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MULTI-SATELLITE ATTITUDE PREDICTION PROGRAM/ORBITING SOLAR OBSERVATORY-8 (MSAP/OSO-8) OPERATING GUIDE

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GODDARD SPACE FLIGHT CENTER
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SECTION 1

INTRODUCTION

The overall objective of the Orbiting Solar Observatory (OSO) program is to develop, launch, and operate a series of Earth-orbiting spacecraft carrying solar physics and astronomy instruments above the Earth's atmosphere, which are designed to detect and measure the electromagnetic radiation from the Sun and especially from solar disturbances, such as flares, that affect the Earth.

1.1 OSO-8 MISSION OBJECTIVES

The primary objectives of the OSO-8 mission are to investigate the Sun's lower corona and chromosphere and their interaction in the X-ray and ultraviolet (UV) spectral regions, and to better understand the transport of energy from the photosphere to the corona. The secondary objectives are to study the interaction between the solar electromagnetic and particle radiation and the Earth's environment, and to investigate the background component of cosmic X-rays.

The specific scientific objectives of the OSO-8 mission are:

- To measure the solar UV line profiles and their variations with time and position on the solar disk by use of a University of Colorado High-Resolution UV Spectrometer in the wavelength range of 950Å to 2300Å to provide insight into the physical conditions in the chromosphere and transition region and to serve in establishing a set of secondary conditions for evaluating solar atmosphere models.

- To make simultaneous line profile measurements or spectroheliograms of the Sun in the calcium-II H and K lines, the magnesium-II H and K lines, and the hydrogen Lyman-alpha and -beta lines with high spatial (1 arc-second), spectral, and temporal resolution, by means of an instrument developed at the Laboratoire de Physique Stellaire et Planetaire (LPSP) of Paris, France.

- To record solar X-rays in the 2- to 30-kiloelectron volts (kev) range with good temporal, spectral, and spatial resolution using the Lockheed Missiles and Space Company Mapping X-ray Heliometer. A further objective is to locate and monitor the time variation of a number of strong extra solar X-ray sources.

- To determine the spectral and spatial structure of the diffuse cosmic X-ray background over energies of 2 to 60 kev, and perform high-density

spectroscopy of stellar X-ray sources, identifying emission lines and spectral discontinuities using the Goddard Space Flight Center (GSFC) Cosmic X-ray Spectrometer.

- To study the galactic latitude dependence of the X-ray background at energies of 0.130 to 35 kev with special emphasis on the very soft X-ray region using the University of Wisconsin soft X-ray experiment.

- To measure the spectrum of all point X-ray sources observable in the energy range of 0.01 to 1 million electron volts (mev) and to search for temporal variations in the intensity and spectrum of these sources using the GSFC high-energy celestial X-ray experiment. Secondary objectives are to measure the diffuse component of celestial X-rays over the strip of sky scanned and to set limits on the intensity and isotropy of the cosmic position annihilation radiation at 0.511 mev.

- To determine the behavior of species, such as hydrogen and neutral and ionized helium, in the Earth's atmosphere by measuring the intensity and distribution of solar radiation scattered by these atoms. A further objective using the U.S. Naval Research Laboratory XUV radiation experiment is to observe extra terrestrial resonance radiation to investigate the interplanetary and interstellar medium.

- To obtain solar X-ray spectra in the energy range from 2 to 8 kev using the Columbia University graphite crystal spectrometer and polarimeter experiment; to obtain stellar X-ray spectra in the same energy range; and to measure the polarization of stellar X-ray emission in the energy range of 2.6 to 5.2 kev.

1.2 OSO-8 SPACECRAFT CHARACTERISTICS

The OSO-8 spacecraft is spin-stabilized and provides a despun observatory platform. The total weight of the spacecraft is 2200 pounds, 800 of which are allocated to experiments. The nominal observatory lifetime is 1 year, although the expected useful lifetime is approximately 2 years.

Figure 1-1 depicts the configuration of the spacecraft. The "wheel" section rotates at 6 ± 1 rpm to provide the gyroscopic stability of the observatory. The wheel consists of nine bays and three ballast arms within and on which are mounted experiments, attitude sensors, the attitude control coil and jets, and their associated electronics. The despun platform, or "sail" section, is maintained in a Sun orientation, as shown in Figure 1-1. A Sun sensor mounted on the sail provides a reference during orbit day for a drive motor which maintains the X_S axis pointed toward the Sun; during orbit night, this reference is provided by a

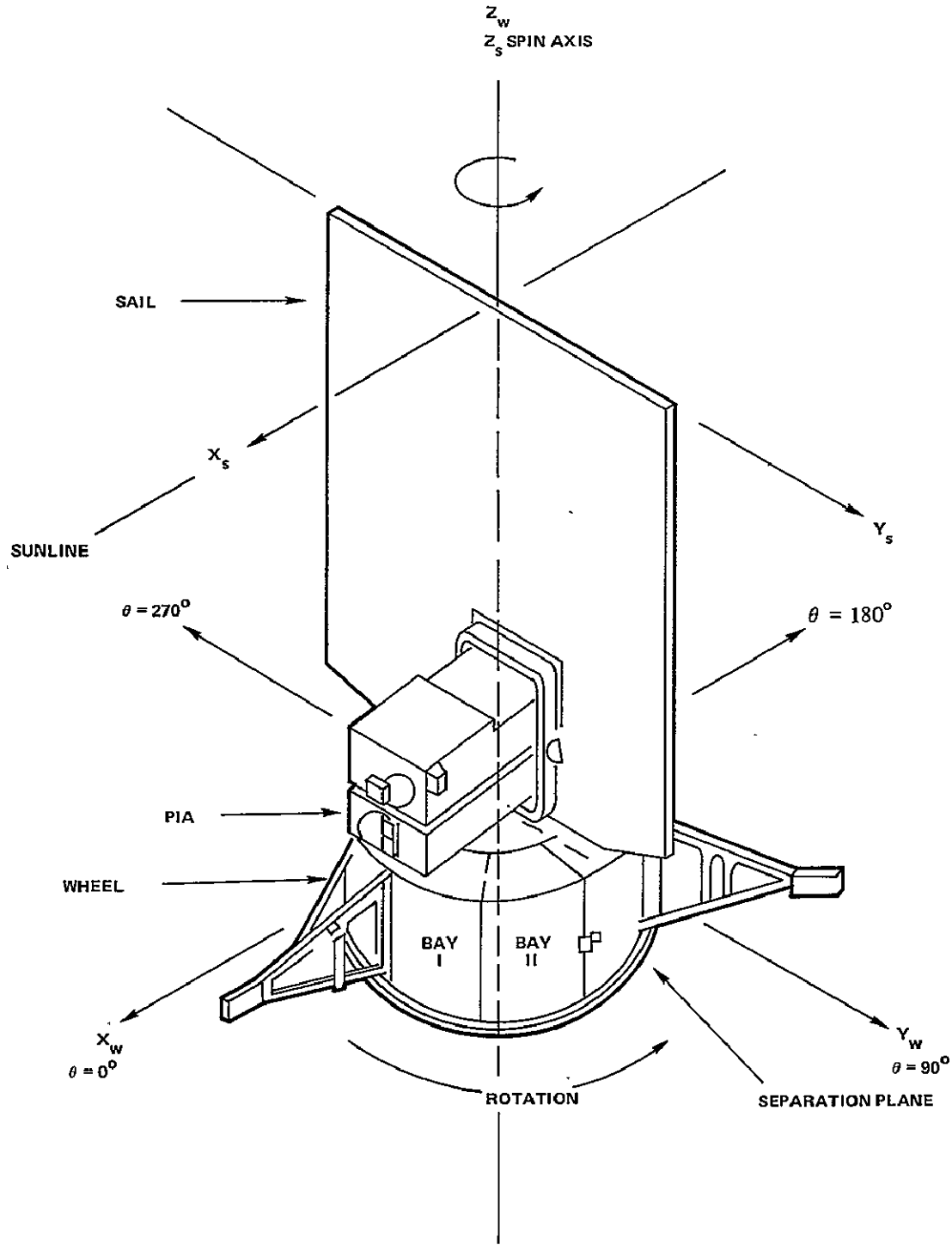

Figure 1-1. OSO-8 Configuration.

gyroscope. The sail section contains a solar cell array, which provides power to the observatory and a pointed instrument assembly (PIA) having the capability of accurate pointing of experiments at regions of the Sun's disk and corona.

1.3 ATTITUDE CONTROL SYSTEM

The OSO-8 spacecraft is equipped with a pneumatic control system, a magnetic torquing system, and a nutation damper. The wheel-mounted pneumatic system provides for both control of the spin rate of the spacecraft and precession in pitch or roll of the spacecraft spin axis. The control torques are those generated by the reaction forces which result when nitrogen gas is expelled from appropriately mounted jets. The pneumatic control system is activated by ground command. The magnetic torquing system provides for precession of the spacecraft spin axis by means of the interaction between an onboard controlled magnetic dipole and the Earth's magnetic field. The magnetic control system can be activated either by ground command or by time-tagged commands stored in the onboard command processor.

The nutation damper is a passive, eddy current device and is mounted on the sail. The device is used to maintain collinearity between the spacecraft spin axis and angular momentum vectors by damping nutation (time-constant less than 5 minutes) induced by control torques.

1.3.1 Magnetic Control System

The magnetic control system consists of a wheel-mounted, air-core coil capable of generating a dipole moment parallel or antiparallel to the spacecraft spin axis. The physical characteristics of the coil are as follows:

- Mean diameter: 55.35 inches
- Number of turns: 364 ±4

The coil current drive is capable of providing 30 nonzero current levels in nominal increments of 5 milliamperes ranging from -75 to +75 milliamperes.

The magnetic control system can be operated in any of three modes. In the continuous mode, direct command control of the coil current drive is used to establish a constant dipole moment. Although the easiest to command, the continuous mode of operation allows only limited control capability. The symmetric quarter orbit (QOMAC) timing mode allows a much greater control capability and is only slightly more difficult to command than the continuous mode. The QOMAC mode has been designated as the prime mode of magnetic control for OSO-8. The asymmetric timing mode results in maximum control capability but is significantly

more difficult to command than either of the other modes. The difficulty arises because sequences of time-tagged continuous-mode commands must be generated and stored in the command processor for execution.

Details of the operation of the magnetic control system in each of the possible modes follows:

- Continuous Mode. A command consisting of the current polarity and magnitude transmitted to the spacecraft causes a constant current to flow in the coil until a command is transmitted to turn the current off (Figure 1-2(a)).

- QOMAC Mode. In the QOMAC mode, the polarity of the current in the coil is reversed at equal intervals. To initiate QOMAC torquing requires that a sequence of two commands be transmitted to the spacecraft. The first command consists of the period — the time that the current will remain at one polarity before changing. The second contains the phase, initial polarity, and current magnitude. When the second command is received, the current is turned on at the initial magnitude and polarity for the duration of the phase time and, subsequently, the polarity is reversed after each period. Figure 1-2(b) depicts coil current as a function of time in the QOMAC mode. The phase duration is selectable from 0 to 33 minutes in 0.26-minute increments. The period is selectable from 0 to 33 minutes in 0.016-minute increments.

- Asymmetric Mode. In the asymmetric mode, sequences of continuous commands are transmitted for storage in the command processor. Each command has a time associated with it. The stored commands will then be executed at the tagged times. Figure 1-2(c) depicts a typical asymmetric mode time profile of the coil current.

1.3.2 Pneumatic Control System

The wheel-mounted pneumatic control system provides the capability for spin rate control and pitch or roll spin axis precession control. The system consists of nitrogen gas supply with pressure regulation and telemetry sensing, redundant pairs of spin control jets, and a pair of pitch/roll precession jets. The spin-rate control subsystem can execute a maximum of 63 increments per command. The precession control subsystem can execute a maximum of 16 gas increments per command. Precession commands can be commanded to have a precession magnitude change of 0.25 or 1.25 degrees per increment.

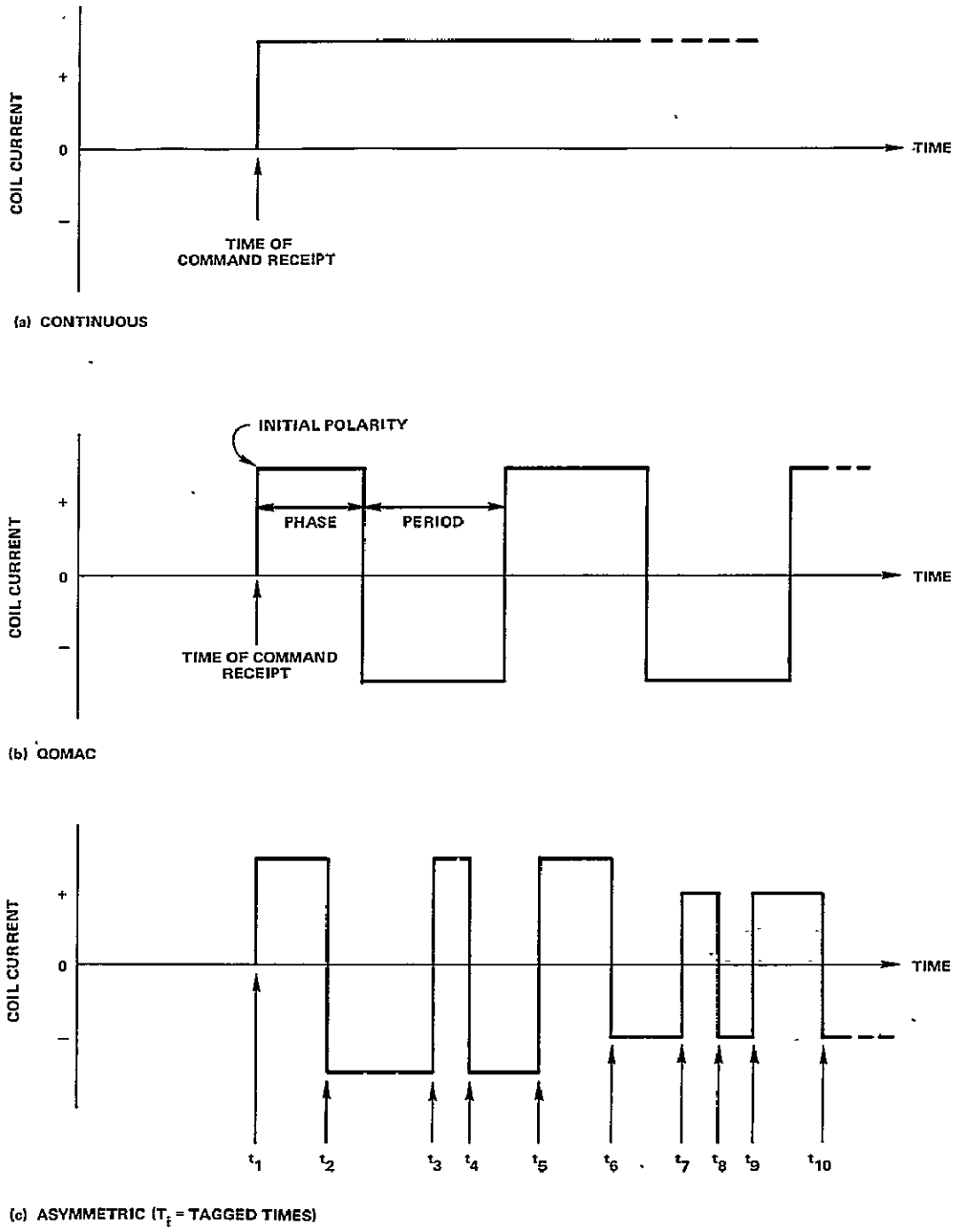

Figure 1-2. Types of Magnetic Controls.

1.4 ATTITUDE CONTROL CONSTRAINTS

The following constraints must be observed when controlling the OSO-8 spacecraft:

- The pitch angle must be maintained at 0 degree ±3 degrees during the mission to ensure proper operation of the pointed experiments. Attitude maneuvers must be accomplished without the pitch angle exceeding the ±3 degree limit.

- The wheel spin rate must be maintained at 6 ±1 rpm to maintain spacecraft stability and to permit reliable operation of the onboard instruments.

- Attitude control must be accomplished whenever possible through magnetic torquing to minimize the consumption of control gas.

SECTION 2

GRAPHICS CAPABILITIES

The Graphics Executive Support System (GESS) graphic capabilities available in this system are discussed in the following sections. Additional information on the use of GESS capabilities may be found in the GESS User's Guide (Reference 1).

2.1 GESS COMMANDS

The following commands are valid in the WHAT NOW field on a display:

SKIP (S, SEXT, SREV) validates (checks for format errors) the current display and proceeds to the next control point.

NEXT (N, NREV, F) validates the current display and advances to its next page.

WRITE (W, WEXT) validates and prints the current display and proceeds to the next display of the control point. If there are no other displays, processing continues to the next control point.

SAME validates and redisplays the current display.

PREV (P, PEXT, B) displays previous page of current display.

DISP1 (PAGE1) validates the current display and then displays page 1 of the current control point.

Fx validates the current display and moves forward x pages.

Bx validates the current display and moves backward x pages.

EXIT proceeds to the next control point without validation.

CALL validates current display and generates display named in DISPLAY NAME field.

DUMP prints current display and produces a full region dump on the GESS DUMP data set.

TERM terminates run.

Key 31 (key 23 on the ADS 6600) on the 2250 graphics device prints the current display.

2.2 GESS NAMELIST - CONTRL

The parameters in the GESS CONTRL NAMELIST are defined below (Reference 1, p. 22-6).

Name	Type	Default	Description
IFTABL	I4	21	FORTRAN unit number for the nonresident tables
IFTUBE	I4	23	FORTRAN unit number for the graphics display device
IFTPRT	I4	6	FORTRAN unit number for the printer
IRDART	I4	0	ARTCOM indicator 1 = read in values for ARTCOM 0 = do not read in values
IRDXST	I4	0	Status flag indicator (XSTOPS) 1 = read in temporary display status flags 0 = do not read in flags
IDIREC	I4	0	Directory array indicator 1 = read in and use directory arrays 0 = do not read in or use arrays
IRDTPD	I4	0	Read indicator 1 = read TPDSET NAMELIST 0 = do not read NAMELIST
NUMCNC	I4	0	Number of conversion and correction routines
NUMSCA	I4	0	Number of special capability routines
KOFFEE	I4	0	Flow indicator 0 = terminate in interactive mode after fine attitude subsystem 1 = recycle to telemetry processor
GSATID	A8	********	Satellite identification for print output titles
GRUNID	A8	********	Run identification for print output titles
IPRINT	I4	0	Print indicator 1 = print changed tabular displays 0 = do not print changed displays

KOFFEE should be set equal to 1.

2.3 DISPLAY STATUS SPECIFICATIONS

Display XSTOPS (Figure 2-1) shows display descriptors and their corresponding status flags. These can be changed through Key 30 on the 2250 graphics device (Key 22 on the ADS 6600). Also Status Flag values can be entered immediately after NAMELIST CONTRL. To read status flag via NAMELIST, IRDXST must be set to 1 and the format n(A8, 2X) is used. The values must be left justified.

```
************************************ G E S S  V 2.1 ************************************
************************************  D I S P L A Y  ********** 76.132.15.06.23 *****
**                                                                                    **
**    XSTOPS                        DISPLAY STATUS FLAGS              ZBDCWG2$   3  **
**    DISPLAY XSTOPS                          :PRINT                                  **
**    DISPLAY MASTER NUMBERS-CALL SETUP       :PRINT                                  **
**    DISPLAY DINPUT-CALL INDIS               :STOP                                   **
**    DISPLAY DOPTN-CALL CONDIS               :STOP                                   **
**    DISPLAY DOUTPT-CALL OUTDIS              :STOP                                   **
**    DISPLAY DATSUM                          :STOP                                   **
**    DISPLAY DATSM2                          :STOP                                   **
**    DISPLAY DSTAT                           :STOP                                   **
**    DISPLAY DINDEP                          :STOP                                   **
**    DISPLAY DOFP                            :STOP                                   **
**    DISPLAY DPOINT                          :STOP                                   **
**    DISPLAY DPITCH                          :STOP                                   **
**    DISPLAY DMAINT                          :STOP                                   **
**    DISPLAY DROLL                           :STOP                                   **
**    DISPLAY DCOILS                          :STOP                                   **
**    DISPLAY DCLIST                          :STOP                                   **
**    DISPLAY DQOMAC                          :STOP                                   **
**    DISPLAY DGAS                            :STOP                                   **
**    DISPLAY DEBUG                           :STOP                                   **
**    DISPLAY PLTX1Y                          :STOP                                   **
**    DISPLAY PLTX2Y                          :STOP                                   **
**                                                                                    **
**                                                                                    **
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**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=MSADE1 WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1    **
**                                                                                    **
************************************ G E S S  V 2.1 ************************************
************************************  D I S P L A Y  ************************************
```

Figure 2-1. XSTOPS Display.

For example:

```
&CONTRL IRDXST = 1, &END
SKIP    SKIP    SPRINT  SPRINT  SPRINT  SPRINT  STOP  STOP
STOP    STOP    STOP    STOP    STOP    STOP    STOP  STOP
SPRINT  SPRINT  STOP    STOP    STOP    END
```

For further information, consult Reference 1, p. 22-18.

2.4 PROGRAM FUNCTION KEYS

The KEYS display (Figure 2-2) shows the keys associated with the major control points and can be reached by CALLing DISPLAY KEYS. The program function keys are defined below:

Key	Function
1	Input Option Menu (DINPUT)
2	Control Option Menu (DOPTN)
3	Output Option Menu (DOUTPT)
4	Terminate Program
30 (22 on ADS 6600)	Display Status (XSTOPS)
31 (23 on ADS 6600)	Print Current Display

2.5 MASTER NUMBERS

The master numbers displays (ARTCOM) gives the size of all arrays displayed in the MSAP as shown in Figure 2-3. The display can be reached through Key 0. These array sizes should never be changed by the operator.

```
GESS V 2.1
DISPLAY                                   76.009.17.42.54

KEYS                    KEY ASSIGNMENTS                  ZBDCWC3$  34

                  KEY     CONTROL POINT

                   0        ARTCMM
                   1        INDR11
                   2        CONDR1
                   3        OUTDR1
                   4        DRIVE1
                  22        XSTOPS
                  23        PRINT

:
      CPOINT=INDR11 WHAT NOW  :          CALL DISPLAY:      DISP   1 OF   1

GESS V 2.1
DISPLAY
```

Figure 2-2. Program Function Keys.

```
**********************************  G.E S S  .V 2.1  **********************************
**********************************   D I S P L A Y  ********** 76.132.15.06.24  ********
**                                                                                    **
**    ARTCOM                              MASTER NUMBERS                ZBDCWG2$   4  **
**    SCROLLED ARRAYS                        :   34                                    **
**    ATTITUDE SUMMARY ARRAYS                :  250                                    **
**    POINT TO POINT COMMAND ARRAYS          :   20                                    **
**    PITCH CONTROL COMMAND ARRAYS           :   10                                    **
**    ATTITUDE MAINTENANCE COMMAND ARRAYS    :   10                                    **
**    ROLL RATE ARRAYS                       :   10                                    **
**    LINE NUMBERS                           :  900                                    **
**    SWITCHING FUNCTION ARRAYS              :  200                                    **
**    CIRCLE ARRAYS                          :  180                                    **
**    COMMAND SPECIFICATIONS TABLE           :  200                                    **
**    QOMAC COMMAND ARRAYS                   :   32                                    **
**    COIL HISTORY TABLE                     :  900                                    **
**    GAS HISTORY TABLE                      :   50                                    **
**    F(T) AND Q(T) PLOT ARRAYS              :  400                                    **
**    STATION LIST                           :  150                                    **
**                                                                                    **
**                                                                                    **
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**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  :                                                                                 **
**        CPOINT=ARTCMM WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1     **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y  **********************************
```

Figure 2-3. Master Numbers Display.

SECTION 3

SYSTEM INPUT DESCRIPTION

3.1 INPUT OPTION MENU - KEY 1 - DINPUT

The input option menu (DINPUT) is the first interactive display reached in the normal operation of MSAP/OSO-8 (Figure 3-1). Through it the operator selects primary program inputs which may be read in via the NAMELIST and the station coverage file. DINPUT is used to call the program control parameter displays and the station coverage display in order to modify the variables for controlling the system. Through DINPUT the operator may elect to save the program control parameters which have been selected, or reinitialize the system by resetting the parameters to the values saved.

3.1.1 Inputs

The various input options are discussed in the order of appearance on the Input Option Menu.

3.1.1.1 Read NAMELIST—This option reads the parameters in the NAMELISTS MSAPIN and OSOIN. If the NAMELISTS are not read, the values of these parameters will be the default values or those left from the previous pass through the system if a backward move has been made.

3.1.1.2 NAMELIST Select Option—This is used to choose a member of a partitioned data set specified by the NAMELIST DD card. The name must be left-justified. A blank field nullifies this option and the NAMELISTS are read from the data set on the FT25F001 DD card. A maximum of 90 cards can be in each NAMELIST member.

3.1.1.3 Read Station Times—This reads the station file as specified on the FT35F001 DD card. The first 150 stations between predictor start and predictor stop time are read in.

3.1.1.4 Read Attitude Solutions—This option is inoperative.

3.1.2 Displays

3.1.2.1 S/C Independent Parameters—This brings up the display (DINDEP) of the satellite independent parameters.

3.1.2.2 S/C Dependent Parameters—This brings up the display (DDEP) of the satellite dependent parameters.

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.009.17.49.42  ****
**
**    DINPUT                    INPUT OPTION MENU                    Z8DCWC3$  35
**
**
**    FUNCTION KEYS(** IS CURRENT DISPLAY)-
**
**      KEY 0 ARRAY ALLOCATION(ARTCOM)
**    **KEY 1 INPUT OPTION MENU(DINPUT)
**      KEY 2 CONTROL OPTION MENU(DOPTN)
**      KEY 3 OUTPUT OPTION MENU(DOUTPT)
**      KEY 4 TERMINATION                              (NAMELIST
**                                                      PARAMETERS)
**
**    INPUTS-
**      READ NAMELIST                        :N        $RNAML
**        NAMELIST SELECTION OPTION          :
**
**      READ STATION TIMES                   :N        $RSTAT
**      READ ATTITUDE SOLUTIONS              :N        $RATTS (INOPERATIVE)
**
**
**    DISPLAYS-
**      S/C INDEPENDENT PARAMETERS (DINDEP)  :Y        $INDEP
**      S/C DEPENDENT PARAMETERS (DDEP)      .Y        $DEP
**      EXPERIMENT PARAMETERS(DEXP)          :N        $EXP
**      STATION COVERAGE(DSTAT)              :N        $STAT
**
**
**    OPTIONS-
**      SAVE PARAMETERS FOR REINITIALIZATION :Y
**      REINITIALIZE FROM STORED PARAMETERS  :N
**
**
**
**
**
**
**
**
**
**  :
**        CPOINT=INDRI1 WHAT NOW  .          CALL DISPLAY.       DISP   1 OF   1
**
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

Figure 3-1. Input Option Menu Display.

3.1.2.3 Experiment Parameters—This option is inoperative.

3.1.2.4 Station Coverage—This brings up the display (DSTAT) of available stations.

3.1.3 Options

3.1.3.1 Save Parameters for Reinitialization—This option saves the parameters set up on the following DINDEP and DDEP displays as well as intermediate output (debug) switches and other program control parameters so that these values may be restored when reinitializing the system. The default is yes (Y) on first entering the system and no (N) on subsequent passes.

3.1.3.2 Reinitialize From Stored Parameters—This option resets the program control parameters to the values most recently saved through the above option, resets predictor time back to predictor start time, and empties the attitude summary tables. A set of parameters must have been first saved before attempting to reinitialize.

3.2 SATELLITE INDEPENDENT NAMELIST DISPLAY - DINDEP

The independent NAMELIST display (DINDEP) is used to access the primary satellite independent parameters from NAMELIST MSAPIN as shown in Figure 3-2.

3.3 SATELLITE INDEPENDENT PARAMETER NAMELIST - MSAPIN

The MSAPIN NAMELIST is defined according to the displays on which the parameters appear. Any MSAPIN parameter not on any display is defined in section 3.3.5.

3.3.1 MSAPIN NAMELIST Parameters on the Input Option Menu

The following MSAPIN variables are from display DINPUT.

Name	Type	Default	Description
$DEP	L1	T	Display dependent parameters
$EXP	L1	F	Display experiment file (inoperative)
$INDEP	L1	T	Display independent parameters
$RATTS	L1	F	Read attitude file (inoperative)
$RNAML	L1	T	Read NAMELIST
$RSTAT	L1	F	Read station AOS times
$STATS	L1	F	Display station coverage table

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.009.17.59.48  **********

DINDEP          SATELLITE INDEPENDENT NAMELIST DISPLAY
                                                  (NAMELIST PARAMETERS)
  PREDICTOR START TIME (YYMMDDHHMMSS)  : 760301000000.   KSTART
  PREDICTOR STOP TIME  (YYMMDDHHMMSS)  : 760303000000.   KSTOP
  INITIAL RIGHT ASCENSION (DEG)        :  210.000000     ALPHA
  INITIAL DECLINATION (DEG)            :   70.000000     DELTA
  INITIAL SPIN RATE (RPM)              :    6.000000     OMEGA

OPBITAL ELEMENTS -
  EPOCH TIME (YYMMDDHHMMSS.)           : 760227000000    OEPOCH (YYMMDD)
  SEMI-MAJOR AXIS (KM)                 : 6927.757813     OAXIS
  ECCENTRICITY                         :    0.000460     OEPSLN
  INCLINATION (DEG)                    :   32.937988     OIOTA
  MEAN ANOMALY (DEG)                   :    0.0          OUPSLN
  ARGUMENT OF PERIGEE                  :   30.023987     OOMEGA
  RIGHT ASC OF ASCENDING NODE (DEG)    :    0.0          OALPHA

APOS PARAMETERS
  NUMBER OF INTEGRATIONS PER ORBIT     :    3            NUMINT
  NUMBER OF OUTPUT POINTS PER ORBIT    :   15            NUMOUT
  TORQUE COMPUTATION STEP SIZE (SEC)   :   60            MDTORQ

TORQUES -
  MAGNETIC (Y,N)                       :Y                IOFF(1)
  GRAVITY  (Y,N)                       :N                IOFF(3)
  AEROM    (Y,N)                       :N                IOFF(4)
  SOLAR    (Y,N)                       :N                IOFF(5)
  MAXIMUM ALTITUDE FOR AERO (KM)       :10000.000000     RMAX
  BROUWER DRAG TERM (RAD/SEC**2)       :    0.0          DRAG0
  AERO DRAG COEFFICIENT                :    2.400000     CD

IO UNITS -
  PRINTED OUTPUT                       :    6            IPRINT
  STATION FILE                         :   35            ISTAT
  ORBIT FILE                           :    0            IORBT
  ATTITUDE FILE OUTPUT                 :    0            ITAPE
  CARD INPUT                           :   50            INCARD

:
     CPOINT=YINDEP WHAT NOW  -NEXT       CALL DISPLAY:       DISP   1 OF   1

**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

Figure 3-2. Satellite Independent NAMELIST Display.

```
*********************************** G E S S   V 2.1 ******************************************
*********************************** D I S P L A Y   ***********  76.009.18 01.05  ****
**                                                                                          **
**   DINDEP            SATELLITE INDEPENDENT NAMELIST DISPLAY         ZBDCWC3S  39  **
**     INTERMEDIATE OUTPUT                          :    6     IDUMP                        **
**     ERROR MESSAGE FILE                           :   12     MSGIN    (NAMELIST           **
**     ERROR MESSAGE OUTPUT                         :   13     MSGOUT      PARAMETERS)      **
**     COMMAND LIST FILE                            :    0     KLIST                        **
**                                                                                          **
**                                                                                          **
**                                                                                          **
**                                                                                          **
**   PREDICTOR TIME IS                           760301000000                               **
**                                                                                          **
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**                                                                                          **
**  :                                                                                       **
**        CPOINT=YINDEP WHAT NOW  :-          CALL DISPLAY:        DISP   1 OF  1          **
**                                                                                          **
*********************************** G E S S   V 2.1 ******************************************
*********************************** D I S P L A Y   ******************************************
```

Figure 3-2. Satellite Independent NAMELIST Display.
(continued)

3.3.2 MSAPIN NAMELIST Parameters on the Satellite Independent NAMELIST Display

The following MSAPIN variables are from display DINDEP.

Name	Type	Default	Description
ALPHA	R4	0.	Right ascension of spin axis (degrees)
CD	R4	2.1	Aerodynamic drag coefficient
DELTA	R4	0.	Declination of spin axis (degrees)
DRAG8	R8	0.	Brouwer drag term
IDUMP	I4	6	Intermediate printed output file
IOFF			Torque consideration flag 0 = use torque 1 = do not use torque
IOFF(1)	I4	1	Magnetic torque
IOFF(3)	I4	1	Gravity gradient torque
IOFF(4)	I4	1	Aerodynamic torque
IOFF(5)	I4	1	Solar radiation torque
IORB1	I4	0	Orbit ephemeris tape input 0 = do not use orbit tape >0 = number of orbit file input
IPRINT	I4	6	Standard printed output
ISTAT	I4	35	Station file
ITAPE	I4	0	Attitude tape output file
KLIST	I4	0	Command list file
KSTART(6)	I4	57,09,01,00,00,00	Predictor start time (YY,MM,DD,HH,MM,SS)
KSTOP(6)	I4	57,09,01,00,00,00	Predictor stop time (YY,MM,DD,HH,MM,SS)
MDTORQ	I4	3600	Torque computation step size (seconds)
MSGIN	I4	12	Error message file
MSGOUT	I4	13	Error message output data set
NUMINT	I4	1	Number of integrations per orbit
NUMOUT	I4	1	Number of output points per orbit
OALPHA	R4	0.	Right ascension of ascending node (degrees)
OAXIS	R4	0.	Semi-major axis (kilometers)
OEPOCH	R4	0.	Epoch date of orbital elements (YYMMDD)
OEPSLN	R4	0.	Eccentricity
OIOTA	R4	0.	Inclination (degrees)
OMEGA	R4	6.	Spin rate at predictor start time (rpm)
OOMEGA	R4	0.	Argument of perigee (degrees)

Name	Type	Default	Description
OTIME	R4	0.	Epoch time of orbital elements (seconds)
OUPSLN	R4	0.	Mean anomaly (degrees)
RMAX	R4	800.	Altitude above which aerodynamic torque may be neglected (kilometers)

3.3.3 MSAPIN NAMELIST Parameters on the Control Option Menu Display

The following MSAPIN variables are from display DOPTN.

Name	Type	Default	Description
ICONOP	I4	1	Processing option 1=normal execution 2=automatic execution
$AUTVC	L1	F	Use automatic pitch correction
$CLIST	L1	F	Display command list table
$COIL	L1	F	Use coil estimation
$COILS	L1	F	Display coil history table
$GAS	L1	F	Display gas history table
$MAINT	L1	F	Display attitude maintenance control table
$PITCN	L1	F	Display pitch control table
$POINT	L1	F	Display point to point control table
$QOMAC	L1	F	Display QOMAC expansion table
$READC	L1	F	Read command list data set
$ROLMN	L1	F	Display roll rate control table

3.3.4 MSAPIN NAMELIST Parameters on the Output Option Menu (DOUPT)

The following MSAPIN variables are from display DOUTPT.

Name	Type	Default	Description
IPLOT	I4	0	Plot indicator 1 = include plots with printed output 0 = do not include plots
IXAXIS	I4	0	X-axis plot option specification
IYAXIS	I4	0	Y-axis plot option specification
IYAX2	I4	0	Second y-axis plot option specification
WRTSUM	I4	0	Write attitude summary indicator 1 = write out attitude summary in non-GESS format 0 = do not write out attitude summary
$OCLST	L1	F	Display command list at output time

Name	Type	Default	Description
$OCOIL	L1	F	Display coil table at output time
$OGAS	L1	F	Display gas table at output time
$OQOMC	L1	F	Display QOMAC table at output time
$SUMRY	L1	T	Display attitude summary
$SUMR2	L1	F	Display attitude summary #2
$WRITE	L1	F	Write commands to data set

3.3.5 MSAPIN NAMELIST Parameters Not Displayed

The following MSAPIN variables are not displayed.

Name	Type	Default	Description
INTOUT(100)	I4	0	Array (of 100) of intermediate output (debug) indicators. Range is from 0 - no output to 10 - maximum output. (See Appendix E)
OLAMDA	R4	0.	Longitude of Greenwich reference to OMDREF (degree)
OMDREF	R4	0.	Reference date for longitude of Greenwich (YYMMDD.)

3.4 SATELLITE DEPENDENT NAMELIST DISPLAY - DDEP

The dependent NAMELIST display (DDEP) is used to access the primary satellite dependent parameters from the NAMELIST OSOIN as shown in Figure 3-3.

3.5 SATELLITE DEPENDENT PARAMETER NAMELIST - OSOIN

The OSOIN NAMELIST is defined according to the displays on which the parameters appear. Any OSOIN parameter not on any display is defined in section 3.5.4.

3.5.1 OSOIN NAMELIST Parameters on the Satellite Dependent NAMELIST Display

The following OSOIN variables are from display DDEP.

Name	Type	Default	Description
ANGMOT	R4	.125	Angular pitch or roll motion per pneumatic command increment (degrees)
CCM	R4	24.657	Composite center of mass (inches)
CHITIM	R4	60.	Stepsize for evaluating fit of commands to F(t) (seconds)

```
**********************************  G E S S   V 2.1  **********************************
**********************************  D I S P L A Y  **********  76.001.13.01.00  ********
**                                                                                    **
**    DDEP                SATELLITE DEPENDENT NAMELIST DISPLAY          ZBDCWG5$   7  **
**                                                                                    **
**    SATELLITE PARAMETERS -                                  (NAMELIST PARAMETERS)   **
**      WHEEL MASS (LB)                  : 1663.188965   WHMASS                       **
**      WHEEL X MOI (SLUG*FT**2)         :  242.000000   WHXMOI                      **
**      WHEEL Y MOI (SLUG*FT**2)         :  230.000000   WHYMOI                      **
**      WHEEL Z MOI (SLUG*FT**2)         :  438.000000   WHZMOI                      **
**      SAIL MASS (LB)                   :  610.264893   SLMASS                     **
**      SAIL X MOI (SLUG*FT**2)          :   57.000000   SLXMOI                     **
**      SAIL Y MOI (SLUG*FT**2)          :   51.000000   SLYMOI                     **
**      SAIL Z MOI (SLUG*FT**2)          :   38.000000   SLZMOI                     **
**      WHEEL CENTER OF MASS (IN)        :   16.099991   WCM                        **
**      SAIL CENTER OF MASS (IN)         :   47.479996   SCM                        **
**      COMPOSITE CENTER OF MASS (IN)    :   24.500000   CCM                        **
**      CP-CM OFFSET (IN)                :   38.519989   CPCM                       **
**      SAIL SPINS AT NIGHT (Y,N)        :N              ISAIL                      **
**      DAY/NIGHT SPINRATE RATIO         :    1.910000   SPROD                      **
**      SPACECRAFT Z-MAGNETIC BIAS (P*CM):    0.0        ZBIAS                      **
**      SAIL X-MAGNETIC BIAS (P*CM)      :    0.0        XBIAS                      **
**      SAIL Y-MAGNETIC BIAS (P*CM)      :    0.0        YBIAS                      **
**                                                                                    **
**    PRECESSION COIL -                                                               **
**      STRENGTH PER INCREMENT (MA)      :    5.000000   COILZ5                      **
**      MAX NUMBER OF INCREMENTS         :   15          MAXINC                     **
**                                                                                    **
**    PRECESSION JETS -                                                               **
**      NOMINAL ANG MOTION/INCREMENT(DEG):    0.250000   ANGMOT                     **
**      PITCH MOTION PER GAS INCREMENT                                                **
**           OF ROLL MOTION              :    0.0        PITMOT                     **
**      SPINRATE CHANGE PER GAS INCREMENT                                             **
**           OF PRECESSION MOTION        :    0.0        SPNMOT                     **
**                                                                                    **
**    SPIN RATE CONTROL-                                                              **
**      RPM CHANGE PER COMMAND INCREMENT :    0.008864   SPNDEL                     **
**      RATE UPPER LIMIT VALUE (RPM)     :   10.000000   SPINHI                     **
**      RATE LOWER LIMIT VALUE (RPM)     :    1.000000   SPINLO                     **
**      CHANGE SPIN RATE BY(RPM) AT LIMIT:    2.000000   SPNINC                     **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=YDEP   WHAT NOW  :NEXT       CALL DISPLAY:       DISP   1 OF   1  **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************  D I S P L A Y  **********************************
```

Figure 3-3. Satellite Dependent NAMELIST Display.

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.001.13.06.50  ****
**                                                          **
**   DDEP          SATELLITE DEPENDENT NAMELIST DISPLAY      ZBDCWG5$   9  **
**                                                          **
**   PITCH ANGLE CONSTRAINTS -                (NAMELIST PARAMETERS)     **
**     PITCH UPPER LIMIT (DEG)          :   90.000000   PUPLIM            **
**     PITCH LOWER LIMIT (DEG)          :  -90.000000   PLOLIM            **
**     ACTIVATE AT PITCH UPPER LIMIT (DEG) :  90.000000   PICHHI         **
**     ACTIVATE AT PITCH LOWER LIMIT (DEG) : -90.000000   PICHLO         **
**     CHANGE PITCH AT LIMIT BY (DEG)   :    0.500000   PDELTA           **
**                                                                       **
**                                                                       **
**                                                                       **
**                                                                       **
**                                                                       **
**                                                                       **
**                                                                       **
**                                                                       **
**   OUTPUT PRINT OPTIONS                                                **
**     REGULAR OUTPUT (Y,N)             :Y             $PTREG           **
**     ASCENDING NODE (Y,N)             :Y             $PTNOD           **
**     COIL EVENT     (Y,N)             :N             $PTCOL           **
**     STATION AOS    (Y,N)             :N             $PTAOS           **
**                                                                       **
**   CONTROL OPTIONS                                                     **
**     COMMANDS START AT STATION AOS (Y,N) :N          $STAT            **
**     CONSIDER ENVIRONMENTAL TORQUES   :Y             $TORK            **
**                                                                       **
**   ROLL RATE MONITORING                                                **
**     MAXIMUM ROLL RATE          DEGREES :    0.100000   RRDEG          **
**                              PER MINUTES :   96.000000   RRTIM          **
**     STEP SIZE (MIN)                  :   96.000000   RRSTEP           **
**     CHECK ROLL RATE AT STATION AOS      .N           $RRAOS           **
**                                                                       **
**   MAGNETIC CONTROL PARAMETERS                                         **
**     MILLAMPERES TO POLE-CM CONVERSION   : 567.000000   MATOPC         **
**     SWITCHING FUNCTION STEPSIZE (SEC)   :  60          IDELTF          **
**     STEPSIZE FOR COMPUTING FIT (SEC)    :  60.000000   CHITIM          **
**                                                                       **
**  :                                                                    **
**       CPOINT=YDEP   WHAT NOW  :NEXT       CALL DISPLAY:      DISP  1 OF  1  **
**                                                                       **
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

Figure 3-3. Satellite Dependent NAMELIST Display. (continued)

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ***********  76.001.13.09.40  ****
**                                                                                   **
**   DDEP.              SATELLITE DEPENDENT NAMELIST DISPLAY                         **
**     NUMBER OF STANDARD DEVIATIONS                         (NAMELIST PARAMETERS)   **
**       FOR QOMAC/CONTINUOUS COMMANDS      :    3.000000    SIGMAQ                  **
**     MAXIMUM QOMAC PERIOD (MIN)           :   32.000000    PERMAX                  **
**     PERIOD GRANULARITY (MIN)             :    0.016000    PERINC                  **
**     MAXIMUM QOMAC PHASE (MIN)            :   32.000000    PHAMAX                  **
**     PHASE GRANULARITY (MIN).             :    0.260000    PHSINC                  **
**     MAXIMUM NUMBER OF ASYMMETRIC ENTRIES :   32           MAXASY                  **
**                                                                                   **
**   PNEUMATIC CONTROL PARAMETERS                                                    **
**     MAX NUMBER OF SPIN GAS INCREMENTS    :   63           MAXSPN                  **
**     MAX NUMBER PITCH/ROLL GAS INCREMENTS     16           MAXPR                   **
**     SPINRATE USED FOR GAS CONTROL                                                 **
**       PARAMETER CALIBRATION              :    6.000000    SPNOM                   **
**                                                                                   **
**                                                                                   **
**                                                                                   **
**                                                                                   **
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**                                                                                   **
**                                                                                   **
**  :                                                                                **
**         CPOINT=YDEP   WHAT NOW  :          CALL DISPLAY;       DISP  1 OF  1      **
**                                                                                   **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure 3-3. Satellite Dependent NAMELIST Display.
(concluded)

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Name	Type	Default	Description
COILZ5	R4	5.	Magnetic control coil strength per increment (milliamperes)
CPCM	R4	0.	Center of pressure - center of mass offset (inches)
IDELTF	I4	60	Stepsize for switching function computation (seconds)
ISAIL	I4	0	Sail spin indicator 1 = sail spins at night 0 = does not spin at night
MATOPC	R4	567.	Milliamps to pole-cm conversion factor
MAXASY	I4	32	Maximum number of asymmetric command entries
MAXINC	I4	15	Maximum number of increments for magnetic control coil
MAXPR	I4	16	Maximum number of pitch/roll gas increments per command
MAXSPN	I4	63	Maximum number of spin gas increments per command
PDELTA	R4	.6	Pitch correction increment (degrees)
PERINC	R4	.016	Period granularity (minutes)
PERMAX	R4	32.0	Maximum QOMAC period (minutes)
PHAMAX	R4	32.0	Maximum QOMAC phase (minutes)
PHSINC	R4	.26	Phase granularity (minutes)
PICHHI	R4	3.0	Upper pitch limit for activating pneumatic control system (degrees)
PICHLO	R4	-3.0	Lower pitch limit for activating pneumatic control system (degrees)
PITMOT	R4	.125	Pitch motion per gas increment roll motion for pneumatic maneuver (degrees)
PLOLIM	R4	-3.0	Lower limit for pitch violation warning (degrees)
PUPLIM	R4	3.0	Upper limit for pitch violation warning (degrees)
RRDEG	R4	.14	Used with RRTIM; RRDEG/RRTIM is the roll rate monitoring limit (degrees/minutes)
RRSTEP	R4	96.	Step size for roll rate monitoring (minutes)
RRTIM	R4	96.	See RRDEG
SCM	R4	47.48	Sail center of mass (inches)
SIGMAQ	R4	3.	Standard deviation limit for F(t) used in computing commands
SLMASS	R4	610.265	Sail mass (pounds)
SLXMOI	R4	57.0	Sail X-axis moment of inertia (slug-feet^2)
SLYMOI	R4	51.0	Sail Y-axis moment of inertia (slug-feet^2)
SLZMOI	R4	38.0	Sail Z-axis moment of inertia (slug-feet^2)

Name	Type	Default	Description
SPINHI	R4	7.5	Upper spin rate constraint for activating gas control (rpm)
SPINLO	R4	4.5	Lower spin rate constraint for activating gas control (rpm)
SPNDEL	R4	.1	Spin rate change per command increment (rpm)
SPNINC	R4	2.0	Spin rate value for automatic spin correction maneuver (rpm)
SPNMOT	R4	0	Spin rate change per gas increment of precession motion (rpm)
SPNOM	R4	6.0	Spin rate used for gas control parameter calibration (rpm)
SPROD	R4	1.91	Ratio of Day/Night spin rate
WCM	R4	16.1	Wheel center of mass (inches)
WHMASS	R4	1663.190	Wheel mass (pounds)
WHXMOI	R4	242.0	Wheel X-axis moment of inertia (slug-feet^2)
WHYMOI	R4	230.0	Wheel Y-axis moment of inertia (slug-feet^2)
WHZMOI	R4	438.0	Wheel Z-axis moment of inertia (slug-feet^2)
XBIAS	R4	0.	Magnetic bias along body X-axis (pole-centimeters)
YBIAS	R4	0.	Magnetic bias along body Y-axis (pole-centimeters)
ZBIAS	R4	0.	Magnetic bias along body Z-axis (pole-centimeters)
$PTAOS	L1	F	Output at station AOS
$PTCOL	L1	F	Output at coil events
$PTNOD	L1	T	Output at ascending node crossings
$PTREG	L1	T	Output at regular intervals (from NUMOUT)
$RRAOS	L1	F	Check roll rate at station AOS (if monitoring roll rate)
$STAT	L1	F	Match command start times to station AOS
$TORK	L1	F	Consider environmental torques when generating a command; accounts for environmental drift

3.5.2 OSOIN NAMELIST Parameters on the Control Option Menu Display

The following OSOIN variable is from display DOPTN.

Name	Type	Default	Description
$RRMON	L1	F	Monitor roll rate

3.5.3 OSOIN NAMELIST Parameters on the Output Option Menu Display

The following OSOIN variables are from display DOUTPT.

Name	Type	Default	Description
MATAPE	I4	0	Option to write attitude tape 1 = write attitude tape 0 = do not write tape
MDTERP	I4	0	Interpolation stepsize for attitude tape (seconds) 0 = do not interpolate >0 = interpolate at this stepsize

3.5.4 OSOIN NAMELIST Parameters Not Displayed

The following OSOIN variables are not displayed.

Name	Type	Default	Description
ANV(3,50)	R4	—	Unit vector normal to each component in spacecraft coordinates for aerodynamic drag model
AREA(50)	R4	—	Area of each component for aerodynamic drag model (centimeter^2)
ATDRFT	R4	.2	Percentage drift allowed before boundary test in attitude maintenance (see appendix A, attitude maintenance)
ATPARM	R4	..001	Singularity correction factor (see appendix A, attitude maintenance)
COLTIM	R4	96.	Coil estimation interval (minutes) must be $\leq$ initial leg length
ITYPE(50)	I4	—	Type of component for aerodynamic model 1 = sphere 2 = cylinder 3 = flat plate
KDELTA	I4	0	Minimum time between controls (minutes) - was never tested
N	I4	24	Number of components for aerodynamic drag model
ORBNO	R4	0.	Orbit number
PANGLE	R4	9999.9	Initial pitch angle (degrees)
RANGLE	R4	none	Initial roll angle (degrees)
RV(3,50)	R4	—	Moment arm vector for each component for aerodynamic drag model
SXYMOI	R4	—	Sail X-Y product of inertia (slug-feet^2)
SXZMOI	R4	—	Sail X-Z product of inertia (slug-feet^2)
SYZMOI	R4	—	Sail Y-Z product of inertia (slug-feet^2)

3.6 STATION LIST

The station list display (DSTAT) provides a list of all stations within the span of the prediction, specifying the station name, acquisition of signal, loss of signal, and consideration flag as shown in Figure 3-4. The flag removes the station from consideration. The maximum number of stations which can be read in and displayed at one time is 150.

DSTAT may be accessed asynchronously!

```
**********************************  G E S S  V 2.1  **********************************
**********************************   D I S P L A Y  ********** 76.132.15.16.11  ********
**                                                                                    **
**    DSTAT                              STATION LIST                ZBDCWG2$  47    **
**                                                                                    **
**    CURRENT SIZE OF STATION LIST              :  54                                 **
**                                                                                    **
**    FLAG VALUES (F)                                                                 **
**      .  UNFLAGGED                                                                  **
**      F  REMOVES STATION FROM CONSIDERATION                                         **
**                                                                                    **
**            F          NAME              AOS                  LOS                  **
**                                     YY.MM.DD.HH.MM       YY.MM.DD.HH.MM          **
**          :.           QUI          76.05.13.01.46       76.05.13.01.54          **
**          :.           SGO          76.05.13.03.34       76.05. 3.03.40          **
**          :.           SGO          76.05.13.05.14       76.05.13.05.22          **
**          :.           SGO          7( 05.13.06.55       76.05.13.07.0J          **
**          :.           ACN          76.05.13.08.53       76.05.13.09.02          **
**          :.           SGO          76.05.13.10.18       76.05.13.10.23          **
**          :.           QUI          76.05.13.13.42       76.05.13.13.49          **
**          :.           ORR          76.05.13.14.48       76.05.13.14.56          **
**          :.           ORR          76.05.13.16.30       76.05.13.16.37          **
**          :.           IIL          76.05.13.17.08       76.05.13.17.16          **
**          :.           IIL          76.05.13.18.49       76.05.13.18.57          **
**          :.           IIL          76.05.13.20.31       76 05.13.20.39          **
**          :.           IIL          76.05.13.22.12       76 05.13.22.19          **
**          :.           QUI          76.05.13 23.58       76.05.14.00.05          **
**          :.           QUI          76.05.14.01.39       76.05.14.01.46          **
**          :.           SGO          76.05.14.03.26       76.05.14.03.33          **
**          :.           SGO          76.05.14.05.07       76.05.14.05.15          **
**          :.           ACN          76.05.14.07.03       76.05.14.07.14          **
**          :.           SGO          76.05.14.08.29       76.05.14.08.36          **
**          :.           QUI          76.05.14.11.54       76.05.14.12.02          **
**          :.           ORR          76.05.14.13.00       76.05.14.13.08          **
**          :.           ORR          76.05.14.14.41       76.05.14.14.49          **
**          :.           IIL          76.05.14.17.01       76.05.14.17.09          **
**          :.           IIL          76.05.14.18.42       76.05.14.18.50          **
**          :.           IIL          76.05.14.20.23       76.05.14.20.31          **
**          :.           IIL          76.05.14.22.05       76.05.14.22.12          **
**          :.           QUI          76.05.14.23.50       76.05.14.23.58          **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=DSTAT  WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1    **
**                                                                                    **
**********************************  G E S S  V 2.1  **********************************
**********************************   D I S P L A Y  **********************************
```

Figure 3-4. Station List Display.

SECTION 4

SYSTEM CONTROL AND PREDICTION DESCRIPTION

This section discusses control types and procedures used in generating commands to control the satellite. A control is defined as a maneuver where the operator specifies a set of conditions such as control start and stop times, current, tolerance, and command leg length to achieve a desired result such as a desired right ascension and declination, pitch angle, or maximum allowed roll rate. The control is done in steps called legs. Legs are operator specified command time intervals. From the control a series of commands will be generated to complete the maneuver. Three types of magnetic commands exist (continuous, QOMAC, optimal) and are discussed in appendix B. Magnetic commands are expanded into history coil events representing the change in polarity of the magnetic coil. Six types of gas commands exist (spin positive, spin negative, roll positive, roll negative, pitch positive, pitch negative). Gas commands are expanded into gas history events representing the number and direction of the gas pulses.

A maximum of 20 controls can be entered in the four different types of control tables at one time. Controls cannot overlap each other.

When specifying a QOMAC/continuous option for the control specification the system determines which type of command (QOMAC or continuous) is most efficient and generates a command using that command type.

Spinrate is controlled by specifying upper and lower limits. When the spinrate exceeds the limits, a spin command is generated automatically and corrects the spinrate. The parameters for spinrate control are on the Satellite Dependent Display and in the OSOIN NAMELIST. These variables are discussed is section 3.5.1.

4.1 TABLE ENTRY PROCEDURES

The control and command displays in the prediction and control section of the MSAP/OSO-8 all take the form of table entry displays. This includes DPOINT, DPITCH, DMAINT, DROLL, DCLIST, DQOMAC, DCOILS, and DGAS. All these displays contain a table section, in which the entries are listed and which is protected except for the flag, and an entry section, through which the operator may enter, recall, or modify lines in the table section.

The DISPLAY CONTROL consists of the REDISPLAY option, which is either Y - yes, in which the display will be shown again after SKIP, N - no, in which

the display will be left after SKIP provided all entries are acceptable, and C - clear table, by which the table is cleared so that all arrays are emptied and the empty display is shown again. The RECALL LINE NUMBER option is used to remove a specified line from the table section and display in the entry section. The line number must be within the range of lines already in the table, and REDISPLAY = Y must also be specified. To enter a new line into the table section, the operator types in the entry in the required fields of the entry section, sets REDISPLAY = Y, and SKIP's. The new line will be entered into the table in order by time. To modify anything other than the flag of a line in the table section, the operator must recall the line to the entry section, make the modifications there, then re-enter the line into the table. If a new line is entered into the table with a time equal to that of a line already in the table, the old line will be replaced by the new one. To leave a table entry display, the operator should leave the fields in the entry section unspecified except for REDISPLAY, which should be set to N (no), then SKIP.

4.2 CONTROL OPTION MENU - KEY 2 - DOPTN

DOPTN is the first display in the prediction and control section of the MSAP/OSO-8 system, through which the operator chooses the control modes and execution options with their associated displays for a single pass through the system. The available control modes are point to point, in which commands are generated to maneuver the spin axis from its initial attitude to a specified desired attitude; pitch control, in which commands are generated to maneuver to a desired pitch angle; attitude maintenance, in which commands are generated to keep the spin axis within a certain tolerance of a specified attitude; and roll rate control in which commands are generated to maintain the roll angle change within a desired limit.

From the Control Option Menu the operator may also call the Command List display (DCLIST), which tabulates commands already executed and into which he may enter specific commands to be executed besides those generated by the control specifications, or alter commands already in the table. The QOMAC Command Table (DQOMAC) may be called from the Command List (DCLIST) to expand a particular QOMAC command, showing possible times for starting the command and its subsequent periodic switching times. The Coil Table (DCOILS) and Gas Table (DGAS) provide a history of each coil and gas event executed and give the operator the option of specifying the commands to be executed on an event by event basis. All modifications to the Command List, Coil Table, and Gas Table must be made after calling these displays from the Control Option Menu (DOPTN); these tables are also available under the Output Option Menu (DOUTPT), but for viewing purposes only. The Control Option Menu is shown in Figure 4-1.

```
**********************************  G E S S   V 2.1  ***********************************
**********************************   D I S P L A Y   ********** 76.001.13.14.08  ********
*                                                                                      **
**    DOPTN                          CONTROL OPTION MENU                 ZBDCWG55$  14  **
*                                                                                      **
*/                                                                                     **
*-    FUNCTION KEYS(** IS CURRENT DISPLAY)-                                            **
*       KEY 0 ARRAY ALLOCATION(ARTCOM)                                                 **
*-      KEY 1 INPUT OPTION MENU(DINPUT)                                                **
*>    **KEY 2 CONTROL OPTION MENU(DOPTN)                                               **
*-      KEY 3 OUTPUT OPTION MENU(DOUTPT)                                               **
*>      KEY 4 TERMINATION                                                              **
*>                                                  (NAMELIST                          **
*>                                                   PARAMETERS)                       **
*-    CONTROL MODES-                                                                   **
**      POINT TO POINT                    :Y        $POINT                             **
**      PITCH CONTROL                     :N        $PITCN                             **
**      ATTITUDE MAINTENANCE              :N        $MAINT                             **
**      ROLL RATE MINIMIZATION            :N        $ROLMN                             **
*>                                                                                     **
*.                                                                                     **
**    DISPLAYS-                                                                        **
**      COMMAND LIST (DCLIST)             :N        $CLIST                             **
*       QOMAC COMMAND TABLE (DQOMAC)      :N        $QOMAC                             **
**      COIL TABLE (DCOILS)               :N        $COILS                             **
*-      GAS TABLE (DGAS)                  :N        $GAS                               **
*<                                                                                     **
*-                                                                                     **
**    OPTIONS-                                                                         **
*<      ESTIMATE COIL STRENGTH            :N        $COIL                              **
*-      MONITOR ROLL RATE                 .N        $RRMON                             **
**      READ COMMAND LIST                 :N        $READC                             **
*-      AUTOMATIC PITCH VIOLATION CORRECTION :N     $AUTVC                             **
**      AUTOMATIC EXECUTION               :N        -                                  **
*<      (FINAL DISPLAYS ONLY)                                                          **
**                                                                                     **
**                                                                                     **
*<                                                                                     **
*-                                                                                     **
**                                                                                     **
*-                                                                                     **
*"  :                                                                                  **
*       CPOINT=CONDR1 WHAT NOW  :          CALL DISPLAY:        DISP  1 OF  1       **
*                                                                                      **
**********************************  G E S S   V 2.1  ***********************************
**********************************   D I S P L A Y   ***********************************
```

Figure 4-1. Control Option Menu Display.

4.3 CONTROL TABLES

4.3.1 Point to Point Control Table

DPOINT is the table entry display used to give the specifications for point-to-point control. A maximum of 20 controls may be specified; their time spans may not overlap those of any other controls specified to the system. The control specifications will be used to generate commands during the course of the prediction as control start time is reached. The commands will be generated over the time span from control start to control stop to maneuver the spin axis to the desired right ascension and declination. The control will cease when the spin axis comes within the specified tolerance of the desired attitude, and the maneuver is done in stages known as 'legs' of a specified duration. The control is examined at each leg to generate the command that will best carry out the control over the leg, so that a new command is generated for each leg of a control (this applies only to magnetic controls). The coil current and leg length used for the command is that specified as normal unless:

a. It is found that the angle (zeta) remaining between the current and desired attitude is less than or equal to the tolerance times the multiple of expected change used to select reduced values; or

b. It is found that the amount of motion acheived on the previous leg is greater than or equal to the remaining angle between the current and desired attitude times the multiple of expected change used to select reduced values; in which case the reduced leg length and current as specified will be used.

For pneumatic (gas) controls, only the times and desired attitude need be specified, since coil current, leg length, and tolerance do not apply to the generation of pneumatic commands.

Figure 4-2 illustrates the point-to-point control table with the corresponding CNTROL NAMELIST variables.

4.3.2 Pitch Angle Control Table

DPITCH is the table entry display used to give the specifications for pitch control. A maximum of 10 controls may be specified whose time spans may not overlap those of any other controls in the system. The same general discussion of control specifications as found in the point-to-point control table description applies here, except that only the final desired pitch angle is controlled and the commands are generated only to reach an attitude for which the specified pitch angle is obtained. See the point-to-point control table description for further details.

```
G E S S   V 2.1
D I S P L A Y          76.001.13.24.02

DPOINT              POINT TO POINT CONTROL TABLE              ZBDCWG5$  16

DISPLAY CONTROL                                          (NAMELIST
  REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N                 PARAMETERS)
  RECALL LINE NUMBER                   : 0

CONTROL SPECIFICATION                                     (MMODE = 1)
  CONTROL FLAG (F)                     ..
     F = FLAGGED    . = UNFLAGGED
  CONTROL TYPE (T)                     :0               KCMODE
     T = 1  - CONTINUOUS
     T = 2  - QOMAC
     T = 3  - OPTIMAL
     T = 4  - PNEUMATIC
  CONTROL START TIME (YYMMDDHHMMSS)    :          0.    CSTART
  CONTROL STOP TIME  (YYMMDDHHMMSS)    :          0.    CSTOP
  DESIRED RIGHT ASCENSION (DEG)        : 0.0            CALPHA
  DESIRED DECLINATION (DEG)            : 0.0            CDELTA
  TOLERANCE ON FINAL ATTITUDE (DEG)    : 0.0            CDEL
  NORMAL LEG LENGTH (DELT1 - MIN)      :   0.           CDELT1
  NORMAL COIL CURRENT (CR1 - MA)       : 0.             CURNT1

ZONE OF REDUCED MOTION
  MULTIPLE OF EXPECTED CHANGE USED TO  :1.0             CDMLT
     SELECT THE REDUCED VALUES (MLT)
  REDUCED LEG LENGTH (DELT2 - MIN)     :   0.           CDELT2
  REDUCED COIL CURRENT (CR2 - MA)      : 0.             CURNT2

     START TM  STOP TM   DES     DES    TOL   DELT1  CR1      DELT2  CR2
F T DD.HH.MM DD.HH.MM  RTASC    DECL  (DEG)  (MIN) (MA) MLT  (MIN) (MA)
: 2 01.00.00 02.00.00 245.000  75.000 0.200   480.  75. 1 0    60.  50.

:
     CPOINT=YPOINT WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1

G E S S   V 2.1
D I S P L A Y
```

Figure 4-2. Point-to-Point Control Table Display.

Figure 4-3 illustrates the pitch angle control table with the corresponding CNTROL NAMELIST variables.

4.3.3 Attitude Maintenance Control Table

DMAINT is the table entry display used to give the specifications for a desired attitude to be maintained. A maximum of 10 controls may be specified whose time spans may not overlap those of any other controls specified to the system. The same general discussion of controls found in the point-to-point control description also applies to DMAINT.

For attitude maintenance, a desired attitude is specified as right ascension and declination, and a cone angle is specified in which the current attitude is to be maintained. The initial attitude at the beginning of an attitude maintenance control must already be within the cone about the desired attitude. The attitude is allowed to drift to the edge of the cone. At this point commands are generated to move the spin axis to a point on the opposite side of the cone that will cause the attitude to drift through the center of the cone. This maximizes the time before a new command needs to be generated to keep the attitude within the cone. The cone angle for attitude maintenance should be at least twice as large as the tolerance on final attitude.

Figure 4-4 illustrates the Attitude Maintenance Control Table with the CNTROL NAMELIST variables.

4.3.4 Roll Rate Control Table

DROLL is the table entry display used to give the specifications for roll rate control. A maximum of 10 controls may be specified whose time spans may not overlap those of any other controls in the system. The same general discussion of control specifications as found in the point-to-point control table description applies, except that only magnetic commands are used to control the roll rate. The maximum allowed roll rate is specified in degrees per orbit. The command time interval is the frequency the roll angle change is checked (and if necessary commands are generated to control roll rate). Roll rate is controlled by checking the total change in roll angle every command time interval and comparing it to the maximum allowed roll angle change. If the roll rate limit is exceeded a command is generated with the current entered by the operator. If the roll rate is unable to be controlled using this current value the current is adjusted accordingly and command reimplemented. If roll rate control is still unable to be controlled a message is sent to the operator. Once the message is sent the roll rate control continues. A current greater than zero must be entered in the roll rate control table.

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.001.13.29.32  ****

   DPITCH                    PITCH ANGLE CONTROL TABLE              ZBDCWG5$  19

   DISPLAY CONTROL                                          (NAMELIST
     REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N                 PARAMETERS)
     RECALL LINE NUMBER                 : 0

   CONTROL SPECIFICATION                                     (MMODE = 2)
     CONTROL FLAG (F)                   :.
        F = FLAGGED    . = UNFLAGGED
     CONTROL TYPE (T)                   :0                  KCMODE
        T = 1  - CONTINUOUS
        T = 2  - QOMAC
        T = 3  - OPTIMAL
        T = 4  - PNEUMATIC
     CONTROL START TIME (YYMMDDHHMMSS)  :          0.       CSTART
     CONTROL STOP TIME  (YYMMDDHHMMSS)  :          0.       CSTOP
     FINAL DESIRED PITCH ANGLE          :  0.0              CETAF
     TOLERANCE ON FINAL ATTITUDE (DEG)  :  0.0              CDEL
     NORMAL LEG LENGTH (DELT1 - MIN)    :    0.            CDELT1
     NORMAL COIL CURRENT (CR1 - MA)     .  0.               CURNT1

   ZONE OF REDUCED MOTION -
     MULTIPLE OF EXPECTED CHANGE USED TO :1.0               CDMLT
        SELECT THE REDUCED VALUES (MLT)
     REDUCED LEG LENGTH (DELT2 - MIN)---:   0.              CDELT2
     REDUCED COIL CURRENT (CR2 - MA)    :  0                CURNT2

          START TM   STOP TM  FINAL   TOL   DELT1   CR1        DELT2   CR2
   F  T   DD.HH.MM  DD.HH.MM  PITCH  (DEG)  (MIN)  (MA)  MLT  (MIN)  (MA)
   :  1   03.00.00  04.00.00    2.0  0.200     0.    0.  1.0     0.    0.

        CPOINT=YPITCH WHAT NOW  :          CALL DISPLAY:      DISP   1 OF   1

**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

Figure 4-3. Pitch Angle Control Table Display.

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ********** 76.001.13.34.06  *****
**                                                                                    **
**    DMAINT              ATTITUDE MAINTENANCE CONTROL TABLE            ZBDCWG5$  22  **
**                                                                                    **
**    DISPLAY CONTROL                                          (NAMELIST             **
**      REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) .N                 PARAMETERS)           **
**      RECALL LINE NUMBER                  : 0                                       **
**                                                                                    **
**    CONTROL SPECIFICATION                                     (MMODE = 3)           **
**    . CONTROL FLAG (F)                  :.                                        **
**        F = FLAGGED    . = UNFLAGGED                                               **
**    . CONTROL TYPE (T)                  :0                  KCMODE                **
**        T = 1  - CONTINUOUS                                                         **
**        T = 2  - QOMAC                                                              **
**        T = 3  - OPTIMAL                                                            **
**        T = 4  - PNEUMATIC                                                          **
**      CONTROL START TIME (YYMMDDHHMMSS)   :          0.   CSTART                  **
**      CONTROL STOP TIME  (YYMMDDHHMMSS)   :          0.   CSTOP                   **
**      DESIRED RIGHT ASCENSION (DEG)          0.0          CALPHA                   **
**      DESIRED DECLINATION (DEG)           .  0.0          CDELTA                   **
**      CONE ANGLE FOR ATTD MAINTENANCE     :  0.0          CTHETO                   **
**      TOLERANCE ON FINAL ATTITUDE (DEG)   :  0.0          CDEL                     **
**      NORMAL LEG LENGTH (DELT1 - MIN)     :    0.         CDELT1                   **
**      NORMAL COIL CURRENT (CR1 - MA)      :  0.           CURNT1                   **
**                                                                                    **
**    ZONE OF REDUCED MOTION                                                          **
**      MULTIPLE OF EXPECTED CHANGE USED TO :1.0            CDMLT                    **
**        SELECT THE REDUCED VALUES (MLT)                                             **
**      REDUCED LEG LENGTH (DELT2 - MIN)    :    0.         CDELT2                   **
**      REDUCED COIL CURRENT (CR2 - MA)     :  0.           CURNT2                   **
**                                                                                    **
**                                                                                    **
**       START TM  STOP TM  DES  DES   CONE  TOL  DELT1  CR1     DELT2  CR2         **
**    F T DD.HH.MM DD.HH.MM RTASC  DECL ANGLE (DEG) (MIN) (MA) MLT (MIN) (MA)        **
**    :. 1 04.00.00 05.00.00 200.0  70.0   1.0 0.3C0  480.  30. 1.0  240.  15.      **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=YMAINT WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1    **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure 4-4. Attitude Maintenance Control Table Display.

Figure 4-5 illustrates the roll rate control table.

4.3.5 Control Specification NAMELIST - CNTROL

The CNTROL NAMELIST is used for entering the control specifications via the NAMELIST. The variables in the CNTROL NAMELIST are defined below:

Name	Type	Default	Description
CALPHA	R4	0.0	Desired right ascension (degrees)
CDEL	R4	0.0	Tolerance for final attitude (degrees)
CDELT	R4	Orbital period	Roll rate command time interval; roll angle change will be checked every CDELT minutes (minutes)
CDELTA	R4	0.0	Desired declination (degrees)
CDELT1	R4	0.0	Command leg length, i.e., time interval, for the larger coil strength (minutes)
CDELT2	R4	0.0	Command leg length, i.e., time interval, for the smaller coil strength (minutes)
CDMLT	R4	0.0	Multiple of desired attitude cone angle, zeta, at which the reduced control current level and command leg length is to be used
CETAF	R4	0.0	Desired final pitch angle for pitch control specification (degrees)
CSTART	R8	—	Control specification start time (YYMMDDHHMMSS) YY = year MM = month DD = date HH = hour MM = minute SS = second
CSTOP	R8	—	Control specification stop time (YYMMDDHHMMSS)
CTHETO	R4	0.0	Desired cone angle to be maintained for attitude maintenance control specification (degrees)
CURNT1	R4	0.0	Control coil current magnitude and polarity for the larger leg length, or control coil current for roll rate control (milliamperes)
CURNT2	R4	0.0	Control coil current magnitude and polarity for the smaller leg length (milliamperes)
KCMODE	I2	—	Type of command 1 = continuous magnetic 2 = QOMAC/continuous magnetic

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ***********  76.001.13.39.25  *****
**                                                                                      **
**    DROLL                        ROLL RATE CONTROL TABLES                ZBDCWG5$  29  **
**                                                                                      **
**    DISPLAY CONTROL                                                 (NAMELIST         **
**      REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N                        PARAMETERS)      **
**      RECALL LINE NUMBER                   : 0                                       **
**                                                                                      **
**    CONTROL SPECIFICATIONS                                          (MMODE = 4)       **
**      CONTROL FLAG (F)                     :.                                        **
**         F = FLAGGED    . = UNFLAGGED                                                **
**      CONTROL TYPE (T)                     :0                 KCMODE                 **
**         T = 1   - CONTINUOUS                                                         **
**         T = 2   - QOMAC                                                              **
**         T = 3   - OPTIMAL                                                            **
**    . CONTROL START TIME (YYMMDDHHMMSS)    :            0.    CSTART                 **
**      CONTROL STOP TIME  (YYMMDDHHMMSS)    :            0.    CSTOP                  **
**      MAXIMUM ROLL RATE (DEG/ORBIT)        : 0.0              ROLRAT                 **
**    . COIL CURRENT (MA)                    : 0.0              CURNT1                 **
**    . COMMAND TIME INTERVAL (MIN)          :    0.            CDELT                  **
**                                                                                      **
**                                                                                      **
*                    START TM      STOP TM      ROLL       COIL                        **
**       F      T    DD.HH.MM     DD.HH.MM      RATE      CURRENT      INTERVAL        **
**      :.      1    05.00.00     06.00.00     0.100        20.0          96.          **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**                                                                                      **
**  :                                                                                   **
**          CPOINT=YROLL  WHAT NOW  :            CALL DISPLAY:       DISP   1 OF   1   **
**                                                                                      **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure 4-5. Roll Rate Control Table Display.

Name	Type	Default	Description
KCMODE (cont'd)	I2	—	3 = asymmetric (time-tagged) magnetic 4 = pneumatic
MMODE	I2	—	Type of maneuver control 1 = point-to-point control 2 = pitch control 3 = attitude maintenance 4 = roll rate control
ROLRAT	R4	0.0	Maximum roll rate for roll rate control specification (degrees/orbit)

4.4 COMMAND LIST DISPLAY

DCLIST is the table entry display used to enter commands manually. A maximum of 200 commands can be entered in the command list. The procedures for entering or retrieving commands from the command list are discussed in section 4.1. Commands can not occur at the same time. If two commands are to be executed at the same time they should be separated by one second in the command list. To terminate a magnetic command a zero current continuous magnetic command is entered at the required stop time. A continuous or optimal magnetic command must be entered to terminate a QOMAC command. If the operator fails to enter a continuous or asymmetric magnetic command to terminate the QOMAC command, the following message will be sent to the operator when the program enters the prediction and control subsystem:

> A QOMAC COMMAND WAS ENTERED WITH NO MAGNETIC COMMAND TO TERMINATE IT. DO NOT CONTINUE. DO A BACKWARD MOVE TO KEY 2. ENTER A MAGNETIC COMMAND TO TERMINATE THE QOMAC COMMAND.

To obtain the QOMAC command table the operator enters the desired QOMAC command number in the Expand Line Number position on the command list and skips. The QOMAC command table switch on the Control Option Menu display must also have been set to yes.

Figure 4-6 illustrates the command list display.

4.4.1 Command List NAMELIST - KOMAND

The KOMAND NAMELIST is used for entering commands via the NAMELIST. The variables in the KOMAND NAMELIST are defined below:

Name	Type	Default	Description
CURRNT	R4	—	Magnetic control coil strength (milliamperes)

Name	Type	Default	Description
DEGDEL	R4	9999.	Change in pitch or roll for a pitch or roll command, respectively (degrees)
INCGAS	I4	9999.	Number of gas increments for a spin, pitch or roll maneuver
KSTART	R8	—	Command start time (YYMMDDHHMMSS) YY = year MM = month DD = date HH = hour MM = minute SS = second
KTYPE	I2	—	Magnetic and gas command type 1 = continuous 2 = QOMAC/continuous 3 = asymmetric (time-tagged) 4 = positive spin -4 = negative spin 5 = positive pitch -5 = negative pitch 6 = positive roll -6 = negative roll
NAMSTA	I4	—	Name of station sending command
PERIOD	R4	—	QOMAC command period (minutes) maximum value: 33 min. granularity: 0.016 min.
PHASE	R4	—	QOMAC command phase (minutes) maximum value: 33 min. granularity: 0.26 min.
RPMDEL	R4	9999.	Change in spin rate for a spin gas command (rpm)

When entering a gas command specify either change in pitch, roll, or rpm and/or number of gas increments. If only pitch, roll, or rpm change is specified the number of gas increments are computed based on an angular momentum state at a wheel spinrate of 6 rpm.

Figure 4-6 illustrates the command list display.

4.5 QOMAC COMMAND FORMAT DISPLAY

DQOMAC is the display used to expand and display a QOMAC command. To obtain the QOMAC Command Table Display the QOMAC command table switch on the Control Option Menu (Figure 4-1) must be set to yes and the desired QOMAC command number must be entered in the command list display (Figure 4-6). To

```
**********************************  G E S S   V 2.1  ***********************************
**********************************   D I S P L A Y   ***********  76.001.13.43.20  *****
**                                                                                      **
**    DCLIST                              COMMAND LIST                 ZBDCWGS$  45    **
**                                                                                      **
**    DISPLAY CONTROL                                                                   **
**      REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) .N                                         **
**      RECALL LINE NUMBER                  :   0                                       **
**      EXPAND LINE NUMBER (QOMAC CMDS ONLY) :   0                                      **
**                                                        (NAMELIST                     **
**    COMMAND SPECIFICATIONS                               PARAMETERS)                  **
**      COMMAND FLAG                        :.                                          **
**        F=FLAGGED  .=UNFLAGGED                                                        **
**      COMMAND TYPE                        :.              KTYPE                       **
**        C =CONTINUOUS Q =QOMAC  T =OPTIMAL                                            **
**        PP=PITCH +    RP=ROLL+  SP=SPIN +                                             **
**        PM=PITCH -    RM=ROLL-  SM=SPIN -                                             **
**      COMMAND START TIME (YYMMDDHHMMSS)   :           0.  KSTART                    **
**      QOMAC PHASE (MINUTES)               :.  0.0         PHASE                     **
**      QOMAC PERIOD (MINUTES)              :   0.0         PERIOD                    **
**      MAGNETIC COIL CURRENT (MILLIAMPS)   :   0.0         CURRNT                    **
**      CHANGE IN PITCH OR ROLL ANGLE (DEG) :   0.0         DEGDEL                    **
**      CHANGE IN SPIN RATE (RPM)           .   0.0         RPMDEL                    **
**      STATION NAME                        :                                         **
**                                                                                    **
**                                                                                    **
**    FLAG LINE TYPE COMMAND STRT TIME PHASE  CURR  PER. ATT-CHG SPN-CHG STAT.        **
**         NMBR      YY.MM.DD.HH.MM.SS (MIN)  (MA) (MIN)  (DEG)   (RPM)   NAME      **
**  :.       1 Q    76.03.01.00.00.00  24.4 -75.0  24.1    0.0     0.0               **
**  :.       2 C    76.03.01.08.00.00   0.0   0.0   0.0    0.0     0.0               **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=YCLIST WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1    **
**                                                                                    **
********************************** G E S S   V 2.1 ************************************
**********************************  D I S P L A Y  ************************************
```

Figure 4-6. Command List Display.

expand the next QOMAC command, set display next command to yes and skip from the table.

The purpose of the QOMAC Command Format display is to provide a convenient format for the operator in completing a QOMAC command form for the control center. The first seven entries on the display provide the required time, phase, and current polarity every two minutes to send the QOMAC command correctly.

Figure 4-7 illustrates the QOMAC Command Format Display.

4.6 COIL TABLE DISPLAY

DCOILS is the display used to display the coil history table. The coil table provides the operator a summary of coil events and the capability of entering or flagging coil events. The coil table can hold a maximum of 900 events. Table entry procedures are discussed in section 4.1. Figure 4-8 illustrates the coil table.

4.7 GAS TABLE DISPLAY

DGAS is the display used to view the gas history table. The gas table provides the operator with a summary of gas events and the capability of entering or flagging gas events. The gas table will hold a maximum of 50 entries. The following are valid gas event types:

PP - pitch positive	RM - roll negative
PM - pitch negative	SP - spin positive
RP - roll positive	SM - spin negative

To enter a gas event the type, time, and number of gas increments must be entered. Table entry procedures are discussed in section 4.1. Figure 4-9 illustrates the gas table.

4.8 HISTORY NAMELIST - HISTRY

The HISTRY NAMELIST is used for entering gas and coil events into their respective tables. The variables for the HISTRY NAMELIST are defined below:

Name	Type	Default	Description
CURRNT	R4	9999.	Control coil current polarity and magnitude (milliamperes)
ITYPE	I2	—	Type of gas command PP = pitch positive PM = pitch negative

```
GESS V 2.1
DISPLAY                                                    76.001.13.48.12

DGOMAC                          QOMAC COMMAND FORMAT                  Z8DCWG5$  56

NOTE- FIRST 7 ENTRIES ARE PRIMARY
      REMAINDER ARE FOR BACKUP FORM

DISPLAY NEXT COMMAND (Y,N)              :N
THIS IS COMMAND NUMBER                  :     1

STATION                                 :
AOS (YYMMDDHHMM.)                       :           0.

PERIOD (MIN)                              24.0800
CURRENT MAGNITUDE (MA)                    75.0000

                  TIME                  PHASE            POLARITY
            YY.MM DD.HH MM.SS           (MIN)
            76.03.01.00.00.00            24.4              -1.
            76.03 01.00.02.00            22.4              -1.
            76.03.01.00.04.00            20.4              -1.
            76.03.01.00.06.00            18.4              -1.
            76.03.01.00 08.00            16.4              -1.
            76.03 01.00.10.00            14.4              -1.
            76.03.01.00.12.00            12.4              -1.
            76.03.01.00.24.26            24.1               1.
            76.03.01.00.48.31            24.1              -1.
            76.03.01.01.12.35            24.1               1.
            76.03.01.01.36.40            24.1              -1.
            76.03.01.02.00.45            24.1               1.
            76.03.01.02.24.50            24.1              -1.
            76.03.01.02.48.55            24.1               1.
            76.03.01.03.12.59            24.1              -1.
            76.03.01.03.37.04            24.1               1.
            76.03.01.04.01.09            24.1              -1.
            76.03.01.04.25.14            24.1               1.
            76.03.01.04.49.19            24.1              -1.
            76.03 01.05.13.23            24.1               1.
            76.03.01.05.37.28            24.1              -1.

   CPOINT=YQOMAC WHAT NOW  :          CALL DISPLAY:      DISP   1 OF   1

GESS V 2.1
DISPLAY
```

Figure 4-7. QOMAC Command Format Display.

```
**********************************  G E S S   V 2.1  ***********************************
*********************************  D I S P L A Y  ********** 76.001.13.45.10 *****

   DCOILS                                COIL TABLE                        ZBDCWG5S  47
   DISPLAY CONTROL
     REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N
     RECALL LINE NUMBER                   :   0
                                                                 (NAMELIST
   TABLE ENTRY-                                                   PARAMETERS)
      FLAG (.,F)                          .
      TIME (YYMMDDHHMMSS.)                :999999999999.   TIME
      CURRENT (MA)                        :  0.            CURRNT

          FLAG          LINE                    TIME              CURRENT
                       NUMBER          YY.MM.DD.HH.MM.SS            (MA)
          :.              1          76.03.01.00.00.00             -75.
          :.              2          76.03.01.00.24.26              75.
          :.              3          76.03.01.00.48.30             -75.
          :.              4          76.03.01.01.12.34              75.
          :.              5          76.03.01.01.36.38             -75.
          :.              6          76.03.01.02.00.42              75.
          :.              7          76.03.01.02.24.46             -75.
          :.              8          76.03.01.02.48.50              75.
          :.              9          76.03.01.03.12.54             -75.
          :.             10          76.03.01.03.36.58              75.
          :.             11          76.03.01.04.01.02             -75.
          :.             12          76.03.01.04.25 06              75.
          :.             13          76.03.01.04.49.10             -75.
          :.             14          76.03.01.05.13.14              75.
          :.             15          76.03.01.05.37.18             -75.
          :.             16          76.03.01.06.01.22              75.
          :.             17          76.03.01.06.25 26             -75.
          :.             18          76.03.01.06.49.30              75.
          :.             19          76.03.01.07.13.34             -75.
          :.             20          76.03.01.07.37.38              75.
          :.             21          76.03.0  08.00.00               0.

   :
        CPOINT=YCOILS WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1

********************************  G E S S   V 2.1  ***********************************
*********************************  D I S P L A Y  ***********************************
```

Figure 4-8. Coil Table Display.

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ********** 76.146.17.00.25 ********

    DGAS                                GAS TABLE                          ZBDCWG7S   4

    DISPLAY CONTROL
      REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N
      RECALL LINE NUMBER                   :   0
                                                                (NAMELIST
    TABLE ENTRY                                                  PARAMETERS)
      FLAG (.,F)                           :.
      TIME (YYMMDDHHMMSS.)                 :999999999999.    TIME
      TYPE                                 :--               ITYPE
        PP=PITCH POS   PM=PITCH NEG
        RP=ROLL POS    RM=ROLL NEG
        SP=SPIN POS    SM=SPIN NEG
      NUMBER OF PULSES                     :   0

        FLAG          LINE                    TIME          TYPE        NO. OF
                     NUMBER          YY.MM.DD.HH.MM.SS                   PULSES
        .              1          76.03.01.12.00.00        PP            10
        .              2          76.03.01.12.10.00        SM            20

    :
        CPOINT=INDRI1 WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure 4-9. Gas Table Display.

Name	Type	Default	Description
ITYPE (cont'd)	I2	—	RP = roll positive RM = roll negative SP = spin positive SM = spin negative
NUMINC	I4	—	Number of gas increments
TIME	R8	—	Time of the coil or gas history event (YYMMDDHHMMSS) YY = year MM = month DD = date HH = hour MM = minute SS = second

4.9 OTHER CONTROL OPTIONS

Five other options exist on the Control Option Menu. Each of these options is discussed in the following subsections in the order of appearance on the Control Option Menu.

4.9.1 Estimate Coil Strength

This provides the capability of allowing the system to estimate the required coil strength to complete a magnetic maneuver. A coil strength greater than zero must be entered in the control specification when using this option. COLTIM is the OSOIN NAMELIST variable used with the estimate coil strength option and is explained in Section 3.5.4. Coil strength estimation may not be used for a roll rate control.

4.9.2 Monitor Roll Rate

This provides the capability of monitoring roll rate during any control or prediction except when the roll rate itself is being controlled. Roll rate monitoring works the same way as roll rate control except a message is sent to the operator when the maximum allowed roll angle change is exceeded. The message reads:

ROLL RATE LIMIT EXCEEDED DURING ROLL RATE MONITORING.
SKIP TO CONTINUE

Roll rate can be monitored from station to station or over a constant specified time interval.

The NAMELIST parameters for roll rate monitoring are in the OSOIN NAMELIST (Section 3.5.1) and are shown on the satellite dependent display (Figure 3-3).

4.9.3 Read Command List

This allows the operator to read the command list data set, described in section 5.4.1.

4.9.4 Automatic Pitch Violation Correction

This provides the capability of correcting the pitch angle automatically using gas commands when a pitch violation has occurred. Any pitch gas command generated this way will appear flagged in the command list and gas table. The NAMELIST parameters for the automatic pitch violation are in the OSOIN NAMELIST and are shown on the satellite dependent display (Figure 3-3).

4.9.5 Automatic Mode Option

This provides the capability of running a prediction without interruptions, such as END OF LEG messages, until the predictor endtime is reached. Automatic mode option is interrupted when a pitch violation occurs or the attitude summary buffer is full. When the above occurs, the operator responds to the messages accordingly and continues. If the program is interrupted due to the above cases or for some other reason the operator may not be able to view certain displays. The reason for this is automatic mode option turns the display status of some displays to skip. To check the displays' status the operator should check the Display Status Flags (XSTOPS) display (Key 30) and reset the flags to the desired status. Section 2.3 discusses display status flags.

SECTION 5

SYSTEM OUTPUT DESCRIPTION

5.1 OUTPUT OPTION MENU - DOUPT - KEY 3

The Output Option Menu is the first display reached upon entering the output section of the MSAP/OSO-8 system; through it the operator selects the summary tables he wishes to view, chooses plot options, and determines if printer plots, command list, or an attitude summary tape are to be written. The attitude summary buffer is a table of size 250 containing the output information from the predictor section of this system. When the operator finishes a pass through the system, this buffer is dumped to print the results and clear the summary table. If the summary table is filled before the completion of a pass through the system, it must be dumped before the prediction can be resumed. To dump the buffer, the operator skips from the final display or plot request from the output option menu without making a backward move, and after the output is complete he will be automatically returned to the output option menu DOUTPT. Figure 5-1 illustrates the Output Option Menu.

5.2 DISPLAYS

5.2.1 Attitude Summary Displays

The attitude summary is a history of the spacecraft attitude over the time span made by the prediction section. The attitude summary is displayed in two tables. The first attitude summary shown in Figure 5-2 displays time in the form MMDDHHMMSS and its associated right ascension (RT.ASC), declination (DECLIN), spin rate (SPINRT), pitch angle (PITCH), roll angle (ROLL), roll rate, zeta, whether spacecraft was in day or night (D/N), the reason output was made at that time, and the station name. The second attitude summary display shown in Figure 5-3 is similar to the first except roll rate and zeta are replaced with the spinrate to three decimal places and the sun north pole roll angle (SNPR). Appendix D explains and illustrates the attitude angles displayed. Roll rate is the instantaneous value of roll angle change displayed in degrees/day. Roll rate is computed by taking the difference of the previous and current roll angle and dividing it by the difference in time. The initial value of roll rate in the prediction is zero. Zeta is defined as the arc angular separation between the current and desired attitude. It defaults to 90 degrees. When a control is implemented a desired attitude is computed. Zeta is computed using this desired attitude until another control is implemented and a new desired attitude is computed. When the system is reinitialized the desired attitude remains as it was at the end of

```
                    G E S S   V 2.1
                    D I S P L A Y   ********** 76.001.13.51.11
DOUTPT                          OUTPUT OPTION MENU                  ZBDCWG5$  63

FUNCTION KEYS(** IS CURRENT DISPLAY)-

  KEY 0 ARRAY ALLOCATION(ARTCOM)
  KEY 1 INPUT OPTION MENU(DINPUT)
  KEY 2 CONTROL OPTION MENU(DOPTN)
**KEY 3 OUTPUT OPTION MENU(DOUTPT)
  KEY 4 TERMINATION                                (NAMELIST
                                                    PARAMETERS)

DISPLAYS-
  ATTITUDE SUMMARY                      :Y         $SUMRY
  ATTITUDE SUMMARY #2                   :Y         $SUMR2
  COMMAND LIST (DCLIST)                 :Y         $OCLST
  QOMAC COMMAND TABLE (DQOMAC)          :Y         $OQOMC
  COIL TABLE (DCOILS)                   :Y         $OCOIL
  GAS TABLE (DGAS)                      :Y         $OGAS

PLOT OPTIONS-
  X AXIS                                : 2        IXAXIS
  FIRST Y AXIS                          : 3        IYAXIS
  SECOND Y AXIS                         :11        IYAX2

  WHERE
   1 = TIME
   2 = RIGHT ASCENSION
   3 = DECLINATION
   4 = PITCH
   5 = ROLL
   6 = SPIN RATE
   7 = FINAL PITCH
   8 = POLL RATE
   9 = F(T)
  10 = Q(T)

:
     CPOINT=OUTDR1 WHAT NOW  :NEXT       CALL DISPLAY:       DISP   1 OF   1
                    G E S S   V 2.1
                    D I S P L A Y
```

Figure 5-1. Output Option Menu Display.

```
**********************************  G E S S   V 2.1  **********************************
**********************************    D I S P L A Y  ********** 76.001.13.52.46 *****
**                                                                                    **
**    DOUTPT                          OUTPUT OPTION MENU                ZBDCWG5$  65  **
**      11 = POINT TOLERANCE                                (NAMELIST                 **
**      12 = MAINT TOLERANCE                                 PARAMETERS)              **
**                                                                                    **
**    WRITE COMMAND LIST                        :N          SWRITE                    **
**                                                                                    **
**    WRITE ATTITUDE SUMMARY                    .N          WRTSUM                    **
**    PRINTER PLOTS WITH SUMMARY                :N          IPLOT                     **
**                                                                                    **
**                                                                                    **
**    WRITE ATTITUDE TAPE                       :N          MATAPE                    **
**      INTERPOLATION STEPSIZE (SEC)            :    0      MDTERP                    **
**        0 = DO NOT INTERPOLATE                                                      **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
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**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  ; ,                                                                               **
**         CPOINT=OUTDR1 WHAT NOW  :          CALL DISPLAY:       DISP   1 OF   1     **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************    D I S P L A Y  **********************************
```

Figure 5-1. Output Option Menu Display. (continued)

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ********** 75.356.17.15.25  ****
**                                                                                    **
**    DATSUM .                    ATTITUDE SUMMARY TABLE  #1                ZBDCWG8$  33  **
**                                                                                    **
**    TYPE OF CHANGE CAUSING OUTPUT                                                   **
**      0 = REGULAR                                                                   **
**      1 = Z-COIL SETTING                                                            **
**      2 = SPIN COMMAND                                                              **
**      3 = PITCH COMMAND                                                             **
**      4 = ROLL COMMAND                                                              **
**      5 = STATION AOS                                                               **
**      6 = PREDICTOR END TIME                                                        **
**      7 = ASCENDING NODE                                                            **
**    * ROLL RATE IN DEG/DAY                                                          **
**                                                                                    **
**          TIME     RT.ASC DECLIN SPINRT  PITCH   ROLL    *ROLL    ZETA D T STAT    **
**   MM.DD.HH.MM.SS  (DEG)  (DEG)  (RPM)  (DEG)   (DEG)    RATE   (DEG) N Y NAME    **
**   03.01.00.00.00 210.00  70.00   6.00 -20.58 353.51    0.0   90.00 N 0           **
**   03.01.00.05.02 210.08  69.96   6.00 -20.59 353.57  15.44   11.43 N 0           **
**   03.01.00.10.04 210.16  69.95   6.00 -20.57 353.60   8.04   11.42 N 0           **
**   03.01.00.15.06 210.20  69.96   6.00 -20.55 353.59  -1.63   11.40 N 0           **
**   03.01.00.20.08 210.15  69.99   6.00 -20.55 353.55 -10.38   11.39 N 0           **
**   03.01.00.25.10 210.08  70.00   6.00 -20.56 353.53  -8.11   11.40 N 0           **
**   03.01.00 30.12 210.23  69.99   6.00 -20.53 353.56  10.96   11.37 D 0           **
**   03 01.00.35.14 210.41  70.01   6.00 -20.47 353.60   8.80   11.32 D 0           **
**   03.01.00.40.16 210.60  70.05   6.00 -20.39 353.59  -0.80   11.24 D 0           **
**   03.01.00.45.18 210.70  70.13   6.00 -20.31 353.55 -11.51   11.16 D 0           **
**   03.01.00.50.20 210.73  70.15   6.00 -20.29 353.54  -4.44   11.14 D 0           **
**   03.01.00.55.22 210.82  70.10   6.00 -20.30 353.61  19.70   11.15 D 0           **
**   03.01.01.00.24 210.93  70.07   6.00 -20.28 353.64  10.66   11.14 D 0           **
**   03.01.01.01.24 210.95  70.07   6.00 -20.28 353.65   5.51   11.13 D 7           **
**   03.01.01 06.26 210.99  70.09   6.00 -20.26 353.64  -0.91   11.11 D 0           **
**   03.01.01.11.28 210.93  70.11   6.00 -20.26 353.61  -8.54   11.11 D 0           **
**   03.01.01.16.30 211.02  70.11   6.00 -20.24 353.64   6.49   11.09 D 0           **
**   03.01.01.21.32 211.20  70.11   6.00 -20.18 353.66   7.68   11.04 D 0           **
**   03.01.01.26.34 211.39  70.16   6.00 -20.11 353.67   1.59   10.97 D 0           **
**   03.01.01.31.36 211.51  70.22   6.00 -20.03 353.64  -8.99   10.89 N 0           **
**   03.01.01.36.38 211.52  70.29   6.00 -19.99 353.57 -18.32   10.84 N 0           **
**   03.01.01.41.40 211.60  70.24   6.00 -20.00 353.63  17.16   10.85 N 0           **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=DATSUM WHAT NOW  :WEXT       CALL DISPLAY:       DISP   1 OF   1   **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure 5-2. Attitude Summary Table #1.

```
**********************************  G E S S   V 2.1  **********************************
**********************************  D I S P L A Y  ********** 75.356.17.15.37  ****
**                                                                                    **
**    DATSM2                    ATTITUDE SUMMARY TABLE  #2              Z8DCWG8$  38  **
**                                                                                    **
**    TYPE OF CHANGE CAUSING OUTPUT                                                   **
**      0 = REGULAR                                                                   **
**      1 = Z-COIL SETTING                                                            **
**      2 = SPIN COMMAND                                                              **
**      3 = PITCH COMMAND                                                             **
**      4 = ROLL COMMAND                                                              **
**      5 = STATION AOS                                                               **
**      6 = PREDICTOR END TIME                                                        **
**      7 = ASCENDING NODE                                                            **
**                                                                                    **
**            TIME       RT.ASC    DECLIN    SPINRT     PITCH     ROLL       SNPR     **
**     MM.DD.HH.MM.SS     (DEG)     (DEG)     (RPM)     (DEG)     (DEG)     (DEG)     **
**     03.01.00.00.00    210.00    70.00      6.000    -20.58    353.51    354.14     **
**     03.01.00.05.02    210.08    69.96      6.000    -20.59    353.57    354.19     **
**     03.01.00.10.04    210.16    69.95      6.000    -20.57    353.60    354.22     **
**     03.01.00.15.06    210.20    69.96      6.000    -20.55    353.59    354.21     **
**     03.01.00.20.08    210.15    69.99      6.000    -20.55    353.55    354.17     **
**     03.01.00.25.10    210.08    70.00      6.000    -20.56    353.53    354.15     **
**     03.01.00.30.12    210.23    69.99      6.000    -20.53    353.56    354.18     **
**     03.01.00.35.14    210.41    70.01      6.000    -20.47    353.60    354.22     **
**     03.01.00.40.16    210.60    70.05      6.000    -20.39    353.59    354.21     **
**     03.01.00.45.18    210.70    70.13      6.000    -20.31    353.55    354.17     **
**     03.01.00.50.20    210.73    70.15      6.000    -20.29    353.54    354.15     **
**     03.01.00.55.22    210.82    70.10      6.000    -20.30    353.61    354.22     **
**     03.01.01.00.24    210.93    70.07      6.000    -20.28    353.64    354.26     **
**     03.01.01.01.24    210.95    70.07      6.000    -20.28    353.65    354.26     **
**     03.01.01.06.26    210.99    70.09      6.000    -20.26    353.64    354.26     **
**     03.01.01.11.28    210.93    70.11      6.000    -20.26    353.61    354.23     **
**     03 01.01.16.30    211.02    70.11      6.000    -20.24    353.64    354.25     **
**     03.01.01.21.32    211.20    70.11      6.000    -20.18    353.66    354.28     **
**     03.01.01.26.34    211.39    70.16      6.000    -20.11    353.67    354.28     **
**     03.01.01.31.36    211.51    70.22      6.000    -20.03    353.64    354.25     **
**     03.01.01.36.38    211.52    70.29      6.000    -19.99    353.57    354.19     **
**     03.01.01.41.40    211.60    70.24      6.000    -20.00    353.63    354.25     **
**     03.01.01.46.42    211.70    70.23      6.000    -19.98    353.67    354.28     **
**                                                                                    **
**                                                                                    **
**          CPOINT=DATSM2 WHAT NOW  :WEXT        CALL DISPLAY:        DISP   1 OF   1  **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************  D I S P L A Y  **********************************
```

Figure 5-3. Attitude Summary Table # 2.

the previous run. The reason entries were made to the attitude summary table are indicated as follows:

Code	Definition
0	REGULAR - at a fixed time interval determined by the number of output points per orbit requested at the Satellite Independent NAMELIST Display
1	COIL EVENT - at coil on/off times or sign changes
2	SPIN COMMAND - before and after execution of a spin gas command
3	PITCH COMMAND - before and after execution of pitch gas command
4	ROLL COMMAND - before and after execution of a roll gas command
5	STATION AOS - at station acquisition of signal time
6	PREDICTOR END TIME
7	ASCENDING NODE

5.2.2 Command, QOMAC Command, Coil, and Gas Table Display

The command, QOMAC command, coil, and gas table displays are the same as the displays discussed in Sections 4.4-4.7. The displays are shown here for operator viewing only. Data should not be entered in these tables while under Key 3.

5.3 PLOT OPTIONS

GESS - generated plots are called from the Output Option Menu for various summary and command parameters. One or two dependent variables may be plotted against a single independent variable. The various options are defined below:

Plot Option	Description
1	Time (MMDDHH)
2	Right ascension (degrees)
3	Declination (degrees)
4	Pitch (degrees)
5	Roll (degrees)

Plot Option	Description
6	Spin rate (rpm)
7	Final pitch (degrees) (projects the final desired pitch angle from a point-to-point or attitude maintenance control specification backwards through the span of the attitude summary)
8	Instantaneous roll rate (degrees/day)
9	F(t) - sign of the magnetic switching function generated for the most recent leg of a magnetic control.
10	Q(t) - sign of coil changes for a QOMAC command generated for the most recent leg of a QOMAC control.
11	Point tolerance - the tolerance circle about the desired attitude for the most recent point-to-point, pitch, or attitude maintenance control.
12	Maint tolerance - the cone angle circle about the desired attitude for the most recent attitude maintenance control.

To print the plots on a Calcomp plotter a plot tape is required. Key 31 on the 2250 graphics device (Key 23 on the ADS 6600) will print the plot. To plot a graph the operator enters the required plot options in their respective fields as defined below:

X-AXIS - The x-axis is the independent parameter for the plot. Valid options are 1-8.

FIRST Y-AXIS - The first y-axis is the first dependent variable for a double plot or the sole dependent variable for a single plot. Options 2-10 are permitted, but 9 and 10 (F(t) and Q(t)) may be plotted only if x-axis is time.

SECOND Y-AXIS - The second y-axis is the second dependent variable for a double plot. Options 2-12 are permitted but F(t) and Q(t) (9 and 10) may be plotted only if the x-axis is time and if the first y-axis is Q(t) or F(t) respectively.

Sample plots are shown in Appendix G.

5.4 OTHER OPTIONS

5.4.1 Write Command List

This option writes the command list to a data set. It causes the command list table to be displayed even when the command list display switch is no. As soon as the display appears the command list has been written.

The command list data set is read and written with the format shown below:

```
|.   |Q   |760301000000.|  22.900|-20.000|  23.900|   0.0|   0.0|       0|ROS.|
COLUMN: 1  4  5  8  9          21 22    29 30    37 38    45 46    53 54    61 62    69 70  73
```

The following is an explanation of this line, column by column.

Columns	Format	Description
1-4	A4	Flag (· = unflagged, F = flagged)
5-8	A4	Type (C, Q, T, PP, PM, RP, RM, SP, SM. See Section 4.4.1)
9-21	F13.0	Start time (YYMMDDHHMMSS)
22-29	F8.3	QOMAC phase (minutes)
30-37	F8.3	Magnetic coil current (milliamperes)
38-45	F8.3	QOMAC period (minutes)
46-53	F8.3	Change in pitch or roll angle (degrees)
54-61	F8.3	Change in spin rate (rpm)
62-69	I8	Number of gas bursts
70-73	A4	Station name

Figure 5-4 is an example of the command list.

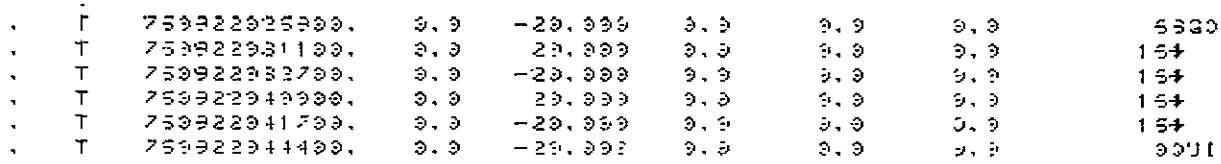


Figure 5-4. Command List Data Set Format

5.4.2 Write Attitude Summary

This option writes the attitude summary in the format shown in Figure 5-5. To write the attitude summary the operator must skip from the last display or plot. When the system returns to the Output Option Menu the writing of the attitude summary has been completed.

5.4.3 Printer Plots with Summary

This option writes out the printer plots as shown in Figures 5-6. The following printer plots are available:

- ALPHA VERSUS TIME
- DELTA VERSUS TIME
- OMEGA VERSUS TIME
- PITCH VERSUS TIME
- ROLL VERSUS TIME
- ZETA VERSUS TIME
- SUN NORTH POLE ROLL ANGLE VERSUS TIME

To write printer plots the operator must skip from the last display or plot. When the system returns to the Output Option Menu the writing of printer plots has been completed.

5.4.4 Write Attitude Tape

This option will write the attitude summary to a data set or tape. To write the attitude tape the operator must skip from the last display or plot. When the system returns to the Output Option Menu the attitude tape has been written.

```
I N F O R M A T I O N   F O R   O R B I T - C O D E - D / N   I N D I C A T O R

        FORMAT = OOOOT.D

                 OOCO = ORBIT NUMBER
                 D    = DAY OR NIGHT INDICATOR(0-NIGHT,1-DAY)
                 T    = TYPE OF CHANGE CAUSING OUTPUT

                        VALUES OF T ARE :
                        0 = REGULAR OUTPUT
                        1 = Z COIL SETTING
                        2 = SPIN COMMAND
                        2 = PITCH COMMAND
                        3 = ROLL COMMAND
                        4 = STATION AOS
```

Figure 5-5. Printer Attitude Summary.

ATTITUDE SUMMARY PREDICTOR START TIME = MAR 1 76

DATE	TIME	RIGHT ASCENSION (DEGREES)	DECLINATION (DEGREES)	SPIN RATE (RPM/S)	PITCH (DEG.)	ROLL (DEG.)	SNP ROLL (DEG.)	ORBIT CODE-D/N
MAR 1 76	8 0 0	70 0	10.0	5 9918	1 0	257 9	258.5	100 0
MAR 1 76	8. 0. 0	70.0	10 0	5.9918	1 0	257 9	258 5	167 0
MAR 1 76	8:57 52	70 4	10.1	5 9905	0.6	258 0	258.5	177.1
MAR 1 76	10:33 28	71 1	10.1	5 9887	:0 0	257 9	258.4	187 1
MAR 1 76	12: 9. 4	71.9	10 1	5 9869	-0.7	257 7	258 3	197 1
MAR 1 76	13.43 48	72 7	10.0	5.9853	-1.4	257.6	258 1	207 1
MAR 1 76	15:19 24	73 4	9 9	5 9838	-2 1	257.4	257.9	217 1
MAR 1 76	16. 0: 0	73 8	9 9	5.9832	-2 4	257 3	257 9	210 0
MAR 1 76	16 0 0	73 8	9.9	5 9832	-2 4	257.3	257.9	277.0
MAR 1 76	16.54.52	74 2	9 8	5.9825	-2 7	257.2	257.7	287 1
MAR 1 76	18 30:28	74 9	9.6	5 9815	-3.3	256 9	257.4	297.1
MAR 1 76	20 6. 4	75.5	9 4	5 9808	-3 9	256 7	257.2	307 1
MAR 1 76	21:40 48	76 1	9.2	5 9803	-4.3	256 4	256 9	317 1
MAR 1 76	23.16.24	76 6	9 0	5.9798	-4 8	256 2	256.7	327 1
MAR 2 76	0: 0: 0	76 9	9.0	5 9796	-5 0	256 1	256 6	320 0
MAR 2 76	0:51:52	76 9	9.0	5 9793	-5.0	256 1	253 6	337 1
MAR 2 76	2 27.28	77 0	9 0	5 9785	-5 0	256 1	256.5	347 1
MAR 2 76	4: 3 4	77.0	8.9	5.9775	-5 0	256 0	256 5	357 1
MAR 2 76	5.37 48	77 1	8 9	5.9763	-5 0	256 0	256.5	367.1
MAR 2 76	7 13:24	77 2	8.9	5 9750	-5 0	256 0	256 5	377 1
MAR 2 76	8.49 0	77 2	8 9	5.9737	-5.0	256 0	256.5	387 1
MAR 2 76	10.24.36	77 3	8 9	5 9725	-5 0	256.0	256.4	397 1
MAR 2 76	12: 0 12	77.4	8 9	5 9714	-5.0	256 0	256 4	407 1
MAR 2 76	13 34:56	77 4	8 9	5.9703	-5 0	256.0	256.4	417 1
MAR 2 76	15:10.32	77.5	8 9	5.9694	-4.9	256 0	256.4	427 1
MAR 2 76	16 46. 8	77 5	8 9	5.9687	-4 9	256 0	256 4	437 1
MAR 2 76	18.21.44	77.6	8.9	5.9683	-4 9	256 0	256 4	447 1
MAR 2 76	19 56:26	77.7	8.9	5.9681	-4 9	256 0	256.4	457 1
MAR 2 76	21:32 4	7:.7	3 9	5.9680	-5 0	256.0	256 3	467 1
MAR 2 76	23 7 40	77 8	8 9	5.9679	-5.0	255 9	256 3	477 1
MAR 3 76	0.43.16	77 9	8 9	5.9676	-5.0	255 9	256.3	487 1
MAR 3 76	2 18: 0	78 0	8 9	5.9672	-5 0	255.9	256.3	497 1
MAR 3 76	3 53 36	78 0	8.9	5 9665	-5.0	255 9	256 3	507 1
MAR 3 76	5.29.12	79 1	8 9	5.9655	-4 9	255.9	256 2	517 1
MAR 3 76	7: 4:48	78 1	8.9	5.9646	-4 9	255 9	256 2	527 1
MAR 3 76	8 40.24	78 2	8 9	5 9636	-4.9	255 9	256.2	537 1
MAR 3 76	10:15. 8	78.2	8 9	5 9628	-4 9	255 9	256 2	547 1
MAR 3 76	11:50 44	78 3	8.9	5 9620	-4 9	255 9	256 2	557.1
MAR 3 76	13.26.20	78 4	8 9	5.9613	-4 9	255 9	256.2	567 1
MAR 3 76	15: 1.56	78.4	8 9	5 9608	-4.9	255 9	256 1	577 1
MAR 3 76	16:36:40	78 5	8.9	5 9605	-4 9	255 9	256 1	587.1
MAR 3 76	18.12.16	78 5	8 9	5.9605	4 9	255 8	256.1	597 1
MAR 3 76	19 47 52	78 6	8.9	5 9600	-4 9	255 8	255 1	607.1
MAR 3 76	21 23.28	78 7	8 9	5 9605	-4.9	255 8	256 1	617 1
MAR 3 76	22.59: 4	78.7	8 9	5.9611	-4 9	255 8	256 1	627 1
MAR 4 76	0 36:48	78.8	8.9	5 9612	-4 9	255.8	256.1	637 1
MAR 4 76	2 9:24	78 8	8 9	5.9610	-4 9	255 8	256.0	647 1
MAR 4 76	3:45. 0	78.9	8 9	5.9605	-4.9	255.8	256 0	657 1
MAR 4 76	5:20:36	79.0	8.9	5 9599	-4 8	255 8	256 0	667.1
MAR 4 76	6 55.20	79.0	8 9	5 9592	-4 9	255 8	256 0	677 1
MAR 4 76	8 30 56	79 1	8 8	5 9586	-4.7	255 8	256 0	687.1
MAR 4 76	10. 6 32	79.1	8 8	5.9581	-4.8	255.8	256 0	697 1
MAR 4 76	11:42: 8	79.2	8.8	5 9576	-4 8	255 8	255.9	707.1
MAR 4 76	13:16.52	79 2	8 8	5.9573	-4 8	255.8	255.9	717.1
MAR 4 76	14 52.28	79 3	8 8	5.9571	-4 7	255.8	255.9	727.1
MAR 4 76	16.28. 4	79 3	8 8	5.9572	-4.7	255 8	255 9	737 1
MAR 4 76	18 3 40	79 4	8.8	5.9576	-4.7	255.8	255.9	747.1
MAR 4 76	19:39:16	79 4	8.9	5.9581	-4.7	255 8	255.9	757 1

Figure 5-5. Printer Attitude Summary.
(continued)

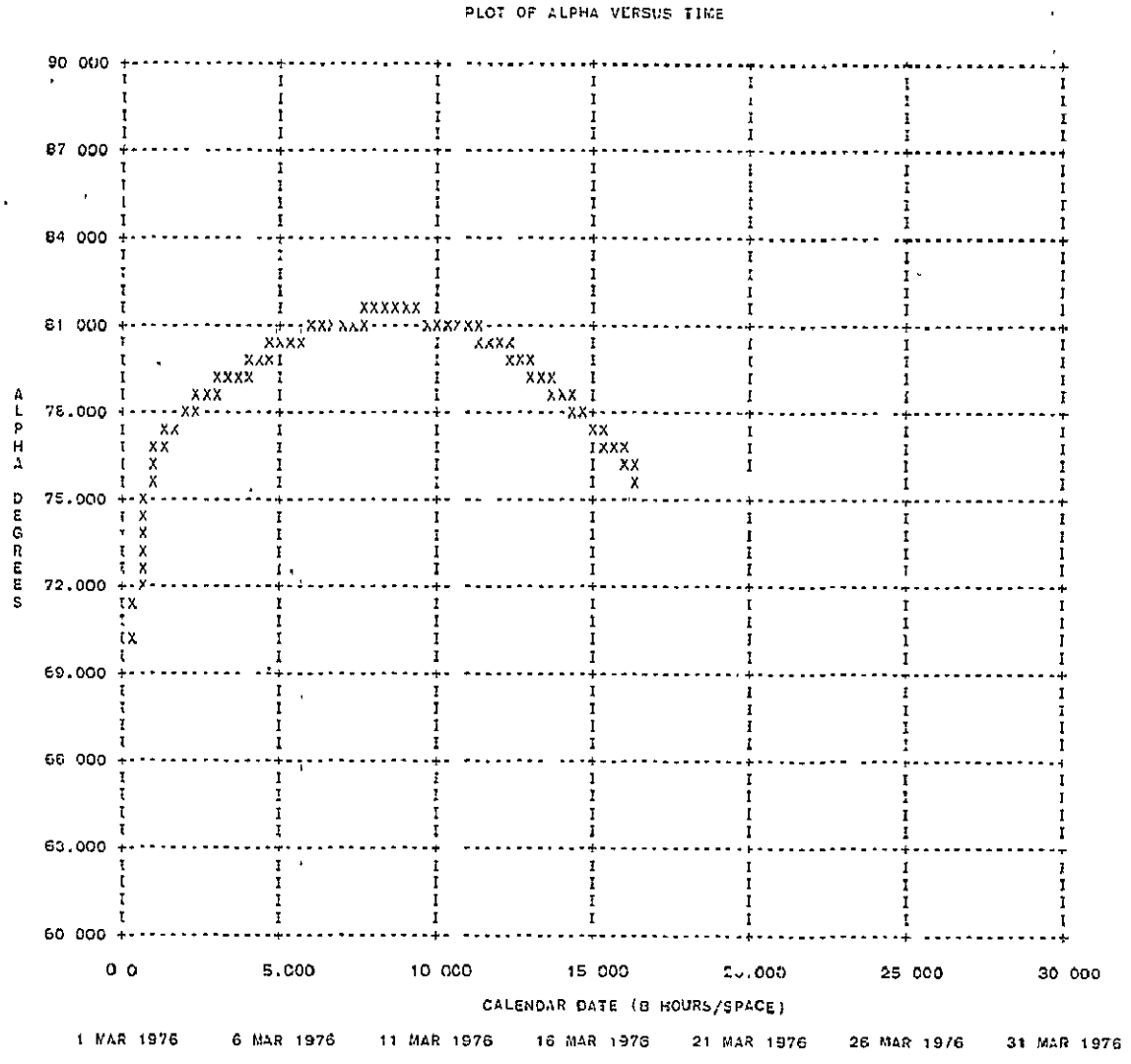


Figure 5-6. Printer Plots.

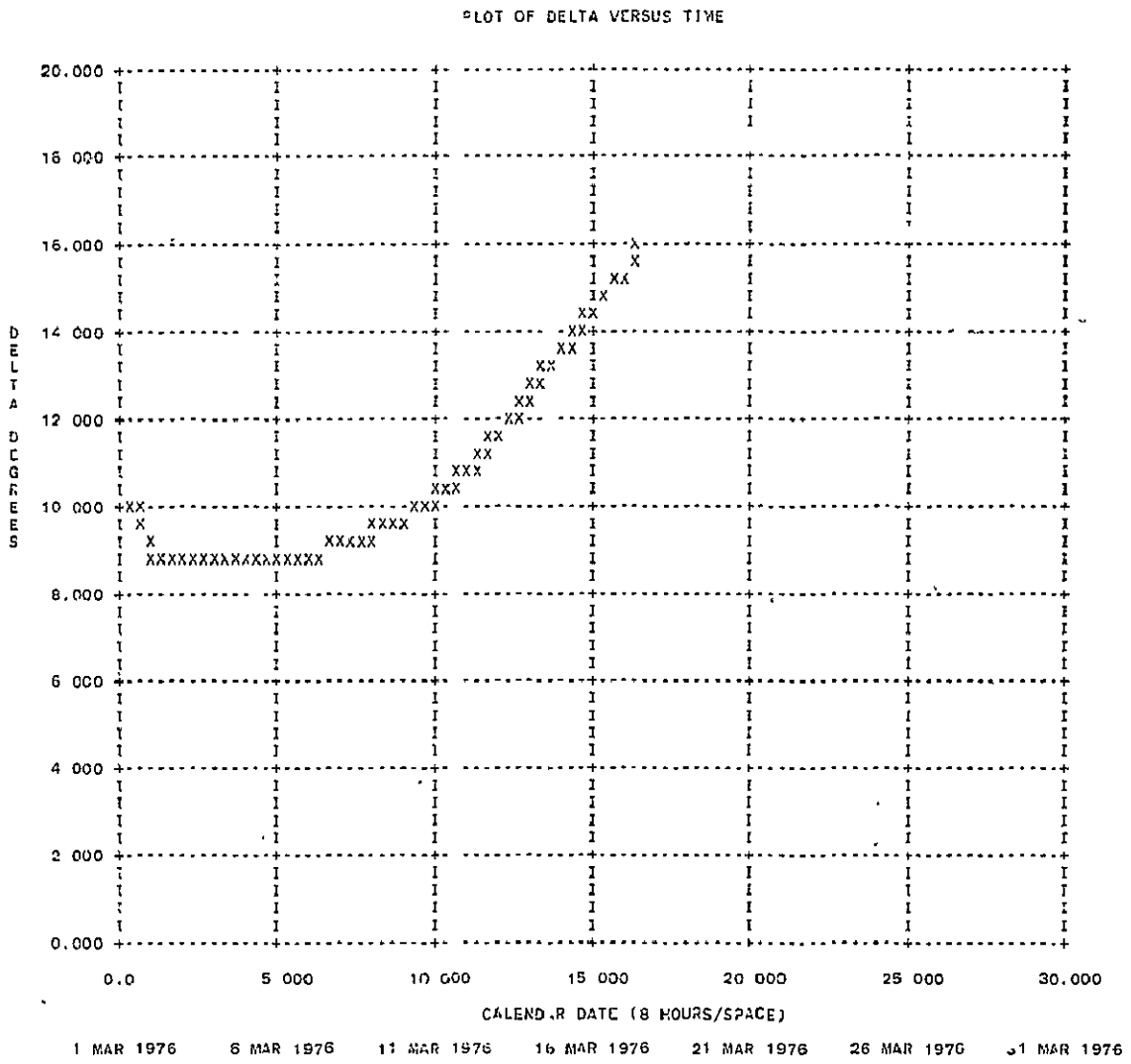


Figure 5-6. Printer Plots.
(continued)

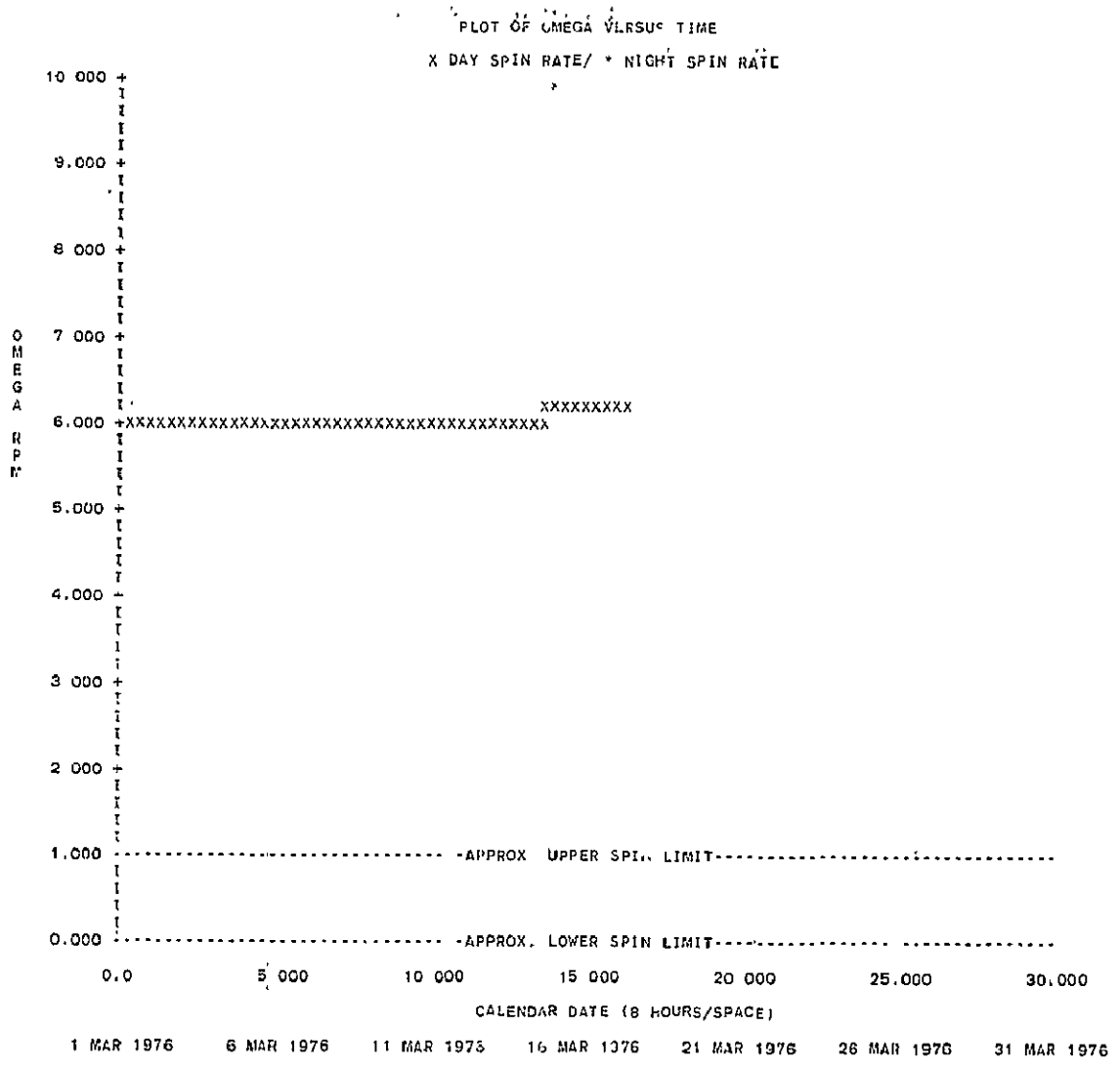


Figure 5-6. Printer Plots.
(continued)

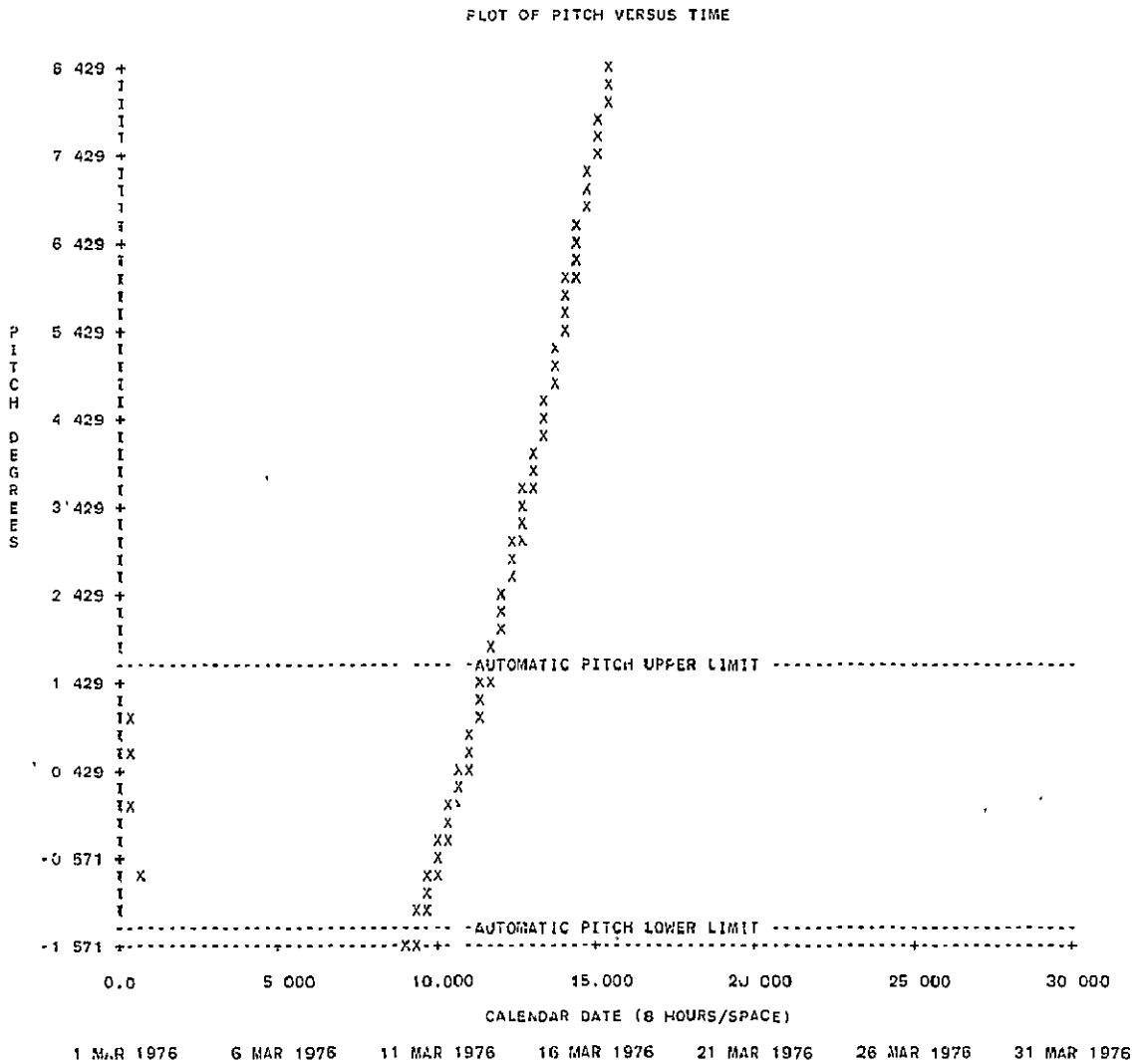


Figure 5-6. Printer Plots.
(continued)

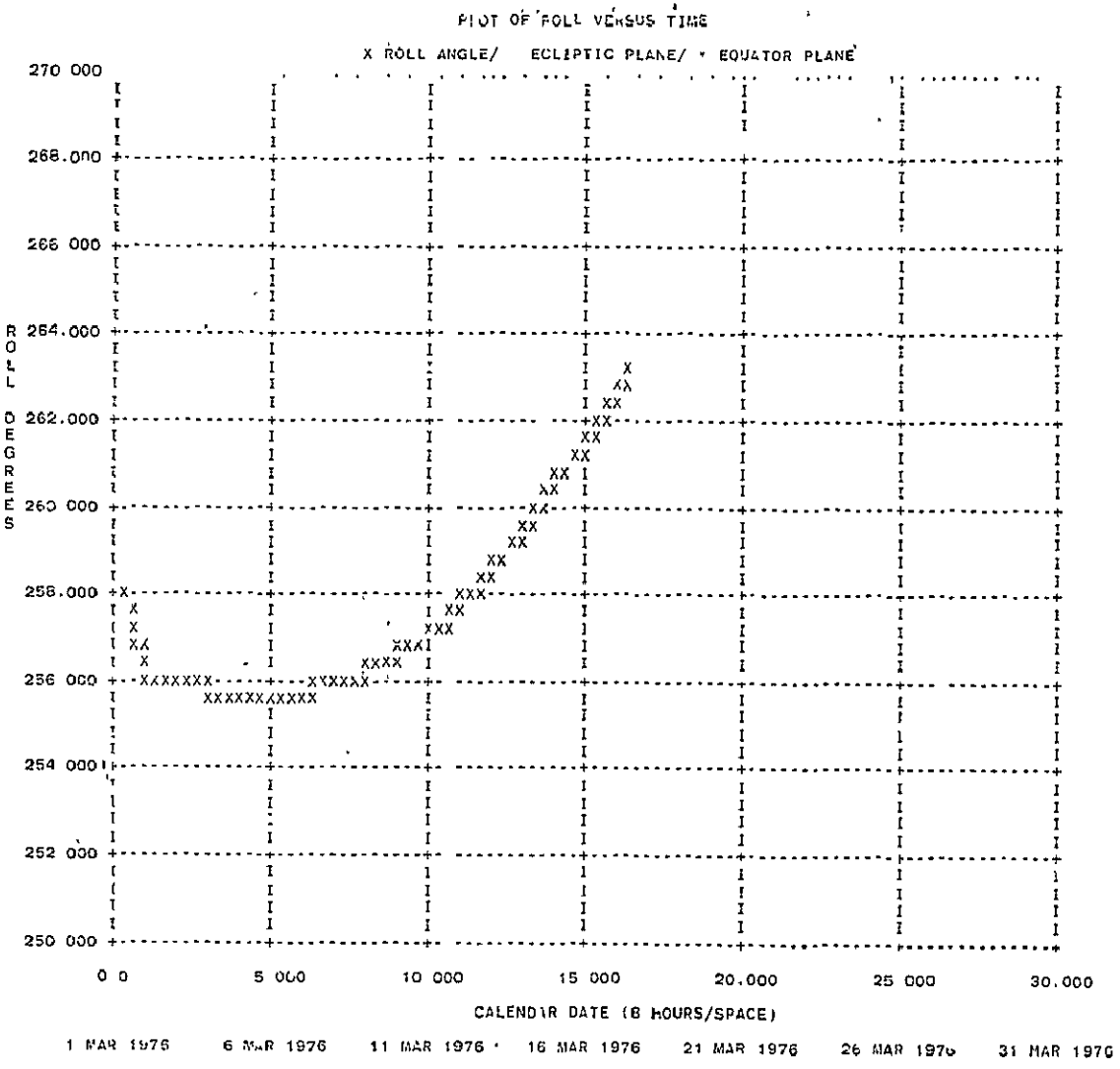


Figure 5-6. Printer Plots.
(continued)

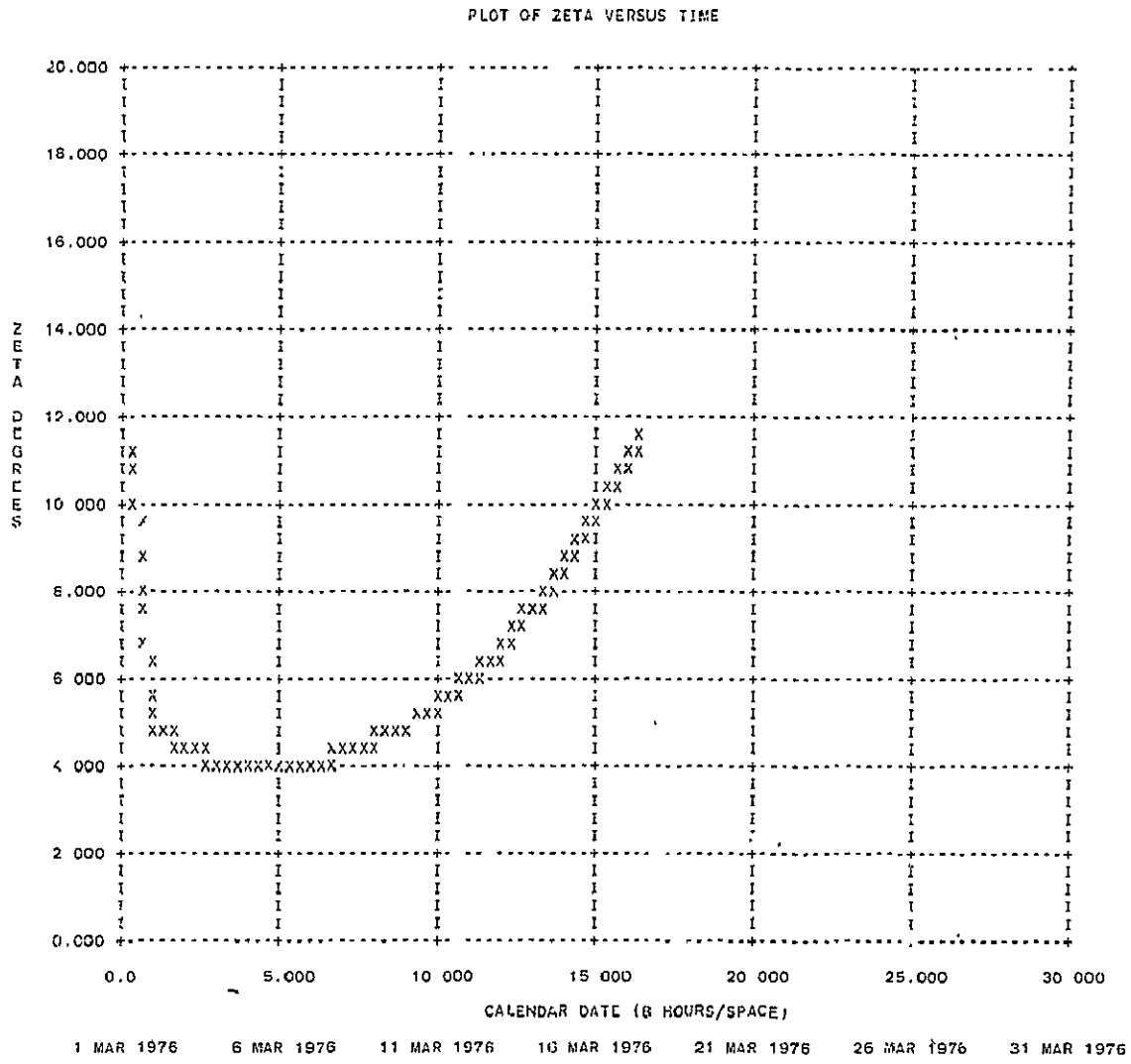


Figure 5-6. Printer Plots.
(continued)

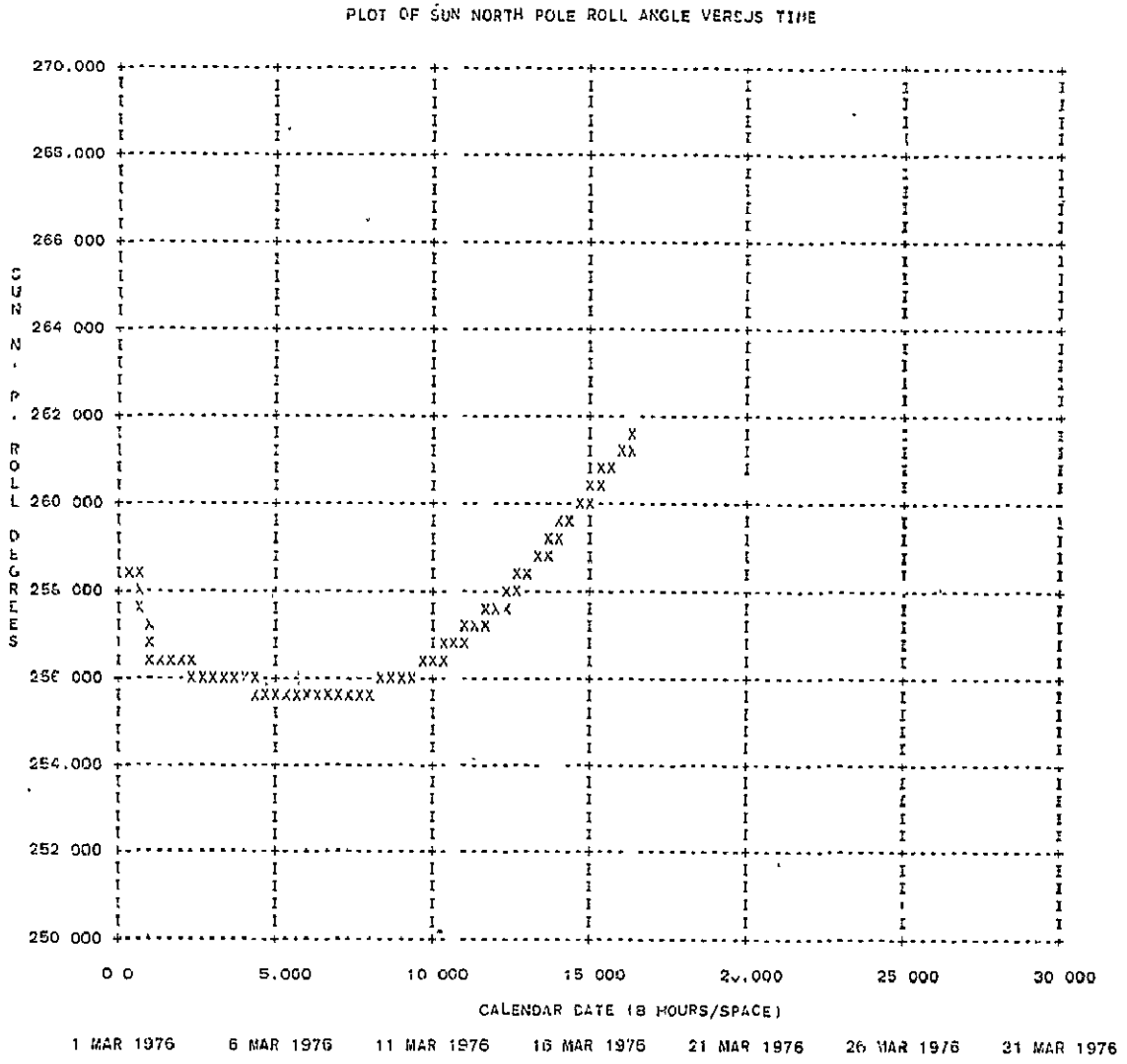


Figure 5-6. Printer Plots.
(concluded)

The attitude summary is written in an unformatted binary form.

The first record is a header record containing the following:

Name	Type	Description
SAT	R*8	Eight-character alphameric name (EBCDIC) identifying the spacecraft
TREF	R*8	Reference time since September 1, 1957 (days)
TSTART	R*8	Time from TREF of first data on tape (seconds)
TSTOP	R*8	Time from TREF of last data on tape (seconds)

Each subsequent data record contains the following:

Name	Type	Description
T	R*8	Time of data from TREF (seconds)
S_x, S_y, S_z	R*4	Components of the unit spin vector at time T (In geocentric inertial coordinates)
OMEGA	R*4	Spin rate (radians per second) at time T

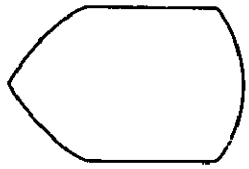
5.4.4.1 Interpolation Stepsize—This allows the attitude tape to be separated by a fixed time interval given in seconds. If 0 is specified, no interpolation will take place and the entries in the attitude tape will be the same as those in the attitude summary.

SECTION 6

OPERATOR FLOW

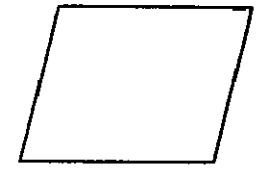
The following pages show first one complete run through from Key 1 to Key 4, and then a sample run showing major option menus only.

KEY to Figure 6-1:



DISPLAY

PROCESS



INPUT/OUTPUT

FUNCTION KEY

DOCUMENT

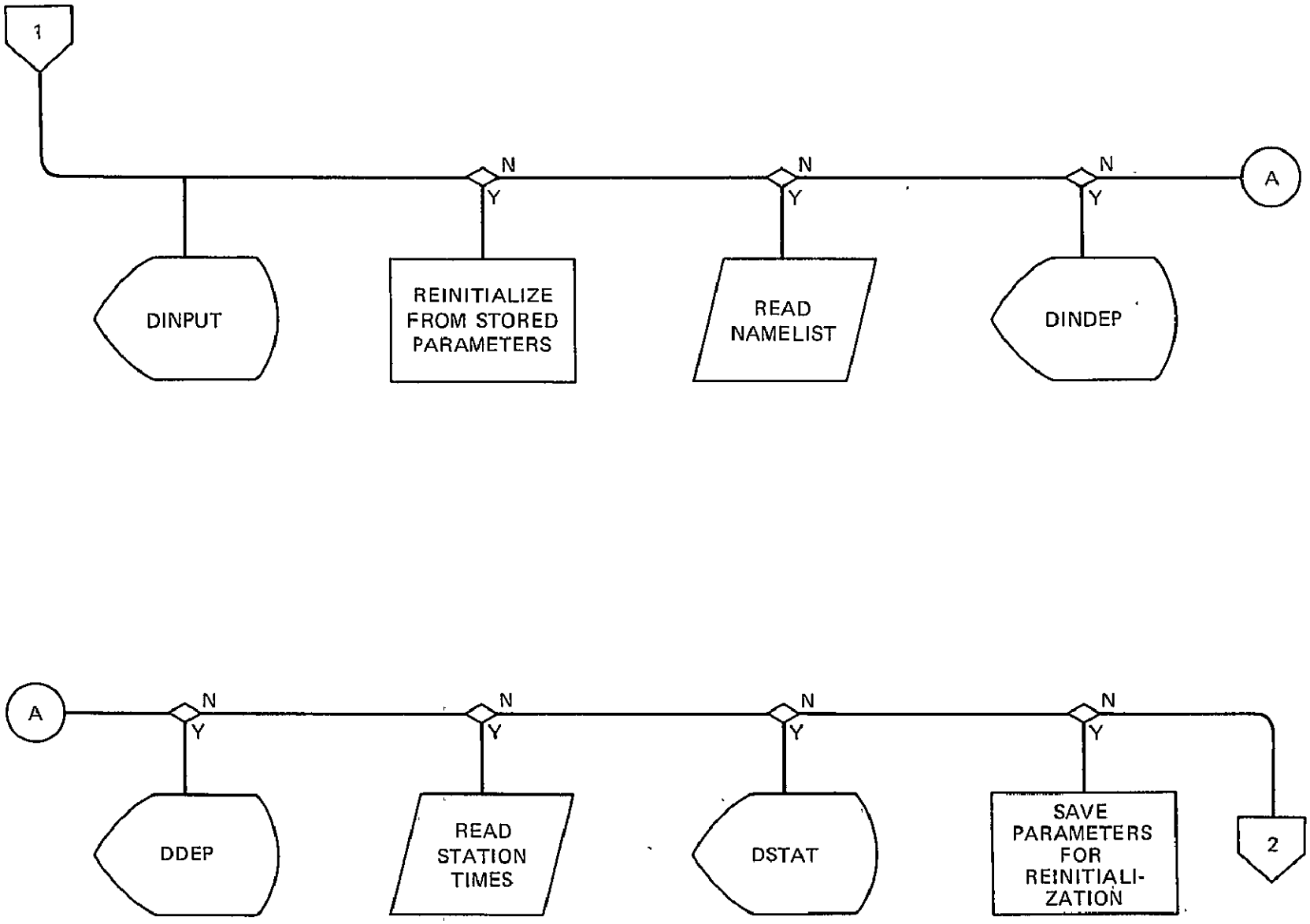


Figure 6-1 Operator Flow

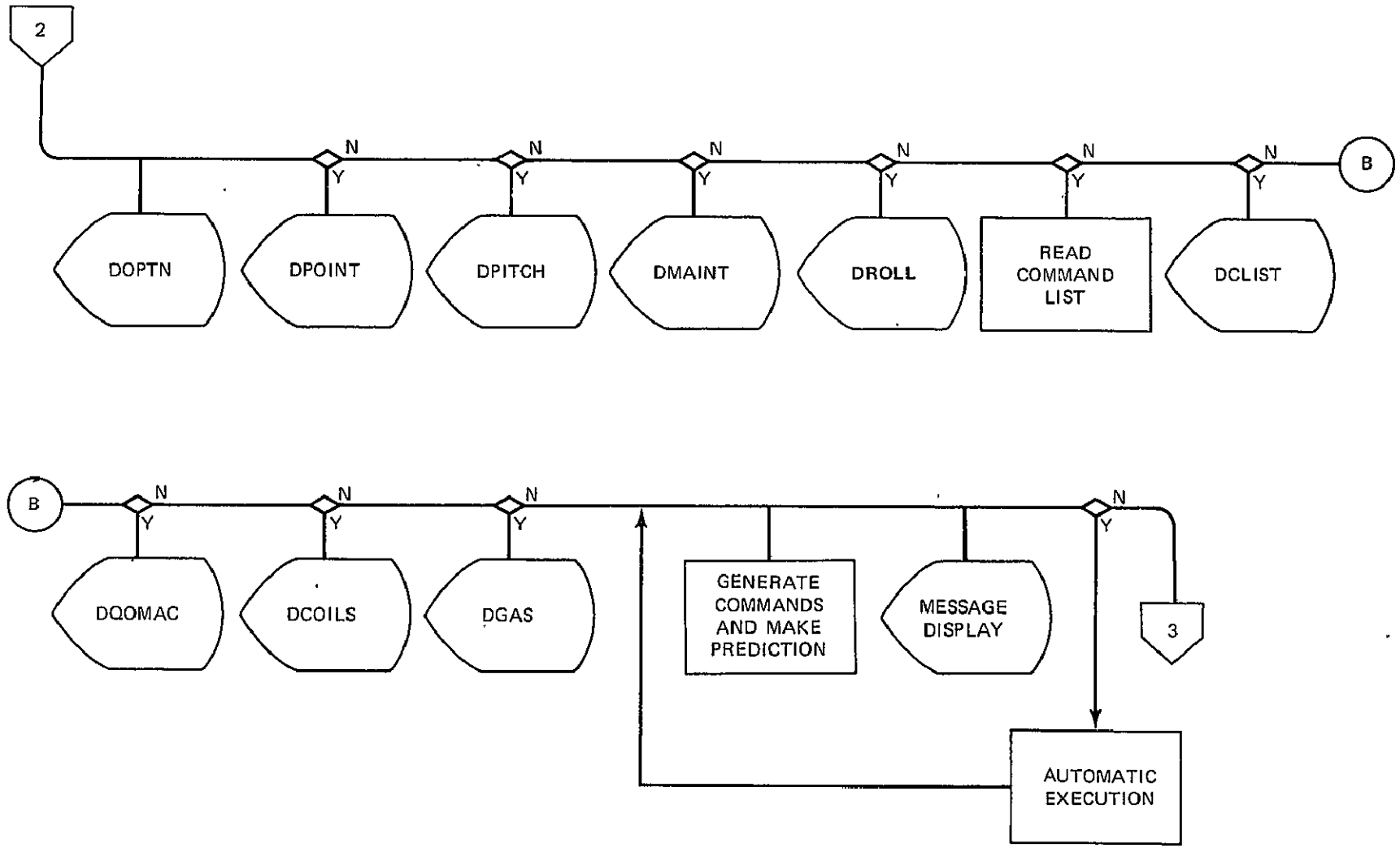


Figure 6-1 (continued)

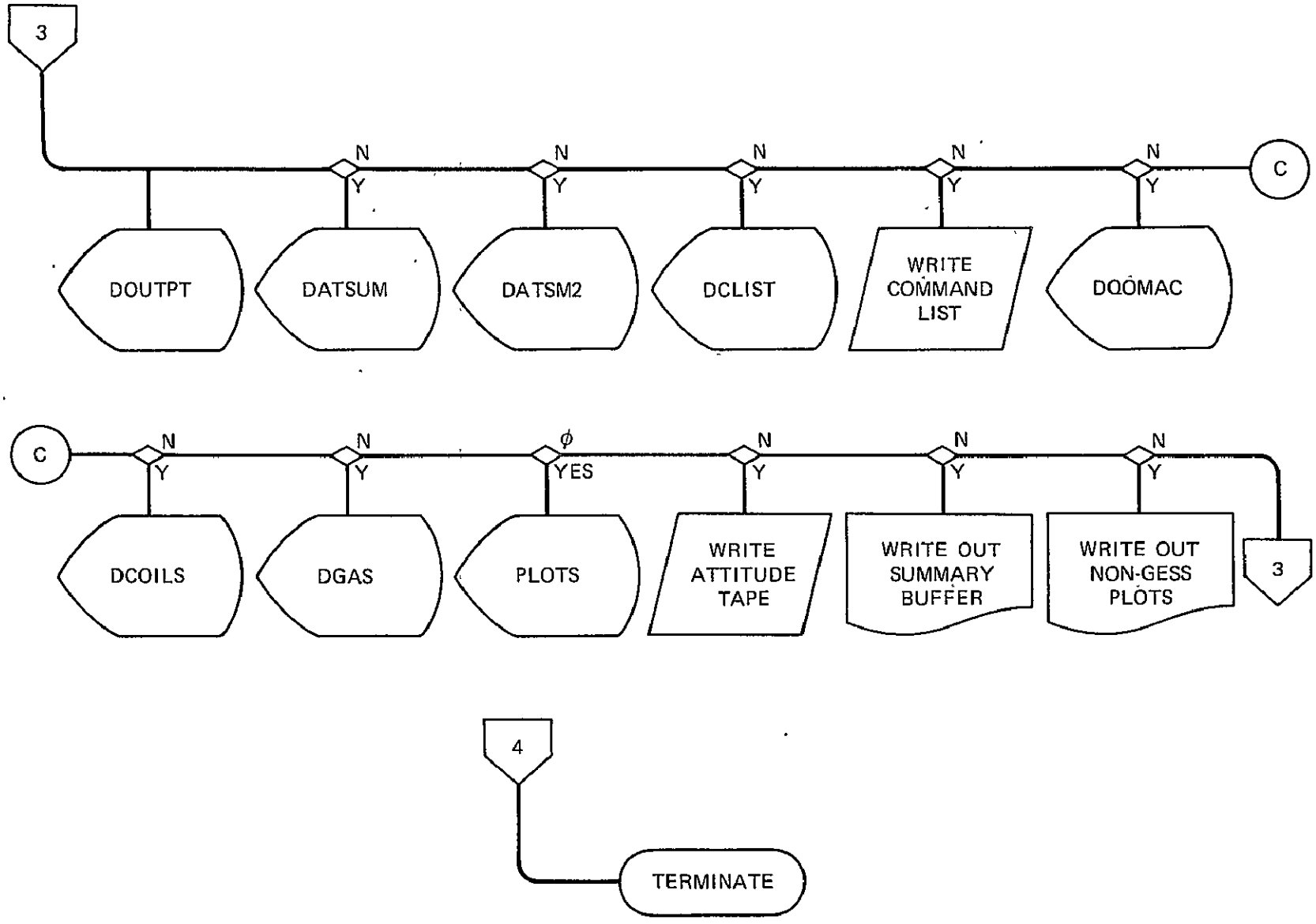
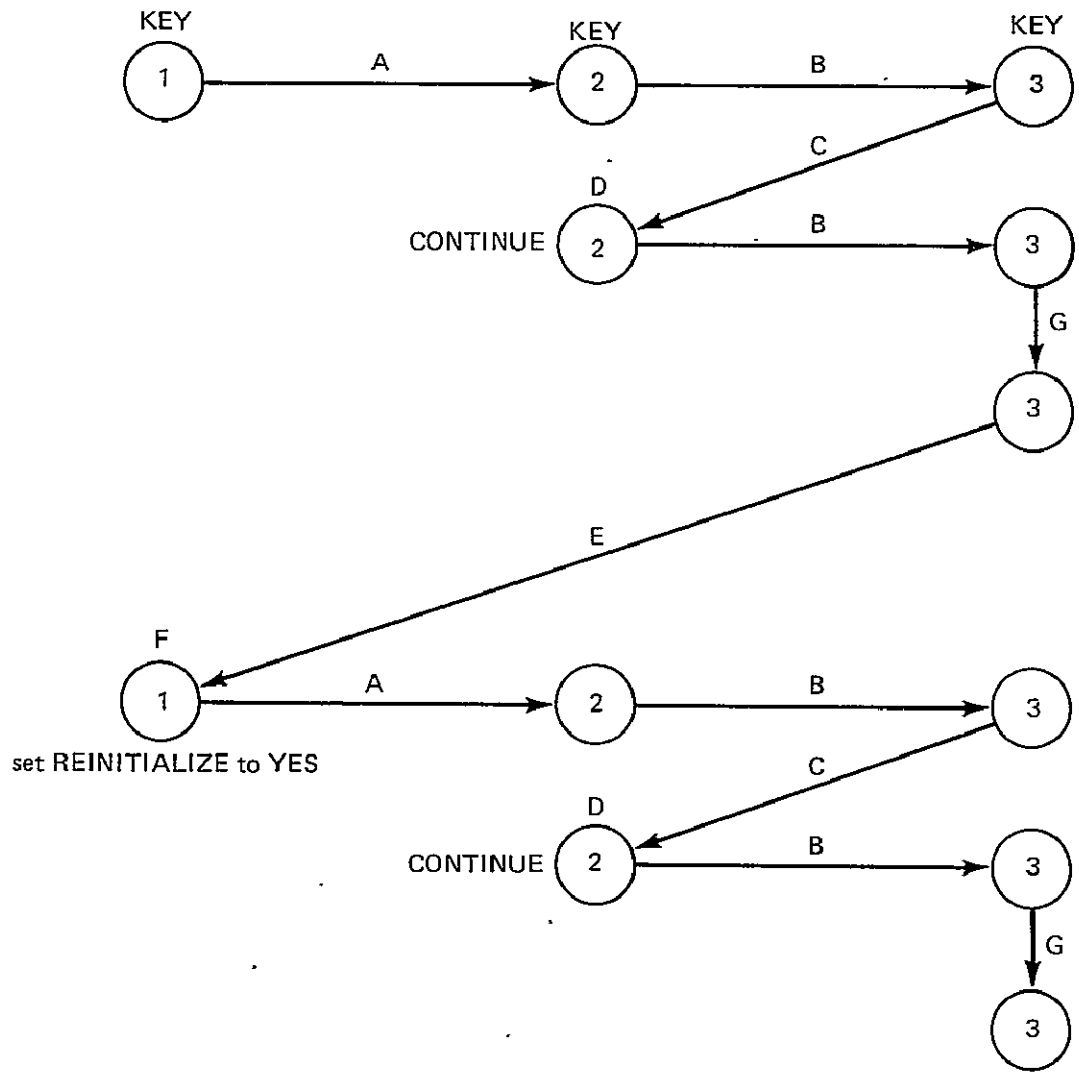


Figure 6-1 (continued)

The following is the flow of a sample run, showing the major option menus only.



Key 1 - Input Option Menu: Operator chooses what input displays to view.

Step-A - Various NAMELISTS are read. Operator can make changes to satellite independent and dependent variables. Station file is read. Parameters are saved for reinitialization.

Key 2 - Control Option Menu: Operator chooses what control, command, and history tables to view and enters data and chooses various control options desired.

Step-B - Commands are generated and implemented for one leg.

Key 3 - Output Option Menu: Operator chooses what output displays to view and chooses various output options desired.

Step-C - To continue prediction do a backward move to Key 2.

Step-D - Same as Key 2; to continue prediction skip to Key 3.

Step-G - Same as Key 3; Skipping off the final display writes out (if desired) the attitude summary to the printer, the attitude file, and the printer plots. The attitude summary buffer is dumped by resetting the counter to 1. Finally the operator is returned to Key 3.

Step-E - To reinitialize the system do a backward move to Key 1 and set reinitialization switch on the Input Option Menu to true and continue. Set save parameters for reinitialization switch to true if parameters are changed and are to be saved.

SECTION 7

COMPUTER REQUIREMENTS

Job control language (JCL), input/output data sets, and software and hardware requirements are described in this section.

7.1 JCL REQUIREMENTS

The following JCL includes all necessary data sets which are detailed on the next page by the number in the left column. Omitting FT23F001, the graphics card, produces a non-graphics run.

```
1    //GO          EXEC  PGM=ATTITMON,REGION=420K
2A   //STEPLIB       DD  DISP=SHR,DSN=ATTIT.OPRLIB.LOAD
2B   //              DD  DISP=SHR,DSN=SYS2.GTS
3A   //TUBE          DD  UNIT=2250
3B   //GPAKDD        DD  UNIT=AFF=TUBE
     //FILE          DD  DISP=SHR,VOL=REF=SYS1.LINKLIB,
     //                  UNIT=DISK
4A   //SYSUT1        DD  UNIT=DISK,SPACE=(CYL,(0,1))
4B   //SYSUT2        DD  UNIT=DISK,SPACE=(CYL,(0,1))
5A   //SYSUDUMP      DD  DUMMY
5B   //GESSDUMP      DD  DUMMY
6    //GESSMSG       DD  DISP=SHR,DSN=ATTIT.GESSMSG.DATA
7    //NAMELIST      DD  DSN=GDJLM.OSOI.MSAP.NAMELIST.DATA,
     //                  DISP=SHR
8    //*PLOTAPE      DD  DISP=(NEW,KEEP),DSN=USRID.PLOT.DATA,
     //*                 VOL=SER=TAPEXX,UNIT=2400-7,
     //*                 LABEL=(,BLP),DCB=DEN=1
9A   //FT03F001      DD  DISP=SHR,DSN=ATTIT.OSOI.EPHEM.DATA,
     //                  DCB=BUFNO=1
9B   //*T03F001      DD  DISP=(OLD,KEEP),LABEL=(1,BLP),
     //*                 DCB=(RECFM=VBS,LRECL=2804,BLKSIZE=2808),
     //*                 UNIT=2400-9,VOL=SER=TAPEXX
10   //FT06F001      DD  SYSOUT=A
11   //FT12F001      DD  DSN=ATTIT.SSS1.MSAP.ERROR.DATA,
     //                  DISP=SHR
12   //FT13F001      DD  SYSOUT=A
13   //FT20F001      DD  DISP=SHR,DSN=ATTIT.OSOI.MSAP.NRT.DATA
14   //FT23F001      DD  UNIT=AFF=GPAKDD
15   //FT25F001      DD  DISP=SHR,DSN=ATTIT.OSOI.MSAP.NL.DATA,
     //                  DCB=BUFNO=1
```

```
     //FT26F001     DD   SYSOUT=A
16   //FT35F001     DD   DISP=SHR,DSN=ATTIT.OSOI.STATNS.DATA
17   //FT50F001     DD   DSN=&&NAML,UNIT=2314,DISP=(NEW,DELETE),
     //                  DCB=(RECFM=FB,LRECL=80,BLKSIZE=7280),
     //                  SPACE=(TRK,(5,2))
18   //FT60F001     DD   DISP=SHR,DSN= [COMMAND LIST DATA SET]
```

Defaults for these files are given in the NAMELISTS referenced below.

1	Specifies program to be executed; indicates region size.
2A, B	Specifies libraries from which program in (1) is to be selected.
3A, B, 14	Specifies graphics device to be used. Changing 2250 to 0F0 on line (3A) causes the job to come up on an ADS 6600 terminal instead of a 2250. Omitting line (14) produces a non-graphics run.
4A, B	Workspace
5A, B	Specifies dump output data sets.
6	Required in GESS version 2 to display complete GESS messages during a run; omission of this line results in messages abbreviated to user numbers only (e.g., M077).
7	Specifies partitioned NAMELIST for NAMELIST Select Option. This data set must have a format of DCB=(RECFM=FB, LRECL=80, BLKSIZE=7280). No member can exceed the blocksize of 90 lines. This line is normally omitted when not using this option.
8	Specifies 7 track tape to which plots are written for later plotting on a CALCOMP plotter. This statement may be omitted if hard copy plots are not desired.
9A, B	Specifies ephemeris data set which must be of the format DCB=(RECFM=VBS, LRECL=2804, BLKSIZE=2808). A data set (9A) or tape (9B) can be used. The ephemeris file is specifies by IORB1 in NAMELIST MSAPIN or on display DINDEP under IO UNITS: Orbit File (see Figure 3-2). If IORB1=0 an internal orbital generator is used, which is the default. IORB1 will automatically be set to 0 if the ephem information needed is outside of the time span on the ephemeris file.

10 Standard printed output goes to main printer. This file is specified through IPRINT in NAMELIST MSAPIN or through display DINDEP under IO UNITS: Printed Output (see Figure 3-2).

11 Direct access error message file for the MSAP routines, specified by MSGIN in NAMELIST MSAPIN or through display DINDEP under IO UNITS: Error Message File (see Figure 3-2).

12 Error message output from certain MSAP routines are written to printer. This file is specified by MSGOUT in NAMELIST MSAPIN or through display DINDEP under IO UNITS: Error Message Output (see Figure 3-2).

13 Non-resident tables - partitioned data set containing information used by GESS to construct the displays. This file is specified by IFTABL in NAMELIST CONTRL. (In the current NAMELIST IFTABL is set to 27; i.e., FT27F001.)

15 Specifies the data set containing all the NAMELISTS: CONTRL, MSAPIN, OSOIN, CNTROL, KOMAND, and HISTRY. This data set is of the format DCB=(RECFM=FB, LRECL=80, BLKSIZE=800).

16 Specifies the data set containing a list of stations, station AOS and LOS. This file is defined by ISTAT in NAMELIST MSAPIN or through display DINDEP under IO UNITS: Station File (see Figure 3-2). The data set has the format DCB = (RECFM = FB, LRECL=80, BLKSIZE=800).

17 Specifies temporary workspace data set for NAMELIST Select Option. May be omitted if option is not used.

18 Specifies data set where command list is read from and written to. This file is specified by KLIST in MSAPIN or through display DINDEP under IO UNITS: Command List File (Figure 3-2). This dataset should have the format of DCB=(RECFM=FB, LRECL=80, BLKSIZE=7280).

7.2 SOFTWARE AND HARDWARE REQUIREMENTS

A region size of 420K is required.

For a graphics run, an IBM 2250 or an ADS 6600 graphics device is required as determined by the graphics card in the JCL. A 9-track tape drive is required if an orbit tape is to be read. A 7-track tape drive is required if a plot tape is to be created. A 9-track tape is required if an attitude tape is desired.

SECTION 8

MESSAGES

Message displays and ADDMSGs are used to inform the operator of the status of the system. Message displays are full page displays and usually require some action by the operator to continue the run. When a message display occurs, processing in the system stops and waits for operator response. ADDMSG messages are informative of conditions encountered during processing. An ADDMSG will appear at the bottom of the display with an associated number.

8.1 MESSAGE DISPLAYS

Since not all message displays are numbered, the messages appear in alphabetical order using the first word of the message as the keyword. Where required, additional explanation of message and operator response are given. Two types of message displays exist.

- GO MESSAGE - When this type of message appears, no action is required by operator.

- STOP MESSAGE - When this type of message appears, the operator must respond as indicated in the message. The message is automatically printed.

1. Message:

   A QOMAC COMMAND WAS ENTERED WITH NO MAGNETIC COMMAND TO TERMINATE IT. DO NOT CONTINUE. DO A BACKWARD MOVE TO KEY 2. ENTER A MAGNETIC COMMAND TO TERMINATE THE QOMAC COMMAND

   Explanation: A continuous or optimal magnetic command is required to terminate a QOMAC command.

   Operator Response: Enter a continuous or optimal magnetic command after the QOMAC command.

2. Message:

   ATTITUDE EXCEEDED ATTITUDE MAINTENANCE CONE ANGLE LIMIT DURING A COMMAND. CONTROL DISCONTINUED

Explanation: When implementing a command during an attitude maintenance control, the spacecraft attitude exceeded the attitude maintenance cone angle plus the tolerance. The control is terminated.

Operator Response: Repeat control with a different current, leg length, and/or tolerance. See Appendix A for more information.

3. Message:

   ATTITUDE SUMMARY BUFFER HAS BEEN FILLED. TO WRITE OUT. SKIP FROM FINAL OUTPUT DISPLAY

   Explanation: The attitude summary table buffer will hold 250 entries. This buffer must be emptied before the prediction or maneuver can be resumed.

   Operator Response: After viewing output under Key 3, skip from the last display or plot to empty the output buffer.

4. Message:

   DESIRED ATTITUDE HAS BEEN REACHED. SKIP TO OUTPUT MENU

   Explanation: The attitude has come within the tolerance limits of the desired attitude. Control is automatically discontinued.

   Operator Response: Continue

5. Message:

   END OF CONTROL LEG HAS BEEN REACHED. SKIP TO OUTPUT MENU

   Explanation: Message is sent at the end of each magnetic command leg and at the end of all gas controls.

   Operator Response: Continue

6. Message:

   END OF ROLL RATE CONTROL

   Explanation: None

   Operator Response: Skip to Continue

7. Message:

   ERROR IN READING ORBIT EPHEM DATA. IF PROCESSING CONTINUES ORBITAL ELEMENTS WILL BE USED. TO CONTINUE-SKIP. TO STOP PERFORM A BACKWARD MOVE

   Explanation: The current predictor time is not within the orbit ephemeris data set times. If one continues, the orbital elements on the header of the ephemeris data set will be used in the orbit generator. When this message occurs, the orbit ephemeris data file number is set to zero.

   Operator Response: Respond as indicated

8. Message:

   PREDICTION AND CONTROL SUBSYSTEM NOW PROCESSING

   Explanation: None

   Operator Response: None

9. Message:

   PREDICTOR ENDTIME HAS BEEN REACHED. SKIP TO OUTPUT MENU

   Explanation: Predictor stop time was reached. Prediction was completed.

   Operator Response: Continue

10. Message:

    ROLL RATE EXCEEDS MAXIMUM ALLOWED ROLL RATE WITH A COMMAND USING THE MAXIMUM CURRENT. SKIP TO CONTINUE

    Explanation: On the first attempt to control roll rate the maximum current was used and was unable to control the roll angle within the desired limit. A larger current is required. The command is left as it exists and the roll rate control continues.

    Operator Response: Continue

11. Message:

    ROLL RATE CONTROL UNABLE TO BE CONTROLLED WITH COMMAND TYPE BEING USED. SKIP TO CONTINUE

    Explanation: After two attempts, first using the inputted current and second computing another current, the roll angle change is still unable to be controlled. Roll rate control continues after skipping.

    Operator Response: Continue

12. Message:

    ROLL RATE LIMIT EXCEEDED DURING ROLL RATE MONITORING. SKIP TO CONTINUE

    Explanation: None

    Operator Response: Continue

13. Message:

    U283. YOU HAVE MORE THAN 10 ENTRIES IN THE PITCH CONTROL TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 10 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

14. Message:

    U293. YOU HAVE MORE THAN 10 ENTRIES IN THE ATTITUDE MAINTENANCE CONTROL TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 10 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

15. Message:

U305. A CONTINUOUS COMMAND MUST BE ENTERED TO TERMINATE QOMAC. MAKE A BACKWARD MOVE TO KEY 2 AND CORRECT ERROR. DO NOT CONTINUE PROCESSING.

Explanation: A QOMAC command was entered without a magnetic command to terminate it.

Operator Response: Enter a continuous or optimal magnetic command to terminate the QOMAC command.

16. Message:

U311. THERE ARE MORE THAN 200 ENTRIES IN THE COMMAND LIST. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 200 OR LESS. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

17. Message:

U381. THE COMBINATION OF ALL CONTROL ARRAY ENTRIES TOTALS MORE THAN 20. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE TOTAL ARRAY SIZE TO 20 OR LESS. DO NOT CONTINUE PROCESSING.

Explanation: All controls entered in the Point-to-Point, Pitch Angle, Attitude Maintenance, and Roll Rate control tables are merged into one common array. The total number of these separate entries cannot exceed 20.

Operator Response: Respond as indicated

18. Message:

U456. THERE ARE MORE THAN 900 ENTRIES IN THE COIL TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 900 OR LESS. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

19. Message:

    U463. YOU HAVE MORE THAN 20 ENTRIES IN THE POINT-TO-POINT CONTROL TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 20 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

20. Message:

    U491: See U381

21. Message:

    U501: See U381

22. Message:

    U512. THERE ARE MORE THAN 200 ENTRIES IN THE COMMAND LIST. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 200 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

23. Message:

    U521. ARRAY SIZE IS TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF POINT-TO-POINT ENTRIES IN NAMELIST CNTROL TO 20 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

24. Message:

U522. ARRAY SIZE IS TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF PITCH CONTROL ENTRIES IN NAMELIST CNTROL TO 10 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

25. Message:

U523. ARRAY SIZE IS TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF ATTITUDE MAINTENANCE ENTRIES IN NAMELIST CNTROL TO 10 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

26. Message:

U524. ARRAY SIZE IS TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF ROLL RATE ENTRIES IN NAMELIST CNTROL TO 10 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

27. Message:

U525. TOTAL ARRAY SIZE TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE TOTAL NUMBER OF ENTRIES IN NAMELIST CNTROL TO 20 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

Explanation: The sum of point-to-point, pitch angle, attitude maintenance, and roll rate controls cannot exceed 20 entries at one time.

Operator Response: Respond as indicated

28. Message:

    U531. ARRAY SIZE TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF COMMAND LIST ENTRIES IN NAMELIST KOMAND TO 200 OR LESS AND REREAD NAMELIST. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

29. Message:

    U542. ARRAY SIZE TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF COIL ENTRIES IN NAMELIST HISTRY TO 900 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

30. Message:

    U543. ARRAY SIZE TOO LARGE. MAKE A BACKWARD MOVE TO KEY 1. REDUCE THE NUMBER OF GAS ENTRIES IN NAMELIST HISTRY TO 50 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

31. Message:

    U555. THERE ARE MORE THAN 50 ENTRIES IN THE GAS TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 50 OR LESS. DO NOT CONTINUE PROCESSING.

    Explanation: None

    Operator Response: Respond as indicated

32. Message:

U603. YOU HAVE MORE THAN 10 ENTRIES IN THE ROLL RATE CONTROL TABLE. MAKE A BACKWARD MOVE TO KEY 2 AND REDUCE THE NUMBER OF ENTRIES TO 10 OR LESS. DO NOT CONTINUE PROCESSING.

Explanation: None

Operator Response: Respond as indicated

33. Message:

U611: Same message as U381

34. Message:

U620: See message 10

35. Message:

WARNING - PITCH VIOLATION WILL OCCUR IF PROCESSING CONTINUES.

Explanation: The pitch violation warning limits have been reached. If the option to correct pitch violations automatically is set to true and a pitch violation does occur, it will be corrected using gas. If the option is false, an ADDMSG will be sent to operator when the violation occurs.

Operator Response: To continue-skip; to stop-do a backward move to key 2 or 1.

8.2 ADDMSGs

ADDMSGs are one line informative messages which appear at the bottom of the display. All ADDMSGs will have a number associated with the message. If more than one ADDMSG is sent at the same display, the message of the last ADDMSG remains on the display. The numbers of the other ADDMSGs will remain in the order they were sent. Once the operator skips from the display, the ADDMSGs will disappear.

Message Number	Message and Explanation
M190	ONCE INTERACTIVE MODE IS ENTERED, DIRECTORY ARRAYS CANNOT BE USED. IDIREC in GESS CONTRL NAMELIST should be 0.
U025	I/O ERROR IN READING SELECTED NAMELIST Check NAMELIST for errors and reread.
U026	SELECTED NAMELIST NOT IN DATA SET The name entered in the NAMELIST Select Option Field on the Input Option Menu display (display DINPUT) does not correspond to a name in the NAMELIST data set. Check the name entered.
U027	CAN NOT REINITIALIZE SINCE PARAMETERS HAVE NOT BEEN STORED An attempt was made to reinitialize the system before any initial state had been saved for reinitialization. The switch for Reinitialize From Stored Parameters on the Input Option Menu must be No for the first entry into the system.
U031	SPIN VIOLATION - FIX COMMAND WAS GENERATED A spin violation occurred and a gas command was generated and implemented to correct it.
U033	AUTOMATIC PITCH FIX HAS OCCURRED A pitch violation occurred and a gas command was generated and implemented to correct the violation.
U034	PITCH VIOLATION OCCURRED AND PROCESSING CONTINUED A pitch violation occurred; however, the option to correct it was not set to true.
U060	RIGHT ASCENSION AND DECLINATION COMPUTED FROM PITCH AND ROLL Pitch and roll was entered in the NAMELIST as the initial attitude rather than right ascension and declination.

Message Number	Message and Explanation
U067	GAS MANEUVER CAN NOT BE DONE AS SPECIFIED PITMOT IS TOO LARGE. . SEE OPERATING GUIDE. The amount of pitch motion per gas increment of roll motion (PITMOT) entered in the Satellite Dependent NAMELIST Display is too large for the program to use correctly.
U069	COIL ESTIMATE GREATER THAN 75MA. . 75MA WILL BE USED. During coil strength estimation a coil strength greater than 75 ma was computed to be required to complete maneuver. 75 ma will be used.
U090	ERROR IN SATCON - CONTROL START TIME PRIOR TO PREDICTOR START TIME Check the control specification entries in the control tables. A control start time is before the predictor start time. Either adjust the control start time to after predictor start time or delete or flag the control.
U091	ABNORMAL END IN SATCON Note type of error and processing you are doing; save printout. Call OSO-8 control software maintenance personnel.
U130	NO STATIONS ARE AVAILABLE NOW OR IN THE FUTURE Current predictor time is greater than any station AOS time.
U170	VECTR2 ORBIT GENERATOR RETURNED FATAL ERROR - PROCESSING STOPS Check all input parameters; especially the orbital elements. Repeat what you were doing. If error continues check with OSO-8 control software maintenance.
U230	PLTDRI - INVALID X-AXIS SPECIFIED Check the x-axis plot option on the Output Option Menu Display. Valid numbers are 1-8.

Message Number	Message and Explanation
U231	PLTDRI NO Y-AXIS SPECIFIED Check the first y-axis plot option entry on the Output Option Menu Display. Valid entries are 2-10.
U232	PLTDRI 1st Y-AXIS SPECIFIED INVALID Same as U231.
U233	PLTDRI 2nd Y-AXIS SPECIFIED INVALID Check the second y-axis plot option entry on the Output Option Menu Display. Valid entries are 2-12.
U250	CMDOFF - ERROR IN SORT PROCEDURE In arranging the commands in subroutine CMDOFF an error occurred in DRANGE. Repeat prediction. Report error to OSO-8 control software maintenance personnel.
U280	TO ENTER A CONTROL, SET REDISPLAY = YES A control was still in the table entry section of the Control Specification Display. To enter the control set redisplay to yes.
U281	XPITCH - ERROR IN SORT PROCEDURE Check all entries in the pitch control table. If error continues, save print-out and contact OSO-8 control software maintenance personnel.
U282	ERROR - RECALLED LINE NOT IN TABLE Check line number of pitch control you are attempting to recall.
U290	TO ENTER CONTROL, SET REDISPLAY TO YES See U280.
U291	XMAINT - ERROR IN SORT PROCEDURE See U281. This is for the attitude maintenance control table.
U292	ERROR - RECALLED LINE NOT IN TABLE See U282 for attitude maintenance control.

Message Number	Message and Explanation
U300	HISGEN - ERROR IN COIL SORT PROCEDURE Check all coil history entries; repeat prediction. If error continues; save print-out and contact OSO-8 control software maintenance personnel.
U301	HISGEN - ERROR IN QOMAC SORT PROCEDURE See U300.
U302	HISGEN - ERROR IN GAS SORT PROCEDURE Same as U300 only check gas history table.
U303	HISGEN - COIL HISTORY TABLE IS FULL Coil history table has 900 or greater entries. Reduce the number of coil events.
U304	HISGEN - GAS HISTORY TABLE IS FULL Gas history table has 50 or greater entries. Reduce the number of gas events.
U310	STOCMD - ERROR IN SORT PROCEDURE Same as U250 except in subroutine STOCMD.
U330	INVALID COMMAND TYPE Check all control types in all the control specification tables. Valid numbers are 1-4.
U360	QOMAC PERIOD TOO BIG - USING CONTINUOUS During a QOMAC/continuous command; when the period is too large a continuous command is used.
U380	DPITCH - SORTING ERROR IN DRANGE Check all pitch control specification entries; Repeat prediction. If error continues save print-out; call OSO-8 control software maintenance personnel.
U390	SPINRATE CORRECTION MADE AT NIGHT A gas spin maneuver occurred while the satellite was in the earth's shadow.
U391	SPINRATE CORRECTION OCCURRED A gas spin correction occurred.
U400	PITCH OR ROLL GAS MANEUVER OCCURRED AT NIGHT

Message Number	Message and Explanation
U410	SPINRATE CORRECTION OCCURRED AT NIGHT A gas spin maneuver occurred while the satellite was in the earth's shadow.
U420	QOMAC COMMAND INDEX EXCEEDS MAXIMUM Check the QOMAC command number which was to be expanded. The value used is greater than the maximum number of commands.
U421	REQUESTED COMMAND QOMAC Check the command number to be expanded. The corresponding command type must be a QOMAC command.
U422	LAST QOMAC COMMAND HAS BEEN EXPANDED All QOMAC commands in the command table have been expanded.
U430	TIME ERROR IN MACFIT Error in subroutine MACFIT. Repeat run; if error continues save print-out and contact OSO-8 control system maintenance personnel.
U450	LINE TO BE RECALLED IS OUT OF RANGE The line number of the coil history event attempting to be recalled is greater than the number of entries in the coil history table. Check line number to be recalled.
U451	DISPLAY CONTROL SET IMPROPERLY To skip from display the redisplay flag should be set to no.
U452	ERROR - LINE NUMBER TO RECALL SET IMPROPERLY Check line number entry.
U453	XCOILS. LINE CANNOT BE ADDED, ARRAYS ARE FULL Maximum number of coil history events is 900. An attempt was made to add more than 900.

C.2

Message Number	Message and Explanation
U454	ERROR - TABLE ENTRY TIME IS NOT ACCEPTABLE Check the coil event time. The time must be after predictor start time.
U455	ERROR IN REORDERING PROCESS Reenter coil event. If error persists; save print-out and contact OSO-8 control system maintenance personnel. Error in subroutine DRANGE.
U460	TO ENTER A CONTROL, SET REDISPLAY = YES Check the redisplay flag. It must be set to yes to enter control.
U461	XPOINT - ERROR IN SORT PROCEDURE Reenter control again. If error persists; save print-out and contact OSO-8 control system maintenance personnel. Error in subroutine DRANGE.
U462	ERROR - RECALLED LINE NOT IN TABLE Same as U450 except this for the point-to-point control table.
U470	CONES DID NOT INTERSECT IN ATMAIN Check all input values for the maneuver. If error continues, use point-to-point control.
U471	CONES DID NOT INTERSECT IN ATMAIN Adjust NAMELIST parameter ATPARM; increasing by increments of .002. Try several times; if problem persists, use point-to-point control.
U472	CONES DID NOT INTERSECT IN ATMAIN See U471.
U490	DPITCH - SORTING ERROR IN DRANGE Check the pitch control which is being entered. Repeat entry procedure. If error continues; save run and contact OSO-8 control system maintenance personnel.

Message Number	Message and Explanation
U500	DMAINT - SORTING ERROR IN DRANGE Same as U490 for attitude maintenance control.
U510	XCLIST - ERROR IN SORTING PROCEDURE Same as U490 for the command list.
U511	ERROR - RECALLED LINE NOT IN TABLE Same as U450 except this is for command table.
U520	MERGE SETUP ERROR IN CNLIST Check the controls being entered via the CNTROL NAMELIST. If error continues; save run and contact the OSO-8 control system maintenance personnel.
U530	MERGE SETUP ERROR IN KNLIST Same as U520 except this is for the commands being entered via the KOMAND NAMELIST.
U540	MERGE SETUP ERROR IN HNLIST FOR A COIL EVENT Same as U520 except this is for the coil history events being entered via the HISTRY NAMELIST.
U541	MERGE SETUP ERROR IN HNLIST FOR A GAS EVENT Same as U540 except for gas event.
U550	ERROR - LINE TO BE RECALLED IS OUT OF RANGE Same as U450 except gas table.
U551	ERROR - LINE NUMBER TO RECALL SET IMPROPERLY Check line number to be recalled.
U552	ERROR - TABLE ENTRY TIME IS NOT ACCEPTED Check the gas event time being entered.
U553	LINE CAN NOT BE ADDED, ARRAYS ARE FULL A maximum of 50 entries in the gas table is possible.

Message Number	Message and Explanation
U554	ERROR IN REORDERING PROCESS Reenter the gas event again; if error continues; save run and contact OSO-8 control system maintenance personnel.
U571	PITCH CONTROL IN PROCESS - FINAL PITCH CAN NOT BE GENERATED A final pitch plot can be plotted only during a point-to-point or attitude maintenance control.
U572	ROLL RATE IN PROCESS - FINAL PITCH CAN NOT BE GENERATED Same as U571.
U580	NO SWITCHING FUNCTION AVAILABLE IN TIME SPAN OF THIS ATTITUDE SUMMARY Switching function plot is only possible after an END OF LEG message.
U581	ARRAY FULL - REMAINDER OF F(t) COULD NOT BE PLOTTED FOR THIS LEG Entire switching functions could not be plotted due to array size.
U591	ARRAY FULL - NO MORE QOMACs CAN BE PLOTTED THIS LEG QOMAC command plotted is not complete due to array size. Number of QOMAC expansion is greater than allocated arrays.
U592	ARRAY FULL: REMAINDER OF THIS QOMAC COMMAND CAN NOT BE PLOTTED Same as U591.
U600	TO ENTER A CONTROL, SET REDISPLAY = YES See U460.
U600	MERGE SETUP IN CMDRED Check all commands in the command list data set. Reread commands. If error continues contact OSO-8 control system maintenance personnel.

Message Number	Message and Explanation
U601	XPOINT - ERROR IN SORT PROCEDURE Same as U461; should be XROLL not XPOINT.
U602	ERROR. RECALLED LINE NOT IN TABLE Check line number being recalled.
U610	DROLL - SORTING ERROR IN DRANGE Same as U490 except for roll rate control.
U730	CIRCLE - NO CONTROL SPECIFIED A tolerance circle cannot be plotted unless a point-to-point or attitude maintenance is in progress or was completed.

SECTION 9

OPERATIONAL CONSIDERATIONS

1. All gas commands generated by the system will be spaced at intervals of ten seconds for each gas increment.

2. A good command leg length to use is 480 minutes.

3. The control specification, command, and history start times must be greater than or equal to the predictor start time.

REFERENCES

1. Computer Sciences Corporation, CSC/SD-75/6057, Graphic Executive Support System (GESS) User's Guide, J. E. Hoover, T. E. Board, A. M. Montgomery, August 1975.

2. Computer Sciences Corporation, 3000-26900-01TR, OSO-I Attitude Support System Specifications and Requirements, R. J. Wetmore, et al., August 1974.

APPENDIX A

ATTITUDE MAINTENANCE CONTROL

The purpose of an attitude maintenance control is to maintain the spacecraft attitude within some limit about a desired attitude. Figure A-1 illustrates an attitude maintenance control. θ is the arc angle in which the attitude must be maintained. To use attitude maintenance the initial attitude ($\hat{A}_o$) must be within the attitude maintenance circle. Environmental torques cause the attitude to drift to the edge of the cone ($\hat{A}_i$). At this time a point ($\hat{A}_f$) is computed on the opposite side of the attitude maintenance circle. The point is computed so as to cause the attitude to drift through the center of the circle thus maximizing the time between commands.

The procedure for maneuvering the attitude from one side of the attitude maintenance circle to the other side (from $\hat{A}_i$ to $\hat{A}_f$) is the same as that used in point-to-point controls. Once the attitude is maneuvered to within the tolerance of the desired point $\hat{A}_f$ the command is turned off. The spacecraft's attitude then drifts and the above procedure is repeated when the attitude reaches the cone's limit.

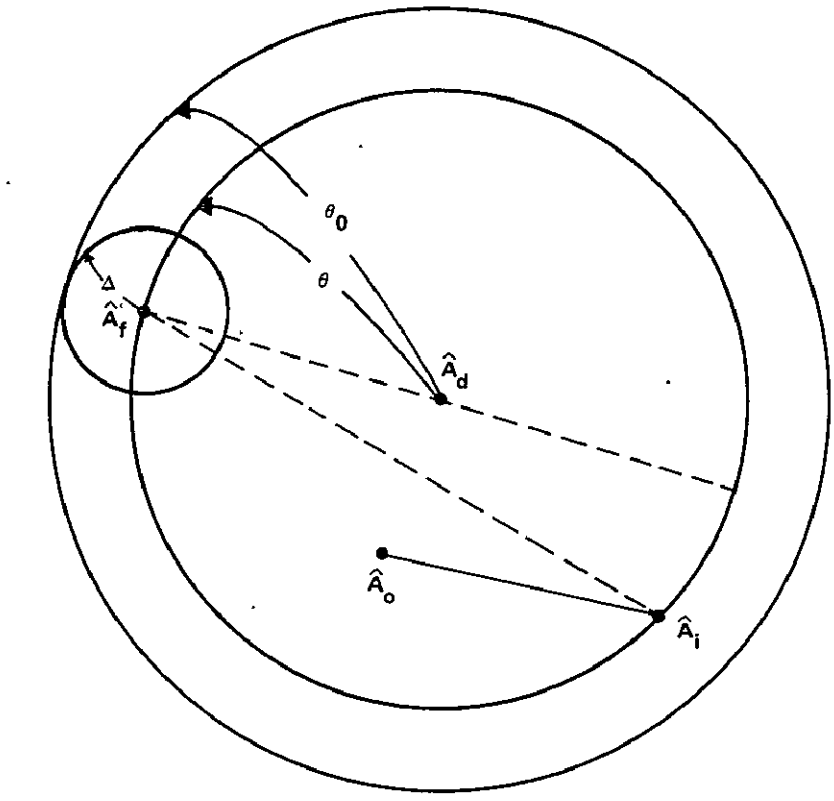


Figure A-1. Attitude Maintenance Geometry

When using attitude maintenance control the cone angle must be larger and should be at least twice as large as the tolerance on final attitude. If the system generates a command to go from $\hat{A}_i$ to $\hat{A}_f$ and it takes the attitude outside the attitude maintenance plus tolerance limit circle (θ_0) the following message is sent to the operator:

ATTITUDE EXCEEDED ATTITUDE MAINTENANCE CONE ANGLE LIMIT DURING A CONTROL COMMAND DISCONTINUED

When this occurs several options exist to correct it:

a. reduce leg length and/or coil current. This causes the system to re-evaluate and update the commands more often.

b. use a different type of command, i.e., if using QOMAC try continuous.

c. increase the tolerance on final attitude if possible.

There can be spacecraft orientations where attitude maintenance control will not achieve the desired results.

Note the attitude maintenance control message is sent only when a command is being implemented, and the command takes the spacecraft's attitude outside the attitude maintenance limit plus the tolerance limit (θ_0) as shown in Figure A-1; thus the attitude maintenance circle can be larger than the cone angle at times. The above situation occurs since there is usually a tolerance limit (Δ) on all commands as shown in Figure A-1.

There are several analytic variables in the OSOIN NAMELIST used in attitude maintenance. These variables normally will not require changing.

ATPARM - Variable used in subroutine ATMAIN for a possible singularity. ATPARM is the radius of the circle about the singularity.

ATDRFT - When the spacecraft attitude has been maneuvered from one side of the attitude maintenance circle to the other by commands, the attitude must drift due to environmental torques inward a certain percentage of the cone angle before the system will begin checking whether the attitude maintenance circle has been exceeded. ATPARM is this percent factor.

For more detailed information on attitude maintenance control see reference 2.

APPENDIX B

MAGNETIC COMMAND TYPES

The magnetic control system can operate in three different modes.

- Continuous - Control coil is maintained at a constant level.
- QOMAC - Control coil current alternates the coil polarity at equal time intervals. (QOMAC - Quarter Orbit Magnetic Attitude Control)
- Optimal (Asymmetric or time-tagged) - Control coil current is commanded from an on-board command processor. Coil current can change at irregular time intervals. Figure 1-2 illustrates each mode.

The basis of the magnetic control system is the Switching Function (F(t)) illustrated in Figure B-1. The Switching Function is defined as

$$\xi = \cos^{-1}\left[(\hat{A}_c \times \hat{H}) \cdot \hat{A}_{f\,x\,y}\right] \qquad \text{(B-1)}$$

where:

A_c - current attitude

A_f - desired attitude

H - geomagnetic field vector

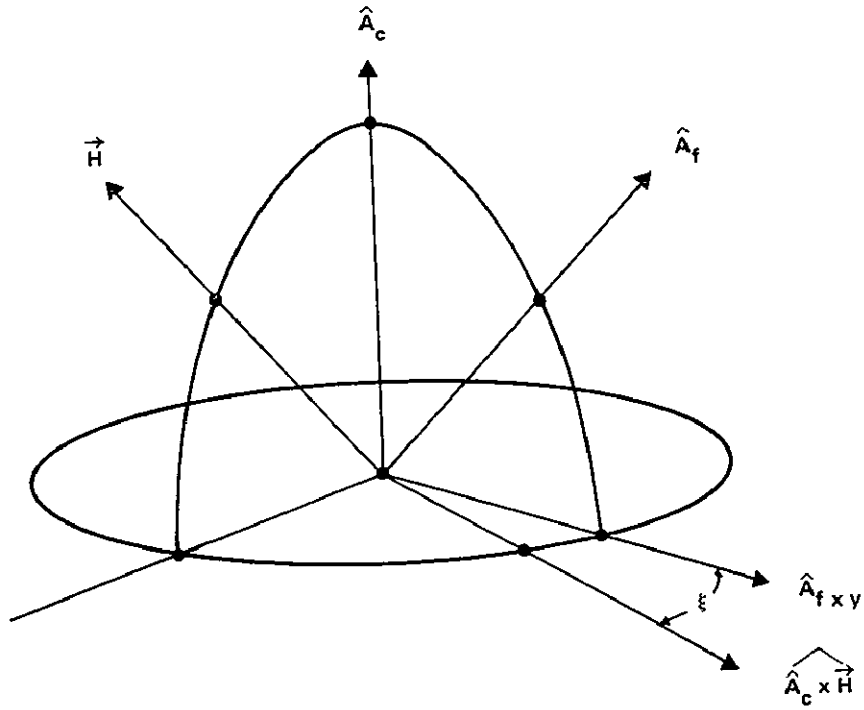


Figure B-1. Geometry Defining Switching Function

An example of a Switching Function is shown in Figure B-2.

When the control coil polarity matches the sign of F(t) the spacecraft's attitude will move toward the desired attitude. For an optimal magnetic command, the commands sent will match the F(t) function. For a continuous command, the system determines whether the F(t) function is more positive or negative. If it is more negative, a negative continuous command will be computed and vice versa. For a QOMAC command the system examines the F(t) function and computes a phase and period which will best model the F(t) function.

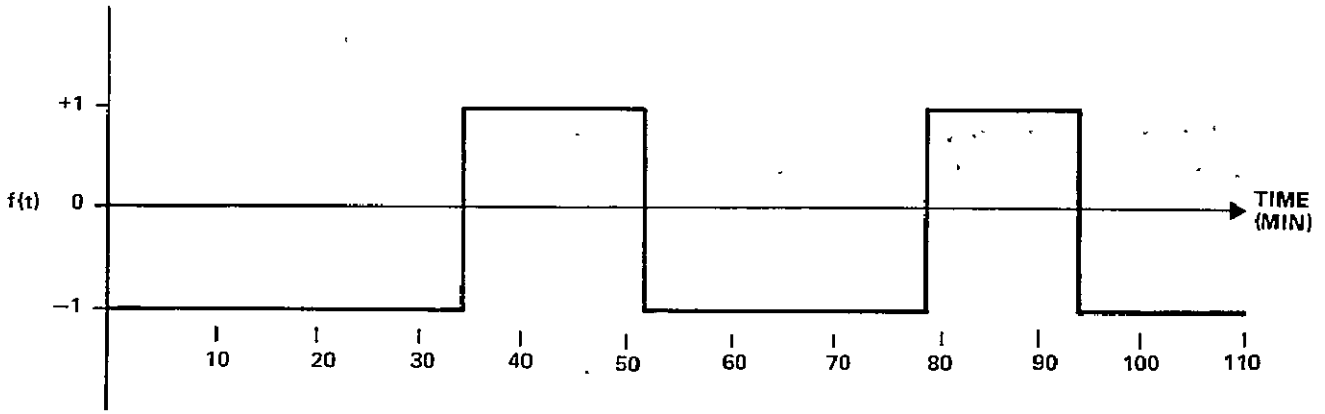


Figure B-2. Switching Function

APPENDIX C

COORDINATE SYSTEMS

C.1 GEOCENTRIC INERTIAL COORDINATE SYSTEM

The Geocentric Inertial Coordinate System (GCI) is depicted in Figure C-1. The X-axis points to the vernal equinox of date, the Z-axis points to true north, and the Y-axis points in the direction of the vector cross product of Z and X. The X-Y plane of the system corresponds to the equatorial plane. The origin of the system can be taken to be either the center of the Earth or the spacecraft, whichever is convenient.

C.2 ECLIPTIC COORDINATE SYSTEM

The ecliptic coordinate system used for OSO-8 is depicted in Figure C-2. The X_e axis points toward the Sun, the Z_e axis points toward the ecliptic North Pole, and the Y_e axis points in the direction of the vector cross product of Z_e and X_e

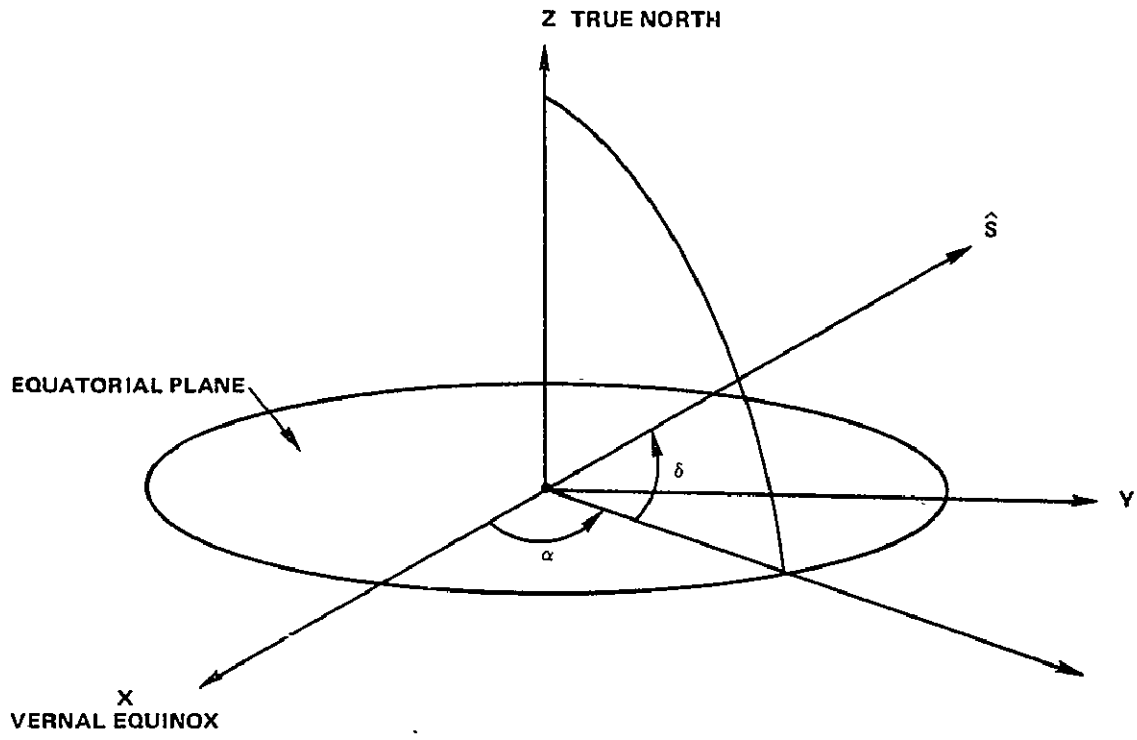


Figure C-1. GCI Coordinate System

to complete the orthogonal triad.[1] The X_e - Y_e axes define the ecliptic plane. The Y_e - Z_e axes define the roll plane, so named because it is the plane in which roll angles are measured. The origin of the coordinate system can be taken to be either the center of the Earth or the spacecraft, whichever is convenient.

C.3 TRANSFORMATIONS BETWEEN ECLIPTIC AND GCI SYSTEMS

Figure C-3 depicts the juxtaposition of the GCI and ecliptic coordinate systems. Two sequential right-handed rotations are required for the transformation from

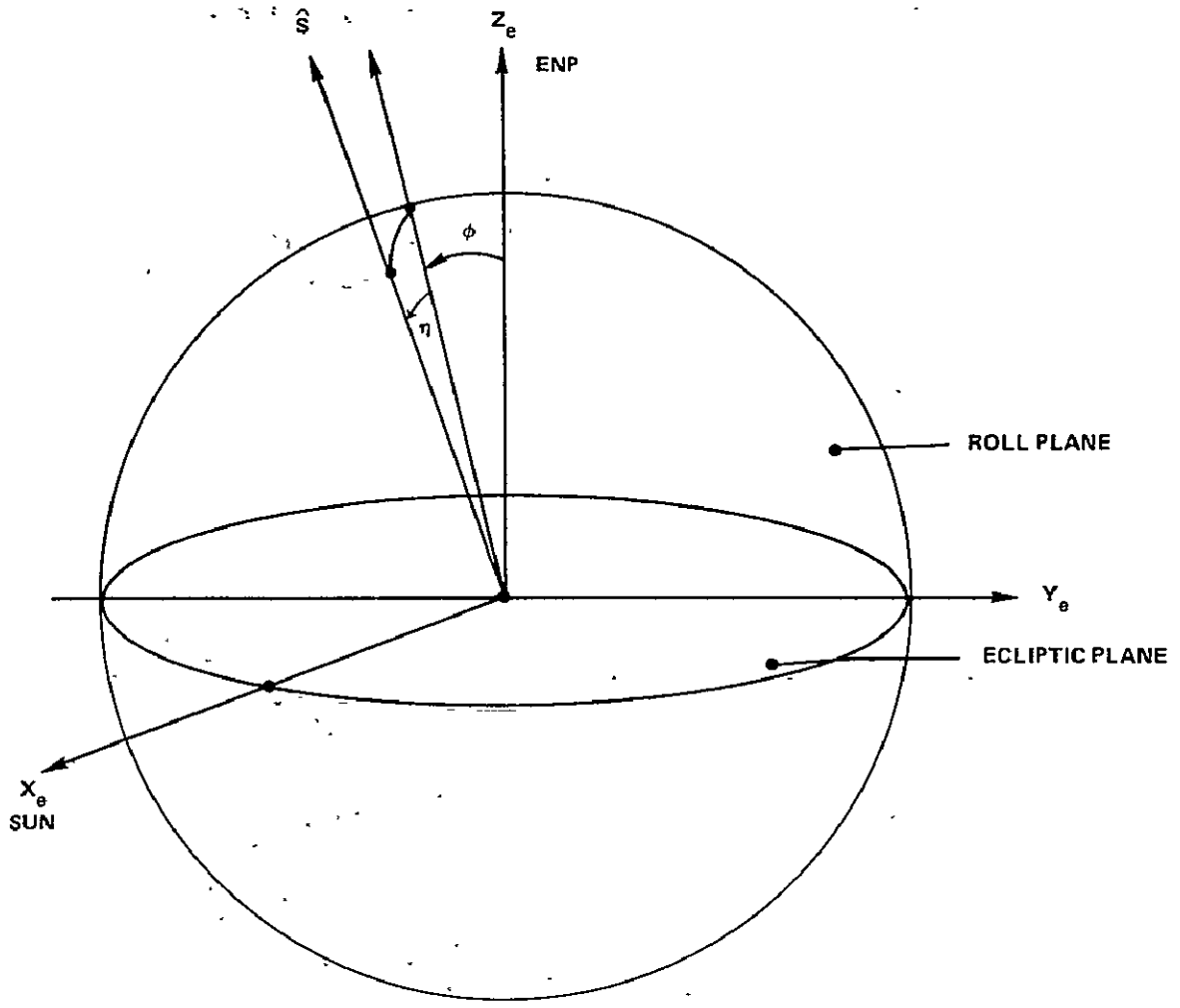


Figure C-2. Ecliptic Coordinate System

[1] The ecliptic system used on OSO-8 is a slightly modified version of the standard ecliptic system which references its X-axis to the vernal equinox.

the GCI system to the ecliptic system. First, a rotation is performed about the X-axis through an angle equal to the obliquity of the ecliptic, ϵ (23.443 degrees). Second, a rotation is performed about the Z_e axis through an angle equal to the celestial longitude of the Sun, λ.

Let R represent the transformation matrix generated by performing the rotations mentioned above, $\vec{V}$ be any vector whose component values are referenced to GCI, and $\vec{V}'$ be the same vector with its component values referenced to the ecliptic system. Then

$$\vec{V}' = R\,\vec{V}$$
$$\vec{V} = R^{-1}\,\vec{V}' \qquad \text{(C-1)}$$

where R^{-1} is the inverse of the R matrix. Equation (C-1) indicates that knowledge of the R matrix permits representations of vectors in either system.

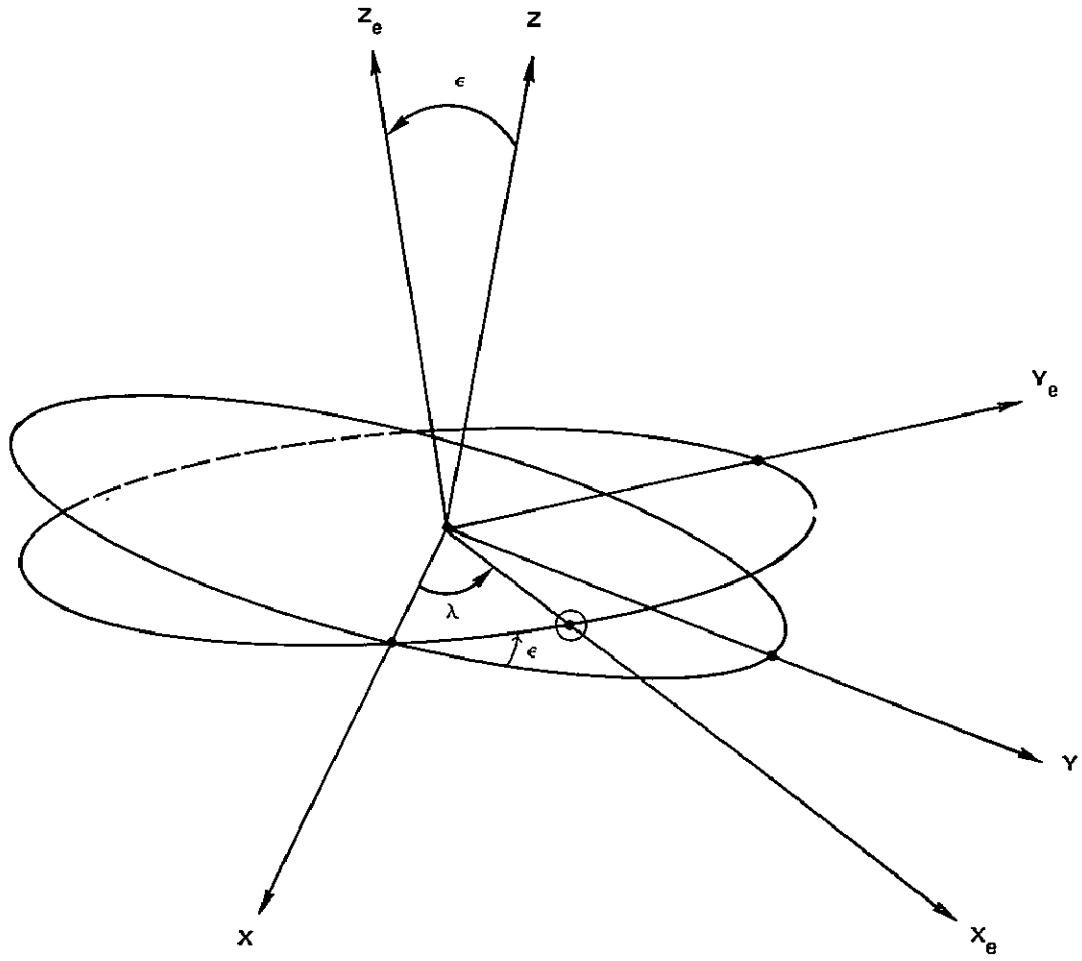


Figure C-3. GCI and Ecliptic Coordinate Systems

APPENDIX D

ATTITUDE ANGLES

D.1 RIGHT ASCENSION AND DECLINATION

The right ascension, α, and declination, δ, are used to specify the orientation of the spin axis of the spacecraft, $\hat{Z}$, in inertial space with reference to the GCI coordinate system (see Figure C-1). The ranges of validity of the angles are

$$\begin{aligned} 0^\circ \leq \alpha \leq 360^\circ \\ -90^\circ \leq \delta \leq 90^\circ \end{aligned} \tag{D-1}$$

with δ measured positively upward from the equatorial plane and α measured in a right-handed sense from the vernal equinox to the projection of $\hat{Z}$ on the equatorial plane.

D.2 PITCH AND ROLL ANGLES

The pitch, η, and roll, ϕ, angles specify the orientation of the spin axis of the spacecraft in the ecliptic coordinate system (see Figures C-2 and D-1). The ranges of validity of the angles are

$$\begin{aligned} 0^\circ \leq \phi \leq 360^\circ \\ -90^\circ \leq \eta \leq 90^\circ \end{aligned} \tag{D-2}$$

with η measured positively upward from the roll plane and ϕ measured in a right-handed rotational sense from the ecliptic North Pole (ENP) to the projection of $\hat{Z}$ on the roll plane.[1]

D.3 SUN'S NORTH POLE ROLL ANGLE

The Sun's North Pole roll angle, ϕ_n, is the phase angle measured from the projection of the Sun's North Pole roll vector on the roll plane to the projection of

[1] The pitch and roll angles are defined in accordance with hardware documentation. The pitch angle defined here is the negative of the OSO-7 pitch angle. The roll angle defined here is equal to 360 degrees minus the roll angle of OSO-7.

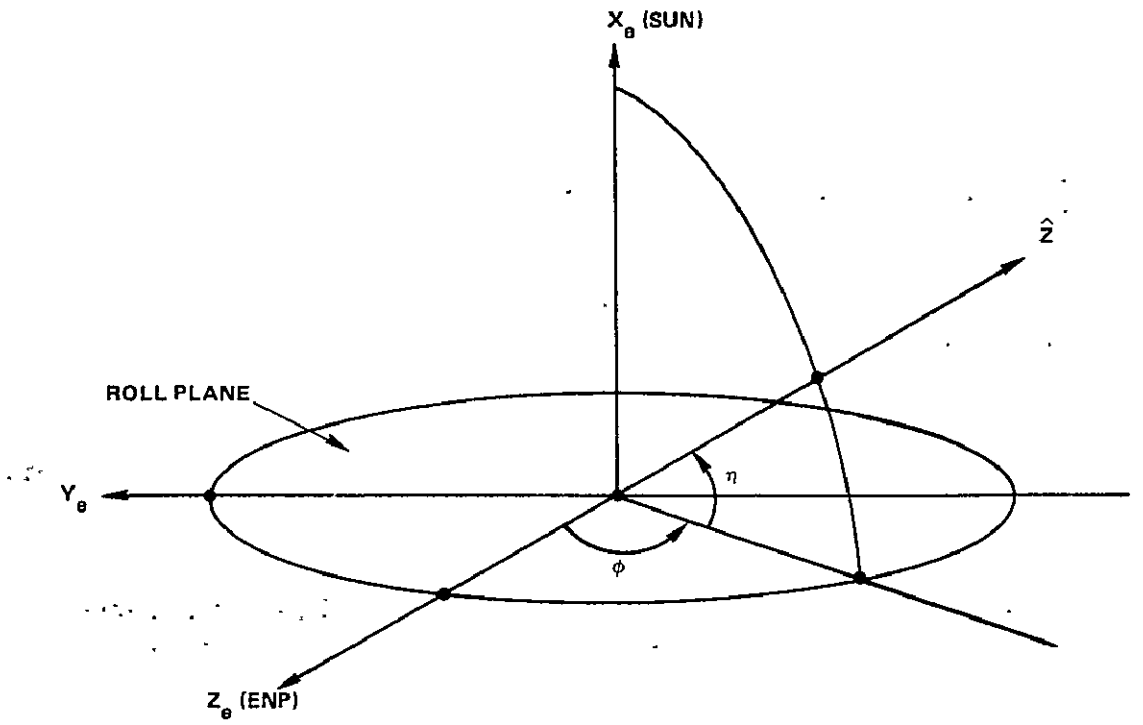


Figure D-1. Pitch and Roll Angles

the spin axis vector on the roll plane. The measurement is made in the counter-clockwise rotational sense, as shown in Figure D-2.

The Sun's North Pole roll angle can be computed as follows: The North Pole unit vector of the Sun, $\hat{N}$, is fixed in inertial space. Its right ascension is 286.0755 degrees and its declination is 63.82862 degrees. From Figure C-1, the components of $\hat{N}$ referenced to GCI are

$$N_1 = 0.12213025$$

$$N_2 = -0.42381120 \qquad \text{(D-3)}$$

$$N_3 = 0.89747882$$

The sun's north pole angle, ϕ_n, is the dihedral angle between $\hat{N}$ and $\hat{Z}$, as shown in Figure D-2.

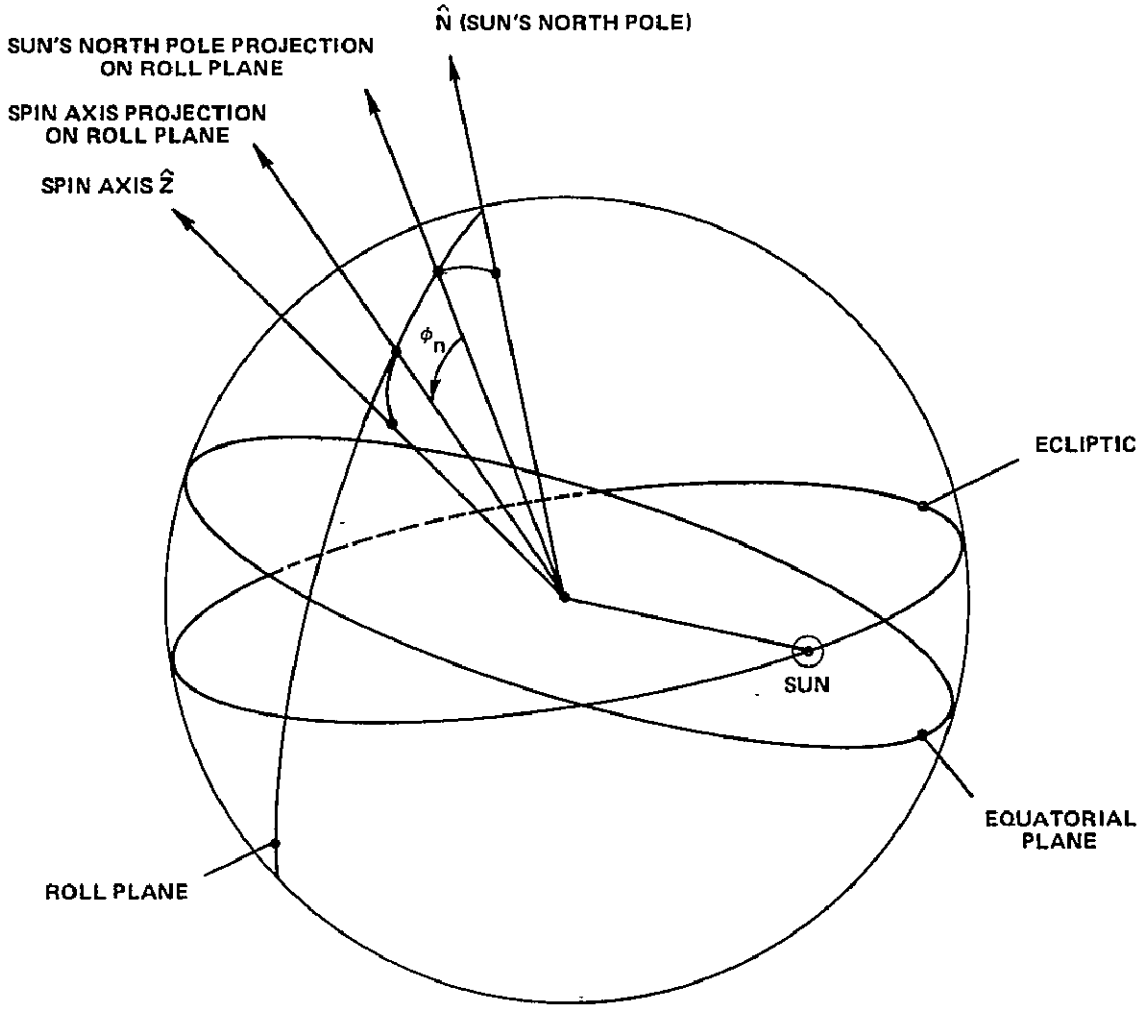


Figure D-2. Sun's North Pole Roll Angle, ϕ_n

APPENDIX E

INTERMEDIATE OUTPUT - DEBUG

The INTOUT array is used to specify levels of intermediate output. Each module providing intermediate output is assigned a position in the array. Into this position a level indicator of 0 to 10 may be input. The 0 specifies no intermediate output, and is the default; 10 specifies maximum intermediate output. Each level includes all lower levels of output. For example, a level of 3 also will produce intermediate output provided with levels 1 and 2. The INTOUT array is displayed on the Debug Display as shown in Figure E-1. The Debug Display can be reached by CALLing DEBUG. If INTOUT(1) is greater than zero the Debug Display will be displayed automatically after the last display viewed under the Input Option Menu. Some subroutines have Debug Displays. These are indicated with an asterisk in Figure E-1. Changes to the INTOUT numbers are permanent only if modified in the input section while the SAVE parameters on the Input Option Menu is Y (yes).

An asynchronous[1] call to BUGOFF changes all INTOUT numbers to zeroes (no debug) which again is permanent only when done in the input section while the SAVE parameter on the Input Option Menu is Y (yes).

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ********** 76.132.15.07.55  ******
**                                                                                    **
**    DEBUG              VARIABLE          SUBROUTINE     LEVEL          ZBDCWG2$   9  **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                  INTOUT(1)        DEBUG     : 0                                   **
**                  INTOUT(2)        INPUT     : 0                                   **
**                 *INTOUT(3)        ATTUDE    : 0                                   **
**                  INTOUT(4)        SOLAR     : 0                                   **
**                  INTOUT(5)        STATS     : 0                                   **
**                  INTOUT(6)        SATIN     : 0                                   **
**                  INTOUT(7)        UPDATE    : 0                                   **
**                  INTOUT(8)        TORQUE    : 0                                   **
**                 *INTOUT(9)        SATCON    : 0                                   **
**                  INTOUT(10)       SATOUT    : 0                                   **
**                  INTOUT(11)       INTGRT    : 0                                   **
**                  INTOUT(12)       SUMPNT    : 0                                   **
**                  INTOUT(13)       STNLOC    : 0                                   **
**                  INTOUT(14)       MGNTIC    : 0                                   **
**                  INTOUT(15)       GRAVTY    : 0                                   **
**                  INTOUT(16)       GRVTYS    : 0                                   **
**                  INTOUT(17)       VECTR1    : 0                                   **
**                  INTOUT(18)       VECTR2    : 0                                   **
**                  INTOUT(19)       GGTORK    : 0                                   **
**                  INTOUT(20)       AERO      : 0                                   **
**                  INTOUT(21)       TABLE     : 0                                   **
**                  INTOUT(22)       SATIN1    : 0                                   **
**                  INTOUT(23)       PLTDRI    : 0                                   **
**                  INTOUT(24)       GRVTYD    : 0                                   **
**                  INTOUT(25)                 : 0                                   **
**                  INTOUT(26)                 : 0                                   **
**                  INTOUT(27)                 : 0                                   **
**                  INTOUT(28)       XPITCH    : 0                                   **
**                  INTOUT(29)       XMAINT    : 0                                   **
**                  INTOUT(30)       HISGEN    : 0                                   **
**                  INTOUT(31)       STOCMD    : 0                                   **
**                 *INTOUT(32)       FOFTEE    : 0                                   **
**                 *INTOUT(33)       POINT     : 0                                   **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=DEBUG  WHAT NOW  ;NEXT        CALL DISPLAY:       DISP   1 OF   1  **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

Figure E-1. Debug Display.

```
**********************************  G E S S   V 2.1  **********************************
*************** ********************  D I S P L A Y  ********** 78.132.15.08.04 ******
**                                                                                    **
**    DEBUG              VARIABLE        SUBROUTINE    LEVEL            ZBDCWG2$  10   **
**                    *INTOUT(34)       COMTIM    : 0                                 **
**                    *INTOUT(35)       CONTIN    : 0                                 **
**                    *INTOUT(36)       PERIOD    : 0                                 **
**                    *INTOUT(37)       QPHASE    : 0                                 **
**                     INTOUT(38)       DPOINT    : 0                                 **
**                     INTOUT(39)       SPNFIX    : 0                                 **
**                     INTOUT(40)       GASMAN    : 0                                 **
**                     INTOUT(41)       SPNGAS    : 0                                 **
**                     INTOUT(42)       XOOMAC    : 0                                 **
**                    *INTOUT(43)       MACFIT    : 0                                 **
**                    *INTOUT(44)       PASGAS    : 0                                 **
**                     INTOUT(45)       XCOILS    : 0                                 **
**                     INTOUT(46)       XPOINT    : 0                                 **
**                    *INTOUT(47)       ATMAIN    : 0                                 **
**                     INTOUT(48)       PITCON    : 0                                 **
**                     INTOUT(49)       DPITCH    : 0                                 **
**                     INTOUT(50)       DMAINT    : 0                                 **
**                     INTOUT(51)       XCLIST    : 0                                 **
**                     INTOUT(52)       CNLIST    : 0                                 **
**                     INTOUT(53)       KNLIST    : 0                                 **
**                     INTOUT(54)       HNLIST    : 0                                 **
**                     INTOUT(55)       XGAS      : 0                                 **
**                     INTOUT(56)       XINDEP    : 0                                 **
**                     INTOUT(57)       FPTCAL    : 0                                 **
**                     INTOUT(58)       FOTCAL    : 0                                 **
**                     INTOUT(59)       QOTCAL    : 0                                 **
**                     INTOUT(60)       XROLL     : 0                                 **
**                     INTOUT(61)       DROLL     : 0                                 **
**                     INTOUT(62)       SLOWRO    : 0                                 **
**                     INTOUT(63)       ROLCNT    : 0                                 **
**                     INTOUT(64)       ROLMIN    : 0                                 **
**                     INTOUT(65)       ROLMON    : 0                                 **
**                     INTOUT(66)       ROLSTR    : 0                                 **
**                     INTOUT(67)       GASERR    : 0                                 **
**                     INTOUT(68)       SPNERR    : 0                                 **
**                     INTOUT(69)       COLEST    : 0                                 **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=DEBUG  WHAT NOW  :NEXT        CALL DISPLAY:      DISP   1 OF   1    **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************  D I S P L A Y  **********************************
```

Figure E-1. Debug Display.
(continued)

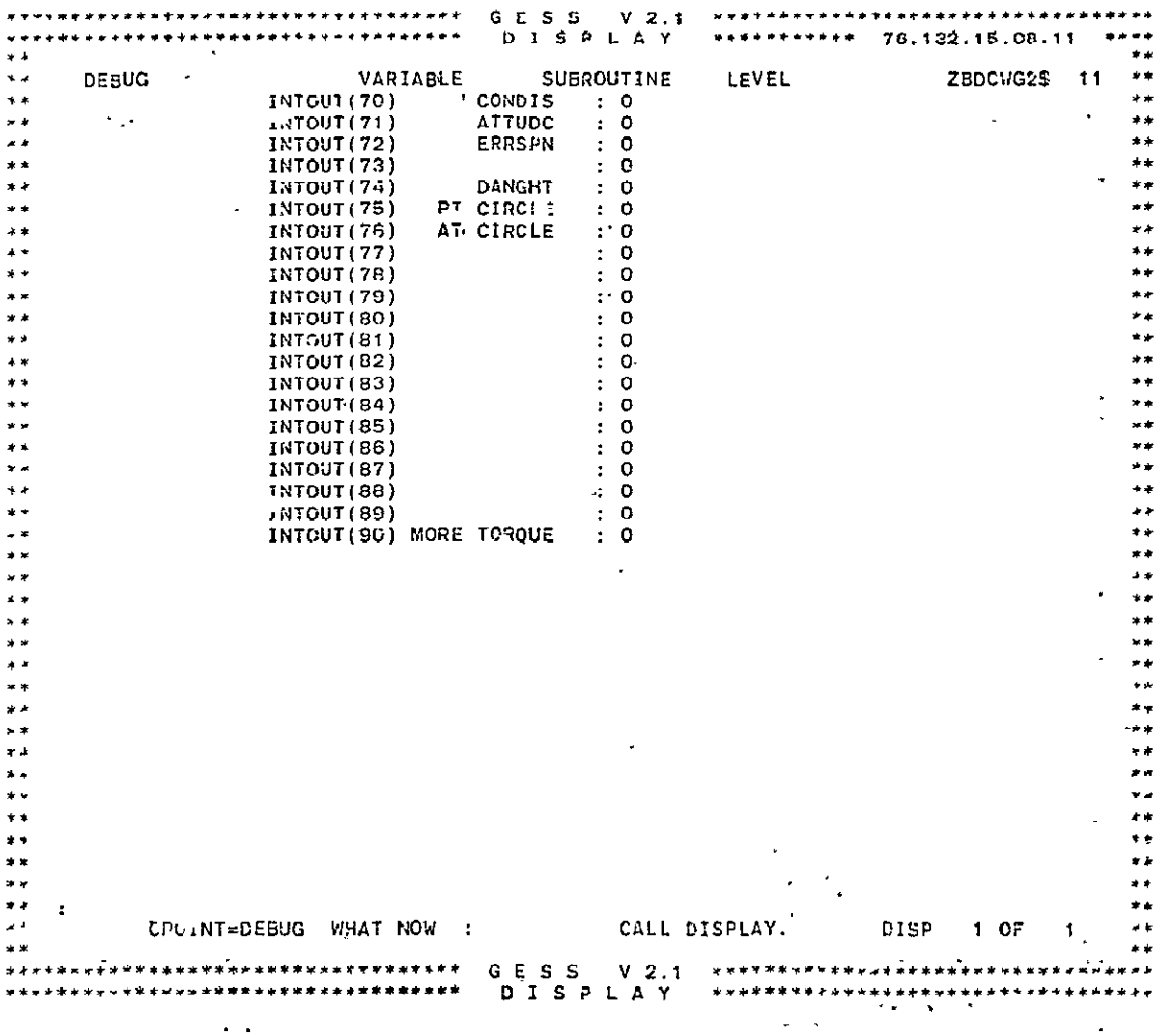
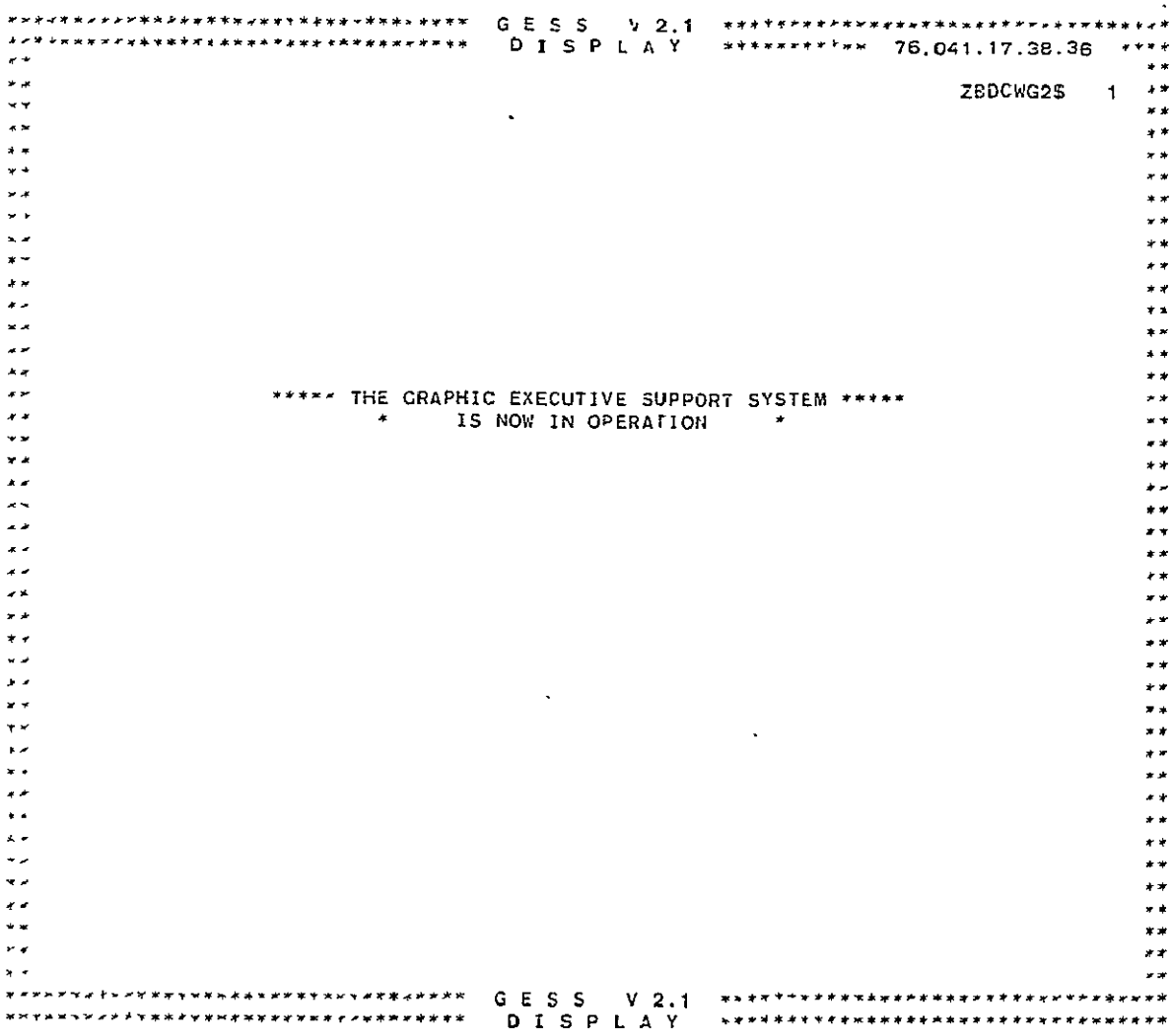


Figure E-1. Debug Display.
(concluded)

APPENDIX F

SAMPLE RUN

The following is a sample run showing a point-to-point control.



```
GESS V 2.1
DISPLAY  76.041.17.38.38

                                                ZBDCWG2$   2


                    M077 NO PLOT TAPE PROVIDED
            REQUESTS FOR HARD COPY OF PLOTS WILL BE IGNORED


GESS V 2.1
DISPLAY
```

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y   **********  76 041.17.38.43  ****
**                                                          **
**    XSTOPS                    DISPLAY STATUS FLAGS        ZBDCWG2S   3  **
**    DISPLAY XSTOPS                      PRINT                          **
**    DISPLAY MASTER NUMBERS-CALL SETUP   .PRINT                         **
**    DISPLAY DINPUT-CALL INDIS           .STOP                          **
**    DISPLAY DOPTN-CALL CONDIS           .STOP                          **
**    DISPLAY DOUTPT-CALL OUTDIS          .STOP                          **
**    DISPLAY DATSUM                      .STOP                          **
**    DISPLAY DATSM2                      .STOP                          **
**    DISPLAY DSTAT                       .STOP                          **
**    DISPLAY DINDEP                      .STOP                          **
**    DISPLAY DDEP                        .STOP                          **
**    DISPLAY DPOINT                      .STOP                          **
**    DISPLAY DPITCH                       STOP                          **
**    DISPLAY DMAINT                       STOP                          **
**    DISPLAY DROLL                        STOP                          **
**    DISPLAY DCOILS                      .STOP                          **
**    DISPLAY DCLIST                       STOP                          **
**    DISPLAY DOOMAC                      .STOP                          **
**    DISPLAY DGAS                        .STOP                          **
**    DISPLAY DEBUG                       .STOP                          **
**    DISPLAY PLTX1Y                      .STOP                          **
**    DISPLAY PLTX2Y                      .STOP                          **
**                                                                       **
**                                                                       **
**                                                                       **
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**                                                                       **
**                                                                       **
**  :                                                                    **
**        CPOINT=MSADE1 WHAT NOW  :          CALL DISPLAY:      DISP  1 OF  1  **
**                                                                       **
**********  G E S S   V 2.1  **********
**********  D I S P L A Y   **********
```

```
*********************************** G E S S  V 2.1 ***********************************
*********************************** D I S P L A Y  ***********  76 041.17.38.44 ****
**                                                                                 **
**    ARTCOM                          MASTER NUMBERS              ZBDCWG2S    4    **
**    SCROLLED ARRAYS                           :   34                             **
**    ATTITUDE SUMMARY ARRAYS                   :  250                             **
**    POINT TO POINT COMMAND ARRAYS                 20                             **
**    PITCH CONTROL COMMAND ARRAYS              :   10                             **
**    ATTITUDE MAINTENANCE COMMAND ARRAYS           10                             **
**    ROLL RATE ARRAYS                          .   10                             **
**    LINE NUMBERS                              .  900                             **
**    SWITCHING FUNCTION ARRAYS                 .  200                             **
**    CIRCLE ARRAYS                             :  180                             **
**    COMMAND SPECIFICATIONS TABLE                 200                             **
**    QOMAC COMMAND ARRAYS                      :   32                             **
**    COIL HISTORY TABLE                        .   30                             **
**    GAS HISTORY TABLE                         :   50                             **
**    F(T) AND Q(T) PLOT ARRAYS                 :  400                             **
**    STATION LIST                              .  150                             **
**                                                                                 **
**  :                                                                              **
**         CPOINT=ARTCMM WHAT NOW  :          CALL DISPLAY:        DISP   1 OF   1 **
**                                                                                 **
*********************************** G E S S  V 2.1 ***********************************
*********************************** D I S P L A Y  ***********************************
```

```
**********-********** G E S S  V 2.1 **********-**********
**********-********** D I S P L A Y **********  76.041.17.39.09  ****
**                                                              **
**  DINPUT                    INPUT OPTION MENU          ZBDCWG2S   5  **
**                                                              **
**                                                              **
**  FUNCTION KEYS(** IS CURRENT DISPLAY)-                       **
**                                                              **
**    KEY 0 ARRAY ALLOCATION(ARTCOM)                            **
**  **KEY 1 INPUT OPTION MENU(DINPUT)                           **
**    KEY 2 CONTROL OPTION MENU(DOPTN)                          **
**    KEY 3 OUTPUT OPTION MENU(DOUTPT)                          **
**    KEY 4 TERMINATION                                         **
**                                                              **
**                                                              **
**  INPUTS-                                                     **
**    READ NAMELIST                    :Y                       **
**      NAMELIST SELECTION OPTION      :                        **
**                                                              **
**    READ STATION TIMES               :N                       **
**    READ ATTITUDE SOLUTIONS          .Y                       **
**                                                              **
**                                                              **
**  DISPLAYS-                                                   **
**    S/C INDEPENDENT PARAMETERS (DINDEP)  .Y                   **
**    S/C DEPENDENT PARAMETERS (DDEP)      .Y                   **
**    EXPERIMENT PARAMETERS(DEXP)          .N                   **
**    STATION COVERAGE(DSTAT)               Y                   **
**                                                              **
**                                                              **
**  OPTIONS-                                                    **
**    SAVE PARAMETERS FOR REINITIALIZATION .Y                   **
**    REINITIALIZE FROM STORED PARAMETERS  :N                   **
**                                                              **
**                                                              **
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**                                                              **
**    .    CPOINT=INDRI1 WHAT ..OW  :S        CALL DISPLAY.     DISP   1 OF   1   **
**                                                              **
**********-********** G E S S  V 2.1 **********-**********
**********-********** D I S P L A Y **********-**********
```

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.041.17 39.29  ****
**                                                          **
**   DINDEP          SATEL .TE INDEPENDENT NAMELIST DISPLAY      ZBDCWG2$   6  **
**                                                          **
**     PREDICTOR START TIME (YYMMDDHHMMSS)  . 760301000000.                    **
**     PREDICTOR STOP TIME  (YYMMDDHHMMSS)    760303000000.                    **
**     INITIAL RIGHT ASCENSION (DEG)            70.000000                      **
**     INITIAL DECLINATION (DEG)            .   10.000000                      **
**     INITIAL SPIN RATE (RPM)              .    6.000000                      **
**                                                                             **
**   ORBITAL ELEMENTS -                                                        **
**     EPOCH TIME (YYMMDDHHMMSS.)           : 760227000000.                    **
**     SEMI-MAJOR AXIS (KM)                 : 6927 757813                      **
**     ECCENTRICITY                         :    0 000460                      **
**     INCLINATION (DEG)                    :   32 937988                      **
**     MEAN ANOMALY (DEG)                       0.0                            **
**     ARGUMENT OF PERIGEE                  .   30.023987                      **
**     RIGHT ASC OF ASCENDING NODE (DEG)    .    0.0                           **
**                                                                             **
**   APCS PARAMETERS                                                           **
**     NUMBER OF INTEGRATIONS PER ORBIT     :    3                            **
**     NUMBER OF OUTPUT POINTS PER ORBIT    :   19                            **
**     TORQUE COMPUTATION STEP SIZE (SEC)   :   60                            **
**                                                                             **
**   TORQUES -                                                                 **
**     MAGNETIC (Y,N)                       :Y                                 **
**     GRAVITY  (Y,N)                       :Y                                 **
**     AEROM    (Y,N)                       :N                                 **
**     SOLAR    (Y,N)                       :Y                                 **
**     MAXIMUM ALTITUDE FOR AERO (KM)       :10000.000000                      **
**     BROUWER DRAG TERM (RAD/SEC**2)       :    0.0                           **
**     AERO DRAG COEFFICIENT                :    2.400000                      **
**                                                                             **
**   IO UN.TS -                                                                **
**     PRINTED OUTPUT                       :    6                            **
**     STATION FILE                         .   35                            **
**     ORBIT FILE                           :    0                            **
**     ATTITUDE FILE OUTPUT                 .    0                            **
**     CARD INPUT                           :   50                            **
**                                                                             **
**  :                                                                          **
**        CPOINT=YINDEP WHAT NOW  .WEXT       CALL DISPLAY:      -DISP   1 OF   1    **
**                                                          **
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

```
******************************************* G E S S  V 2 1  **************************************
******************************************* D I S P L A Y   ************ 76.041.17.39.31  ****
**                                                                                          **
**.   DINDEP            SATELLITE INDEPENDENT NAMELIST DISPLAY          ZBDCWG2S    7       **
**      INTERMEDIATE OUTPUT                  .    6                                         **
**      ERROR MESSAGE FILE                       12                                         **
**      ERROR MESSAGE OUTPUT                 :   13                                         **
**      COMMAND LIST FILE                    .    0                                         **
**                                                                                          **
**                                                                                          **
**                                                                                          **
**                                                                                          **
**    PREDICTOR TIME IS                         760301000000                               -**
**                                                                                          **
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**  :                                                                                       **
**         CPOINT=YINDEP WHAT NOW  :W        CALL DISPLAY:       DISP   1 OF   1            **
**                                                                                          **
******************************************* G E S S  V 2.1  ************************************
******************************************* D I S P L A Y   ************************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********  76.041.17.39.36  ****
**                                                        **
**   DDEP          SATELLITE DEPENDENT NAMELIST DISPLAY     ZBDCWG2S   8  **
**                                                        **
**   SATELLITE PARAMETERS -                               **
**     WHEEL MASS (LB)                  1663.188965       **
**     WHEEL X MOI (SLUG-FT**2)          212.000000       **
**     WHEEL Y MOI (SLUG-FT**2)          230.000000       **
**     WHEEL Z MOI (SLUG-FT**2)          438.000000       **
**     SAIL MASS (LB)                    610.264893       **
**     SAIL X MOI (SLUG-FT**2)            57.000000       **
**     SAIL Y MOI (SLUG-FT**2)            51.000000       **
**     SAIL Z MOI (SLUG-FT**2)            38.000000       **
**     WHEEL CENTER OF MASS (IN)          16.099991       **
**     SAIL CENTER OF MASS (IN)           47.479996       **
**     COMPOSITE CENTER OF MASS (IN)      24.700000       **
**     CP-CM OFFSET (IN)                  38.519989       **
**     SAIL SPINS AT NIGHT (Y,N)         :N               **
**     DAY/NIGHT SPINRATE RATIO           1.910000        **
**     SPACECRAFT Z-MAGNETIC BIAS (P-CM)  1800.000000     **
**     SAIL X-MAGNETIC BIAS (P-CM)        1400.000000     **
**     SAIL Y-MAGNETIC BIAS (P-CM)        1400.000000     **
**                                                        **
**   PRECESSION COIL -                                    **
**     STRENGTH PER INCREMENT (MA)        5.000000        **
**     MAX NUMBER OF INCREMENTS           15              **
**                                                        **
**   PRECESSION JETS -                                    **
**     NOMINAL ANG MOTION/INCREMENT(DEG)  0.250000        **
**     PITCH MOTION PER GAS INCREMENT                     **
**          OF ROLL MOTION                0.0             **
**     SPINRATE CHANGE PER GAS INCREMENT                  **
**          OF PRECESSION MOTION          0.0             **
**                                                        **
**   SPIN RATE CONTROL                                    **
**     RPM CHANGE PER COMMAND INCREMENT   0.008864        **
**     RATE UPPER LIMIT VALUE (RPM)       10.000000       **
**     RATE LOWER LIMIT VALUE (RPM)       1.000000        **
**     CHANGE SPIN RATE BY(RPM) AT LIMIT  2.000000        **
**                                                        **
**  :                                                     **
**       CPOINT=YDEP   WHAT NOW  :WEXT      CALL DISPLAY.     DISP  1 OF  1  **
**                                                        **
**********  G E S S   V 2.1  **********
**********  D I S P L A Y  **********
```

```
G E S S   V 2.1
D I S P L A Y                                   76.041.17.39.50

DDEP              SATELLITE DEPENDENT NAMELIST DISPLAY          ZBDCWG2$   9

PITCH ANGLE CONSTRAINTS -
  PITCH UPPER LIMIT (DEG)                .     3.000000
  PITCH LOWER LIMIT (DEG)                     -3.000000
  ACTIVATE AT PITCH UPPER LIMIT (DEG)    .     3.000000
  ACTIVATE AT PITCH LOWER LIMIT (DEG)    :    -3.000000
  CHANGE PITCH AT LIMIT BY (DEG)         .     0.500000

OUTPUT PRINT OPTIONS
  REGULAR OUTPUT (Y.N)                  :N
  ASCENDING NODE (Y.N)                  .Y
  COIL EVENT     (Y.N)                  .N
  STATION AOS    (Y.N)                  .N

CONTROL OPTIONS
  COMMANDS START AT STATION AOS (Y.N)   :N
  CONSIDER ENVIRONMENTAL TORQUES        :Y

ROLL RATE MONITORING
  MAXIMUM ROLL RATE              DEGREES      0.100000
                               PER MINUTES .  96.000000
  STEP SIZE (MIN)                       .    96.000000
  CHECK ROLL RATE AT STATION AOS        :N

MAGNETIC CONTROL PARAMETERS
  MILLAMPERES TO POLE-CM CONVERSION     .  567.000000
  SWITCHING FUNCTION STEPSIZE (SEC)     :   60
  STEPSIZE FOR COMPUTING FIT (SEC)      :   60.000000

     CPOINT=YDEP   WHAT NOW  .W          CALL DISPLAY:       DISP   1 OF   1

G E S S   V 2 1
D I S P L A Y
```

```
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   ********** 76.041.17.40.00  *****
**                                                                                    **
**    DDEP                SATELLITE DEPENDENT NAMELIST DISPLAY          ZBDCWG2$  10  **
**      NUMBER OF STANDARD DEVIATIONS                                                 **
**        FOR QOMAC/CONTINUOUS COMMANDS       :    3.000000                         **
**      MAXIMUM QOMAC PERIOD (MIN)            .   32.000000                         **
**      PERIOD GRANULARITY (MIN)              :    0.016000                         **
**      MAXIMUM QOMAC PHASE (MIN)             :   32.000000                         **
**      PHASE GRANULARITY (MIN)               .    0.260000                         **
**      MAXIMUM NUMBER OF ASYMMETRIC ENTRIES  :   32                                  **
**                                                                                    **
**    PNEUMATIC CONTROL PARAMETERS                                                    **
**      MAX NUMBER OF SPIN GAS INCREMENTS     :   63                                  **
**      MAX NUMBER PITCH/ROLL GAS INCREMENTS  :   16                                  **
**      SPINRATE USED FOR GAS CONTROL                                                 **
**        PARAMETER CALIBRATION               :    6.000000                         **
**                                                                                    **
**                                                                                    **
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**  :                                                                                 **
**         CPOINT=YDEP    WHAT NOW    W          CALL DISPLAY:       DISP   1 OF   1  **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
**********************************   D I S P L A Y   **********************************
```

```
                    G E S S   V 2.1
                      D I S P L A Y          76.041.17.40.09

   DOPTN                        CONTROL OPTION MENU                  ZBDCWG2$  11

   FUNCTION KEYS(** IS CURRENT DISPLAY)-
     KEY 0 ARRAY ALLOCATION(ARTCOM)
     KEY 1 INPUT OPTION MENU(DINPUT)
   **KEY 2 CONTROL OPTION MENU(DOPTN)
     KEY 3 OUTPUT OPTION MENU(DOUTPT)
     KEY 4 TERMINATION

   CONTROL MODES-
     POINT TO POINT                    Y
     PITCH CONTROL                    .N
     ATTITUDE MAINTENANCE              N
     ROLL RATE MINIMIZATION           :N

   DISPLAYS-
     COMMAND LIST (DCLIST)            :N
     QOMAC COMMAND TABLE (DQOMAC)     :N
     COIL TABLE (DCOILS)              :N
     GAS TABLE (DGAS)                  N

   OPTIONS-
     ESTIMATE COIL STRENGTH           :N
     MONITOR ROLL RATE                :N
     READ COMMAND LIST                :N
     AUTOMATIC PITCH VIOLATION CORRECTION :N
     AUTOMATIC EXECUTION              :N
       (FINAL DISPLAYS ONLY)

   :
       CPOINT=CONDR1 WHAT NOW  :W          CALL DISPLAY        DISP   1 OF   1

                    G E S S   V 2.1
                      D I S P L A Y
```

```
G E S S   V 2 1
D I S P L A Y                                   76 041 17.40 14

DPOINT                 POINT TO POINT CONTROL TABLE                ZBDCWG2S  12

DISPLAY CONTROL
  REDISPLAY (Y=YES N=NO,C=CLEAR TABLE)  N
  RECALL LINE NUMBER                    . 0

CONTROL SPECIFICATION
  CONTROL FLAG (F)                      :
     F = FLAGGED    . = UNFLAGGED
  CONTROL TYPE (T)                      :0
     T = 1  - CONTINUOUS
     T = 2  - QUMAC
     T = 3  - OPTIMAL
     T = 4  - PNEUMATIC
  CONTROL START TIME (YYMMDDHHMMSS)     .          0.
  CONTROL STOP TIME  (YYMMDDHHMMSS)     :          0.
  DESIRED RIGHT ASCENSION (DEG)         :  0 0
  DESIRED DECLINATION (DEG)             :  0 0
  TOLERANCE ON FINAL ATTITUDE (DEG)     .  0.0
  NORMAL LEG LENGTH (DELT1 - MIN)       :    0.
  NORMAL COIL CURRENT (CR1 - MA)           0.

ZONE OF REDUCED MOTION
  MULTIPLE OF EXPECTED CHANGE USED TO   1 0
     SELECT THE REDUCED VALUES (MLT)
  REDUCED LEG LENGTH (DELT2 - MIN)      :    0.
  REDUCED COIL CURRENT (CR2 - MA)          0.

      START TM  STOP TM   DES      DES     TOL   DELT1  CR1       DELT2  CR2
  F T DD HH.MM DD HH.MM  RTASC    DECL   (DEG)  (MIN) (MA) MLT   (MIN) (MA)
  . 2 01 00.00 02 00.00  80.000   5.000 0 200   480.  75. 1.0    60.  50.

       CPOINT=YPOINT WHAT NOW  :W          CALL DISPLAY:       DISP   1 OF   1

G E S S   V 2.1
D I S P L A Y
```

```
************************************  G E S S   V 2.1  ************************************
************************************  D I S P L A Y    ***********  76.041.17 40.39  ****
**                                                                                      **
**                                                                  ZBDCWG2S   14       **

                                  END OF CONTROL LEG
                                  HAS BEEN REACHED

                                  SKIP TO OUTPUT MENU

**   :M160 SATCO1 WAS THE LAST CONTROL POINT PASSED.                                    **
**          CPOINT=SATCO1 WHAT NOW              CALL DISPLAY                            **
**                                                                                      **
************************************  G E S S   V 2 1  ************************************
************************************  D I S P L A Y    ************************************
```

```
**********************************  G E S S   V 2.1  ***********************************
*********************************  D I S P L A Y  ********** 76.041.17.40 50 *****
**                                                                              **
**   DOUTPT                        OUTPUT OPTION MENU              ZBDCWG2S  16 **
**                                                                              **
**                                                                              **
**   FUNCTION KEYS(* IS CURRENT DISPLAY)-                                       **
**                                                                              **
**     KEY 0 ARRAY ALLOCATION(ARTCOM)                                           **
**     KEY 1 INPUT OPTION MENU(DINPUT)                                          **
**     KEY 2 CONTROL OPTION MENU(DOPTN)                                         **
**   **KEY 3 OUTPUT OPTION MENU(DOUTPT)                                         **
**     KEY 4 TERMINATION                                                        **
**                                                                              **
**                                                                              **
**   DISPLAYS-                                                                  **
**     ATTITUDE SUMMARY                    .Y                                   **
**     ATTITUDE SUMMARY #2                 :Y                                   **
**     COMMAND LIST (DCLIST)               :Y                                   **
**     QOMAC COMMAND TABLE (DOOMAC)        :Y                                   **
**     COIL TABLE (DCOILS)                 .Y                                   **
**     GAS TABLE (DGAS)                    :Y                                   **
**                                                                              **
**                                                                              **
**   PLOT OPTIONS-                                                              **
**     X AXIS                              . 0                                  **
**     FIRST Y AXIS                        . 0                                  **
**     SECOND Y AXIS                       : 0                                  **
**                                                                              **
**     WHERE                                                                    **
**      1 = TIME                                                                **
**      2 = RIGHT ASCENSION                                                     **
**      3 = DECLINATION                                                         **
**      4 = PITCH                                                               **
**      5 = ROLL                                                                **
**      6 = SPIN. RATE                                                          **
**      7 = FINAL PITCH                                                         **
**      8 = ROLL RATE                                                           **
**      9 = F(T)                                                                **
**     10 = Q(T)                                                                **
**                                                                              **
**                                                                              **
**        CPOINT=OUTDR1 WHAT NOW  .WEXT       CALL DISPLAY:       DISP   1 OF   1 **
**                                                                              **
**********************************  G E S S   V 2.1  ***********************************
*********************************  D I S P L A Y  ***********************************
```

```
                                  G E S S   V 2.1
                                  D I S P L A Y                    76.041.17.40.58

 W DOUTPT                          OUTPUT OPTION MENU                      ZBDCWG2S  17
     11 = POINT TOLERANCE
     12 = MAINT TOLERANCE

    WRITE COMMAND LIST                        :N

    WRITE ATTITUDE SUMMARY                     N
    PRINTER PLOTS WITH SUMMARY                .N


    WRITE ATTITUDE TAPE                        N
      INTERPOLATION STEPSIZE (SEC)            :    0
        0 = DO NOT INTERPOLATE

          CPOINT=OUTDR1 WHAT NOW  W          CALL DISPLAY:        DISP   1 OF   1

                                  G E S S   V 2.1
                                  D I S P L A Y
```

G E S S V 2.1
D I S P L A Y 76.041.17.41.16

DATSUM ATTITUDE SUMMARY TABLE #1 ZBDCWG2S 18

TYPE OF CHANGE CAUSING OUTPUT
0 = REGULAR
1 = Z-COIL SETTING
2 = SPIN COMMAND
3 = PITCH COMMAND
4 = ROLL COMMAND
5 = STATION AOS
6 = PREDICTOR END TIME
7 = ASCENDING NODE
* ROLL PATE IN DEG/DAY

TIME MM.DD HH MM SS	RT ASC (DEG)	DECLIN (DEG)	SPINRT (RPM)	PITCH (DEG)	ROLL (DEG)	*ROLL RATE	ZETA (DEG)	D N	T Y	STAT NAME
03.01.00 00.00	70 00	10 00	6.00	0 65	257.94	0.0	90.00	N	0	
03.01 01 00.52	70.33	10 06	6.00	0.36	257 96	0 34	10.83	D	7	
03.01.02 36.28	70.85	10.10	6.00	-0 10	257 93	-0.44	10.40	D	7	
03 01.04 12.04	71.41	10 17	6.00	-0.58	257.93	-0.02	9.96	D	7	
03 01.05.46.48	72 02	10 24	5.99	-1.12	257.92	-0.17	9 48	D	7	
03 01.07.22.24	72 70	10 29	5 99	-1.73	257.88	-0.62	8 96	D	7	
03 01.08.00.00	73.02	10.24	5.99	-2.01	257.80	-3.10	8.68	N	0	

CPOINT=DATSUM WHAT DW :W CALL DISPLAY DISP 1. OF 1

G E S S V 2.1
D I S P L A Y

```
G E S S   V 2.1
D I S P L A Y                                   76.041.17.41.19

DATSM2                    ATTITUDE SUMMARY TABLE  #2                ZBDCWG2S  19

TYPE OF CHANGE CAUSING OUTPUT
  0 = REGULAR
  1 = Z-COIL SETTING
  2 = SPIN COMMAND
  3 = PITCH COMMAND
  4 = ROLL COMMAND
  5 = STATION AOS
  6 = PREDICTOR END TIME
  7 = ASCENDING NODE

          TIME       RT.ASC   DECLIN    SPINRT    PITCH     ROLL      SNPR
     MM.DD.HH.MM.SS   (DEG)    (DEG)    (RPM)     (DEG)     (DEG)     (DEG)
     03.01 00.00.00    70.00    10.00     6 000     0.65    257.94    258 57
     03.01 01.00.52    70 33    10.06     5 999     0.36    257.96    258.58
     03.01.02.36 28    70.85    10.10     5.998    -0.10    257.93    258.54
     03.01.04.12.04    71.41    10.17     5 996    -0.58    257.93    258.53
     03 01.05 46.48    72.02    10.24     5 994    -1.12    257.92    258.51
     03 01.07.22 24    72.70    10.29     5.993    -1.73    257.88    258.46
     03.01.08.00.00    73 02    10 24     5 992    -2.01    257.80    258.38

        CPOINT=DATSM2 WHAT NOW  .W          CALL DISPLAY:       DISP   1 OF   1

G E S S   V 2.1
D I S P L A Y
```

```
GESS V2.1 DISPLAY 76.041.17.41.26
DCLIST                          COMMAND LIST                    ZBDCWG2S  20

DISPLAY CONTROL
  REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N
  RECALL LINE NUMBER                   :   0
  EXPAND LINE NUMBER (QOMAC CMDS ONLY) :   0

COMMAND SPECIFICATIONS
  COMMAND FLAG                        :.
    F=FLAGGED  .=UNFLAGGED
  COMMAND TYPE                        :.
    C =CONTINUOUS Q =QOMAC   T =OPTIMAL
    PP=PITCH +    RP=ROLL+   SP=SPIN +
    PM=PITCH -    RM=ROLL-   SM=SPIN -
  COMMAND START TIME (YYMMDDHHMMSS)    :          0.
  QOMAC PHASE (MINUTES)                :   0 0
  QOMAC PERIOD (MINUTES)               :   0.0
  MAGNETIC COIL CURRENT (MILLIAMPS)    :   0.0
  CHANGE IN PITCH OR ROLL ANGLE (DEG)      0.0
  CHANGE IN SPIN RATE (RPM)            .   0.0
  STATION NAME                         .

 FLAG LINE TYPE COMMAND STRT TIME PHASE  CURR  PER. ATT-CHG SPN-CHG STAT.
      NMBR      YY MM DD.HH.MM.SS (MIN)  (MA) (MIN)  (DEG)   (RPM)  NAME
.       1 C    76 03 01.00.00.00   0 0 -75.0   0.0    0 0     0 0
:       2 C    76 03.01.08.00 00   0 0   0.0   0.0    0 0     0.0

:
       CPOINT=YCLIST WHAT NOW  .W          CALL DISPLAY:       DISP   1 OF   1
GESS V2.1 DISPLAY
```

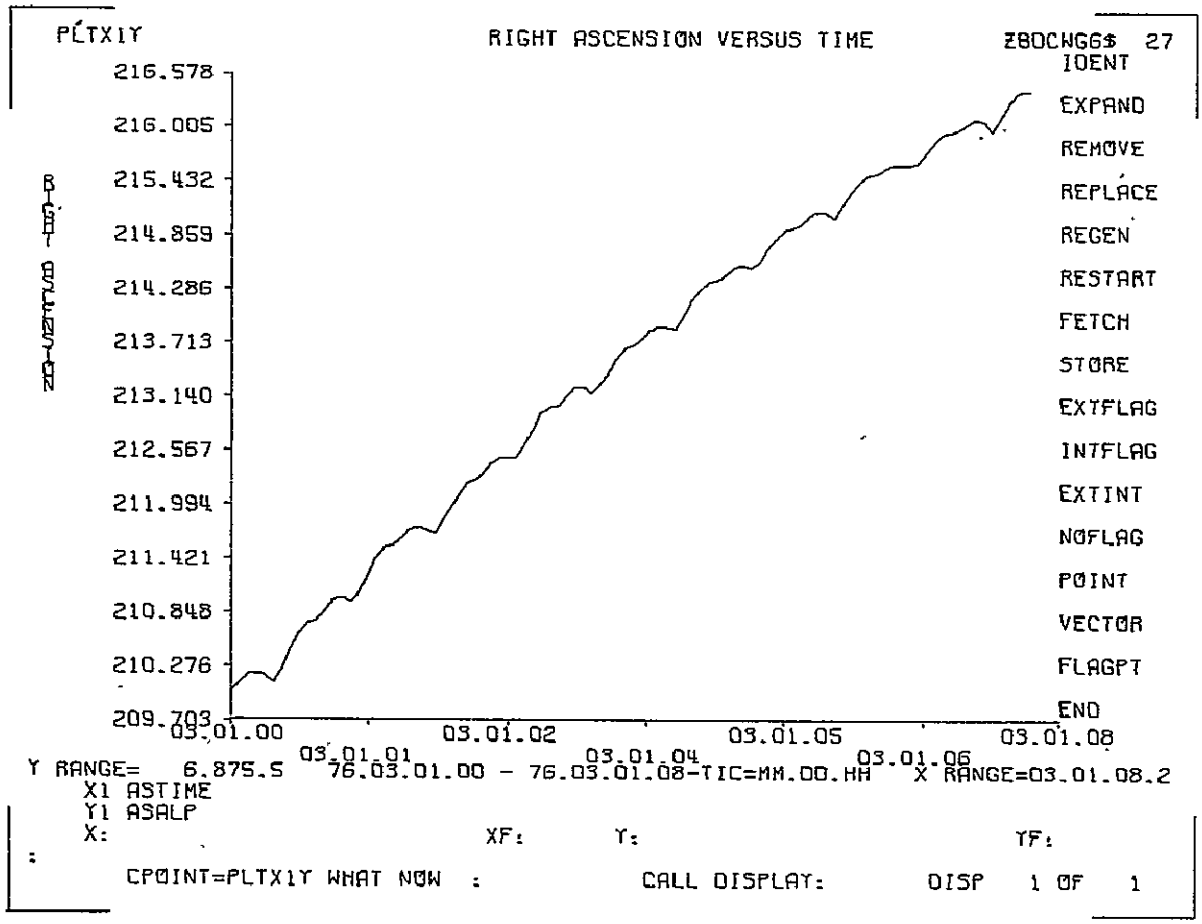
```
**********************************  G E S S   V 2 1  **********************************
*********************************   D I S P L A Y   ********** 76.041.17.41.28  *******
**                                                                                    **
**    DCOILS                              COIL TABLE                    ZBDCWG2$  21   **
**    DISPLAY CONTROL                                                                 **
**      REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N                                       **
**      RECALL LINE NUMBER                   :   0                                    **
**                                                                                    **
**    TABLE ENTRY-                                                                    **
**       FLAG (.,F)                          .                                        **
**       TIME (YYMMDDHHMMSS )                :999999999999.                           **
**       CURRENT (MA)                        .  0                                     **
**                                                                                    **
**           FLAG          LINE                    TIME              CURRENT         **
**                        NUMBER          YY MM.DD HH.MM.SS            (MA)          **
**           ..              1           76.03.01 00.00.00            -75.           **
**           ..              2           76.03.01.08.00.00              0.           **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**                                                                                    **
**  :                                                                                 **
**         CPOINT=YCOILS WHAT NOW  :W          CALL DISPLAY.       DISP   1 OF   1    **
**                                                                                    **
**********************************  G E S S   V 2.1  **********************************
*********************************   D I S P L A Y   **********************************
```

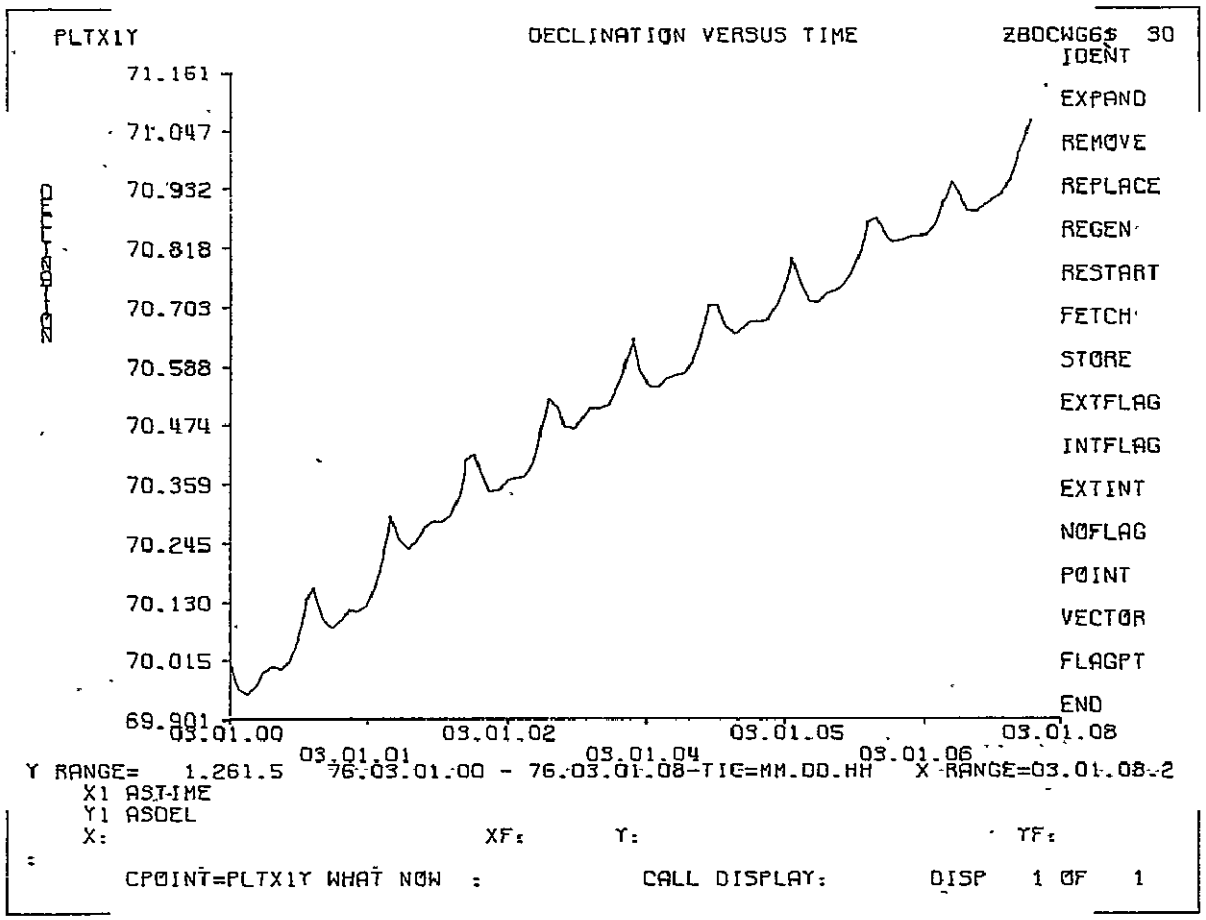
ORIGINAL PAGE IS
OF POOR QUALITY

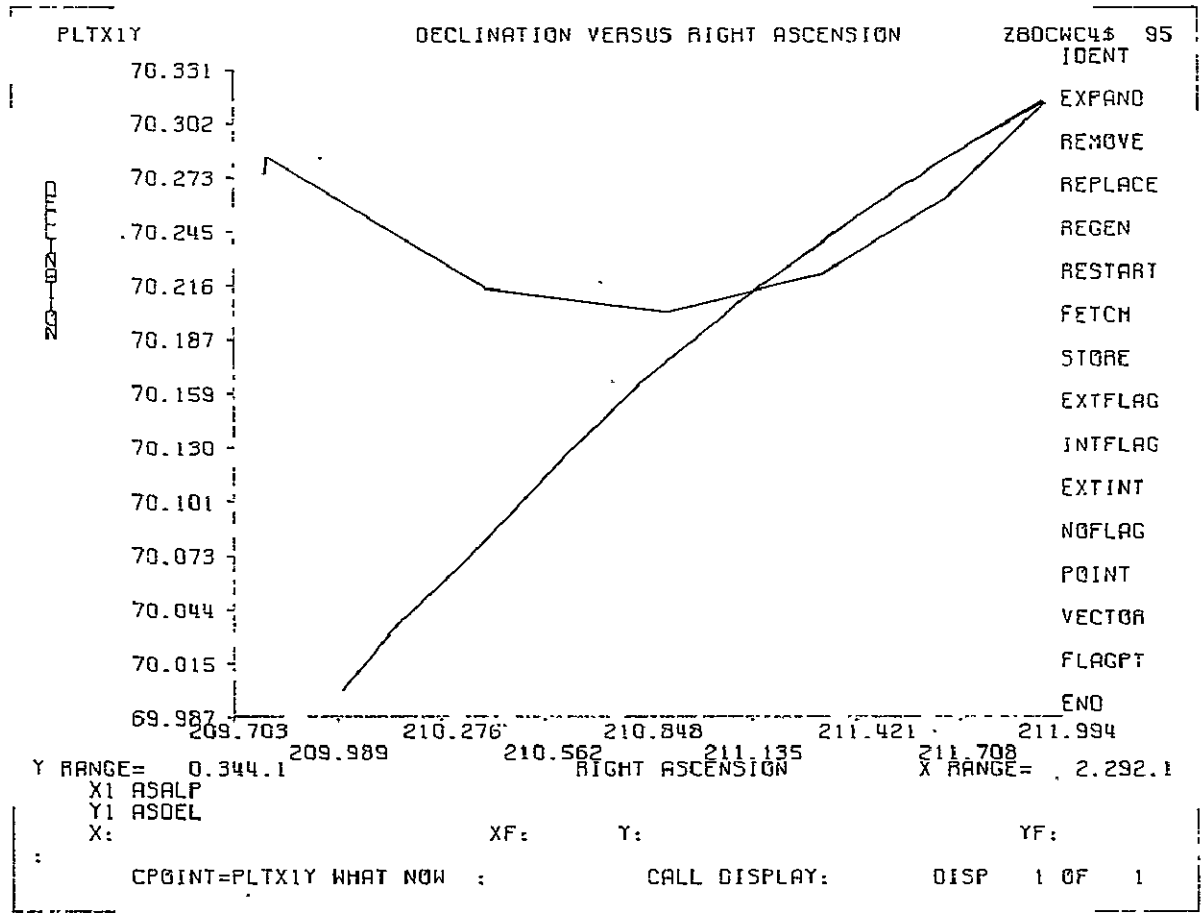
```
                              G E S S   V 2.1
                               D I S P L A Y                  76.041.17.41.32

  DGAS                                GAS TABLE                        ZBDCWG2$  22

  DISPLAY CONTROL
    REDISPLAY (Y=YES,N=NO,C=CLEAR TABLE) :N
    RECALL LINE NUMBER                   :   0

  TABLE ENTRY
    FLAG (..F)                           :.
    TIME (YYMMDDHHMMSS.)                 :999999999999.
    TYPE                                 :--
      PP=PITCH POS   PM=PITCH NEG
      RP=ROLL POS    RM=ROLL NEG
      SP=SPIN POS    SM=SPIN NEG
    NUMBER OF PULSES                        0


       FLAG          LINE                  TIME          TYPE        NO. OF
                    NUMBER        YY.MM.DD.HH.MM.SS                   PULSES
        EE           EEEE        EEEEEEEEEEEEEEEE        EE          EEEE

 :M300 M300 M300 M300 M300 ARRAY NOT ALLOCATED (A) OR ARRAY EMPTY(E)
       CPOINT=YGAS   WHAT NOW  :W          CALL DISPLAY:    .   DISP   1 OF   1

                              G E S S   V 2.1
                               D I S P L A Y
```

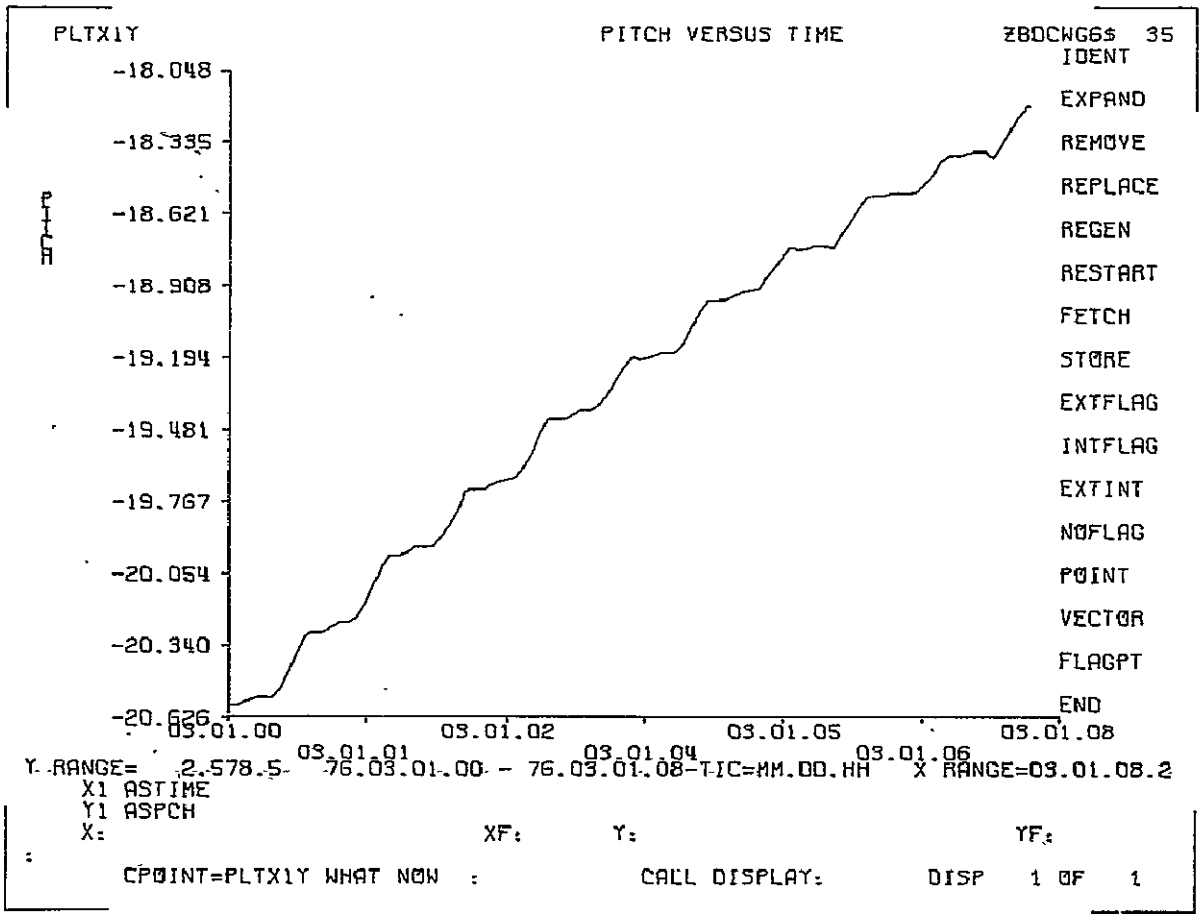
APPENDIX G

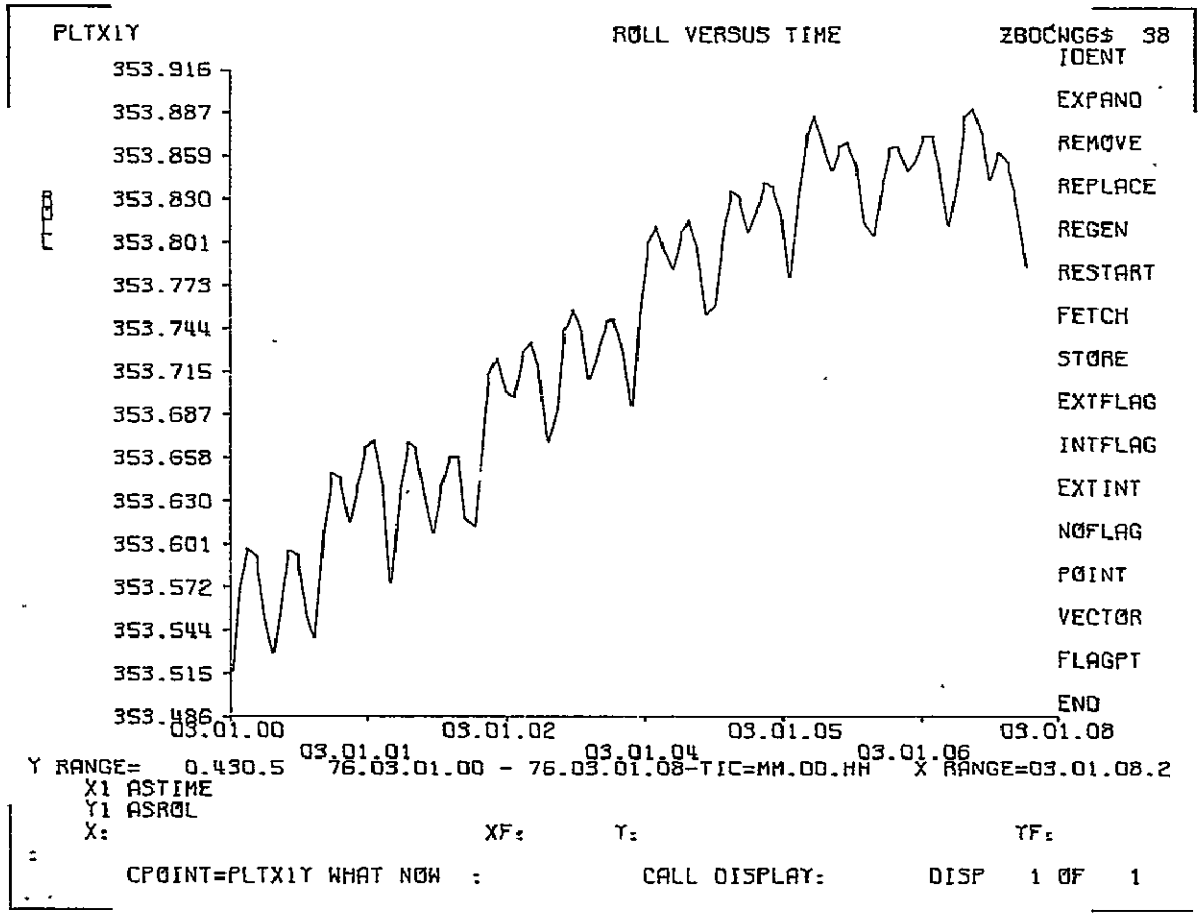
SAMPLE GESS PLOTS

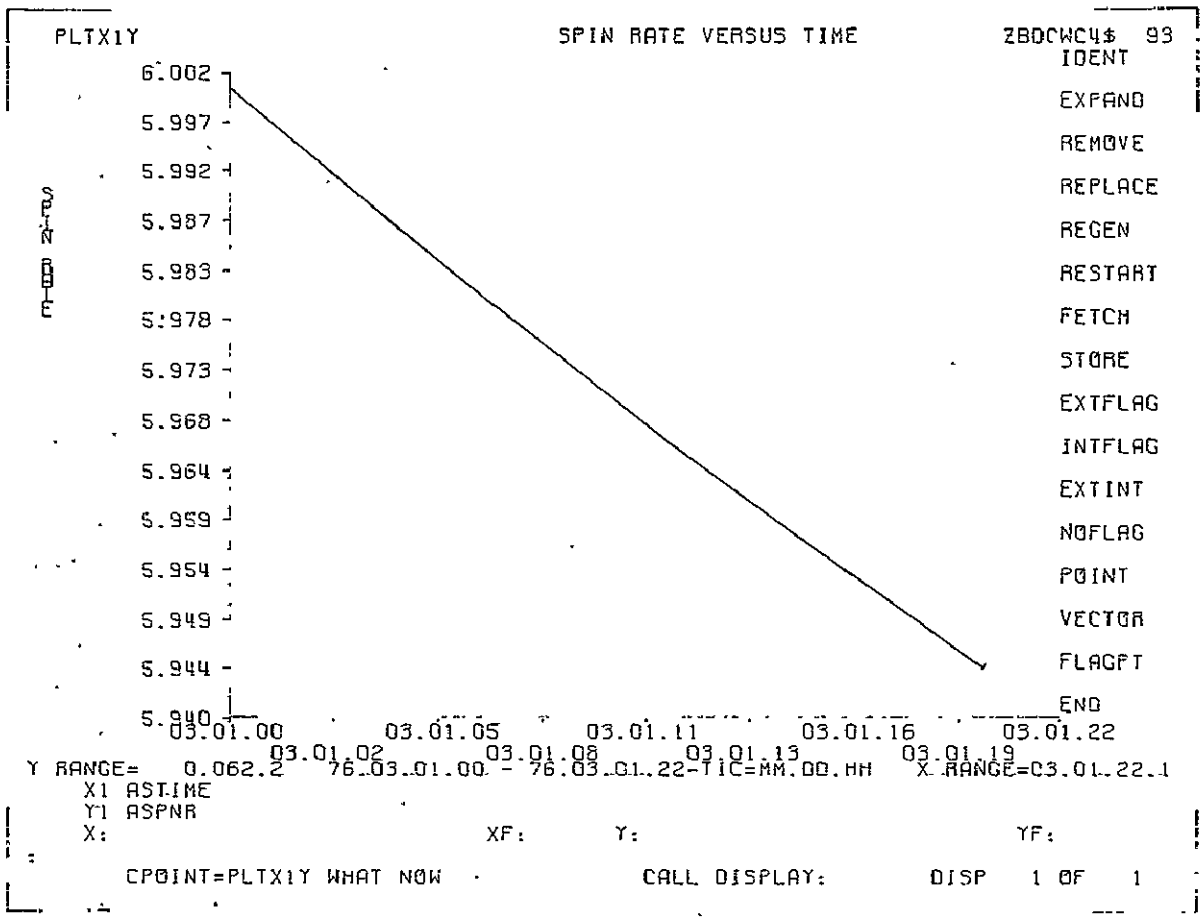


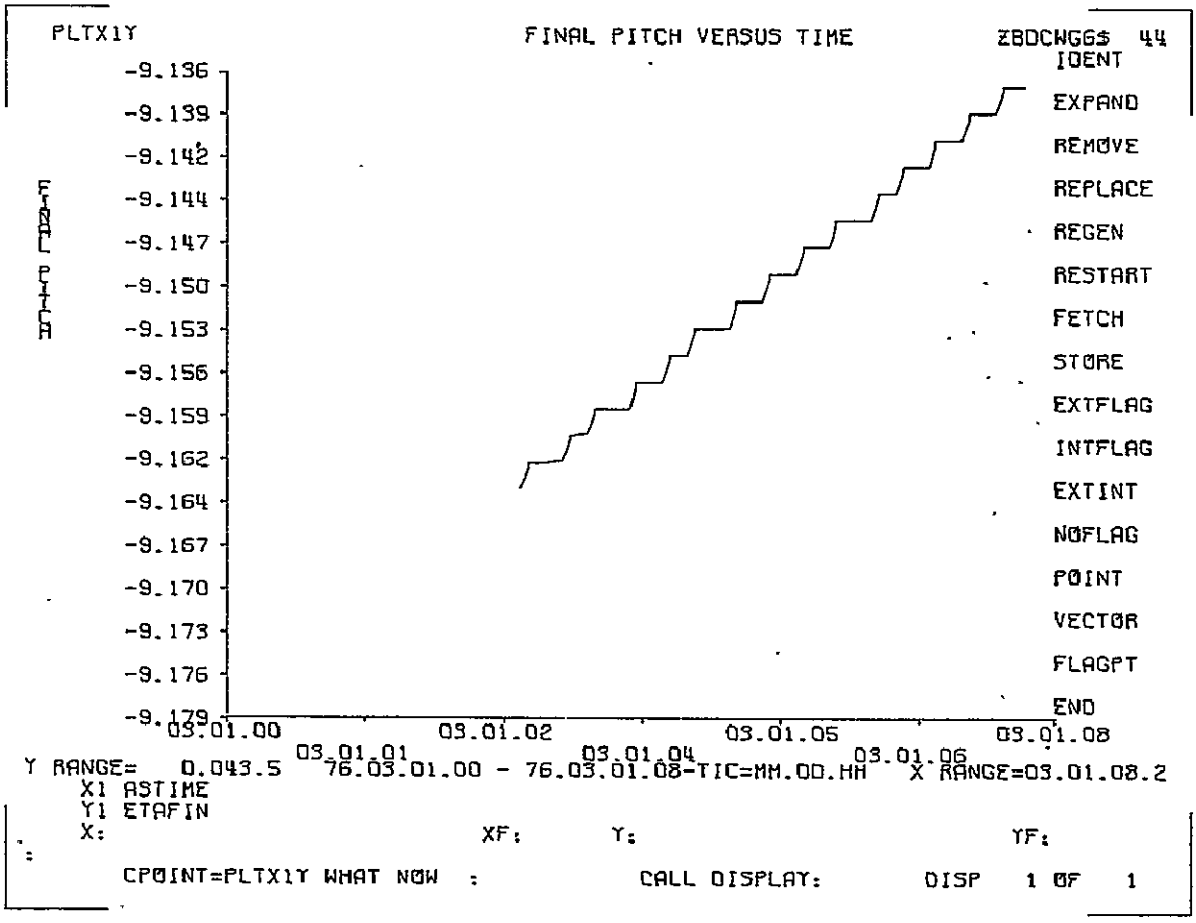

PLTX1Y
DECLINATION VERSUS TIME
Z80CWG6$ 30
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
71.161
71.047
70.932
70.818
70.703
70.588
70.474
70.359
70.245
70.130
70.015
69.901
DELTA-DECL-DEG
03.01.00
03.01.01
03.01.02
03.01.04
03.01.05
03.01.06
03.01.08
Y RANGE= 1.261.5 76.03.01.00 - 76.03.01.08-TIC=MM.DD.HH X RANGE=03.01.08.2
X1 AST-TIME
Y1 ASDEL
X: XF: Y: YF:
CPOINT=PLTX1Y WHAT NOW : CALL DISPLAY: DISP 1 OF 1

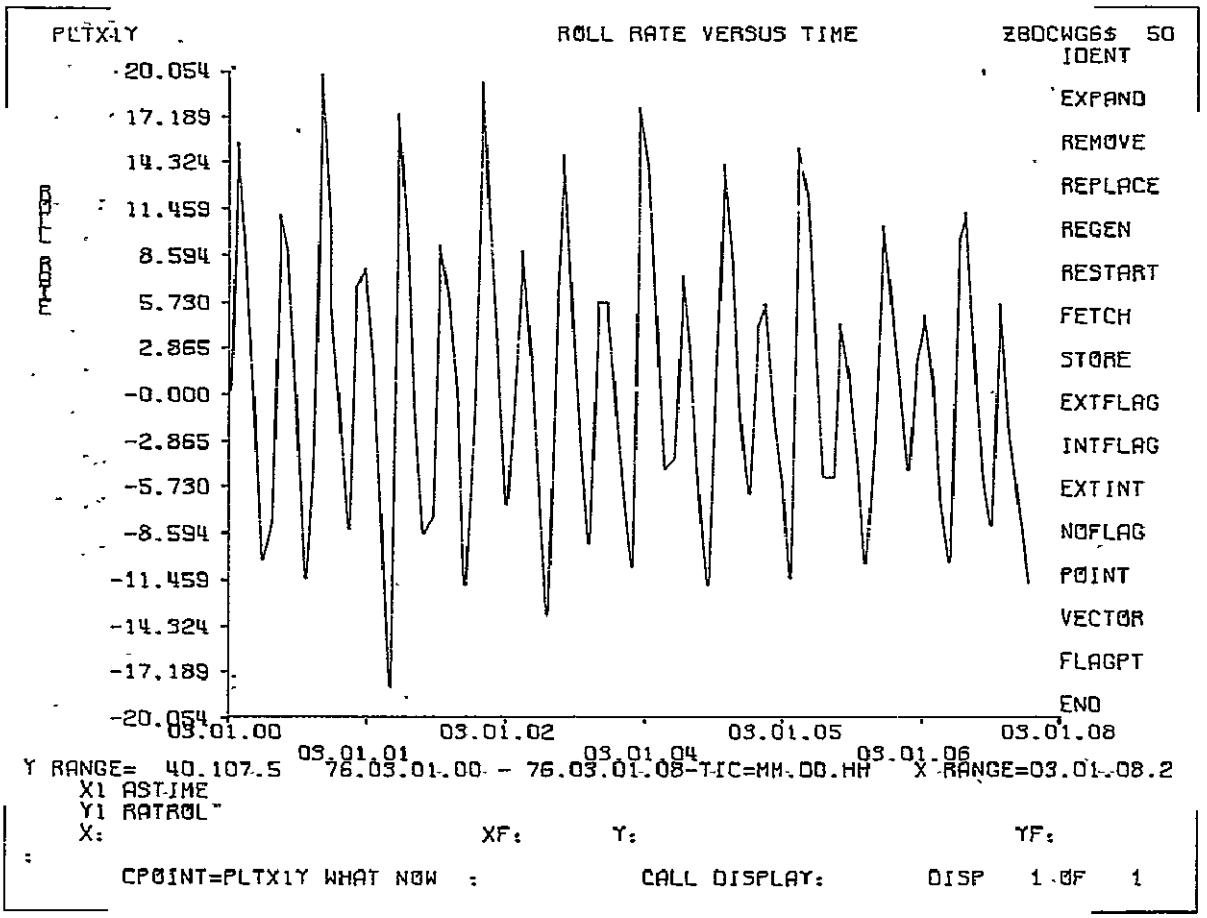


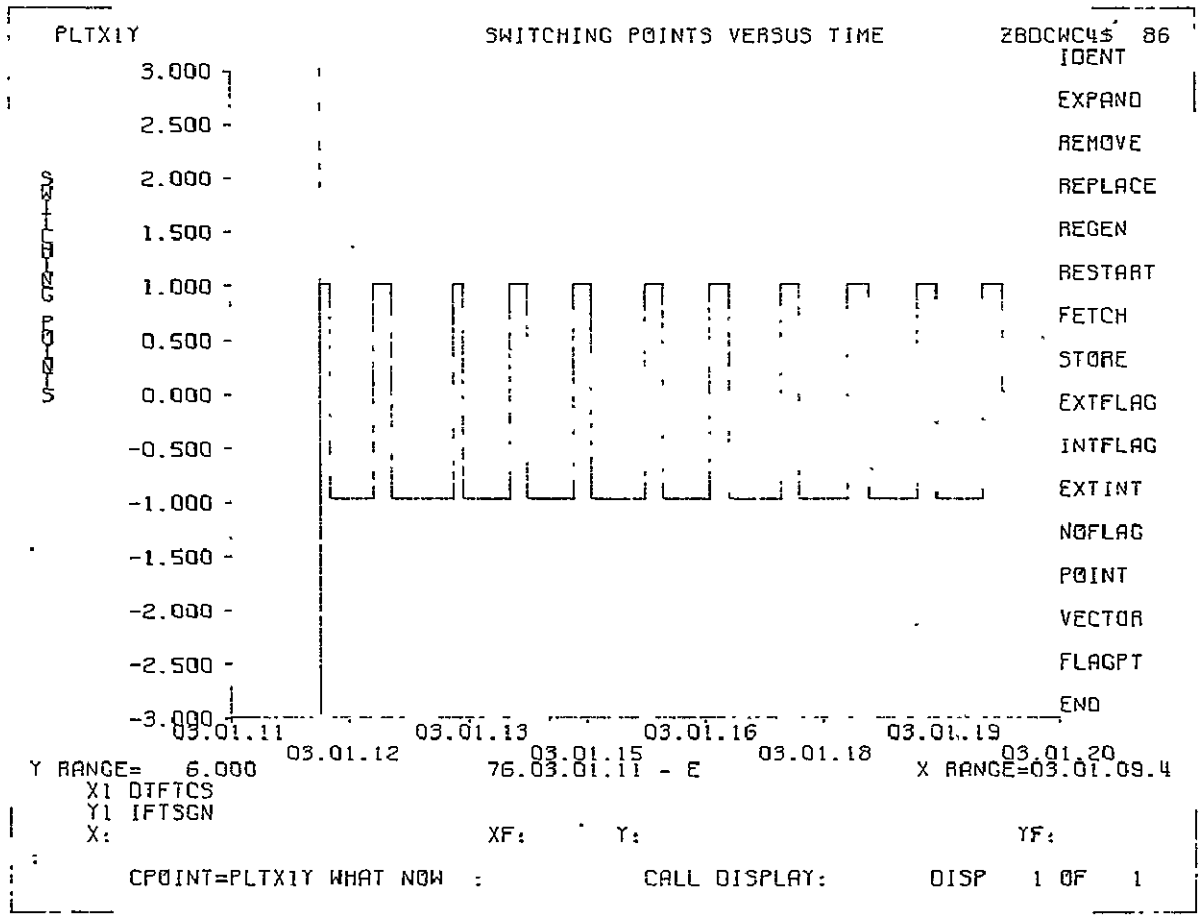

PLTX1Y
PITCH VERSUS TIME
ZBDCWG6$ 35
-18.048
-18.335
-18.621
-18.908
-19.194
-19.481
-19.767
-20.054
-20.340
-20.626
PITCH
03.01.00
03.01.01
03.01.02
03.01.04
03.01.05
03.01.06
03.01.08
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
Y RANGE= 2,578.5 76.03.01.00 - 76.03.01.08 TIC=MM.DD.HH X RANGE=03.01.08.2
X1 ASTIME
Y1 ASPCH
X: XF: Y: YF:
CPOINT=PLTX1Y WHAT NOW :
CALL DISPLAY: DISP 1 OF 1

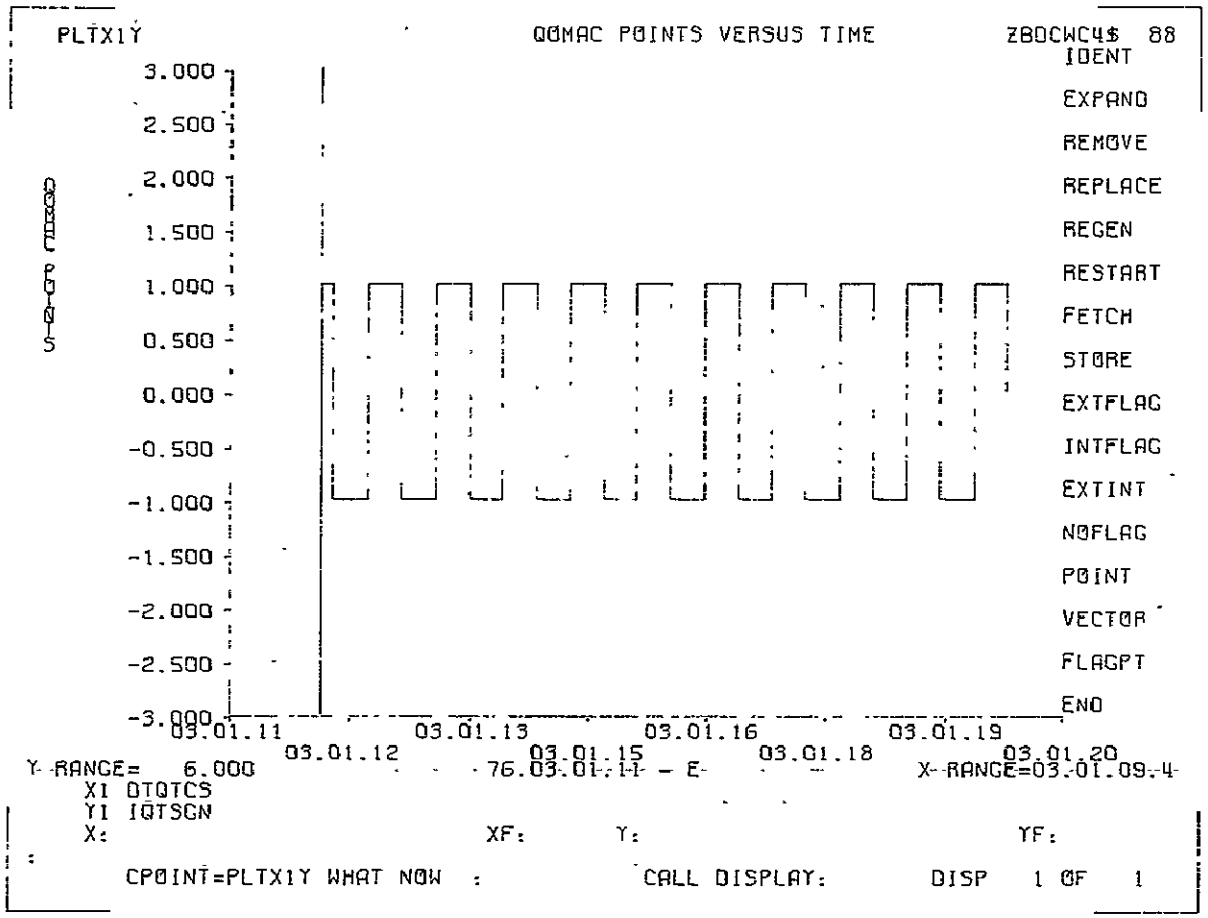

PLTX1Y
ROLL VERSUS TIME
ZBOCNG6$ 38
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
353.916
353.887
353.859
353.830
353.801
353.773
353.744
353.715
353.687
353.658
353.630
353.601
353.572
353.544
353.515
353.486
ROLL
03.01.00
03.01.01
03.01.02
03.01.04
03.01.05
03.01.06
03.01.08
Y RANGE= 0.430.5 76.03.01.00 - 76.03.01.08-TIC=MM.DD.HH X RANGE=03.01.08.2
X1 ASTIME
Y1 ASROL
X: XF: Y: YF:
CPOINT=PLTX1Y WHAT NOW : CALL DISPLAY: DISP 1 OF 1

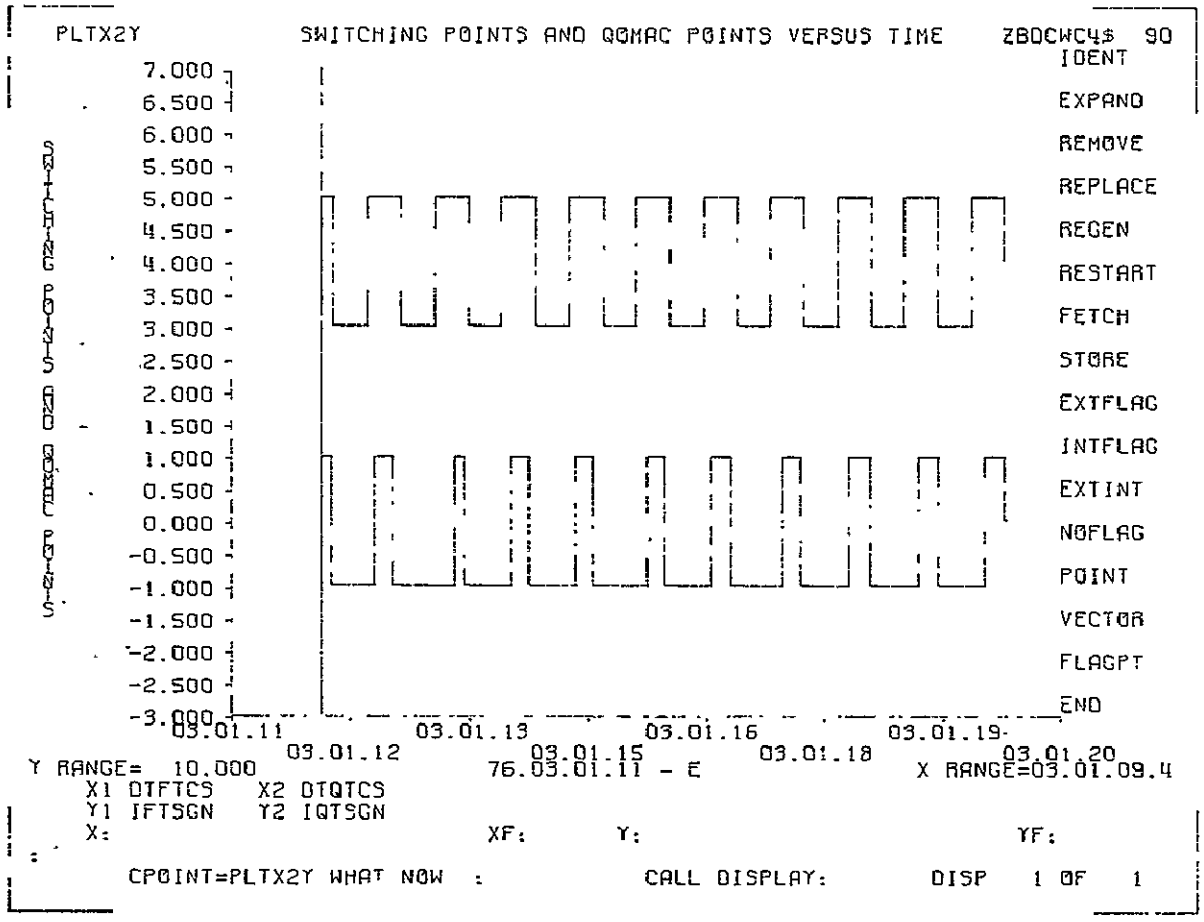

PLTX1Y
SPIN RATE VERSUS TIME
ZBDCWC4$ 93
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
SPIN RATE
6.002
5.997
5.992
5.987
5.983
5.978
5.973
5.968
5.964
5.959
5.954
5.949
5.944
5.940
03.01.00
03.01.02
03.01.05
03.01.08
03.01.11
03.01.13
03.01.16
03.01.19
03.01.22
Y RANGE= 0.062.2
76.03.01.00 - 76.03.01.22-TIC=MM.DD.HH
X RANGE=03.01.22.1
X1 ASTIME
Y1 ASPNR
X:
XF:
Y:
YF:
CPOINT=PLTX1Y WHAT NOW
CALL DISPLAY:
DISP 1 OF 1

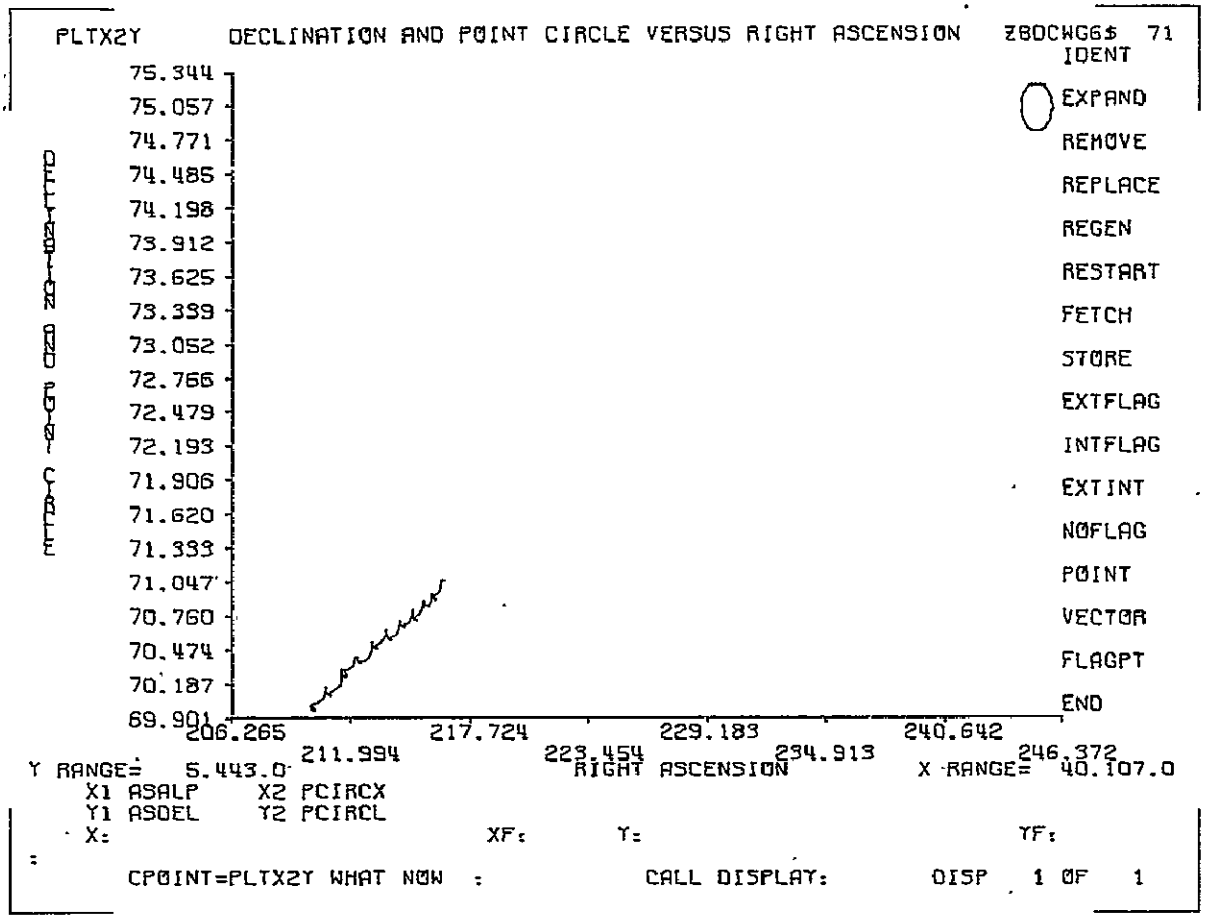

PLTX1Y
FINAL PITCH VERSUS TIME
ZBDCWGGS 44
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
FINAL PITCH
-9.136
-9.139
-9.142
-9.144
-9.147
-9.150
-9.153
-9.156
-9.159
-9.162
-9.164
-9.167
-9.170
-9.173
-9.176
-9.179
03.01.00
03.01.01
03.01.02
03.01.04
03.01.05
03.01.06
03.01.08
Y RANGE= 0.043.5 76.03.01.00 - 76.03.01.08-TIC=MM.DD.HH X RANGE=03.01.08.2
X1 ASTIME
Y1 ETAFIN
X: XF: Y: YF:
CPOINT=PLTX1Y WHAT NOW : CALL DISPLAY: DISP 1 OF 1

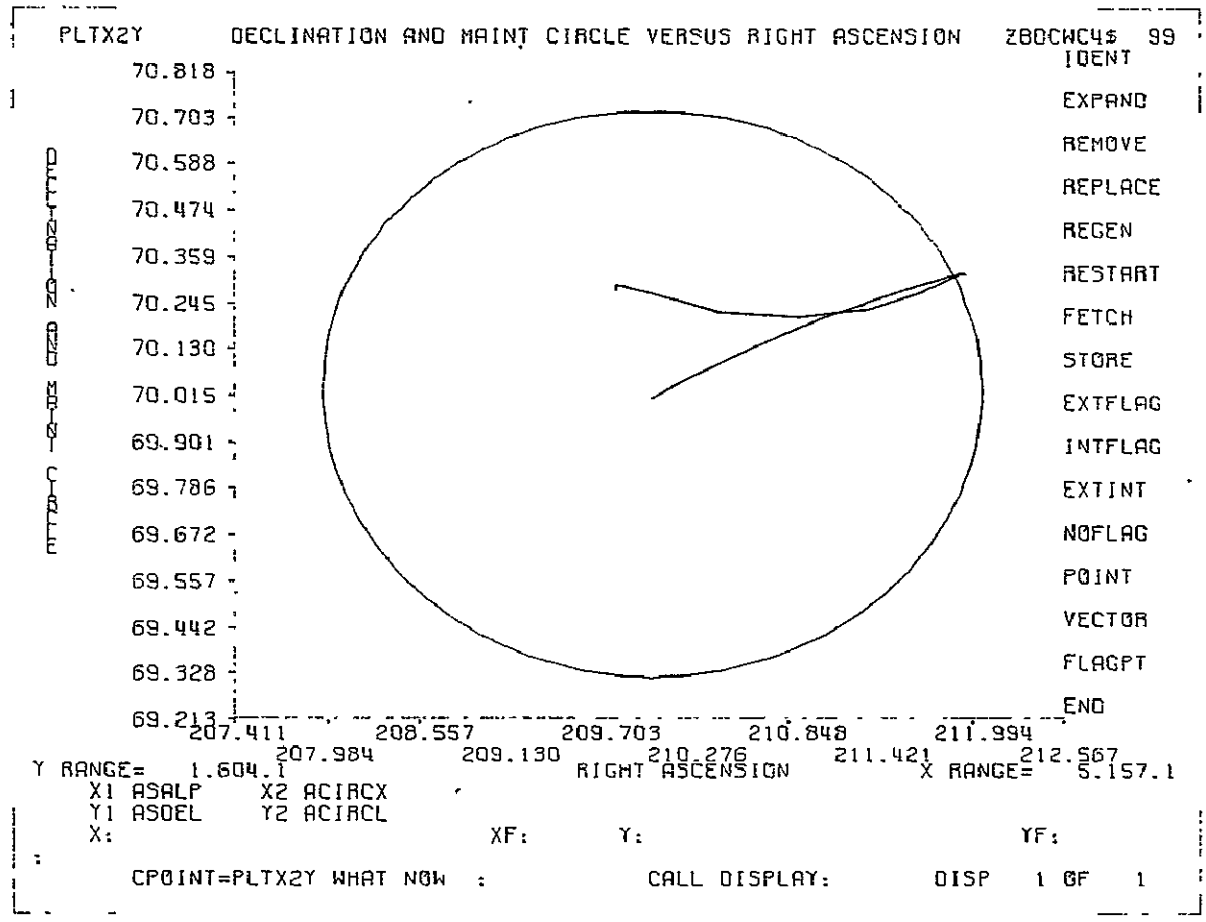

PLTX1Y
ROLL RATE VERSUS TIME
Z80CWG6$ 50
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
20.054
17.189
14.324
11.459
8.594
5.730
2.865
-0.000
-2.865
-5.730
-8.594
-11.459
-14.324
-17.189
-20.054
03.01.00
03.01.01
03.01.02
03.01.04
03.01.05
03.01.06
03.01.08
Y RANGE= 40.107.5
76.03.01.00 - 76.03.01.08-TIC=MM.00.HH
X RANGE=03.01.08.2
X1 AST-IME
Y1 RATROL"
X:
XF:
Y:
YF:
CPOINT=PLTX1Y WHAT NOW :
CALL DISPLAY:
DISP 1 OF 1




PLTX1Y
Q0MAC P0INTS VERSUS TIME
Z80CWC4$ 88
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
03.01.11
03.01.12
03.01.13
03.01.15
03.01.16
03.01.18
03.01.19
03.01.20
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
Y-RANGE= 6.000
X-RANGE=03.01.09.4
XI QTQTCS
YI IQTSGN
X:
XF:
Y:
YF:
CP0INT=PLTX1Y WHAT NOW :
CALL DISPLAY:
DISP 1 OF 1




PLTX2Y DECLINATION AND POINT CIRCLE VERSUS RIGHT ASCENSION ZBOCWG6$ 71
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
DECLINATION
75.344
75.057
74.771
74.485
74.198
73.912
73.625
73.339
73.052
72.766
72.479
72.193
71.906
71.620
71.333
71.047
70.760
70.474
70.187
69.901
206.265
211.994
217.724
223.454
229.183
234.913
240.642
246.372
RIGHT ASCENSION
Y RANGE= 5.443.0
X RANGE= 40.107.0
X1 ASALP X2 PCIRCX
Y1 ASDEL Y2 PCIRCL
X: XF: Y: YF:
CPOINT=PLTX2Y WHAT NOW :
CALL DISPLAY: DISP 1 OF 1


PLTX2Y DECLINATION AND MAINT CIRCLE VERSUS RIGHT ASCENSION Z80CWC4$ 99
IDENT
EXPAND
REMOVE
REPLACE
REGEN
RESTART
FETCH
STORE
EXTFLAG
INTFLAG
EXTINT
NOFLAG
POINT
VECTOR
FLAGPT
END
70.818
70.703
70.588
70.474
70.359
70.245
70.130
70.015
69.901
69.786
69.672
69.557
69.442
69.328
69.213
207.411
207.984
208.557
209.130
209.703
210.276
210.848
211.421
211.994
212.567
Y RANGE= 1.604.1
RIGHT ASCENSION
X RANGE= 5.157.1
X1 ASALP X2 ACIRCX
Y1 ASDEL Y2 ACIRCL
X: XF: Y: YF:
CPOINT=PLTX2Y WHAT NOW : CALL DISPLAY: DISP 1 OF 1

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*f indicates figure.