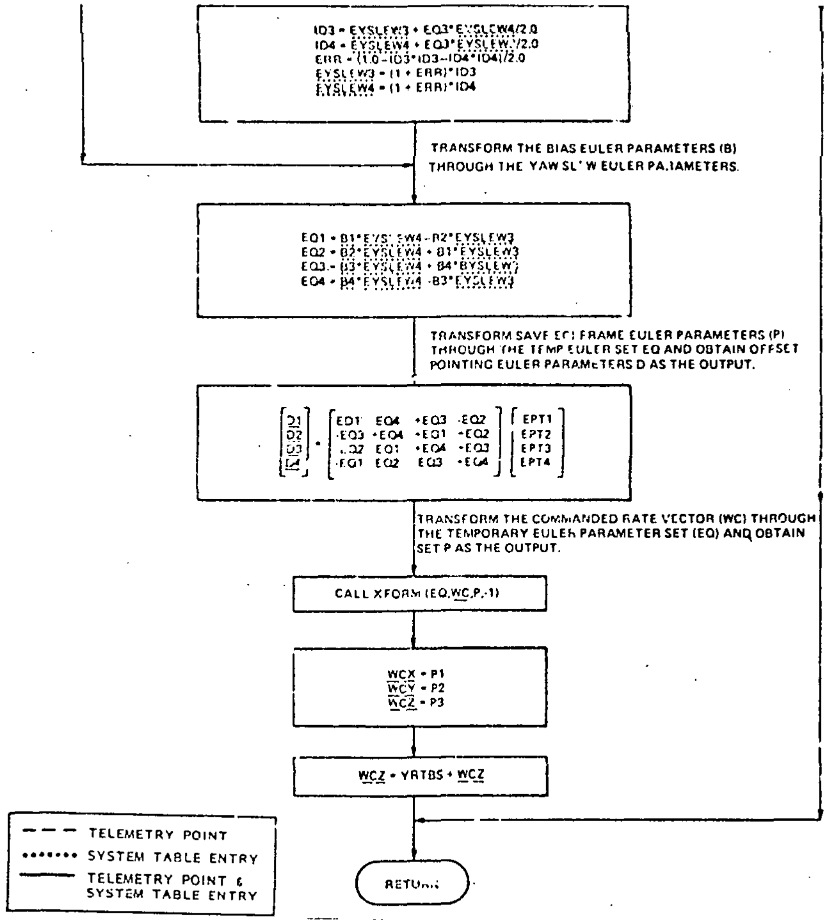

Figure B.3.12-18. EULERC Flow Chart

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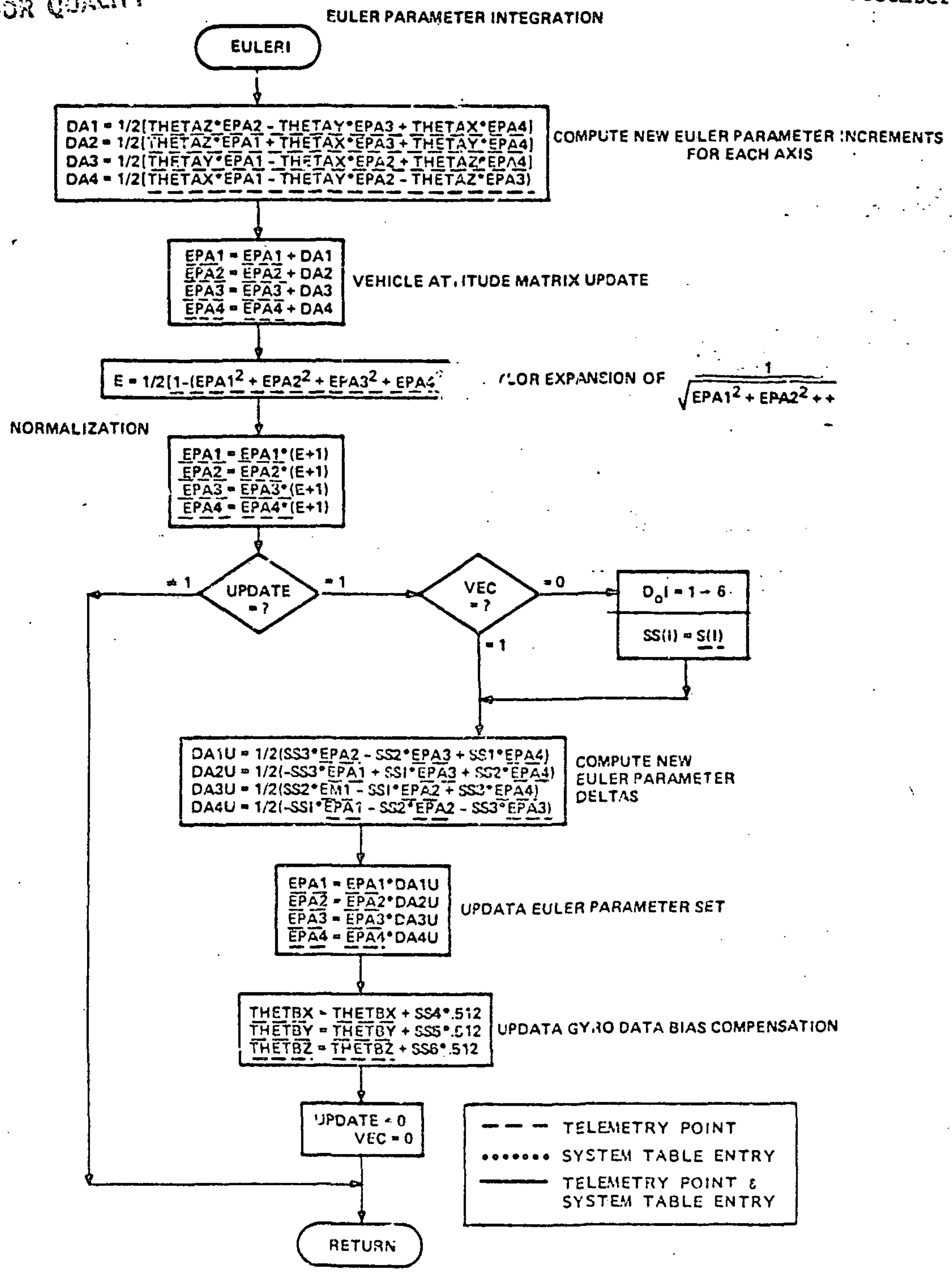

Figure B.3.12-19. EULER I Flow Chart

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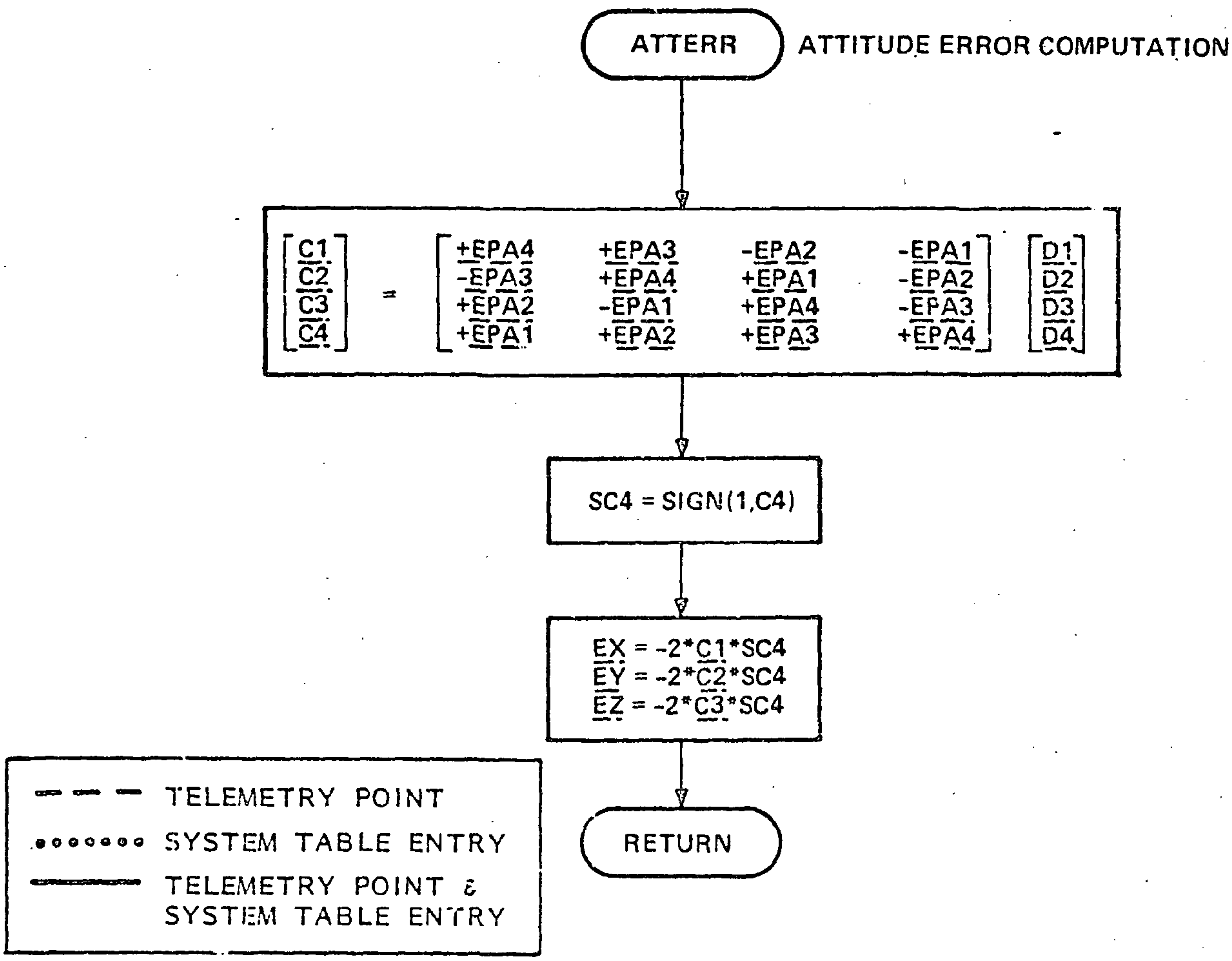
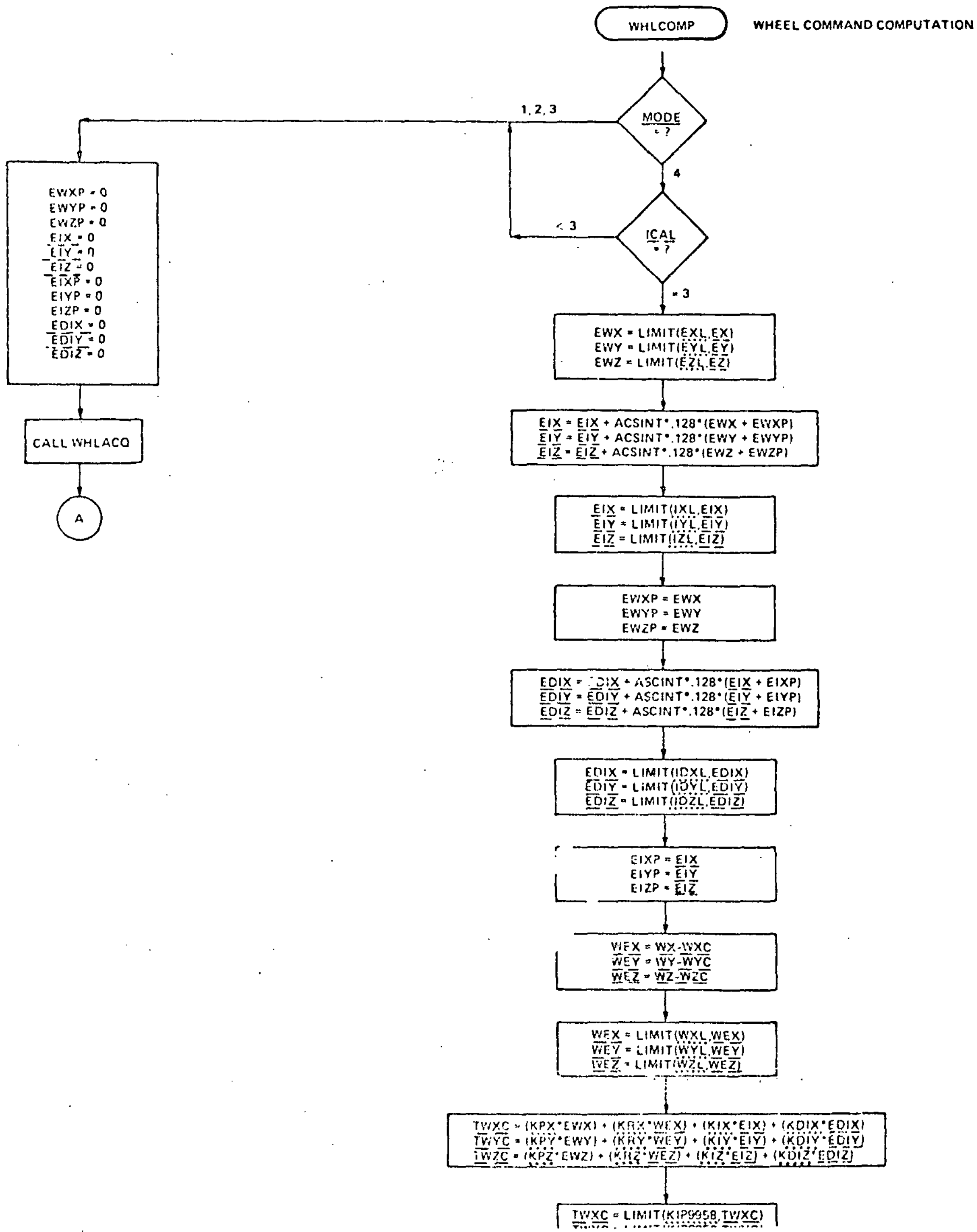


Figure B.3.12-20. ATTERR Flow Chart



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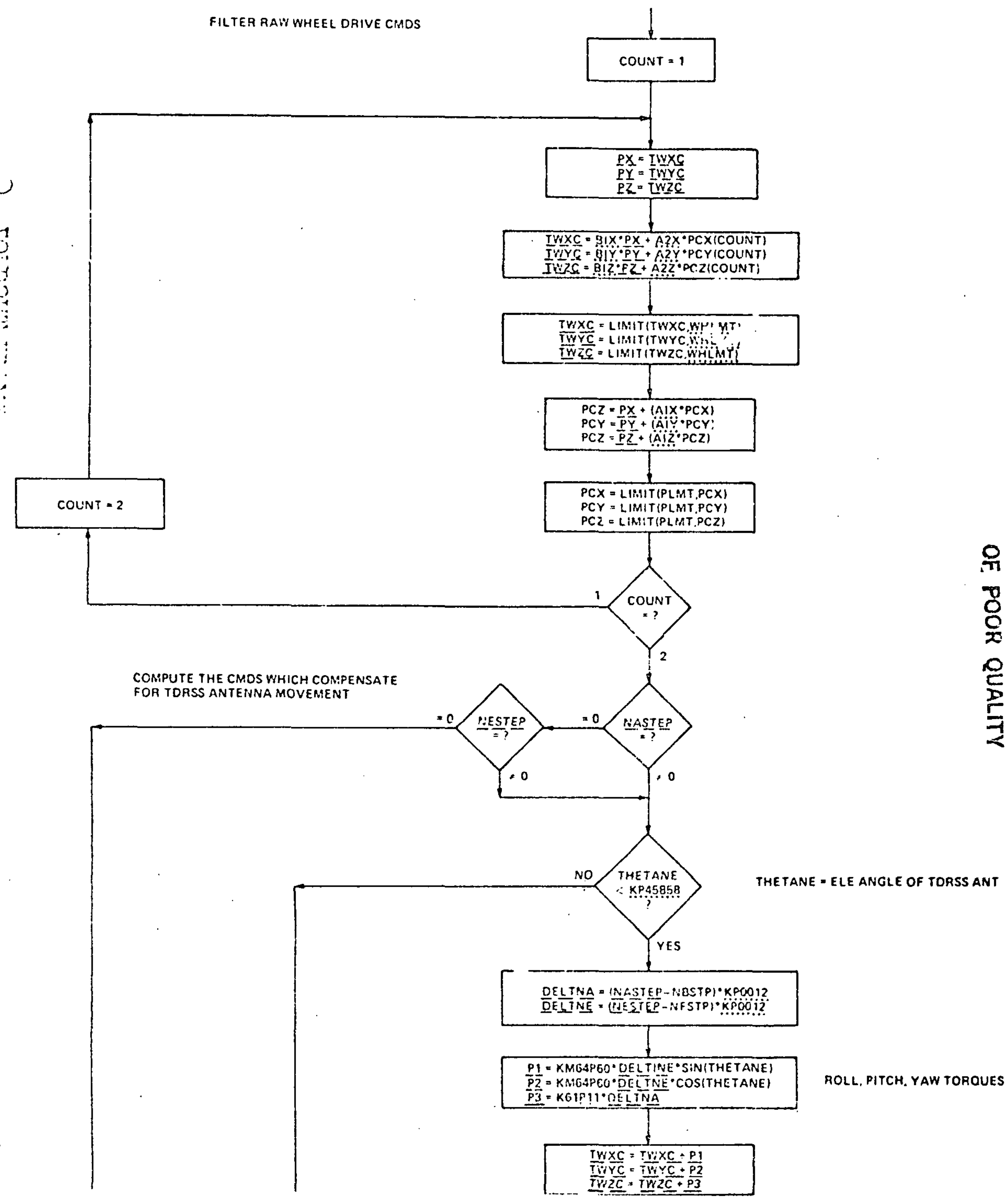

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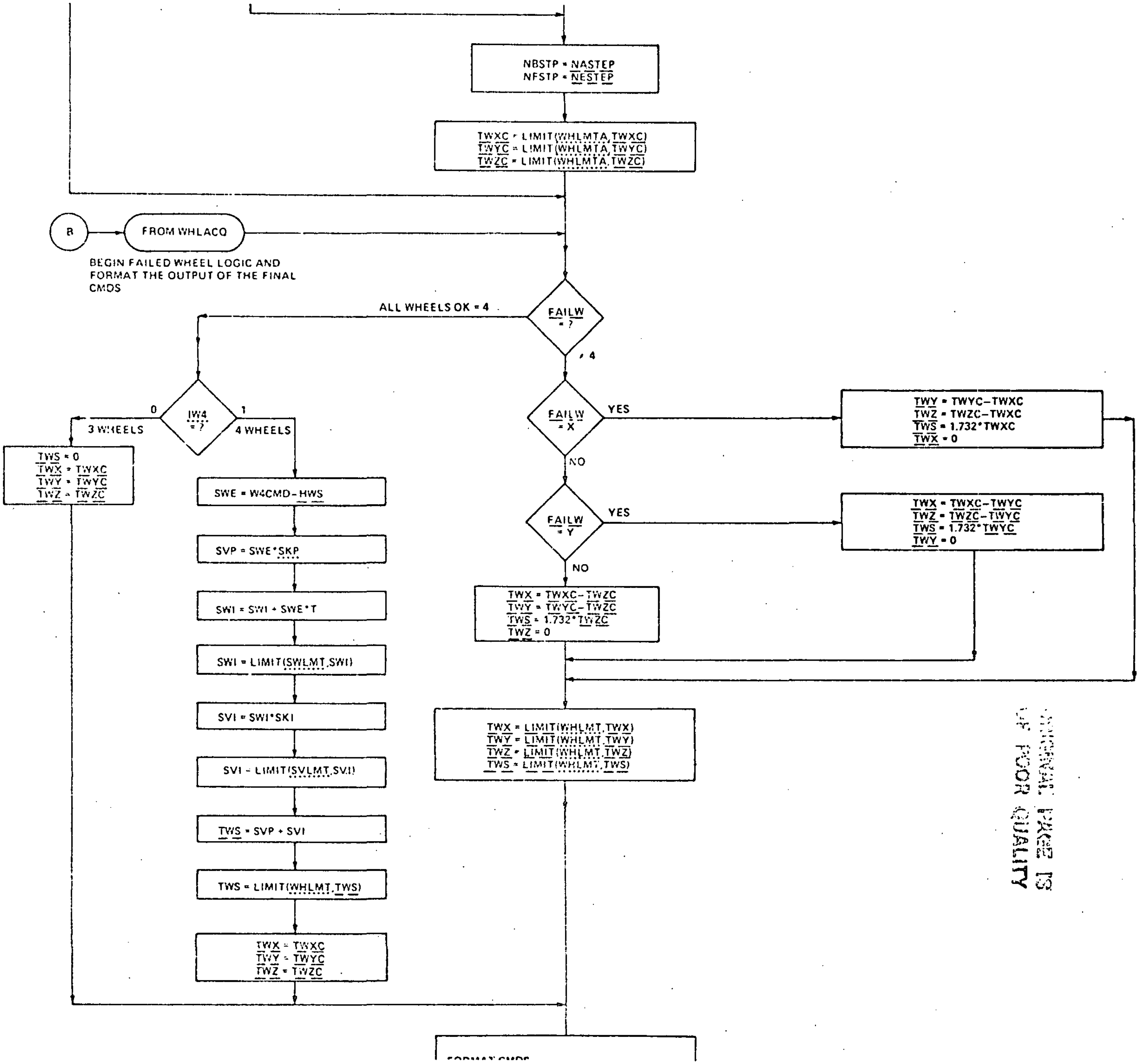

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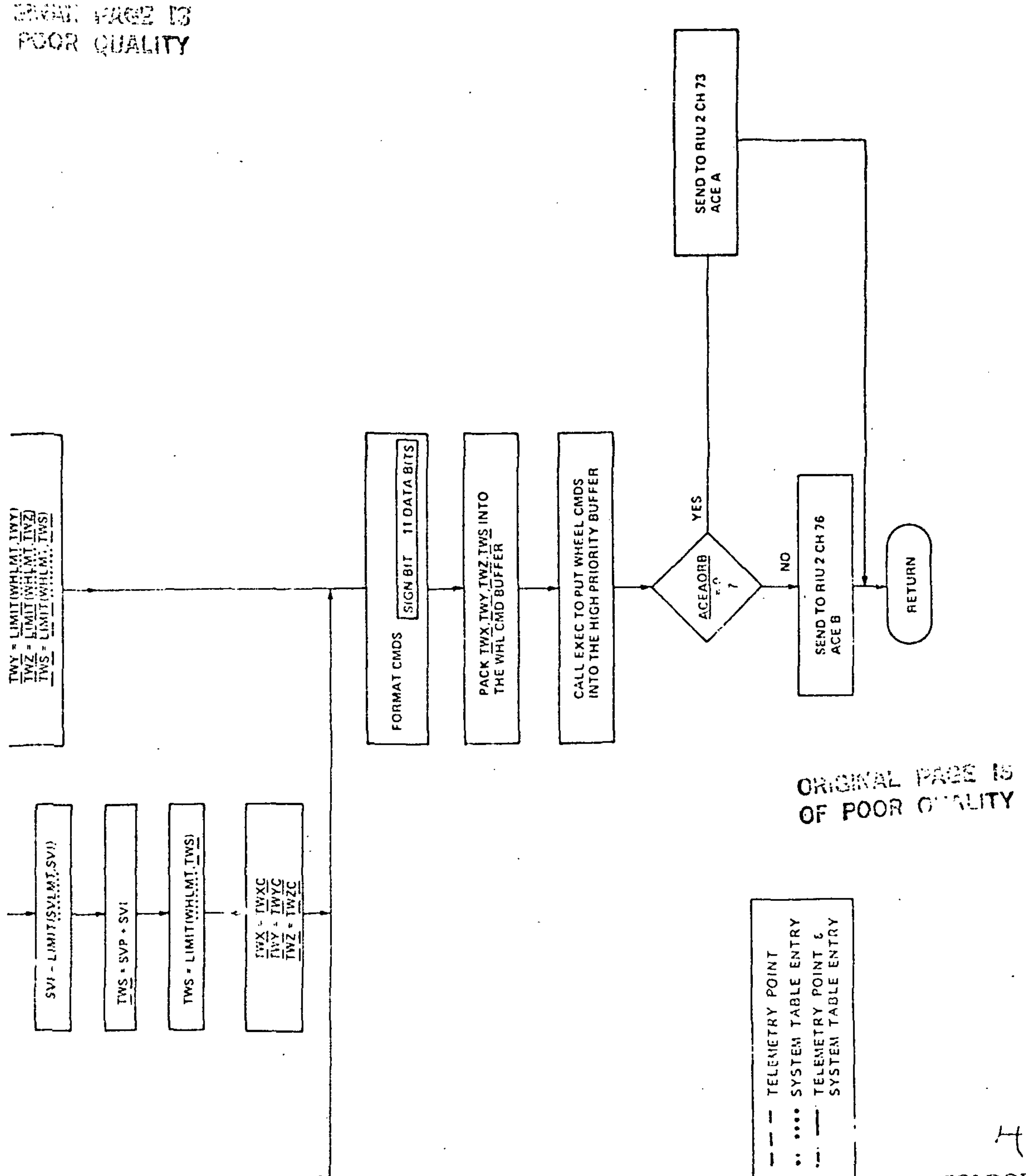

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Figure B.3.12-21. WHLCOMP Flow Chart

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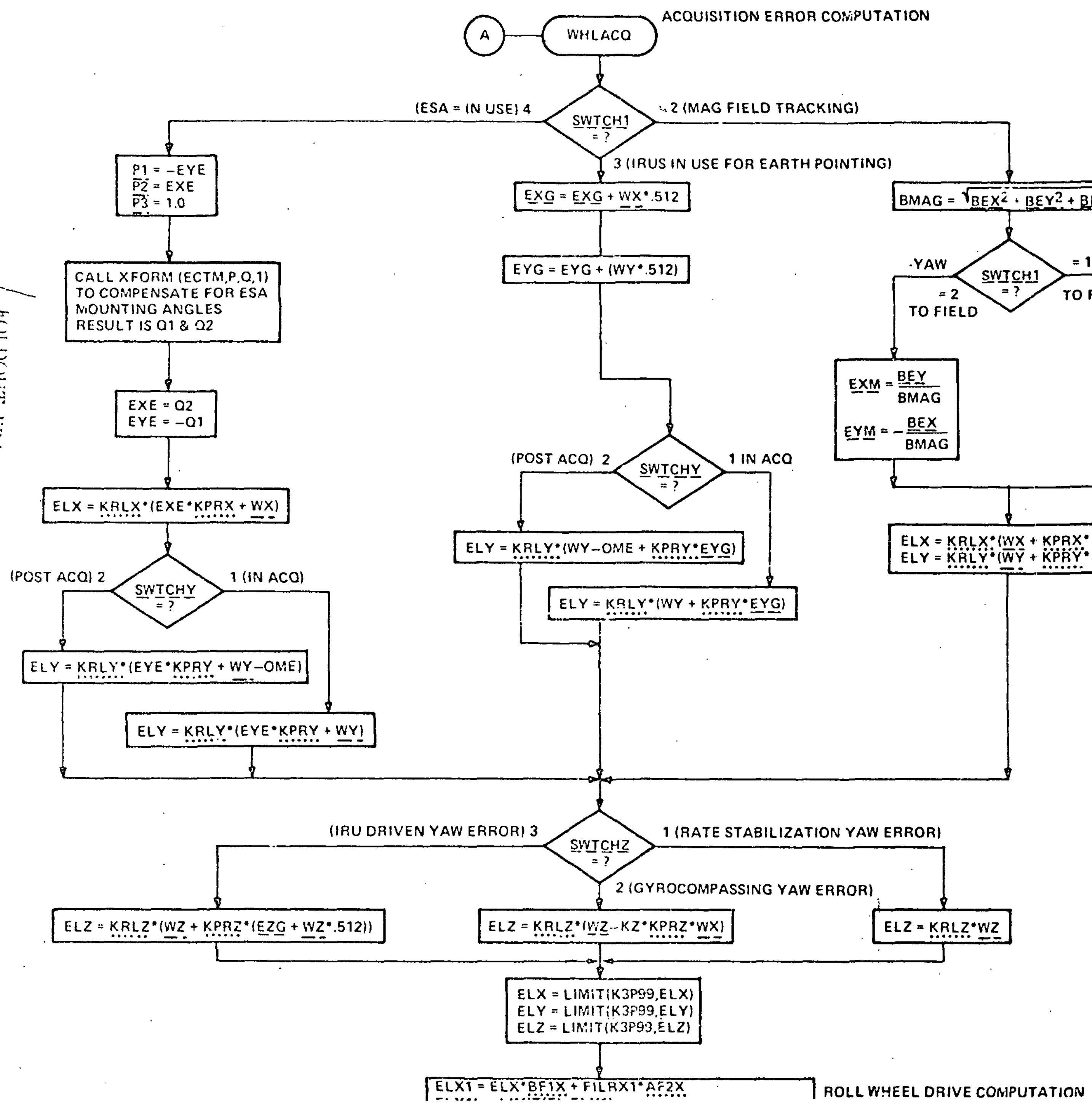

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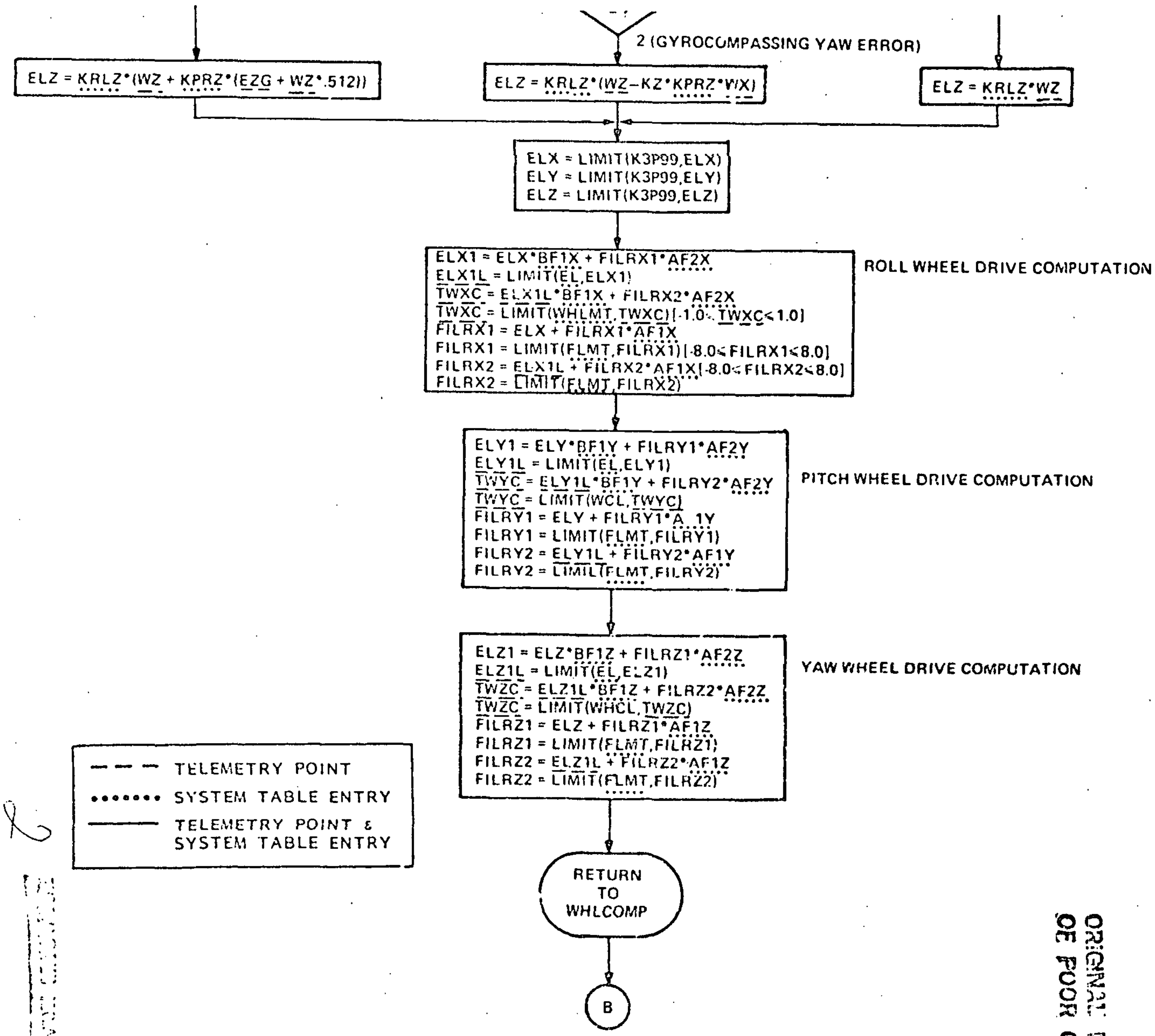

Figure B.3.12-22. WHLACQ Flow Chart

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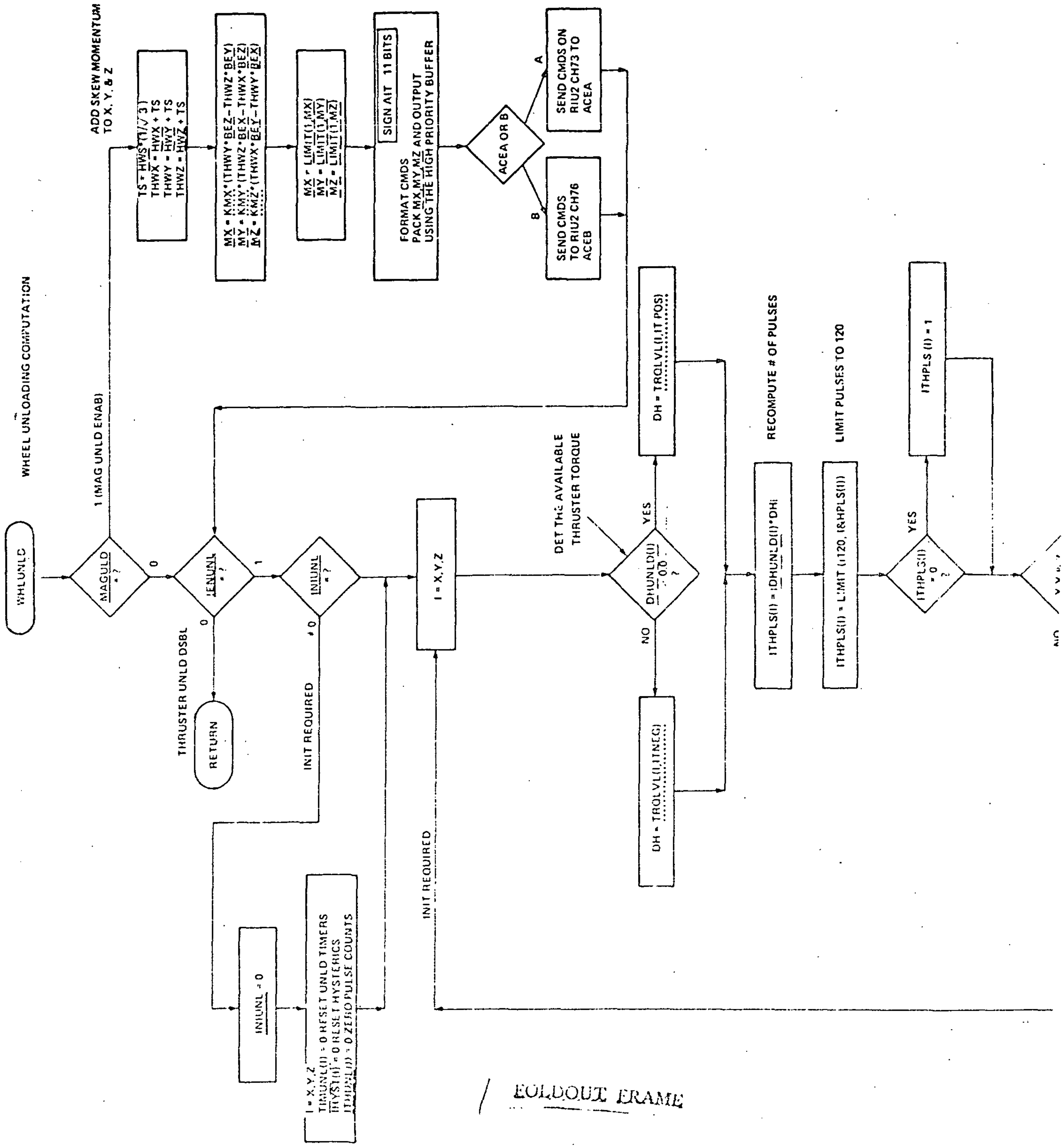

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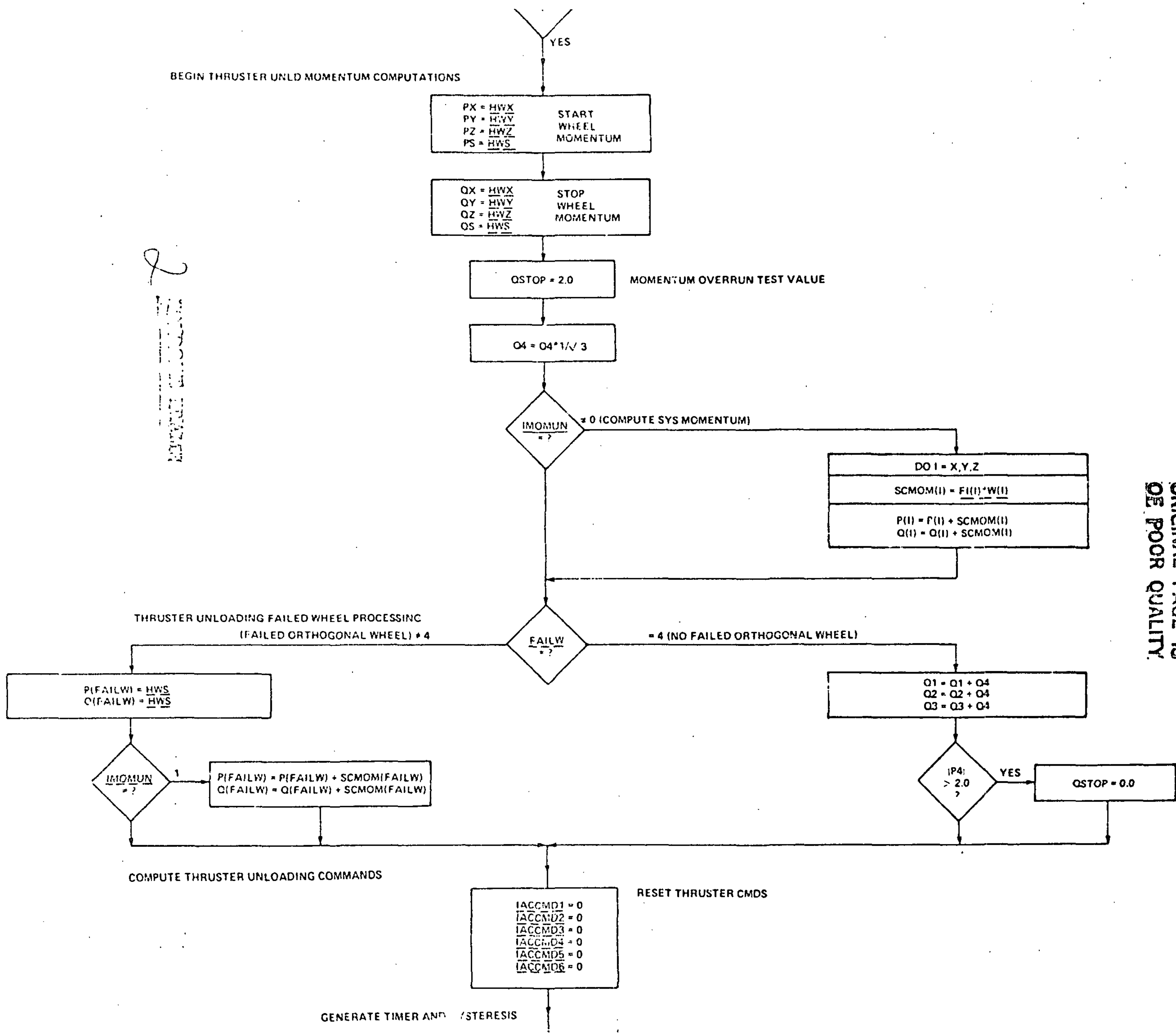

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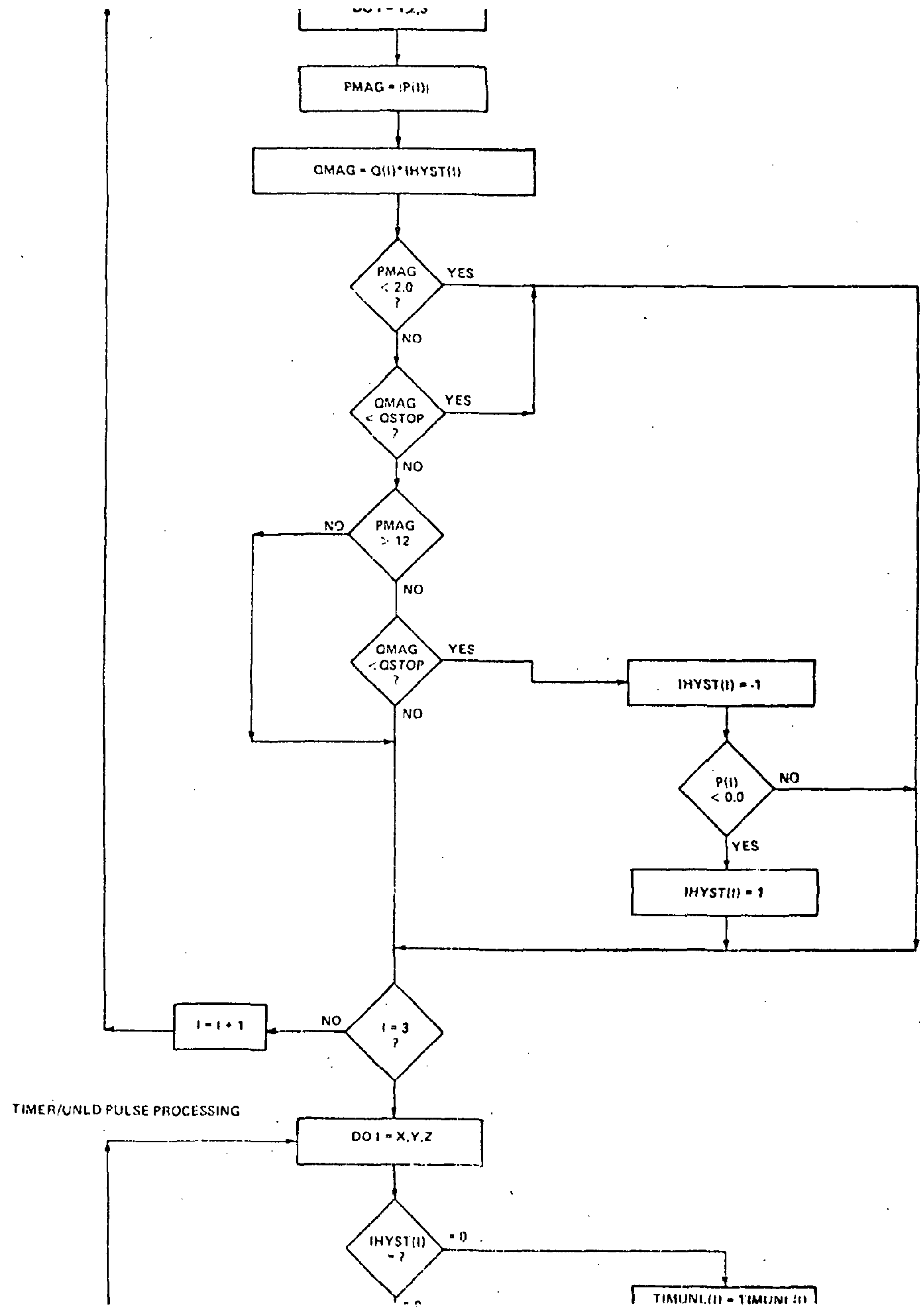

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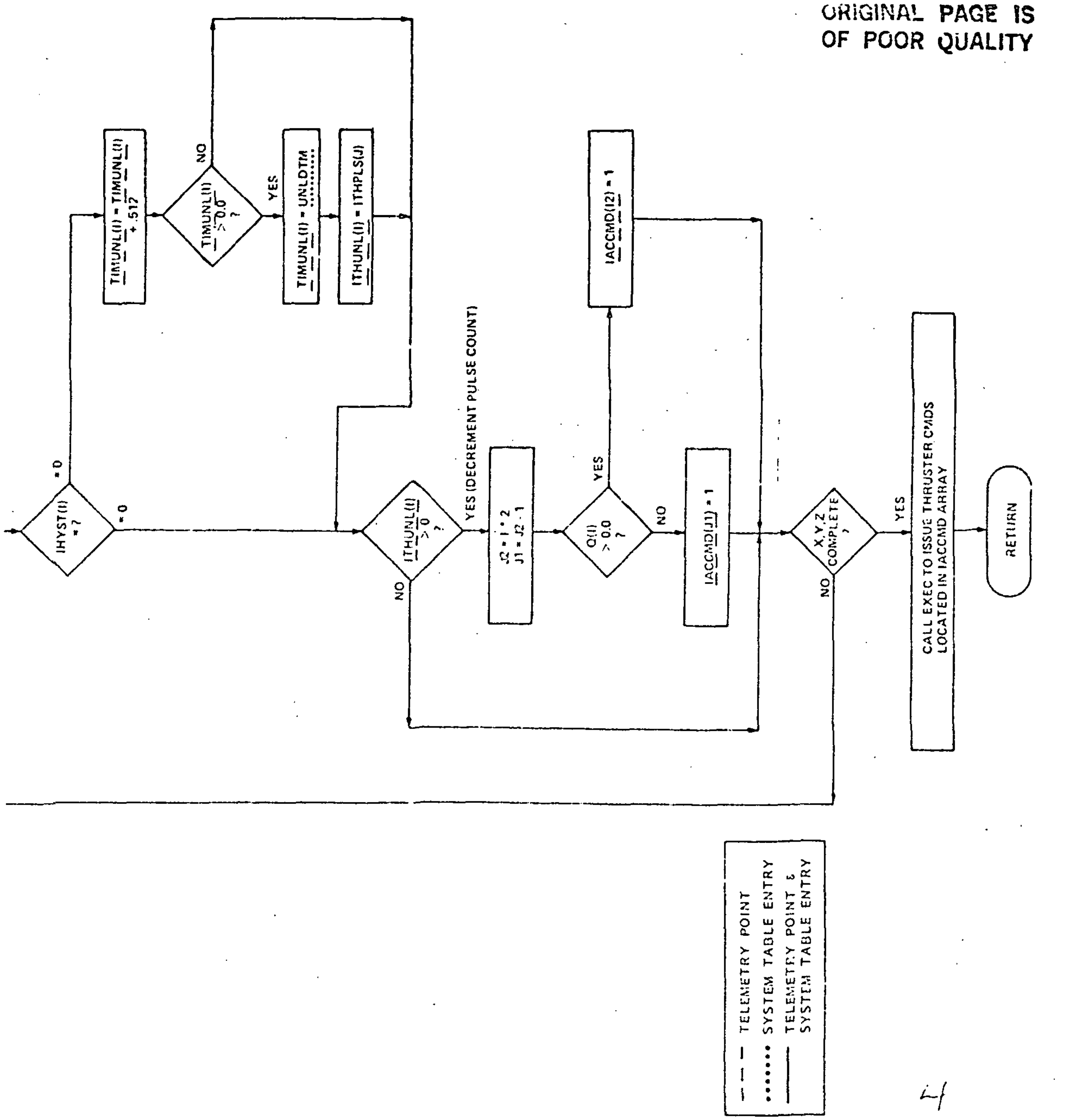

Figure B.3.12-23. WHLUNLD Flow Chart

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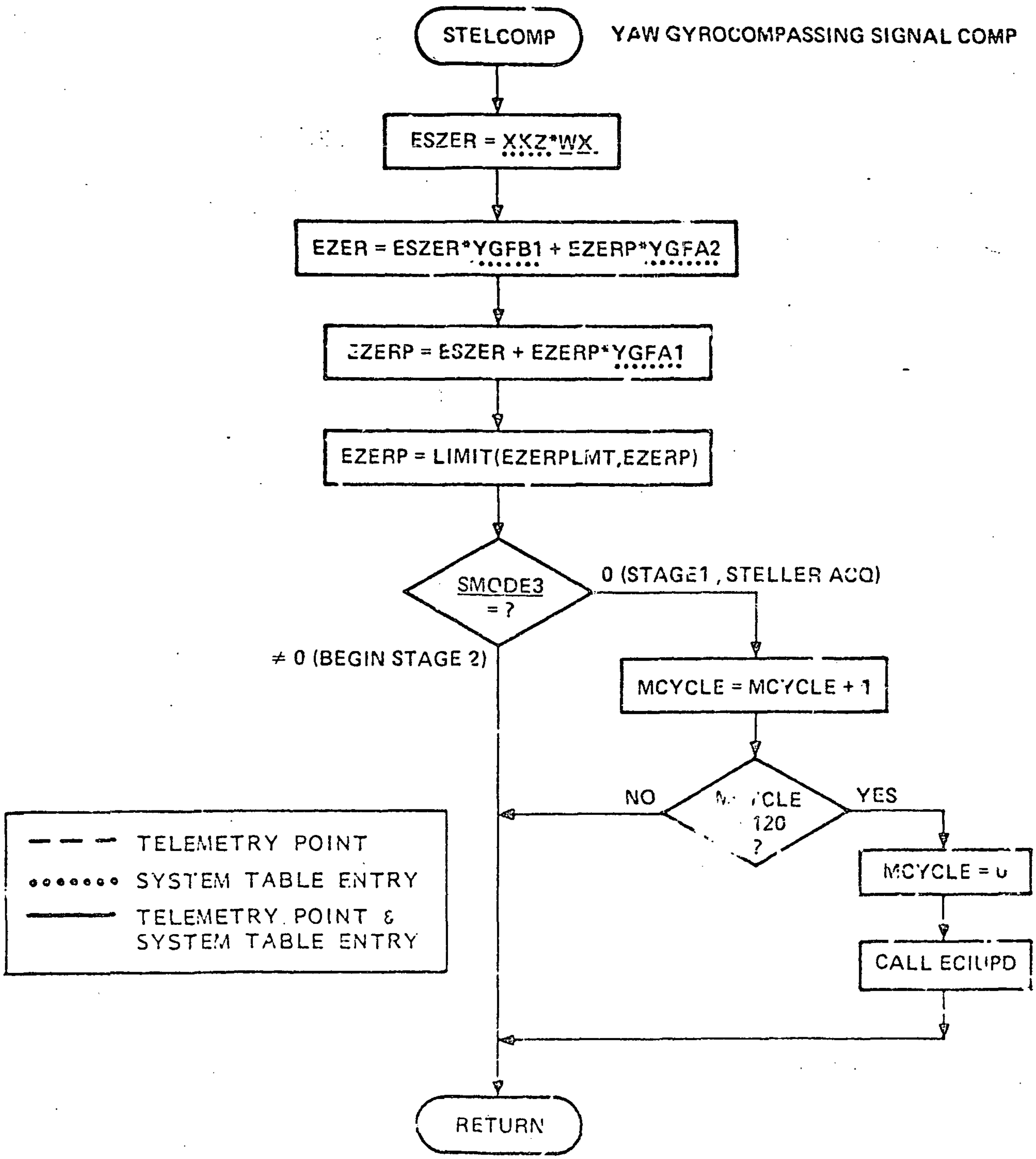
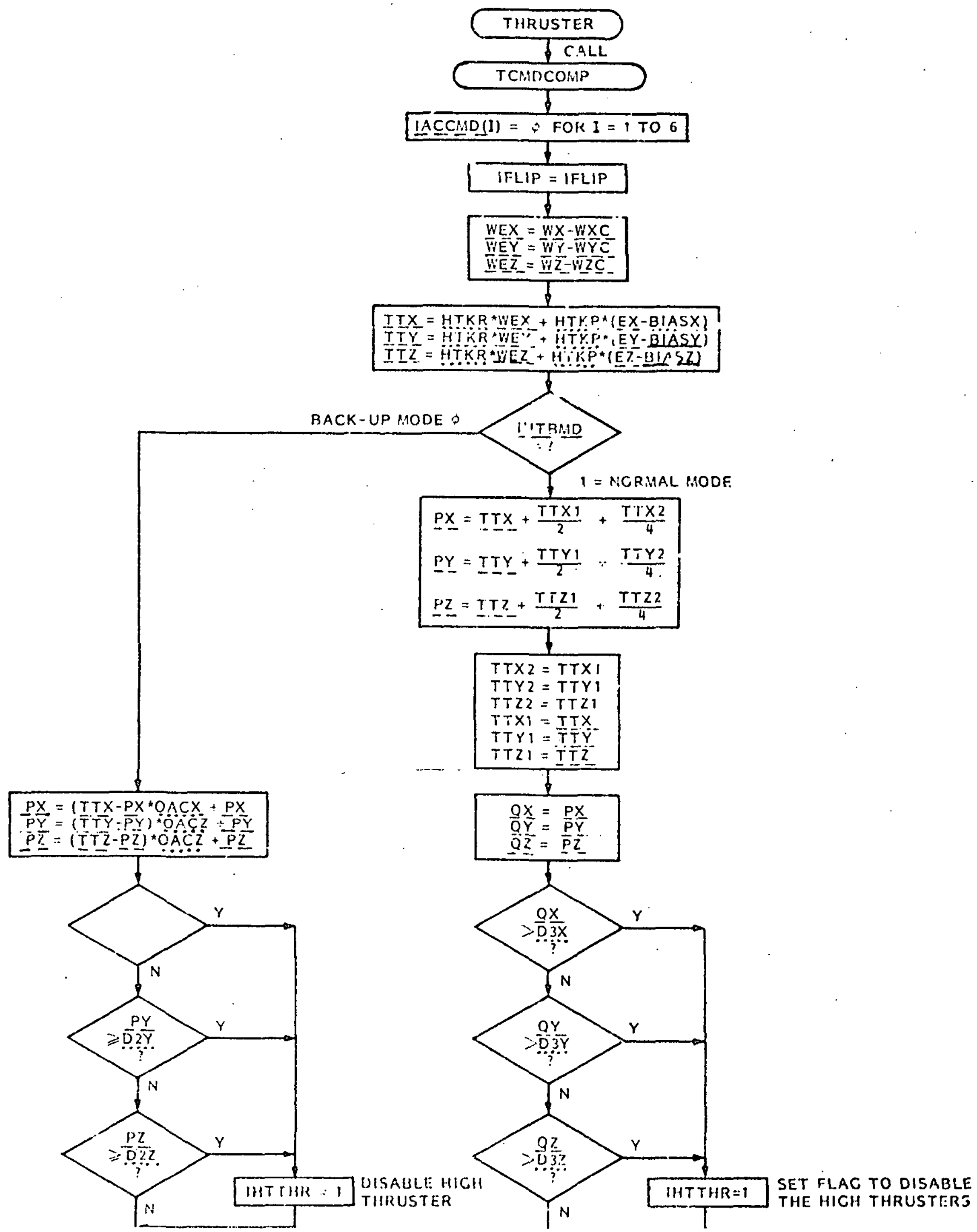


Figure B.3.10-24. STELCOMP Flow Chart



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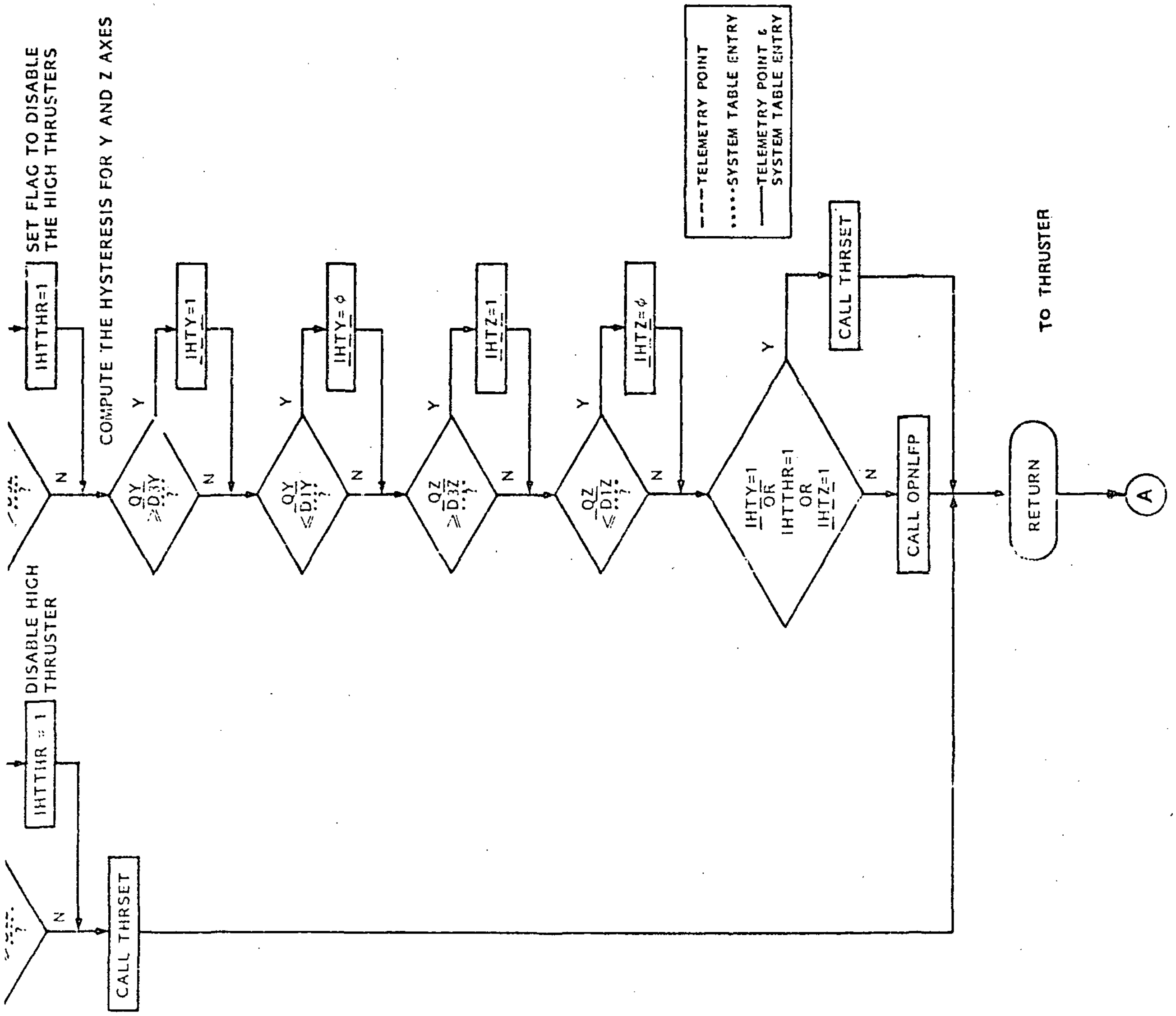

Figure B.3.12-25. THRUSTER Flow Chart

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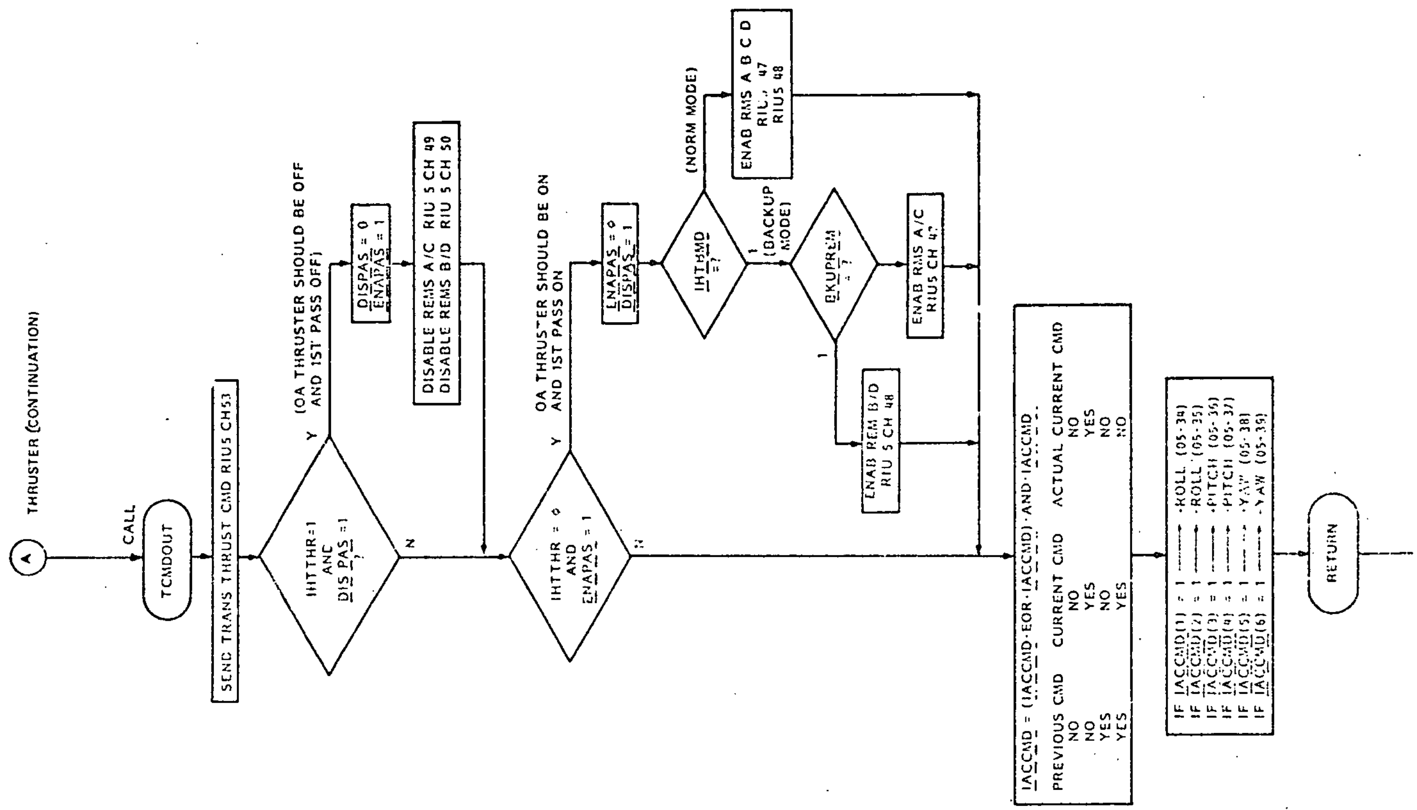

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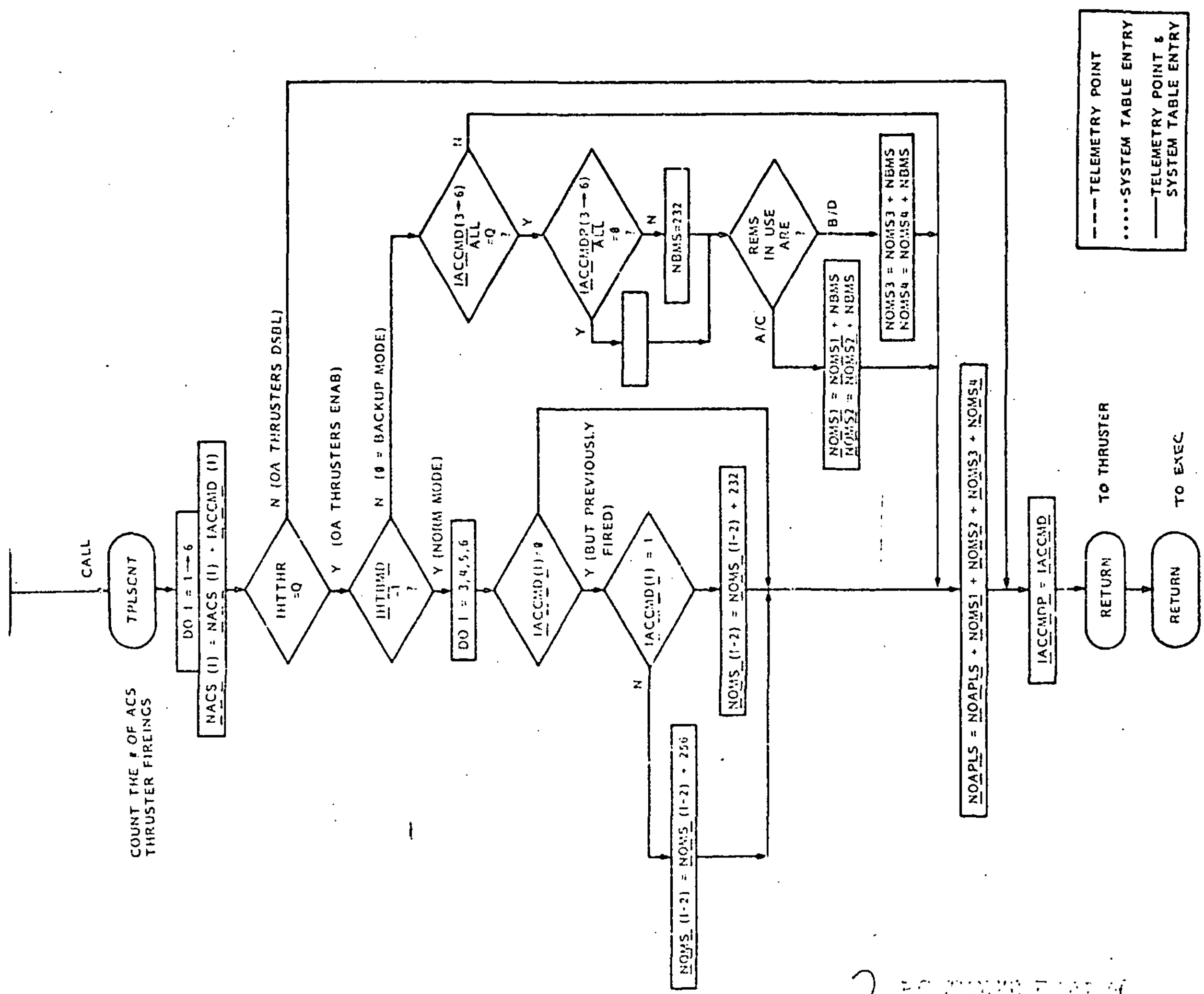

Figure B.3.12-25. THRUSTER Flow Chart (Con't.)

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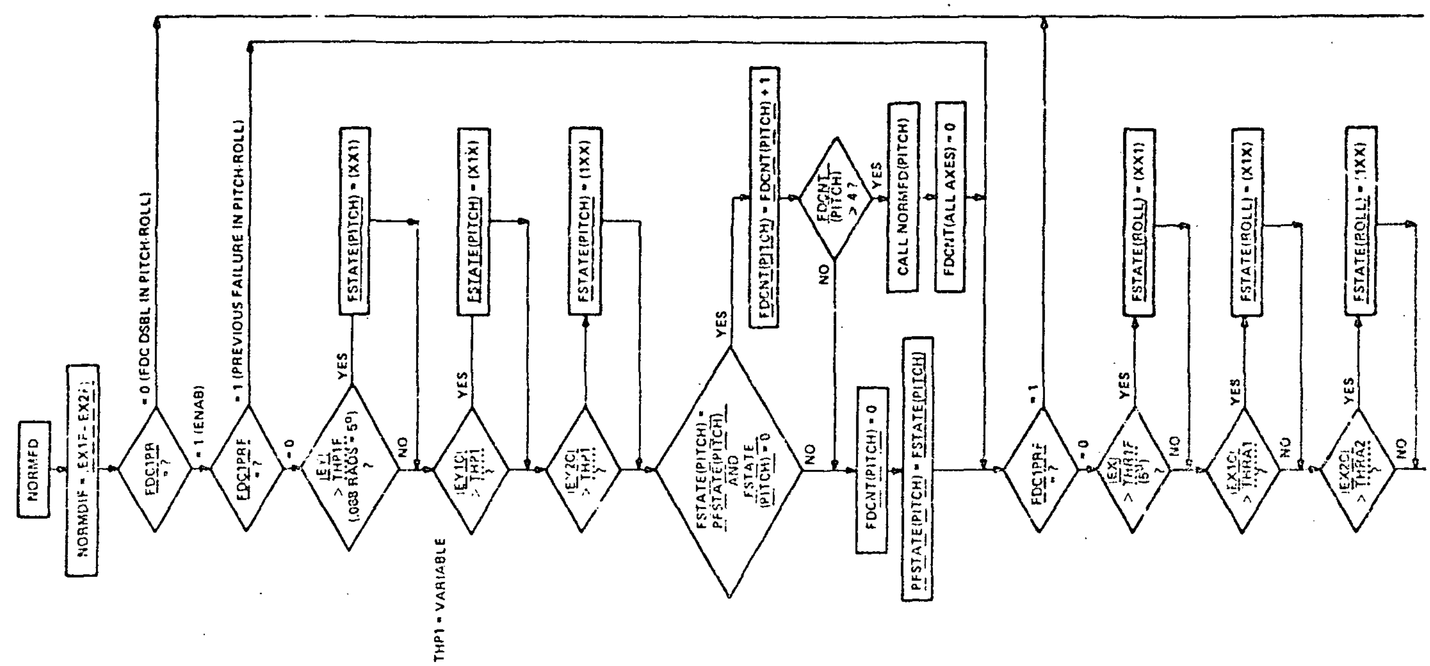

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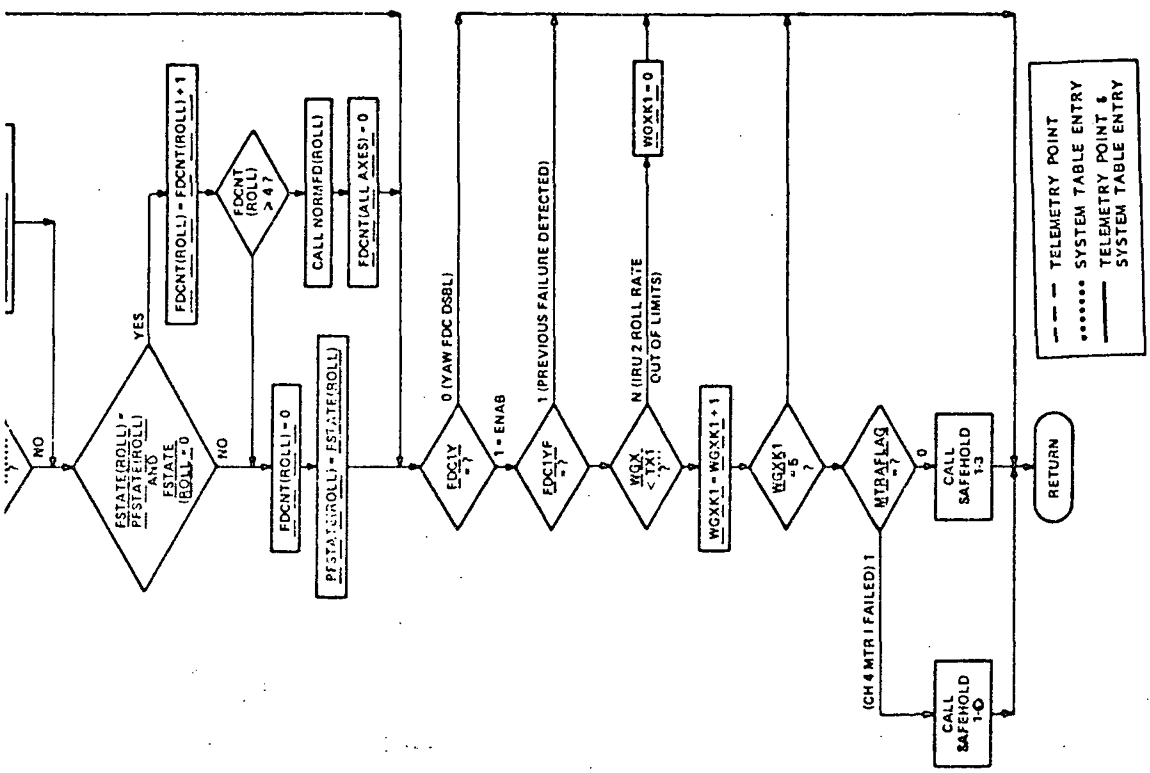

Figure B.3.12-26. NORMFD Flow Chart

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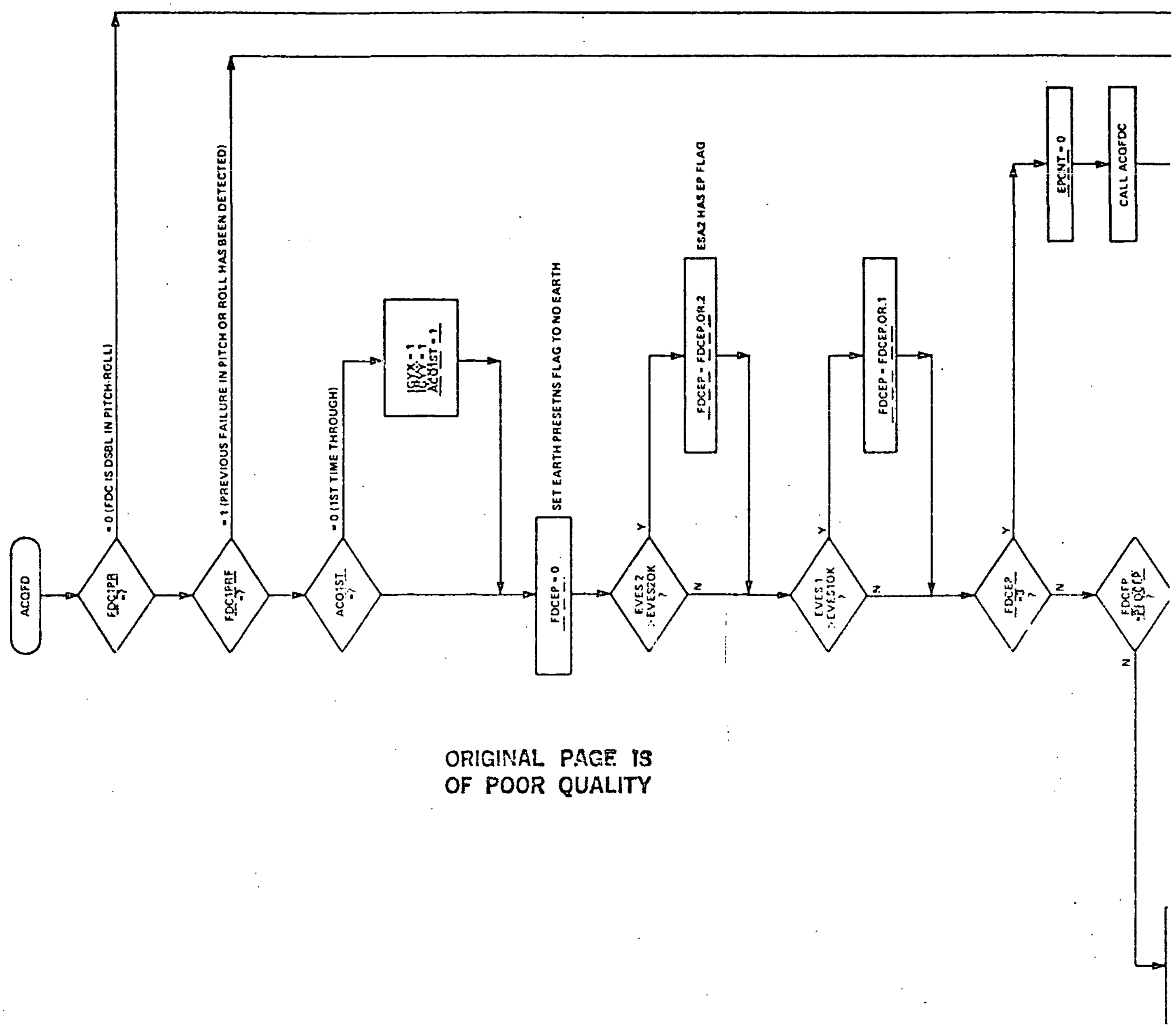

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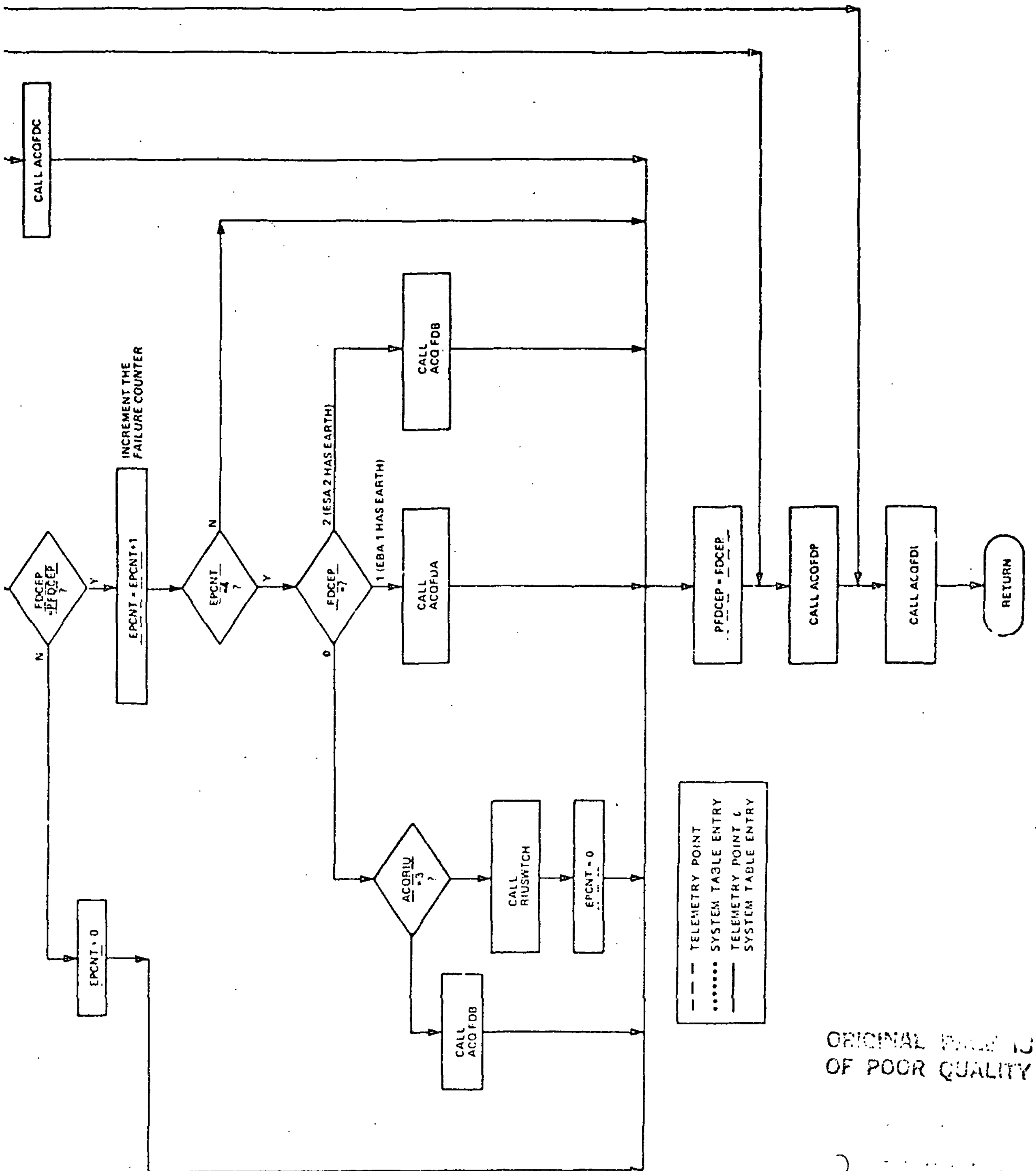

Figure B.3.12-27. ACQFD Flow Chart

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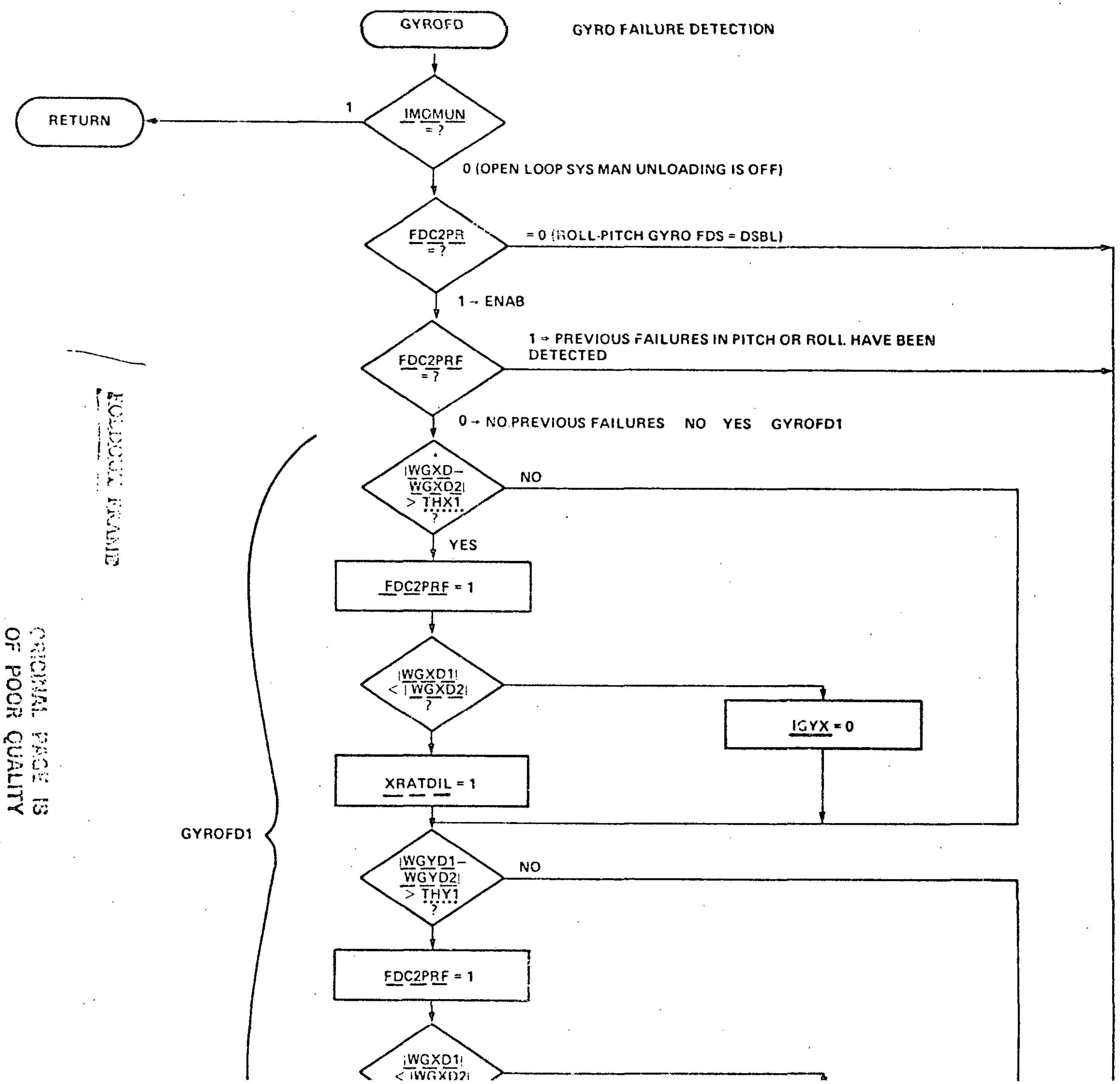

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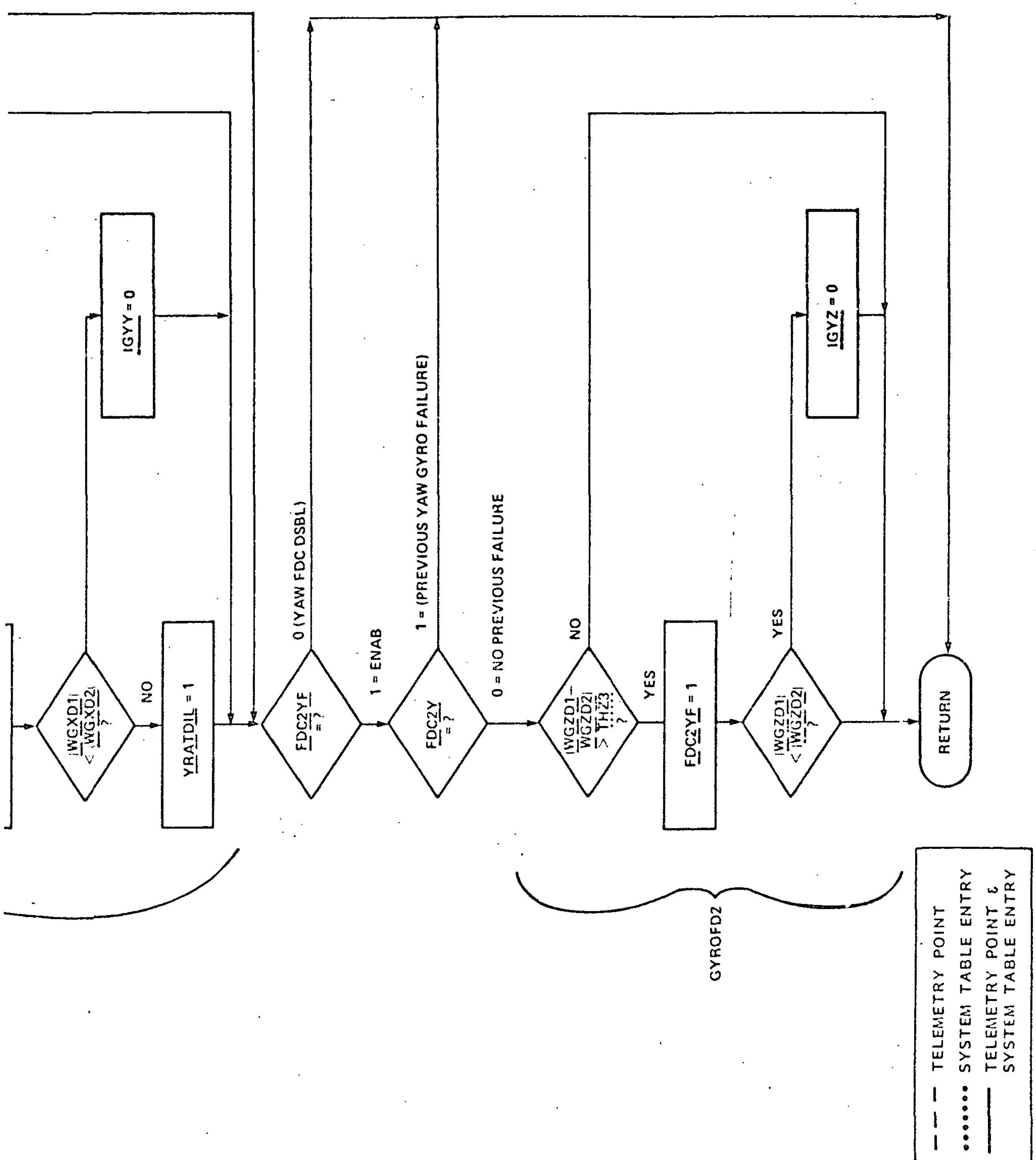

Figure B.3.12-28. GYROFD Flow Chart

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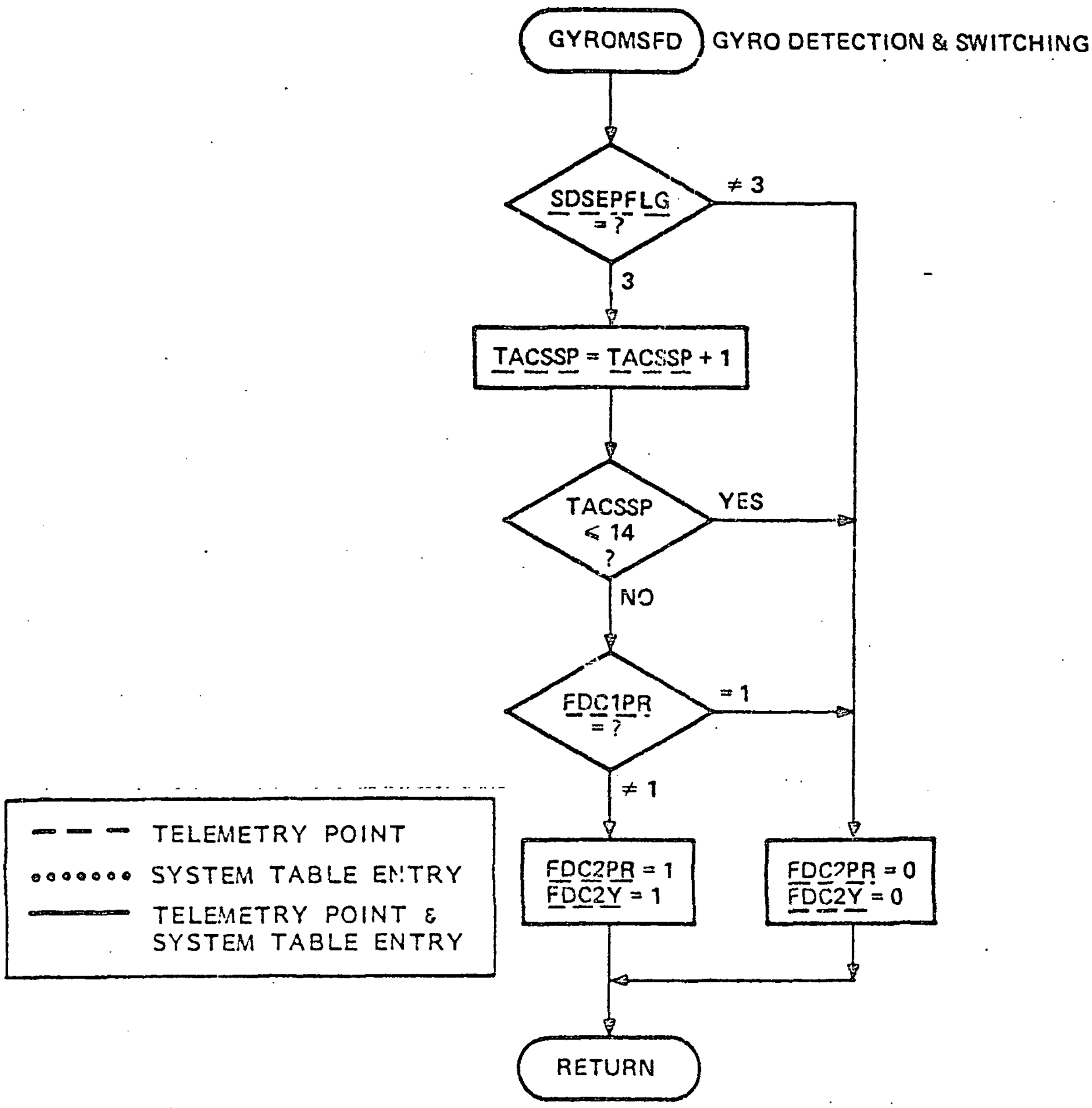

Figure B.3.12-29. GYROMSFD Flow Chart

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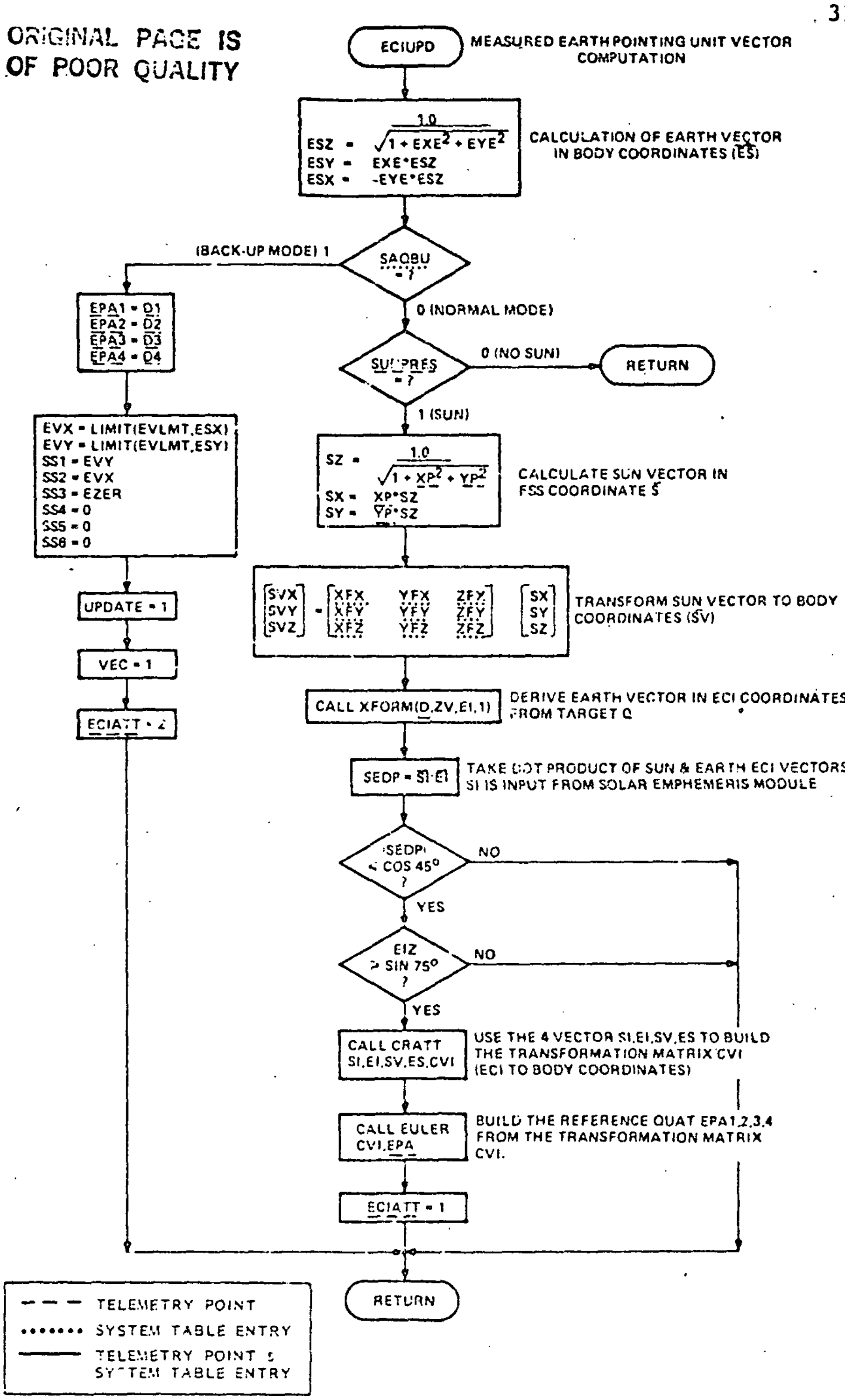

Figure B.3.[illegible]. ECIUPD Flow Chart

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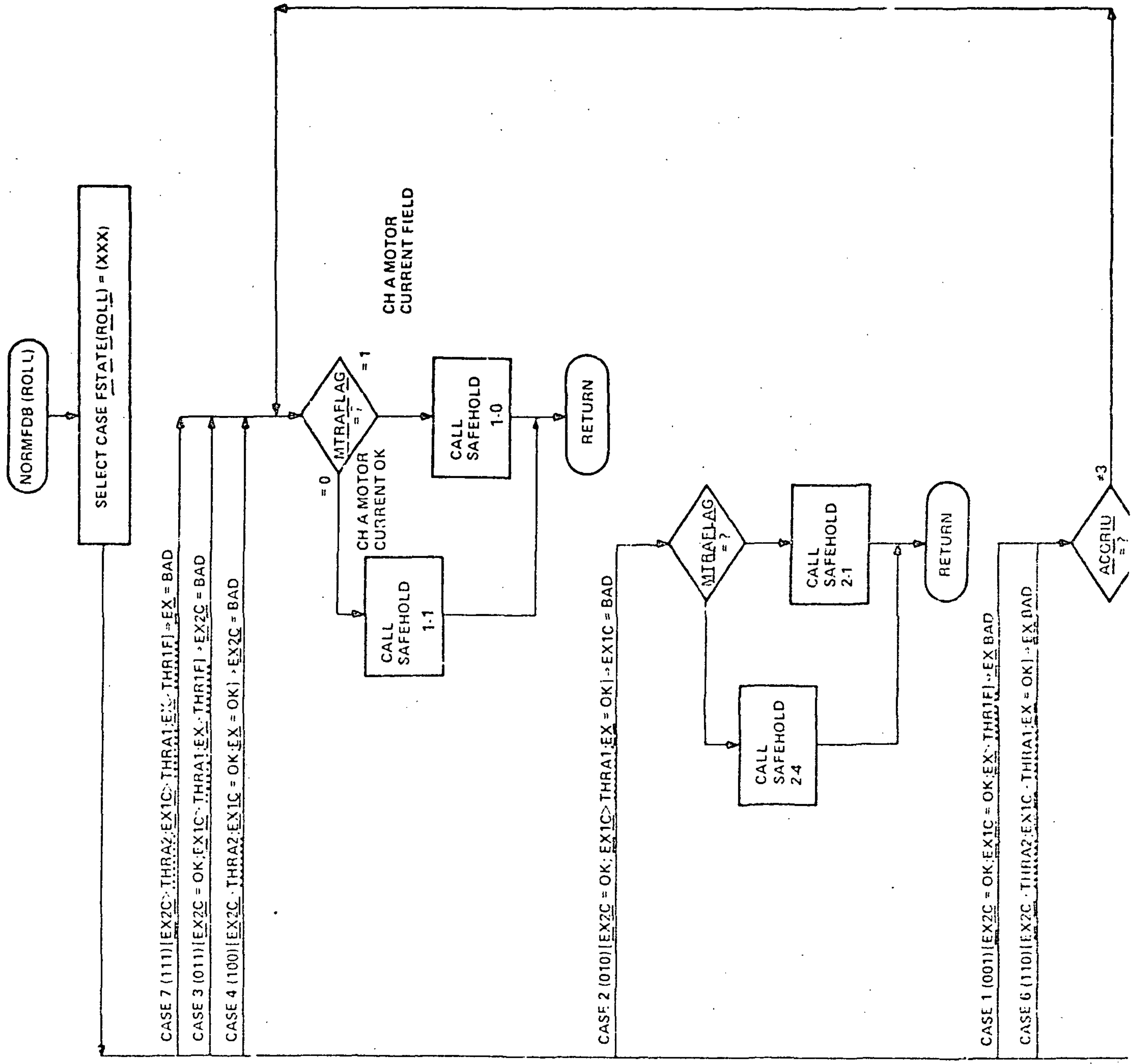

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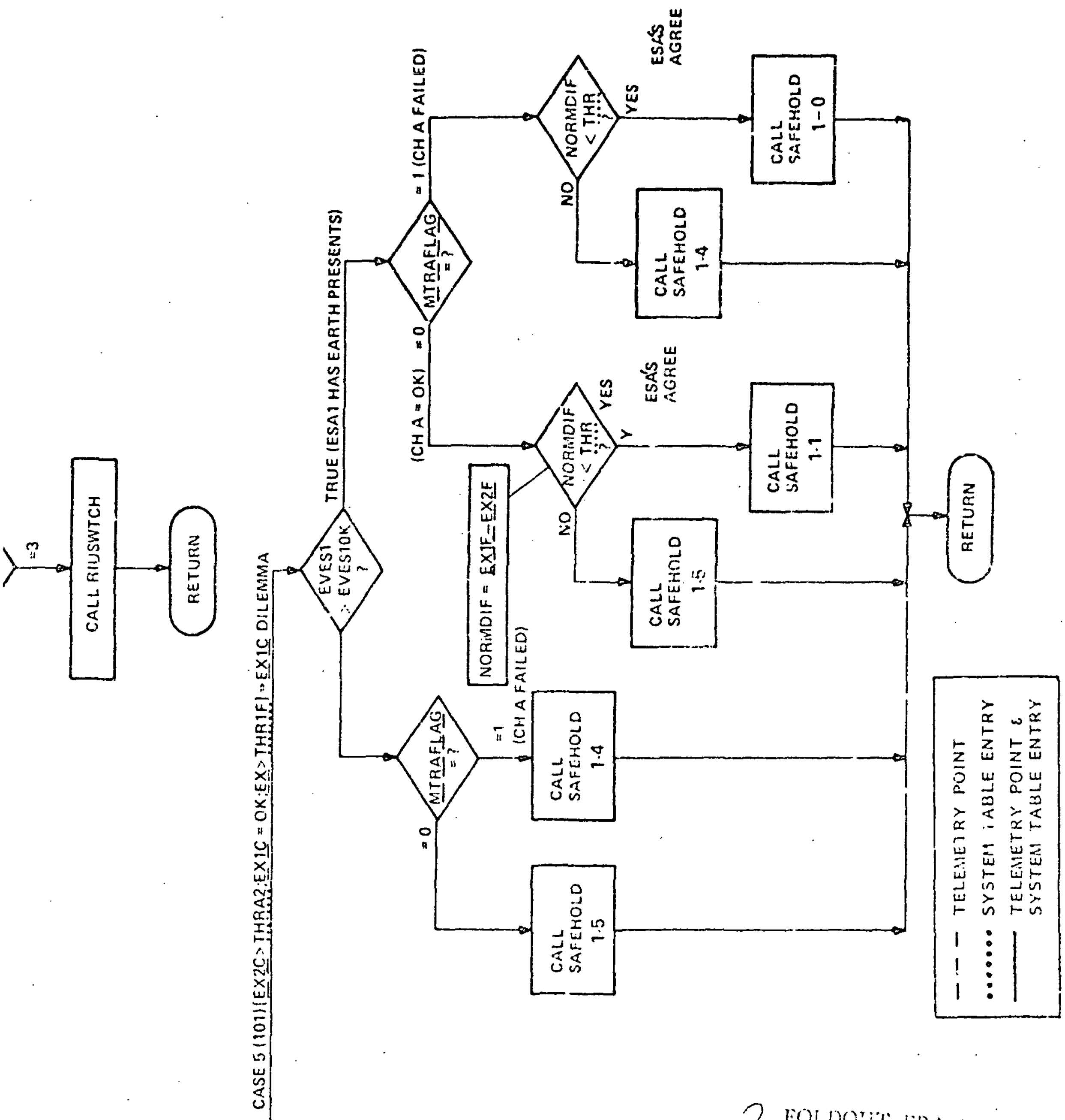

Figure B.3.12-31. NORMFDB Flow Chart

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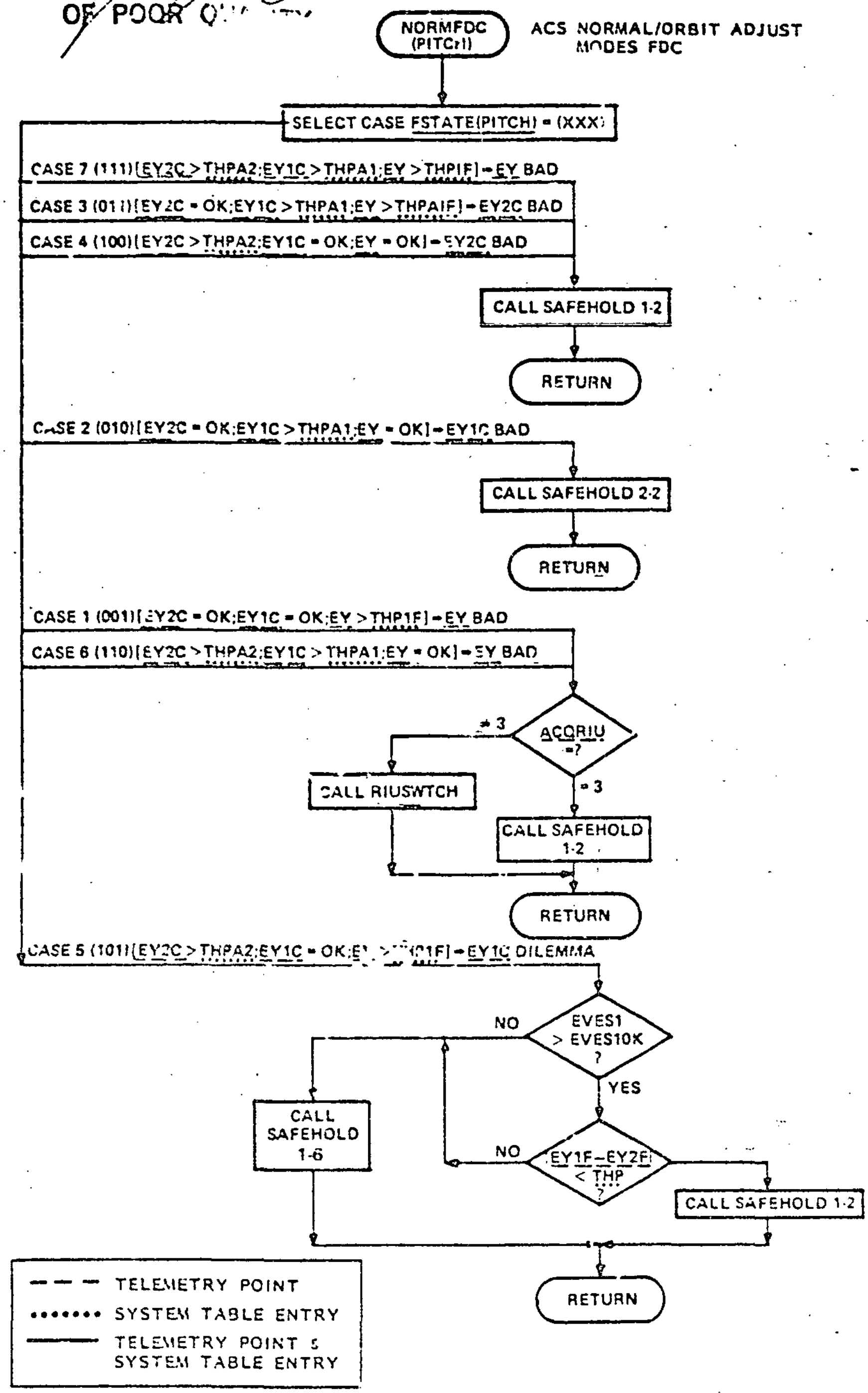

Figure B.3.12-32. NORMFDC Flow Chart

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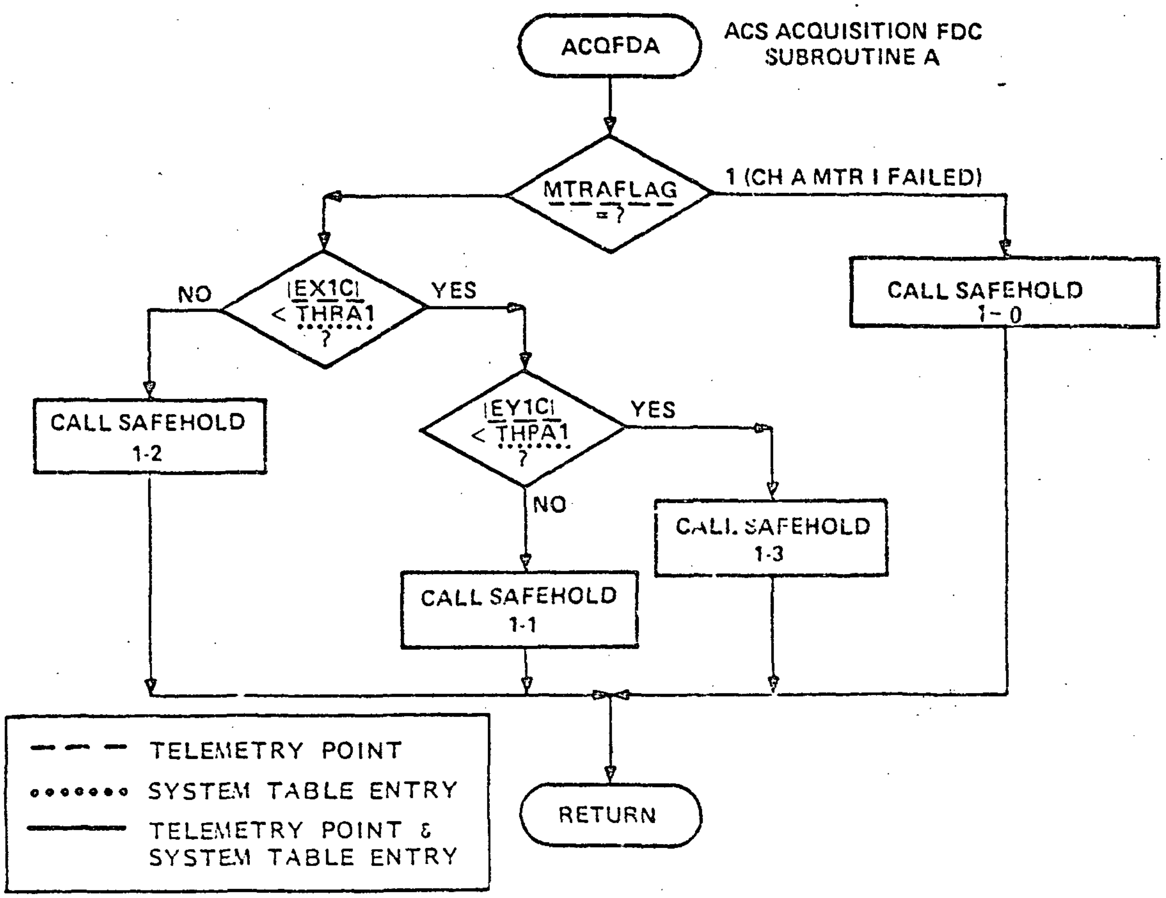

Figure B.3.12-33. ACQFDA Flow Chart

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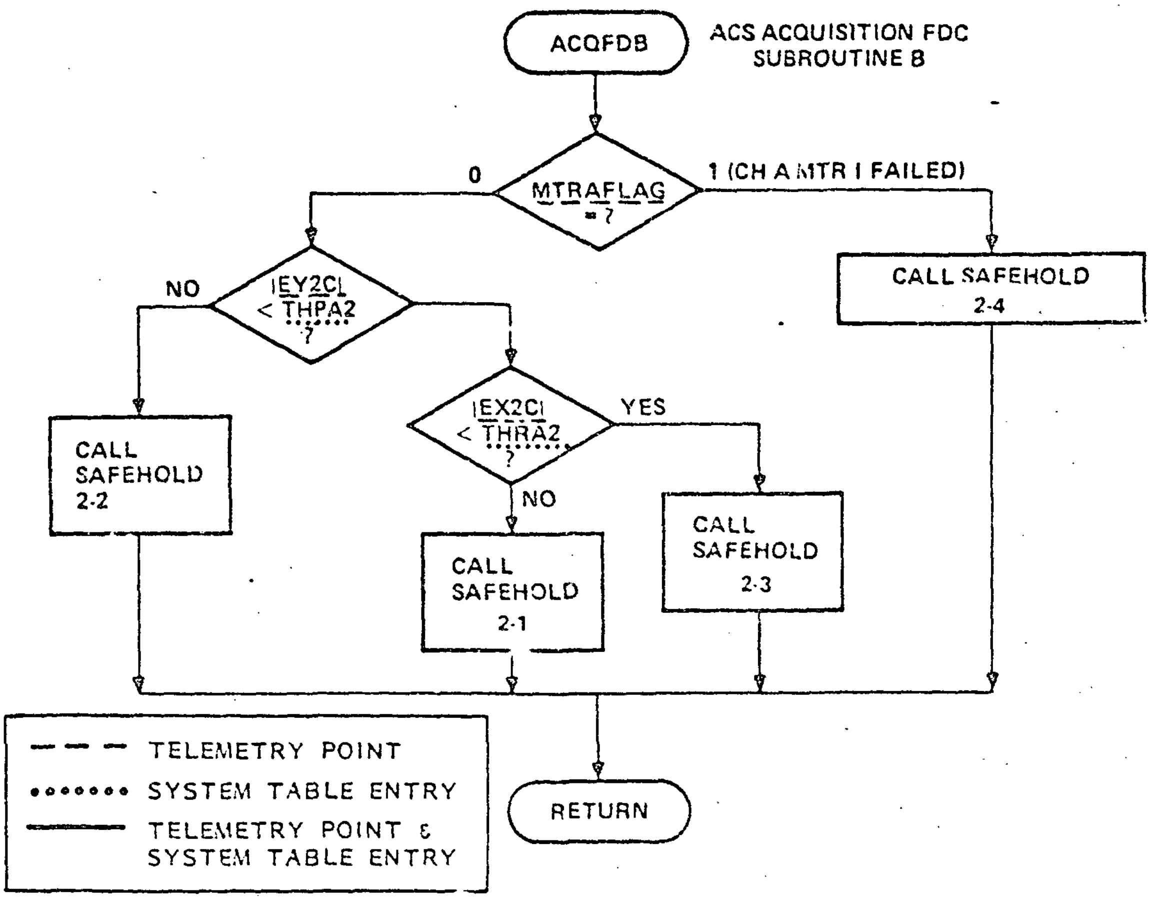

Figure B.3.10-34. ACQFDB Flow Chart

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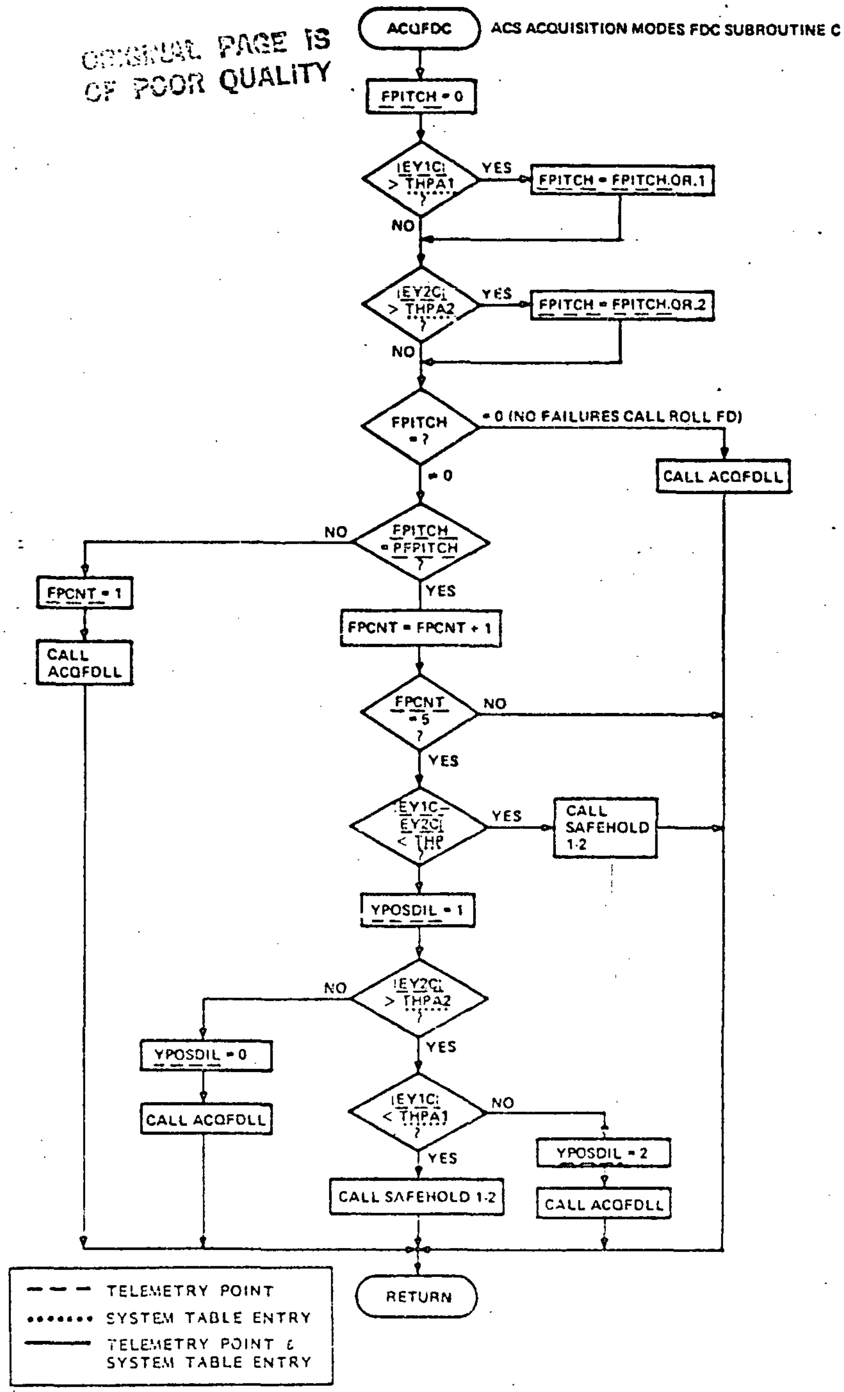

Figure B.3.12-35. ACQFDC Flow Chart

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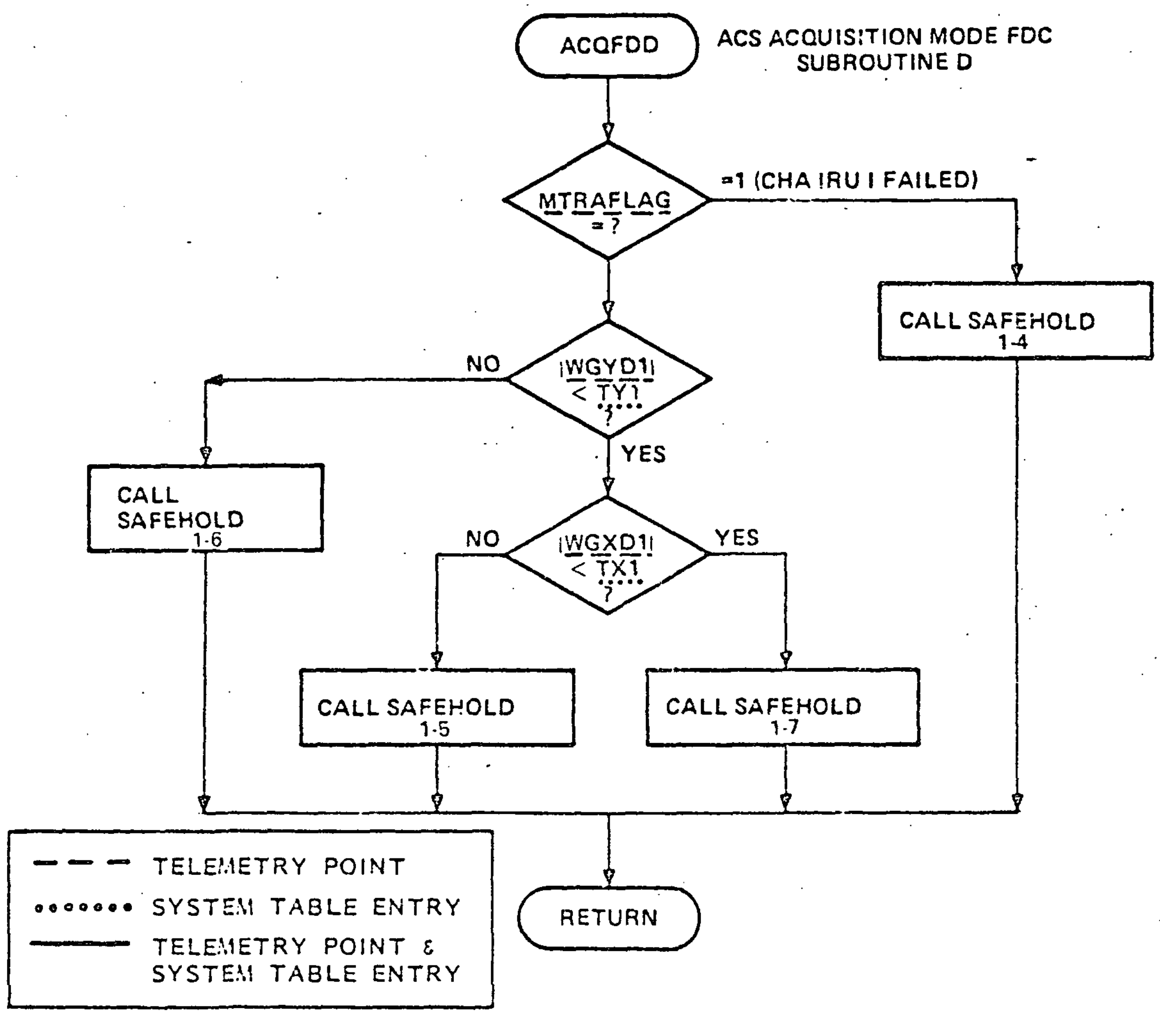

Figure B.3.12-36. ACQFDD Flow Chart

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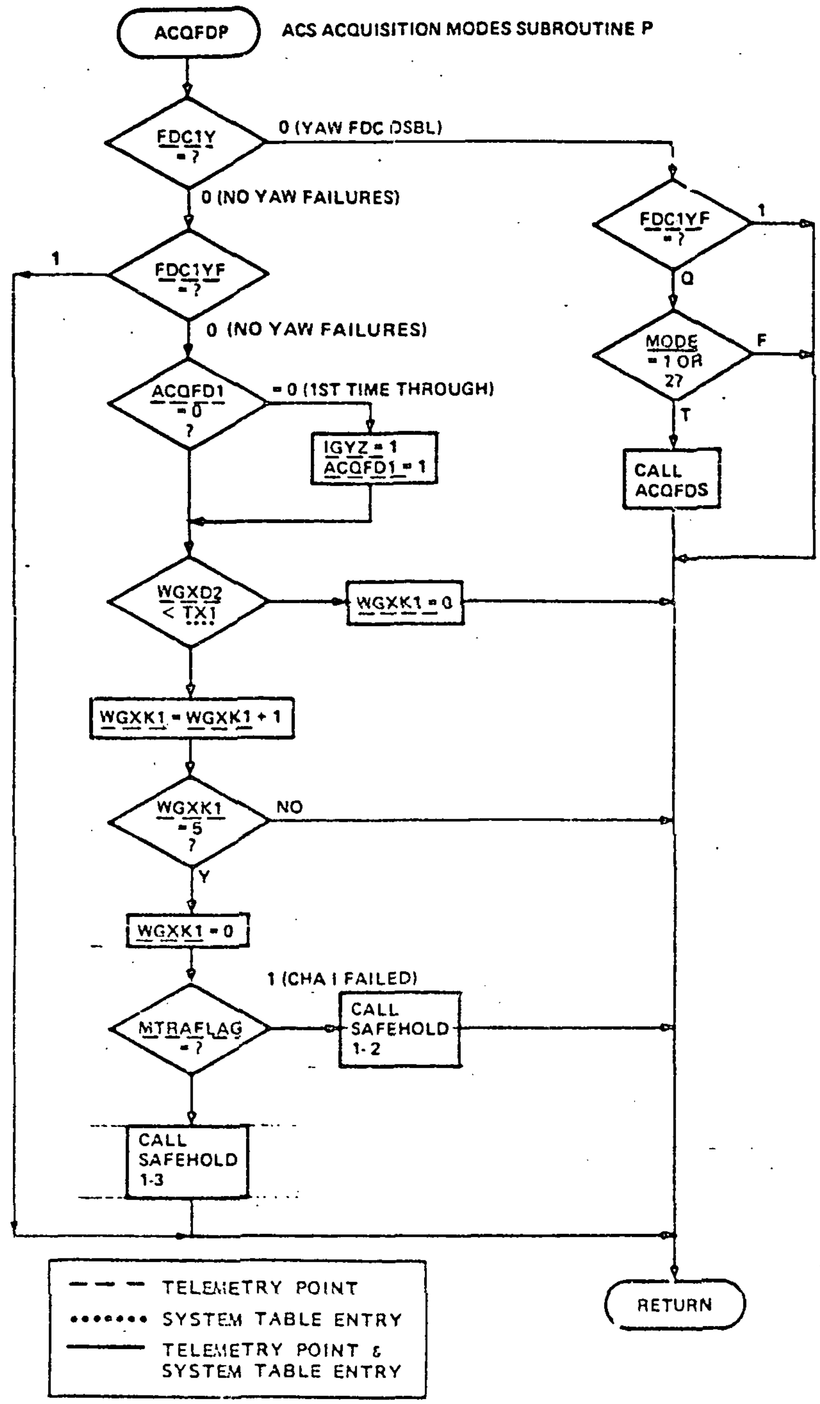

Figure B.3.12-37. ACQFDP Flow Chart

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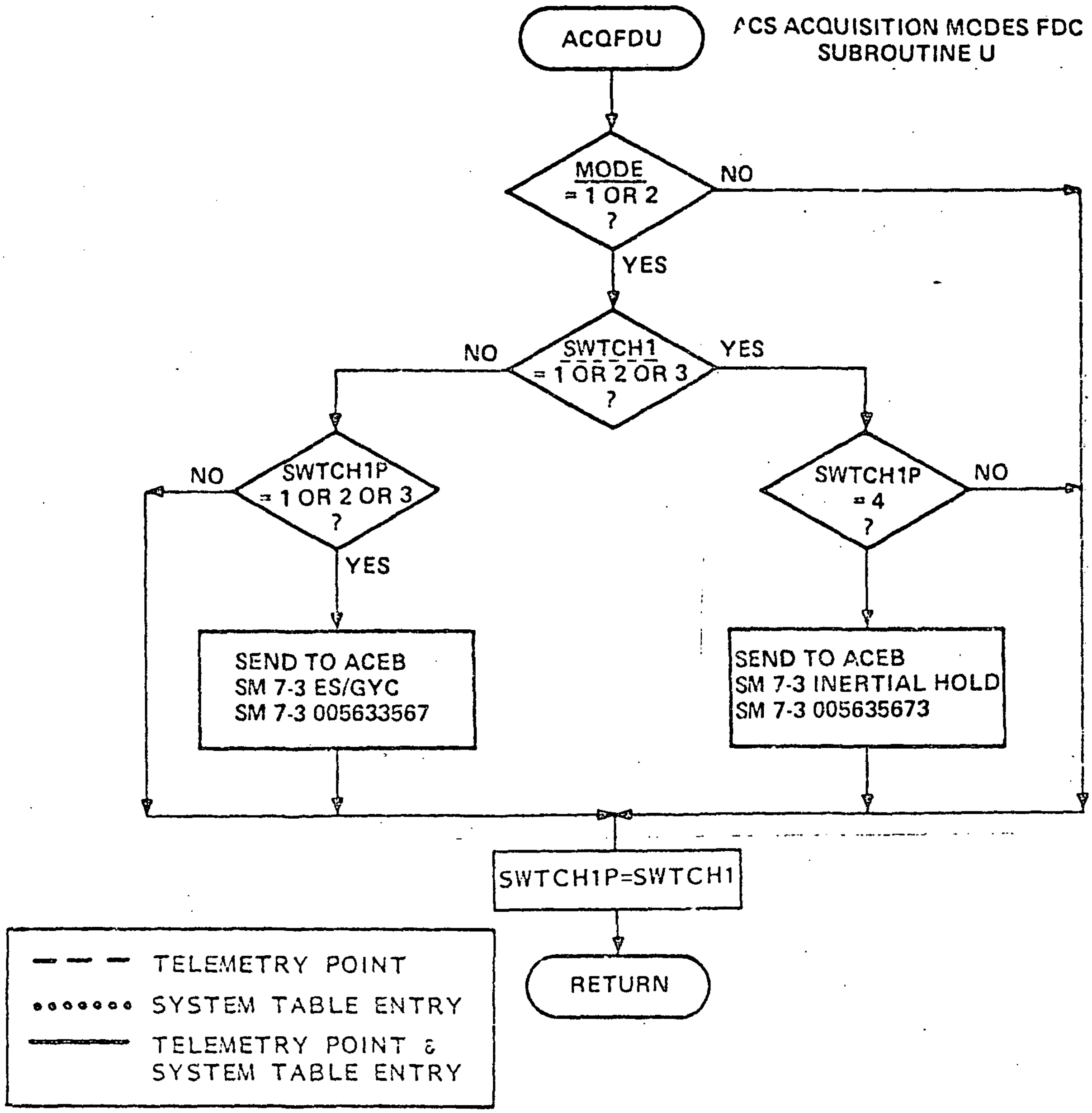

Figure B.3.12-38. ACQFDU Flow Chart

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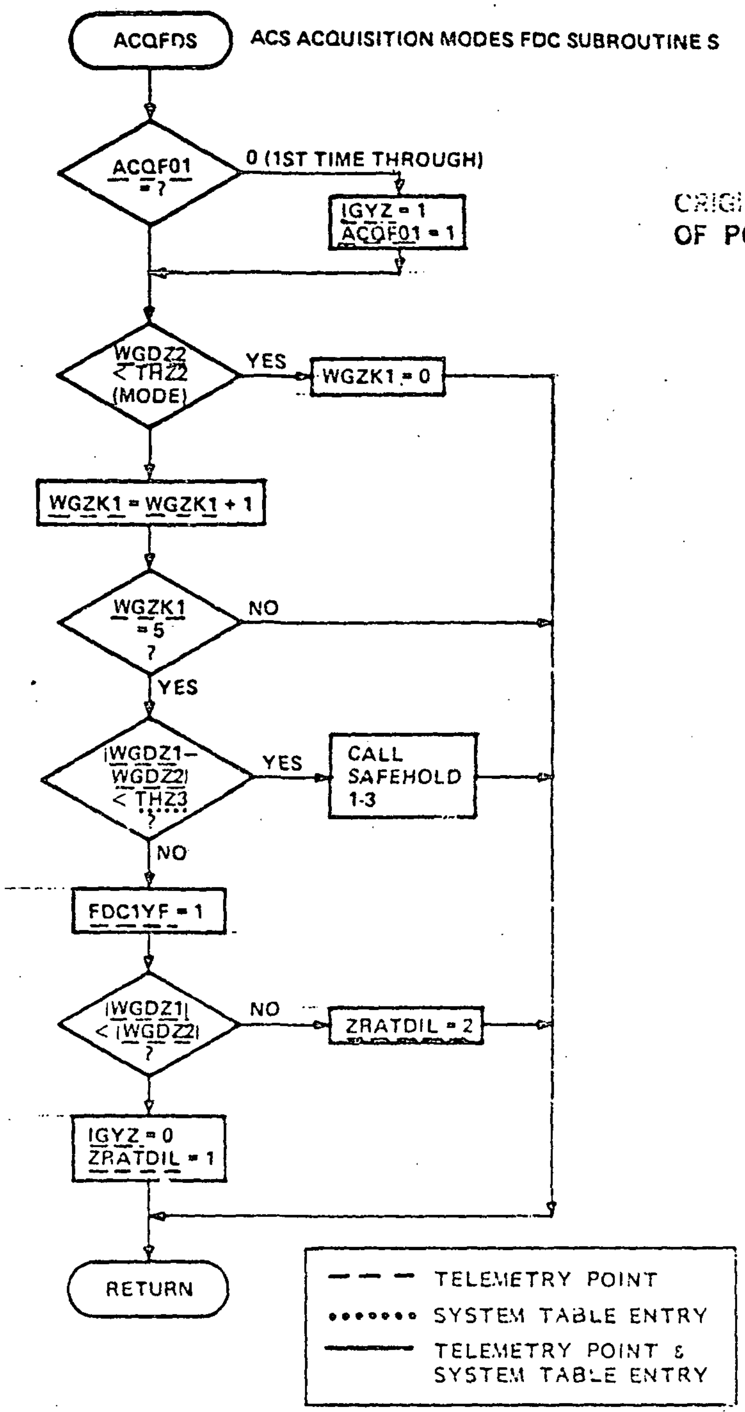

Figure B.3.12-39. ACQFDS Flow Chart

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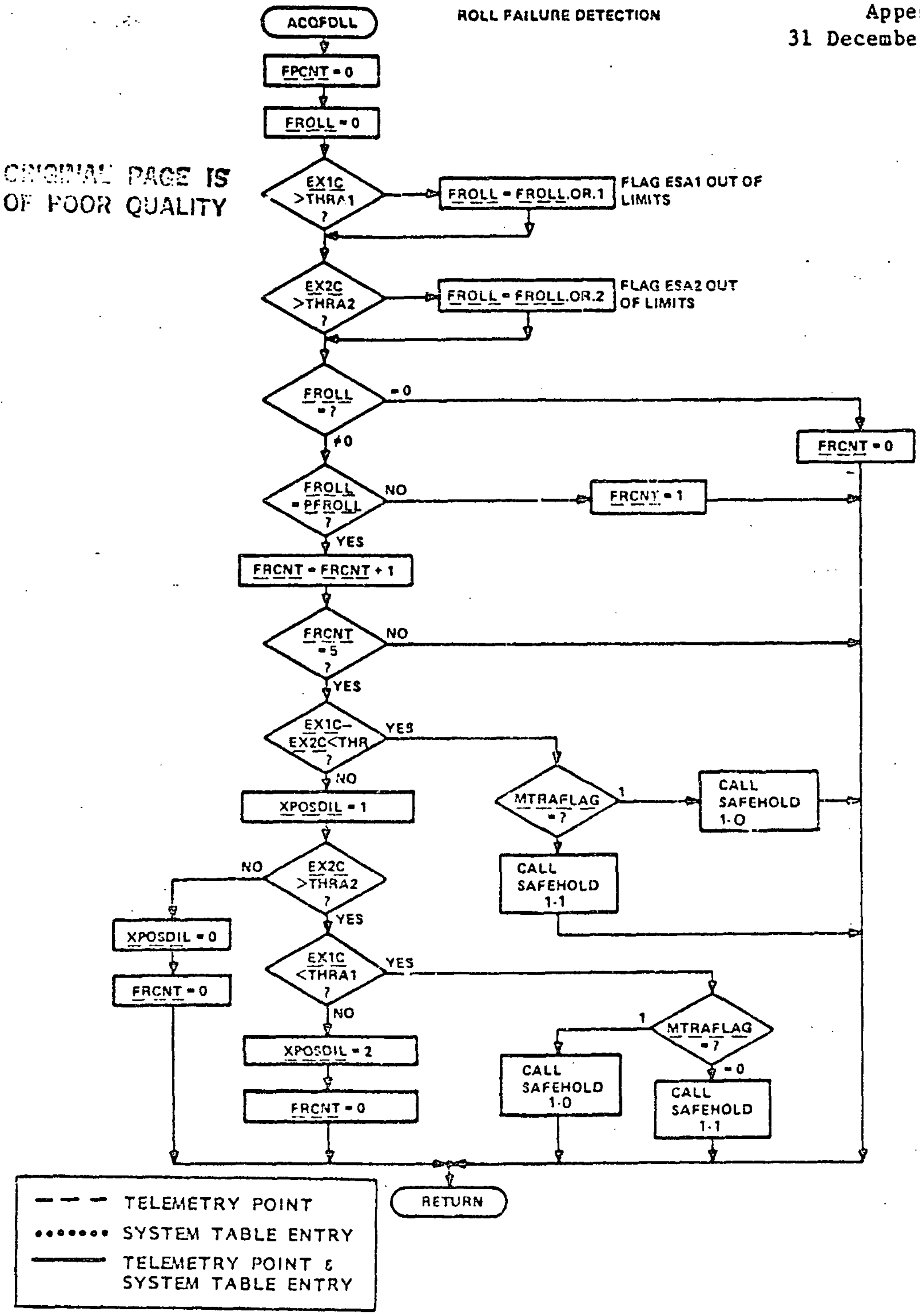

Figure B.3.12-40. ACQFDLL Flow Chart

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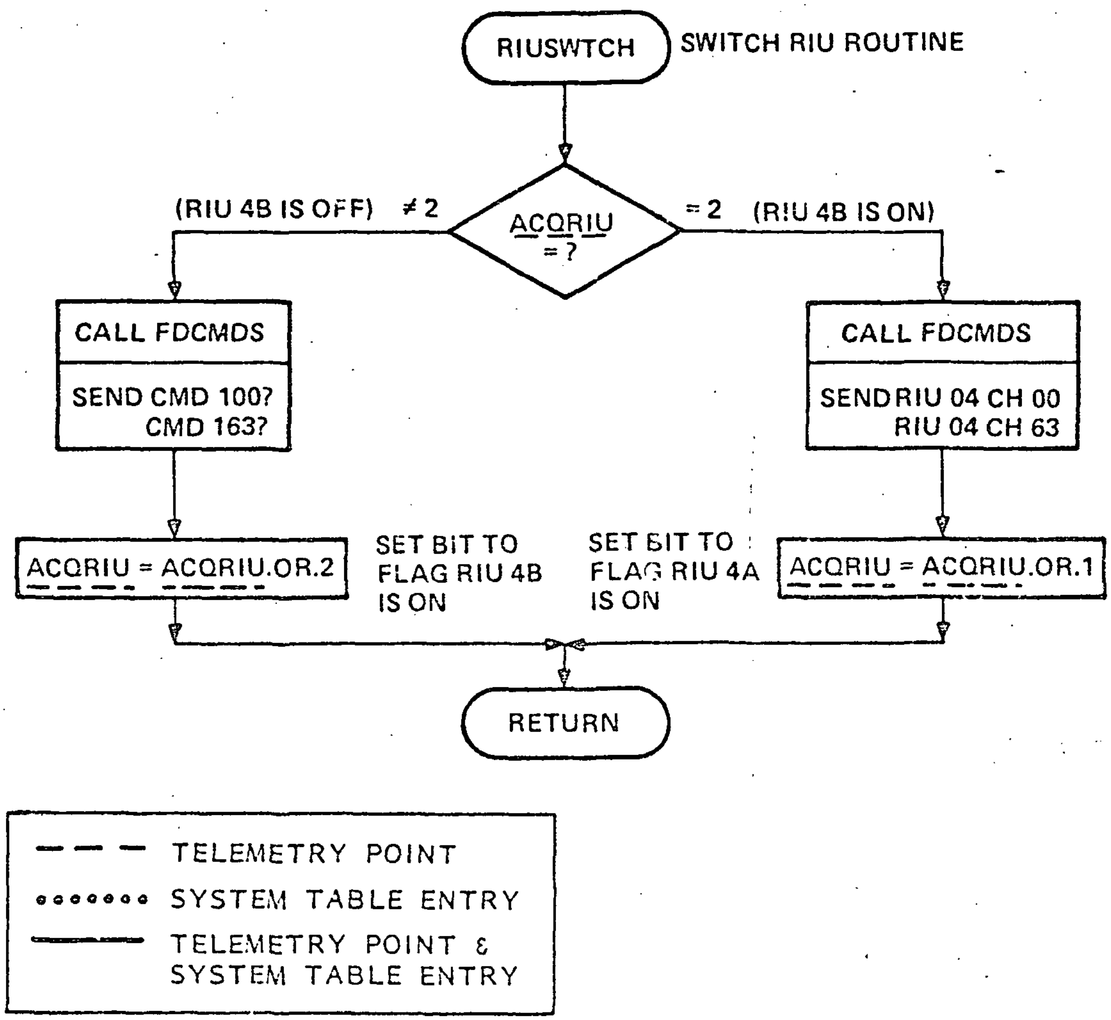

Figure B.3.12-41. RIUSWTCH Flow Chart

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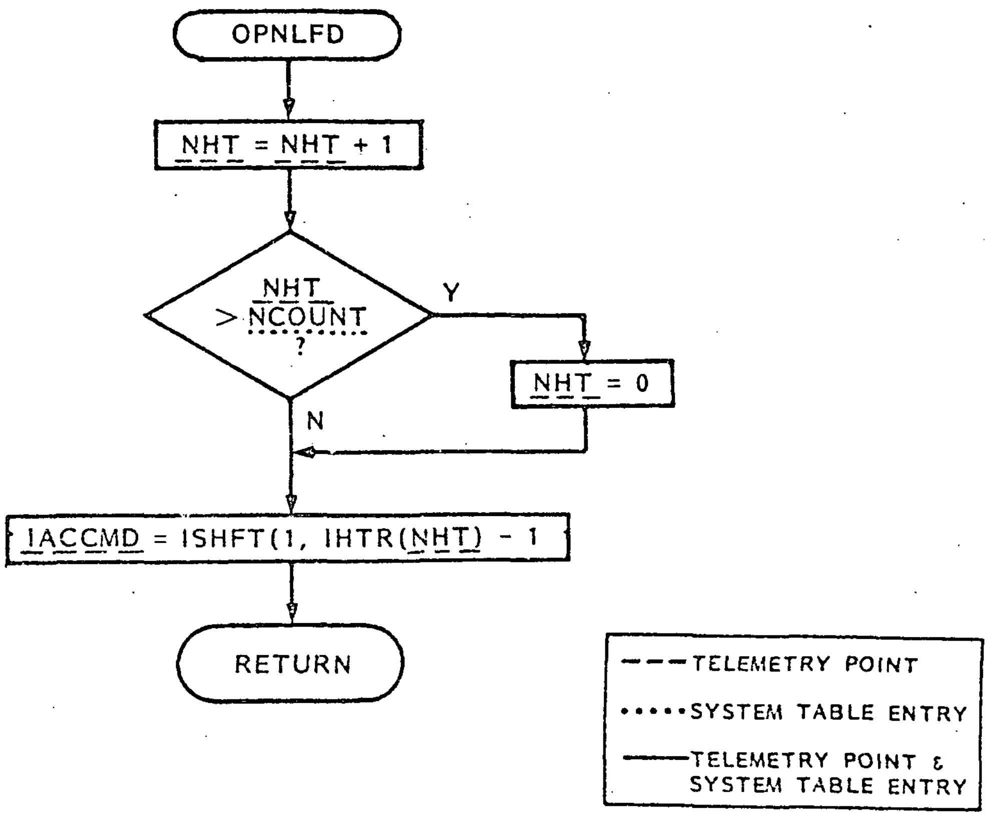

Figure B.3.12-42. OPNLFD Flow Chart

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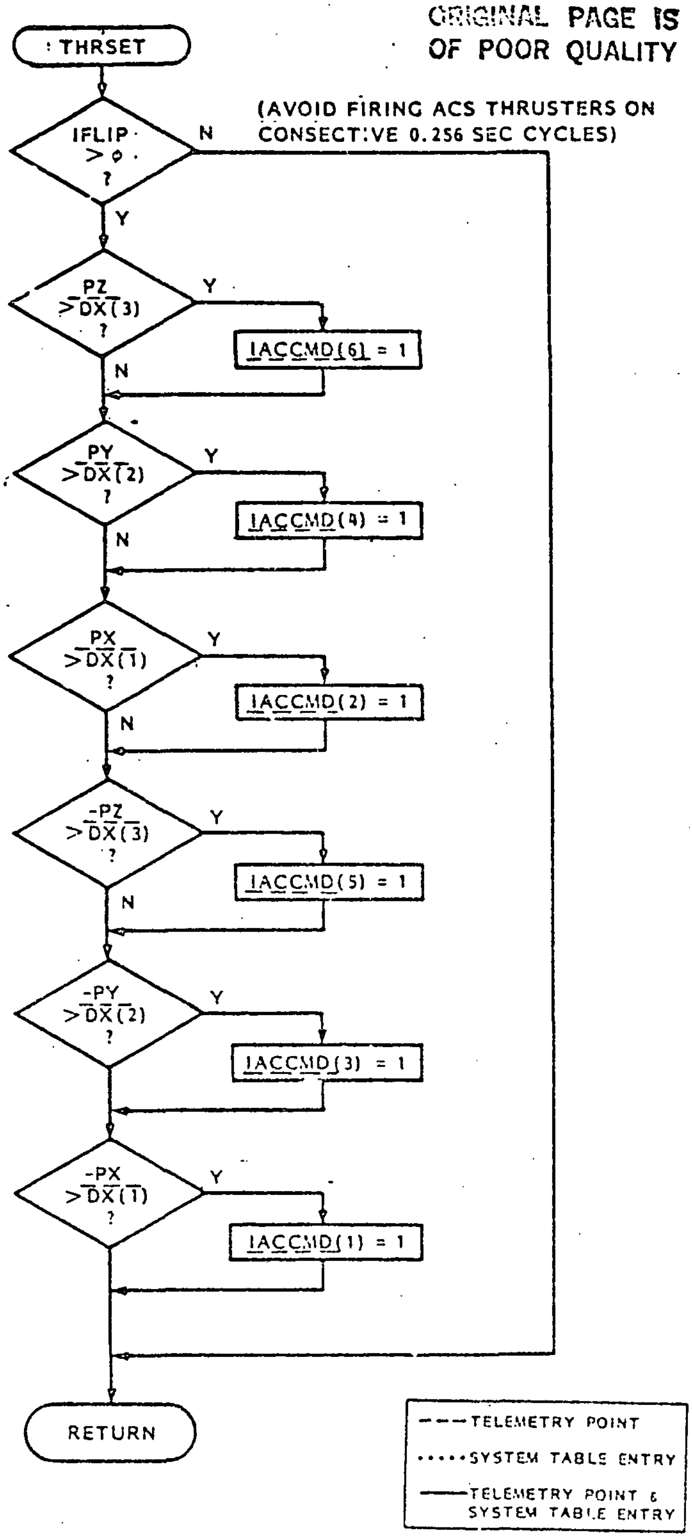

Figure B.3.12-43. THRSET Flow Chart

B.3.13 GMT UPDATE/CORRECTION (GMTCOR)

B.3.13 GMT UPDATE CORRECTION (GMTCOR)

B.3.13.1 GMT Update Correction (GMTCOR) Processor Description

The GMT Update Correction (GMTCOR) processor performs the function of providing a means by which the Flight Segment Clock (FSC) can be updated. This is accomplished using the current DPU time and update information uplinked from the Ground Segment. The Ground Segment, by either uplinked real time command or stored command, must "enable" GMTCOR in order for it to be executed, since this processor inhibits itself from further execution after it completes its function. Real time command and stored command formats are defined in SVS-10124, "Landsat-D Data Format Control Book, Volume III - Command".

The GMT Update Correction (GMTCOR) processor is an on-demand processor with a priority of 6 in the Flight Executive Scheduler Table. This processor consists of two subroutines as delineated in Table B.3.13-1 and a control function GMTCOR. This is diagrammed in Figure B.3.13-1. When execution of GMTCOR is requested, the GMTCOR control function verifies that the current telemetry minor frame number is greater than or equal to MNFRAME (8), and also less than or equal to MXFRAME (123). If both these conditions are satisfied, indicating that the Spacecraft Control Processor has had adequate time to decode the current DPU time, and that there is sufficient time to complete update of the DPU time prior to initiation of the next major frame, GMTCOR verifies the validity of the decoded DPU time. This is accomplished by checking TSDCDSTS, set in SCP processor. If all these conditions are satififsied, the control function calls GMTDUP subroutine to update the DPU time. This update utilizes the uplinked parameter DELTU, which appears in System Table #66. After the time is updated, GMTCOR formats the DPU time code comands and sends these commands to the DPU via the Flight Executive's high priority command stack to update the time. This is accomplished in the subroutine GMTSEND. The current DPU time and the updated DPU time are sent to the telemetry along with the status of GMTCOR, again set in the GMTCOR control function. GMTCOR status is defined by the word GMTSTAT. GMTSTAT can assume values equal to 1, 2, or 3. This appears in OBC Telemetry Report #37, Section B.3.13.5, with explanation of the meaning of assumed values. Further execution of GMTCOR is inhibited and control is returned to the Flight Executive.

If the indicated conditions for updating DPU time are not satisfied; that is, current telemetry frame number is <MNFRAME (nominally 8), or >MXFRAME (nominally 123), the update will not be executed, the processor exited and rescheduled 1.024 seconds later. If the decoded DPU time is invalid, however, the processor will be aborted, a status flag set to appear in telemetry to indicate same (GMTSTAT=3), and the processor inhibited. In the former situation, no new command is required to enable GMTCOR processing, while the latter situation requires a new real time or stored command.

The GMT Update Correction (GMTCOR) processor utilizes System Table #66, GMTCOR - GMT Update Correction Data. This table, consisting of 5 words sets minimum and maximum frame numbers relative to the telemetry frame boundaries in which GMTCOR shall be executed, and also contains the DPU offset. The table is discussed in greater detail in Section B.3.13.4.

GMTCOR provides inputs to OBC Telemetry Report #37. Those inputs are discussed in Section B.3.13.5.

Table B.3.13-1. GMT Update/Correction (GMTCOR)

GMT Update/Correction (GMTCOR)

Number:	9
Type:	On Demand Processor
Priority:	6
Period:	On demand by either uplinked real time command or stored command
Function:	Update and correction of Flight Segment Clock (FSC)

Subroutines:

GMTDPU	Update DPU time
GMTSEND	Send DPU time code commands

System Tables:

#	Mneumonic	Type	# Words	Description
66	GMTCOR	Variable	5	GMT Update/Correction Data

Telemetry Reports: OBC Report 37

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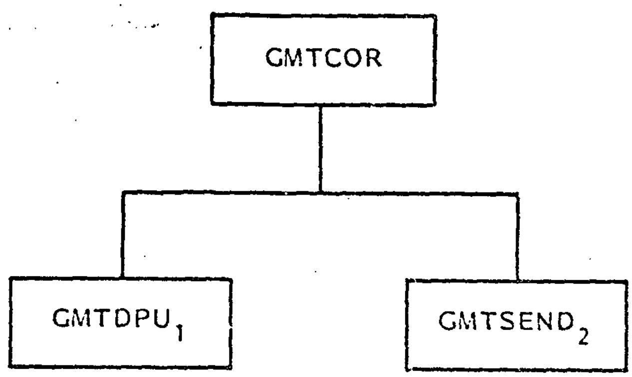

Figure B.3.13-1. GMTCOR Top Level Diagram

B.3.13.2 GMT Update Correction (GMTCOR) Processor Operation

As shown in Figure B.3.13-1, GMTCOR processor consists of the GMTCOR control function and two subroutines, GMTDPM and GMTSEND. The control function is described in Section B.3.13.1, Processor Description and the subroutines described here in Sections B.3.13.2.1 and B.3.13.2.2.

B.3.13.2.1 Subroutine GMTDPU

This subroutine, GMTDPU, updates the DPU time. The DPU time, TDPU, a triple precision word in the Spacecraft Control processor expressed in milliseconds, is brought to the working area (expressed as TDPUCUR). The new DPU time, TUPDATE, is computed by first generating TUPDATE as a function of DELTU, where DELTU represents the required correction for leap second time change and/or time drift in excess of the 20 millisecond specification, and then computing TUPDATE as the sum of TUPDATE and the current DPU time, TDPUCUR. TUPDATE is then converted from milliseconds to days, hours, minutes, seconds, and milliseconds. The subroutine is exited and control is returned to GMTCOR control function.

B.3.13.2.2 Subroutine GMTSEND

The subroutine GMTSEND, send time code commands, takes the outputs of GMTDPU, and formats these data into four commands which are then sent to the DPU via the Flight Executive high priority command stack. These commands are sent using the proc CMDS. TDPUCUR and TUPDATE are then moved into telemetry buffer GMT%01 and the subroutine is exited; control is returned to the GMTCOR control function.

B.3.13.3 GMT Update Correction (GMTCOR) Software Constraints

GMTCOR will be executed on demand when DPU time is in error $\geq$20 millisec, or when a leap second update is desired. Under no circumstances will either correction be made when the Landsat-D Flight Segment is imaging. Additionally, the leap second update will be made in conjunction with associated leap second procedures as outline is SVS-10147, Vol.1, "Landsat-D FS Flight and Operations Plan for the OCC." The constraint here is that the correction will be made concurrent with the first OBC ephemeris parameter update which occurs subsequent to the announcement of UTC leap second correction.

B.3.13.4 GMT Update Correction (GMTCOR) System Table

The GMTCOR processor utilizes System Table #66, GMT Update/Correction Data.

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #66 - GMTSYSTB (GMT System Table)					
0000	DELTU		V	GMTDPU	This is the offset for DPU counter correction estimated update frequency is ~once/day or when spacecraft clock is >20 ms out of sync.
0003	MNFRAME		C	GMTCOR	Minimum minor frame number on which GMTCOR will be executed initialized to 8.
0004	MXFRAME		C	GMTCOR	Maximum minor frame number on which GMTCOR will be executed. Initialized to 123.

B.3.13.5 GMT Update/Correction (GMTCOR) Telemetry

The GMTCOR processor contributes to Telemetry Report #37.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #37			
0000	GMTSTAT	GMTCOR	GMTCOR status flag 1 => Awaiting minor frame #8 2=> DPU time update (Decoded DPU time in error)
0001	TDPUCUR	GMTSEND	Current DPU time (equal TDPU)
0007	TDUPDATE	GMTSEND	Updated DPU time

B.3.13.6 GMT Update Correction (GMTCOR) Flow Charts

Figures B.3.13-2 through B.3.13-4 present the flow charts for the GMTCOR processor.

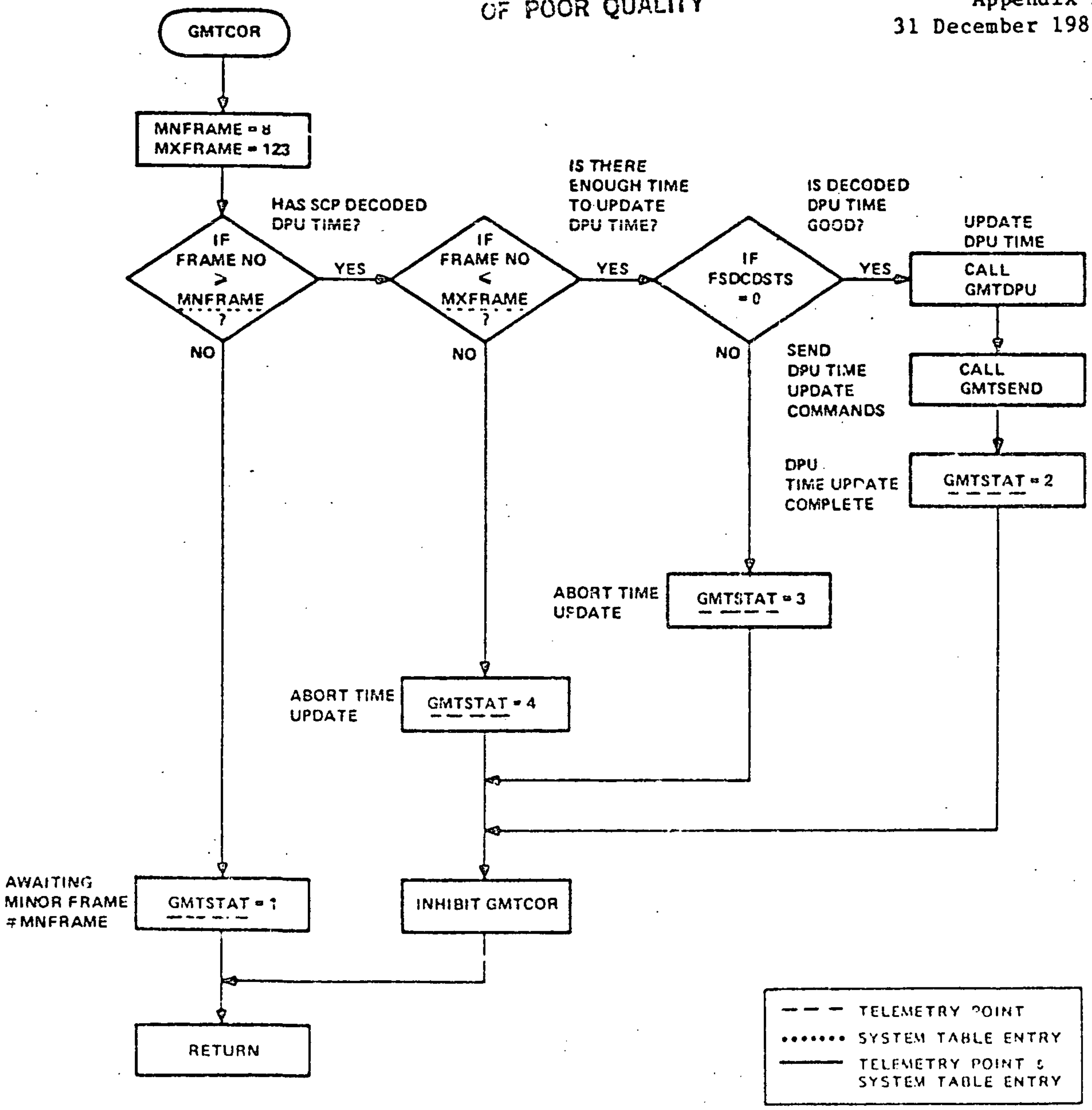

Figure B.3.13-2. GMTCOR Flow Chart

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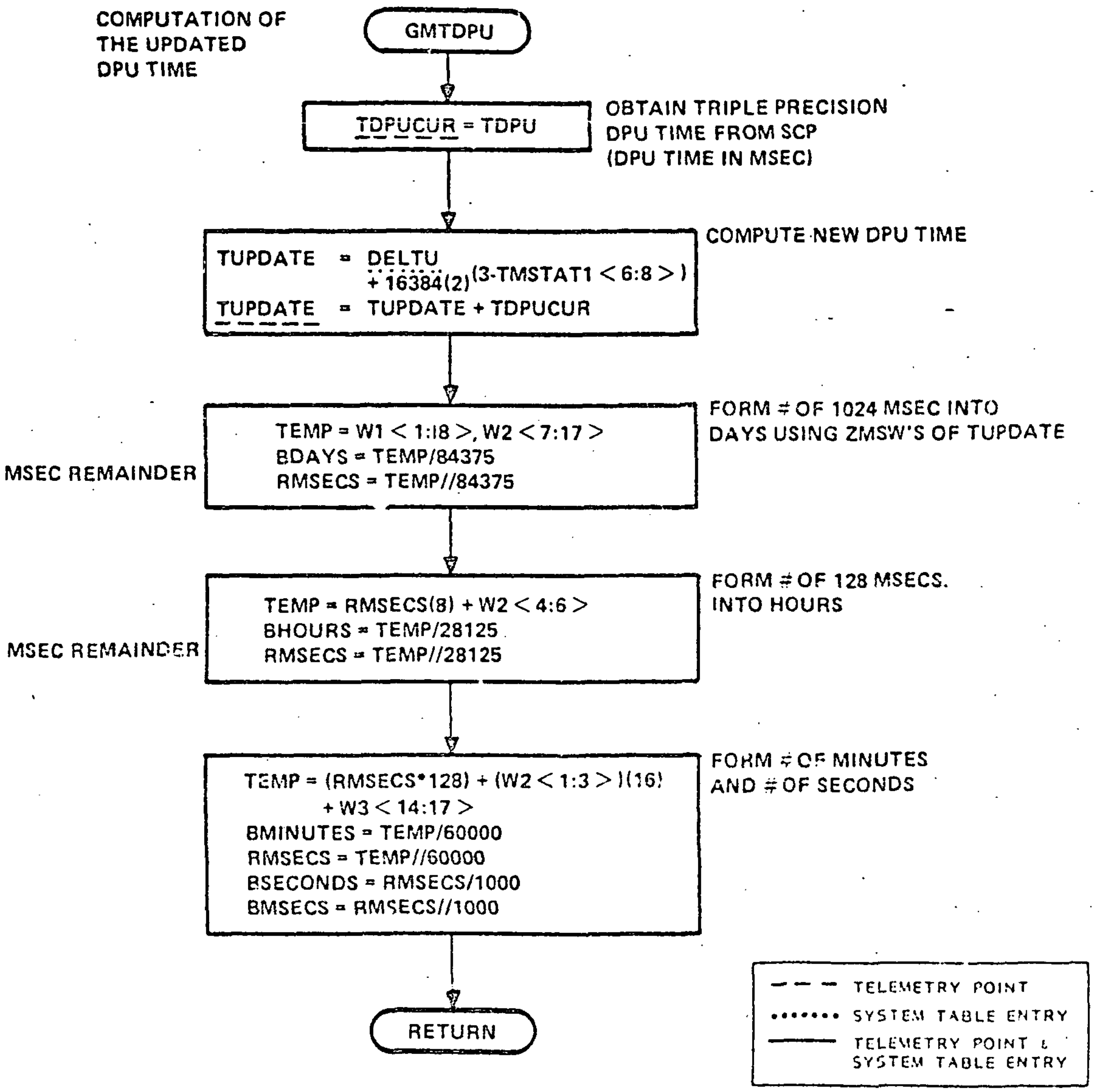

Figure B.3.13-3. GMTDPU Flow Chart

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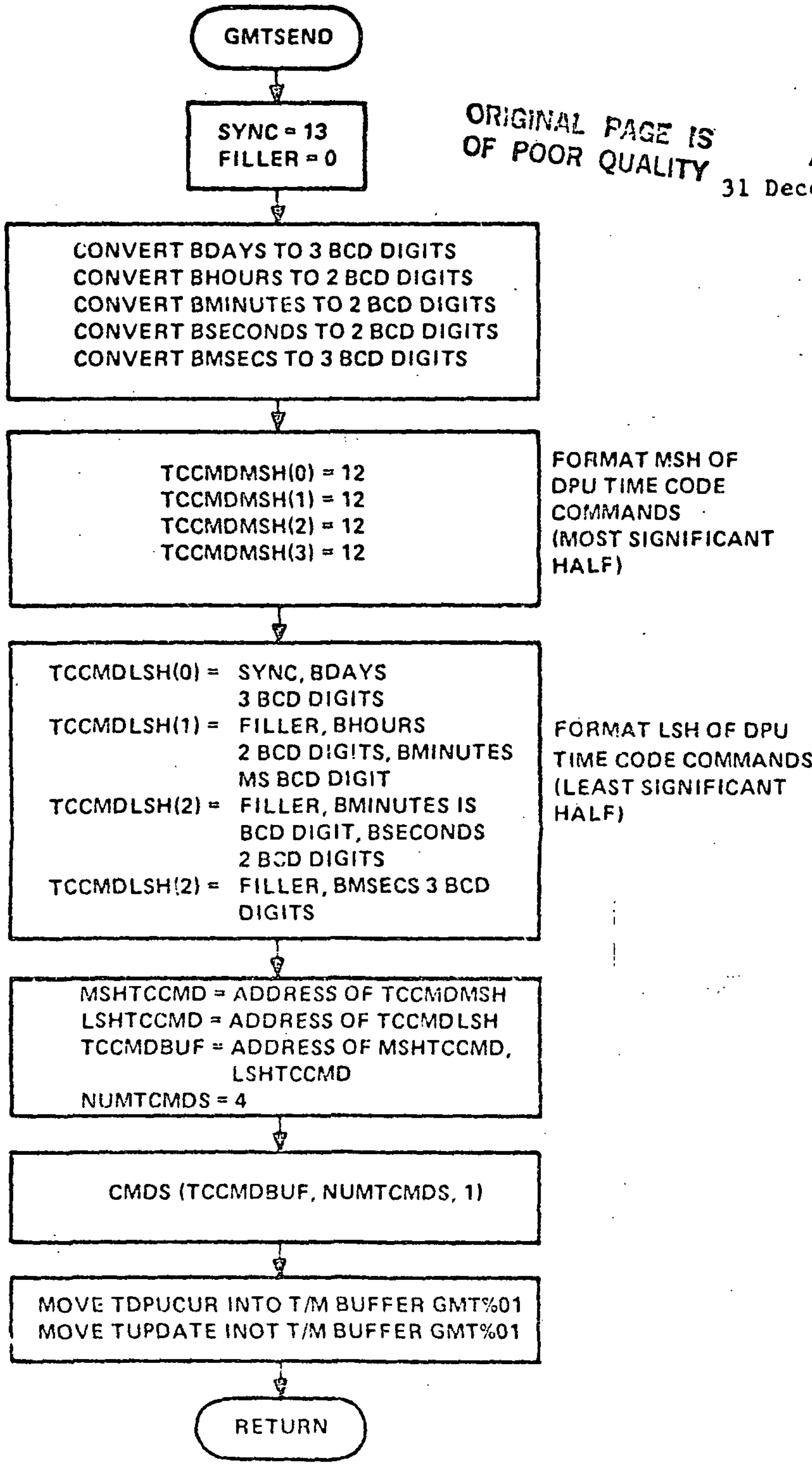

Figure B.3.13-4. GMTSEND Flow Chart

B.3.14 FAIL CHECK (FAIL CK)

B.3.14 FAIL CHECK (FAILCK)

B.3.14.1 Fail Check (FAILCK) Processor Description

The FAILCK processor sends out pulse commands once a second to the Attitude Control System, Modular Power Subsystem, and Command and Data Handling Subsystem to provide indication to these subsystems that the OBC is operating normally. If this computer status monitor is not received by the named subsystems for a period of approximately 3 seconds, the spacecraft will be placed into Safehold taking control of the spacecraft away from the OBC. The processor uses System Table 16 for the commands to be transmitted. When this processor is initialized it jumps back to the top of the command table, otherwise it continues to cycle thru the command list. The FAILCK processor is summarized in Table B.3.14-1.

Table B.3.14-1. Fail Check (FAILCK)

Number: 10
Type:
Priority: 7
Period: 3 times each 1.024 sec
Function: Provide Computer Status Monitor (CSM) ("I'M OK" signal) to the ACE, MPS and C&DH subsystems

Subroutines: None

System Tables:

#	Mneumonic	Type	# Words	Description
16	FAILCMDS	P		Failure detection signal commands
17	FLCMDEND	P		End of table for fail det signals

Telemetry Reports: None

B.3.14.2 Fail Check (FAILCK) Processor Operation

See the flowchart in Section B.3.14.6.

B.3.14.3 Fail Check (FAILCK) Software Constraints

TBD

B.3.14.4 Fail Check (FAILCK) System Tables

Entry	Name	TLM	Using Subroutine	Description/Remarks
System Table #16 (FAILCMD)				
0 2 4 6	FAILCMDS		FAILCK	Commands to be sent out by FAILCK

Entry	Name	TLM	Using Subroutine	Description/Remarks
System Table #17 (FLCMEND)				
0	FLCMEND		FAILCK	End of commands for FAILCK

B.3.14.5 Fail Check (FAILCK) Telemetry

None

B.3.14.6 Fail Check (FAILCK) Flow Charts

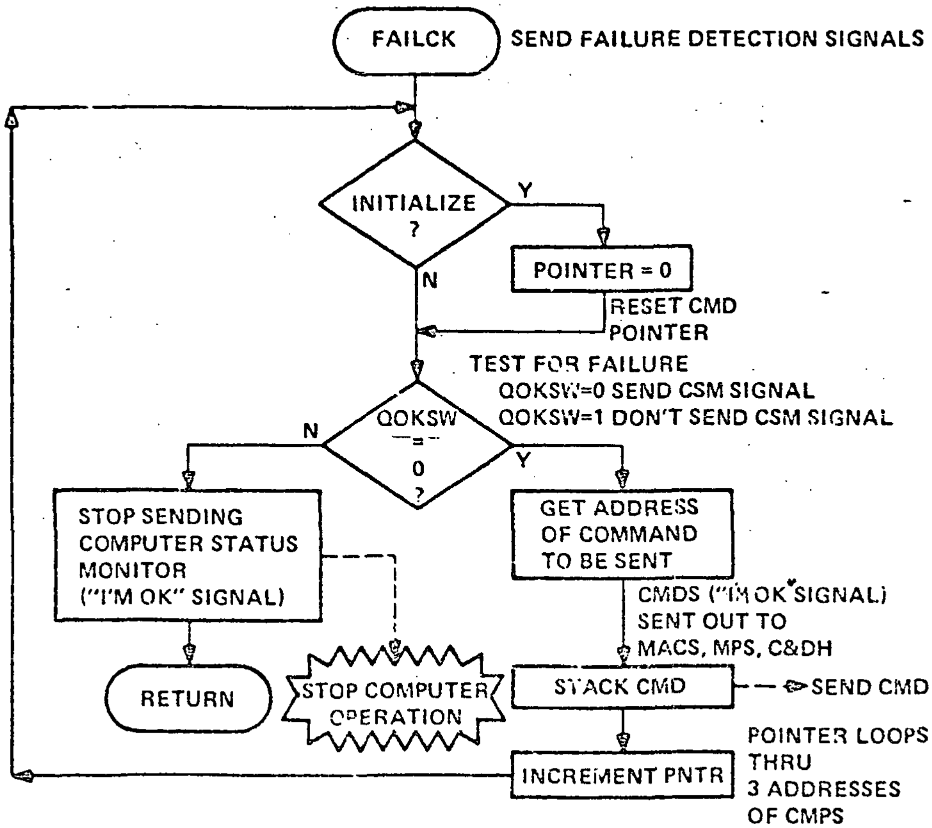

Figure B.3.14-1. FAILCK Flow Chart

B.3.15 ABSOLUTE TIME COMMAND PROCESSOR (ATCP)

B.3.15 ABSOLUTE TIME COMMAND (ATCP)

B.3.15.1 Absolute Time Command (ATCP) Processor Description

The Absolute Time Command Processor (ATCP) sends commands from the stored command buffer. Each stored command has a time tag associated with it. The ATCP takes the 18 low-order bits of time tags as 18-bit positive numbers and compares them with an 18 bit "Clock Word" derived from Flight Software Time. When the two numbers are equal, the command is sent.

Commands are processed sequentially and a time tag is not examined until the preceding command has been sent. If commands are out of order so that a command is not reached until after its time has passed, all stored command processing will stop. It will not resume until the "Clock Word" has will not resume until CLOCK/18 has cycled past zero and the time given in the time tag has again been reached. A complete cycle takes a little over 37 hours.

Commands with identical times are packed into batches and sent as close to maximum hardware speed as possible (one command each millisecond). Batches will have 16 commands if possible. Shorter batches may be necessary because pulse commands must start a new batch and all commands in a batch must occupy sequential locations in the stored command buffer. The ATCP can send several batches of commands during one execution.

The Executive Command Stack stores ATCP-sent commands for distribution or execution. If the stack is full when ATCP sends a command, then up to 7 commands can be temporarily saved for and re-sent on the next ATCP execution.

The remaining ATCP capabilities include both pseudo-op command processing and inhibiting command sending if certain unpredictable conditions are discovered by TMON Processor.

ATCP is executed every 1.024 seconds as an Executive Scheduler Table entry. ATCP is comprised of the following subroutines and processors.

ATCP - ATCP Main Routine

STAT - (Processor) Stores a report in the status buffer.

ESR - (Processor) Sets a bit in the Executive Status Report

CMDS - (Processor) Asks the Executive to stack a request for sending a burst of commands

PSUEDO - (Subroutine) Executes psuedo-op functions

JUMP - (Subroutine) Changes the stored command buffer pointer to a new location.

PGONEXT - (Subroutine) Skips the current command and goes to the next

HALT - (Subroutine) Inhibits ATCP from execution

PREDEF - (Subroutine) Sends a pre-defined block of commands

ACTIVRTS - (Subroutine) Activates a Relative Time Sequence

SWCPCTL - (Subroutine) Controls processors

SWSYSTAB - (Subroutine) Loads a system table

SENDCMDS - (Subroutine) Asks the executive to stack a batch of commands for sending

NEXT - (Processor) Increments the stored command buffer pointer

RETURN - (Subroutine) Returns to the Executive or STCDRIVE

EXITX - (Processor) Interrupts the Executive

SEND - (Processor) Adds a block of commands to the Executive Command Stack for sending

RTRN - (Processor) Return to the Executive or STCDRIVE

B.3.15.2 Absolute Time Command (ATCP) Processor Operation

B.3.15.2.1 ATCP Operation Description

Section B.3.15.6 contains a detailed flowchart of ATCP operation. The following document gives an in depth description of ATCP programming details and operation:

Multimission Modular Spacecraft
Absolute Time Command Processor
Program Documentation
October, 1978
Goddard Space Flight Center
Greenbelt, Maryland
408-2110-0007

The flowcharts in the above report do not reflect changes made to ATCP by General Electric. Therefore, flowcharts in Section B.3.15.6 should also be referenced.

B.3.15.3 Absolute Time Command (ATCP) Software Constraints

ATCP has no software contraints.

B.3.15.4 Absolute Time Command (ATCP) System Tables

ATCP has no system tables.

B.3.15.5 Absolute Time Command (ATCP) Telemetry

ATCP contributes to telemetry in three ways. The first is by setting bits in the Executive Status Report. The second way is by storing reports in the Status Buffer. The third and final method is through a single telemetry report. Each of these contributions is described below.

B.3.15.5.1 Executive Status Report Bits

The Executive Status Report is in OBC telemetry report #39. This occurs four times in the telemetry matrix - in minor frames 7, 39, 71 and 103. In each minor frame, the report is found in words 91 to 95 and words 108-127.

Table B.3.15.5-1 shows two classes of bits, those set by ATCP and those set by the Flight Executive (Bits 83 and 84). The table gives the meaning of each bit and whether it is latched* or not.

*Latching means that once a bit is set to 1, it remains set until the entire buffer is zeroed by ground command.

Table B.3.15.5-1. Executive Status Report Bits for ATCP

Bit #	Latched	Bit Meaning
21	Yes	Invalid Psuedo-op in Absolute Time command
22	Yes	Absolute Time command lost due to command stack overflow
23	Yes	Invalid starting point for Absolute Time command processing
84	No	Processor inhibited from sending commands
85	No	Processor inhibited from executing
129	Yes	Too many commands for the processor command storage area

B.3.15.5.2 Status Buffer Report

ATCP will store error information in certain status buffer reports. The buffer is presently not part of telemetry and can only be examined through a buffer dump.

Status report codes are defined in SVS-10123 Data Format Control Book, Vol II (Telemetry) and S-700-56 MMS OBC Flight Executive Technical Description, Appendix B.

B.3.15.5.3 ATCP Contribution to OBC TLM Reports

There is one item contributed to OBC TLM other than those found in Telemetry Report #39 and that is Absolute Time Command Pointer (ATCPTR). This resides in words 1 and 2 of OBC Telemetry Report #45.

The balance of report #45 is devoted to RTCP telemetry.

Entry #	Name	Generating Subroutine	Description/Comment
ATCP OBC TLM Report #45			
0	SCPRPRT	ATCP	Current Absolute Time Command Pointer

B.3.15.6 Absolute Time Command (ATCP) Flow Charts

To help the reader understand the flowcharts, the following explanations are made.

- Program segments called more than once were arbitrarily made subroutines. When these subroutines are called in the flowchart, a circled letter is attached to the box. This identifies the sheet that the subroutine is flowcharted on.

- In the main flowchart there are places where a subroutine is called, but nothing follows that box. This means that the program flow continues in the subroutines, and that it will eventually RETURN from there.

- A description of an operation is used whenever possible.

- The following flowchart variables always represent certain registers:

  ACC = Accumulator register
  EACC = Extended accumulator register
  X = Index register

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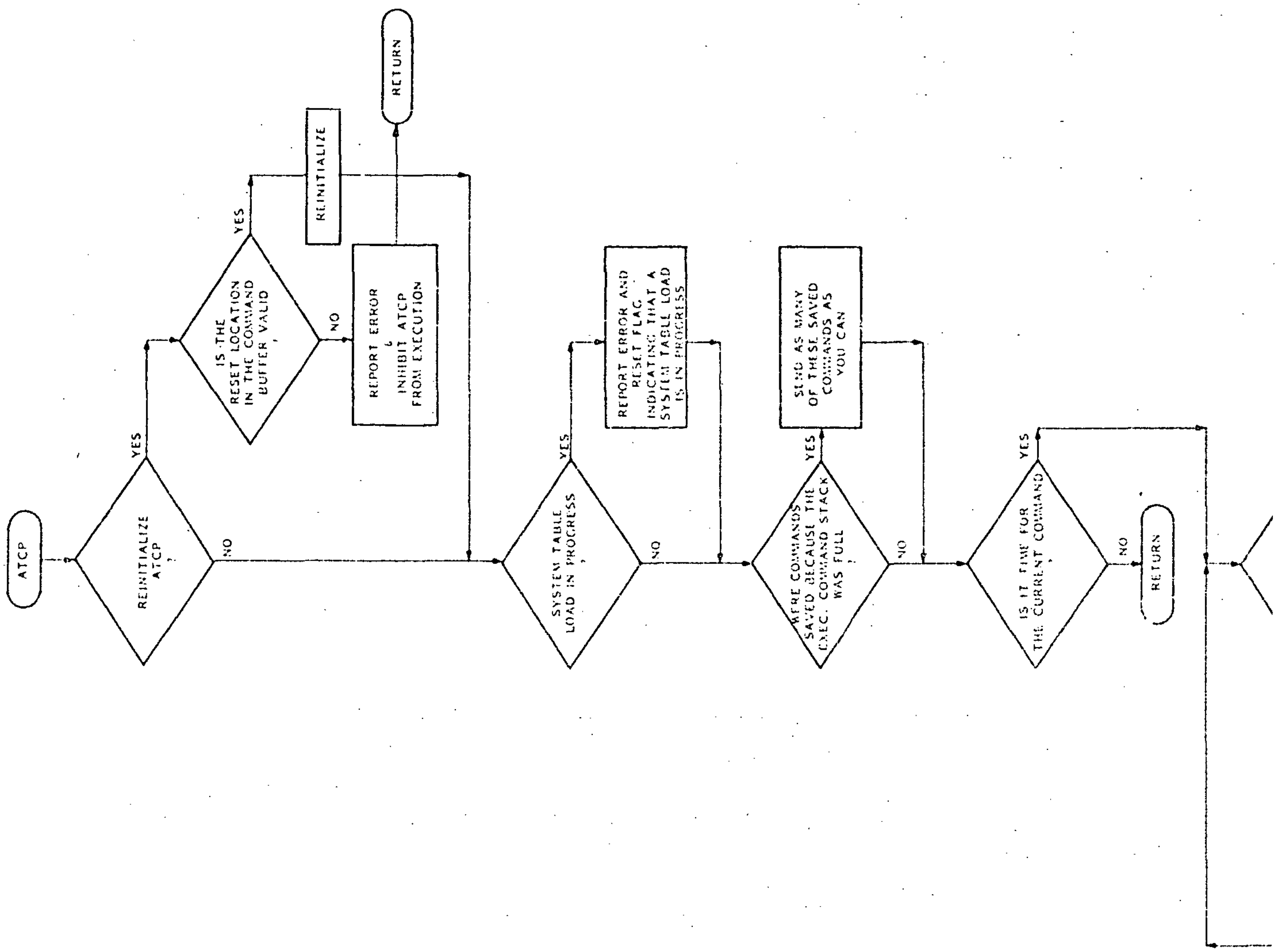

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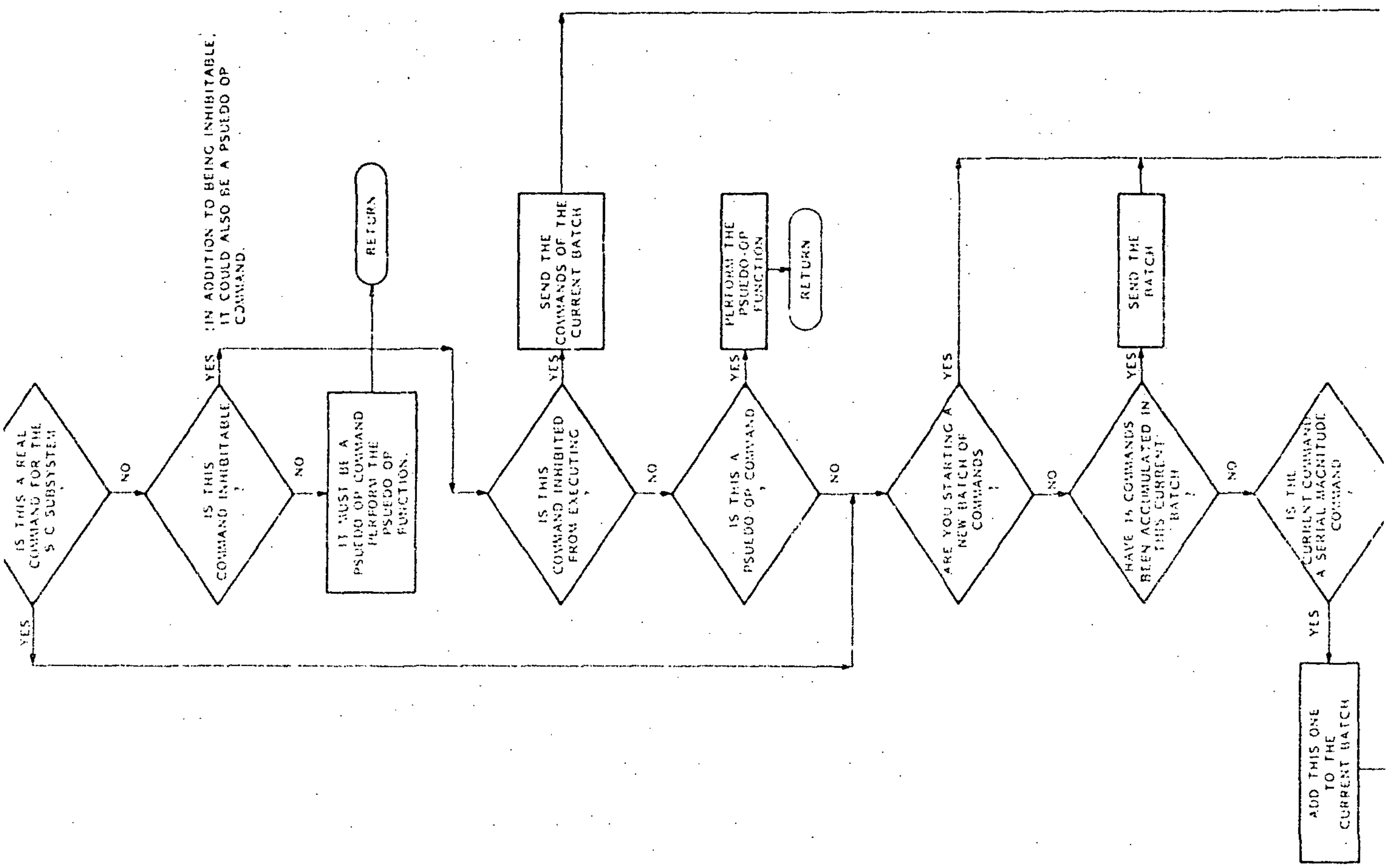

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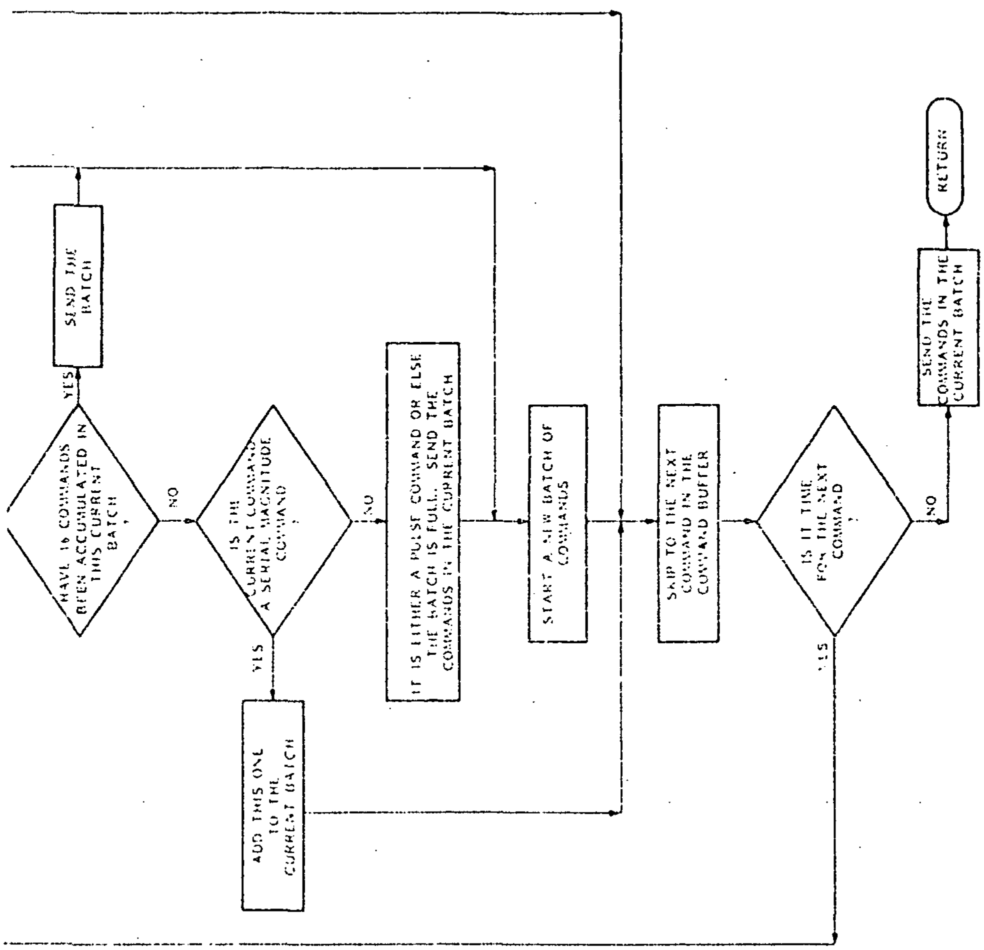

Figure B.3.15-1. ATCP Top Level Flow Chart

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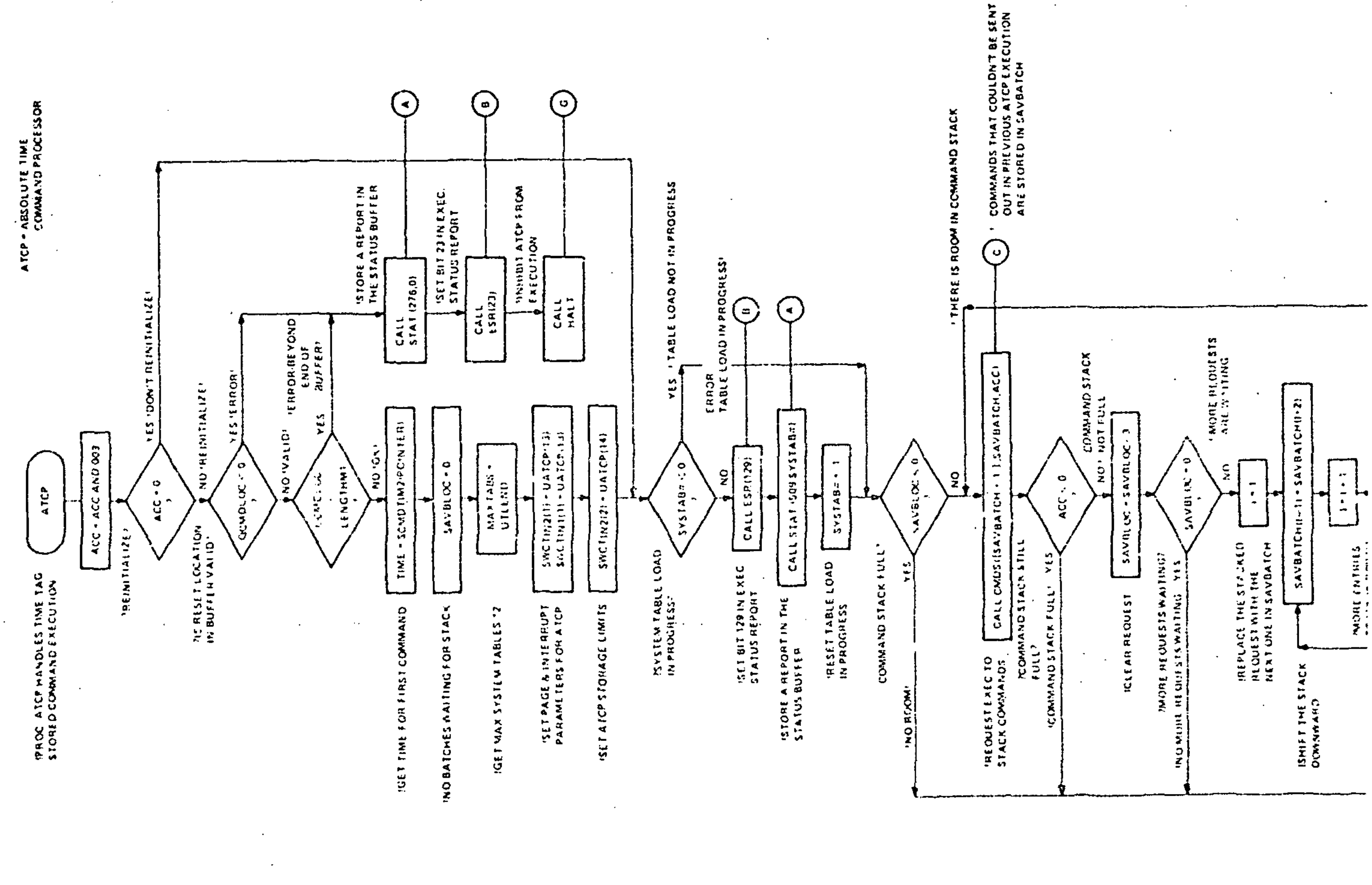

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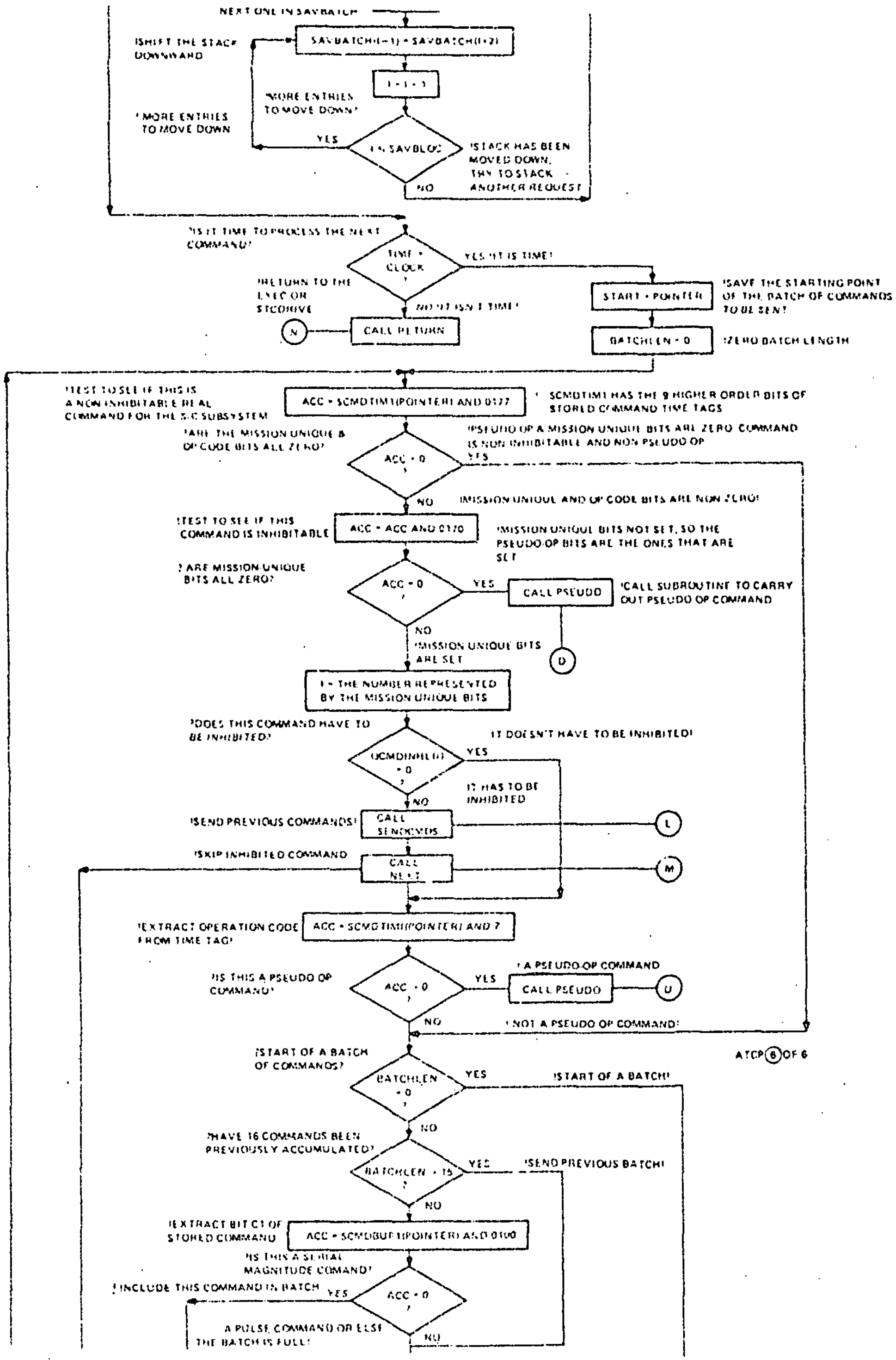

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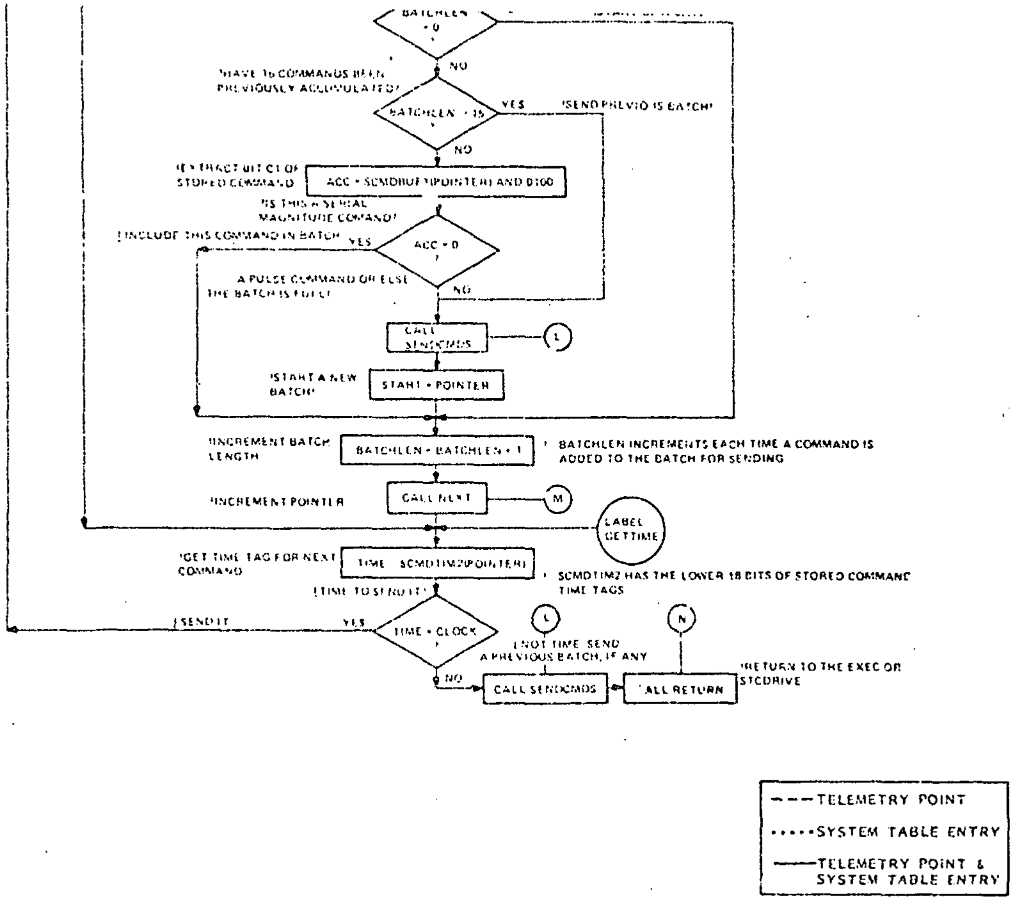

Figure B.3.15-2. ATCP Detailed Flow Chart

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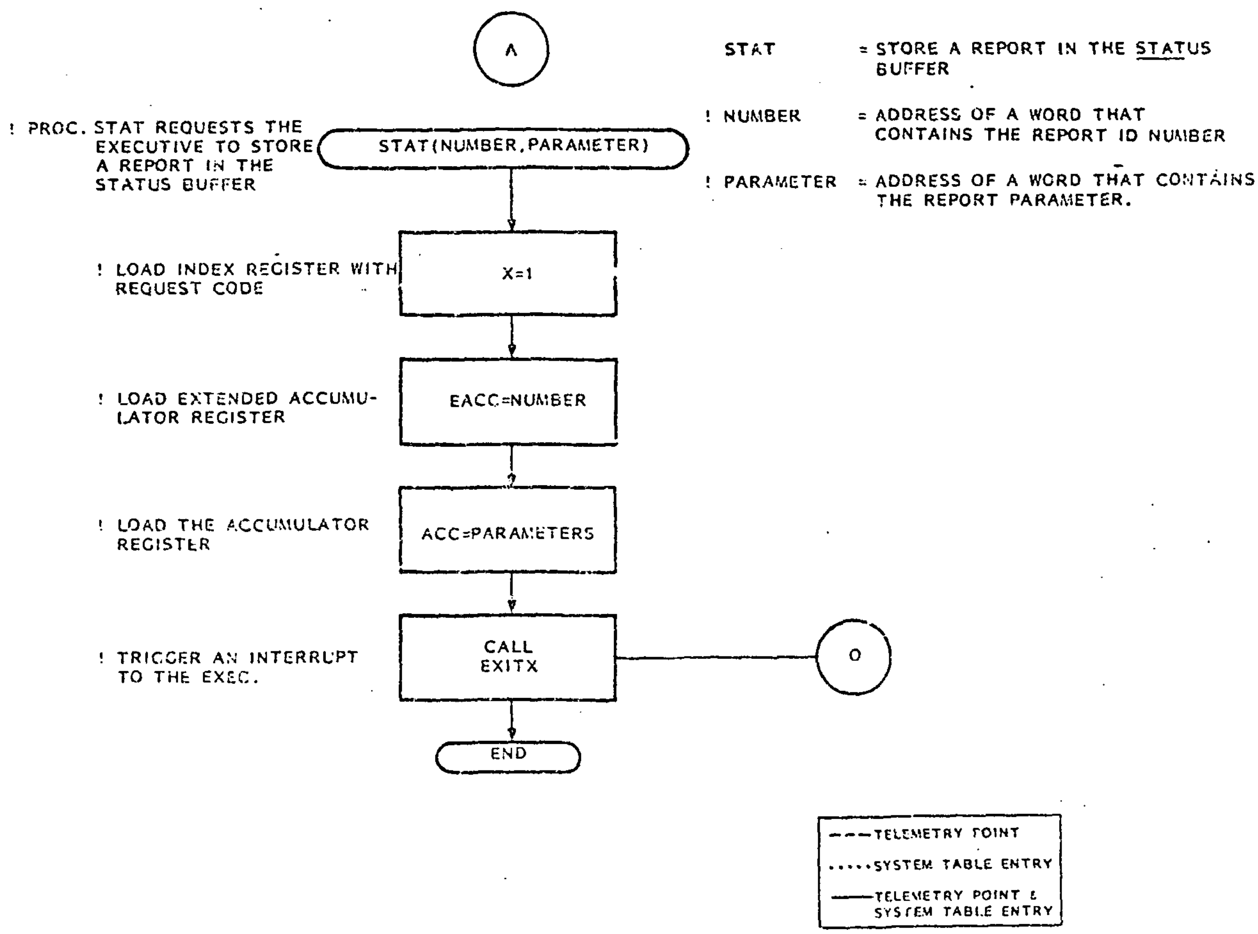

Figure B.3.15-3. STAT Flow Chart

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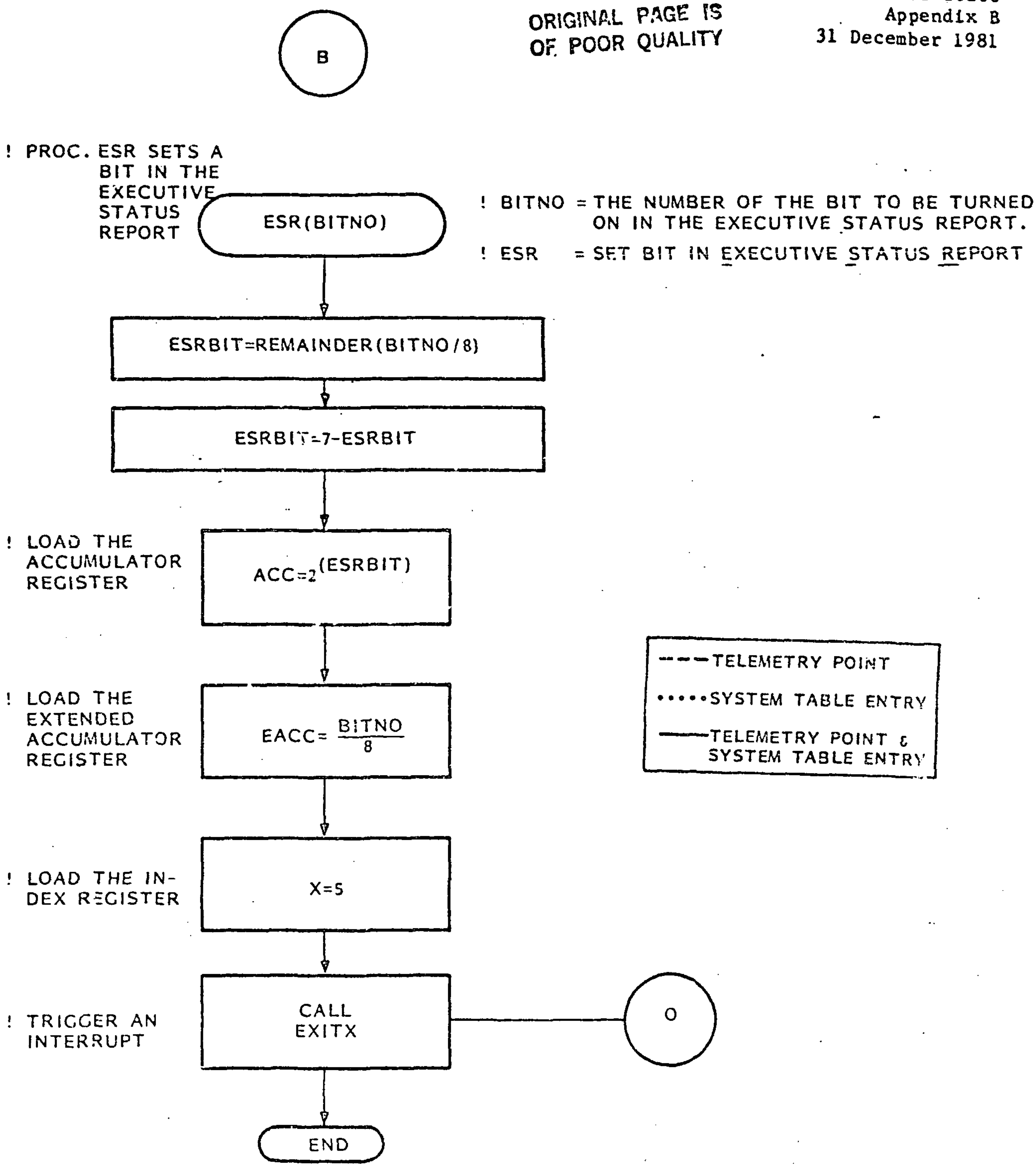

Figure B.3.15-4. ESR Flow Chart

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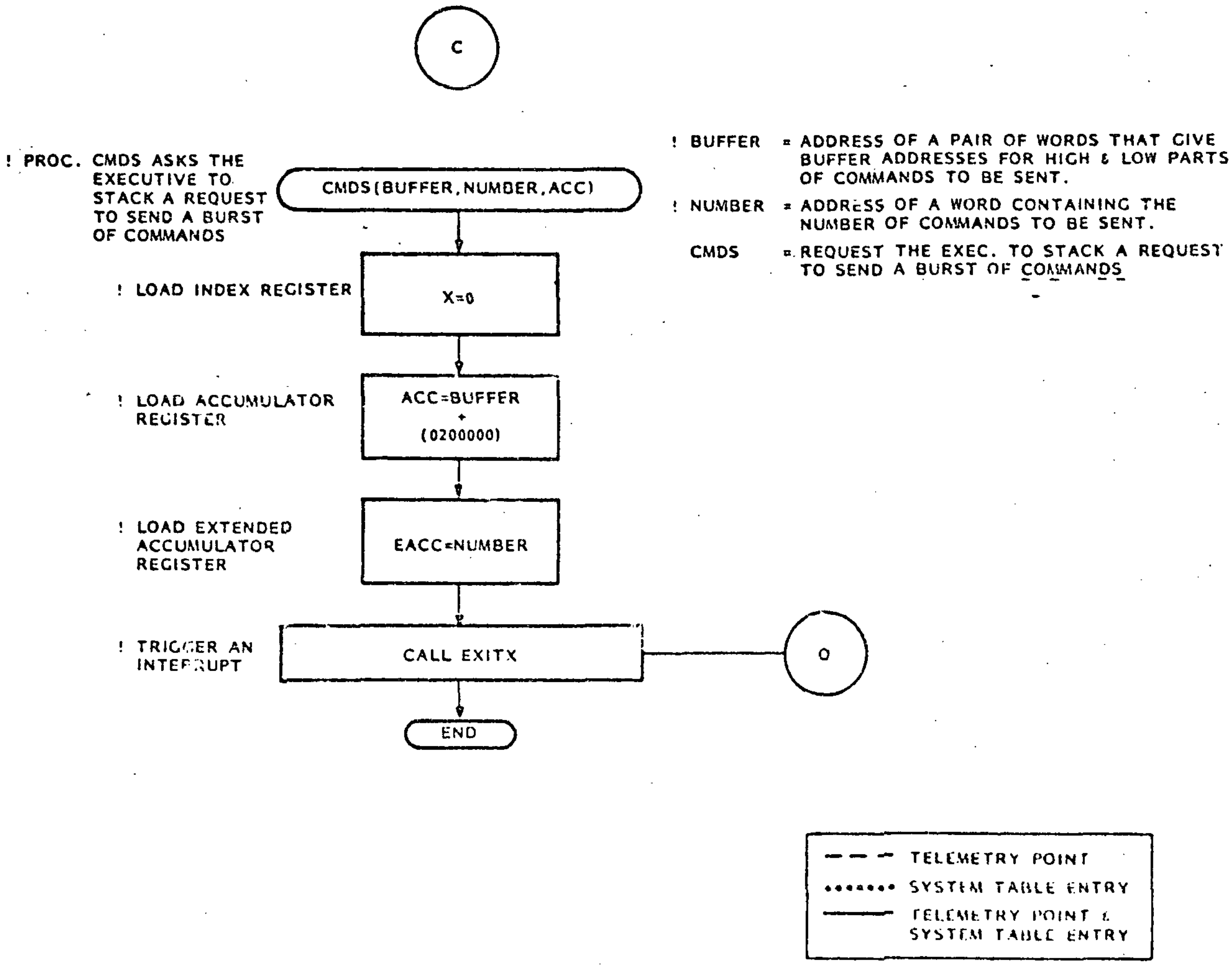

Figure B.3.15-5. CMDS Flow Chart

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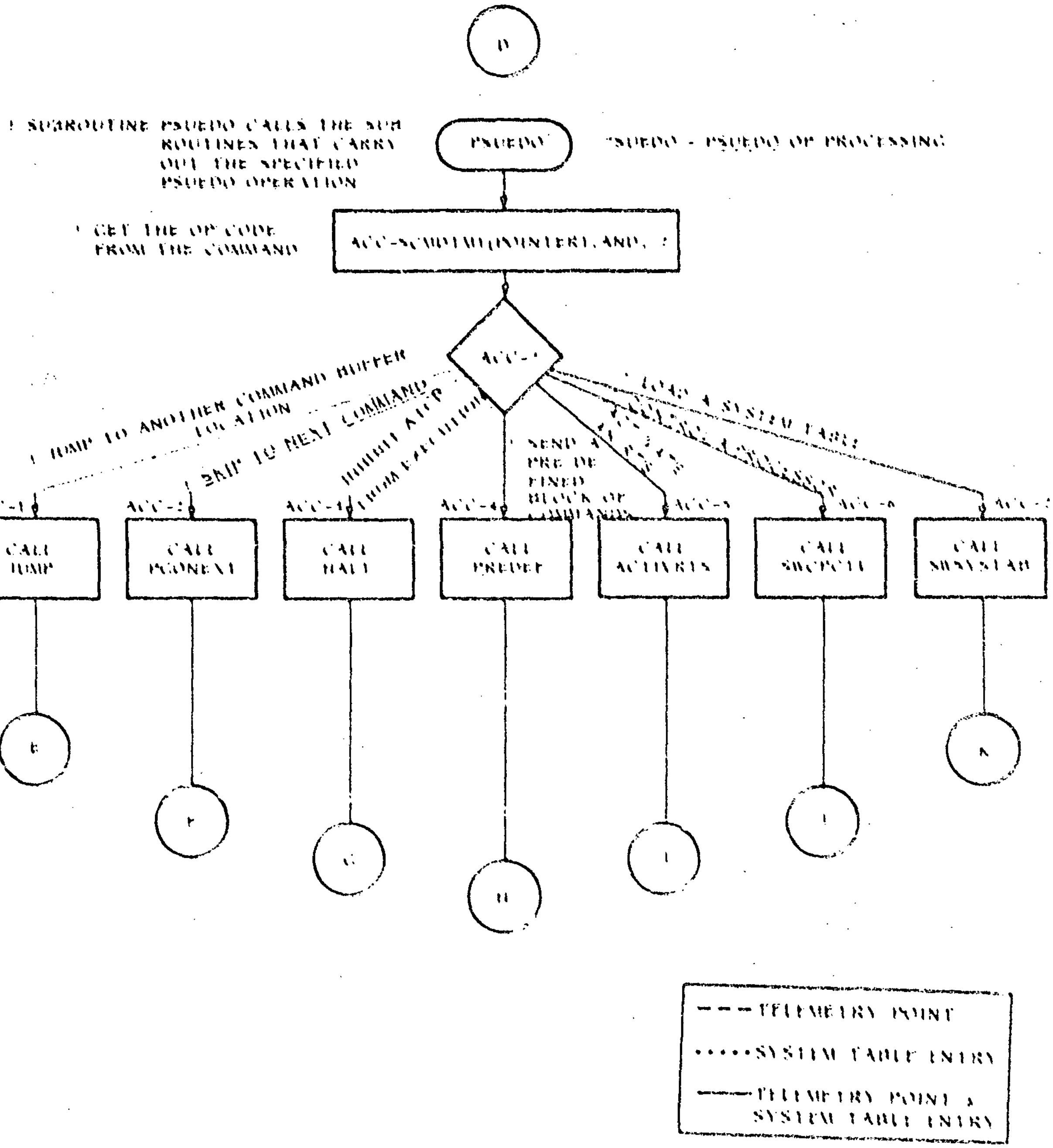

Figure B.3.15-6. PSUEDO Flow Chart

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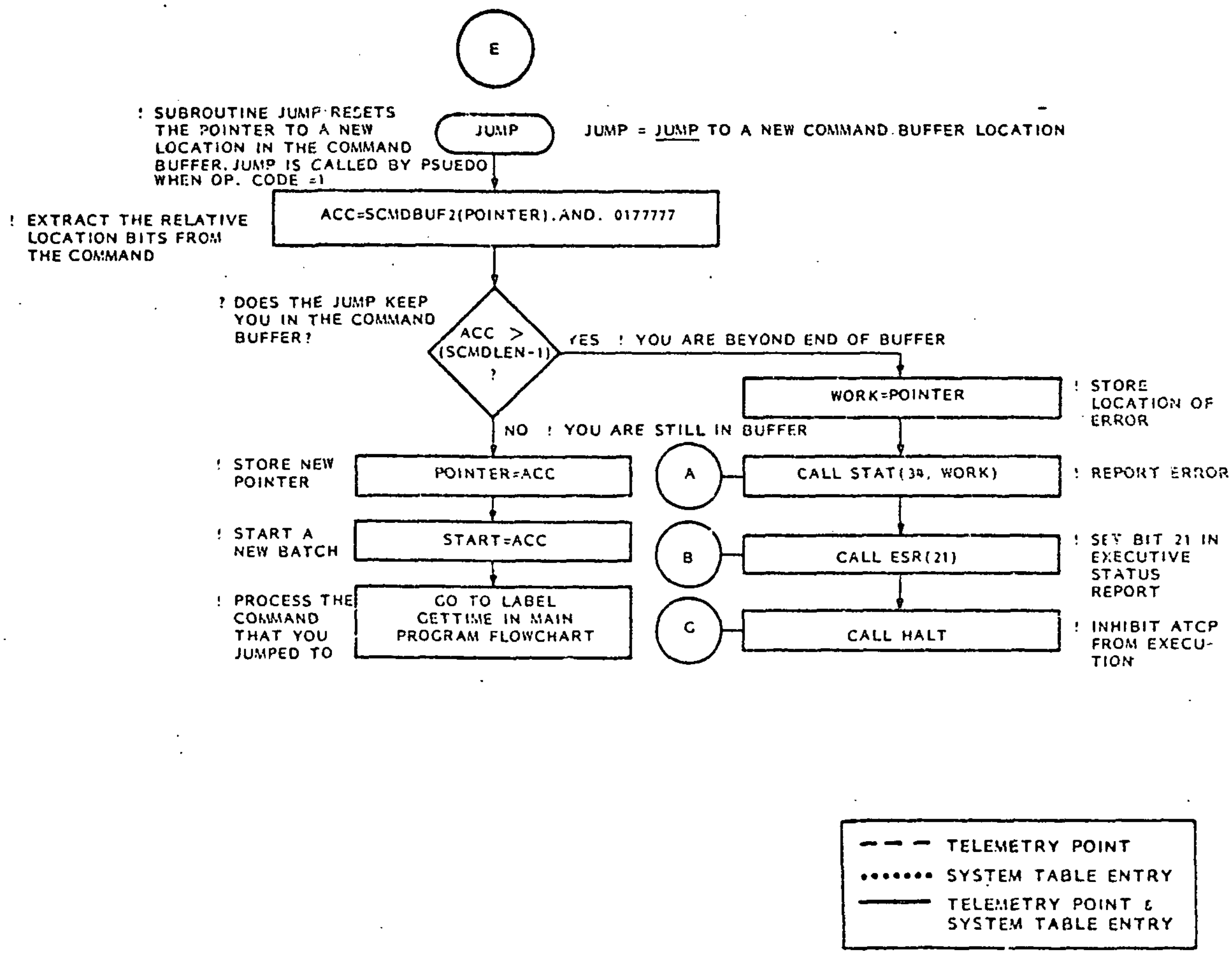

Figure B.3.15-7. JUMP Flow Chart

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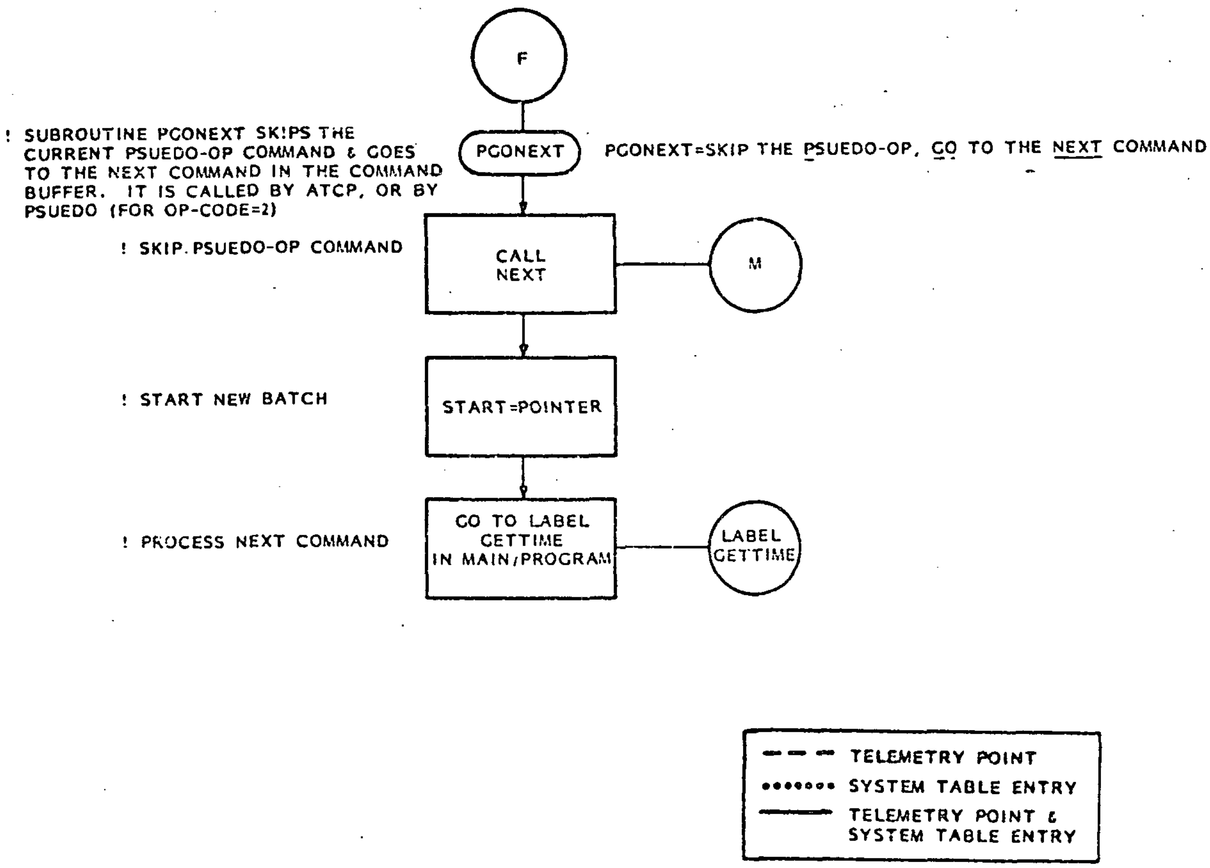

Figure B.3.15-8. PGONEXT Flow Chart

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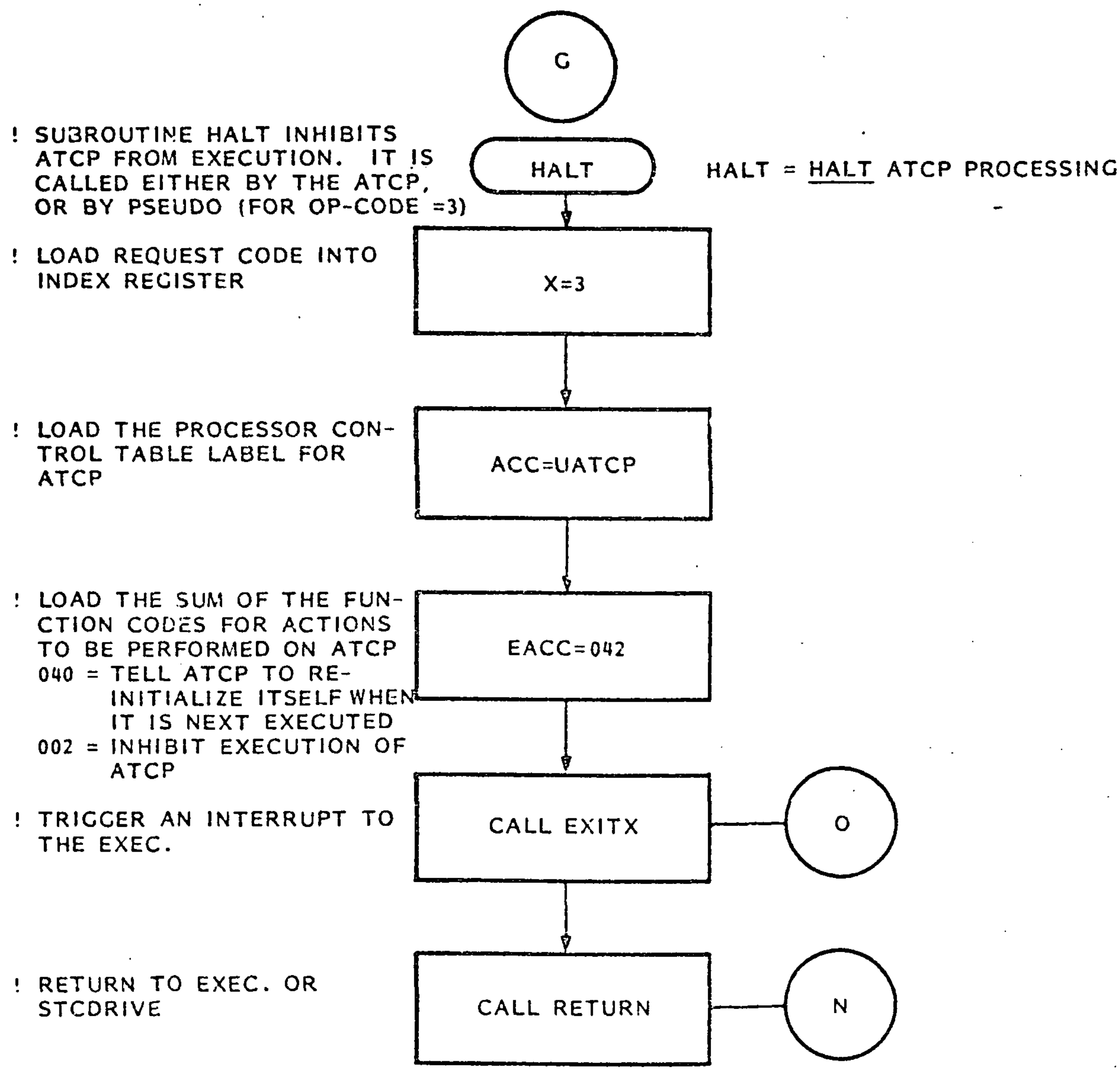

Figure B.3.15-9. HALT Flow Chart

---TELEMETRY POINT
.....SYSTEM TABLE ENTRY
——TELEMETRY POINT & SYSTEM TABLE ENTRY

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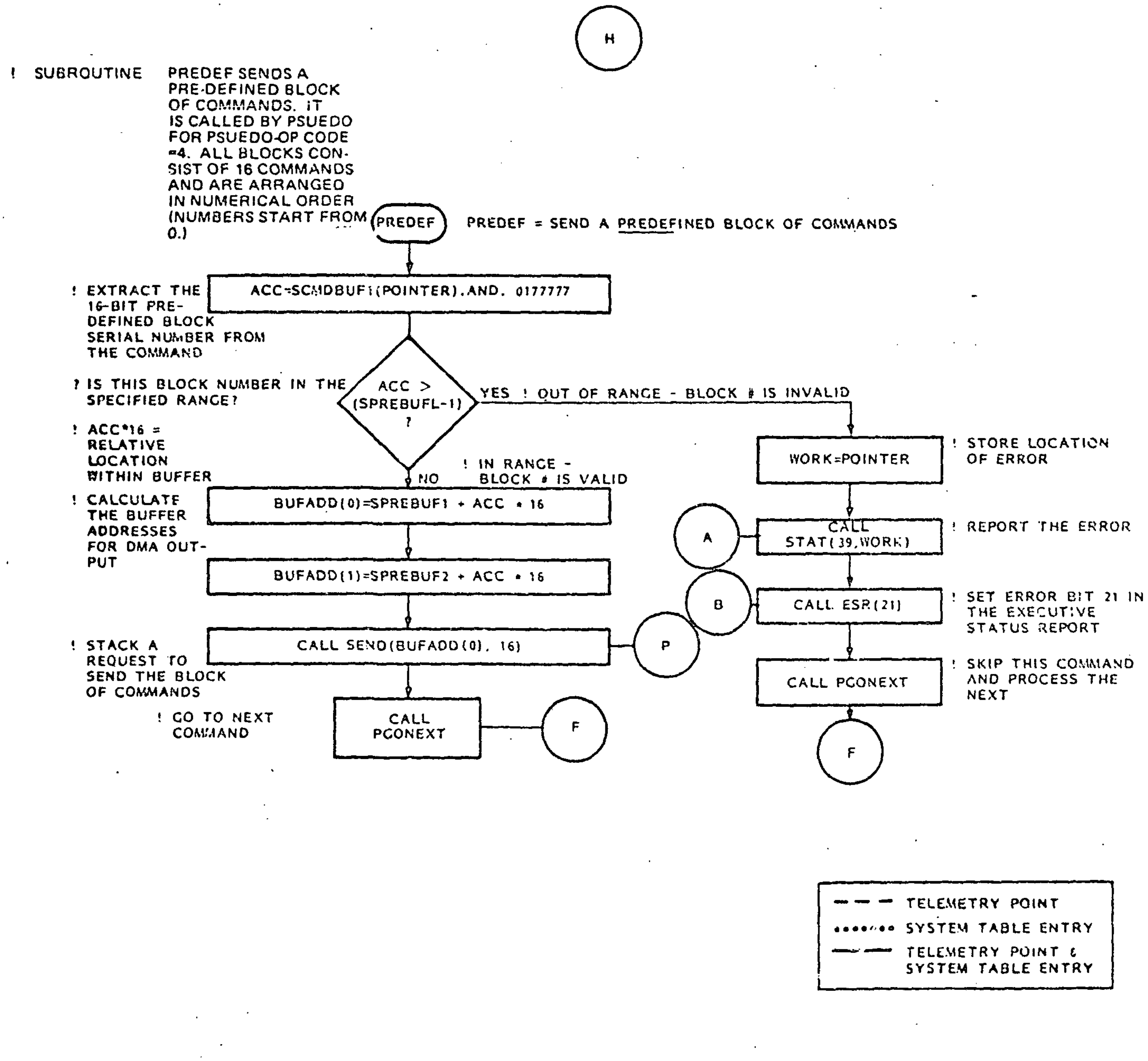

Figure B.3.1-10. PREDEF Flow Chart

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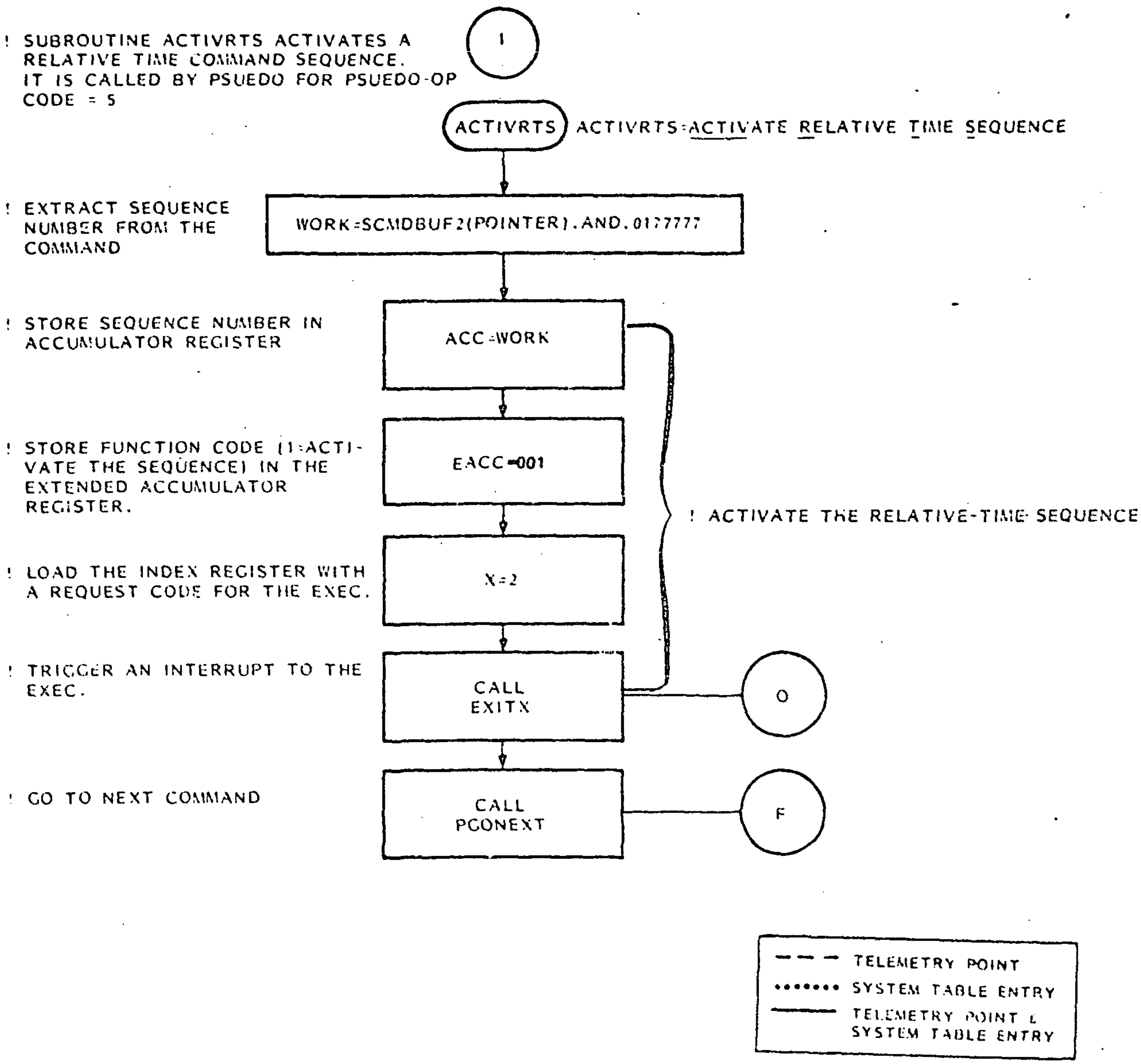

Figure B.3.15-11. ACTIVRTS Flow Chart

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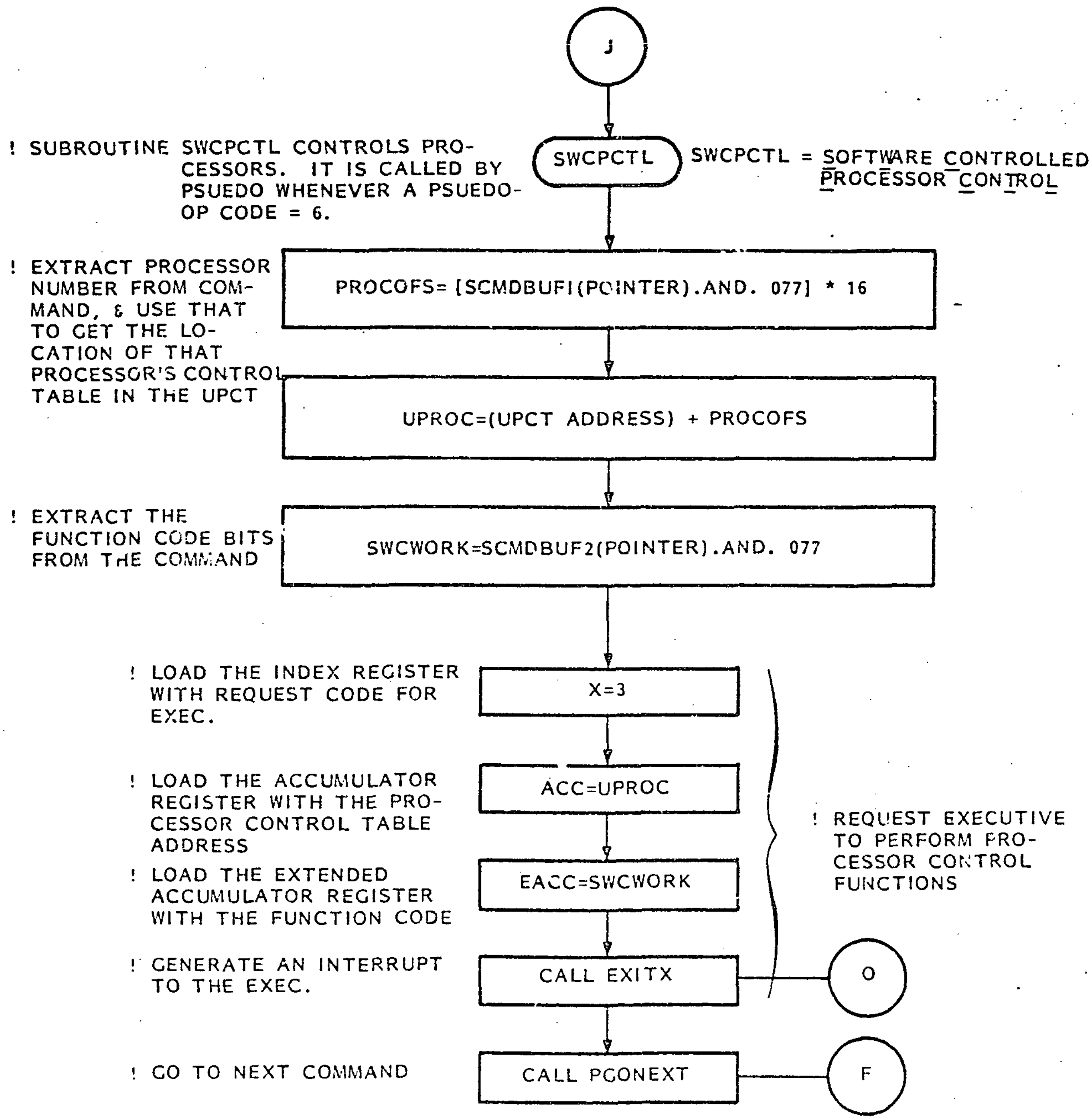
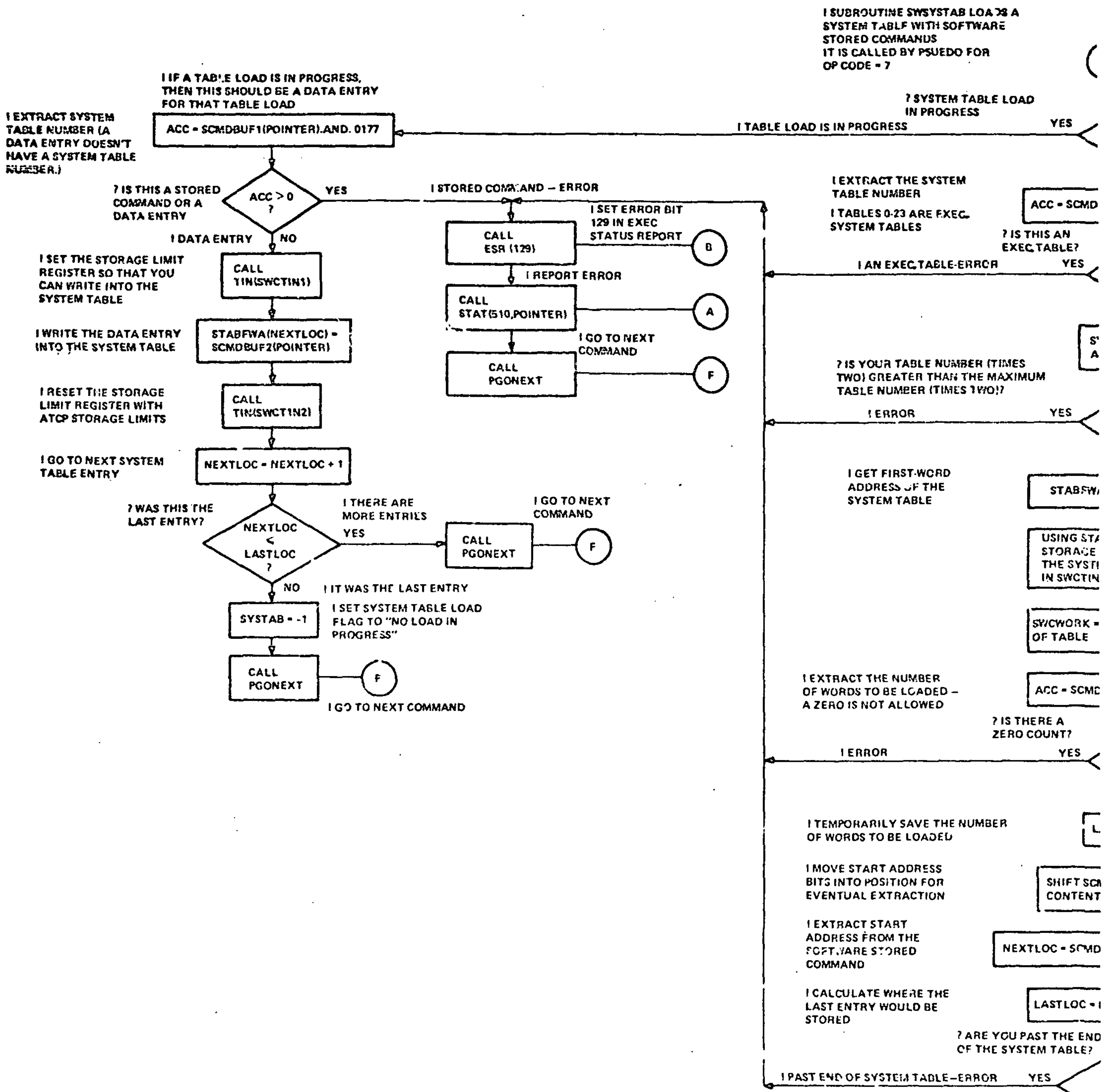


Figure B.3.15-12. SWCPCTL Flow Chart

---TELEMETRY POINT
•••••SYSTEM TABLE ENTRY



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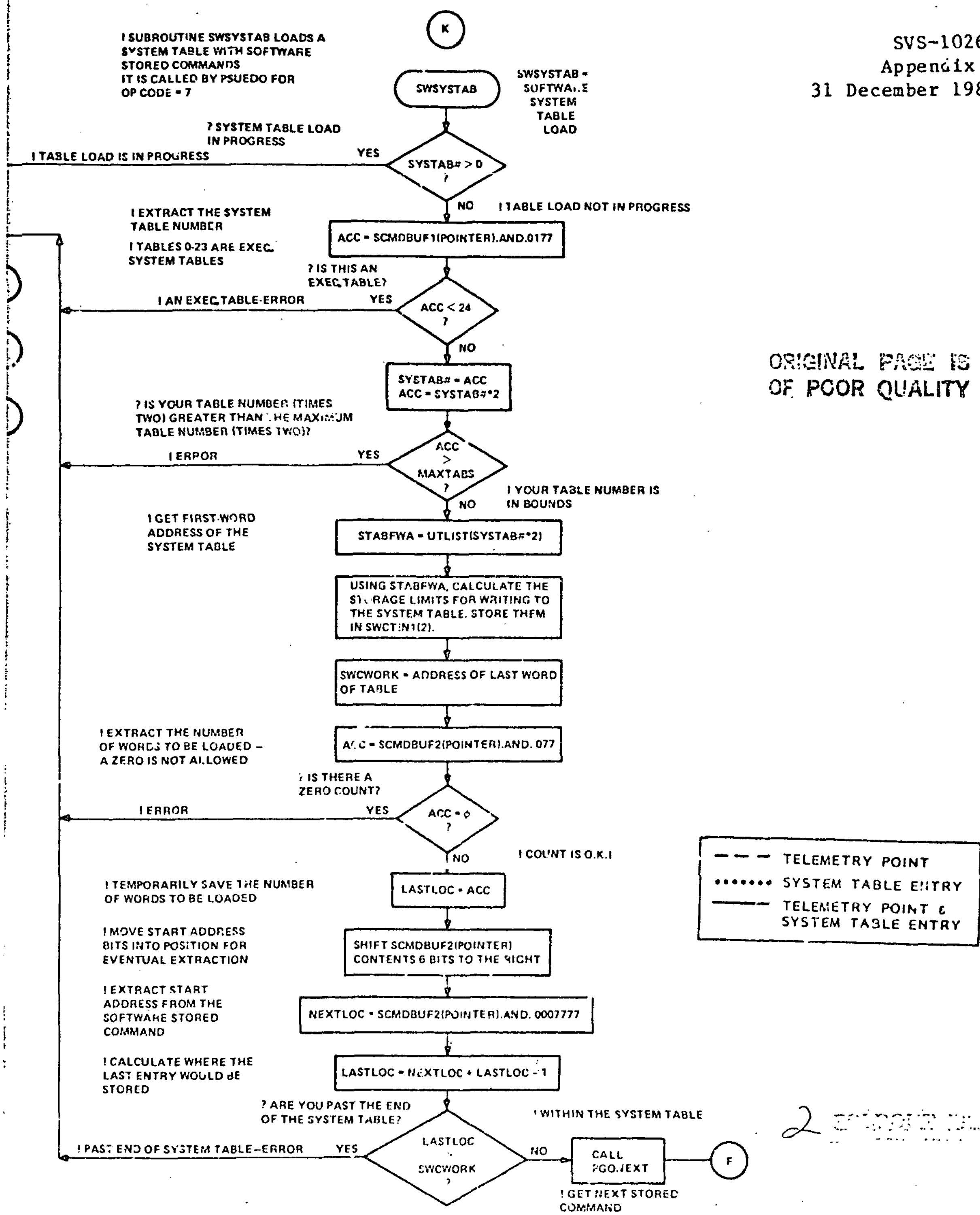

Figure B.3.15-13 SWSYSTAB Flow Chart

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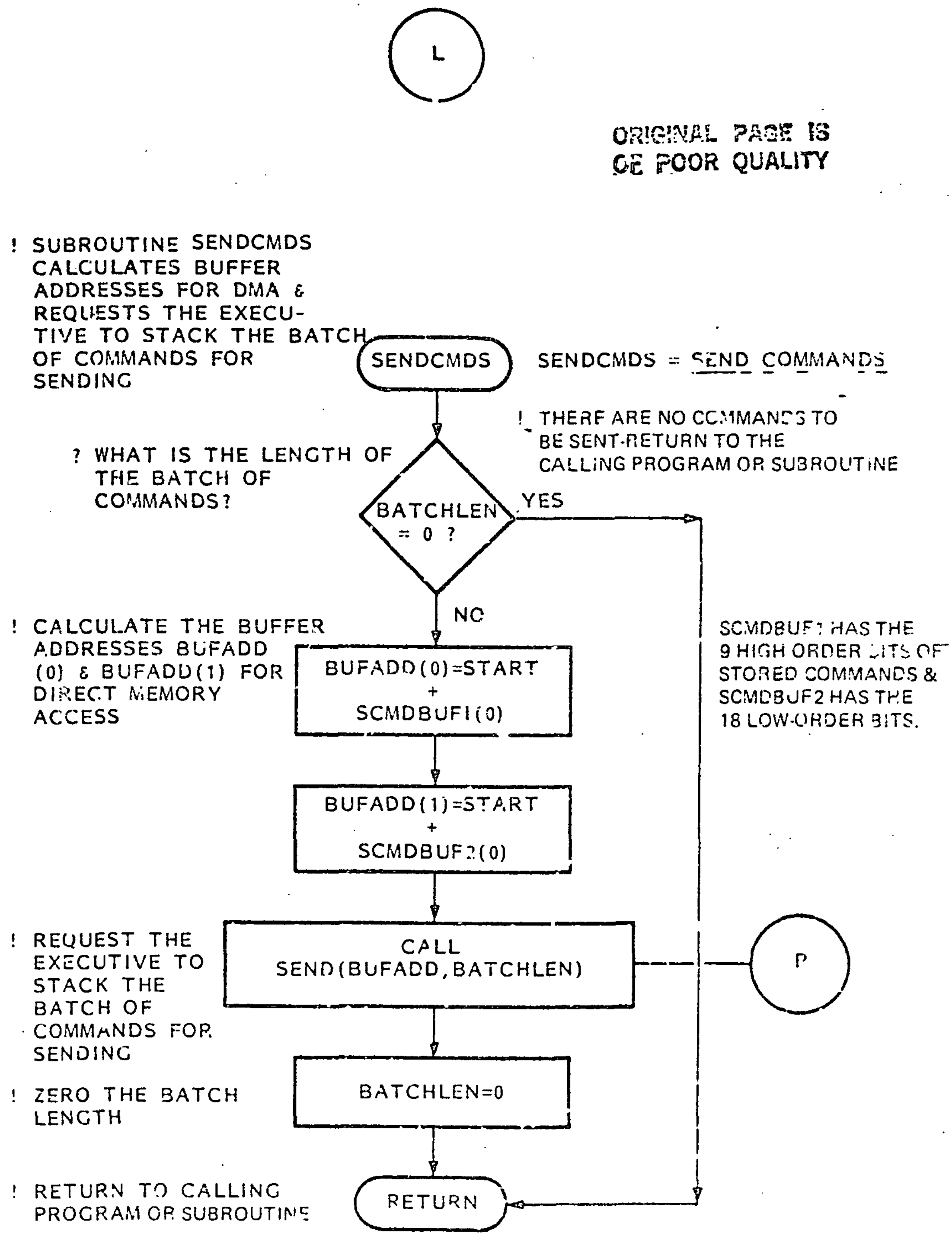

Figure B.3.15-14. SENDCMDS Flow Chart

--- TELEMETRY POINT
••••• SYSTEM TABLE ENTRY

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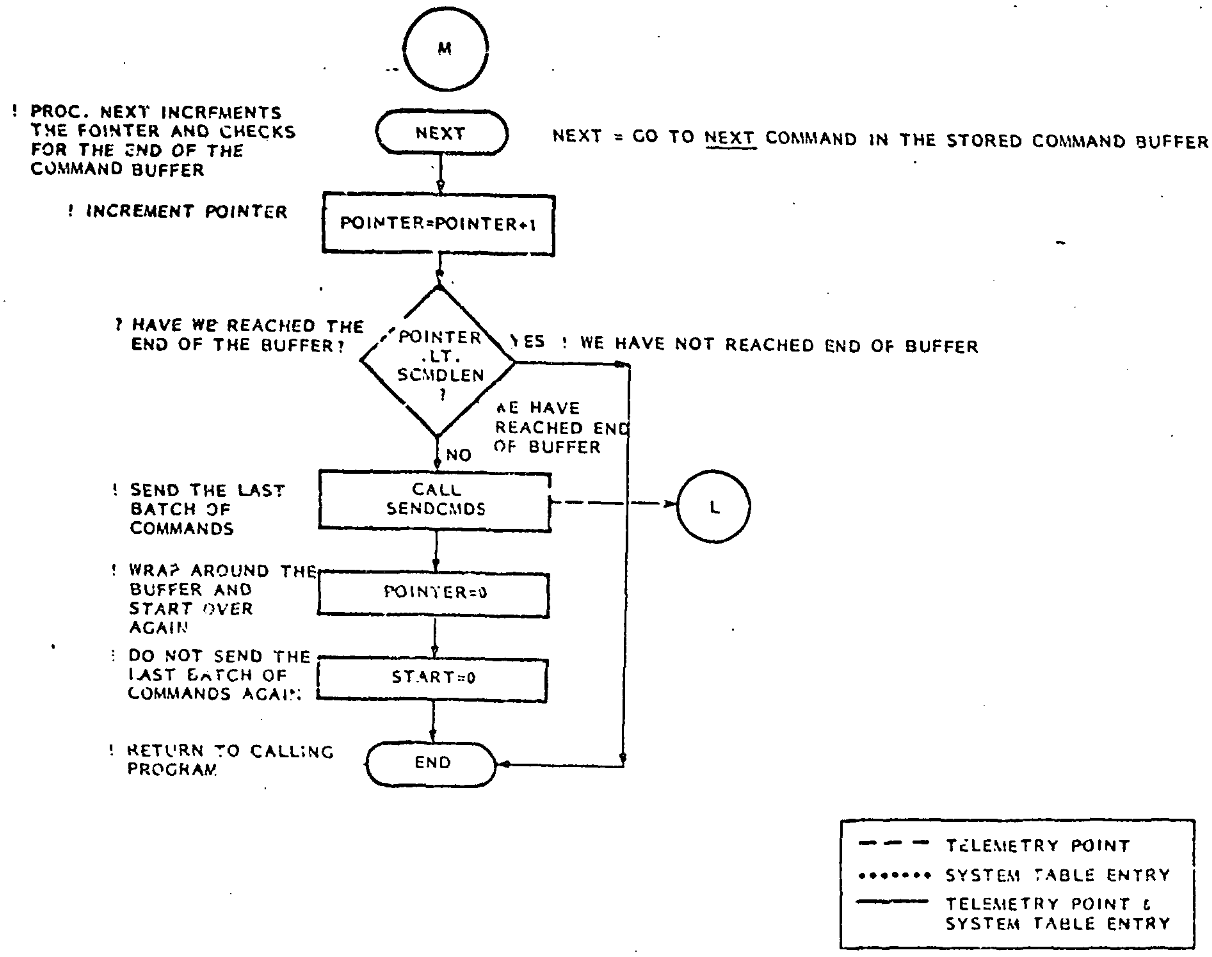

Figure B.3.15-15. NEXT Flow Chart

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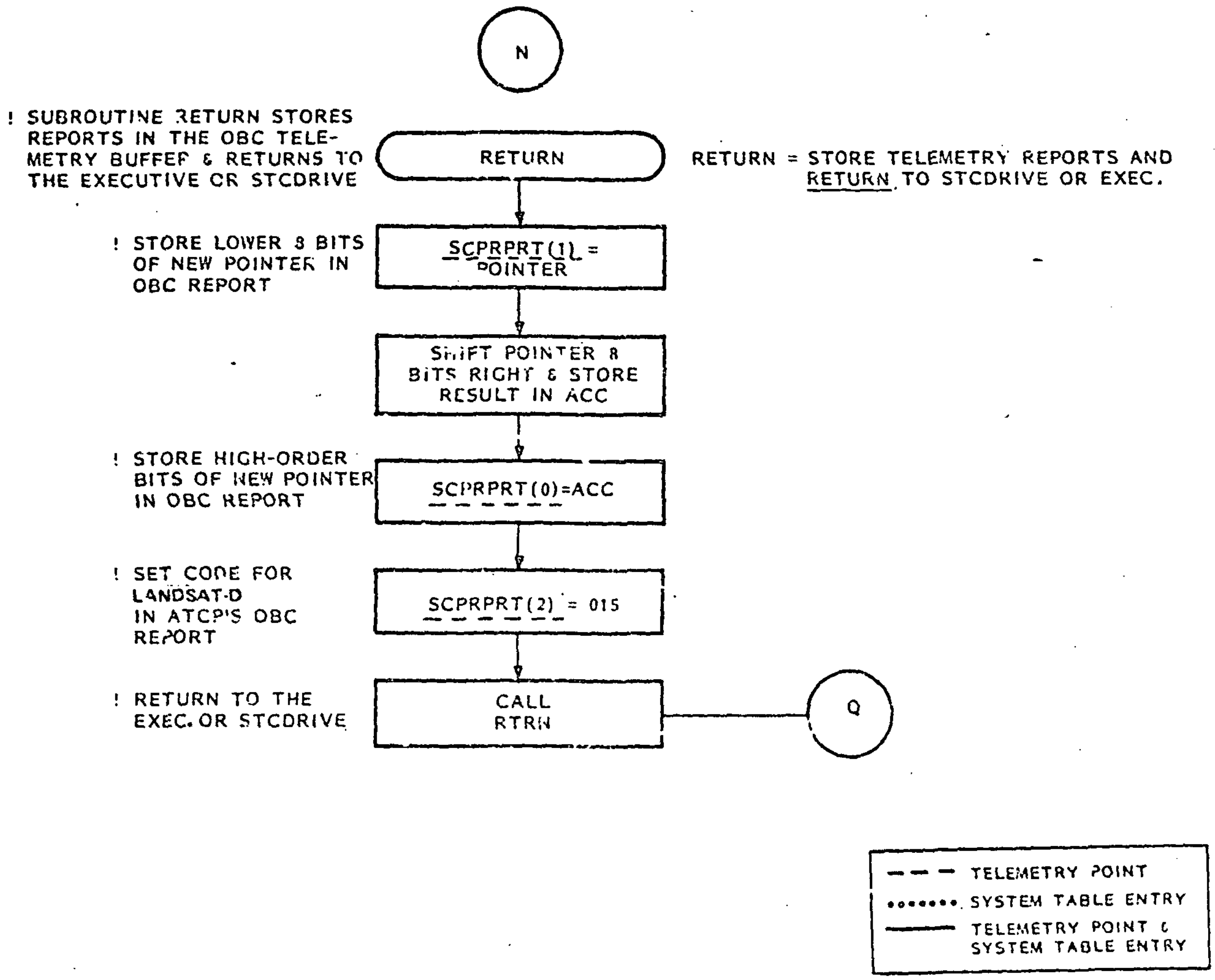

Figure B.3.15-16. RETURN Flow Chart

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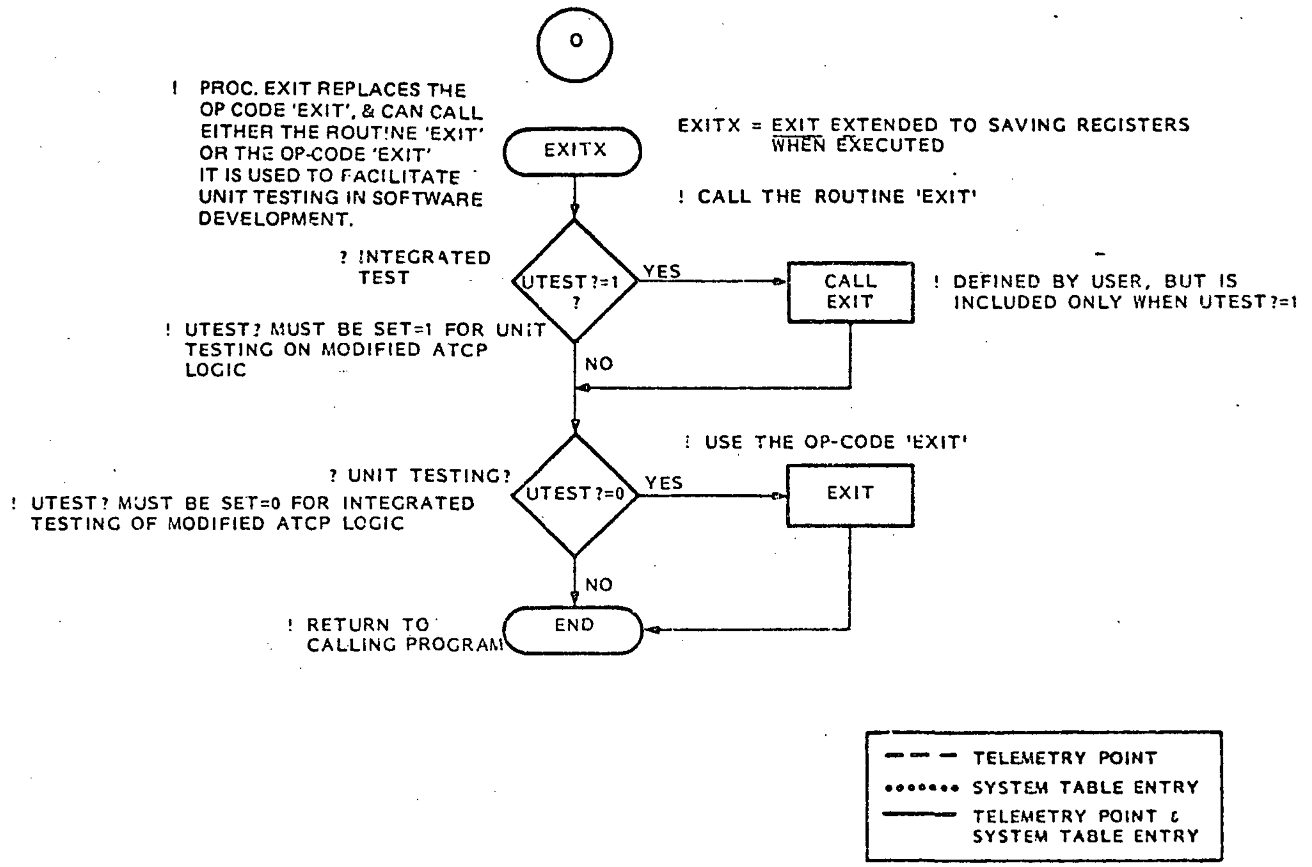

Figure B.3.15-17. EXITX Flow Chart

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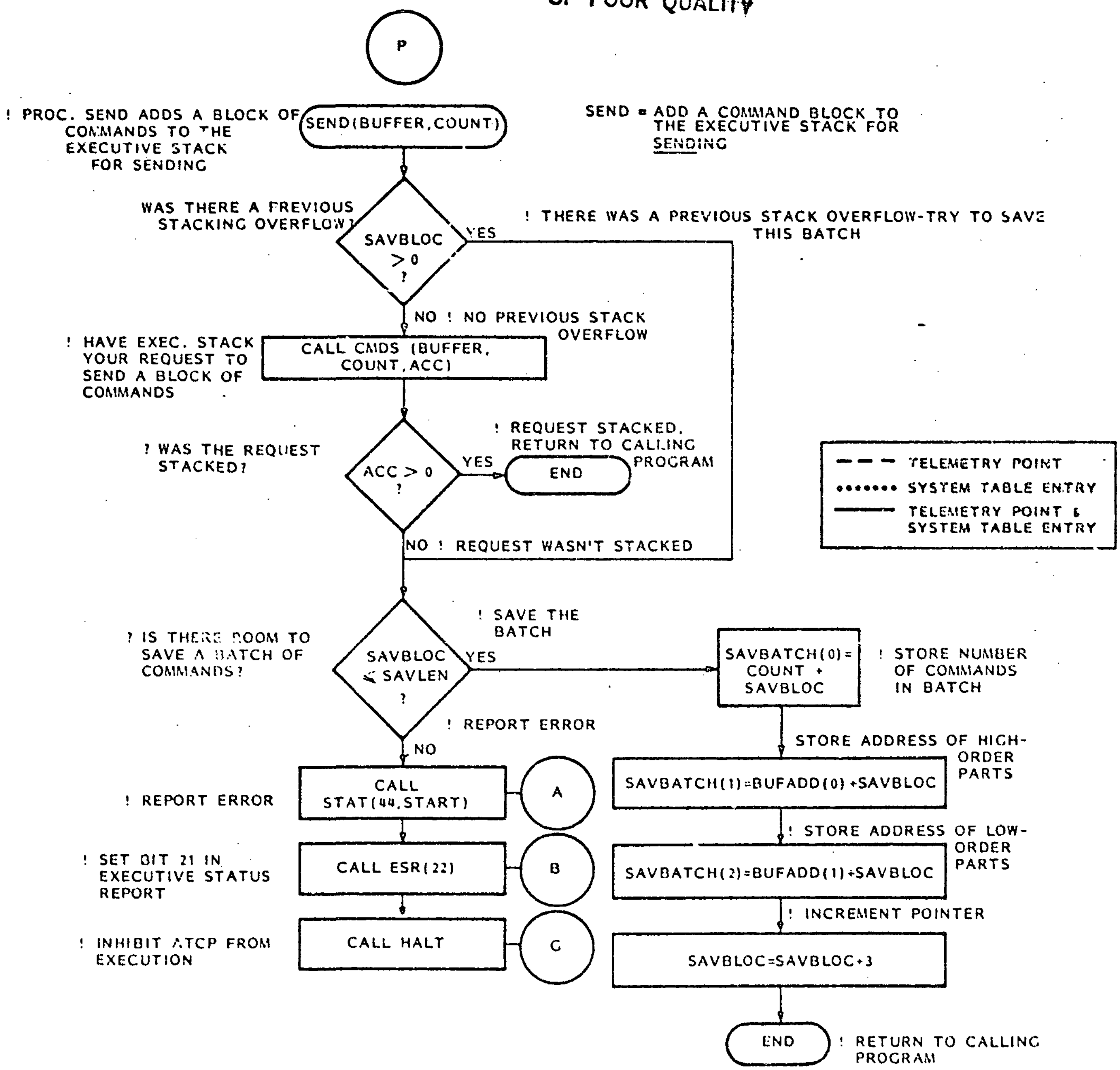

Figure B.3.15-18. SEND Flow Chart

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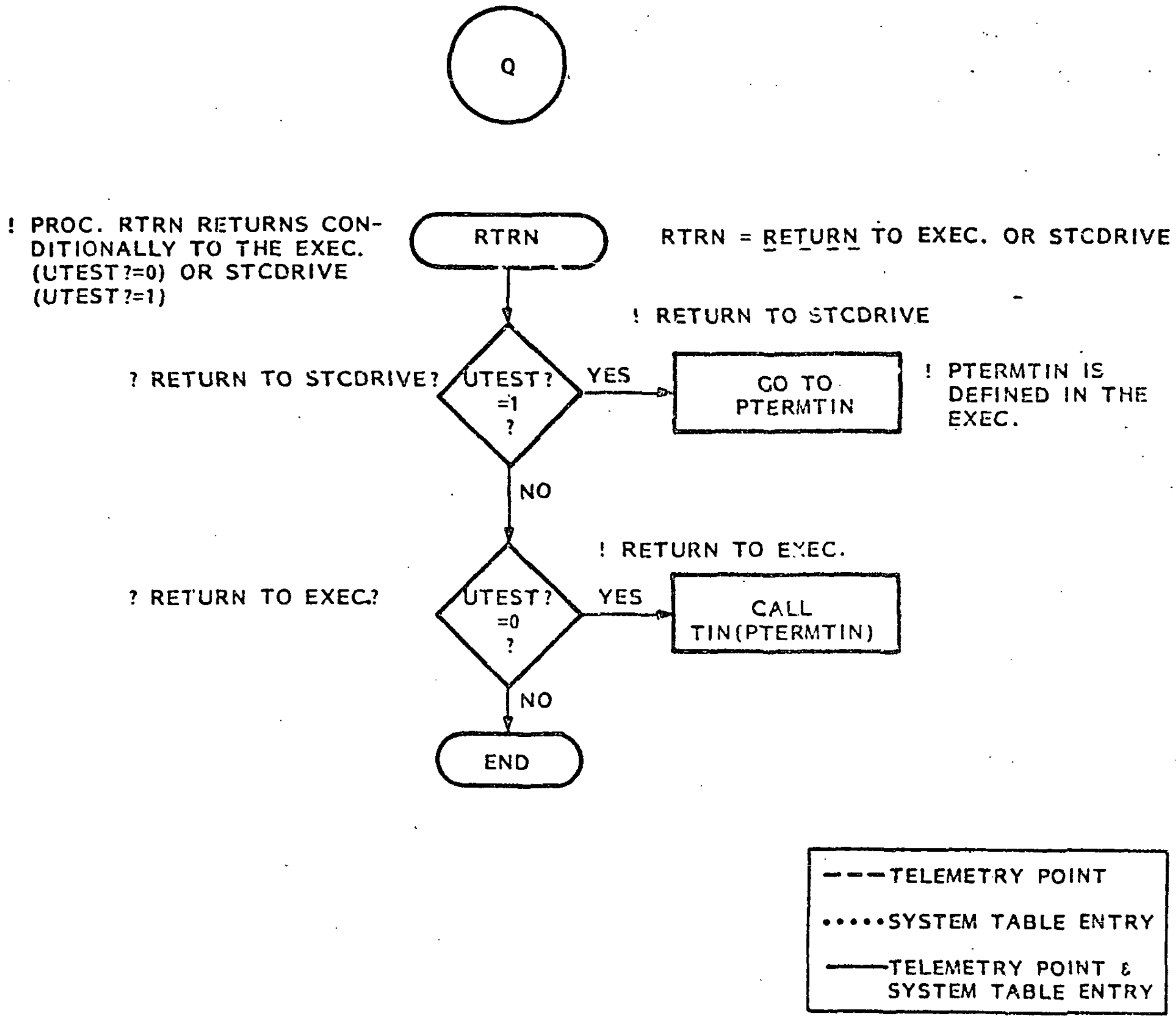

Figure B.3.15-19. RTRN Flow Chart

B.3.16 RELATIVE TIME COMMAND PROCESSOR (RTCP)

B.3.16 RTCP

B.3.16 RELATIVE TIME COMMAND (RTCP)

B.3.16.1.1 Relative Time Command (RTCP) Processor Description

The Relative Time Command Processor (RTCP) processes the relative time command sequences stored in onboard computer (OBC) memory. An RTS is a set of commands sent at prespecified intervals measured in RTCP executions. The RTCP can thus execute a relatively lengthy command procedure with prescheduled delays. This allows one command or group of commands to achieve its full effect (such as warming up an instrument) before the next command or set of commands is issued.

Commands within an RTS are processed sequentially, and a series of commands with intervals of zero will be sent (within hardware limitations) as a block at 1 millisecond intervals. Longer intervals between commands are expressed in numbers of RTCP executions. A count of 1 means that the command is sent on the first RTCP execution after the one on which the previous command was sent, a count of 2 means that it is sent on the second execution, and so forth. The maximum count is 131,071 (2**17-1). An RTS can be executed many times.

RTSs can be activated by pseudo-op commands stored in the absolute time command buffer. RTSs can also be activated, halted, inhibited, and reenabled by commands from ground control or from another processor. Several RTSs can be active at one time. Each active RTS is examined during an RTCP execution. The commands from one RTS are sent before RTCP processes the next RTS. Multiple commands from an RTS are sent in a block. Commands from separate sequences go out in separate 16 millisecond slots.

Commands are always transmitted directly from their storage buffer. They are never moved or modified. Two buffers must be used, because commands are 27 bits long and OBC words have only 18 bits. The 9 high order bits of successive commands go out over input/output (I/O) device 6, and the 18 low order bits of the same commands go out simultaneously over device 7.

RTCP is executed every 1.024 seconds as an Executive Scheduler Table entry. RTCP is comprised of the following subroutines and processors.

RTCP - RTCP Main Routine

RSENDCMDS - Asks the Flight Executive to add a batch of commands to the Executive Command Stack.

B.3.16.2 <u>Relative Time Command (RTCP) Processor Operation</u>

B.3.16.2.1 RTCP Operation Description

A detailed flowchart of RTCP operation is given in Section B.3.16.6. An in depth description of RTCP programming details and operation is given by the following document:

Multimission Modular Spacecraft (MMS)
Relative Time Command Processor (RTCP)
Program Documentation
October 1978
Goddard Space Flight Center
Greenbelt, Maryland
408-2110-0006

B.3.16.2.2 Modes of Operation

There are no modes of operation associated with RTCP.

B.3.16.2.3 RTCP Subroutine Description

RSENDCMDS

Asks the Flight Executive to stack a batch of commands in the Executive Command Stack. If the batch is successfully stacked, then it RETURNS normally. If the batch was not stacked, then it returns to the main program location labeled NEXTSEQ. This causes the program to skip to the next sequence.

B.3.16.3 Relative Time Command (RTCP) Software Constraints

RTCP has no software constraints.

B.3.16.4 Relative Time Command (RTCP) System Tables

RTCP has no system tables.

B.3.16.5 Relative Time Command (RTCP) Telemetry

RTCP contributes to telemetry in two ways. The first is by setting bits in the Executive Status Report. (This is not done by RTCP itself, however.) The second way is through a single telemetry report. Each of these contributions is described below.

B.3.16.5.1 Executive Status Report Bits

The Executive Status Report is in OBC telemetry report #39. This occurs four times in the telemetry matrix - in minor frames 7, 39, 71 and 103. In each minor frame, the report is found in words 91, 95, and 108-127.

The bits for RTCP are listed in Table B.3.16-1. These bits are set by the Flight Executive. The table also includes the meaning of each bit and whether it is latched or not. (Latching means that once a bit is set to 1, it will remain set until the entire buffer is zeroed by command from the ground).

Table B.3.16-1. Executive Status Report Bits for RTCP

Bit #	Latched	Bit Meaning
86	No	Processor inhibited from sending commands
87	No	Processor inhibited from executing

B.3.16.5.2 RTCP Telemetry Report

RTCP will provide telemetry in the OBC TLM reports via words 3 thru 23 of OBC TLM Report #45. This telemetry shows the status of all of the RTS groups, whether they are active or inhibited.

Entry	Name	TLM	Using Subroutine	Description/Remarks*
OBC TLM Report #45				
0	ATCPTR		ATCP	Current absolute time command pointer
2	SWVERNO		--	Software version number
3	RTS1		RTCP	Inhibit/active status of RTS #0-15
7	RTS2		RTCP	Inhibit/active status of RTS #16-31
11	RTS3		RTCP	Inhibit/Active status of RTS #32-47
15	RTS4		RTCP	Inhibit/active status of RTS #48-63
19	RTS5		RTCP	Inhibit/active status of RTS #64-79
23	RTS6		RTCP	Inhibit/active status of RTS #80-87

*Each RTS status report is two bits long. An inhibited sequence has the first bit = 1. An active sequence has the second bit = 1.

B.3.16.6 Relative Time Command (RTCP) Flow Charts

To help the reader understand the flowcharts, the following explanations are made.

- Certain subroutine calls have a circled letter attached to them. This identifies the sheet that the subroutine is flowcharted on.

- The following flowchart variables always represent certain registers:

  ACC = Accumulator Register
  EACC = Extended Accumulator Register
  X = Index Register

- The CALL RTRN statement is equivalent to RETURN in FORTRAN.

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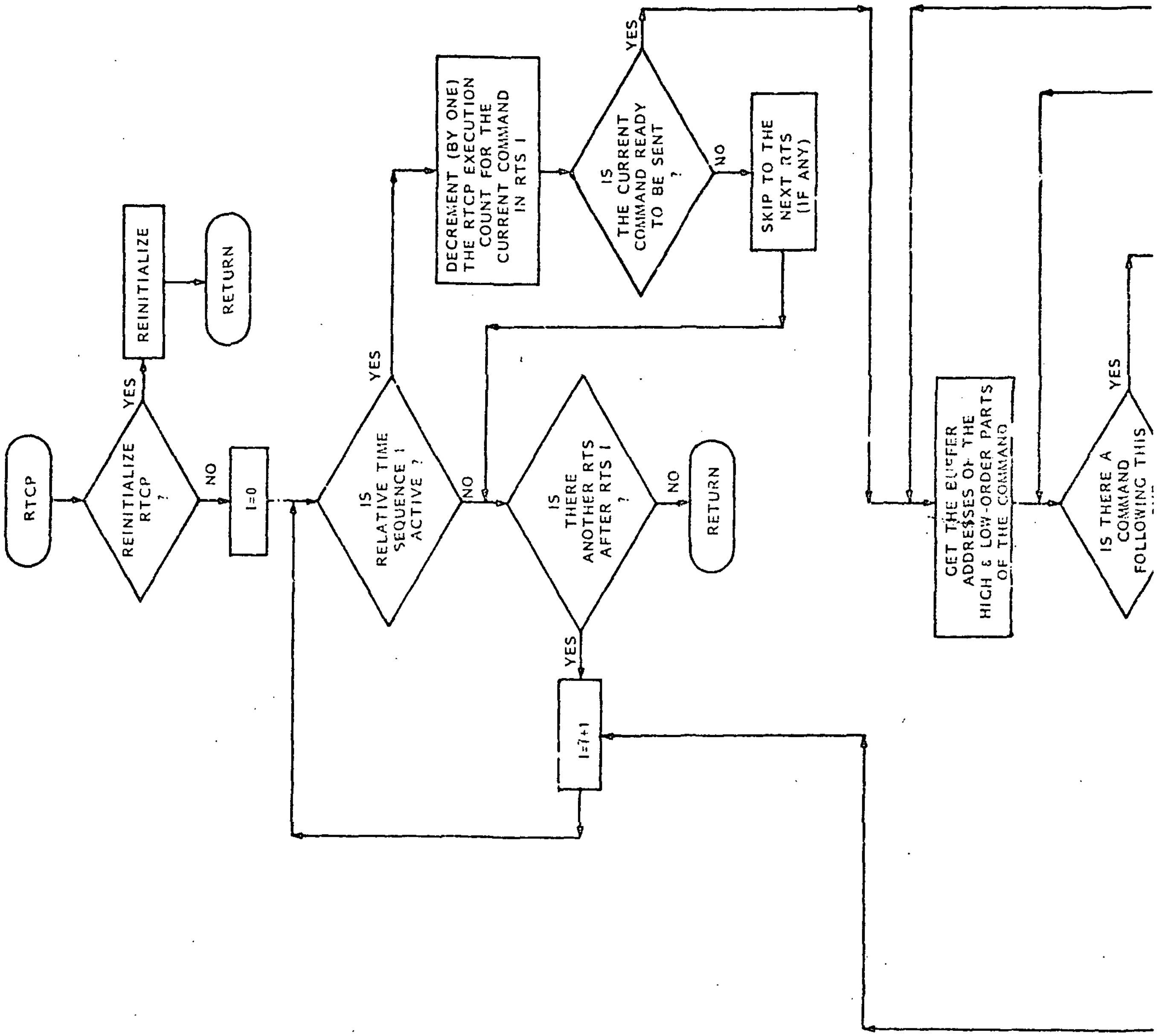

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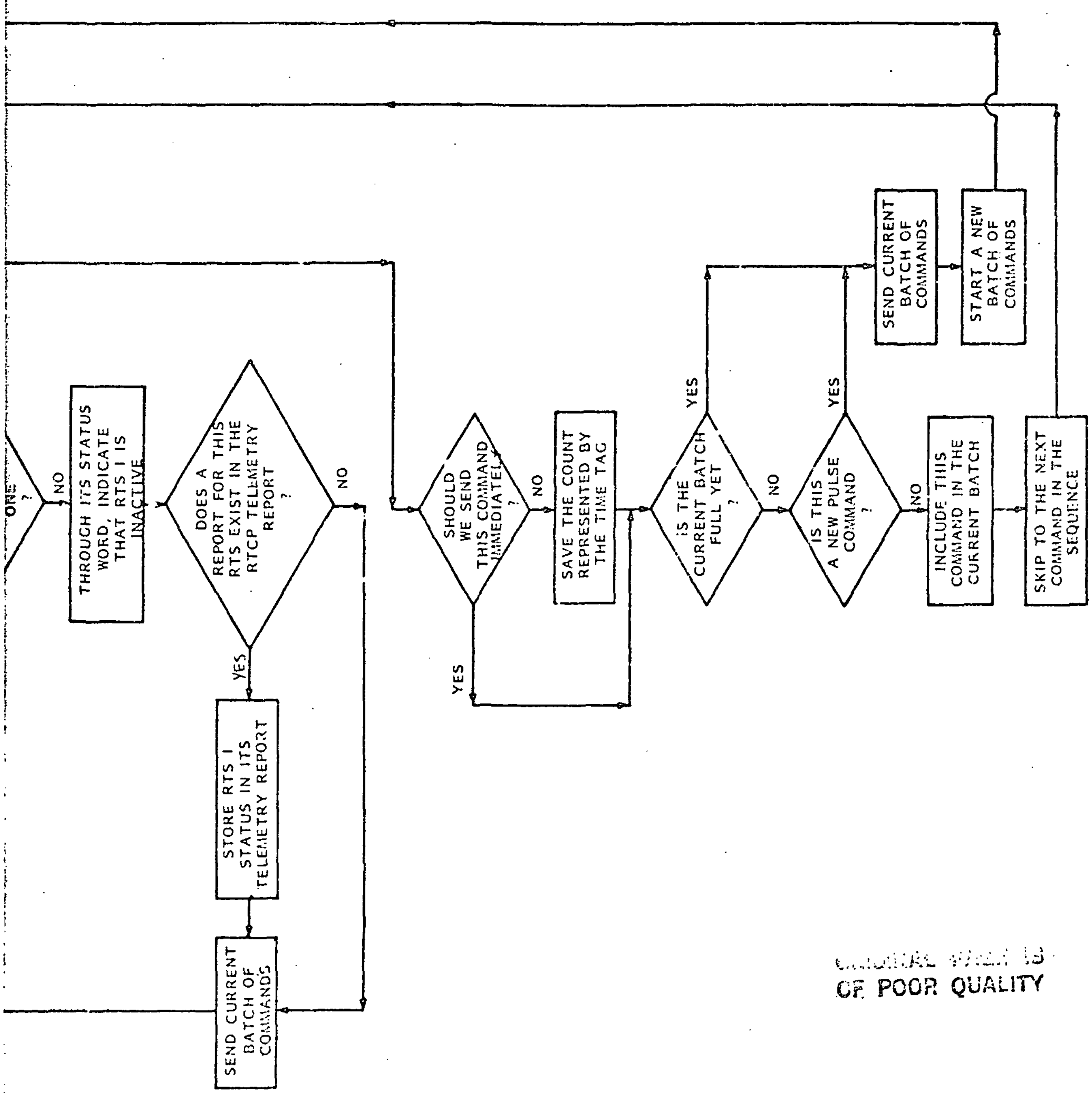

Figure B.3.16-1 RTCP Top Level Flow Chart

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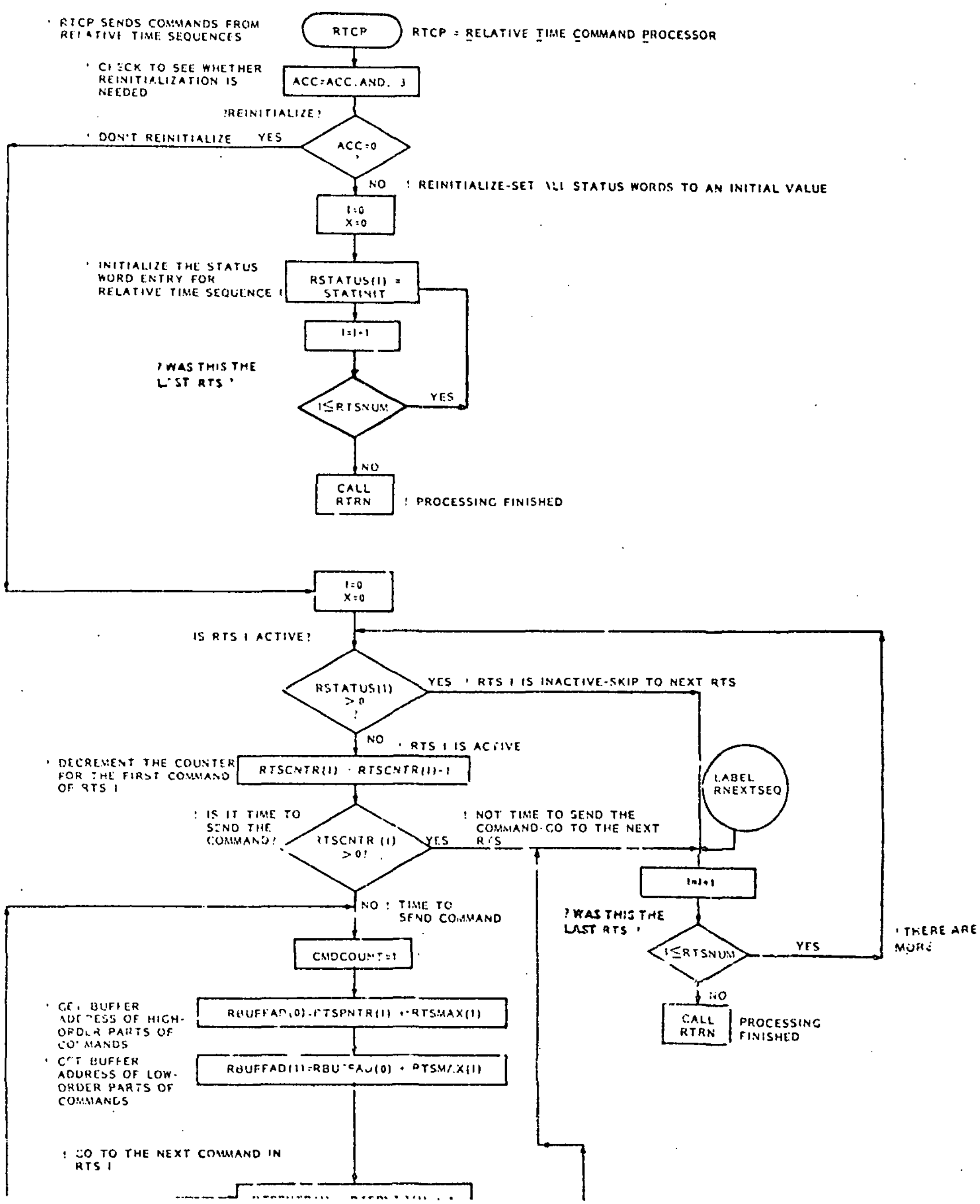

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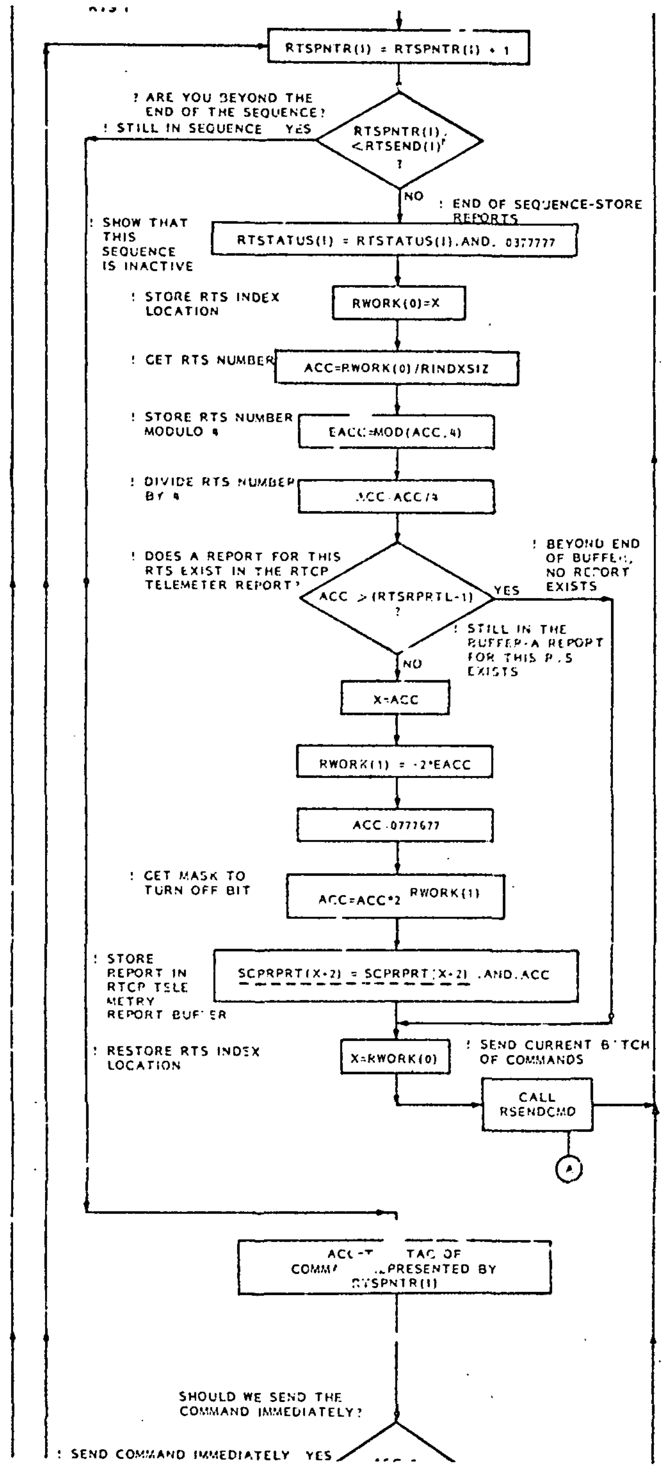

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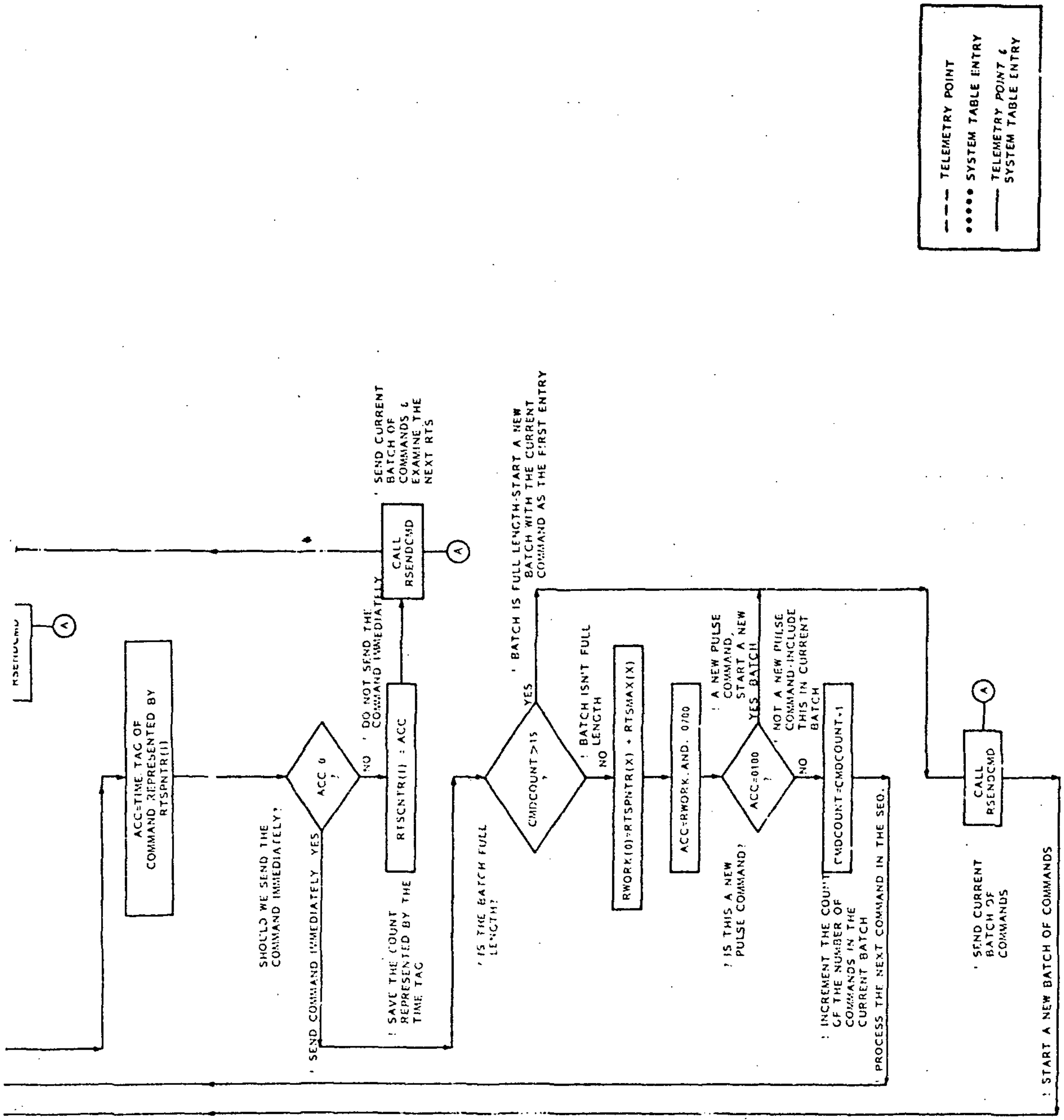

Figure B.3.16-2. RTCP Detailed Flow Chart

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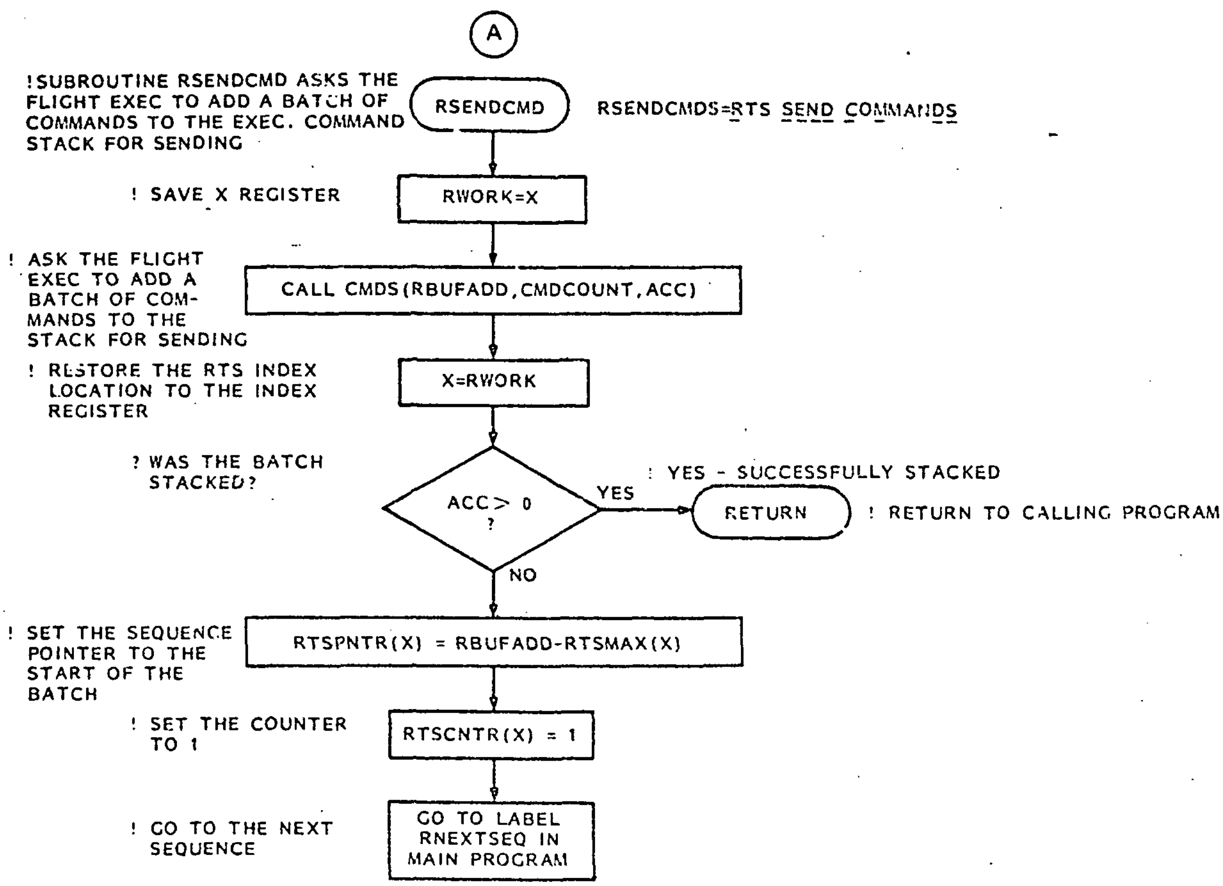

Figure B.3.16-3. RSENDCMD Flow Chart

B.3.17 UPDATE FILTER (UFLTR)

B.3.17 UPDATE FILTER (UFLTR)

B.3.17.1 Update Filter (UFLTR) Processor Description

The function of the Update Filter is to use data from stellar referenced sensors to update the spacecraft inertial attitude determination and gyro bias compensation. Normally the Update Filter will employ data from the two Fixed Head Star Trackers (FHST), but by ground command data from the Fine Sun Sensor (FSS) can be processed.

The Update Filter module is a background processor which is called every 32.768 seconds or every 32 cycles of the Flight Executive Scheduler table. This processor will be interrupted by foreground processors, but has a higher priority than other background processors.

The Update Filter Processor is comprised of 17 subroutines. These subroutines are listed in Table B.3.17-1, and diagrammed in Figure B.3.17-1. During operation of the software, these subroutines use Systems Tables 35 thru 49 for parameters, and updates. Table 38 is the Star Catalog which provides up to 55 stars to be used in update filter operations. This table is updated periodically w.th new stars occuring in the field of view of the FHST's.

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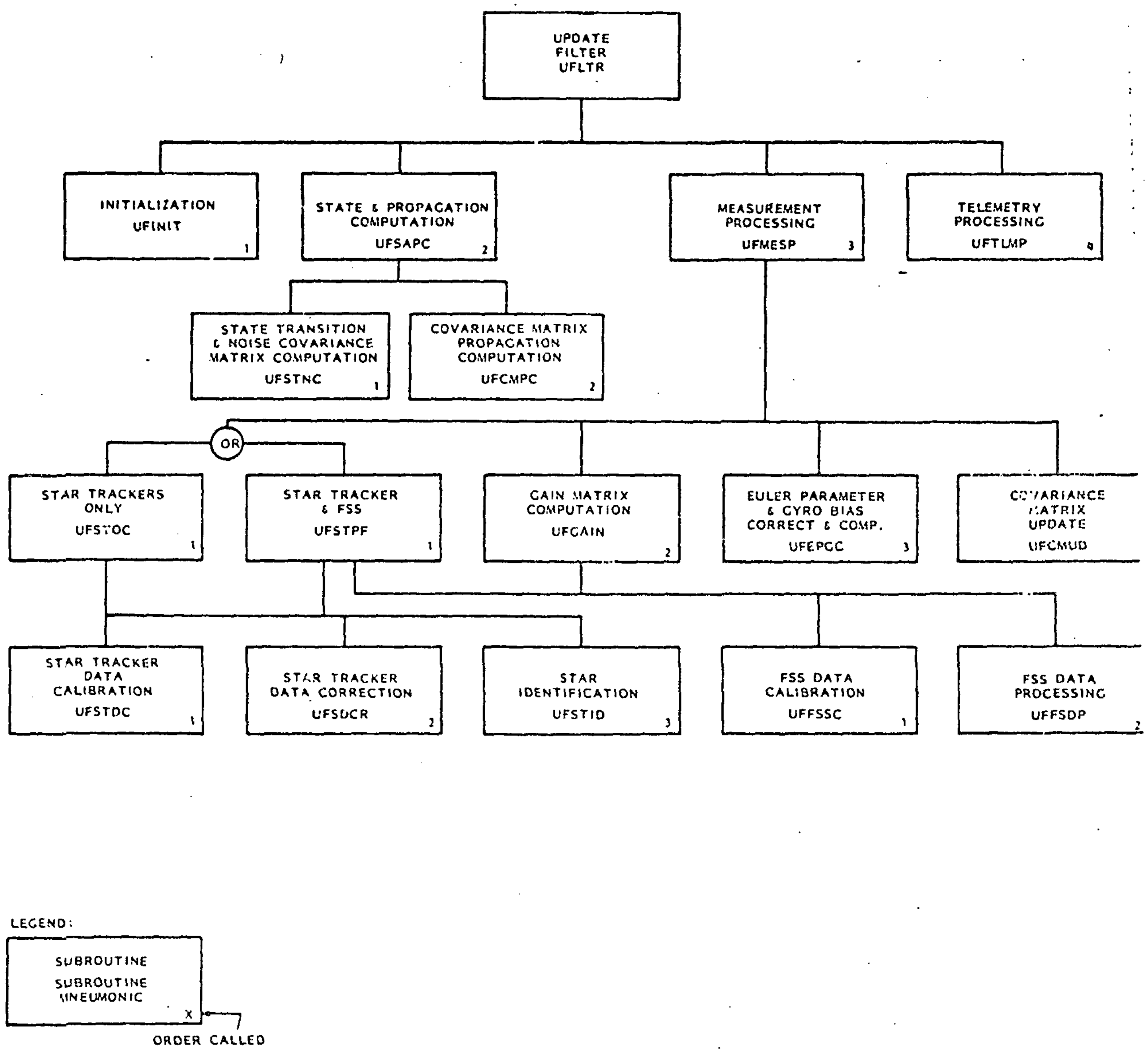

Figure B.3.17-1. Update Filter (UFLTR) Overview

Table B.3.17-1. Update Filter (UFLTR)

Number: 13
Type: Background
Priority: 10
Period: 32.768
Function: Provide Attitude determination and gyro bias compensation to ACS software processor.

Subroutines:

UFINIT	Initialization
UFSAPC	State propagation computation
UFSTNC	State transition and noise matrix computation
UFCMPC	Covariance matrix propagation
UFDYSC	Dynamic scaling
UFMESP	Measurement processing
UFSTDC	Star trackers only
UFSTPF	Star trackers plus FSS
UFSTDC	Star tracker data calibration
UFSDCR	Star tracker data correction
UFSTID	Star identification
UFFSDP	FSS data processing
UFGAIN	Gain matrix computation
UFEPGC	Euler parameter and gyro bias correction computation
UFCMUD	Covariance matrix update
@ABERB	Total aberation velocity
UFTELM	Telemetry processing

Table B.3.17-1 (Continued)

System Tables

#	Mnemonic	Type	Description
35	UFGNPARM	P	Gyro Noise Model Parameters
36	UFHNPARM	P	FHST Noise Model Parameters
37	UFPARMS	P	Parameters for Update Filter
38	STARCAT	V(1)	Star Catalog
39	UFSSUVEC	P	FSS Unit Vector
40	UFMFCOC1	P	Torquer Bar Mag. Fld. Sens. Coeff. FHST #1
41	UFMFCOC2	P	Torquer Bar Mag. Fld. Sens. Coeff. FHST #2
42	UFISTUV1	P	Unit Vector Components FHST #1
43	UFISTUV2	P	Unit Vector Components FHST #2
44	UFFTCOF1	P	Flat Field and Temp Coeff. FHST #1
45	UFFTCOF2	P	Flat Field and Temp Coeff. FHST #2
46	UFICCOF1	P	Star Intensity Calibration Coeff. FHST #1
47	UFICCOF2	P	Star Intensity Calibration Coeff. FHST #2
48	UFCCEMF1	P	Magnetic Field Calib. Coeff. FHST #1
49	UFCCEMF2	P	Magnetic Field Calib. Coeff. FHST #2

P = Parametric - nominally will not change
V = Variable - Change necessary periodically

(1) Star Catalog - updated every 3 days

Telemetry Reports

OBC Reports 24 thru 34

B.3.17.2 Update Filter (UFLTR) Processor Operation

The update filter uses data from 2 FHST's or from 1 FHST and the FSS to provide independent corrections to the attitude reference quaternion, EPA1,2,3,4, and the gyro bias vector, THETBX,Y,Z. The update filter implements a Kalman filter which is a sequential estimating algorithm that processes one measurement at a time to continually reduce the error magnitude. The ground controls the update filter mode of operation with the parameter ST. If ST=1 the mode will be to alternately use data from both FHST's. If ST=0 the mode will be to alternately use data from the FSS and 1 predefined FHST. The ST=0 mode is a backup mode for the case of a failed FHST. Upon entry the update filter saves a time consistent set of the following data:

EPA1,2,3,4	reference quaternion	8 words
BEX,Y,Z	magnetometer data	3 words
MX,Y,Z	torquer commands	3 words
WX,Y,Z	spacecraft rates	3 words
TF	flight software time	2 words
ZLX-XLZ	orbit position data	4 words
AST1HORZ	FHST #1 horizontal pos	2 words
AST1VERT	FHST #1 vertical pos	2 words
AST2HORZ	FHST #2 horizontal pos	2 words
AST2VERT	FHST #2 vertical pos	2 words
AST1MAG	FHST #1 star intensity	1 word
AST2MAG	FHST #2 star intensity	1 word
AST1TEMP	FHST #1 temperature	1 word
AST2TEMP	FHST #2 temperature	1 word
AFSSOUT	Fine Sun Sensor data word	4 words

On-Board Star Catalog:

OBC system table #38 is reserved for the star catalog. The catalog can hold as many as 55 stars (500 words).

Star Identification:

Star identification is performed by the subroutine UFSTID. A single star measurement is compared to each star in the catalog (55 catalog stars is the largest catalog) and the number of catalog stars identified with the measurement is saved. If and only if 1 identification is made and it is the second (or greater) time that the measurement is identified with that particular star an update is executed. Three tests are performed (in order) for each catalog star given a star measurement. If any test fails for a particular catalog entry the next test or 2 tests are not performed but rather testing for the next catalog star is begun.

Test #1 Orbit Angle Test:

A star orbit angle defines the spacecraft position in orbit at which the spacecraft can view the star. Orbit angles for stars are constants and part of the star catalog load while the spacecraft orbit angle is a function of the ephemeris and which FHST is the preferred sensor.

RS = Spacecraft orbit angle
DR(FHST) = Correction to RS for either FHST #1 or FHST #2
RT = RS+DR (FHST) = effective spacecraft orbit angle
RF = allowable tolerance
CATRS = star orbit angle uplinked as part of the star catalog

The orbit angle test is then accepted if:

$$(RT-RF) < CATRS < (RT+RF)$$

Test #2 Threshold Test

The measured star intensity, IS, is compared to the threshold tolerance limits, CATSU and CATS2, uplinked for each star as part of the star catalog. The threshold test is accepted if:

$$CATSL < IS < CATSU$$

Test #3 Measurement Residual Test:

The measurement residual test is accepted if:

$$SX < VS1 \text{ and } SY < VS2$$

where: SX and SY are the absolute values of the differences between FHST measured X and Y positions and expected positions. The expected positions are calculated from the star vector uplinked as part of the star catalog.

and: VS1 = KS*SQRT(R+V1)

and: VS2 = KS*SQRT(R+V2)

where: KS is a gain constant

and: R is either RL or RU depending on whether the star measured position is within RLM (RLM=?) of the tracker origin.

and: V1 and V2 are uncertainties associated with the best estimated value of the attitude.

Normal 2 FHST Operation (ST=1):

The following physical considerations were the driving force for the update filter logic involving star data use.

1. To avoid using bad star data, a star must be identified twice before the data is to be used to generate an update.

2. The preferred tracker is always the one which has gone the longest without providing data for an update. This is to avoid errors accumulating about the boresight of one tracker.

3. There is not enough time to process 2 star identifications and 2 updates in one 32 second cycle. There is, however, enough time to process 2 star identifications and one update in a single 32 second cycle. Therefore, if the preferred tracker has no valid star, the opportunity is then taken to check the other tracker and update from it if it has a valid star.

Consider the following scenario to explain the update filters logic for star data use.

1. ST=1 --> 2 star tracker not 1 FHST + FSS.

2. A single star will pass through the FHST field of view in roughly 3 minutes.

3. Consider the case when a valid star enters the field of view of each tracker at roughly the same time. Each tracker has a unique star since the tracker fields of view do not overlap.

4. Assume that this time the preferred tracker is tracker #1 or FHST=1.

5. Scenario

   a. 1st 32 Sec Update Filter Cycle

      UFSTOC will call UFSTID which will identify the star in tracker #1 but set ISC=-1 since this is the 1st identification for this star. UFSTID will return control to UFSTOC and since ICS=1 a second try using tracker #2 will be executed. This second try will call UFSTID a second time to identify the star in tracker #2. The star will be identified but ISC will be set to -1 again since this is the 1st identification for this star also. UFSTID will then return control to UFSTOC and the preferred sensor will be set back to tracker #1. VSD will remain 0 since it can only be set to 1 if ISC is 1. UFSTOC will then return control to UFMESP which then returns control to UFMESP which will bypass the update since VSD=0.

b. 2nd 32 Sec Update Filter Cycle

UFSTOC will call UFSTID which will again identify the star in tracker #1 and set ISC=1 since now this is the second identification for this star. UFSTOC will then set VSD=1 and "Flip" the preferred sensor word to tracker #2 and then exit. (No second try will be executed since ISC=1). Then UFMESP will execute the update, then exit.

3. 3rd 32 Sec Update Filter Cycle

Repeat the logic in the second cycle except that the update will use tracker #2 and the preferred sensor will then flip back to tracker #1.

FSS/1 FHST Backup Operation:

The subroutine UFSTPF controls the logic for this back-up mode of operation. The parameter FHST is the preferred tracker flag which, unlike the normal mode, is not changed. The sensor, either FSS or the preferred tracker, which has gone the longest without providing data for an update is the preferred sensor. The parameter FSS controls the cycling between sensors. If FSS=1 then Fine Sun Sensor is the preferred sensor. If SUNPRS=1 an update is performed using the sun data. If SUNPRS=0 a second try will be attempted this time, however, with FSS=0 indicating the prefered FHST as the preferred sensor. When FSS=0 the logic is identical to the normal mode with the exception; if the preferred FHST fails to yield an update the second try is executed using the Fine Sun Sensors.

Interesting Telemetry:

NCAMAX	The number of stars in the on-board star catalog. (≤55) Also the number of cycles of the star/ identification loop for each star measurement.
NFAIL1 NFAIL2	The number of star identification failures for FHST 1 and FHST 2. NFAIL 1 and NFAIL 2 are reset to 0 only when 1 and only 1 star is identified for a single star measurement.
LSTID1 LSTID2	LSTID1 and 2 gives the catalog sequence number (NCA) for the last unique identification.

RS	RS gives the spacecraft orbit angle.
VS1 VS2	VS1,2 give the position tolerances for the measurement residual test.
KCOUNT	KCOUNT is incremented each time an update is performed.
PCOUNT	PCOUNT is incremented each time the covariance matrix is propigated. (The covariance matrix is propigated every 32 sec cycle to allow for errors being transferred from one axis to another due to spacecraft rotation.)

B.3.17.2.1 Update Filter Subroutines Operation

UFLTR

UFLTR is the control routine for the update filter processor. Since this processor requires a long period for its computation it saves a data set with the setting of Update Filter Data Required (UFDTREQD) Flag to 1. This signals the SCP to use its subroutines COMPDSAVE and MVUFDATA to acquire and save the following data set:

Raw Star Tracker Data	(12 words)
Euler Parameters	(8 words)
Magnetometer Data	(3 words)
Magnetic Torquer Cmds	(3 words)
Angular Rates	(3 words)
Flight Software Time	(3 words)
Orbit Position Data	(4 words)
Fine Sun Sensor Data	(4 words)

When SCP has completed the data acquisition and save it resets UFDTREQD to zero signaling UFLTR that data save has been completed. The setting of the Filter Initialization (FLTRI flag to other than zero will initialize the processor via UFINIT. UFSAPC, UFMESP and UFTELM are called to complete the Update Filter processing.

UFINIT

Update Filter Initialization is called by UFLTR if FLTRI is not equal to zero. The Attitude Error Covariance Matrix PM11(I), Cross Covariance Matrix PM12(I) and Gyro Drift Error PM22(I) are reset to zero then Attitude Error and Gyro drift are initialized to PA0 and PG0 respectively which are resident in System Table 37. The propagation interval TPS and Initialization Flag (FLTRI) are reset to zero and the Past Time (TUS) is reset. The P and K matrix counter are also reset to zero. DYNSCLE is utilized to initialize scale values SCP 11, 12, 22.

UFSAPC

Update Filter State Transition and Propagation Computation is called by UFLTR to compute propogation interval and compare it to the past value. If it has not changed UFSTNC is not called before UFCMPC processing.

UFSTNC

Update Filter State Transition and Noise Covariance Matrix is called in UFSAPC only when the propagation interval has changed. The stat transition and noise covariance matrices are used in the Update Filter error covariance matrix propagation. These matrices are a function of the propagation time interval. Upon entry the propagation interval is saved in TPS and computation of necessary intermediate variables, used in the matrices computation, takes place. This is followed with computation of the state transition matrix and computation of the state noise covariance matrix.

UFCMPC

The Covariance Matrix Propagation is subroutine called to compute the Update Filter error covariance matrix propagation algorithm. Intermediate matrices X1, X2, X3, and X4 are used throughout the routine in the covariance matrix propagation. The covariance matrix propagation routine is entered every time the Update Filter processor is called. The coutner PCOUNT which is incremented each time UFCMDC is executed is an indication, along with KCOUNT of UFEPGC, in telemetry of a successful update.

UFMESP

Update Filter Measurement processing is called by UFLTR. It resets the Valid Data Flag (VSD), the TRY flag, and the PASS flag to zero, then tests the star tracker data XS1B2/XS2B2 for FHST 1 and 2 respectively, for a 1 in Bit #2 which indicates data present in the FHST. It sets STARU 1/2 to 1 if data is available, which will be used in UFSTOC. The subroutine then calls UFSTPF if ST, the flag for FSS & FHST or FHST only selection, is set to zero or UFSTOC if ST equals 1. If UFSTPF or UFSTOC returns a Valid Data indication VSD=1 then the

PASS flag is incremented and the three processors as shown in Figure B.3.17 are called and a second produces 2 measurements for processing. If VSD=0 then a return to UFLTR is made.

UFSTOC

The star trackers only subroutine is called by UFMESP in the normal mode where the update sensors are the two FHST's. The preferred star tracker is tested for data (STARU(FHST) is set on entry of UFMESP), if data is not available (STARU(FHST)=0) then the other tracker is selected and tested for data. When the star tracker has data available UFSTDC, UFSDCR and UFSTID are called respectively. Upon return from UFSTID if the index star counter (ISC) is set to 1 the valid data flag is set and the other star tracker is made the preferred sensor. If VSD is not 1 the other tracker is selected and if it is only the first try will test the second tracker. Each time this routine is entered it returns dat from only one star tracker.

UFSTDC

The Star Tracker Data Calibration subroutine is called to convert the raw star tracker data, XS1B1, XS1B2, YS1B1, YS1B2, XS2B1, XS2B2, YS2B1, YS2B2, to a form suitable for further processing. Which of the duplicate star trackers is used depends on the value of the star tracker flag, FHST. The data is compensated for the effects of geometric distortion, magnetic fields, temperature variations and star intensity variations. Output consists of the star magnitude, MS, and the vector components, XS, YS and ZS.

UFSDCR

The Star Tracker Data Correction subroutine is called to compensate the star tracker measurements for the effects of velocity abberation and time delay in measurement.

UFSTPF

The UFSTPF subroutine is called in UFMESP if the FHST only/FHST & FSS mode flag (ST) is set to other than 1, when input is from both FSS and FHST is desired. This subroutine works similar to UFSTOC with the use of the FSS and one of the FHTS's instead of 2 FHST's. The FHST to be used is selected by Entry 1 in System Table #37 (FHST). If the FSS is the preferred sensor (FSS=1) then FSS is set to zero to make the star tracker the preferred sensor for the next pass. A test for sun present (SUNPRS≠0) is performed and UFFSDP continues processing FSS data if the sun is present returning a Valid Data Flag (VSD) if successful; if not, processing as in UFSTOC occurs with the selected FHST. Each pass through this routine produces no more than one data input to the update filter.

UFFSDP

This subroutine is called in UFSTPF when Fine Sun Sensor processing is required. It compensates the Fine Sun Sensor data for velocity abberation, and parallax measurement errors, and computes the update filter. FSS measurement residuals, error valiances and elements of update filter matrix.

UFSTID

UFSTID is to determine if the star currently being tracked is in the active star catalog (Systems Table #38) and exactly which star it is. The first test UFSTID performs is a check for a new star catalog. If STARCAT=1 and Software Time (TU) is greater than or equal to time to use new catalog (TUSE) then the new star catalog is moved into the update filter for use. If not the old catalog continues to be used. Computation of orbit angle is performed and a search of the catalog d made looking at orbit angle (RSU/RSL), intensity (IS) and measurement residuals. The indexing thru the catalog is NCA to a aximum in the catalog of NCAMAX. If a catalog star matches, ISC is incremented and ISTR is set to the index NCA of the star, the search continues thru the entire catalog. If at the end of the search ISC remains 1, the failure counter for FHST 1/2 (NFAIL 1/2) is set to 0 and if the current star index (ISTR) equals the last star index (LSTID) then the update is completed. If the index doesn't match LSTID is set to ISTR and ISC is set to -1 to prevent the update. If at the end of a catalog search ISC is not equal to 1 NFAIL (1/2) is incremented, Last Index (LSTID) is set to -1 and commands are sent to the star tracker to break track. ISC must equla 1 for a Valid Data Flag (VSD) to be set in UFSTOC or UFSTPF. Note that the test of Last Star Index (LSTID) to current Star Index ISTR) makes it necessary to identify a star twice before it is used for an update.

UFGAIN

UFGAIN is called in UFMESP if the Valid Dta Flag (VSD) is set to 1. This subroutine computes and compares the elements of the Update Filter Gain matrix. The Gain Matrix computation will be executed twice during an Update Filter cycle to process data from both sensors.

UFEPGC

This subroutine will combine the Update Filter estimates of Euler Parameters and Gyro Bias compensation errors into a vector that can be used to update these quantities. Two senso measure ents must be processed before the total vector is available. The counter of number of times thru UFEPGC (KCOUNT) is an indication in telemetry of successful update.

UFCMUD

The Covariance Matrix Update subroutine is called to adjust the elements of the Update Filter error covariance matrix to account for the error reduction achieved by the processing the update sensor data. When covariance matrix is completed a call to Dynamic Scaling is made to improve the accuracy of the covariance matrix. There will be two passes through the Covariance Matrix Update during each execution of the Update Filter.

B.3.17.3 Update Filter (UFLTR) Software Constraints

TBD

B.3.17.4 Update Filter (UFLTR) System Tables

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #35 (UFGNPARM)					
0 1 2	VGX VGY VGZ		C	UFSTNC	• Gyro white noise drift variances X, Y, Z axis • Used to compute state noise covariance matrix W11, 12, 13
3 4 5	VRX VRY VRZ			UFSTNC	• Gyro random walk drift variance X, Y, Z axis • Used to compute state noise covariance matrix
System Table #36 (UFHNPARM)					
0	RLM		C	UFSTID	• Measured threshold for star radius squared from tracker boresight • Used to select near or far star in UFSTID
1	RL		C	UFSTID	• FHST measurement error variance for stars near tracker origin • Used in UFSTID to set FHST measurement variance
2	RU		C	UFSTID	• FHST measurement error variance for stars far from tracker origin • Used as RL (above)
System Table #37 (UFPARMS)					
0	ST	*	F	UFMESP	• Star tracker configuration flag

Entry	Name	TLM	Type	Using Subroutine	Description
					0 = FHST + FSS 1 = 2 FHST
					• Used in UFHMESP to branch to UFSTOC or UFSTPF
					• Set by ground to configure to 1 FHST and FSS or 2 FHST
1	FHST	*	F		• Star tracker selection flag 1 = FHST #1 2 = FHST #2
					• Used to select which FHST if ST (above) = 0
2	PAO		C	UFINIT	• Initial attitude error variance
4	PGO		C	UFINIT	• Initial gyro bias variance
6	KST		C	UFSTC	• Scaling constant for star tracker raw data
7	CI		C	UFSDCR	• Inverse of speed of light
8	TMD		C	UFSDCR	• Mean star tracker measure manual time delay
					• Used in UFSDCR to correct measurement rates XSD, YSD
9	KS		C	UFSTID	• Residual STD dev. mult. for star ID criteria
10	RF		C	UFSTID	• Star rotation angle tolerance
					• Used in UFSTID to compute allowable orbit angle

Entry	Name	TLM	Type	Using Subroutine	Description
11	DRI-1		C	UFSTID	• FHST #1 rotational angle (Delta-RHO)
12	DRI-2		C	UFSTID	• FHST #2 rotational angle (Delta-RHO)
13	RFSS		C	UFFSDP	• FSS error variance
Systems Table #38 (STARCAT)					
0	STRCAT	*	F	UFSTID	• Star catalog available flag 0 = not available 1 = available • Used to load new star catalog set by ground reset by UFSTID when new catalog transferred to UFLTR data base
1	TUSE		V	UFSTID	• Time to begin using the star catalog relative to software time • Used in UFSTID to execute new star catalog use
4	CATMAX	*	V	UFSTID	• Number of stars in catalog • Used in UFSTID to test for end of catalog (NCAMAX)
5	LSIX(NCA)		V	UFSTID	• X component of the (NCA)th star LOS unit vector
7	LSIY(NCA)		V	UFSTID	• Y component of the (NCA)th star LOS unit vector
9	LSIZ(NCA)		V	UFSTID	• Z component of the (NCA)th star LOS unit vector

Entry	Name	TLM	Type	Using Subroutine	Description
11	ISU(NCA)		V	UFSTID	• Star intensity upper limit for NCA # star
12	ISL(NCA)		V	UFSTID	• Star intensity lower limit for NCA # star
13	RS(NCA)		V	UFSTID	• NCA star orbit angle -
Entries 5 thru 13 repeated from 1 to CATMAX					
System Table #39 (UFSSUVEC)					
0	XFX(1)		C	UFFSDP	• Unit vectors along FSS axes in terms of vehicle X axis
1	XFX(2)		C		
2	XFX(3)		C		
3	YFX(1)		C	UFFSDP	• Unit vector along FSS axes in terms of vehicle Y axis
4	YFX(2)		C		
5	YFX(3)		C		
6	ZRX(1)		C	UFFSDP	• Unit vector along FSS axes in terms of vehicle Z axis
7	ZFX(2)		C		
8	ZFX(3)		C		
System Table #40 (UFMFCOC1)					
0-8	KFXX1(N) N=0->8		C	UFSTDC	• 9 coefficients that relate magnetic field at FHST #1 to magnetic torquer bar current
System Table #41 (UFMFCOC2)					
0-8	KFXX2(N) N=0->8		C	UFSTDC	• 9 coefficeints that relate magnetic field at FHST #2 to magnetic torquer bar current
System Table #42 (UFISTUV1)					
0-8	XTX1(N) N=0->8		C	UFSTDC	• Components of FHST #1 unit vector

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #43 (UFISTUV2)					
0-8	XTX2(N) N=0->8		C	UFSTDC	• Component of FHST #2 unit vector
System Table #44 (UFFTCOF1)					
0-18			C	UFSTDC	• "A" coefficient set for FHST #1
19-37			C	UFSTDC	• "A" coefficient set for FHST #2
					• Coefficients for flat field and temperature effects correction
System Table #45 (UFFTCOF2)					
0-19			C	UFSTDC	• "B" coefficient set for FHST #1
19-37			C	UFSTDC	• "B" coefficient set for FHST #2
					• Coefficients for flat field and temperature effects correction
System Table #46 (UFICCOF1)					
0-18			C	UFSTDC	• "C" coefficient set for FHST #1
19-37			C	UFSTDC	• "C" coefficient set for FHST #2
					• Star intensity calibration coefficients

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #47 (UFICCOF1)					
0-18			C	UFSTDC	• "D" coefficient set for FHST #1
19-37			C	UFSTDC	• "D" coefficient set for FHST #2
					• Star intensity calibration coefficients
System Table #48 (UFCCEMF1)					
0-18			C	UFSTDC	• "EB" coefficient set for FHST #1
19-37			C	UFSTDC	• "EB" coefficient set for FHST #2
38-57			C	UFSTDC	• "EH" coefficient set for FHST #1
58-75			C	UFSTDC	• "EH" coefficient set for FHST #2
76-94			C	UFSTDC	• "EV" coefficient set for FHST #1
95-113			C	UFSTDC	• "EV" coefficient set for FHST #2
					• Magnetic field corrections coefficients
System Table #49 (UFCCEMF2)					
0-18			C	UFSTDC	• "FB" coefficient set for FHST #1
19-37			C	UFSTDC	• "FB" coefficient set for FHST #2

Entry	Name	TLM	Type	Using Subroutine	Description
38-56			C	UFSTDC	• "FH" coefficient set for FHST #1
57-75			C	UFSTDC	• "FH" coefficient set for FHST #2
76-94			C	USTDC	• "FH" coefficient set for FHST #1
95-113			C	UFSTDC	• "FH" coefficient set for FHST #2 • Magnetic field corrections coefficients

B.3.17.5 Update Filter (UFLTR) Telemetry

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report 24 (UFLTRØ1)			
0-5	S1-3	UFEPGC	Estimated roll/pitch/yaw attitude determination error
6-10	S4-6	UFEPGC	Estimated roll/pitch/yaw gyro bias compensation error Updated every 32 seconds Used in EULER I (ACS) to compute EPA 1-4 (Quaternion) and THEATBX,Y,Z gyro bias factors
12-20	PM11(1,2,3)	UFCMPC	Attitude error covariance matrix elements Initialized in UFINIT (if FLTRI is on) cleared to zero element 1,5,9 ---> PAO (Table 37) Propagated in UFCMPC Updated in UFCMUD Scaled by SCP11 (TLM Report 29) Used as VP1,2,3 in gain matrix computation (UFGAIN) TLM Report 25 contains PM11 (5,6,9)
24	FHST	UFSTOC/GND	Star Tracker Selection 1 = FHST #1 2 = FHST #2 Set by ground in FSS + FHST mode Selected by UFSTOC in FHST only mode Used by UFSTOC, UFSTPF, UFSTDC
OBC TLM Report 25 (UFLTR 02)			
0-8	PM11(5,6,9)	UFEPGC	See TLM Report 25 entry 12-20
12-20	PM22(1,2,3)	UFCMPC	Gyro bias error covariance matrix elements Initialized by UFINIT (if FLTR1 = 1) cleared to zero element 1,5,9 set to PGO (Table 37) Propagated in UFCMPC

Entry Number	Name	Generating Subroutine	Description/Comment
			Updated by UFCMUD Scaled by SCP22 (TLM Report 29) TLM Report 26 contains PM22 (5,6,9)
24	NFAIL1	UFSTID	Star ID failure counter FHST #1 Incremented in UFSTID if ISC ≠1 ISC = # of stars accepted - If ISC = 1 NFAIL 1 cleared to 0
OBC TLM Report 26 (UFLTR 03)			
0-8	PM22(5,6,9)	UFCMPC	See TLM Report 25 entry 12-20
12-20	PM12(1,2,3)	UFCMPC	Attitude error and gyro bias error cross covariance matrix elements Propagated in UFCMPC Scaled by SCP12 (TLM Report) Used as VP4,5,6 in UFGAIN PM12(4-9) in TLM Report 27
24	NFAIL2	UFSTID	See TLM Report 25 FHST #2
OBC TLM Report 27 (UFLTR 04)			
0-20	PM12(4-9)	UFCMPC	See TLM Report 26 entry 12-20
OBC TLM Report 28 (UFLTR 05)			
0-10	K(1)-K(6)	UFGAIN	Update filter gain matrix elements K(I) 1st pass KI(I) 2nd pass
12-24	KI(1)-KI(6)		Scaled by SCKIL (low) and SCKIH (high) of TLM Report 29 Used in EULER Parameter and gyro bias correction (UFEPGC)
OBC TLM Report 29 (UFLTR 06)			

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Entry Number	Name	Generating Subroutine	Description/Comment
0-2	XS,YS	UFSDCR	Star tracker LOS vector components along tracked X/Y axis Used in UFSTID $ZS = (1 - (XS^2) - (YS^2))$ ZS is computed in UFSDCR
4-10	SCP11,12,22 SCKL/H SCKIL/H		Scaling Factors SCP11 ---> PM11 (RPT 24/25) SCP12 ---> PM12 (RPT 27) SCP22 ---> PM22 (RPT 25/26) SCKL/H ---> K (RPT 28) SCKIL/H---> KI (RPT 28)
<u>OBC TLM Report 30 (UFLTR 07)</u>			
0	TP	UFSAPC	Propagation interval TP = Flight software time - past SW time Compared to TPD (delta prop int.) to call UFSTNC or not TPD is in data base
1-3	Z1,Z2	UFSTID for FHST UFFSDP for FSS	Sensor (FHST or FSS) measurement residuals Scale -3 for FHST only -2 for FHST and FSS Used in UFEPGC
5-9 11-15	H1(1/2/3) H2(1/2/3)	UFSTID or UFFSDP	Elements of measurement matrix for X/Y measurement Used in UFGAIN and UFEPGC
17-19	VS1,VS2	UFSTID	FHST X/Y axis measurement residual accuracy criteria Used in UFSTID Used for star acceptance test (SX<VS1.AND.SY<VS2)
21	RS		Spacecraft orbit rotation angle Used in UFSTID

Entry Number	Name	Generating Subroutine	Description/Comment
			Used to compute FHST orbit angle RT = RS + DR (FHST)
OBC TLM Report 31 (UFLTR 08)			
0	THETAM	UFSTDC	Star tracker compensated measurement Used in UFSTDC THETAM = VVM3*KST KST = constant VVM3 = Result of calibration polynominal calculation
2	PHIM	UFSTDC	Fully compensated FHST measurement Used in UFSTDC PHIM = HHM3*KST KST = constant HHM3 = result of cal. poly. calc.
4 8	XSC ZSC	UFSTDC	Tracker star LOS unit vector along tracker X/Z axis Used in UFSDCR YSC in TLM Report 34 (1)
10 12	XP YP	UFFSDP	Compensated FSS roll/pitch axis measurement Compensated for abberation Used in UFFSDP to compute measurement residuals
14,16	XPE,YPE	UFFSDP	Expected FSS measurement for X/Y axis Used in UFFSDP to compute measurement residual and measurement error variance
18	PCOUNT	UFCMPC	Count of number of times through covariance matrix propagation Initialized to zero when UFINIT executed

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Entry Number	Name	Generating Subroutine	Description/Comment
			Incremented in UFCMPC TLM indicator that ACS is being updated by UFLTR
19	KCOUNT	UFKPGC	Count of number of times through gain matrix computation Initialized to zero when UFINIT executed Incremented in UFKPGC Indication (along with PCOUNT) that ACS is bei e updated
20,21	LSX,LSY	UFSDCR	Component of measured star LOS along vehicle X/Y axis Used in UFSTID to compute measurement matrix components
OBC TLM Report 12 (UFLTR 09)			
0	LSZ		See OBC TLM Report 11 (20,21)
2,4	SX,SY	UFSTID	Star tracker measurement residuals Used in star ID to test for acceptance residuals
6	IS	UFSTDC	Star tracker intensity Used for star intensity correction Used in UFSTID in star catalog search
[illegible]	TS	UFSTDC	Star tracker temperature Used to compensate for FHST temp effects
8	ISTR	UFSTID	Identified star index Present identified star obtained from NCA count Tested against last star ID LSTID-1 for acceptance

Entry Number	Name	Generating Subroutine	Description/Comment
9,10	LSTID-1/2	UFSTID	Last star identified by FHST 1/2 ISTR becomes LSTID upon exit from star test
11	TRY	UFSTOC UFSTPF	Update sensor sequence counter 1 = data from 1st sensor has been processed 2 = data from 2nd sensor has been processed Reset in UFMESP
12	ISC	UFSTID	Number of stars in catalog that pass ID criteria Initialized to 0 when star catalog entered Incremented when acceptable measurement residuals found If ISTR ≠ LSTID ---> ISC = -1 preventing update
13	NCA	UFSTID	Index of accepted star Incremented from 1 to NCAMAX in star catalog search ISTR = NCA when star accepted
14	NCAMAX	UFSTID (GND)	Number of stars in catalog Set by ground when new star catalog loaded NCA increments from 1 to NCAMAX
15	PASS	UFMESP	Index for gain matrix comp. Initialized to 0 in UFMESP Incremented in UFMESP Pass = 1, 1st sensor process Pass = 2, 2nd sensor process Used in UFGAIN to select proper data set
16	STRCAT	UFSTID (GND)	Star catalog ready flag Set to 1 by ground when new catalog

Entry Number	Name	Generating Subroutine	Description/Comment
			is ready for use Set to 0 by program when STARCAT BUFFER moved into STAR CATALOG
17	VSD	UFSTOC UFSTPF	Valid star data flag Reset to 0 in UFMESP Set to one in UFSTOC if FHST has good data Set to one in UFSTPF if FSS has good data Checked in UFMESP
18	UFDTREQAD	UFLTR	Update filter data request flag Set to 1 to request SCP to save data set Reset to 0 when save is complete
19	ST		FHST configuration flag 0 = FHST + FSS 1 = 2 FHST's Set by ground to switch into FSS + FHST mode Checked in UFMESP to select FSS + FHST or 2 FHST SW path
OBC TLM Report 33 (UFLTR 10)			
0	U	UFGAIN	UF residual variance Used in UFGAIN
5	UI	UFGAIN	Inverse of U
10	SCU	UFGAIN	Scale of U
13	SCUI	UFGAIN	Scale of UI
OBC TLM Report 34 (UFLTR 11)			
0	YSC		See OBC TLM Report 31 (4,8)

Entry Number	Name	Generating Subroutine	Description/Comment
2	H	UFSTDC	FHST horizontal measurement Used to compute HHT, VVT in UFSTDC
4	TST1		FHST #1 star intensity data Obtained when SCP called to save data
5	V	UFSTDC	FHST vertical measurement Used to compute HHT, VVT in UFSTDC
7	TST2		FHST #2 star intensity data Obtained when SCP saves data for UF
8,9	ST1T,ST2T	UFSTDC	Temperature data from FHST #1/2 Obtained when SCP saves data for UF

B.3.17.6 Update Filter (UFLTR) Flow Charts

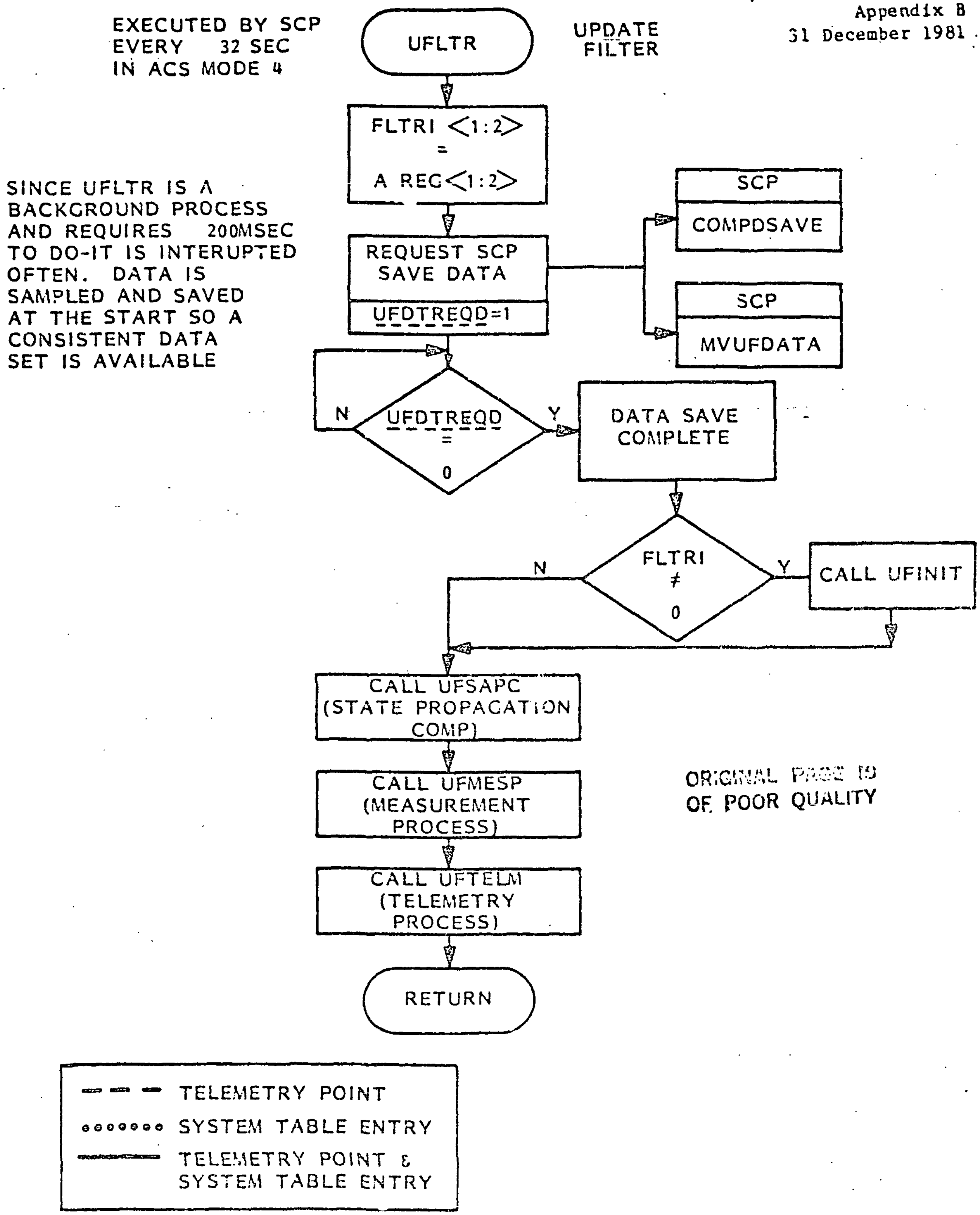

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FIGURE B.3.17-2 UFLTR Flow Chart

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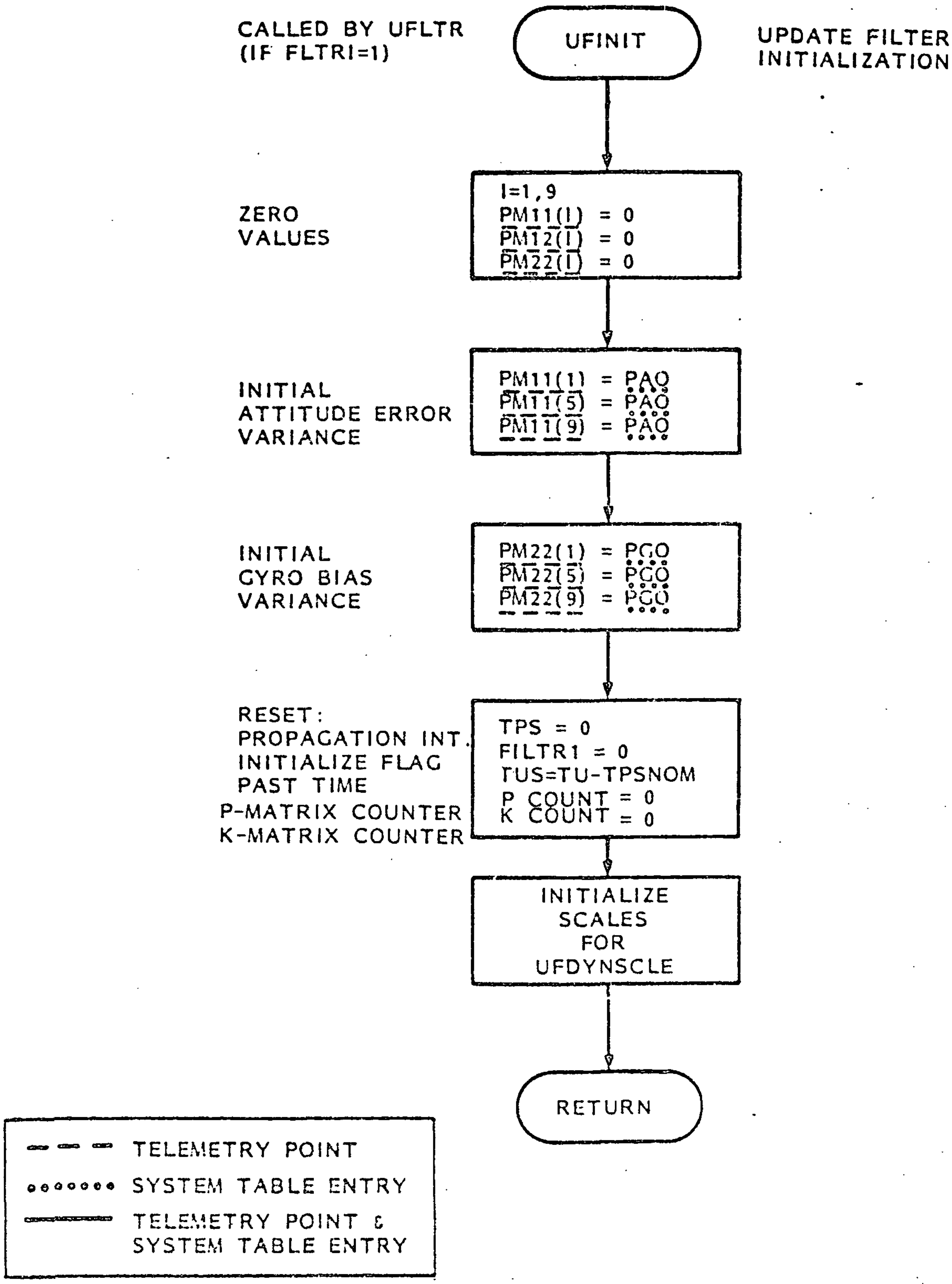

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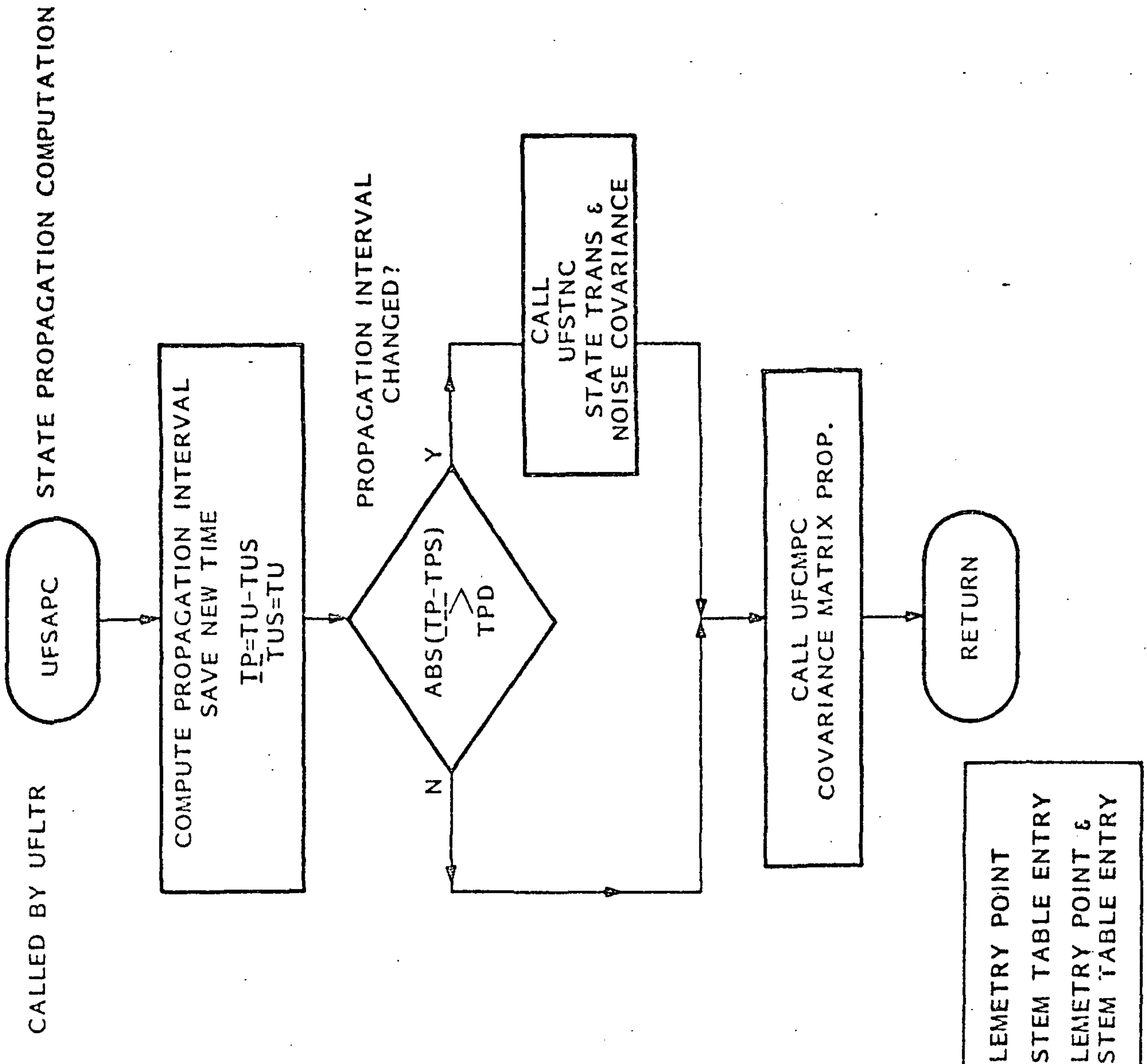

FIGURE B,3.17-4 UFSAPC Flow Chart

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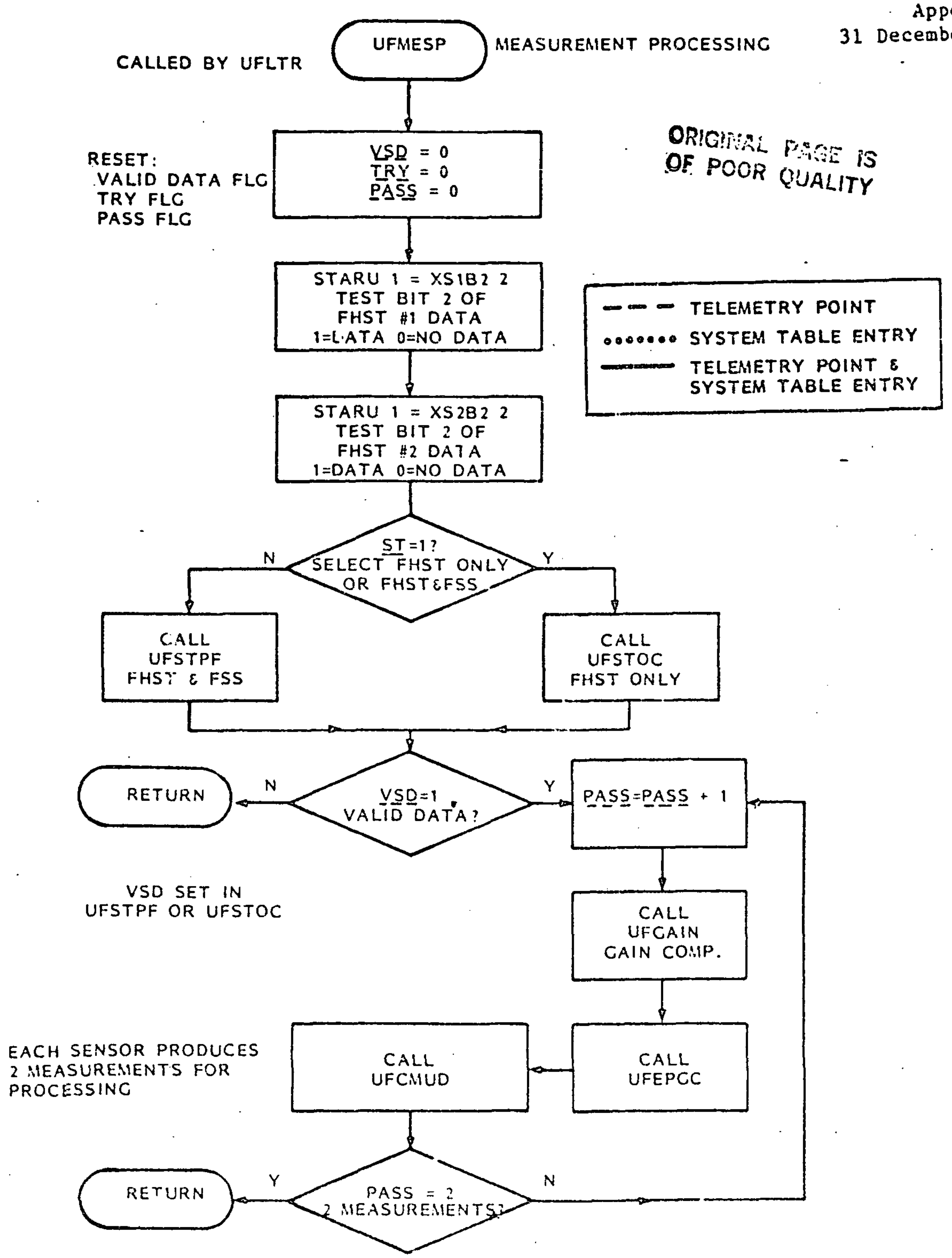

FIGURE B.3.17-5 UFMESP Flow Chart

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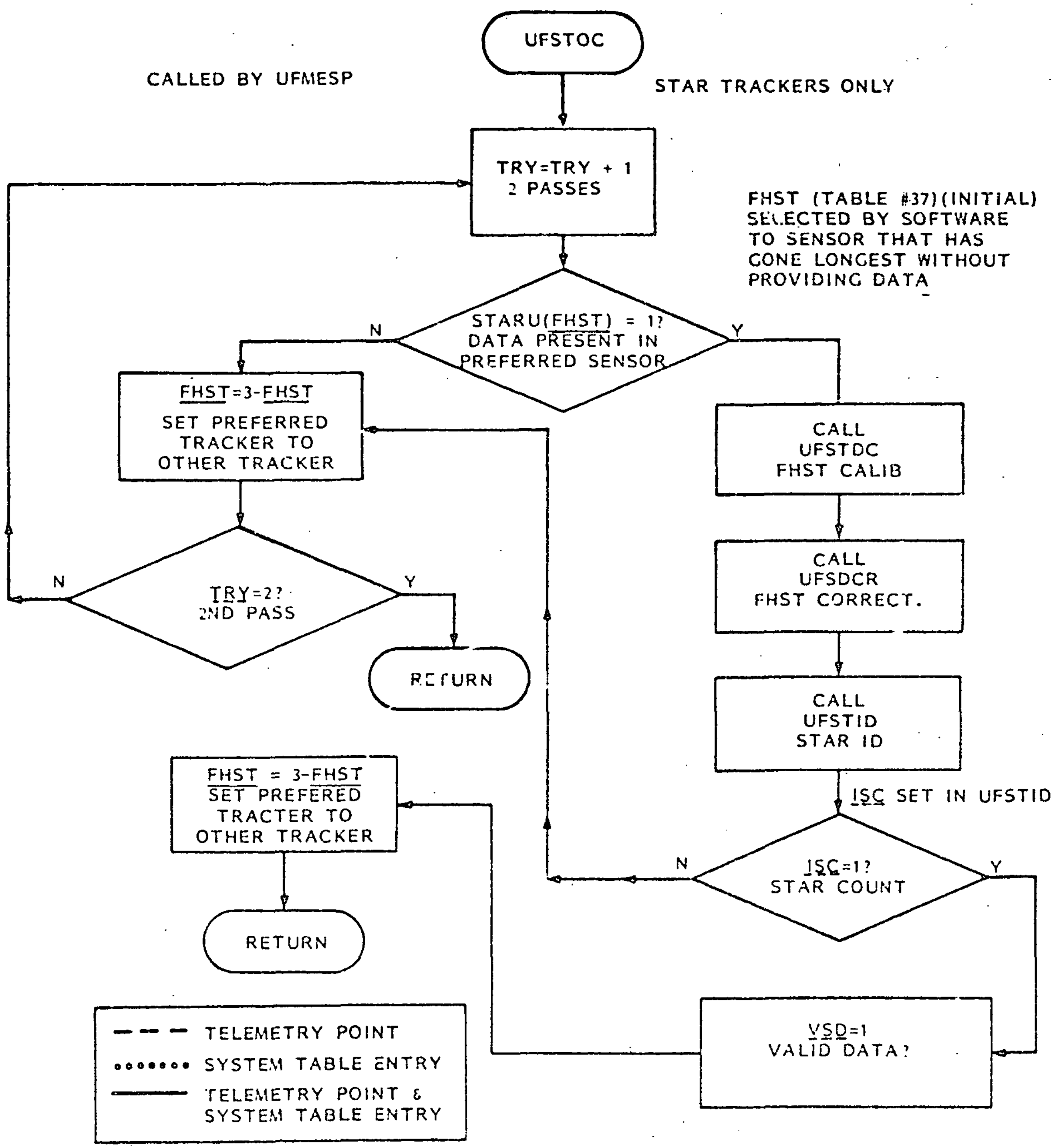
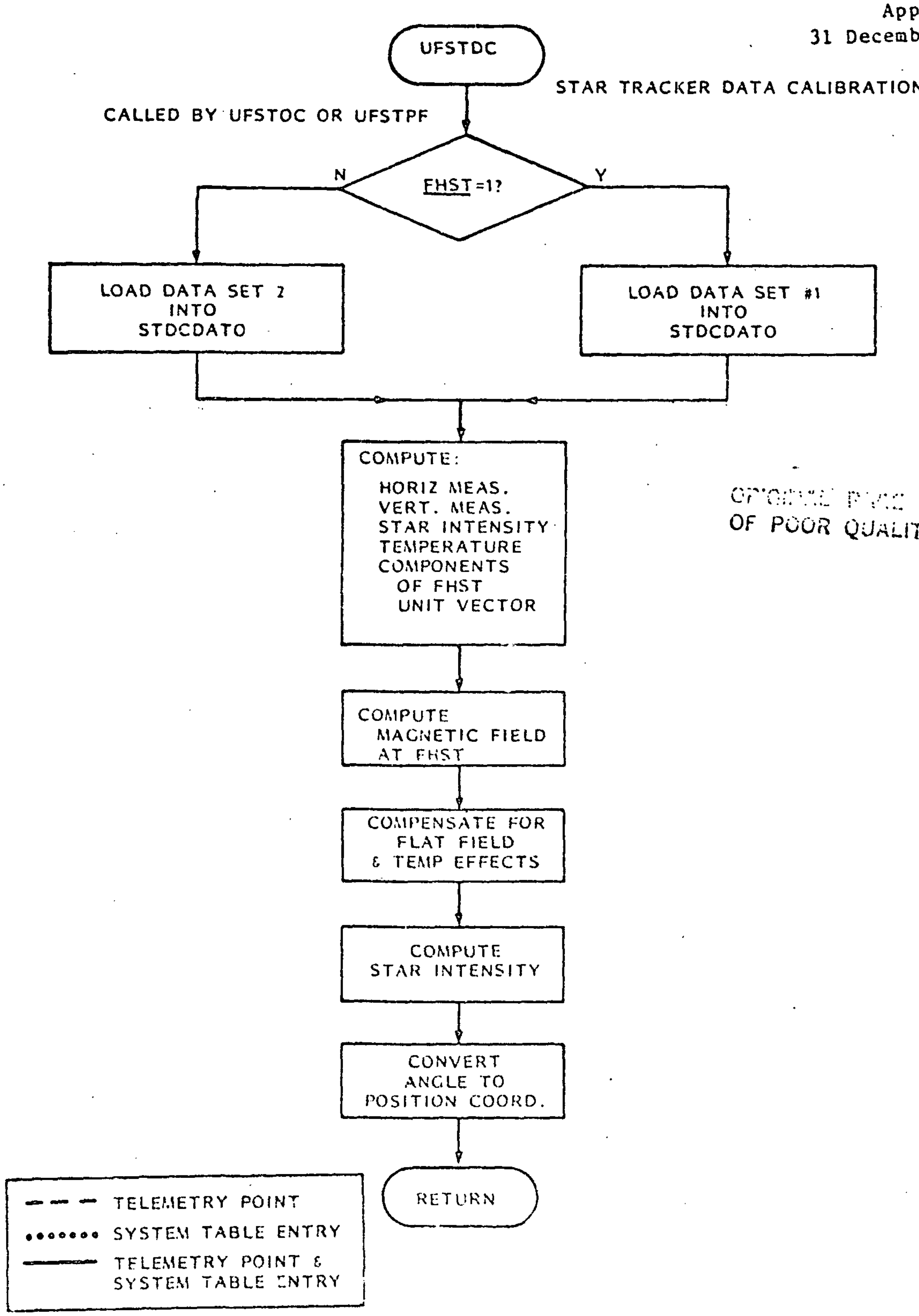


FIGURE B.3.17-6 UFSTOC Flow Chart



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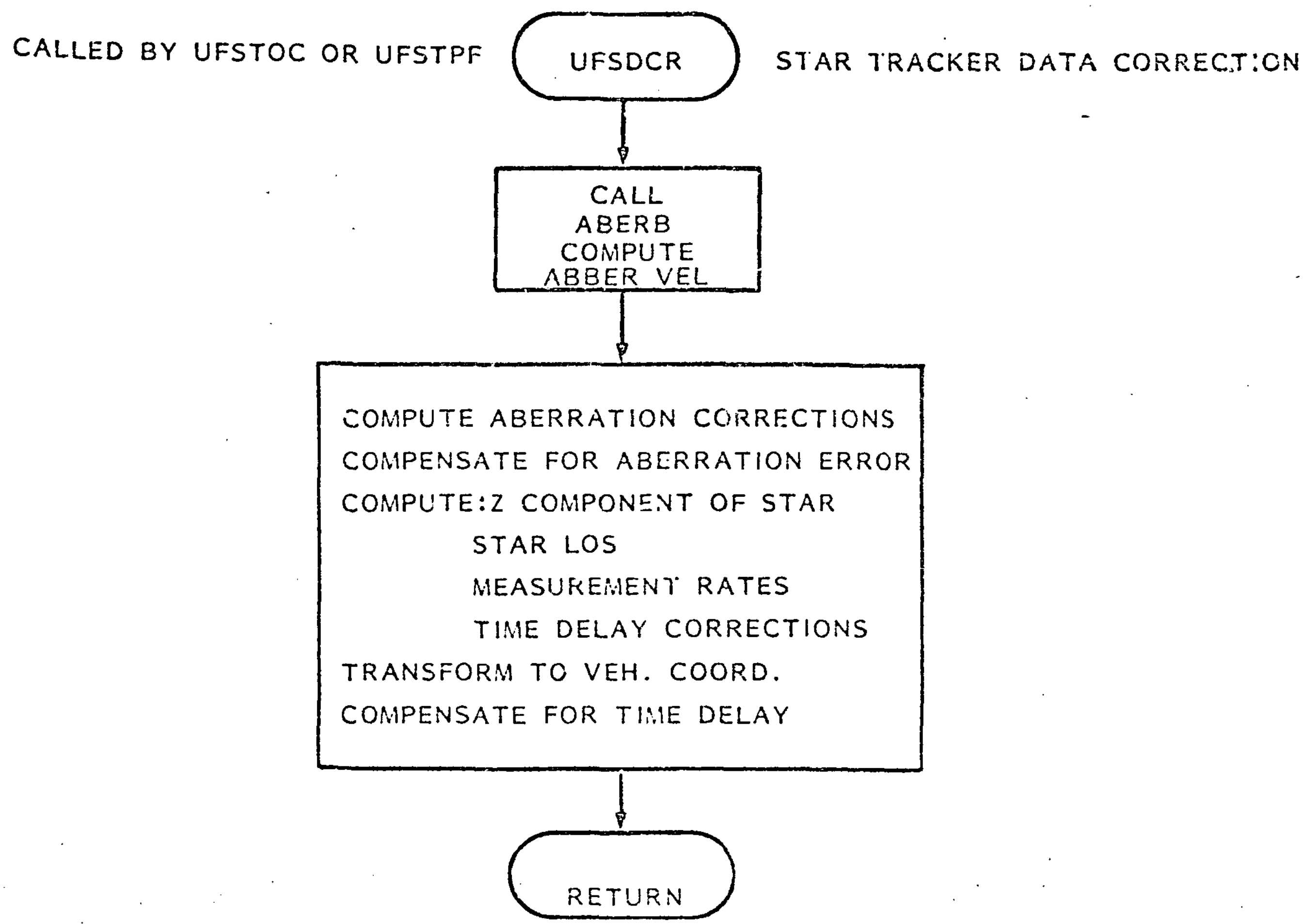

FIGURE B.3.17-B UFSDCR Flow Chart

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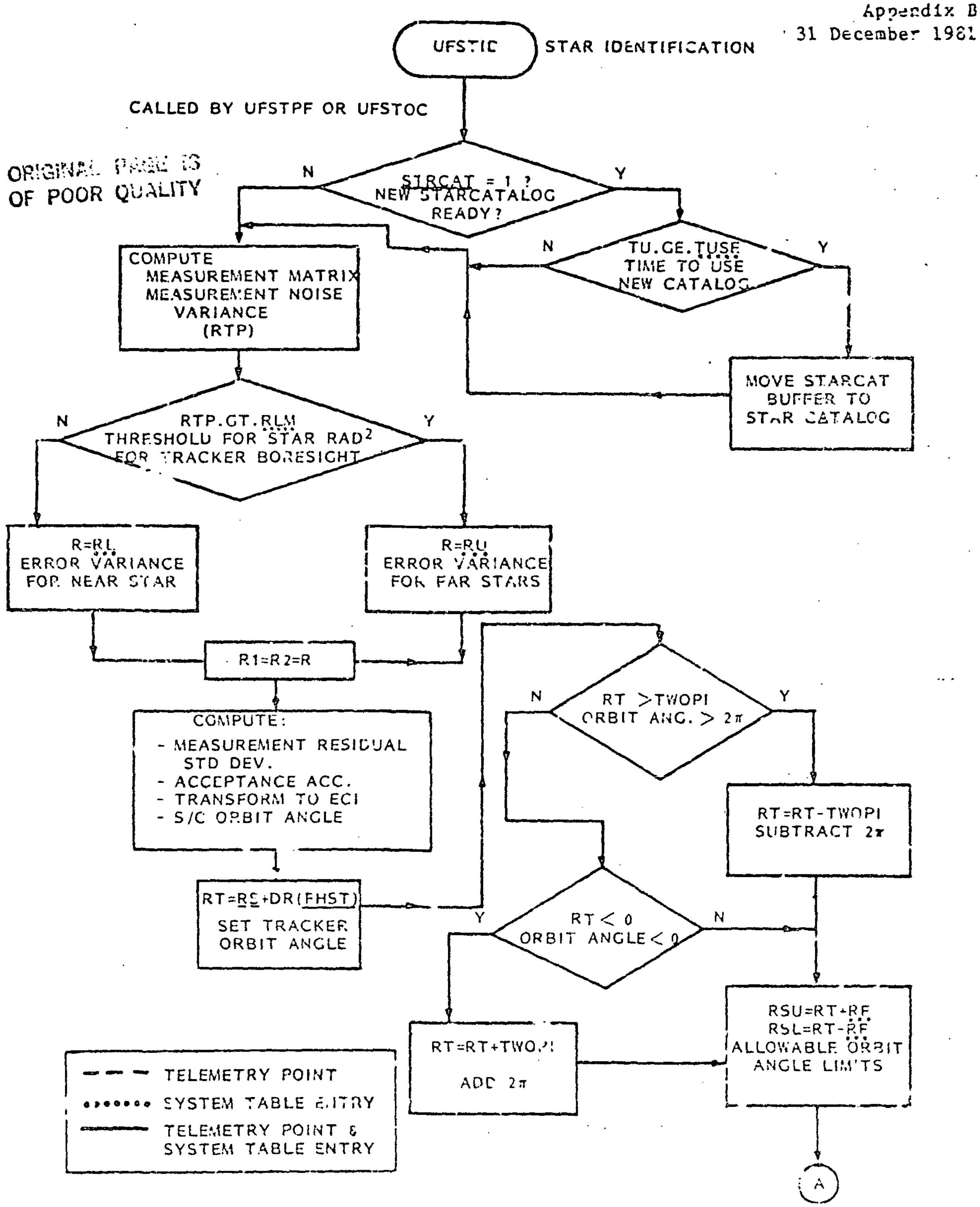

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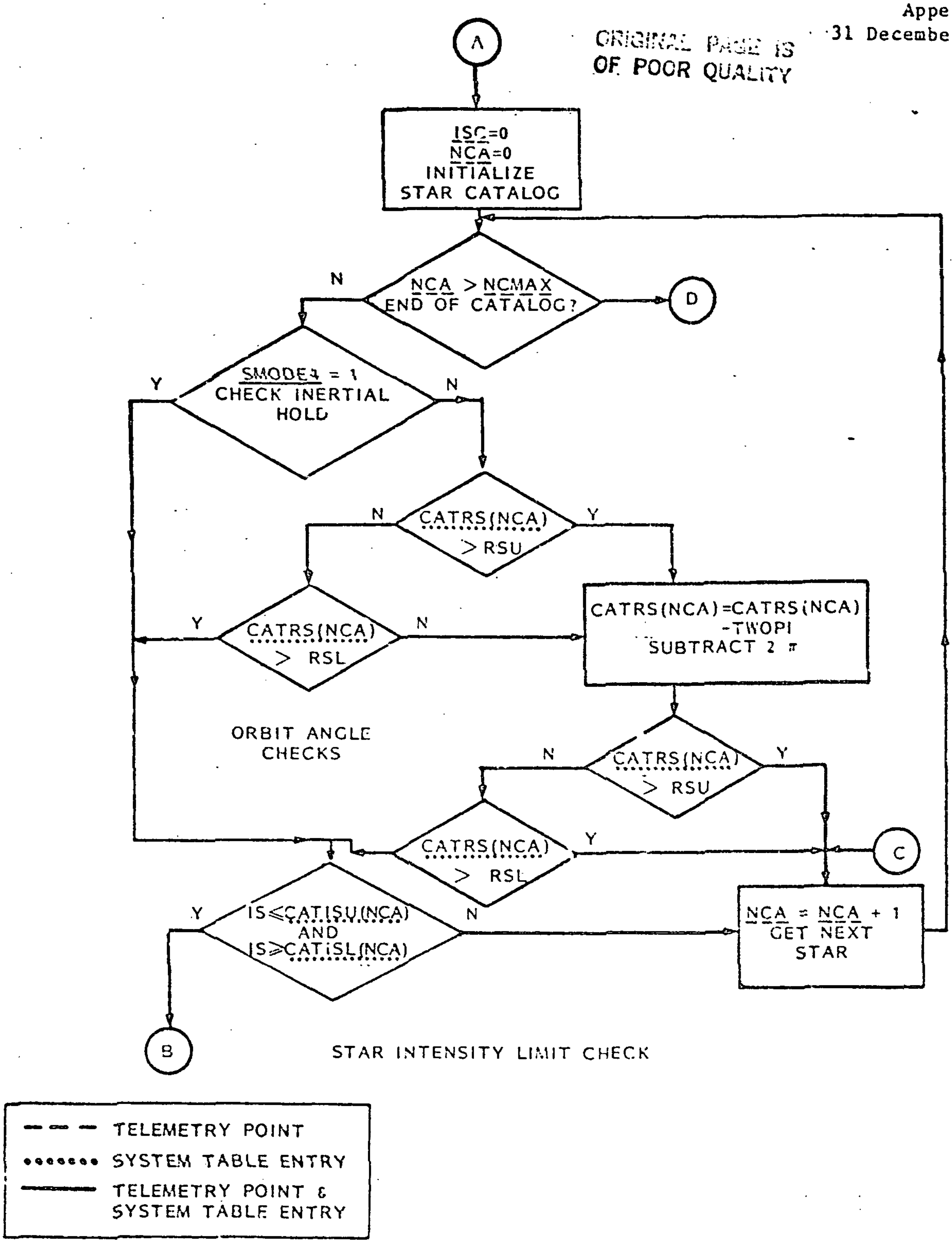

FIGURE B.3.17-9 UFSTID Flow Chart (continued)

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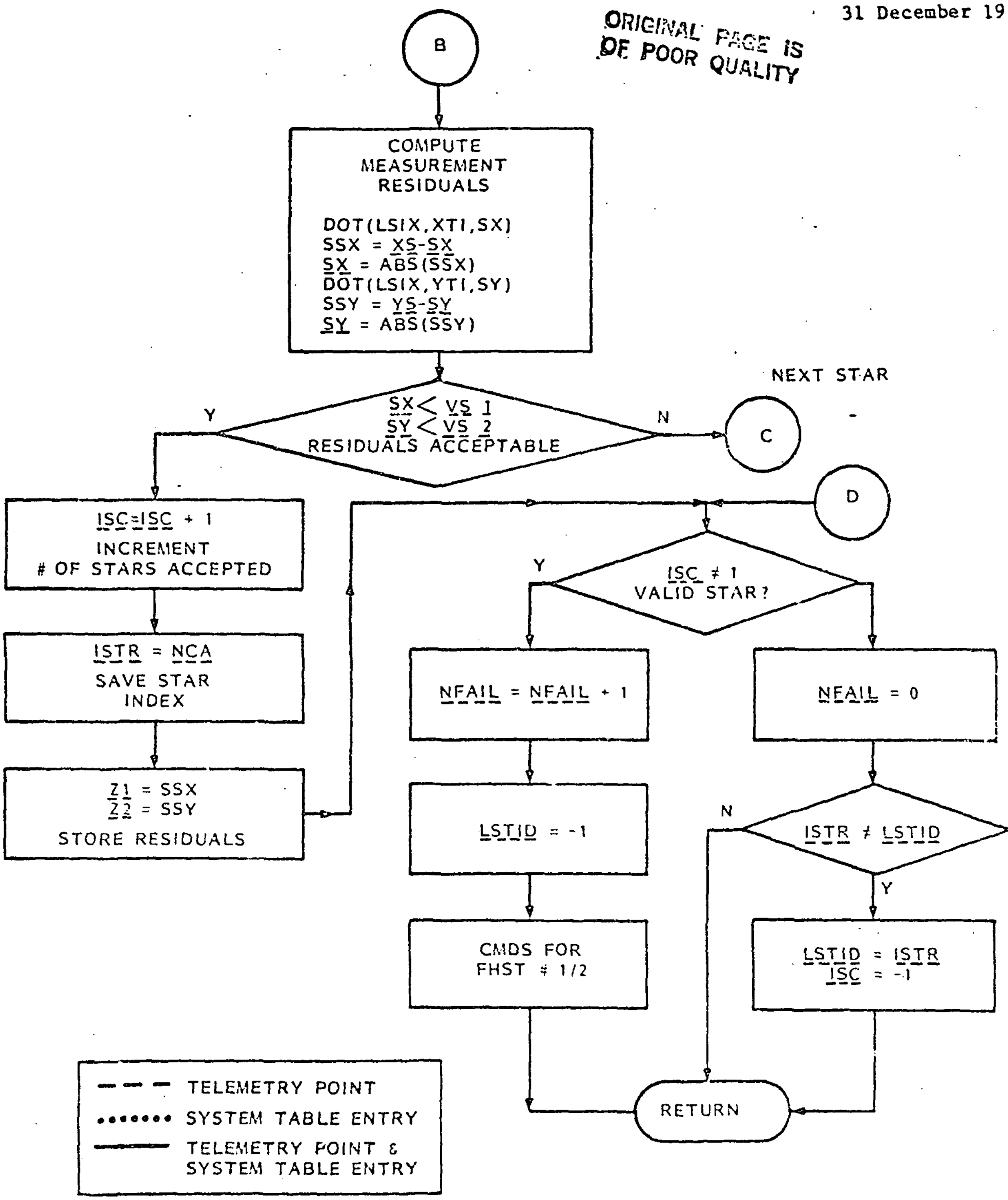

FIGURE B.3.17-9 UFSTID Flow Chart (continued)

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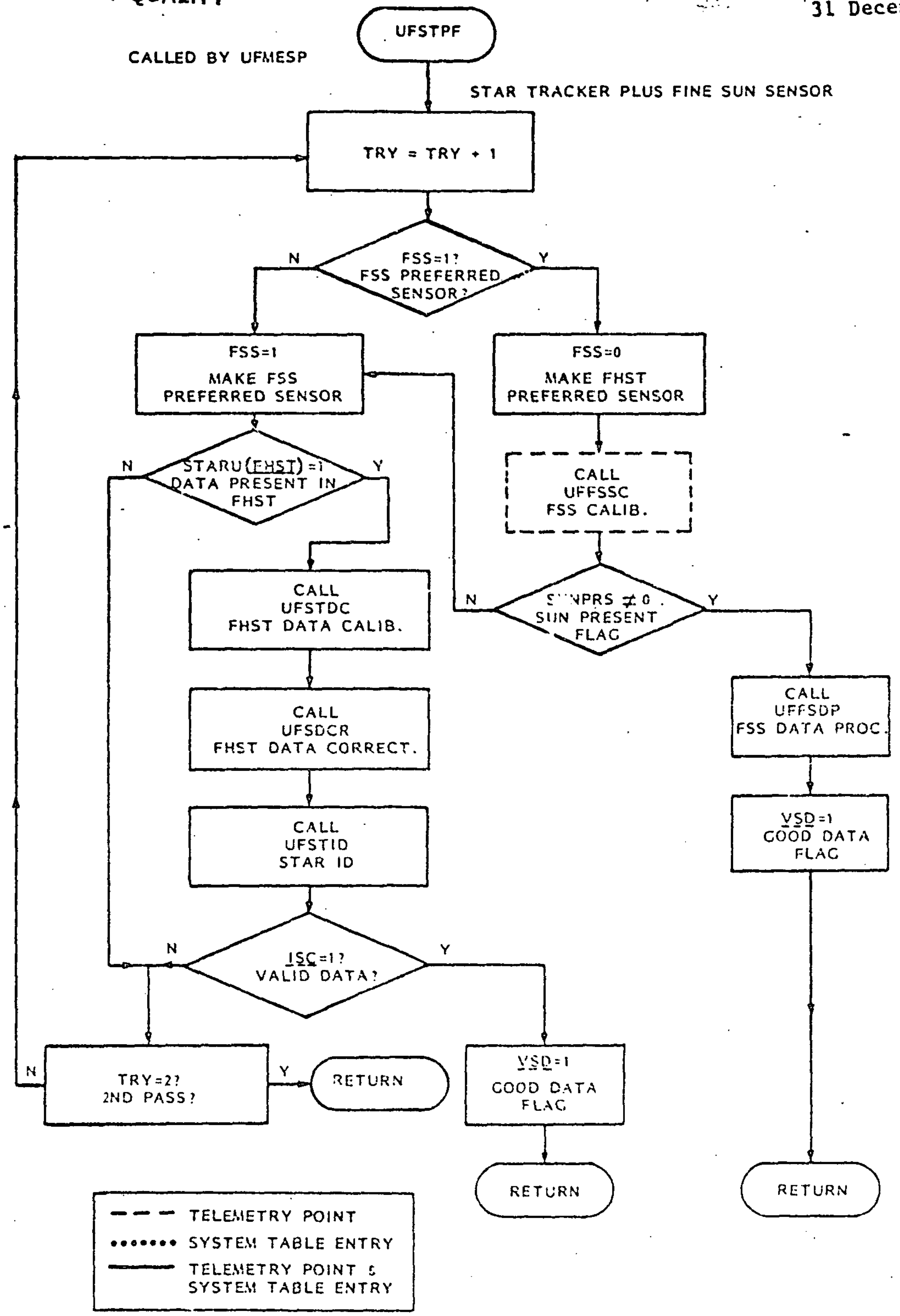

FIGURE B.3.17-10 UFSTPF Flow Chart

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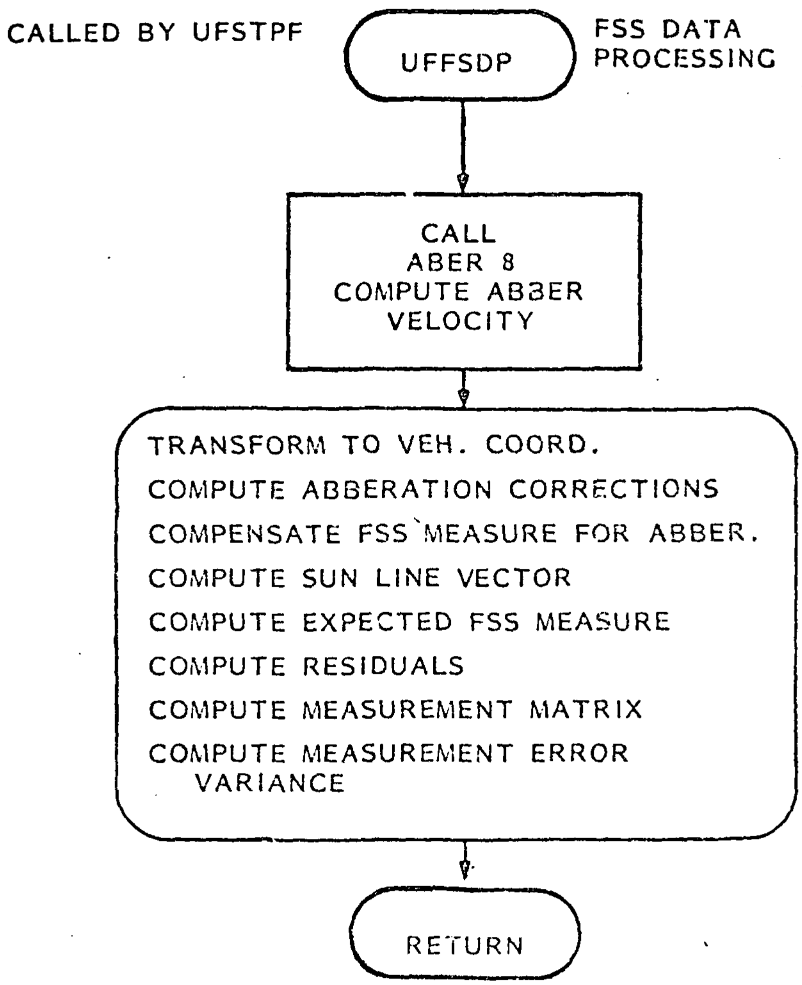

FIGURE B.3.17-11 UFFSDP Flow Chart

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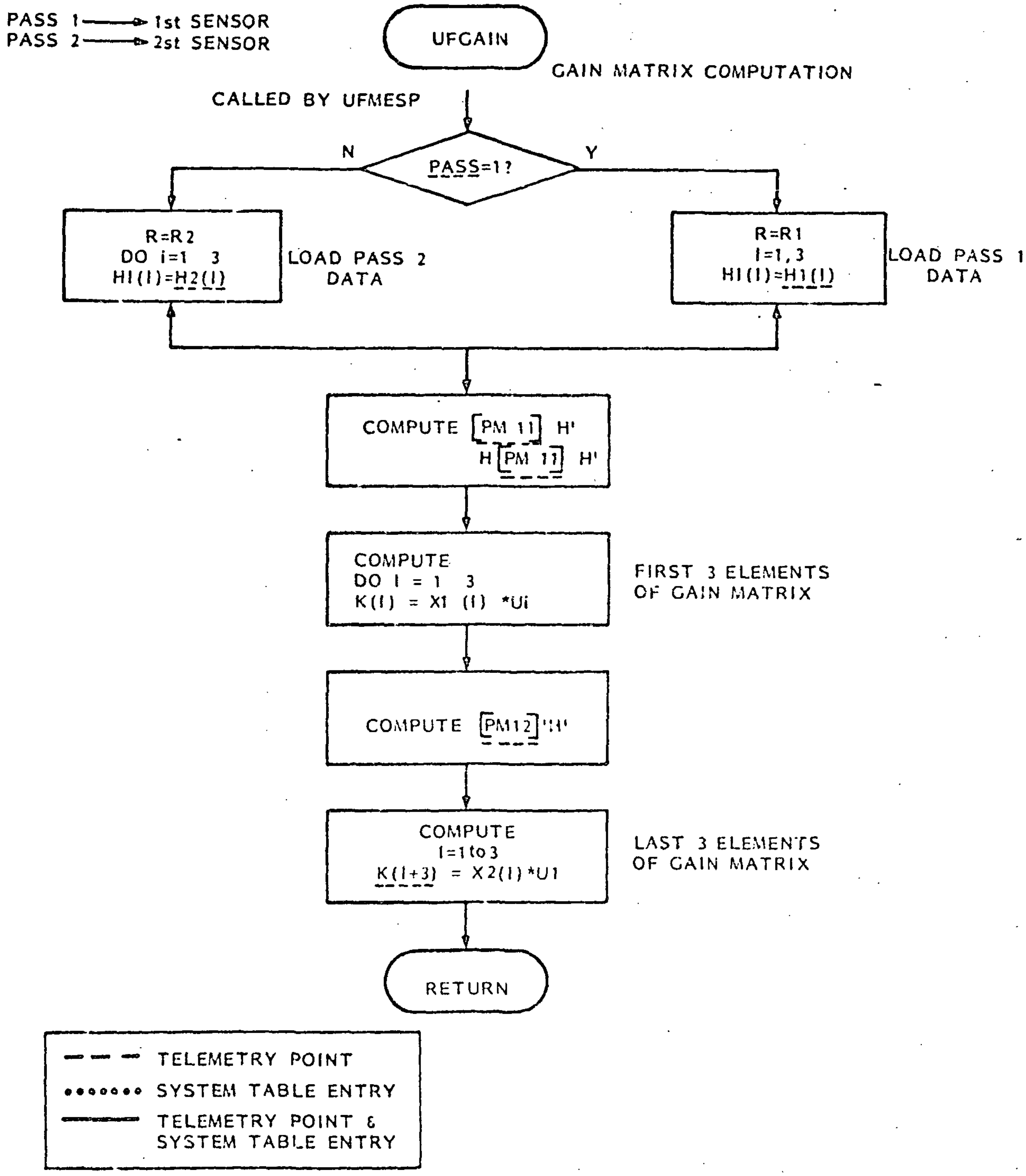

FIGURE B.3.17-12 UFGAIN Flow Chart

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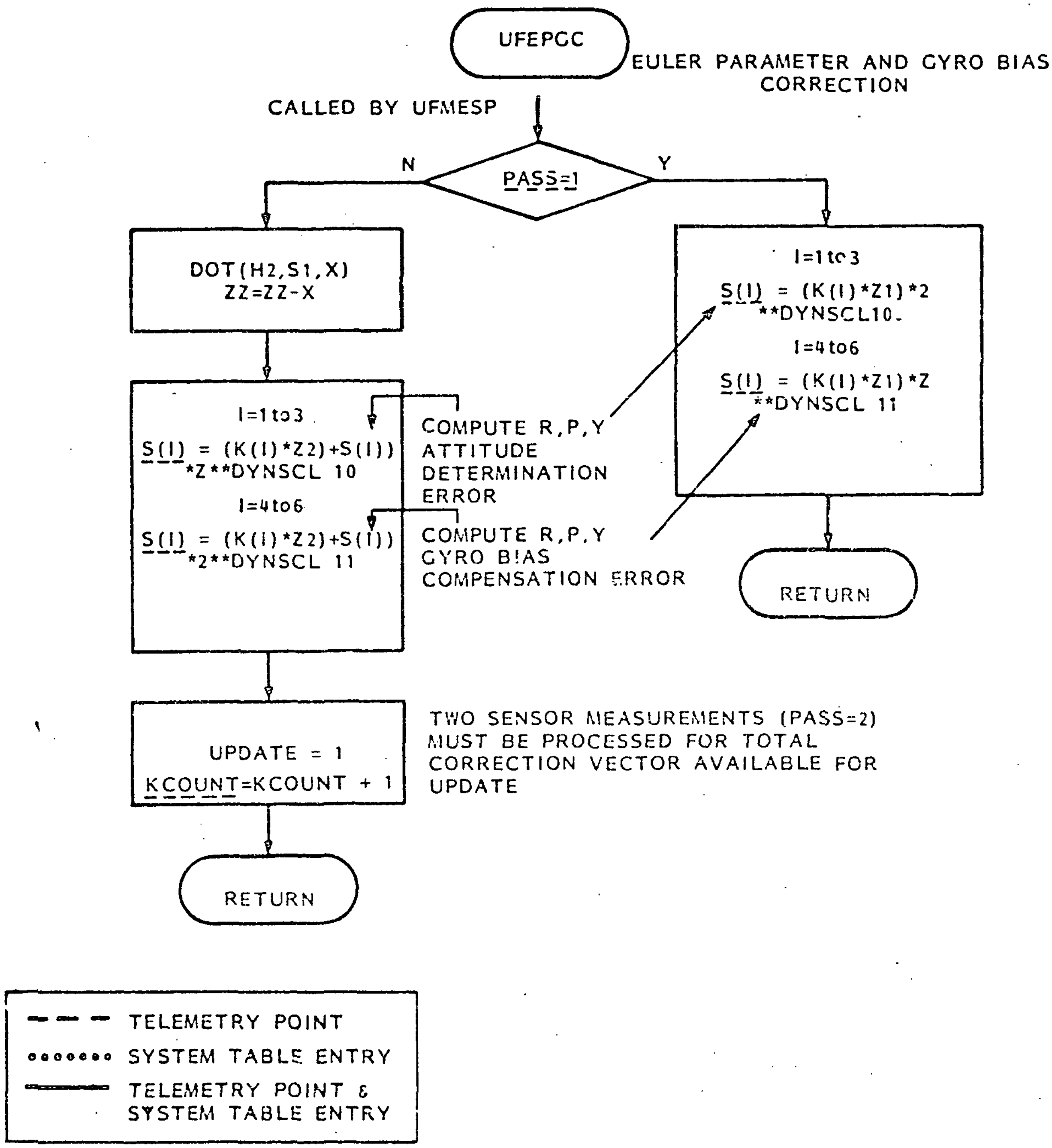

FIGURE B.3.17-13 UFEPGC Flow Chart

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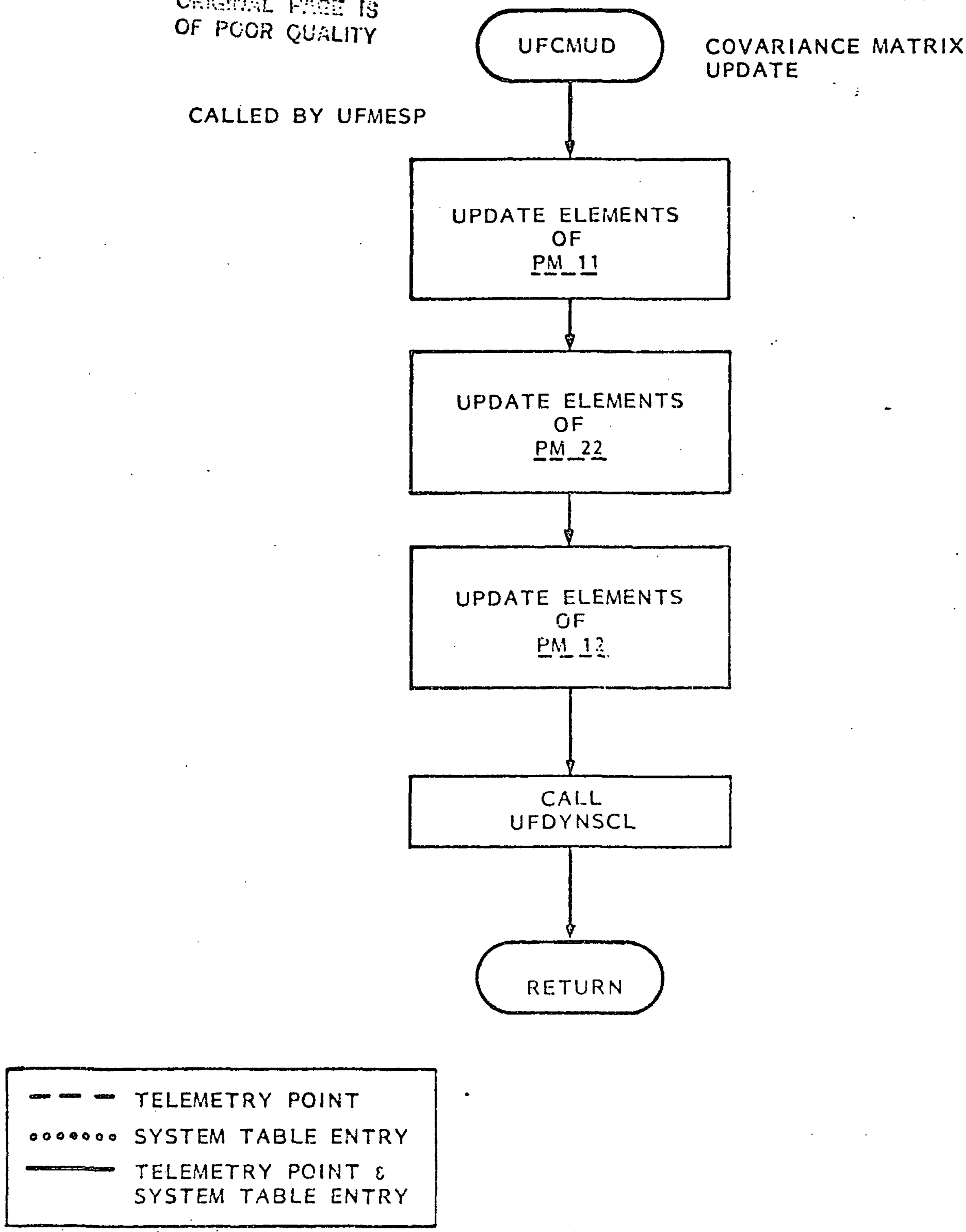

FIGURE B.3,17-14 UFCMUD Flow Chart

B.3.18 TELEMETRY MONITOR/RESPONSE PROCESSOR (TMRP)

B.3.18 TELEMETRY MONITOR/RESPONSE PROCESSOR (TMRP)

B.3.18.1 Telemetry Monitor/Response (TMRP) Processor Description

Telemetry Monitor/Response Processor (TMRP) is a generalized limit checking and group response program that is initialized by Flight Executive every 16.384 seconds. The software is table driven. The TMON processor is summarized in Table B.3.18-1. TMRP can be used to perform three safety actions; (1) report when a specified set of conditions are met, (2) turn subsystems off when their critical limits are exceeded, (3) implement thermostatic functions (turn heater ON/OFF). These actions will be reported to the ground by a status buffer array. The following steps will be taken to determine proper action. The output tables will be initialized with zero's and the input tables will be verified and initialzed. Every 16.384 seconds selected groups of telemetry items will be compared to their preset bits or limits on a group by group basis, starting with the first group and ending at the seventy-fifth group. Within each group the telemetry items will be compared to their preset bits or limits in a sequential fashion. There is no restriction in the number of times an item can be sampled. The number of items which can be specified for a given group is only limited by the table size. An item can be any main frame telemetry point or any NSSC memory location. When a group has checked out of limits three consecutive times (approximately 48 seconds at the 8 kbps rate and 2 minutes at the 1 kbps rate) the ground segment will be notified (at the end of checking all groups) and TMRP will inhibit itself from further executions. If this occurs the ground segment must uplink a new table and reenale the TMRP. The ground segment, however, can reenable the group for limit checking or inhibit a group from limit checking, inhibit groups from sending commands or reenable groups for sending commands.

Information about the check/response of tables will be reported via both the OBC contribution to telemetry and the Flight Executive status buffer, regardless of whether any commands are issued or not.

Table B.3.18-1. Telemetry Monitor (TMON)

Telemetry Monitor

Number: 16
Type:
Priority: 3
Period: 16.384
Function:

Subroutines:

TINIT	TMON Initialization Processing
TVERIFY	TMON Table Verification
TCNTRL	TMON Control Processing
TCHECK	TMON Compare Processing
TREACT	TMON Reaction Processing

Systems Tables:

#	Mnemonic	Description
28	TMREQCMD	Real Time Cmds for TMON
29	TMGRUPS	Group Definitions for TMON
30	TMITEMS	Item Definitions for TMON

Telemetry:

OBC Reports 44, 45, 46

B.3.18.2 Telemetry Monitor/Response (TMRP) Processor Operation

B.3.18.2.1 TMON (Telemetry Monitor)

TMON is the main controlling routine for check/response of groups and items tables. The Flight Executive invokes TMON every 16.384 seconds. When TMON is entered the Executive passes it a code in the accumulator. If either bit 1 or 2 of the accumulator is on (=1) the status buffers are set to zero and the group and item table are verified if flag TINITFLAG is greater than zero. After checking the tables if an error is detected by checking flag TINITFLAG NOT equal to a negative one, control will be returned to the Flight Executive. If no errors are detected (TINITFLAG=1) the current telemetry rate is set and frame counter is set for use.

Next TMON checks for a ground command for control of a given group. Then the frame counter is set to 8 kbps or 1 kbps by the telemetry rate and group and items table limits are checked. After checking all 75 groups and setting the status array control is given back to the Flight Executive.

B.3.18.2.2 TINIT (Telemetry Monitor Initialization)

The initialization component, TINIT is called by TMON and performs the following functions:

1. sets the status buffer to zero,

2. controls the call to the verification routine to verify group and items tables,

3. sets the initialization and error flag.

B.3.18.2.3 TVERIFY (Table Verification and Initialization)

TVERIFY is called by TINIT to verify and initialize the entries of the group and item tables, TMGRUPS and TMITEMS. The entries will be validated and initialized sequentially, starting with the entries for the first group. If an invalid entry is encountered in either table, TMERROR will be set to a non-zero value.

B.3.18.2.4 TCNTRL (Telemetry Control)

The component TCNTRL is called when control of a group is requested by the ground segment. The subroutine first checks to see if the number of the group to be controlled is valid. If it is not, the control error bit for each of the groups will be set to one (bit 6 of TMRSTATS (I) I=1, 75). If it is valid, the control bits will be set as specified by bits 10 and 11 of TMREQCMD. Bit 18 of TMREQCMD will be set and program control will be returned to the caller.

B.3.18.2.5 TCHECK (Telemetry Check)

The component TCHECK is called whenever a group is enabled for limit checking. Its function is to compare the items to their associated limits or bits and take the appropriate action. The items will be retrieved and compared to the specified limits or bits in a sequential fashion, starting with the first item, until the group is determined to be in-limit or out-of-limit.

B.3.18.2.6 TREACT (Telemetry Reaction)

The component TREACT is called whenever a group checks out-of-limits. TREACT tests the out-of-limits counter to see if the group checked out-of-limits three consecutive times. If the test fails, program control is returned to TCHECK immediately. If the test is successful the time and group ID are stored in the status buffer.

The next thing TREACT does is check if the group is enabled for sending commands. If the group is not enabled from sending commands the routine will inhibit the group from being limit checked. If the group is enabled for sending commands, the specified RTS will be activated, or the Flight Executive will be called to issue the specified block of predefined commands. In either case, the stored commands inhibitors (if any) will be set and program control will be returned to the caller. The ground segment can instruct TMON to reenable the group for limit checking.

B.3.18.2.7 Telemetry Monitor Examples

This section will give the user three examples of how telemetry groups are checked in TCHECK. To show these examples we use Table #30 which defines how bits of TMITEMS are used, and Table B.3.10-2A which defines the Telemetry Monitor Decision Table. These examples are stated below. Table B.3.18-2 shows the examples as logic statements and defines the bits in TMITEMS along with the branching of TCHECK.

Example 1: Check four telemetry limits. If all four are out of limits then the group is out of limits.

Example 2: Check four telemetry limits. If the first three check out of limits the group is out of limits. If the 4th checks out of limits the group is out of limits.

Example 3: Check four telemetry limits. If either one of the first two check out of limit set the error flag, and if both of the last two check out of limits the group is out of limits.

Table B.3.18-2. (TMITEMS) Bit Definition

TCHECK, AND, TMITEMS Bit Definition by Examples

Example 1: TLM 1 > Limit 1
.AND.
TLM 2 = Limit 2
.AND.
TLM 3 = Limit 3
.AND.
TLM 4 = Limit 4

.AND. and .OR. represent circuit logical operators

TMGRUPS(I) Number of Levels	TMITEMS Bits 9-7 (See Note 1)	6-4	3-1	TCHECK BRANCHING Condition Met	Condition Not Met
1	1	0	0	Check next item	Reset counter
	4	0	0	Check next item	Reset counter
	4	0	0	Check next item	Reset counter
	2	0	4	Call TRACT	Reset counter

Table B.3.18-2. (TMITEMS) Bit Definition (Continued)

TCHECK, AND, TMITEMS Bit Definition by Examples

Example 2: TLM 1 < Limit 1
.AND.
TLM 2 > Limit 2
.AND.
TLM 3 = Limit 3
.OR.
TLM 4 = Limit 4

.AND. and .OR. represent circuit logical operators

TMGRUPS(I) Number of Levels	TMITEMS Bits 9-7 (See Note 1)	6-4	3-1	TCHECK BRANCHING Condition Met	Condition Not Met
2	2	0	2	Check next item	Go to next level
	1	0	2	Check next item	Go to next level
	4	0	1	Call TRACT	Go to next level
	4	1	4	Call TRACT	Reset counter

*See Note 1

Table B.3.18-2. (TMITEMS) Bit Definition (Continued)

TCHECK, AND, TMITEMS Bit Definition by Examples

```
Example 3:  TLM 1 = Limit 1
                .OR.
            TLM 2 > Limit 2
                .OR.
            TLM 3 < Limit 3
                .AND.
            TLM 4 > Limit 4
```

.AND. and .OR. represent circuit logical operators

TMGRUPS(I) Number of Levels	TMITEMS Bits 9-7 (See Note 1)	TMITEMS Bits 6-4	TMITEMS Bits 3-1	TCHECK BRANCHING Condition Met	TCHECK BRANCHING Condition Not Met
3	4	0	1	Call TREACT	Go to next level
	1	1	1	Call TREACT	Go to next level
	2	2	0	Check next item	Reset counter
	1	2	4	Call TREACT	Reset counter

*See Note 1

These examples are written to show how TCHECK branches based on information stored in bits 9-1 of TMITEMS. THis section is not written to show how TMITEMS tables are set up or to explain group levels, only to show how TCHECK reacts to information it receives.

Note 1

Bits 9-7 of TMITEMS tells TCHECK what comparison to make with the test points and its out-of-limits value. (1 = greater than, 2 = less than, 4 = equal to)

Bits 6-4 of TMITEMS tells TCHECK how many levels or subgroups are to be compared together (0-7)

Bits 3-1 of TMITEMS tells TCHECK how to branch and when to go to a new group (Bit 3-1 = 4 means new group)

Table B.3.18-2A

Telemetry Monitor Decision Table

Condition Test	Logical Operator Action Number Bits 1-3 of TMITEMS Word 1 =0	=1	=2	=3	=4
Test is True	A	C	A	B	C
Test is False	D	A	B	A	D

Action Take

A = Check the next item

B = Jump to the next group level

C = Perform out of limits processing

D = Perform in limits processing

NOTE: Bits 1-3 of TMITEMS will be set to "4" to indicate the last level of a group.

Table B.3.18-3. (TMREQCMD) Bit Definition

TMREQCMD is a 18 bit word numbered 18-7

Bit 18 shows CMD processed = 1

Bit 17-12 unassigned

Bit 11-10 Enable/inhibits TMON from limit checking or sending commands

0 0 = ENA CHECKING AND CMDS
0 1 = ENA CHECKING AND INH CMDS
1 0 = INH CHECKING AND ENA CMDS
1 1 = INH CHECKING AND CMDS

Bit 9-8 Unassigned

Bit 7-1 Indicates group number (1-75)

Bits 11-10 of TMREQCMD are passed to word 1 of TMGRUPS bits 18 and 17

Table B.3.18-4. (TMGRUPS) Bit Definition

TMGRUPS contains 3 words each having 18 bits numbered 18-1

Word 1	contains information about test done/to be taken by TMON
Word 2	contains inhibitor STORED CMDS number
Word 3	contains telemetry item to be checked

<u>WORD 1</u>

Bit 13	enables/inhibits group from limit checking (0 = enable)
Bit 17	enables/inhibits from sending commands (0 = enable)
Bit 16	indicates telemetry point check in/out-of-limits (0 = in)
Bit 15-14	number of successive times the specified conditions were met
Bit 13-10	unassigned
Bit 9	tells whether to send predefined block of CMDS/ACTIVATE on RTS (0 = predefined block)
Bit 8-1	give RTS/predefined block CMD number
Bit 18-14	OF TMGRUPS WORD 1 passed to TMRSTATS bits 5-1

Table B.3.18-4. Bit Definition (TMGRUPS) (Continued)

WORD 2

Bit 18-13	unassigned
Bit 12-9	3rd stored CMD inhibitor, if any, to be set when the group checks out-of-limits
Bit 8-5	2nd stored CMD inhibitor, if any, to be set when the group checks out-of-limits
Bit 4-1	1st stored CMD inhibitor, if any, to be set when the group checks out-of-limits

WORD 3

Bit 18-1	First Word Address (FWA) of the entry for the first telemetry item to be checked

Table B.3.18-5. (TMITEMS) Bit Definition

TMITEMS contains 4 words each having 18 bits numbered 18-1

WORD 1	Used while limit checking telemetry items in the tables
WORD 2	DATA MASK
WORD 3	give limiting value
WORD 4	Telemetry address

<u>WORD 1</u>

Bit 18-10	unassigned
Bit 9-7	Type of comparison to be made 1 = greater than, 2 = less than, 4 = equal to
Bit 6-4	level number or subgroup number from 0-7
Bit 3-1	The action to be taken after limit checking 4 = end of group.

<u>WORD 2</u>

Bit 18-1	DATA MASK

<u>WORD 3</u>

Bit 18-1	limiting value/expected bits

<u>WORD 4</u>

Bit 18	Retrieve item from specified absolute address or main telemetry (0 = specified address)
Bit 17	unassigned
Bit 16-1	Absolute address, or main telemetry column number for the item to be checked.

B.3.18.3 Telemetry Monitor/Response (TMRP) Software Constraints

TBD

B.3.18.4 Telemetry Monitor/Response (TMRP) System Tables

The Telemetry Monitor uses Flight Software System Tables number 28, 29 and 30. Table #28 contains the controls that the ground wants TMON to monitor while limit checking groups. Table #29 contains information about the groups that TMON is monitoring Table #30 give TMON the parameter to use for limit checking each group.

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #28 (TMREQCMD)					
0	TMREQCMD		P	TMON	Command to control the limit checking for a group
				TCNTRL	Bit 18 a 1=command processed Ø=NO COMMAND from ground
				TCNTRL	Bits 7-1 gives the number of the group to be controlled
				TCNTRL	Bits 11-10 give the function to be controlled
					Bits 8, 9 unassigned

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #29 (TMGRUPS)					
0	TNUMGRPS		P	TMON TCNTRL	Number of groups to be processed
1	TMGRUPS		P	TMON TCNTRL TREACT	Group Word entries Bit 18 a Ø=enabled for limit checking. 1=inhibited from limit checking (this word sequence can be repeated 75 times).
				TMON TCNTRL TREACT	Bit 17 a Ø=enabled for sending commands. 1=inhibited from sending commands
				TMON TCNTRL TCHECK TREACT	Bit 16 a Ø=in limits. 1=out of limits
				TMON TCNTRL TCHECK TREACT	Bit 15 and 14 - number of successive times the specified conditions were met
					Bit 13, 12, 11, 10 - unassigned
				TVERIFY TREACT	Bit 9 a Ø=issue block of predefined commands 1=activate on RTS
				TVERIFY TREACT	Bits 8 to 1 - RTS predefined command block number
2	TMGRUPS		P	TREACT	Bits 12 to 9 - gives the number of the third stored CMD inhibitor, if any, to be set when the group checks out-of-limits

Entry	Name	TLM	Type	Using Subroutine	Description
2	TMGRUPS		P	TREACT	Bits 8 to 5 - give the number of the second stored cmd. Inhibitor, if any, to be set when the group checks out-of-limits
				TREACT	Bits 4 to 1 give the number of the first stored CMD inhibitor, if any, to be set when the group checks out-of-limits
3	TMGRUPS		P	TVERIFY TCHECK	Bits 18 to 1 - FWA of the entry for the first TLM item to be checked

Entry	Name	TLM	Type	Using Subroutine	Description
OBC System Table #30 (TMITEMS)					
0	TNUMITMS		P		Number of TLM items to be processed
1	TMITEMS		P		Items word entries
					Bits 18-10 unassigned
				TVERIFY	Bits 9 to 7 - Type of compare to be made. 1=greater than, 2=less than, 3=equal to
				TVERIFY TCHECK	Bits 6 to 4 - Level number for up to 8 levels pregroup from 0-7.
				TVERIFY TCHECK	Bits 3 to 1 specifies the action to be taken if a group checks IN/OUT of limits (up to 967 repeats of this word group) a 4 in bits 3-1 indicates the end of the group.
2	TMITEMS		P	TCHECK	Bits 18 to 1 Data mark
3	TMITEMS		P	TCHECK	bits 18 to 1 limiting value/expected bits
4	TMITEMS		P		Bit 18 a Ø=retrieve item from specified absolute address. 1=retrieve item from main telemetry
					Bit 17 - unassigned
				TCHECK	Bits 16 to 1 - absolute address, or main telemetry column number, for the item to be checked.

B.3.18.5 Telemetry Monitor/Response (TMRP) Telemetry

TMON monitors information from OBC System Table #29 and 30. These tables are checked by group number and errors or out of limits conditions information is passed to the ground segment thru OBC Telemetry Report #47, 48 and 49. Data Format Control Book Volume II (Telemetry) gives detail of format.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC Telemetry Report #47			
I	TMSTATS	TRACT	Bits 18-10 used by OBC to record time of three consecutive errors
I=1-25 (Group #)			
		TVERIFY	Bit 8 - errors in the number of maximum groups
		TVERIFY	Bit 7 - error in RTS number
		TCNTR L TVERIFY	Bit 6 - Invalid group number
		TCNTRL TMON	Bit 5 OFF=enabled for limit checking ON=inhibited from limit checking
		TCNTRL TMON	Bit 4 OFF=enabled for ending CMDS ON=inhibited from sending CMDS
		TCNTRL TMON	Bit 3 OFF=in limits ON=out-of-limits
		TCNTRL TMON	Bit 2-1 - number of times the group checked out-of-limits

*OBC TLM Report #48, and #49 give information on group 26 thru 75 with the same bit identification

B.3.18.6 Telemetry Monitor/Response (TMRP) Flow Charts

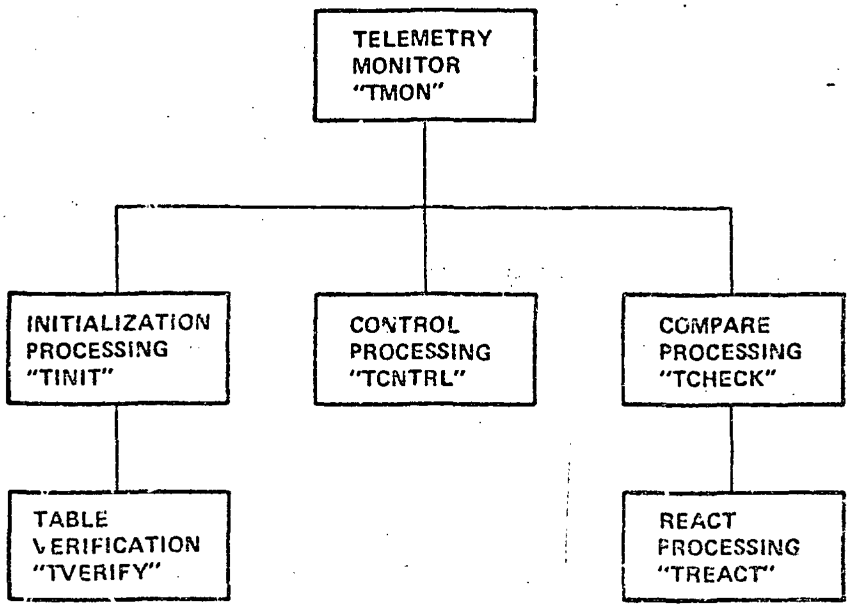

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FIGURE B.3.18-1 TMRP top level Flow Chart

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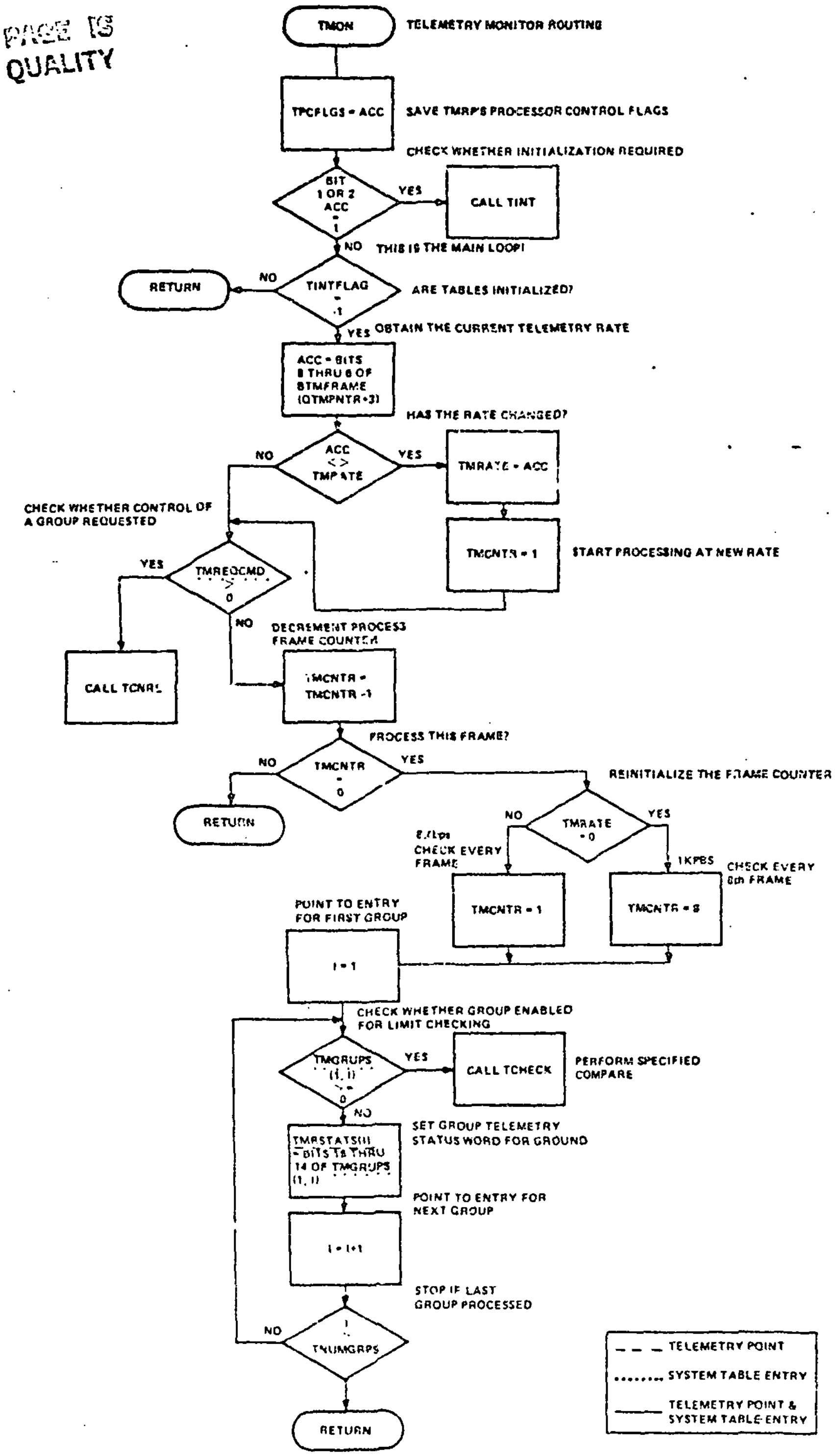

FIGURE B.3.18-2 TMON Flow Chart

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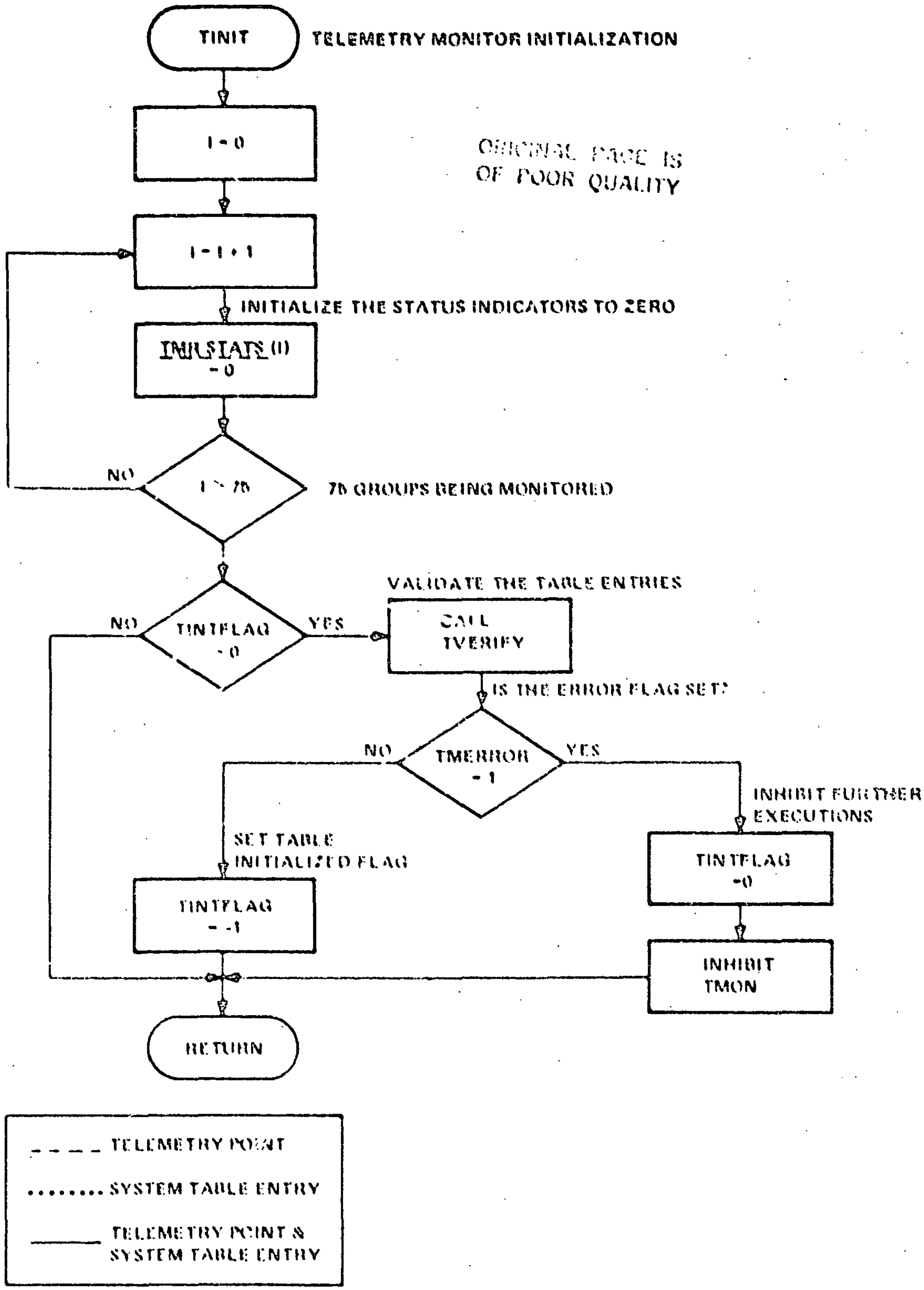

FIGURE B.3.18-3 TINIT Flow Chart

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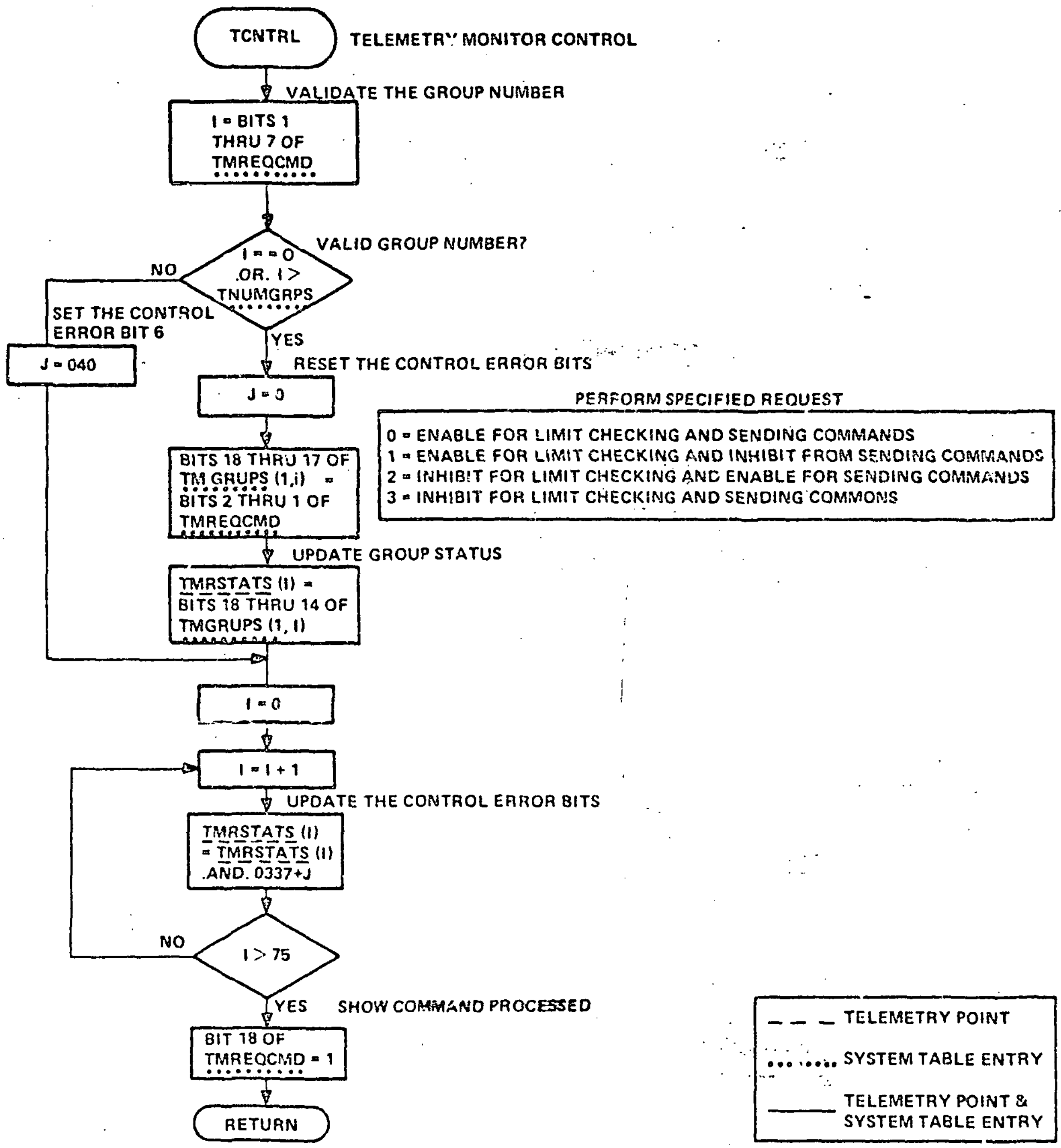

FIGURE B.3.18-4 TCNTRL Flow Chart

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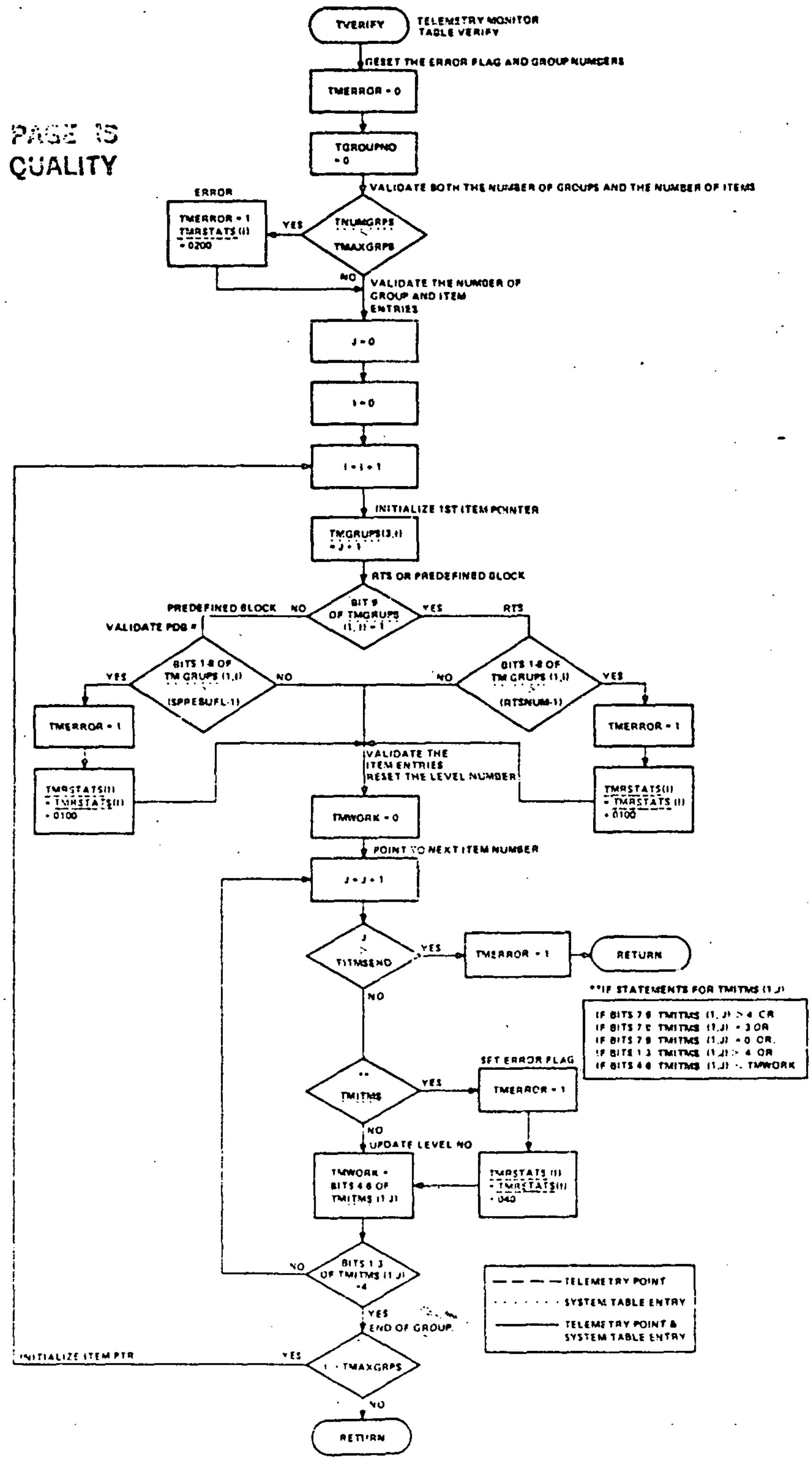

FIGURE B.3.18-5 TVERIFY Flow Chart

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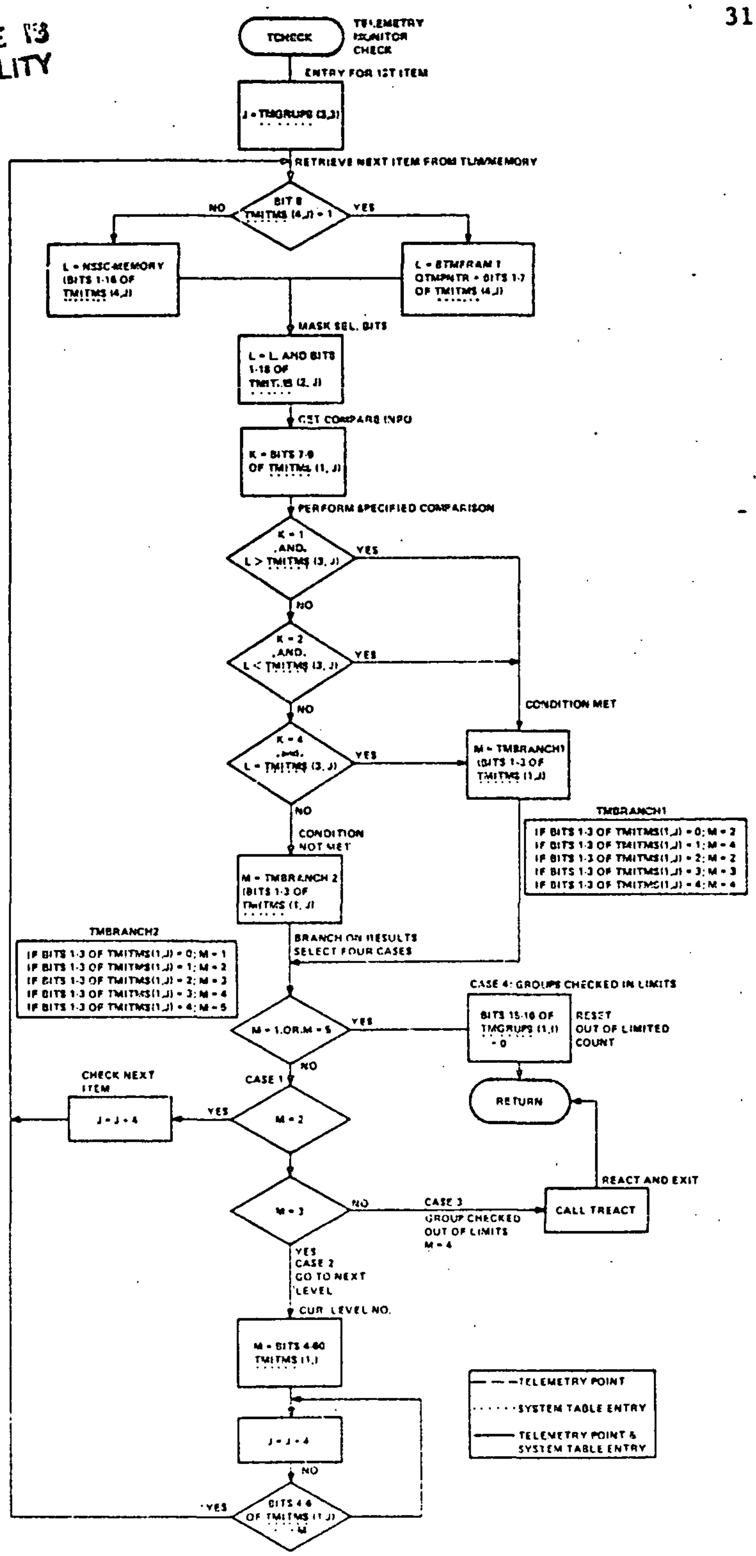

FIGURE B.3.18-6 TCHECK Flow Chart

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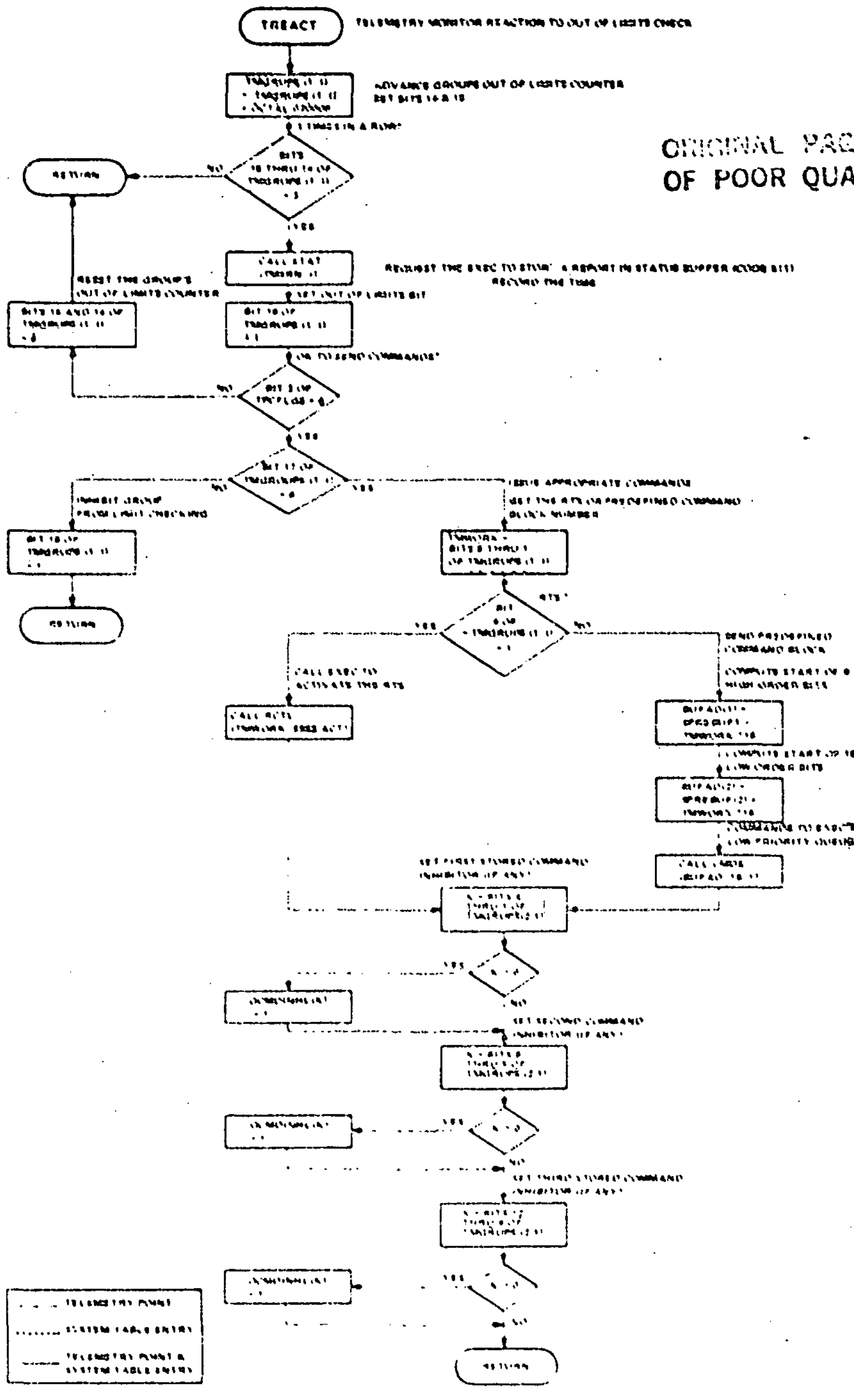

FIGURE B.3.18-7 TREACT Flow Chart

B.3.19 SOLAR EPHEMERIS COMPUTATION (SEPHEM)

B.3.19 SOLAR EPHEMERIS COMPUTATION (SEPHEM)

B.3.19.1 Solar Ephemeris Computation (SEPHEM) Processor Description

The Solar Ephemeris Computation module is comprised of one routine SEPHEM. It is called by the executive every 614.4 seconds. This module computes the direction cosine of the Sun Pointing Unit Vector (SIX, SIY, SIZ) used by the ECI Attitude Update (ECIUPD) of the ACS processor and FSS Data Processing (OFFSDP) of the Update Filter Module. It also computes Mean Earth Orbital Velocity (VEX, VEY, VEZ) which is used in UFFSDP of the Update Filter. Table B.3.19-1 summarizes the SEPHEM processor.

Table B.3.19-1. Solar Ephemeris Processor (SEPHEM)

Number:	19
Priority:	17
Execution:	614.4 sec
System Table:	62
Telemetry:	OBC TLM Report #43 SEPHEM01
Function:	Compute: SIX,Y,Z - Sun Pointing Vector VEX,Y,Z - Mean Earth Orbital Velocity

B.3.19.2 Solar Ephemeris Computation (SEPHEM) Processor Operation

The flowchart in Section B.3.19.6 shows in detail the operation of the SEPHEM routine.

B.3.19.3 Solar Ephemeris Computation (SEPHEM) Software Constraints

TBD

B.3.19.4 *Solar Ephemeris Computation (SEPHEM) System Tables*

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #62 (SEPHEM)					
0	CEOB		C	SEPHEM	Cosine of mean obliquity of earths orbit
2	SEOB		C	SEPHEM	Sine of mean obliquity of earths orbit
4	EC		C	SEPHEM	Mean eccentricity of earths orbit
6	MO		C	SEPHEM	Initial solar mean anomaly
8	M1		C	SEPHEM	Solar mean anomaly rate
10	STO		C	SEPHEM	Conversion constant flight S/W time to solar ephemeris time
12	VEM		C	SEPHEM	Mean earth orbital velocity
14	VEMNEG		C	SEPHEM	Negative of mean earth orbital velocity
16	WO		C	SEPHEM	Initial solar longitude of perigee
18	W1		C	SEPHEM	Solar longitude of perigee rate

B.3.19.5 Solar Ephemeris Computation (SEPHEM) Telemetry

Entry Number	Name	Generating Subroutine	Description/Comment
OBC TLM Report #43 SEPHEM01			
0	TSOL	SEPEHM	Solar ephemeris time
4	L	SEPHEM	Solar true longitude
7	SIX	SEPHEM	X component of direction cosine of sun pointing vector
11	SIY	SEPHEM	Y component of direction cosine of sun pointing vector
15	SIZ	SEPHEM	Z component of direction cosine of sun pointing vector
19	VEX	SEPHEM	X component of mean earth orbital velocity
21	VEY	SEPHEM	Y component of mean earth orbit velocity
23	VEZ	SEPHEM	Z component of mean earth orbital velocity

B.3.19.6 Solar Ephemeris Computation (SEPHEM) Flow Charts

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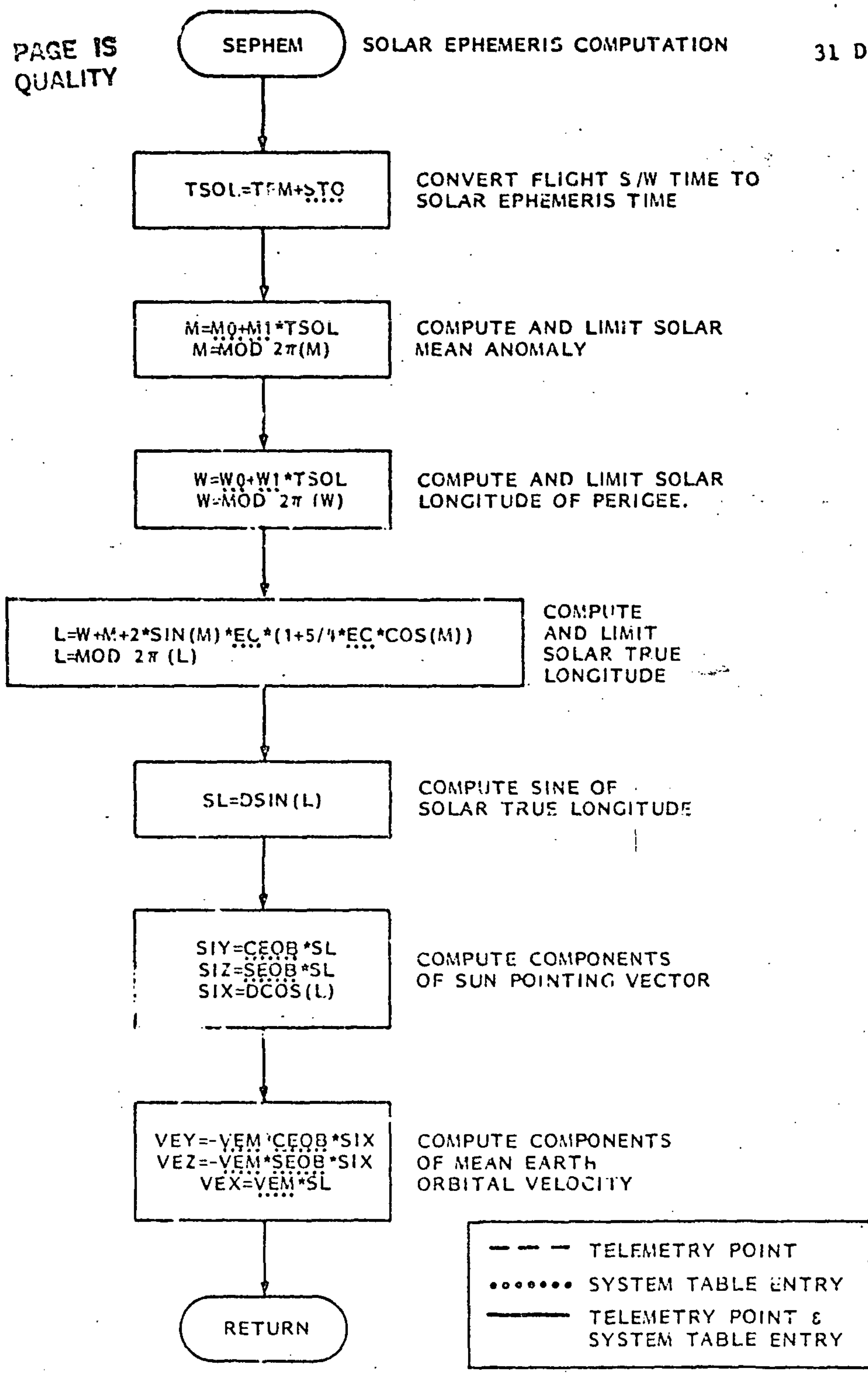

FIGURE B.3.19-1 SEPHEM Flow Chart

B.3.20 CMDTST

B.3.20 COMMAND TEST (CMDTST)

B.3.20 COMMAND TEST (CMDTST)

B.3.20.1 Command Test (CMDTST) Processor Description

The Command Test (CMDTST) processor will send commands to the OBC and test whether they are received correctly. It will also check for spurious commands received and not sent by CMDTST as well as for commands lost or garbled. Errors discovered are reported via the OBC Status Buffer and Executive Telemetry Report. If commands sent do not equal commands received a report with ID 42 is placed in the OBC status buffer along with the number of commands lost (Neg. #) or number of spurious commands (Pos #) received. If a command sent, is not received as sent bit 54 in the executive's contribution to telemetry is set to 1. Both errors stop the computer status monitor (I'm OK signal) causing an OBC shutdown and safehold mode. CMDTST is summarized in Table B.3.20-1.

Table B.3.20-1. Command Test (CMDTST)

Number: 20
Type:
Priority: 18
Period: 131.072
Function: OBC command self test

Subroutines: None

System Tables: None

Telemetry: OBC Report #39 Bit 54 Status Buffer (obtained via OBC dump)

B.3.20.2 Command Test (CMDTST) Processor Operation

The flowchart in Section B.3.20.6 provides a detailed description of processor operation.

B.3.20.3 Command Test (CMDTST) Software Constraints

TBD

B.3.20.4 Command Test (CMDTST) System Tables

None

B.3.20.5 Command Test (CMDTST) Telemetry

An error in CMDTST is reported via OBC TLM Report #39, Flight Executive Contribution to TLM, bit 54. If this bit is set to 1 this means a command test has failed.

B.3.20.6 Command Test (CMDTST) Flow Charts

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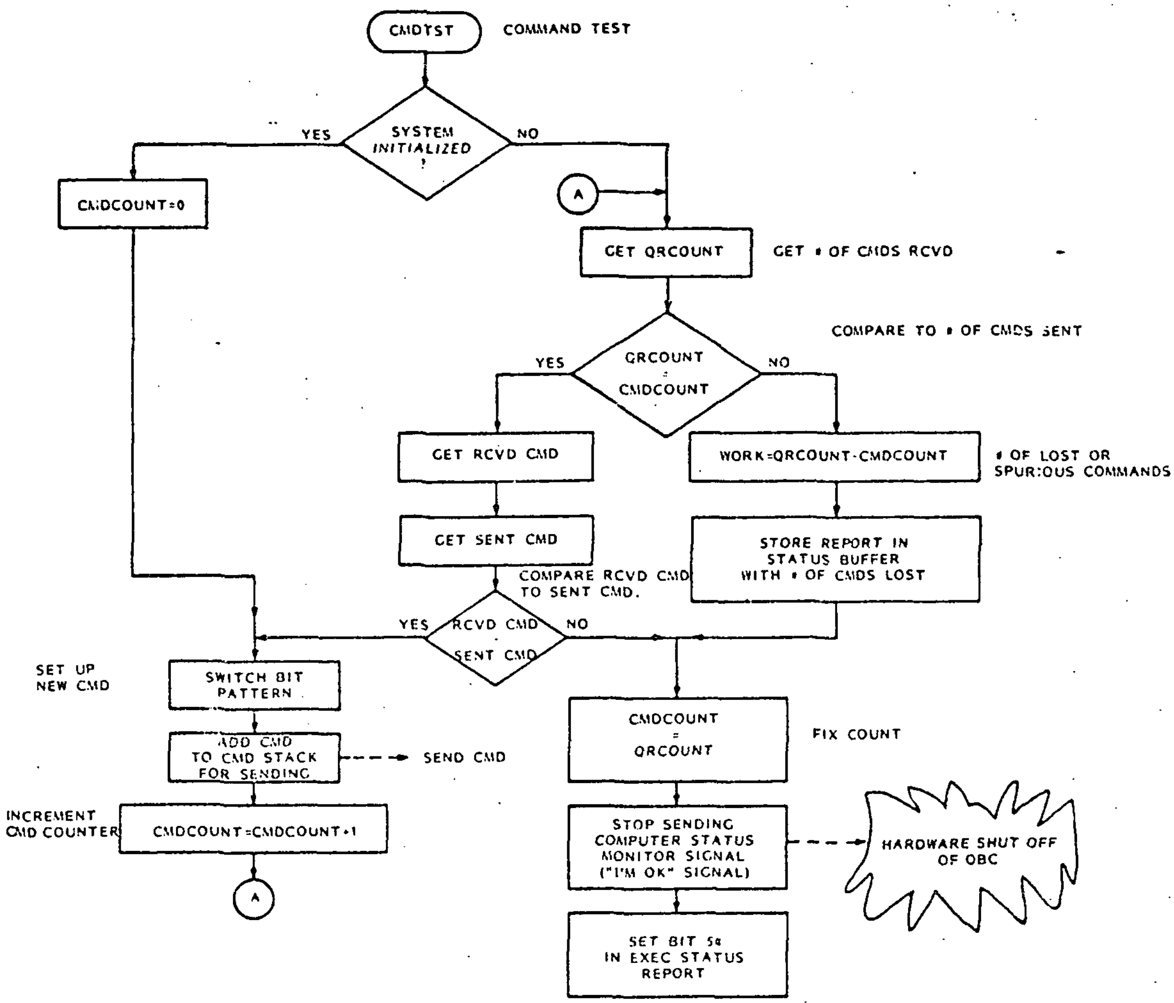

Figure B.3.20-1. CMDTST Flow Chart

B.3.21 MEMORY CHECK (MEMCK)

B.3.21 MEMORY CHECK (MEMCK)

B.3.21.1 Memory Check (MEMCK) Processor Description

MEMCK executes every 65.536 seconds to perform a checksum test on a designated area of OBC memory. It calculates a checksum by exclusive OR'ing all the words in an area of memory, designated by entries in System Table 14 (QLIMITS). This checksum is compared to a ground loaded value in System Table 13 (QMEMCK). If this comparison fails and QMEMIGNR of System Table 13 is less than or equal to zero, then this error is reported via bit 53 of the Executive Status Report and the computer status monitor signal will be stopped thus halting OBC operation. If QMEMIGNR is greater than zero then the error is not reported and OBC operation continues. By using QMEMIGNR greater than zero MEMCK can be allowed to calculate its own checksum, because the calculated checksum (MEMSUM) replaces QMEMCKSM when an error is found.

B.3.21.2 Memory Check (MEMCK) Operation

See the flowchart in Section B.3.21.6 for detailed description of MEMCK operation.

B.3.21.3 Memory Check (MEMCK) Constraints

TBD

B.3.21.4 Memory Check (MEMCK) System Tables

MEMCK uses two System Tables 13 and 14.

Entry	Name	TLM Type	Using Subroutine	Description
System Table Ø13 (QMEMCK)				
0	QMEMIGNR	F	MEMCK	• Flag to ignore erros found in checksum calculation • If > 0 ignore errors • If < = 0 report error • Used to avoid false error when memory is being loaded • When inhibiting the MEMCK processor the EXEC will set QMEMIGNR >0
1	QMEMCKSM	V	MEMCK	• Calculated checksum • Uplinked by ground or • If QMEMIGNR is set > 0 the processor is allowed to calculate its own checksum and store it in QMEMCKSM • Exclusive OR of all words in area being checked

Entry	Name	TLM Type	Using Subroutine	Description
System Table #14 (QLIMITS)				
0	QLIMIT	V	MEMCK	• BSTCODE • Location to start memory check
1	QLIMIT-1	V	MEMCK	• QENDCODE - 1 Last location to include in memory check

B.3.21.5 Memory Check (MEMCK) Telemetry

MEMCK makes no contribution to telemetry. Its error reporting is via the Executive Status buffer which may be dumped via ground command.

B.3.21.6 Memory Check (MEMCK) Flow Charts

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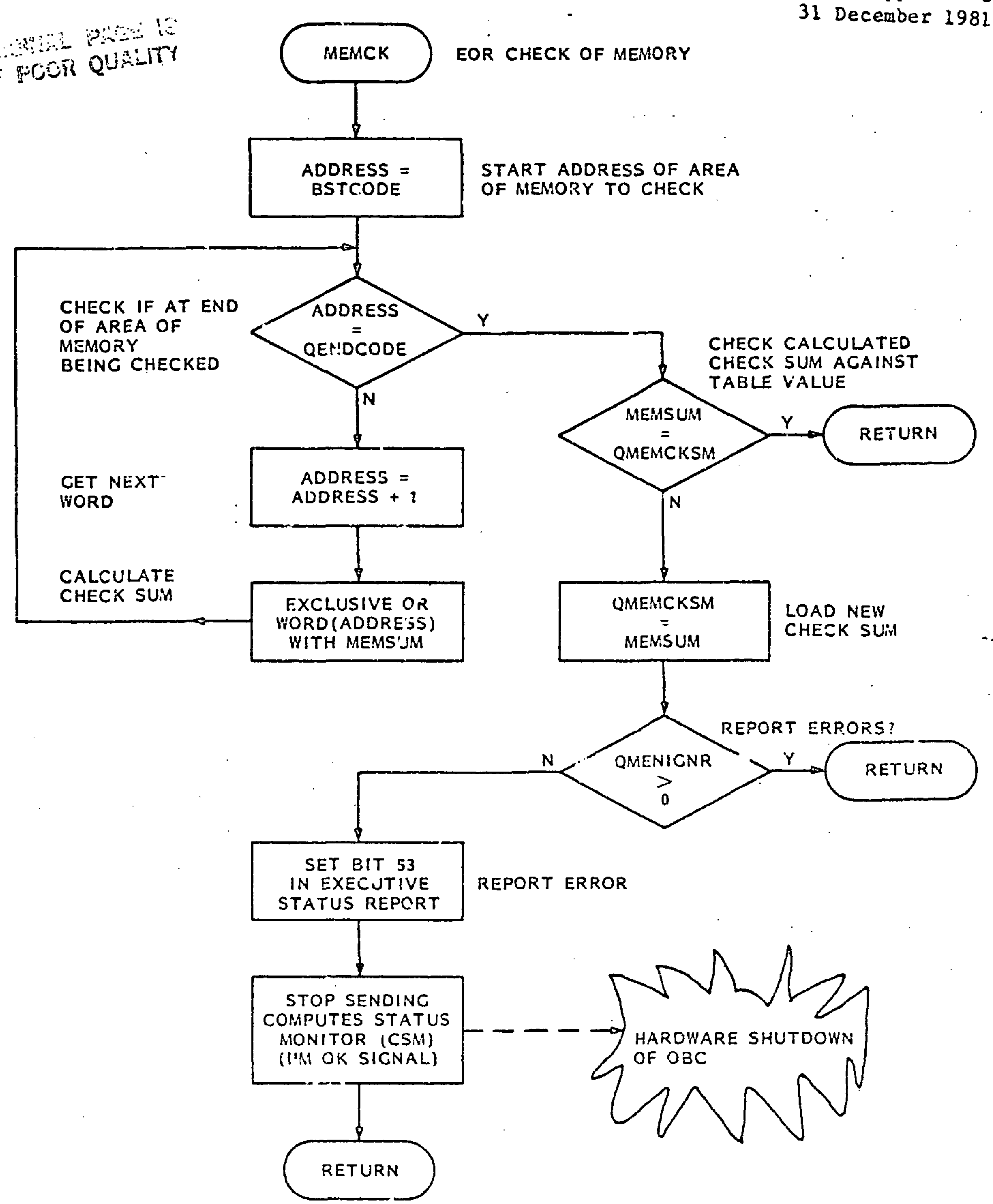

FIGURE B.3.21-1 MEMCK Flow Chart

B.3.22 MEMORY MONITOR (MONTOR)

B.3.22 MEMORY MONITOR (MONTOR)

B.3.22.1 Memory Monitor (MONTOR) Processor Description

The Memory Monitor (MONTOR) processor will monitor eighteen words of OBC memory and report these words via OBC telemetry. An overview of this processor is given in Table B.3.22-1. The addresses to be monitored by this routine are listed as QMONADDS(1) to QMONADDS(18) in Systems Table 15 (QMONITOR). If less than 18 location are desired then the entry after the last addressed required should be set to zero. The contents of these memory locations are inserted into OBC TLM Reports 40, 41, 42 - 6 bits per word right justified. Thus 3 telemetry words are required for the contents of 1 memory location.

Table B.3.22-1. Memory Monitor (MONTOR)

Number: 13
Type: Background
Priority: 20
Period: 8.192
Function: Report 18 memory locations via O[illegible] Telemetry Reports 40, 41 and 42

Subroutines: None

System Tables

#	Mnemonic	Type	Description
15	QMONITOR	V	Memory locations to be monitored

Telemetry Reports: OBC Reports 40 thru 42

B.3.22.2 Memory Monitor (MONTOR) Processor Operation

The operation of MONTOR is described by the flowchart in Section B.3.22.6.

B.3.22.3 Memory Monitor (MONTOR) Software Constraints

TBD

B.3.22.4 Memory Monitor (MONTOR) System Tables

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #15 (QMONITOR)					
N	QMONADDS (N+1)		V	MONTOR	o Address of nth memory location to be monitored by MONTOR o End of list of addresses is designated by zero o Number of addresses limited to 18 by telemetry output size

B.3.22.5 Memory Monitor (MONTOR) Telemetry

The monitored memory location are output via OBC TLM Report 40, 41 and 42. Each word contains 6 bits of information right justified. SVS-10123 Data Format Control Book Volume II (Telemetry) gives details of format.

Entry Number	Name	Generating Subroutine	Description/Comment
OBC Telemetry Report #40 (MON 01)			
I I=0,4,8,12, 16,20		MONTOR	Bits 13 through 18 of memory location QMONADDS(N) N = 1-->6
I+1		MONTOR	Bits 7 through 12 of memory location QMONADDS(N)
I+2		MONTOR	Bits 1 through 6 of memory location QMONADDS(N)
I+3		MONTOR	Zero byte

Report 41 and 42 similar format but contain QMONADDS(7-12) and QMONADDS(13-18) respectively.

B.3.22.6 Memory Monitor (MONTOR) Flow Charts

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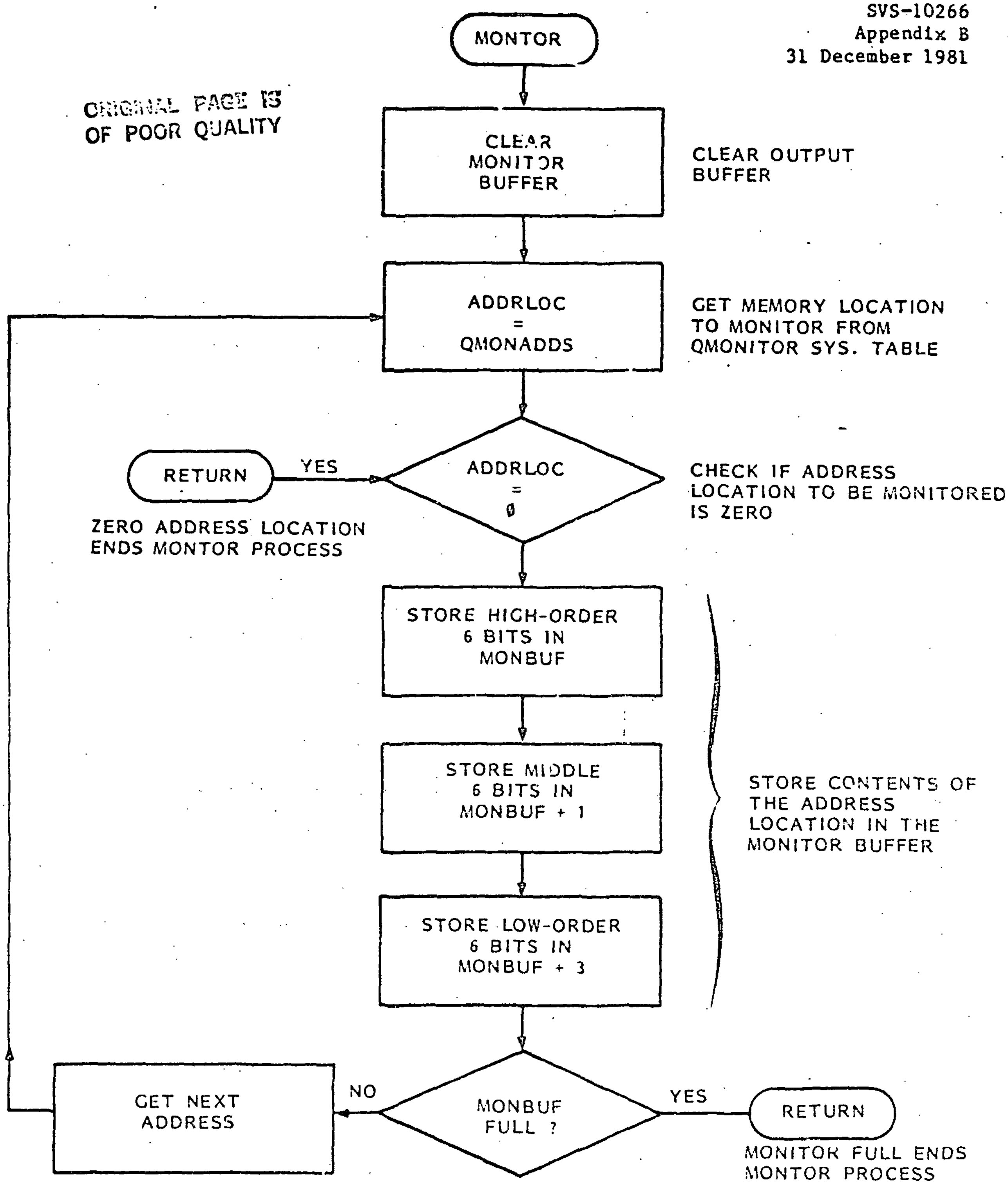

FIGURE B.3.22-1 MONTOR Flow Chart

B.3.23 SOLAR ARRAY FAILURE DETECTION AND CORRECTION (SADFDC)

B.3.23 SOLAR ARRAY FAILURE DETECTION AND CORRECTION (SADFDC)

B.3.23.1 Solar Array Failure Detection and Correction (SADFDC) Processor Description

SADFDC processor is enabled from ground control via an Executive Request when the solar array is in the 1X orbit rate mode. It will then be called every 16.384 seconds until it disables itself as a result of a failure detection. SADFDC's function is to detect lack of rotation of SAD during this mode. If the SAD has stopped, commands will be sent to switch the PDU and RIU 6 and then SADFDC will be disabled. Telemetry output of SADFDC is done by processor POTDAT. SADFDC's processor number and priority number are 23 and 14, respectively.

The subroutines that comprise SADFDC are the following:

SADFDC - Control Routine
SADINIT - SAD Fail Detect Initialization Processing
SADPROC - SAD Detection Processing
DELAY - Delay Processing

B.3.23.2 Solar Array Failure Detection and Correction (SADFDC) Processor Operation

B.3.23.2.1 SADFDC

The flowchart shown in Section B.3.23.6 describes the detailed software operations of SADFDC. Its function is to test if initialization is requested, if so it calls subroutine SADINIT to initialize data. It will check if SADFDC is in safehold, call subroutine SADPROC and SADTELM. If SADPROC finds an error 3 consecutive times, SADFDC will call subroutine DELAY.

B.3.23.2.2 SADINIT

SADINIT, flowcharted in Section B.3.23.6, is called by SADFDC and DELAY. Its function is to clear data variables and counters.

B.3.23.2.3 SADPROC

Subroutine SADPROC, flowcharted in Section B.3.23.6, determines which potentiometer to use by testing the system table word, ISAPI, and saves this pot position. This data is then used in computing the pot difference, POTDIF. The solar array drive rate, SADRATE, is then computed and checked if in limits. If it is out of limits three consecutive times, CLOCK 18 is saved. The RIU and PDU are switched by testing the system table words, RIUFLG and PDUFLG. The fail flag, SADFAIL, is set to 3 and SAD Fail Detect is disabled.

B.3.23.2.4 Delay

Subroutine DELAY, flowcharted in Section B.3.23.6, is called by processor SADFDC if subroutine SADPROC detects 3 consecutive errors. DELAY's function is to delay the sending of 1X Orbit Rate Command to new on line PDU (A or B) one cycle time or 16.384 seconds. It also sets the flag DPUUSE = 0. Subroutine FSTIME, which is in the SCP processor, reads this flag and, therefore, does not reset the flight time, TF, to the DPU time. Delay sets flag FDCSADF = 1 to disable SADFDC processor. It then calls SADINIT to reset POT data saving and processing counters.

B.3.23.3 Solar Array Failure Detection and Correction (SADFDC) Software Constraints

Turn OFF when SA is in closed loop to correct SA position.

B.3.23.4 Solar Array Failure Detection and Correction (SADFDC) System Table

SADFDC uses data words found in System Table 68. These words are described below.

Entry	Name	TLM	Type	Using Subroutine	Description
SAD Failure Detection System Table #68					
0	ISAPI		F	SADPROC	If=1, use potentiometer 1. Else, use potentiometer 2. Change pots if data becomes noisy etc.
1	RIUFLG		F	SADPROC	RIU select flag 0 = RIU A 1 = RIU B SADPROC switches to the RIU designated by RIUFLG if the subroutine detects an error 3 consecutive times.
2	PDUFLG		F	SADPROC	PDU select flag 0 = PDU A on 1 = PDU B on SADPROC switches to the PDU designated by PDUFLG if the subroutine detects an error 3 consecutive times.
3	DPUUSE	*	F	DELAY	Flag for ignoring large DPU time delay. If the SAD rate is out of limits 3 consecutive times, subroutine DELAY will set DPUUSE to 0. This value is read by subroutine FSTIME in the SCP processor which will then not update the flight software time TF.

B.3.23.5 Solar Array Failure Detection and Correction (SADFDC) Telemetry

The status of SADFDC can be monitored by the telemetry report output from processor POTDAT, Telemetry Report 35. This report is described in Section B.3.24.5.

B.3.23.6 Solar Array Failure Detection and Correction (SADFDC) Flow Charts

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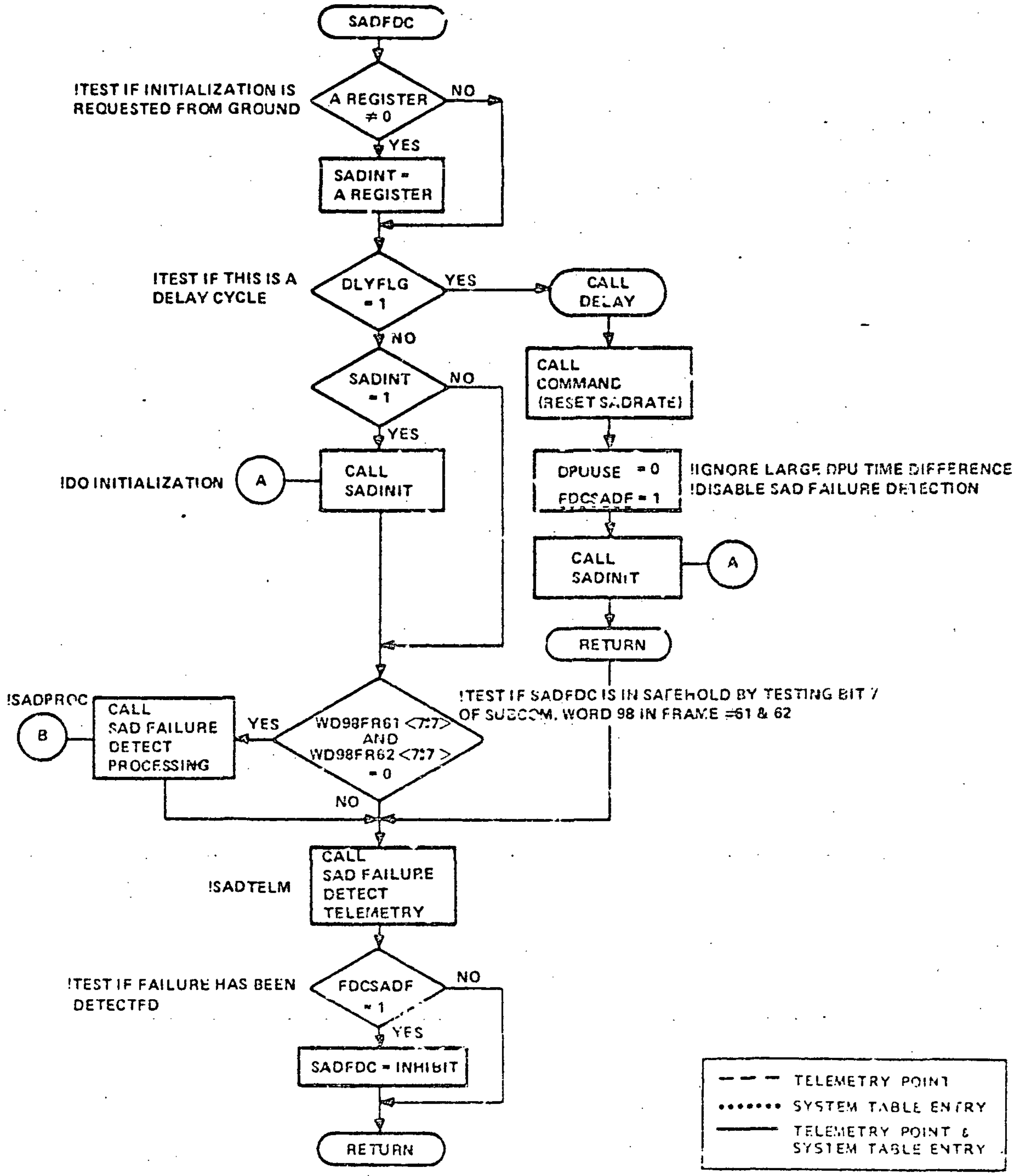

Figure B.3.23-1 SADFDC/DELAY Flow Chart

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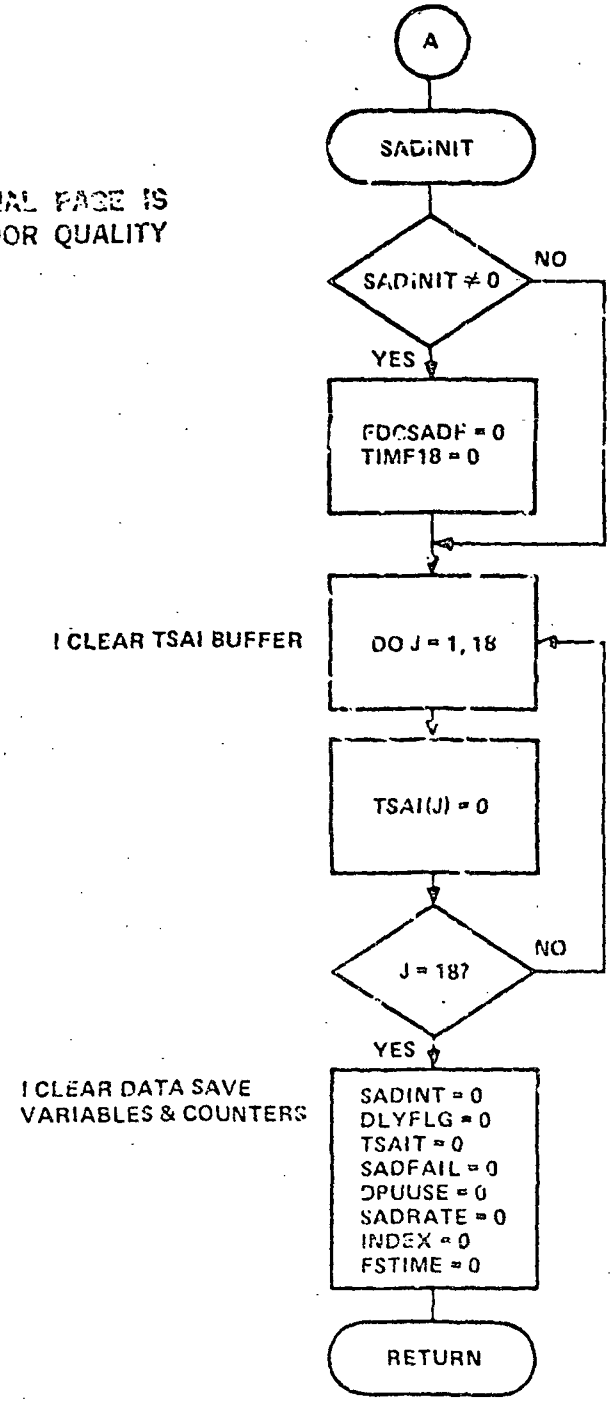

Figure B.3.23-2. SADINIT Flow Chart

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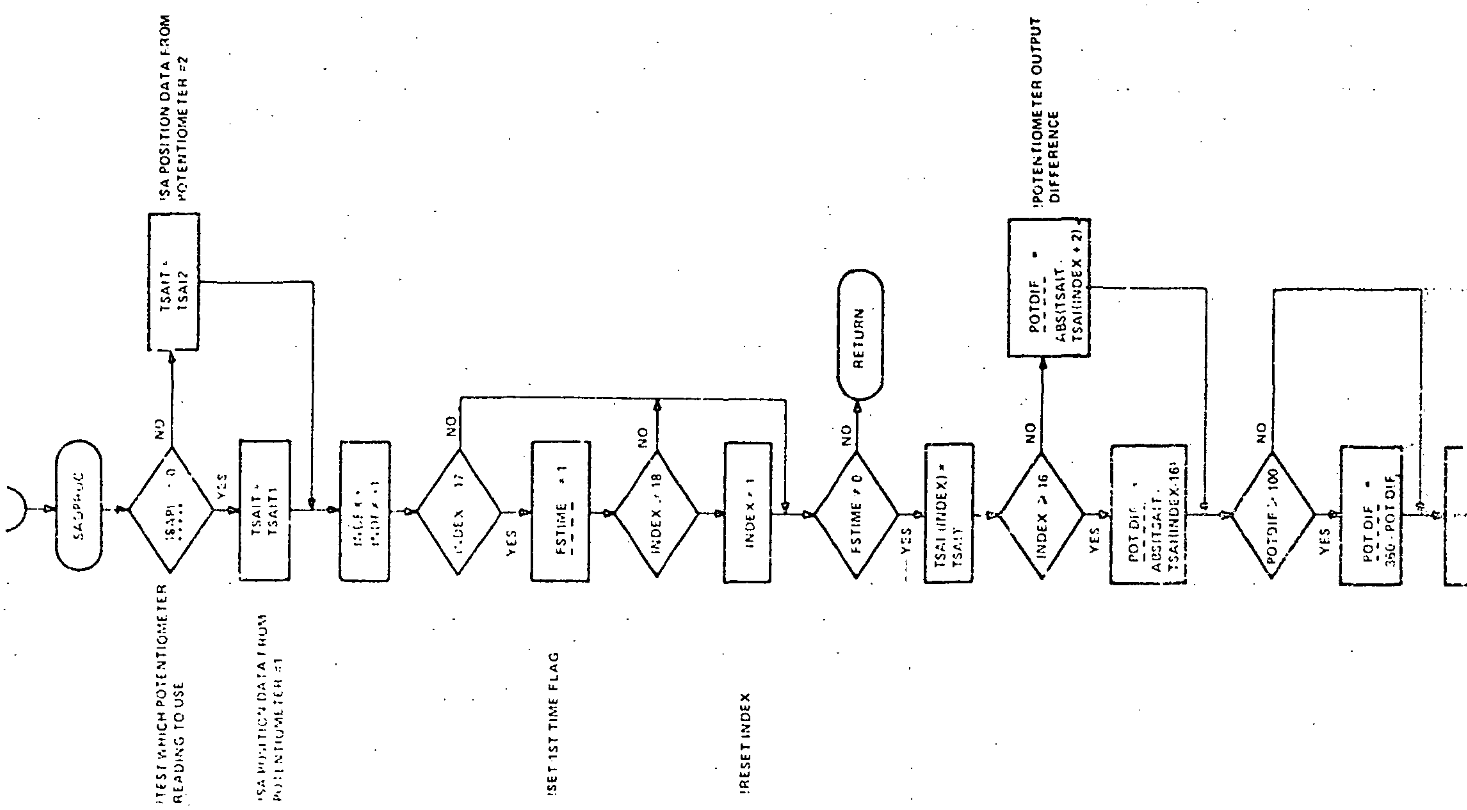

FOLDOUT FRAME

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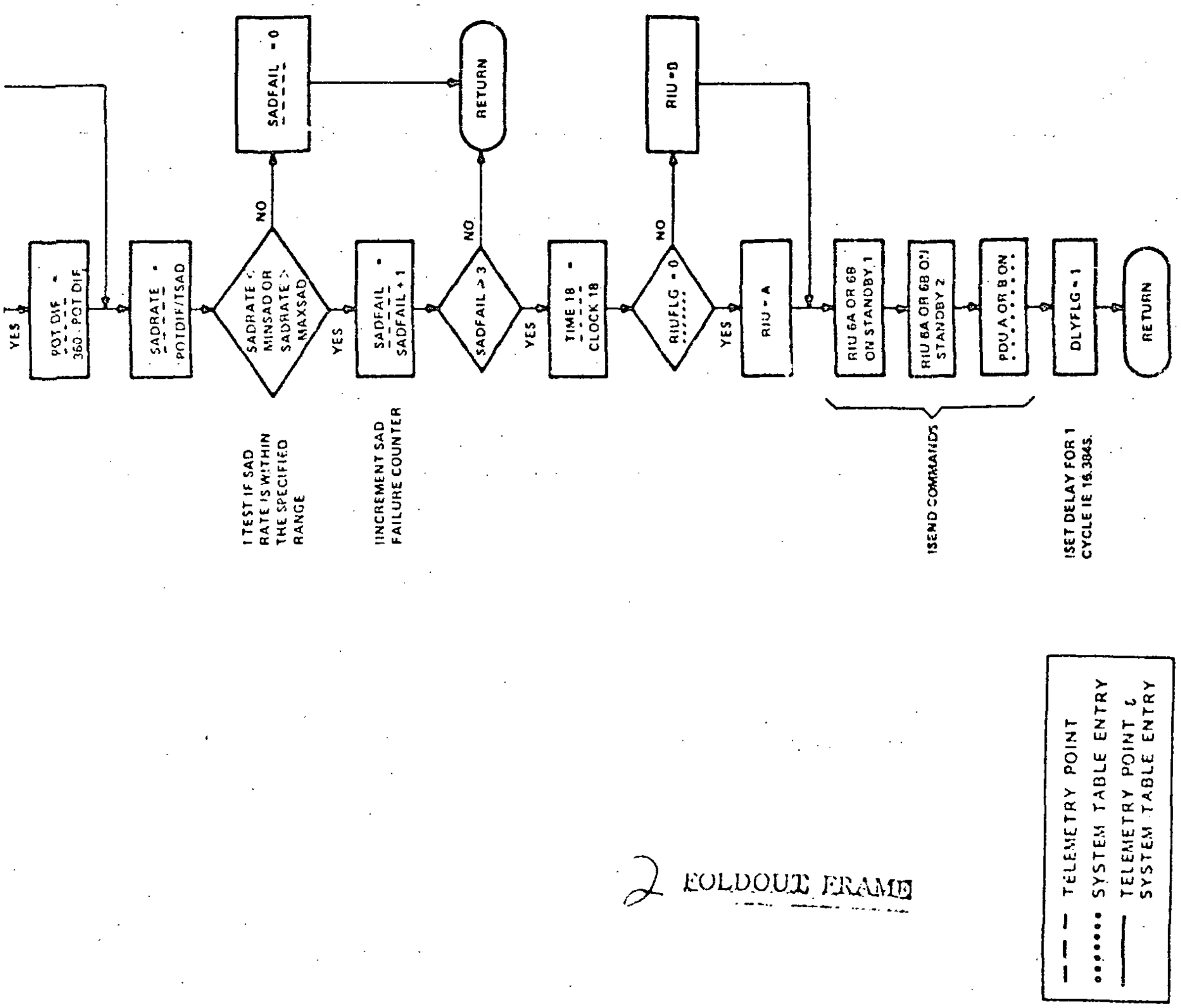

Figure B.3.23-3 SADPROC Flow Chart

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B.3.24 POTENTIOMETER DATA (POTDAT)

B.3.24 POTENTIOMETER DATA (POTDAT)

B.3.24.1 Potentiometer Data (POTDAT) Processor Description

The Potentiometer Data Processor is scheduled for execution every 8.192 seconds. It consists of 2 subroutines:

1. POTDAT - Potentiometer Data Processing

2. PTELEM - POTDAT Telemetry

Its primary function is to convert the SA position data from counts to degrees and then format and store it into a telemetry buffer, along with data items from SADFDC.

B.3.24.2 Potentiometer Data (POTDAT) Processor Operation

B.3.24.2.1 POTDAT

The POTDAT processor is flowcharted in Section B.3.24.6. It checks the SA position data, SAIP1 or SAIP2, to determine if it lies within the uplinked lower and upper limits, SAPMN and SAPMX, respectively. The status flag, SCFLAGS, will be set to indicate the status (valid or invalid) of the data received. It then converts the SA position data from counts to degrees.

B.3.24.2.2 PTELEM

PTELEM formats and stores into telemetry buffer POT%01 the data from potentiometers 1 and 2, the status flag indicating good data and data items from SADFDC.

B.3.24.3 Potentiometer Data (POTDAT) Software Constraints

TBD

B.3.24.4 Potentiometer Data (POTDAT) System Tables

The POTDAT uses the uplinked data words in system table #61. This table consists of 2 words which define the upper and lower limits for acceptable SA data position.

Entry	Name	TLM	Type	Using Subroutine	Description
System Table #61 (POTDAT)					
0	SAPMN		P	POTDAT	Lower boundary threshold for potentiometer data. Potentiometer data only valid above this designated number of counts. Appears as SCSAPMN in PDL.
1	SAPMX		P	POTDAT	Upper boundary threshold for potentiometer data. Potentiometer data only valid below this designated number of counts. Appears as SCSAPMX in PDL.

B.3.24.5 Potentiometer Data (POTDAT) Telemetry

The status of the POTDAT processor is contained in OBC TLM Report #35, minor frame 0. This report also contains data from the SADFC processor.

Entry #	Name	Generating Subroutine	Description/Comment
OBC TLM Report #35			
0	TSAI1	POTDAT	Solar array orientation in degrees from Pot #1.
3	TSAI2	POTDAT	Solar array orientation in degrees from Pot #2
6	TBD		
7	FDCSADF	DELAY	If a failure is detected 3 consecutive times, this flag is set to 1 to disable SADFDC.
*8	SADFAIL	SADPROC	SAD failure counter
9	FSTIME	SADPROC	.st time buffer filled flag
10	SADRATE	SADPROC	SAD rate
12	POTDIF	SADPROC	Potentiometer output difference
14	TIME18	SADPROC	Time when 3 consecutive errors are detected.

* TLM alarm: SADFAIL = 3

B.3.24.6 Potentiometer Data (POTDAT) Flow Charts

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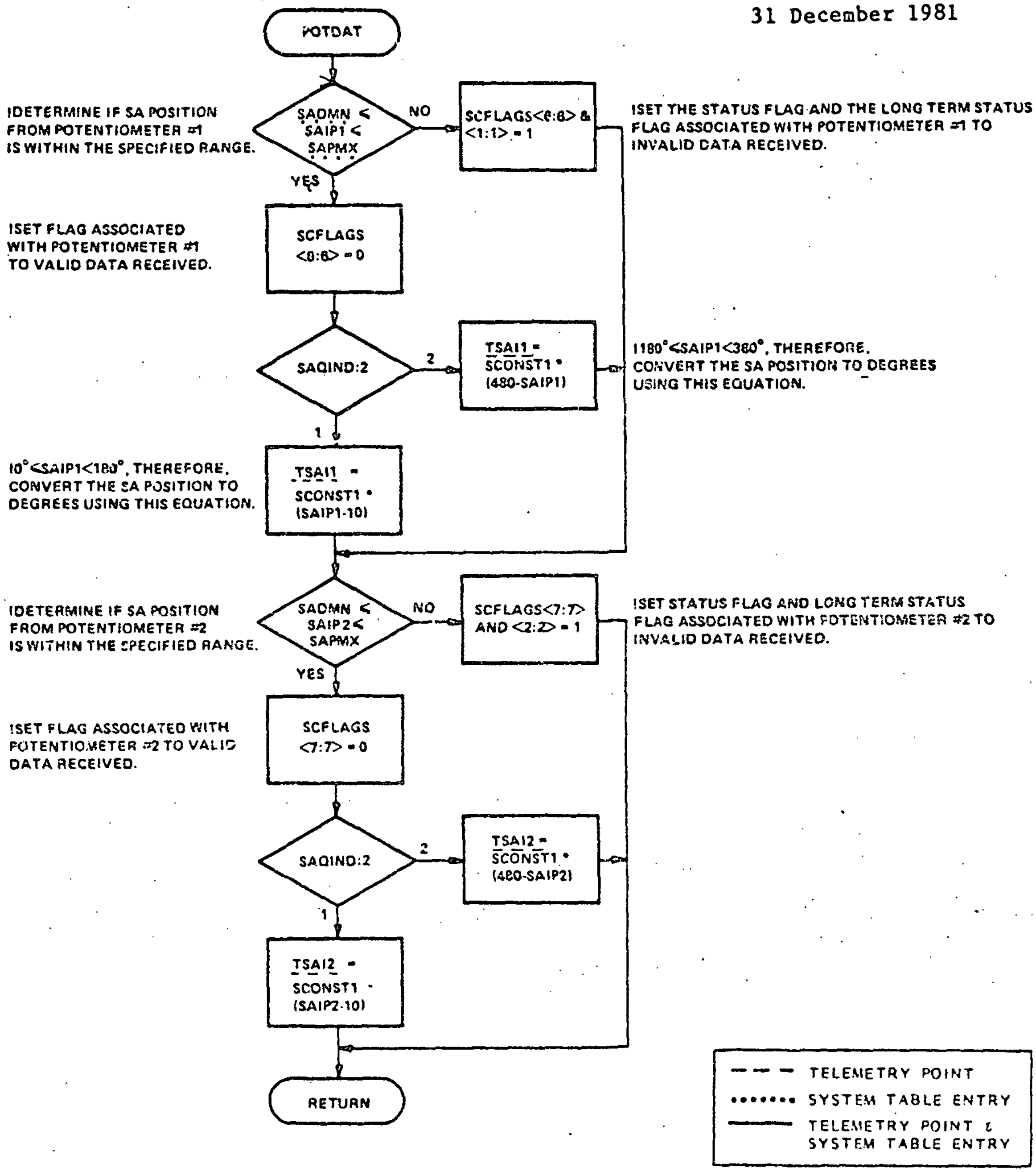

Figure B.3.24-1. POTDAT Flow Chart

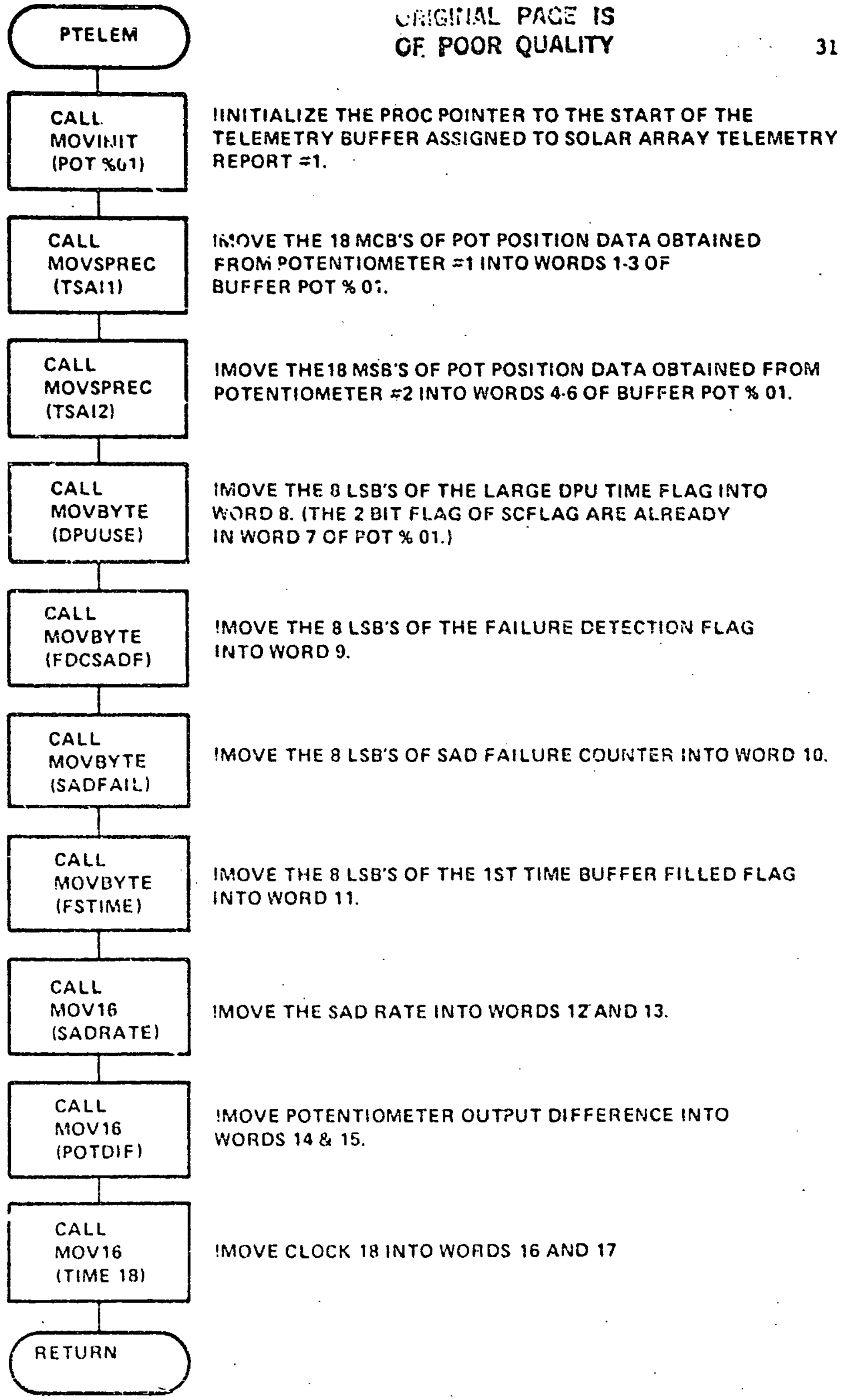

Figure B.3.25-2 PTELEM Flow Chart