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# LIST OF ABBREVIATIONS

<table>
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<th>Abbreviation</th>
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<tr>
<td>APD</td>
<td>Attitude Profile Design</td>
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<tr>
<td>ECI</td>
<td>earth-centered inertial</td>
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<td>ECID</td>
<td>earth-centered inertial of date</td>
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<td>SCOOT</td>
<td>Simplex Computation of Optimum Orbital Trajectories</td>
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1. INTRODUCTION

The Attitude Profile Design (APD) Program is designed to be used as a stand-alone addition to the Simplex Computation of Optimum Orbital Trajectories (SCOOT). The program uses information from a SCOOT output file and the user-defined attitude profile to produce time histories of attitude, angular body rates, and accelerations.

The APD program is written in standard FORTRAN 77 and should be portable to any machine that has an appropriate compiler. The input and output are through formatted files. The program reads the basic flight data, such as the states of the vehicles, acceleration profiles, and burn information, from the SCOOT output file. The user inputs information about the desired attitude profile during coasts in a high-level manner. The program then takes these high level commands and executes the maneuvers, outputting the desired information.
2. COORDINATE SYSTEMS

There are four coordinate systems that the user may utilize in specifying his attitude pointing commands. They are:

1. Earth-centered inertial coordinate system,
2. Solar coordinate system,
3. Local north-east-down coordinate system, and
4. Stellar coordinate system.

The earth-centered inertial (ECI) system is the same as the earth-centered inertial of date (ECID) system used in SCOOT. The +x-axis points along the vernal equinox. The +z-axis points north along the earth's spin axis. The y-axis completes the right-handed orthogonal system.

The solar coordinate system is a pure rotation of the ECI system at a particular time. The ECI system is rotated about its +z-axis, and then about its new +y-axis until the +x-axis lines up with the sun vector. The resulting right-handed orthogonal system is the solar coordinate system.

The local north-east-down system rotates with the vehicle. It's x- and y-axes are in the local horizontal plane and point north and east, respectively. The +z-axis points along the negative earth radius vector.

The stellar coordinate system is defined with the use of the two star vectors that the user inputs. The +x-axis lies along the vector to star#1. The +z-axis lies in the direction of the cross product of the +x-axis with the vector to star#2. The y-axis completes the right-handed orthogonal system.
3. **INPUT FORMAT**

The basic means of entering data for the user is through a formatted input file. An example of such a file is shown below:

NAME OF NAV FILE:
STAR #1 DECLINATION:
STAR #1 RIGHT ASCENSION:
STAR #2 DECLINATION:
STAR #2 RIGHT ASCENSION:
ROLL ATTITUDE DURING BURN:
BURN PRINT INTERVAL (SECONDS):
COAST PRINT INTERVAL (SECONDS):

-------------------------------------------------------------------------------------------------------------------------

COAST #:
MANEUVER #:
NAME:
COORDINATE SYSTEM (A,B,C,D):

-------------------------------------------------------------------------------------------------------------------------

POINTING ANGLES:
SLEW RATE, ACCELERATION:
ROLL RATE, ACCELERATION:

-------------------------------------------------------------------------------------------------------------------------

BODY RATE COMMANDS:
BODY ACCELERATION LIMITS:

-------------------------------------------------------------------------------------------------------------------------

TIME OF MANEUVER (MINUTES):

-------------------------------------------------------------------------------------------------------------------------

The first section above appears at the top of every file. The user enters the alpha-numeric name of the data file from SCOOT to be used. The next four entries pertain to star locations and should be entered in degrees immediately following the colon. Entering preceding blanks may cause unpredictable results and is discouraged throughout the input file. The next input is the roll attitude during burns. The angle entered is defined with respect to the projection of the sun vector onto the body yz plane. Zero is defined when the +y-axis is aligned with the projection. Positive rotation is clockwise. The next input is the desired printout interval in seconds for the burn and coast intervals.
The next section is the standard maneuver definition section. Each maneuver requires a section like this. The first entry is the coast number, and the second entry is the maneuver number. The program checks the user to make sure that he has numbered the coasts and maneuvers properly. The important thing here is to remember to enter them. The next entry is the name of the maneuver. This is purely for the user’s benefit in keeping things straight. The next entry is the coordinate system. The user should enter the letter (A, B, C, or D) of the system in which he wishes to define the maneuver. The user should always enter something here.

If the maneuver is to be a pointing command (as opposed to a rate command) then the user should fill in the next subsection. A pointing command is defined with the use of three angles. The angles are defined in the following manner for all coordinate systems except the stellar system.

ANGLE #1 - the angle of rotation about the +z-axis
ANGLE #2 - the angle of rotation about the new +y-axis
ANGLE #3 - the roll angle with respect to the projection of the sun vector onto the body yz plane as measured to the body +y-axis (exactly as defined above for the roll attitude during burns)

For the stellar system, the pointing vector is always along the stellar +z-axis; therefore, the following definitions exist for a pointing command.

ANGLE #1 - the roll angle from the vector to star#1 to the body +y-axis. Positive rotation is toward star#2.
ANGLE #2 - the roll angle from the vector to star#2 to the body +y-axis. Positive rotation is away from star#1.

Only one of the first two angles may be entered at a time and the third angle is not used.

The user should enter three angles in degrees, separated by commas, unless the desired attitude is the beginning attitude of the upcoming burn. In this case, the user should enter a “B” in the space for the pointing angles. The program will then use the burn attitude as the target attitude.

If the command is a pointing command, then the user has the option of entering rates and accelerations that must be observed in achieving the desired attitude. The user should enter these in the appropriate spaces. If a rate or acceleration is left blank, then the program assumes that they are infinite.

If the user wants a rate-commanded maneuver, then the next section should be completed. The body-rate commands are to be entered in roll, pitch, and yaw order and separated by commas. An “X” may
be used instead of a number to indicate that no new command is to be entered for a particular axis. For example, a desired pitch rate of 2 deg/s would be achieved by the following entry:

BODY RATE COMMANDS: X, 2.0

The roll and yaw body rates would remain unchanged, but the pitch rate would go to 2 deg/s.

The user may also supply accelerations to be observed in achieving the desired rates. They are entered in the same manner as the rates.

The final entry in each maneuver definition is the time of maneuver, and it may contain three different types of entries:

1. A blank indicates that once the desired end condition of this maneuver has been achieved, then the vehicle should move on to the next maneuver,
2. A number indicates that once the desired end condition has been achieved, the vehicle should hold this condition for the indicated length of time,
3. A "+" indicates that the end condition is to be held for an undetermined length of time. The following maneuvers are included in this variable time calculation. The next maneuver reached that has a time entered here constrains the problem. For example:

MAN #1 TIME OF MANEUVER: +
MAN #2 TIME OF MANEUVER:
MAN #3 TIME OF MANEUVER: 10.0

This example says that from the beginning of maneuver #1 to the end of maneuver #3 should take 10 minutes. Since maneuver #1 has a "+" entered, the extra time is added in holding its end condition until maneuver #2 begins.

The other means of input to the APD program is through an input file from SCOOT. It contains several items:

1. Julian day of the start of the mission,
2. Number of legs in the mission,
3. Time history of vehicle position,
4. Time history of gravitational acceleration,
5. Time history of thrust acceleration,
6. Time history of burn/coast condition,
7. Time history of thrust vector direction.
4. **OUTPUT FORMAT**

There are six output files. They are:

1. **INACC.DAT** - mission time (s), inertial accelerations $x,y,z$ (m/s/s),
2. **GRACC.DAT** - mission time (s), gravitational accelerations $x,y,z$ (m/s/s),
3. **CONACC.DAT** - mission time (s), contact accelerations $x,y,z$ (m/s/s),
4. **WBODY.DAT** - mission time (s), body angular rates $p,q,r$ (rad/s),
5. **QUAT.DAT** - mission time (s), body attitude quaternions $q_0,q_1,q_2,q_3$
6. **APD.LOG** - a time history of events.

The first line of the first five output files above contains an integer indicating the number of data lines to follow.
5. EXPLANATION OF PROGRAM

5.1 GENERAL METHODOLOGY

During a burn interval, the user only has one degree of freedom through the use of the input file. The rest are defined through the navigation input file. The one input that the user can enter is roll attitude with respect to the sun during burns. Otherwise, the attitude of the vehicle at each timepoint of interest (namely, the output timepoints) is taken to be pointing along the thrust vector at all times. The body rates are calculated by taking numerical derivatives of the Euler angles at the desired timepoints to get Euler rates. These are then converted to body rates.

During a coast, the user may define either a pointing command or a body rate command—with one exception. The first maneuver of the first coast always defines the initial attitude of the vehicle and an error will occur if the user tries to do otherwise.

If the user enters a pointing command, the vehicle already has a given attitude and, possibly, body rotational rates. The first thing that is done is that any body rotational rates that are left over from the previous maneuver are nulled out. Any existing roll rate and slew rate are nulled simultaneously and independently according to the user-defined accelerations for rolling and slewing.

The next thing to be done is to roll the vehicle to the proper orientation with respect to the sun. This is done while obeying the user-defined roll rate and acceleration.

Next, the vehicle slews in a plane to the desired pointing vector, obeying the user-defined slew rate and acceleration. Simultaneously, the roll attitude is being changed so that at the time the slew maneuver is completed, the correct roll attitude is being reached also. If the total amount of roll required exceeds the physical limitations imposed by the user-defined roll rate and acceleration and the time limit imposed by the slew maneuver, then the vehicle rolls at its maximum, and the roll is completed as soon after the slew as possible. Otherwise, the roll rate is kept at the minimum rate required to achieve the above-stated condition.

Once the vehicle has achieved the desired attitude conditions, there may be a station-keeping requirement imposed by the user. If the user has used the north-east-down system to define the pointing command, then a station-keeping command requires that the inertial attitude continue to change to maintain the desired conditions. The new attitude is calculated for each timepoint and numerical differentiation is used to obtain body rates. If any of the other coordinate systems were used, then no movement is required because they are assumed inertial for the station-keeping length.

If the user has entered a rate command rather than a pointing command, then each axis is treated simultaneously and independently. The body rates are changed from the current rates to the desired rates.
while obeying the accelerations entered by the user. If a hold maneuver condition is called for, the desired body rates continue for that length of time and are integrated to determine position at necessary points.

When the vehicle is commanded to a particular attitude (either roll or pointing) the user-defined rates and accelerations are used and obeyed. If the user does not enter a rate, the vehicle assumes the desired attitude instantaneously. If a rate is entered without an acceleration, it is achieved instantaneously, maintained until the desired attitude is reached, and then nulled out instantaneously. If the user enters a rate and an acceleration, then the vehicle accelerates at the user-defined value until the rate is achieved. The rate is then maintained for the appropriate time and the vehicle decelerates until a rate of zero and the desired attitude are achieved at the same time. Sometimes the attitude change required is so small that the above scheme overshoots the desired attitude no matter how short the time at maximum rate. In this case, the vehicle accelerates to some sub-maximum rate and immediately begins decelerating to a rate of zero and the desired attitude at the same time.

5.2 SUBROUTINE EXPLANATIONS

Listed below are brief descriptions of each subroutine:

ANG  - converts any angle in radians to an angle between 0 and 2π
CONVERT  - converts a character string to a real number
GETPROJ  - determines the angle necessary to rotate the vehicle in order to align the body y-axis along the projection of the sun vector onto the body yz plane
GETSTATE  - determines (through interpolation) the state of the vehicle at a given time using the data read from the navigation input file
LVLH  - determines the coordinate transformation matrix and Euler angles for a given attitude in north-east-down coordinates
QUAT  - determines the four quaternions from a coordinate transformation matrix
QUATUP  - integrates body rates to obtain new quaternion values and the coordinate transformation matrix
POINTER  - determines the coordinate transformation matrix for an attitude defined in any system
RMAN  - reads a single maneuver from the user input file
ROLLER  - computes and executes a roll maneuver from an initial roll attitude to the desired roll attitude
ROTATE  - executes rotations about a body axis and computes the new coordinate transformation matrix
SLEWER - executes a slew maneuver with accompanying roll to a predetermined schedule
SUNV - determines the right ascension and declination of the sun at the desired time
OUTPUT - outputs the desired information to the appropriate files
6. **SAMPLE INPUT FILE**

The following is a maneuver-by-maneuver explanation of a sample input file that covers the capability of the Attitude Profile Design (APD) Program.

**COAST #1**

**MAN#1** - the initial maneuver always defines the initial conditions of the vehicle. The coordinate system is ECI, as indicated by the letter “A”. The initial conditions are a right ascension of 10.0° and a declination of 20.0°. The body y-axis makes an angle of 30.0° with the projection of the sun vector onto the body yz plane. This condition is held for 10.0 minutes before moving to the next maneuver.

**MAN#2** - the vehicle slews to the indicated pointing conditions in the solar coordinate system using slew and roll rates of 5.0 deg/s and 2.0 deg/s, respectively. Slew and roll accelerations are both 2.0 deg/s/s. This attitude is not held before moving to the next maneuver.

**MAN#3** - the vehicle achieves a clockwise roll of 3.0 deg/s using an acceleration of 2.0 deg/s. Once the desired rate is achieved, it is held for 25.0 minutes.

**MAN#4** - the vehicle achieves a counterclockwise roll of 3.0 deg/s and is held for 25.0 minutes.

**MAN#5** - the vehicle slews to the indicated attitude in north-east-down coordinates at the indicated rates and accelerations. The “+” in the time entry, along with the 10.0 minutes in the next maneuver time entry, indicates that the time elapsed from the beginning of maneuver#5 to the end of maneuver#6 is to be 10.0 minutes.

**MAN#6** - the vehicles slews to the desired solar orientation

**MAN#7 thru MAN#10** - repeats MAN#3 thru MAN#6

**MAN#11 thru MAN#14** - repeats MAN#3 thru MAN#6

**MAN#15 thru MAN#18** - repeats MAN#3 thru MAN#6

**MAN#19 thru MAN#22** - repeats MAN#3 thru MAN#6

**MAN#23** - vehicle slews to stellar pointing vector. The body y-axis makes an angle of 10.0° with the vector to star#1

**MAN#24** - vehicle rolls so that body y-axis makes an angle of -10.0° with the vector to star#1

**MAN#25** - vehicle rolls so that body y-axis makes an angle of 10.0° with the vector to star#2

**MAN#26** - vehicle rolls so that body y-axis makes an angle of -10.0° with the vector to star#2
MAN#27 - vehicle slews to the attitude for burn #1, as indicated by the "B" in the pointing angle entry.

COAST#2

MAN#1 - vehicle slews to the attitude for burn#2

COAST#3

MAN#1 - vehicle slews to the attitude for burn#3

The sample data input file associated with the previous explanation is presented on the following pages.
NAME OF NAV FILE : BRET NAV.DAT

STAR #1 DECLINATION : 15.2
STAR #1 RIGHT ASCENSION : 20.3
STAR #2 DECLINATION : 16.3
STAR #2 RIGHT ASCENSION : 22.4
ROLL ATTITUDE DURING BURN : 0.0

BURN PRINT INTERVAL (SECONDS) : 1.
COAST PRINT INTERVAL (SECONDS) : 20.

ROLL ATTITUDE DURING BURN : 0.0

COAST # : 1
MANEUVER # : 1
NAME : INERTIAL POINTING
COORDINATE SYSTEM (A,B,C,D) : A

POINTING ANGLES : 10.0, 20.0, 30.0
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :
BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) : 10.0

---

COAST # : 1
MANEUVER # : 2
NAME : SLEW TO SOLAR ORIENTATION
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :
BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :

---

COAST # : 1
MANEUVER # : 3
NAME : ROLL CLOCKWISE
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :
BODY RATE COMMANDS : 3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

---

COAST # : 1
MANEUVER # : 4
NAME : COUNTERCLOCKWISE ROLL
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :
BODY RATE COMMANDS : -3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

---

COAST # : 1
MANEUVER #: 5
NAME: SLEW TO NEGATIVE EARTH RADIUS VECTOR
COORDINATE SYSTEM (A, B, C, D): C

POINTING ANGLES: 0.0, 90.0, 0.0
SLEW RATE, ACCEL: 5.0, 2.0
ROLL RATE, ACCEL: 3.0, 2.0

BODY RATE COMMANDS:
BODY ACCEL LIMITS:

TIME OF MANEUVER (MINUTES):

COAST #: 1
MANEUVER #: 6
NAME: SLEW TO SOLAR ORIENTATION
COORDINATE SYSTEM (A, B, C, D): B

POINTING ANGLES: 0.0, 40.0, 0.0
SLEW RATE, ACCEL: 5.0, 2.0
ROLL RATE, ACCEL: 3.0, 2.0

BODY RATE COMMANDS:
BODY ACCEL LIMITS:

TIME OF MANEUVER (MINUTES):

COAST #: 1
MANEUVER #: 7
NAME: ROLL CLOCKWISE
COORDINATE SYSTEM (A, B, C, D): B

POINTING ANGLES:
SLEW RATE, ACCEL:
ROLL RATE, ACCEL:

BODY RATE COMMANDS: 3.0
BODY ACCEL LIMITS: 2.0

TIME OF MANEUVER (MINUTES):

COAST #: 1
MANEUVER #: 8
NAME: COUNTERCLOCKWISE ROLL
COORDINATE SYSTEM (A, B, C, D): B

POINTING ANGLES:
SLEW RATE, ACCEL:
ROLL RATE, ACCEL:

BODY RATE COMMANDS: -3.0
BODY ACCEL LIMITS: 2.0

TIME OF MANEUVER (MINUTES):

COAST #: 1
MANEUVER #: 9
NAME: SLEW TO NEGATIVE EARTH RADIUS VECTOR
COORDINATE SYSTEM (A, B, C, D): C

POINTING ANGLES: 0.0, 90.0, 0.0
SLEW RATE, ACCEL: 5.0, 2.0
ROLL RATE, ACCEL: 3.0, 2.0

BODY RATE COMMANDS:
BODY ACCEL LIMITS:
TIME OF MANEUVER (MINUTES) : +  
-----------------------------------------------
COAST #: 1  
MANEUVER #: 10  
NAME : SLEW TO SOLAR ORIENTATION  
COORDINATE SYSTEM (A,B,C,D) : B  

POINTING ANGLES : 0.0,40.0,0.0  
SLEW RATE,ACCEL : 5.0,2.0  
ROLL RATE,ACCEL : 3.0,2.0  

BODY RATE COMMANDS :  
BODY ACCEL LIMITS :  

TIME OF MANEUVER (MINUTES) : 10.0  
-----------------------------------------------
COAST #: 1  
MANEUVER #: 11  
NAME : ROLL CLOCKWISE  
COORDINATE SYSTEM (A,B,C,D) : B  

POINTING ANGLES :  
SLEW RATE,ACCEL :  
ROLL RATE,ACCEL :  

BODY RATE COMMANDS : 3.0  
BODY ACCEL LIMITS : 2.0  

TIME OF MANEUVER (MINUTES) : 25.0  
-----------------------------------------------
COAST #: 1  
MANEUVER #: 12  
NAME : COUNTERCLOCKWISE ROLL  
COORDINATE SYSTEM (A,B,C,D) : B  

POINTING ANGLES :  
SLEW RATE,ACCEL :  
ROLL RATE,ACCEL :  

BODY RATE COMMANDS : -3.0  
BODY ACCEL LIMITS : 2.0  

TIME OF MANEUVER (MINUTES) : 25.0  
-----------------------------------------------
COAST #: 1  
MANEUVER #: 13  
NAME : SLEW TO NEGATIVE EARTH RADIUS VECTOR  
COORDINATE SYSTEM (A,B,C,D) : C  

POINTING ANGLES : 0.0,90.0,0.0  
SLEW RATE,ACCEL : 5.0,2.0  
ROLL RATE,ACCEL : 3.0,2.0  

BODY RATE COMMANDS :  
BODY ACCEL LIMITS :  

TIME OF MANEUVER (MINUTES) : +  
-----------------------------------------------
COAST #: 1  
MANEUVER #: 14  
NAME : SLEW TO SOLAR ORIENTATION  
COORDINATE SYSTEM (A,B,C,D) : B  

POINTING ANGLES : 0.0,40.0,0.0  
SLEW RATE,ACCEL : 5.0,2.0  

6-5
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) : 10.0

COAST # : 1
MANEUVER # : 15
NAME : ROLL CLOCKWISE
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :

BODY RATE COMMANDS : 3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

COAST # : 1
MANEUVER # : 16
NAME : COUNTERCLOCKWISE ROLL
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :

BODY RATE COMMANDS : -3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

COAST # : 1
MANEUVER # : 17
NAME : SLEW TO NEGATIVE EARTH RADIUS VECTOR
COORDINATE SYSTEM (A,B,C,D) : C

POINTING ANGLES : 0.0, 90.0, 0.0
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) : +

COAST # : 1
MANEUVER # : 18
NAME : SLEW TO SOLAR ORIENTATION
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES : 0.0, 40.0, 0.0
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) : 10.0

COAST # : 1
MANEUVER # : 19
NAME : ROLL CLOCKWISE
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :

BODY RATE COMMANDS : -3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

COAST # : 1
MANEUVER # : 20
NAME : COUNTERCLOCKWISE ROLL
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES :
SLEW RATE, ACCEL :
ROLL RATE, ACCEL :

BODY RATE COMMANDS : 3.0
BODY ACCEL LIMITS : 2.0

TIME OF MANEUVER (MINUTES) : 25.0

COAST # : 1
MANEUVER # : 21
NAME : SLEW TO NEGATIVE EARTH RADIUS VECTOR
COORDINATE SYSTEM (A,B,C,D) : C

POINTING ANGLES : 0.0, 90.0, 0.0
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :

COAST # : 1
MANEUVER # : 22
NAME : SLEW TO SOLAR ORIENTATION
COORDINATE SYSTEM (A,B,C,D) : B

POINTING ANGLES : 0.0, 40.0, 0.0
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :

COAST # : 1
MANEUVER # : 23
NAME : SLEW TO SOLAR ORIENTATION
COORDINATE SYSTEM (A,B,C,D) : D

POINTING ANGLES : 10.0, 40.0, 0.0
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
COAST #: 1
MANEUVER #: 24
NAME: ROLL THROUGH STAR 1
COORDINATE SYSTEM (A,B,C,D) : D

POINTING ANGLES : -10.0
SLEW RATE, ACCEL :
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
----------------------------------------

COAST #: 1
MANEUVER #: 25
NAME: ROLL THROUGH STARS 1 AND 2
COORDINATE SYSTEM (A,B,C,D) : D

POINTING ANGLES : X, 10.0
SLEW RATE, ACCEL :
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
----------------------------------------

COAST #: 1
MANEUVER #: 26
NAME: ROLL THROUGH STAR 2
COORDINATE SYSTEM (A,B,C,D) : D

POINTING ANGLES : X, -10.0
SLEW RATE, ACCEL :
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
----------------------------------------

COAST #: 1
MANEUVER #: 27
NAME: SLEW TO BURN ATTITUDE
COORDINATE SYSTEM (A,B,C,D) : A

POINTING ANGLES : B
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
----------------------------------------

COAST #: 2
MANEUVER #: 1
NAME: SLEW TO BURN ATTITUDE
COORDINATE SYSTEM (A,B,C,D) : A

POINTING ANGLES : B
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

6-8
BODY RATE COMMANDS :

BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :

COAST # : 3
MANEUVER # : 1
NAME : SLEW TO BURN ATTITUDE
COORDINATE SYSTEM (A, B, C, D) : A

POINTING ANGLES : B
SLEW RATE, ACCEL : 5.0, 2.0
ROLL RATE, ACCEL : 3.0, 2.0

BODY RATE COMMANDS :
BODY ACCEL LIMITS :

TIME OF MANEUVER (MINUTES) :
APPENDIX A. FORTRAN LISTING OF APD PROGRAM
FUNCTION ANG(X)
IMPLICIT REAL*8 (A-H,O-Z)
COMMON/COM3/PI,TWOFPI,P102
ANG=X-TWOFPI*FLOAT(INT(X/TWOFPI))
IF(ANG) 1,2,2
1 ANG=ANG+TWOFPI
2 RETURN
END
PROGRAM ATTITUDE
IMPLICIT REAL*8 (A-H,O-Z)

THIS PROGRAM REQUIRES INPUT FROM A SAMBO OUTPUT RUN AND INPUT FROM
A FORMATTED INPUT FILE THAT DEFINES THE ATTITUDE PROFILE HISTORY

COMMON/COM1/DTIME, DX, DGACC, DMACC, IBRN,
1 DR, DDEC
COMMON/COM2/PINT, TIME0
COMMON/COM3/P, PI0, PI02
COMMON/COM4/RBURN
COMMON/COM6/TH, TR, TR2, WPMAX
COMMON/COM7/SANG, SANG2, STARROT, STARROT2, S1, S2

CHARACTER*15 SFIE
CHARACTER*20 NAME, NAMEZ

DATA PI /3.14159265/
DATA TWOPI /6.28318531/
DATA PI02 /1.57079633/
DATA TOL /0.1/
DATA TDIFF /0.01/
DATA TTOL /0.1/

WRITE (6,*) 'WELCOME TO THE ATTITUDE PROFILE HISTORY PROGRAM'
WRITE (6,*) 'PLEASE ENTER THE NAME OF THE INPUT DATA FILE'
READ (5,99) NAME

OPEN INPUT FILE

OPEN (UNIT=13,FILE='APD.LOG', STATUS='NEW')
OPEN (UNIT=20, FILE=NAME, STATUS='OLD')
OPEN (UNIT=31, FILE='INACC.DAT', STATUS='NEW')
OPEN (UNIT=42, FILE='GMACC.DAT', STATUS='NEW')
OPEN (UNIT=33, FILE='CONACC.DAT', STATUS='NEW')
OPEN (UNIT=34, FILE='WBODY.DAT', STATUS='NEW')
OPEN (UNIT=35, FILE='QUAT.DAT', STATUS='NEW')

READ SAMBO FILE NAME

READ (20,100) SFIE

READ JULIAN DAY

READ (20,101) IYY, IMM, IDD, IHR, IMM, S3

CHECK FOR MISTAKES
IF (IMM .LT. 0 .OR. IMM .GT. 12) THEN
  WRITE (6,*) 'YOU HAVE ENTERED AN INVALID MONTH'
  STOP
ELSE IF (IDD .LT. 0 .OR. IDD .GT. 12) THEN
  WRITE (6,*) 'YOU HAVE ENTERED AN INVALID DAY'
  STOP
ELSE IF (IDD .EQ. 31 .AND. (IMM .EQ. 2 .OR. IMM .EQ. 4 .OR. IMM .EQ. 11 .OR. IMM .EQ. 8 .OR. IMM .EQ. 10)) THEN
  WRITE (6,*) 'THE MONTH YOU HAVE ENTERED DOES NOT HAVE 31 DAYS'
  STOP
ELSE IF (SS .LT. 0 .OR. SS .GE. 60.0) THEN
  WRITE (6,*) 'YOU HAVE ENTERED AN INVALID SECOND'
  STOP
END IF

GET STAR COORDINATES

DO I = 1, 2
  READ (20,102) STARDEC(I)
  STARDEC(I) = STARDEC(I) * PI / 180.0
  READ (20,103) STARRA(I)
  STARRA(I) = STARRA(I) * PI / 180.0
END DO

SV1(1) = COS(STARDEC(1)) * COS(STARRA(1))
SV1(2) = COS(STARDEC(1)) * SIN(STARRA(1))
SV1(3) = SIN(STARDEC(1))
SV2(1) = COS(STARDEC(2)) * COS(STARRA(2))
SV2(2) = COS(STARDEC(2)) * SIN(STARRA(2))
SV2(3) = SIN(STARDEC(2))
SCANV(1) = SV1(2) * SV2(3) - SV1(3) * SV2(2)
SCANV(2) = SV1(3) * SV2(1) - SV1(1) * SV2(3)
SCANV(3) = SV1(1) * SV2(2) - SV1(2) * SV1(1)
XMAG = (SCANV(1)**2 + SCANV(2)**2 + SCANV(3)**2) ** 0.5
SCANV(1) = SCANV(1) / XMAG
SCANV(2) = SCANV(2) / XMAG
SCANV(3) = SCANV(3) / XMAG
SANG1 = ATAN2(SV1M(3), SV1M(2))
STARROT2 = ATAN2 (SV2M(3), SV2M(2))
READ (20, 194) RBURN
RBURN = RBURN*PI/180.0
194 FORMAT (28X,F20.10)
READ (20, 195) PINTB
195 FORMAT (31X,F20.10)
READ (20, 196) PINTC
196 FORMAT (32X,F20.10)
C READ SAMBO STUFF
C
READ (21, *) TIME0, NLEGS
IBRN = 0
ILEG = 1
DO I = 1, 5000
READ (21, *, END=200) DTIME(I), DX(I, 1), DX(I, 2), DX(I, 3),
1
DGACC(I, 1), DGACC(I, 2), DGACC(I, 3),
2
DMACC(I, 1), DMACC(I, 2), DMACC(I, 3),
3
IBRN(I), DRA(I), DDEC(I)
IF ((IBRN .EQ. 0 .AND. IBRN(I) .EQ. 1) THEN
TIMEB(ILEG) = DTIME(I)
RAB(ILEG) = DRA(I)
DECB(ILEG) = DDEC(I)
ELSE IF (IBRN .EQ. 1 .AND. IBRN(I) .EQ. 0) THEN
TIMEB(ILEG) = DTIME(I-1)
ILEG = ILEG + 1
END IF
IBRN = IBRN(I)
END DO
200 TIMEC(ILEG) = DTIME(I-1)
NPNT = 1
DO I = 1, ILEG
IF (I .EQ. 1) THEN
NPNT = NPNT + INT(TIMEB(1)/PINTC) +
1
INT((TIMEC(1) - TIMEB(1))/PINTB) + 2
ELSE
NPNT = NPNT + INT((TIMEB(I) - TIMEB(I-1))/PINTC) +
1
INT((TIMEC(I) - TIMEB(I))/PINTB) + 2
END IF
END DO
WRITE (31, *) NPNT
WRITE (32, *) NPNT
WRITE (33, *) NPNT
WRITE (34, *) NPNT
WRITE (35, *) NPNT
A(1, 1) = 1.0
A(2, 2) = 1.0
A(3, 3) = 1.0
Q0 = 1.0
IREAD = 0
C INITIALIZE COAST AND MANEUVER COUNTERS
C
ICOAST = 1
IMAN = 1
1000 PINT = PINTC
CALL QUAT (A, Q0, Q1, Q2, Q3)
SRA = RAB(ICOAST)
SDEC = DEC0(ICOAST)
999 IF (TIME .GE. TIMEB(ICOAST)) THEN
IF (PINT .EQ. PINTC) THEN
PINT = PINTB
TIME = TIMEB(ICOAST)
PTIME = TIME
CALL GETSTATE (TIME, X, DUM1, DUM2, RA, DEC)
PSIM = RA
THTM = -DEC
DO I = 1, 3
  DO J = 1, 3
    IF (I .EQ. J) THEN
      A(I,J) = 1.0
      B(I,J) = 1.0
      C(I,J) = 1.0
    ELSE
      A(I,J) = 0.0
      B(I,J) = 0.0
      C(I,J) = 0.0
    END IF
  END DO
END DO
CALL ROTATE (A, RA, -DEC, 0.0, 3, 2, 0)
CALL GETPROJ (TIME, A, ROT)
CALL ROTATE (A, 0.0, 0.0, ROT+RBURN, 0, 0, 1)
PHIM = ROT+RBURN
CALL GETSTATE (TIME+TDIFF, X, DUM1, DUM2, RA, DEC)
CALL ROTATE (B, RA, -DEC, 0.0, 3, 2, 0)
CALL GETPROJ (TIME+TDIFF, B, ROT)
PSIP = RA
THTP = -DEC
PHIP = ROT+RBURN
PSI = (PSIP+PSIM) * 0.5
THT = (THTP+THTM) * 0.5
PHI = (PHIP-PHIP) * 0.5
PSID = (PSIP-PSIM) / TDIFF
THTD = (THTP-THTM) / TDIFF
PHID = (PHIP-PHIP) / TDIFF
WP = PHID - PSID * SIN(THT)
WQ = THTD * COS(PHI) + PSID * COS(THT) * SIN(PHI)
WR = PSID * COS(THT) * COS(PHI) - THTD * SIN(PHI)
CALL OUTPUT (0.0, TIME, A, WP, WQ, WR, PTIME)
GOTO 999
END IF
IF (PTIME .GT. TIMZC(ICOAST)) THEN
  PINT = PINTC
  TIME = TIMEC(ICOAST)
  CALL GETSTATE (TIME-TDIFF, X, DUM1, DUM2, RA, DEC)
  PSIM = RA
  THTM = -DEC
  DO I = 1, 3
    DO J = 1, 3
      IF (I .EQ. J) THEN
        A(I,J) = 1.0
        B(I,J) = 1.0
      ELSE
        A(I,J) = 0.0
        B(I,J) = 0.0
      END IF
    END DO
  END DO
  CALL ROTATE (B, RA, -DEC, 0.0, 3, 2, 0)
  CALL GETPROJ (TIME, B, ROT)
  PHIM = ROT+RBURN
  CALL GETSTATE (TIME, X, DUM1, DUM2, RA, DEC)
  PSIP = RA
  THTP = -DEC
  CALL ROTATE (A, RA, -DEC, 0.0, 3, 2, 0)
  CALL GETPROJ (TIME, A, ROT)
  CALL ROTATE (A, 0.0, 0.0, ROT+RBURN, 0, 0, 1)
  PHIP = ROT+RBURN
  PSI = (PSIP+PSIM) * 0.5
\[ \begin{align*}
THT &= (THTP + THTM) \times 0.5 \\
PHI &= (PHIP + PHIM) \times 0.5 \\
PSID &= (PSIP - PSIM) / TDIFF \\
THTD &= (THTP - THTM) / TDIFF \\
PHID &= (PHIP - PHIM) / TDIFF \\
WP &= PHID - PSID \times \sin(THT) \\
WQ &= THTD \times \cos(PHI) + PSID \times \cos(THT) \times \sin(PHI) \\
WR &= PSID \times \cos(THT) \times \cos(PHI) - THTD \times \sin(PHI) \\
\end{align*} \]

CALL OUTPUT (0, TIME, A, WP, WQ, WR, PTIME)

ELSE

\[ \begin{align*}
TIME &= PTIME - TDIFF \times 0.5 \\
\end{align*} \]

CALL GETSTATE (TIME, X, DUM1, DUM2, RA, DEC) \\
PSIM = RA \\
THTM = -DEC \\
DO I = 1, 3 \\
  DO J = 1, 3 \\
    IF (I .EQ. J) THEN \\
    A(I,J) = 1.0 \\
    B(I,J) = 1.0 \\
    C(I,J) = 1.0 \\
    ELSE \\
    A(I,J) = 0.0 \\
    B(I,J) = 0.0 \\
    C(I,J) = 0.0 \\
    END IF \\
  END DO \\
END DO \\
CALL ROTATE (B, RA, -DEC, 0.0, 3, 2, 0) \\
CALL GETPROJ (TIME, B, ROT) \\
PHIM = ROT + RBURN \\
TIME = PTIME \\
CALL GETSTATE (TIME, X, DUM1, DUM2, RA, DEC) \\
PSI = RA \\
THT = -DEC \\
CALL ROTATE (A, RA, -DEC, 0.0, 3, 2, 0) \\
CALL GETPROJ (TIME, A, ROT) \\
CALL ROTATE (A, 0.0, 0.0, ROT + RBURN, 0.0, 1) \\
PHI = ROT + RBURN \\
PSIP = RA \\
THTP = -DEC \\
CALL ROTATE (C, RA, -DEC, 0.0, 3, 2, 0) \\
CALL GETPROJ (TIME + 0.5 * TDIFF, C, ROT) \\
PHIP = ROT + RBURN \\
PSID = (PSIP - PSIM) / TDIFF \\
THTD = (THTP - THTM) / TDIFF \\
PHID = (PHIP - PHIM) / TDIFF \\
WP = PHID - PSID \times \sin(THT) \\
WQ = THTD \times \cos(PHI) + PSID \times \cos(THT) \times \sin(PHI) \\
WR = PSID \times \cos(THT) \times \cos(PHI) - THTD \times \sin(PHI) \\
\end{align*} \]

CALL OUTPUT (0, TIME, A, WP, WQ, WR, PTIME) \\
GOTO 999

END IF

END IF

C C READ A MANEUVER

C IF (IREAD .LE. 1) THEN \\
  CALL RMAN (JCOAST, JMAN, NAME, SYS, POINT, IPOINT, SLEW, ISLEW, ROLL, 1 \\
  IROLL, RATE, IRATE, ACCEL, IACCEL, STIME, ITIME)

C C CHECK COAST AND MANEUVERS

C IF (ICOAST .EQ. 1 .AND. IMAN .EQ. 1 .AND. (JCOAST .NE. 1 .OR. JMAN

A-7
.NE. 1)) THEN
   WRITE (6,*) 'THE FIRST MANEUVER MUST BE COAST #1 AND MANEUVER #
11'
   STOP
ELSE IF (ICOAST .EQ. JCOAST) THEN
   IF (IMAN .NE. JMAN) THEN
      WRITE (6,*) 'YOU HAVE MISNUMBERED YOUR MANEUVERS', JCOAST,
1   STOP
   END IF
ELSE
   IF (JCOAST .NE. ICOAST + 1 .AND. JMAN .EQ. 1) THEN
      WRITE (6,*) 'YOU HAVE MISNUMBERED YOUR COASTS OR NOT RESTARTED YOUR MANEUVER NUMBERS', JCOAST, JMAN
      STOP
   END IF
IF (ICOAST .GT. NLEGS) THEN
   WRITE (6,*)
   'YOU HAVE EXCEEDED THE NUMBER OF COASTS IN THIS MISSION'
   STOP
END IF
IF (ITIME .EQ. 2 .OR. IREAD .EQ. 1) THEN
    IF (IREAD .EQ. 0) THEN
      IMANS = IMAN-1
      DO I = 1,3
         DO J = 1,3
            ASV(I,J) = A(I,J)
         END DO
      END DO
      WPSV = WP
      WQSV = WQ
      WRSV = WR
      TIMESV = TIME
      PTIMESV = PTIME
   END IF
   ITIMEF = 1
   NAMEZ(IND) = NAME
   ISYSZ(IND) = ISYS
   STIMEZ(IND) = STIME
   ITIMEZ(IND) = ITIME
   DO I = 1,3
      POINTZ(IND,I) = POINT(I)
      IPOINTERZ(IND,I) = IPOINTER(I)
      RATEZ(IND,I) = RATE(I)
      IRATEZ(IND,I) = IRATE(I)
      ACCELZ(IND,I) = ACCEL(I)
      IACELERZ(IND,I) = IACELER(I)
      IF (I .NE. 3) THEN
         SLEWZ(IND,I) = SLEW(I)
         ISLEWZ(IND,I) = ISLEW(I)
      END IF
      END DO
      IND = IND + 1
      IREAD = 1
      IF (ITIME .EQ. 1) THEN
         IREAD = 2
      END IF
   ELSE IF (IREAD .EQ. 2) THEN
IF (IMAN-IMANS .EQ. 1) THEN
  DO I = 1,3
    DO J = 1,3
      A(I,J) = ASV(I,J)
    END DO
  END DO
  WP = WPSV
  WQ = WQSV
  WR = WRSV
  TIME = TIMESV
  PTIME = PTIMESV
END IF
NAME = NAMEZ(IMAN-IMANS)
ISYS = ISYSZ(IMAN-IMANS)
STIME = STIMEZ(IMAN-IMANS)
ITIME = ITIMEZ(IMAN-IMANS)
DO I = 1,3
  POINT(I) = POINTZ(IMAN-IMANS, I)
  IPOINT(I) = IPOINTZ(IMAN-IMANS, I)
  RATE(I) = RATEZ(IMAN-IMANS, I)
  ACCEL(I) = ACCELZ(IMAN-IMANS, I)
  IACCEL(I) = IACCELZ(IMAN-IMANS, I)
  IF (I .NE. 3) THEN
    SLEW(I) = SLEWZ(IMAN-IMANS, I)
    ISLEW(I) = ISLEWZ(IMAN-IMANS, I)
    ROLL(I) = ROLLZ(IMAN-IMANS, I)
    IROLL(I) = IROLLZ(IMAN-IMANS, I)
  END IF
END DO
IF (ITIMEF .EQ. 0 .AND. ABS(TINC) .LT. TTOL .AND. IMAN - IMANS .EQ. 1) THEN
  IREAD = 0
  ITIME = 0
END IF
IF (IMAN .EQ. 1) THEN
  WRITE (13,*) 'BEGINNING COAST ', ICOAST
  WRITE (6,*) 'BEGINNING COAST ', ICOAST
END IF
WRITE (13,*) 'BEGINNING MANEUVER ', IMAN
WRITE (6,*) 'BEGINNING MANEUVER ', IMAN
C CHECK 1ST MANEUVER
C
IF (ICOAST .EQ. 1 .AND. IMAN .EQ. 1) THEN
  IF (IPOINT(1) .EQ. 2) THEN
    CALL ROTATE (A, SRA, SDEC, 0.0, 3, 2, 0)
    CALL GETPROJ (TIME, A, ROT)
    CALL ROTATE (A, 0.0, 0.0, ROT+RBURN, 0, 0, 0)
  ELSE IF (IPOINT(1) .EQ. 1 .AND. IPOINT(2) .EQ. 1 .AND.
            IPOINT(3) .EQ. 3) THEN
    CALL POINTER (TIME, POINT, IPOINT, ISYS, A)
  ELSE IF (ISYS .EQ. 3 .AND. IPOINT(1) .EQ. 1 .OR. IPOINT(2) .EQ. 1) THEN
    CALL POINTER (TIME, POINT, IPOINT, ISYS, A)
  ELSE
    WRITE (6,*) 'YOU HAVE ENTERED AN INCORRECT OR INCOMPLETE SET OF INITIAL CONDITIONS'
  END IF
  CALL QUAT (A, Q0, Q1, Q2, Q3)
END IF
C
CALL POINTER (TIME+TDIFF, POINT, IPOINT, ISYS, B)
PSIP = ATAN2 (B(1,2),B(1,1))
THTP = ASIN (-B(1,3))
PHIP = ATAN2 (B(2,3),B(3,3))
PSID = (PSIP-PSI) / TDIFF
THTP = (THTP-THT) / TDIFF
PHID = (PHIP-PHI) / TDIFF
WP = PHID - PSID * SIN(THT)
WQ = THTD * COS(PHI) + PSID * COS(THT) * SIN(PHI)
WR = PSID * COS(THT) * COS(PHI) - THTD * SIN(PHI)
ELSE
WP = 0.0
WQ = 0.0
WR = 0.0
END IF
CALL OUTPUT (ITIMEF,TIME,A, WP, WQ, WR, PTIME)
END IF
C CHECK THE STATION KEEPING TIME FOR THIS MANEUVER
IF (ITIME .EQ. 2) THEN
XTIME = TIME
MAN = IMAN
STIME = TSTAY(IMAN)
IF (STIME .EQ. 0.0) IPRINT = 0
END IF
C THIS SECTION OF CODE HANDLES THE CASE WHERE A POINTING COMMAND HAS
C BEEN ISSUED AND NOW THE VEHICLE MUST STOP ANY CURRENT MOTION THAT IT
C HAS AND THEN SLEW TO THE COMMANDED ATTITUDE
IF (IPOINT(1) .NE. 0 .OR. IPOINT(2) .NE. 0 .OR. IPOINT(3) .NE. 1) THEN
C THE FIRST PART HERE IS THE STOPPING OF ANY ROLL AND/OR SLEW RATE
C THAT MAY BE PRESENT FROM THE PREVIOUS MANEUVER
WRITE (13,*) 'STOPPING MOTION TIME,WP, WQ, WR = ', TIME, WP, WQ, WR
CALL QUAT (A,Q0,Q1,Q2,Q3)
IEVENT = 0
IF (IROLL(2) .EQ. 0) TTSR = WP
ELSE IF (WP .LT. 0.0) THEN
SROLL = -ROLL(1)
SACCEL = -ROLL(2)
ELSE
SROLL = ROLL(1)
SACCEL = ROLL(2)
END IF
TTSR = WP / SACCEL
END IF
IF (ISLEW(2) .EQ. 0) THEN
WQ = 0.0
WR = 0.0
TTSS = 0.0
ELSE
SLEWR = (WQ**2 + WR**2)**0.5
IF (WR .LT. 0.0 .OR. WQ .LT. 0.0) THEN
SLEWA = ATAN2 (WR,WQ)
ELSE
SLEWA = ATAN2 (WQ,WR)
ENDIF
TTSS = SLEWR / SLEW(2)
END IF
IF (TTSS .EQ. 0.0 .AND. TTSR .EQ. 0.0) THEN

A-10
IEVENT = 3
ELSE IF (IEVENT .LE. 1) THEN
  IEVENT = 1
  IF (TTSR .GT. TTSS) THEN
    IHIGH = 1
    ELSE
      IEVENT = TTSS
      IHIGH = 2
  END IF
END IF
ELSE IF (IEVENT .NE. 3) THEN
  IF (TINT .LT. TEVENT) THEN
    DELT = TINT
  ELSE
    DELT = TEVENT
    IF (IEVENT .EQ. 1) THEN
      IEVENT = 2
      IF (IHIGH .EQ. I) THEN
        TEVENT = TTSR
      ELSE
        TEVENT = TTSS
      END IF
    ELSE
      IEVENT = 3
    END IF
  END IF
END IF
IF (TIME + DELT .GT. PTIME) THEN
  IF (WP .NE. 0.0) THEN
    ANGTRAVR = WP * (PTIME-TIME) - 0.5 * SACCEL * (PTIME-TIME)**2
    WPP = WP - SACCEL * (PTIME-TIME)
  ELSE
    WPP = WP
  END IF
  IF (SLEWR .NE. 0.0) THEN
    ANGTRAVS = SLEWR * (PTIME-TIME) - 0.5 * SLEW(2) * (PTIME-TIME)**2
    SLEWR = SLEWR - SLEW(2) * (PTIME-TIME)
    WRP = SLEWR * SIN(SLEWA)
    WQP = SLEWR * COS(SLEWA)
  ELSE
    WQP = WQ
    WR = WRP
    CALL QUATUP (THTDX, THTDY, THTDZ, PTIME-TIME, Q0, Q1, Q2, Q3, A)
    TEVENT = TEVENT - (PTIME-TIME)
    TIME = PTIME
    WP = WPP
    WQ = WQP
    WR = WRP
    CALL OUTPUT (ITIMEF, TIME, A, WP, WQ, WR, PTIME)
    GOTO 10
  ELSE
    TEVENT = TEVENT - DELT
    TIME = TIME + DELT
    IF (WP .NE. 0.0) THEN
      ANGTRAVR = WP * DELT - 0.5 * SACCEL * DELT ** 2
      WPP = WP - SACCEL * DELT
    ELSE
      WPP = WP
    END IF
IF (SLEWR .NE. 0.0) THEN
ANGTRAVS = SLEWR * DELT - 0.5 * SLEW(2) * DELT ** 2
SLEWR = SLEWR - SLEW(2) * DELT
WRP = SLEWR * SIN(SLEWA)
WQP = SLEWR * COS(SLEWA)
ELSE
WRP = WR
WQP = WQ
END IF
THTDX = (WP + WPP) * 0.5
THTDY = (WQ + WQP) * 0.5
THTDZ = (WR + WRP) * 0.5
CALL QUATUP (THTDX, THTDY, THTDZ, DELT, Q0, Q1, Q2, Q3, A)
IF (DELT .NE. TINT) THEN
IF (:EVENT .EQ. 3) THEN
WP = 0.0
WQ = 0.0
WR = 0.0
SLEWR = 0.0
ELSE IF (IHIGH .EQ. 1) THEN
WP = 0.0
WQ = WQFP
WR = WRP
END IF
ELSE
WP = WPFP
WQ = WQP
WR = WRP
END IF
GOTO 10
ELSE
WP = 0.0
WQ = 0.0
WR = 0.0
END IF
WRITE (13, *) 'MOTION STOPPED, TIME = ', TIME
C NOW THAT ANY MOTION LEFT OVER FROM THE PREVIOUS MANEUVER HAS BEEN
C NULLLED OUT, THE NEXT OBJECTIVE IS TO GET INTO THE PROPER ROLL ATTITUDE
IF (ISYS .NE. 4) THEN
CALL ROLLER (TIME, PTIME, A, IPOINT, POINT, ROLL, IROLL, ITIMEF, WP, ISYS)
END IF
C NOW THAT THE DESIRED ROLL ATTITUDE HAS BEEN REACHED, THE SLEWING
C MOTION TAKES PLACE
RDDELAY = 0.0
PTIME = TIME
TV1(1) = A(1, 1)
TV1(2) = A(1, 2)
TV1(3) = A(1, 3)
DO I = 1, 3
DO J = 1, 3
IF (I .EQ. J) THEN
B(I,J) = 1.0
ELSE
B(I,J) = 0.0
END DO
END DO
A-12
IF (IPOINT(1) .EQ. 2) THEN
    CALL ROTATE (B, SRA, -SDEC, 0.0, 3, 2, 0)
ELSE IF (ISYS .EQ. 1) THEN
    CALL ROTATE (B, POINT(1), -POINT(2), 0.0, 3, 2, 0)
ELSE IF (ISYS .EQ. 2) THEN
    CALL SUNV (FTIME, SUNRA, SUNDEC)
    CALL ROTATE (B, SUNRA, -SUNDEC, 0.0, 3, 2, 0)
ELSE IF (ISYS .EQ. 3) THEN
    CALL GETSTATE (FTIME, X, DUM1, DUM2, T1, T2)
    ANGI = ATAN2 (X(2), X(1))
    ANG2 = ATAN2 (X(3), (X(1)**2 + X(2)**2)**0.5)
    CALL ROTATE (B, ANGI, -ANG2, 0.0, 3, 2, 0)
    CALL ROTATE (B, POINT(1), -POINT(2), 0.0, 3, 2, 0)
ELSE IF (ISYS .EQ. 4) THEN
    CALL ROTATE (B, SANG1, -SANG2, 0.0, 3, 2, 0)
ENDIF

T1 = TV1(1)*B(1,1) + TV1(2)*B(1,2) + TV1(3)*B(1,3)
IF (T1 .GT. 1.0) T1 = 1.0
IF (T1 .LT. -1.0) T1 = -1.0
SLEWANG = ACOS (T1)
IF (SLEWANG .EQ. 0.0 .OR. ABS(T1) .EQ. 1.0) GOTO 666
IF (ISLEW(1) .EQ. 0 .AND. ISLEW(2) .EQ. 0) THEN
    TTS = 0.0
    WQ = 0.0
    WQ = 0.0
ELSE IF (ISLEW(1) .EQ. 1 .AND. ISLEW(2) .EQ. 0) THEN
    TTS = SLEWANG / SLEW(1)
ELSE IF (ISLEW(1) .EQ. 1 .AND. ISLEW(2) .EQ. 1) THEN
    DACCEL = 0.5 * SLEW(2) * TACCEL ** 2
    DDECEL = SLEW(1) * TACCEL - DACCEL
    IF (SLEWANG .LT. DACCEL + DDECEL) THEN
        TTS = (4.0 * SLEWANG / SLEW(2)) ** 0.5
        T1 = TIME + TTS * 0.5
        T2 = T1
    ELSE
        TTS = 2.0 * TACCEL + (SLEWANG-DACCEL-DDECEL) / SLEW(1)
        T1 = TIME + TACCEL
        T2 = TIME + TTS - TACCEL
    END IF
ENDIF

END IF
IF (ISYS .EQ. 2 .OR. ISYS .EQ. 3) THEN
    IF (ABS(TIME+TTS+RDELAY-FTIME) .GT. TOL) THEN
        FTIME = TIME + TTS + RDELAY
        GOTO 50
    END IF
ELSE
    FTIME = TIME + TTS
ENDIF

C12M(1,1) = TV1(1)
C12M(1,2) = TV1(2)
C12M(1,3) = TV1(3)
C12M(3,1) = TV1(2) * B(1,3) - TV1(3) * B(1,2)
C12M(3,2) = TV1(3) * B(1,1) - TV1(1) * B(1,3)
C12M(3,3) = TV1(1) * B(1,2) - TV1(2) * B(1,1)
XMAG = (C12M(3,1)**2 + C12M(3,2)**2 + C12M(3,3)**2)**0.5
C12M(3,1) = C12M(3,1) / XMAG
C12M(3,2) = C12M(3,2) / XMAG
C12M(3,3) = C12M(3,3) / XMAG
C12M(2,1) = C12M(3,2)*C12M(1,3) - C12M(3,3)*C12M(1,2)
C12M(2,2) = C12M(3,3)*C12M(1,1) - C12M(3,1)*C12M(1,3)

A-13
\[ CI2M(2,3) = CI2M(3,1) \times CI2M(1,2) - CI2M(3,2) \times CI2M(1,1) \]

\[
\text{DO } J = 2, 3 \\
\quad \text{ROLLM}(2, J) = 0.0 \\
\text{DO } K = 1, 3 \\
\quad \text{ROLLM}(2, J) = \text{ROLLM}(2, J) + CI2M(2, K) \times A(J, K) \\
\text{END DO} \\
\text{END DO} \\
\text{ROLLTEMP} = \text{ATAN2} (\text{ROLLM}(2, 3), \text{ROLLM}(2, 2)) \\
\text{IF } (\text{TTS} \leq 0.0) \text{ THEN} \\
\quad \text{CALL ROTATE} (A, 0.0, 0.0, \text{ROLLTEMP}, 0, 0, 1) \\
\quad \text{CALL ROTATE} (A, \text{SLEWANG}, 0.0, 0.0, 3, 0, 0) \\
\quad \text{CALL ROTATE} (A, 0.0, 0.0, -\text{ROLLTEMP}, 0, 0, 1) \\
\text{GOTO 666} \\
\text{END IF} \\
\text{ROLLI} = -\text{ROLLTEMP} \\
\text{DO } I = 1, 3 \\
\quad \text{DO } J = 1, 3 \\
\quad \quad D(I, J) = CI2M(I, J) \\
\text{END DO} \\
\text{END DO} \\
\text{CALL ROTATE} (D, \text{SLEWANG}, 0.0, 0.0, 3, 0, 0) \\
\text{IF } (\text{ISYS} \neq 4) \text{ THEN} \\
\quad \text{CALL GETPROJ} (\text{FTIME}, B, \text{ROT}) \\
\quad \text{IF } (\text{IPOINT} \leq 2) \text{ THEN} \\
\quad \quad \text{CALL ROTATE} (B, 0.0, 0.0, \text{ROT+RBURN}, 0, 0, 1) \\
\quad \else \\
\quad \quad \text{CALL ROTATE} (B, 0.0, 0.0, \text{ROT+POINT}(3), 0, 0, 1) \\
\quad \end{IF} \\
\text{ELSE} \\
\quad \text{IF } (\text{IPOINT} \leq 0) \text{ THEN} \\
\quad \quad \text{CALL ROTATE} (B, 0.0, 0.0, \text{STARROT1+POINT}(1), 0, 0, 1) \\
\quad \else \\
\quad \quad \text{CALL ROTATE} (B, 0.0, 0.0, \text{STARROT2+POINT}(2), 0, 0, 1) \\
\quad \end{IF} \\
\text{END IF} \\
\text{END IF} \\
\text{DO } J = 2, 3 \\
\quad \text{ROLLM}(2, J) = 0.0 \\
\text{DO } K = 1, 3 \\
\quad \text{ROLLM}(2, J) = \text{ROLLM}(2, J) + D(2, K) \times B(J, K) \\
\text{END DO} \\
\text{END DO} \\
\text{ROLLF} = -\text{ATAN2} (\text{ROLLM}(2, 3), \text{ROLLM}(2, 2)) \\
\text{DELTROLL} = \text{ROLLF} - \text{ROLLI} \\
\text{SROLL} = \text{ROLL}(1) \\
\text{SACCEL} = \text{ROLL}(2) \\
\text{IF } (\text{DELTROLL} \geq \text{PI}) \text{ DELTROLL} = \text{DELTROLL} - 2.0 \times \text{PI} \\
\text{IF } (\text{DELTROLL} \leq -\text{PI}) \text{ DELTROLL} = \text{DELTROLL} + 2.0 \times \text{PI} \\
\text{IF } (\text{DELTROLL} \leq 0.0) \text{ THEN} \\
\text{SROLL} = -\text{SROLL} \\
\text{SACCEL} = -\text{SACCEL} \\
\text{END IF} \\
\text{WPAVG} = \text{DELTROLL} / \text{TTS} \\
\text{TR0} = \text{TIME} \\
\text{WPWAVG} = \text{WPAVG} \\
\text{TR1} = \text{TIME} \\
\text{TR2} = \text{TIME} + \text{TTS} \\
\text{IF } (\text{IROLL} \leq 0) \text{ THEN} \\
\quad \text{IF } (\text{ABS(WPMAX}) \geq \text{ABS(SROLL)}) \text{ THEN} \\
\quad \quad \text{WPWAVG} = \text{SROLL} \\
\quad \else \\
\quad \quad \text{TR2} = \text{TIME} + \text{TTS} \\
\quad \end{IF} \\
\text{ELSE} \\
\text{TEMP1} = \text{TTS} \times 2.0 \times \text{DELTROLL} / \text{SACCEL} \\
\text{IF } (\text{TEMP1} \geq 0.0) \text{ THEN} \\
\quad \text{TACCI} = 0.5 \times (\text{TTS} - \text{TEMP1} \times 0.5) \\
\quad \text{WPWAVG} = \text{SACCEL} \times \text{TACCI} \\
\text{END IF}
```
IF (ABS(WPMAX) .GT. ABS(SROLL)) THEN
  WPMAX = SROLL
  TACC1 = SROLL / SACCEL
  TR1 = TR0 + TACC1
  ANGT = (TTS-TACC1) * WPMAX
  TR2 = TIME+TTS-TACC1 + (DELTROLL-ANGT)/WPMAX
ELSE
  TR1 = TR0 + TACC1
  TR2 = TIME+TTS - TACC1
END IF
ELSE
  TACC1 = (DELTROLL/SACCEL)**0.5
  IF (TACC1 .GT. SROLL/SACCEL) THEN
    TACC1 = SROLL/SACCEL
    TR1 = TR0 - TACC1
    WPMAX = SROLL
    ANGT = (TTS-TACC1) * SROLL
    TR2 = TIME+TTS- TACC1 + (DELTROLL-ANGT)/SROLL
  ELSE
    TR1 = TR0 + TACC1
    WPMAX = SACCEL * TACC1
    TR2 = TR1
  END IF
END IF
END IF
END IF
IF (ISYS .EQ. 2 .OR. ISYS .EQ. 3) THEN
  RDELAY = TR2+TR1-TR0-PTIME
  IF (RDELAY .GT. TOL) GOTO 50
END IF
WRITE (13, *) 'BEGIN SLEWING, TIME, SLEWANG, DELTROLL=', TIME, SLEWANG, DELTROLL
IF (ISLEW(1) .EQ. 1 .AND. ISLEW(2) .EQ. 0) THEN
  TTS = SLEWANG / SLEW(1)
  IF (TIME + TTS .GT. PTIME) THEN
    ANGTRAV = SLEW(1) * (PTIME-TIME-TDIFF*0.5)
    SLEWANG = SLEWANG - ANGTRAV
    CALL SLEWER (PTIME-.5*TDIFF, CI2M, ROLLTEMP, ANGTRAV, POINT, IPOINT, ROLLI, PSI, THT, PHI, A)
    ANGTRAV = SLEW(1) * TDIFF * 0.5
    SLEWANG = SLEWANG - ANGTRAV
    CALL SLEWER (PTIME, CI2M, ROLLTEMP, ANGTRAV, POINT, IPOINT, ROLLI, PSI, THT, PHI, A)
  DO I = 1,3
    DO J = 1,3
      B(I,J) = CI2M(I,J)
    END DO
  END DO
  ROLLTEMPB = ROLLTEMP
  ANGTRAV = SLEW(1) * TDIFF * 0.5
  CALL SLEWER (PTIME-.5*TDIFF, B, ROLLTEMPB, ANGTRAV, POINT, IPOINT, ROLLI, PSI, THT, PHI, C)
  PSID = (PSIP-PSIM) / TDIFF
  THTD = (THTP-THTM) / TDIFF
  PHID = (PHIP-PHIP) / TDIFF
  WP = PHID - PSID * SIN(THT)
  WQ = THTD * COS(PHI) + PSID * COS(THT) * SIN(PHI)
  WR = PSID * COS(THT) + COS(PHI) - THTD * SIN(PHI)
  TIME = PTIME
  CALL OUTPUT (ITIMEF, TIMZ, A, WP, WQ, WR, PTIME)
  GOTO 51
ELSE
  TIME = TIME + TTS
  CALL SLEWER (TIME,
```

A-15
CI2M, ROLLEMP, SLEWANG, POINT, IPOINT, ROLLI,
PSI, THT, PHI, A

WQ = 0.0
WR = 0.0
IF (TIME .LE. TR2) THEN
WP = WPMAX
ELSE IF (TIME .GE. TR2+TR1-TR0) THEN
WP = 0.0
ELSE
WP = -WPMAX / (TR1-TR0) * (TIME-TR2) + WPMAX
END IF
END IF
ELSE IF (ISLEW(1).EQ.1 .AND. ISLEW(2).EQ.1) THEN
IF (TIME + TTS .GT. PTIME) THEN
IF (PTIME-TIME-TDIFF*0.5 .GT. 0.0) THEN
ISG = 1
ELSE
ISG = -1
END IF
ANGTRAV = SLEWR * (PTIME-TIME-TDIFF*0.5) + 0.5 * SLEW(2)*ISG*(PTIME-TIME-TDIFF*0.5)**2
SLEWR = SLEWR + SLEW(2) * (PTIME-TIME-TDIFF*0.5)**2
ELSE IF (T2 .GT. PTIME) THEN
ANGTRAV = SLEWR * (T1-TIME) + 0.5 *
SLEWR = SLEWR + SLEW(1) * (PTIME-TIME-TDIFF*0.5)
ELSE
ANGTRAV = SLEW(1) * (PTIME-TIME-TDIFF*0.5)
END IF
SLEWR = SLEW(1)
ELSE
IF (TIME .LT. T1) THEN
ANGTRAV = SLEWR * (T1-TIME) + 0.5 *
* SLEW(2) * (T1-TIME)**2 + SLEW(1) * (PTIME-T2-TDIFF*0.5)
SLEWR = SLEW(1) - SLEW(2) * (PTIME-T2-TDIFF*0.5)*0.5
ELSE IF (TIME .LT. T2) THEN
ANGTRAV = SLEWR * (PTIME-TIME-TDIFF*0.5) - 0.5 * SLEW(2) * (PTIME-TIME-TDIFF*0.5)**2
SLEWR = SLEWR - SLEW(2) * (PTIME-TIME-TDIFF*0.5)
ELSE
ANGTRAV = SLEWR * (PTIME-TIME-TDIFF*0.5) - 0.5 * SLEW(2) * (PTIME-TIME-TDIFF*0.5)**2
SLEWR = SLEWR - SLEW(2) * (PTIME-TIME-TDIFF*0.5)
END IF
END IF
SLEWANG = SLEWANG - ANGTRAV
CALL SLEWER (PTIME-.5*TDIFF,
CI2M, ROLLEMP, ANGTRAV, POINT, IPOINT, ROLLI,
PSI, THT, PHI, A)

IF (T1 .GT. PTIME) THEN
IF (SLEWR .LT. 0.0) THEN
TT0 = -SLEWR/SLEW(2)
ANGTRAV = - (SLEWR * TT0 + 0.5 * SLEW(2) * TT0)**2 + 0.5 * SLEW(2) * (TDIFF*0.5 - TT0)**2
SLEWR = SLEW(2) * (TDIFF*0.5- TT0)

A-16
ELSE
ANGTRAV = SLEWR * (TDIFF*0.5) + 0.5 * SLEW(2) * (TDIFF*0.5)*2
SLEWR = SLEWR + SLEW(2) * (0.5*TDIFF)
END IF
ELSE IF (T2 .GT. PTIME) THEN
ANGTRAV = SLEW(1) * (TDIFF*0.5)
SLEWR = SLEW(1)
ELSE
ANGTRAV = SLEWR * (TDIFF*0.5) - 0.5 * SLEW(2) * (TDIFF*0.5)*2
SLEWR = SLEWR - SLEW(2) * (TDIFF*0.5)
END IF
SLEWANG = SLEWANG - ANGTRAV
CALL SLEWER (PTIME, CI2M, ROLLTEMP, ANGTRAV, POINT, IPOINT, ROLLI, PSI, THT, PHI, A)
DO I = 1, 3
DO J = 1, 3
B(I,J) = CI2M(I,J)
END DO
END DO
ROLLTEMPS = ROLLTEMP
IF (T1 .GT. PTIME) THEN
ANGTRAV = SLEWR * (TDIFF*0.5) + 0.5 * SLEW(2) * (TDIFF*0.5)*2
ELSE IF (T2 .GT. PTIME) THEN
ANGTRAV = SLEW(1) * (TDIFF*0.5)
ELSE
ANGTRAV = SLEWR * (TDIFF*0.5) - 0.5 * SLEW(2) * (TDIFF*0.5)*2
END IF
CALL SLEWER (PTIME+.5*TDIFF, CI2M, ROLLTEMP, SLEWANG, POINT, IPOINT, ROLLI, PSI, THT, PHI, A)
PSID = (PSIP-PSIM) / TDIFF
THTD = (THTP-THTM) / TDIFF
PHID = (PHIP-PHIPM) / TDIFF
WP = PHID + PSID * SIN(THT)
WQ = THTD * COS(PHI) + PSID * COS(THT) * SIN(PHI)
WR = PSID * COS(THT) * COS(PHI) - THTD * SIN(PHI)
TTS = TTS - (PTIME-TIME)
TIME = PTIME
CALL OUTPUT (ITIMES, TIME, A, WP, WQ, WR, PTIME)
GOTO 60
ELSE
TIME = TIME + TTS
CALL SLEWER (TIME, CI2M, ROLLTEMP, SLEWANG, POINT, IPOINT, ROLLI, PSI, THT, PHI, A)
WQ = 0.0
WR = 0.0
IF (TIME LT. TR2) THEN
WP = WPMax
ELSE IF (TIME GT. TR2+TR1-TR0) THEN
WP = 0.0
ELSE
WP = -WPMax / (TR1-TR0) * (TIME-TR2) + WPMax
ENDIF
ENDIF
WRITE (13,*) ' END SLEWING MOTION ,TIME=' , TIME
CALL ROLLER (TIME, PTIME, A, IPOINT, POINT, ROLL, IROLL, ITIMES, WP, ISYS)

A-17
AT THIS POINT THE DESIRED POINTING ATTITUDE SHOULD HAVE BEEN ACHIEVED
AND THE CURRENT SLEW RATE OF 0 BUT A POSSIBLE NON-ZERO ROLL RATE

THE NEXT THING TO CONSIDER IS STATION KEEPING. THE ONLY STATION
KEEPING MODE WHERE THE ATTITUDE IS CHANGING IS THE LVLH STATION
KEEPING, THE OTHERS ARE INERTIALLY FIXED. THE ATTITUDE WITH RESPECT
TO THE SUN CHANGES SLIGHTLY WITH TIME, AND IF DRIFT FROM THE DESIRED
ATTITUDE IS A PROBLEM, THE USER SHOULD ENTER PERIODIC MANEUVER
CORRECTIONS TO MAINTAIN THE PROPER ATTITUDE. THE SLEW AND ROLL RATES
INVOLVED IN MAINTAINING A PARTICULAR SOLAR ATTITUDE ARE SO SMALL THAT
IT WAS FELT THAT PERIODIC CORRECTIONS WOULD BE MADE RATHER THAN TRY TO
MOVE AT THESE VERY SMALL RATES.

IF (IPOINT(1).EQ.2) THEN
  STIME = TIMEB(ICOAST) - TIME
  ITIME = 1
END IF

IF (ITIMEF.EQ.1 .AND. ITIME .EQ. 1) THEN
  TINC = TIME - (TIME-XTIME)
  IF (ABS(TINC) .GT. TTOL) THEN
    TSTAY(MAN) = TSTAY(MAN) + TINC
  ELSE
    ITIMEF = 0
  END IF

ELSE IF (ITIMEF .EQ. 0 .AND. ITIMEF .EQ. 1) THEN
  STIME = TIME - (PTIME-TIME)
  TIME = PTIME
ELSE
  TIME = TIME + STIME
  STIME = 0.0
END IF

IF (ISYS .EQ. 3) THEN
  CALL LVLH(TIME-TDIFF*0.5, POINT, IPOINT, A, PSI, THT, PHI)
  CALL LVLH(TIME, POINT, IPOINT, A, PSI, THT, PHI)
DO I = 1,3
  DO J = 1,3
    B(I,J) = A(I,J)
  END DO
END DO

CALL LVLH(TIME+TDIFF*0.5, POINT, IPOINT, B, PSI, THT, PHI)
PSID = (PSI-PSIM) / TDIFF
THTD = (THT-THTM) / TDIFF
PHID = (PHI-PHIM) / TDIFF
WQ = THTD * COS(PHI) + PSID * COS(THT) * SIN(PHI)
WR = PSID * COS(THT) * COS(PHI) - THTD * SIN(PHI)
ELSE
  WP = 0.0
  WQ = 0.0
  WR = 0.0
END IF

IF (TIME .EQ. PTIME) THEN
  CALL OUTPUT (ITIMEF, TIME, A, WP, WQ, WR, PTIME)
ENDIF

IF (TIME .NE. 0.0) GOTO 61
END IF

AT THIS POINT EVERYTHING IS DONE FOR THIS MANEUVER IF IT IS A
POINTING COMMAND

ELSE

HERE A RATE COMMANDED MANEUVER WILL BE HANDLED

WRITE (13,*) 'BEGIN RATE COMMAND, TIME=',TIME
BRATE(1) = WP
BRATE(2) = WQ
BRATE(3) = WR
TSTOP = 9.99E9

DO I = 1, 3
   IACC(I) = 0
   IF (IRATE(I) .EQ. 1 .AND. IACCEL(I) .EQ. 0) THEN
      BRATE(I) = RATE(I)
      TACC(I) = 0.0
   ELSEIF (IRATE(I) .EQ. 1 .AND. IACCEL(I) .EQ. 1) THEN
      IF (BRATE(I) .GT. RATE(I)) THEN
         SACC(I) = -ACCEL(I)
      ELSE
         SACC(I) = ACCEL(I)
      END IF
      TACC(I) = (RATE(I) - BRATE(I)) / SACC(I)
      IACC(I) = 1
   END IF
END DO

DELT = TINT
ITEMP = 0
DO I = 1, 3
   IF (IACC(I) .EQ. 1 .AND. TACC(I) .LT. DELT) THEN
      DELT = TACC(I)
      ITEMP = I
   END IF
END DO

IF (TSTOP - TIME .LT. DELT) THEN
   DELT = TSTOP - TIME
END IF

IF (TIME + DELT .GT. PTIME) THEN
   DO I = 1, 3
      IF (IACC(I) .EQ. 0) THEN
         BRATEP(I) = BRATE(1) + SACC(I) * (PTIME - TIME)
      ELSE
         BRATEP(I) = BRATE(1)
      END IF
   END DO
   THTDX = (BRATEP(1) + BRATE(1)) * 0.5
   THTDY = (BRATEP(2) + BRATE(2)) * 0.5
   THTDZ = (BRATEP(3) + BRATE(3)) * 0.5
   CALL QUATUP(THTDX, THTDY, THTDZ, PTIME - TIME, Q0, Q1, Q2, Q3, A)
   TIME = TIME + DELT
   BRATE(1) = BRATEP(1)
   BRATE(2) = BRATEP(2)
   BRATE(3) = BRATEP(3)
   CALL OUTPUT(ITEMP, TIME, A, BRATE(1), BRATE(2), BRATE(3), PTIME)
   IF (IKEEP .EQ. 0) GOTO 70
   GOTO 75
ELSE
   DO I = 1, 3
      IF (IACC(I) .EQ. 0) THEN
         BRATEP(I) = BRATE(I)
      ELSE
         BRATEP(I) = BRATE(1) + SACC(I) * (DELT)
      END IF
   END DO
   THTDX = (BRATEP(1) + BRATE(1)) * 0.5
   THTDY = (BRATEP(2) + BRATE(2)) * 0.5
   THTDZ = (BRATEP(3) + BRATE(3)) * 0.5
   CALL QUATUP(THTDX, THTDY, THTDZ, DELT, Q0, Q1, Q2, Q3, A)
   TIME = TIME + DELT
   BRATE(1) = BRATEP(1)
   BRATE(2) = BRATEP(2)
   BRATE(3) = BRATEP(3)
END IF

IF (ITEMP .EQ. 0) THEN
   IACC(ITEMP) = 0
END IF

THTDX = (BRATEP(1) + BRATE(1)) * 0.5
THTDY = (BRATEP(2) + BRATE(2)) * 0.5
THTDZ = (BRATEP(3) + BRATE(3)) * 0.5
CALL QUATUP(THTDX, THTDY, THTDZ, DELT, Q0, Q1, Q2, Q3, A)
TIME = TIME + DELT
BRATE(1) = BRATEP(1)
BRATE(2) = BRATEP(2)
BRATE(3) = BRATEP(3)

IF (IACC(1) .EQ. 1 .OR. IACC(2) .EQ. 1 .OR. IACC(3) .EQ. 1)
1 THEN
   IKEEP = 0
   GOTO 70
ELSE IF (ITIMEF .EQ. 1 .AND. ITIME .EQ. 1) THEN
   TINC = STIME - (TIME - XTIME)
   IF (ABS(TINC) .GT. TTOL) THEN
      TSTAY(MAN) = TSTAY(MAN) + TINC
   ELSE
      ITIMEF = 0
   END IF
   IMAN = MAN - 1
ELSE IF (ITIME .EQ. 1) THEN
   IF (IKEEPI .EQ. 0) THEN
      IKEEP = 1
      TSTOP = TIME + STIME
   END IF
   IF (TIME .LT. TSTOP) GOTO 75
END IF
END IF

WP = BRATE(1)
WQ = BRATE(2)
WR = BRATE(3)
END IF
IMAN = IMAN + 1
IF (TIME .GT. TIMEB(ICOAST)) THEN
   WRITE (*,*) 'YOU HAVE DESIGNED COAST MANEUVERS DURING A BURN'
   STOP
END IF
GOTO 1000
END
SUBROUTINE CONVERT (STRNI, LEN, LOC, DNUMI)
CHARACTER STRNI (1:LEN)
CHARACTER NUMT (10)
CHARACTER SIGN
CHARACTER MINUS, PLUS, COMMA, DECIML, DOLLAR, BLANK, NULL
INTEGER LOC, POINT, LEN
INTEGER CNT2
DOUBLE PRECISION DNUMI, VAL, VAL2, AMT

NULL=CHAR(0)
BLANK=''
MINUS='-
PLUS='+
COMMA=','
DECIML='.'
DOLLAR='$
NUMT(1)='0'
NUMT(2)='1'
NUMT(3)='2'
NUMT(4)='3'
NUMT(5)='4'
NUMT(6)='5'
NUMT(7)='6'
NUMT(8)='7'
NUMT(9)='8'
NUMT(10)='9'

CNT2=0
SIGN=PLUS
VAL=0
VAL2=0

IF (LOC.LT.1) GOTO 10
IF (LOC.GT.LEN) GOTO 10
GOTO 15

10 CONTINUE
DNUMI=0
RETURN

15 CONTINUE
POINT=LOC-1

20 CONTINUE
POINT=POINT+1
IF (POINT.GT.LEN) GOTO 10
IF (STRNI(POINT).EQ.BLANK) GOTO 20
IF (STRNI(POINT).EQ.PLUS) GOTO 30
IF (STRNI(POINT).EQ.MINUS) GOTO 30
GOTO 50

25 CONTINUE
AMT=ICHAR(STRNI(POINT))
AMT=AMT-48
VAL=VAL+AMT
GOTO 40

28 CONTINUE
AMT=ICHAR(STRNI(POINT))
AMT=AMT-48
VAL2=VAL2+AMT
CNT2=CNT2+1
VAL2=VAL2*10
GOTO 70

30 SIGN=STRNI(POINT)

40 CONTINUE
POINT=POINT+1
IF (POINT.GT.LEN) GOTO 61

50 CONTINUE
IF (STRNI(POINT).EQ.COMMA) GOTO 40
IF (STRNI(POINT).EQ.DOLLAR) GOTO 40
IF (STRNI(POINT).EQ.BLANK) GOTO 40
DO 60 I=1,10

60 CONTINUE

IF (STRN1 (POINT) .EQ. NUMT (I)) GOTO 25
60 CONTINUE
61 VAL = VAL / 10
62 IF (STRN1 (POINT) .NE. DECIML) GOTO 100
70 CONTINUE
71 POINT = POINT + 1
72 IF (POINT .GT. LEN) GOTO 85
80 CONTINUE
81 IF (STRN1 (POINT) .EQ. NUMT (I)) GOTO 28
85 VAL2 = VAL2 / 10
86 DO 90 I = 1, I0
87 VAL2 = VAL2 / 10
90 CONTINUE
91 CONTINUE
100 CONTINUE
101 IF (POINT .GT. LEN) GOTO 120
102 IF (STRN1 (POINT) .EQ. BLANK) GOTO 105
103 IF (SIGN .EQ. PLUS) GOTO 110
104 IF (SIGN .EQ. MINUS) GOTO 110
105 POINT = POINT + 1
106 IF (POINT .GT. LEN) GOTO 120
107 GOTO 100
110 CONTINUE
111 SIGN = STRN1 (POINT)
120 CONTINUE
121 DNUM = VAL + VAL2
122 IF (SIGN .EQ. MINUS) DNUM = DNUM * (-1.)
123 RETURN
124 END
SUBROUTINE GETPROJ (TIME, A, ROT)
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION A(3,3), SUND(3), SUNM(3)
CALL SUNV (TIME, RA, DEC)
SUND(1) = COS(DEC) * COS(RA)
SUND(2) = COS(DEC) * SIN(RA)
SUND(3) = SIN(DEC)
DO I = 1, 3
  SUNM(I) = 0.0
  DO J = 1, 3
    SUNM(I) = SUNM(I) + A(I,J) * SUND(J)
  END DO
END DO
ROT = ATAN2 (SUNM(3), SUNM(2))
RETURN
END
SUBROUTINE GETSTATE (T,XI,G1,THI,R1,DECI)
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION XI(3),G1(3),THI(3),VAR(I1,3),VALUE(I1)
COMMON /COM1/ DTIME(5000),DX(5000,3),DGACC(5000,3),DMACC(5000,3),
IBRN(5000),DRA(5000),DDEC(5000)

IF (IFIRST.EQ.0) THEN
  T1 = DTIME(1)
  T2 = DTIME(2)
  T3 = DTIME(3)
  TC = DTIME(4)
  IC = 4
END IF

10 IF (T.GT.T2 .AND. T-T1.GT.TC-T) THEN
  T1 = T2
  T2 = T3
  T3 = TC
  IC = IC + 1
  TC = DTIME(IC)
  GOTO 10
END IF

DO I = 1,11
  DO J = 1,3
    IF (I .LE. 3) THEN
      VAR(I,J) = DX(IC-4+J,I)
    ELSE IF (I .LE. 6) THEN
      VAR(I,J) = DGACC(IC-4+J,I-3)
    ELSE IF (I .LE. 9) THEN
      VAR(I,J) = DMACC(IC-4+J,I-6)
    ELSE IF (I .EQ. 10) THEN
      VAR(I,J) = DKA(IC-4+J)
    ELSE
      VAR(I,J) = DDEC(IC-4+J)
    END IF
  END DO
END DO

IF (IBRN(IC-3).EQ.1 .AND. IBRN(IC-2).EQ.1 .AND. IBRN(IC-1).EQ.0) THEN
  DO I = 1,11
    IF (I.GE.7 .AND. I.LE.9 .AND. T.GT.DTIME(IC-2)) THEN
      A = 0.0
      B = (DMACC(IC-3,I-6)-DMACC(IC-4,I-6))
      C = DMACC(IC-3,I-6) - B * DTIME(IC-3)
    ELSE
      A = 0.0
      B = (VAR(I,1)-VAR(I,2)) / (DTIME(IC-3)-DTIME(IC-2))
      C = VAR(I,1) - B * DTIME(IC-3)
    END IF
    VALUE(I) = B * T + C
  END DO
END IF
ELSE IF (IBRN(IC-3).EQ.0 .AND. IBRN(IC-2).EQ.1 .AND. IBRN(IC-1).EQ.1) THEN
  DO I = 1,11
    IF (I.GE.7 .AND. I.LE.9 .AND. T.LT.DTIME(IC-2)) THEN
      A = 0.0
      B = (DMACC(IC-3,I-6)-DMACC(IC-4,I-6))
      C = DMACC(IC-3,I-6) - B * DTIME(IC-3)
    ELSE
      A = 0.0
      B = (VAR(I,2)-VAR(I,3)) / (DTIME(IC-2)-DTIME(IC-1))
      C = VAR(I,2) - B * DTIME(IC-2)
    END IF
    VALUE(I) = B * T + C
  END DO
END IF
ELSE

A-24
DO I = 1, 11
  IF (I.GE. 7 .AND. I.LE. 9 .AND. IBRN(IC-3) .EQ. 0 .AND.
    IBRN(IC-2) .EQ. 0 .AND. IBRN(IC-1) .EQ. 1) THEN
    A = 0.0
    B = (VAR(I,2) - VAR(I,3)) / (DTIME(IC-2) - DTIME(IC-1))
    C = VAR(I,2) - B * DTIME(IC-2)
  ELSE IF (I.GE. 7 .AND. I.LE. 9 .AND. IBRN(IC-3) .EQ. 1
    .AND. IBRN(IC-2) .EQ. 0 .AND. IBRN(IC-1) .EQ. 0) THEN
    A = 0.0
    B = (VAR(I,1) - VAR(I,2)) / (DTIME(IC-3) - DTIME(IC-2))
    C = VAR(I,1) - B * DTIME(IC-3)
  ELSE
    A = (((VAR(I,1) - VAR(I,2)) * (DTIME(IC-3) - DTIME(IC-1)) -
      (VAR(I,1) - VAR(I,3)) * (DTIME(IC-3) - DTIME(IC-2))) /
      (DTIME(IC-3)**2 - DTIME(IC-2)**2) * (DTIME(IC-3) -
      DTIME(IC-1)**2) - (DTIME(IC-3)**2 - DTIME(IC-2)**2) *
      (DTIME(IC-3) - DTIME(IC-2)))
    B = (VAR(I,1) - VAR(I,2) - A * (DTIME(IC-3)**2 - DTIME(IC-2)**2)) /
      (DTIME(IC-3) - DTIME(IC-2))
    C = VAR(I,1) - A * DTIME(IC-3)**2 - B * DTIME(IC-3)
  END IF
END DO
END IF
END I

DO I = 1, 11
  IF (I.LE. 3) THEN
    XI(I) = VALUE(I)
  ELSE IF (I.LE. 6) THEN
    GI(I-3) = VALUE(I)
  ELSE IF (I.LE. 9) THEN
    THI(I-6) = VALUE(I)
  ELSE IF (I.EQ. 10) THEN
    RA1 = VALUE(I)
  ELSE
    DECI = VALUE(I)
  END IF
END DO
RETURN
END
SUBROUTINE LVLH (TIME, POINT, IPOINT, A, PSI, THT, PHI)

IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION POINT (3), IPOINT (3), A(3, 3), X(3), DUM1 (3), DUM2 (3)
COMMON/COM3/PI, TWOP I, PI02

IF (IPOINT(3) .EQ. 0) THEN
  CALL GETPROJ (TIME, A, ROTI)
END IF

DO I = 1, 3
  DO J = 1, 3
    IF (I .EQ. J) THEN
      A(I,J) = 1.0
    ELSE
      A(I,J) = 0.0
    END IF
  END DO
END DO

CALL GETSTATE (TIME, X, DUM1, DUM2, RA, DEC)
ANG1 = ATAN2 (X(2), X(1))
ANG2 = ATAN2 (X(3), (X(1) ** 2 + X(2) ** 2) ** 0.5)
CALL ROTATE (A, ANG1, -ANG2, .5 * PI, 0.0, 3, 2, 0)
CALL ROTATE (A, POINT(1), -POINT(2), 0.0, 3, 2, 0)
CALL GETPROJ (TIME, A, ROT)
IF (IPOINT(3) .EQ. 1) THEN
  CALL ROTATE (A, 0.0, 0.0, ROT + POINT(3), 0, 0, 1)
ELSE
  CALL ROTATE (A, 0.0, 0.0, ROT - ROTI, 0, 0, 1)
END IF

PSI = ATAN2 (A(1, 2), A(1, 1))
THT = ASIN (-A(1, 3))
PHI = ATAN2 (A(2, 3), A(3, 3))
RETURN
END
SUBROUTINE OUTPUT (ITIMEF,TIME,A,WP,WQ,WR,PTIME)
IMPLICIT REAL*8 (A-H,O-Z)
COMMON /COM2/ PINT,TIME0
DIMENSION A(3,3),G(3),TH(3),DUM(3)
PTIME = PTIME + PINT
IF (ITIMEF .EQ. 0) THEN
CALL QUAT (A,Q0,Q1,Q2,Q3)
CALL GETSTATE (TIME,DUM,G,TH,T1,T2)
WRITE (31,100) TIME,G(1)+TH(1),G(2)+TH(2),G(3)+TH(3)
WRITE (32,100) TIME,G(1),G(2),G(3)
WRITE (33,100) TIME,TH(1),TH(2),TH(3)
WRITE (34,100) TIME,WP,WQ,WR
WRITE (35,101) TIME,Q0,Q1,Q2,Q3
END IF
RETURN
END
SUBROUTINE POINTER (TIME, POINT, IPOINT, ISYS, A)
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION POINT(3), A(3,3), X(3), IPOINT(3), SV1(3), SV1M(3), SV2(3),
1 SV2M(3)
COMMON/COM3/PI, TWOPI, PIO2
COMMON/COM7/SANG1, SANG2, STARROT1, STARROT2, SV1, SV2
DO I = 1, 3
  DO J = 1, 3
    IF (I .EQ. J) THEN
      A(I,J) = 1.0
    ELSE
      A(I,J) = 0.0
    END IF
  END DO
END DO
IF (ISYS .EQ. 1) THEN
  CALL ROTATE (A, POINT(1), -POINT(2), 0.0, 3, 2, 0)
  CALL GETPROJ (TIME, A, ROT)
ELSE IF (ISYS .EQ. 2) THEN
  CALL SUNRV (TIME, SUNRA, SUNDEC)
  CALL ROTATE (A, SUNRA, -SUNDEC, 0.0, 3, 2, 0)
  CALL GETPROJ (TIME, A, ROT)
  CALL ROTATE (A, POINT(1), -POINT(2), 0.0, 3, 2, 0)
ELSE IF (ISYS .EQ. 3) THEN
  CALL GETSTATE (TIME, X)
  ANGI = ATAN2 (X(2), X(1))
  ANG2 = ATAN2 (X(3), (X(1)**2 + X(2)**2) ** 0.5)
  CALL ROTATE (A, ANGI, -ANG2-0.5*PI, 0.0, 3, 2, 0)
  CALL ROTATE (A, POINT(1), -POINT(2), 0.0, 3, 2, 0)
  CALL GETPROJ (TIME, A, ROT)
  CALL ROTATE (A, 0.0, 0.0, ROT+POINT(3), 0, 0, 1)
ELSE IF (ISYS .EQ. 4) THEN
  CALL ROTATE (A, SANG1, -SANG2, 0.0, 3, 2, 0)
  IF (IPOINT(1) .EQ. 1) THEN
    CALL ROTATE (A, 0.0, 0.0, STARROT1+POINT(1), 0, 0, 1)
  ELSE
    CALL ROTATE (A, 0.0, 0.0, STARROT2+POINT(2), 0, 0, 1)
  END IF
END IF
RETURN
END
SUBROUTINE QUAT (COORD, Q0, Q1, Q2, Q3)
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION COORD(3,3)
Q0 = 0.5 * (1.0 + COORD(1,1) + COORD(2,2) + COORD(3,3)) ** 0.5
Q1 = (Q0 * Q0 - 0.5 * (COORD(2,2) + COORD(3,3))) ** 0.5
IF (COORD(2,3) - COORD(3,2) .LT. 0.0) THEN
  Q1 = -Q1
END IF
Q2 = (Q0 * Q0 - 0.5 * (COORD(1,1) + COORD(3,3))) ** 0.5
IF (COORD(3,1) - COORD(1,3) .LT. 0.0) THEN
  Q2 = -Q2
END IF
Q3 = (Q0 * Q0 - 0.5 * (COORD(1,1) + COORD(2,2))) ** 0.5
IF (COORD(1,2) - COORD(2,1) .LT. 0.0) THEN
  Q3 = -Q3
END IF
RETURN
END
SUBROUTINE QUATUP (THTDX, THTDY, THTDZ, DELTA, Q0, Q1, Q2, Q3, A)
IMPLICIT REAL*8 (A-H, O-Z)
DIMENSION A(3, 3)
THTD = (THTDX**2 + THTDY**2 + THTDZ**2)**0.5
IF (THTD .NE. 0.0) THEN
  Q5 = COS (THTD*DELTA/ 2.0)
  Q6 = SIN (THTD*DELTA/ 2.0) / THTD
  Q0P = Q5 * Q0 - Q6 * (Q1 * THTDX + Q2 * THTDY + Q3 * THTDZ)
  Q1P = Q5 * Q1 + Q6 * (Q0 * THTDX + Q2 * THTDZ - Q3 * THTDY)
  Q2P = Q5 * Q2 + Q6 * (Q0 * THTDY - Q1 * THTDZ + Q3 * THTDX)
  Q3P = Q5 * Q3 - Q6 * (Q0 * THTDZ + Q1 * THTDX - Q2 * THTDY)
  Q0 = Q0P
  Q1 = Q1P
  Q2 = Q2P
  Q3 = Q3P
  DQ = 0.5 * (1.0 - Q0*Q0 - Q1*Q1 - Q2*Q2 - Q3*Q3)
  Q0 = Q0 * (1.0 + DQ)
  Q1 = Q1 * (1.0 + DQ)
  Q2 = Q2 * (1.0 + DQ)
  Q3 = Q3 * (1.0 + DQ)
END IF
A(1,1) = Q0 * Q0 + Q1 * Q1 - Q2 * Q2 - Q3 * Q3
A(1,2) = 2.0 * (Q1 * Q2 + Q3 * Q0)
A(1,3) = 2.0 * (Q1 * Q3 - Q2 * Q0)
A(2,1) = 2.0 * (Q1 * Q2 - Q3 * Q0)
A(2,2) = Q0 * Q0 - Q1 * Q1 + Q2 * Q2 - Q3 * Q3
A(2,3) = 2.0 * (Q2 * Q3 + Q1 * Q0)
A(3,1) = 2.0 * (Q1 * Q3 + Q2 * Q0)
A(3,2) = 2.0 * (Q2 * Q3 - Q1 * Q0)
A(3,3) = Q0 * Q0 - Q1 * Q1 - Q2 * Q2 + Q3 * Q3
RETURN
END
SUBROUTINE RMAN (JCOAST, JMAN, NAME, ISYS, POINT, IPOINT, SLEW, ISLEW, ROLL, IROLL, RATE, IRATE, ACCEL, IACCEL, TIME, ITIME)

IMPLICIT REAL*8 (A-H,O-Z)

COMMON/COM3/PI, TWOPI, PIO2
CHARACTER*1 CTYPE, ATEMP
CHARACTER*40 NAME, TEMP
CHARACTER*60 ALPHA
DIMENSION POINT(3), IPOINT(3), SLEW(2), ISLEW(2), ROLL(2), IROLL(2), RATE(3), IRATE(3), ACCEL(3), IACCEL(3)

DO I = 1, 3
  POINT(I) = 0.0
  RATE(I) = 0.0
  ACCEL(I) = 0.0
  IPOINT(I) = 0
  IRATE(I) = 0
  IACCEL(I) = 0
  IF (I.NE. 3) THEN
    SLEW(I) = 0.0
    ROLL(I) = 0.0
    ISLEW(I) = 0
    IROLL(I) = 0
  END IF
END DO

C
READ A BLANK LINE
C
READ (20,*)
C
GET COAST NUMBER
C
READ (20,110) JCOAST
110 FORMAT (9X, I10)
  IF (JCOAST .LE. 0) THEN
    WRITE (6,*) 'YOU HAVE ENTERED A NON-POSITIVE COAST NUMBER : ',
    JCOAST
  END IF
STOP
READ (20,111) JMAN
111 FORMAT (12X, I10)
  IF (JMAN .LE. 0) THEN
    WRITE (6,*) 'YOU HAVE ENTERED A NON-POSITIVE MANEUVER NUMBER :
    JMAN
  END IF
STOP
READ (20,112) NAME
112 FORMAT (6X, A40)
READ (20,113) CTYPE
113 FORMAT (29X, A1)
  IF (CTYPE .EQ. 'A' .OR. CTYPE .EQ. 'a') THEN
    ISYS = 1
  ELSE IF (CTYPE .EQ. 'B' .OR. CTYPE .EQ. 'b') THEN
    ISYS = 2
  ELSE IF (CTYPE .EQ. 'C' .OR. CTYPE .EQ. 'c') THEN
    ISYS = 3
  ELSE IF (CTYPE .EQ. 'D' .OR. CTYPE .EQ. 'd') THEN
    ISYS = 4
  ELSE
    WRITE (6,*) 'YOU HAVE ENTERED AN IMPROPER COORDINATE SYSTEM :
    CTYPE
  END IF
STOP
READ (20,*)
READ (20,114) ALPHA
114 FORMAT (17X, A60)
IF (ALPHA(I:1) .EQ. 'B' .OR. ALPHA(I:1) .EQ. 'b') THEN  
IPOINT(1) = 2  
ELSE IF (ALPHA(I:1) .EQ. ' ') THEN  
IPOINT(1) = 0  
IPOINT(2) = 0  
IPOINT(3) = 0  
ELSE  
IF (ALPHA(I:1) .EQ. 'X' .OR. ALPHA(I:1) .EQ. 'x') THEN  
IPOINT(1) = 0  
INUM = 3  
ELSE  
INUM = 2  
IF (ALPHA(INUM:INUM) .EQ. ',' .AND. ALPHA(INUM:INUM) .EQ. ' ') THEN  
INUM = INUM + 1  
IF (INUM .EQ. 61) GOTO 11  
GOTO 10  
END IF  
10  
TEMP(1:40) = ' '  
TEMP = ALPHA(1:INUM-1)  
CALL CONVERT (TEMP,40,1,T1)  
POINT(1) = T1  
IPOINT(1) = 1  
INUM = INUM + 1  
IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. ' ') GOTO 40  
END IF  
IF (ALPHA(INUM:INUM) .EQ. ' ') THEN  
IPOINT(2) = 0  
IPOINT(3) = 0  
ELSE  
IF (ALPHA(INUM:INUM) .EQ. 'X' .OR. ALPHA(INUM:INUM) .EQ. 'x') THEN  
IPOINT(2) = 0  
INUM = INUM + 2  
ELSE  
INUM = INUM  
INUM = INUM + 1  
IF (ALPHA(INUM:INUM) .EQ. ',' .AND. ALPHA(INUM:INUM) .EQ. ' ') THEN  
INUM = INUM + 1  
IF (INUM .EQ. 61) GOTO 21  
GOTO 20  
END IF  
20  
TEMP(1:40) = ' '  
TEMP = ALPHA(INUM:INUM-1)  
CALL CONVERT (TEMP,40,1,T1)  
POINT(2) = T1  
IPOINT(2) = 1  
INUM = INUM + 1  
IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. ' ') GOTO 40  
END IF  
IF (ALPHA(INUM:INUM) .EQ. ' ') THEN  
IPOINT(3) = 0  
ELSE  
TEMP(1:40) = ' '  
TEMP = ALPHA(INUM:60)  
CALL CONVERT (TEMP,40,1,T1)  
POINT(3) = T1  
IPOINT(3) = 1  
END IF  
END IF  
40  
READ (20,114) ALPHA  
IF (ALPHA(I:1) .EQ. ' ') THEN  
ISLEN(1) = 0
ELSE
IF (ALPHA(INUM:INUM) .NE. ',') THEN
INUM = INUM + 1
IF (INUM .EQ. 61) GOTO 31
GOTO 30
END IF
31
TEMP(1:40) = ' '
TEMP = ALPHA(1:INUM-1)
CALL CONVERT (TEMP,40,1,T1)
SLEW(1) = T1
ISLEW(1) = 1
INUM = INUM + 1
IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. '. ') GOTO 50
END IF
IF (ALPHA(INUM:INUM) .EQ. '. ') THEN
ISLEW(2) = 0
ELSE
TEMP(1:40) = ' '
TEMP = ALPHA(INUM:60)
CALL CONVERT (TEMP,40,1,T1)
SLEW(2) = T1
ISLEW(2) = 1
END IF
END IF
50
READ (20,114) ALPHA
IF (ALPHA(1:1) .EQ. '. ') THEN
IROLL(1) = 0
IROLL(2) = 0
ELSE
IF (ALPHA(1:1) .EQ. 'X' .OR. ALPHA(1:1) .EQ. 'x') THEN
IROLL(1) = 0
INUM = INUM + 1
END IF
IF (ALPHA(INUM:INUM) .EQ. ' ' .AND. ALPHA(INUM:INUM) .EQ. ' ' ) GOTO 231
GOTO 230
END IF
230
TEMP(1:40) = ' '
TEMP = ALPHA(1:INUM-1)
CALL CONVERT (TEMP,40,1,T1)
IROLL(1) = T1
IROLL(1) = 1
INUM = INUM + 1
IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. '. ') GOTO 250
END IF
IF (ALPHA(INUM:INUM) .EQ. '. ') THEN
IROLL(2) = 0
ELSE
TEMP(1:40) = ' '
TEMP = ALPHA(INUM:60)
CALL CONVERT (TEMP,40,1,T1)
IROLL(2) = T1
IROLL(2) = 1
END IF
END IF
250
READ (20,*)
READ (20, 116) ALPHA
116 FORMAT (20X, A60)
   IF (ALPHA(1:1).EQ. ' ') THEN
      IRATE(1) = 0
      IRATE(2) = 0
      IRATE(3) = 0
   ELSE
      IF (ALPHA(1:1).EQ. 'X' .OR. ALPHA(1:1).EQ. 'x') THEN
         IRATE(1) = 0
         INUM = 3
      ELSE
         INUM = 2
         IF (ALPHA(INUM:INUM).NE. ',' .AND. ALPHA(INUM:INUM).NE. ' ' ) THEN
            INUM = INUM + 1
            IF (INUM.GE. 61) GOTO 311
            GOTO 310
         END IF
      END IF
      END IF
   END IF
   IF (ALPHA(INUM:INUM).EQ. ' ') THEN
      IRATE(2) = 0
      IRATE(3) = 0
   ELSE
      IF (ALPHA(INUM:INUM).EQ. 'X' .OR. ALPHA(INUM:INUM).EQ. 'x') THEN
         IRATE(2) = 0
         INUM = INUM + 2
      ELSE
         INUM = INUM + 1
         IF (ALPHA(INUM:INUM).NE. ',' .AND. ALPHA(INUM:INUM).NE. ' ') THEN
            INUM = INUM + 1
            IF (INUM.GE. 61) GOTO 321
            GOTO 320
         END IF
      END IF
      END IF
   END IF
   IF (ALPHA(INUM:INUM).EQ. ' ') THEN
      IRATE(3) = 0
   ELSE
      IF (ALPHA(INUM:INUM).EQ. ' ' ) THEN
         TEMP(1:40) = ' '
         TEMP = ALPHA(INUM:INUM)
         CALL CONVERT (TEMP, 40, 1, T1)
         RATE(2) = T1
         IRATE(2) = 1
         INUM = INUM + 1
         IF (INUM.GE. 60 .OR. ALPHA(INUM-1:INUM-1).EQ. ' ') GOTO 340
         GOTO 321
      END IF
      END IF
   END IF
310 IF (ALPHA(INUM:INUM).NE. ',' .AND. ALPHA(INUM:INUM).NE. ' ') THEN
   IF (INUM.GE. 61) GOTO 311
   GOTO 310
311 TEMP(1:40) = ' '
   TEMP = ALPHA(1:INUM-1)
   CALL CONVERT (ALPHA, 40, 1, T1)
   RATE(1) = T1
   IRATE(1) = 1
   INUM = INUM + 1
   IF (INUM.GT. 60 .OR. ALPHA(INUM-1:INUM-1).EQ. ' ') GOTO 340
   END IF
   IF (ALPHA(INUM:INUM).EQ. ' ') THEN
      IRATE(2) = 0
      IRATE(3) = 0
   ELSE
      IF (ALPHA(INUM:INUM).EQ. 'X' .OR. ALPHA(INUM:INUM).EQ. 'x') THEN
         IRATE(2) = 0
         INUM = INUM + 2
      ELSE
         INUM = INUM + 1
         IF (ALPHA(INUM:INUM).NE. ',' .AND. ALPHA(INUM:INUM).NE. ' ') THEN
            INUM = INUM + 1
            IF (INUM.GE. 61) GOTO 340
            GOTO 321
         END IF
      END IF
      END IF
   END IF
   IF (ALPHA(INUM:INUM).EQ. ' ') THEN
      IRATE(3) = 0
   ELSE
      IF (ALPHA(INUM:INUM).EQ. ' ' ) THEN
         TEMP(1:40) = ' '
         TEMP = ALPHA(INUM:INUM)
         CALL CONVERT (TEMP, 40, 1, T1)
         RATE(3) = T1
         IRATE(3) = 1
         END IF
      END IF
   END IF
320 IF (ALPHA(INUM:INUM).NE. ',' .AND. ALPHA(INUM:INUM).NE. ' ') THEN
   IF (INUM.GE. 61) GOTO 321
   GOTO 320
321 IF (ALPHA(INUM:INUM).EQ. ' ') THEN
   IRATE(3) = 0
   ELSE
      IF (ALPHA(INUM:INUM).EQ. ' ' ) THEN
         TEMP(1:40) = ' '
         TEMP = ALPHA(INUM:INUM)
         CALL CONVERT (TEMP, 40, 1, T1)
         RATE(3) = T1
         IRATE(3) = 1
      END IF
   END IF
   END IF
340 READ (20, 117) ALPHA
117 FORMAT (19X, A60)
   IF (ALPHA(1:1).EQ. ' ') THEN
IACCEL(1) = 0
IACCEL(2) = 0
IACCEL(3) = 0

ELSE
   IF (ALPHA(1:1) .EQ. 'X' .OR. ALPHA(1:1) .EQ. 'x') THEN
      IACCEL(1) = 0
      INUM = 3
   END IF
   ELSE
      INUM = 2
   IF (ALPHA(INUM:INUM) .NE. ',' .AND. ALPHA(INUM:INUM) .NE. ')') THEN
      INUM = INUM + 1
      IF (INUM .EQ. 61) GOTO 411
   END IF
   GOTO 410
410 IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. ' ') THEN
   IACCEL(1) = 0
   END IF
   IF (ALPHA(INUM:INUM) .EQ. 'X' .OR. ALPHA(INUM:INUM) .EQ. 'x') THEN
      IACCEL(1) = 0
      INUM = INUM + 2
   ELSE
      INUM = INUM + 1
      IF (ALPHA(INUM:INUM) .NE. ',' .AND. ALPHA(INUM:INUM) .NE. ')') THEN
         INUM = INUM + 1
         IF (INUM .EQ. 61) GOTO 421
      END IF
      GOTO 420
420 IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. ' ') THEN
   IACCEL(2) = 0
   ELSE
      INUM = INUM + 1
      IF (ALPHA(INUM:INUM) .EQ. 'X' .OR. ALPHA(INUM:INUM) .EQ. 'x') THEN
         IACCEL(2) = 0
         INUM = INUM + 2
      ELSE
         INUM = INUM + 1
         IF (ALPHA(INUM:INUM) .NE. ',' .AND. ALPHA(INUM:INUM) .NE. ')') THEN
            INUM = INUM + 1
            IF (INUM .EQ. 61) GOTO 421
         END IF
         GOTO 420
521 IF (INUM .GT. 60 .OR. ALPHA(INUM-1:INUM-1) .EQ. ' ') THEN
   IACCEL(3) = 0
   ELSE
      INUM = INUM + 1
      IF (ALPHA(INUM:INUM) .EQ. 'X' .OR. ALPHA(INUM:INUM) .EQ. 'x') THEN
         IACCEL(3) = 0
         END IF
   END IF
   GOTO 440
END IF
END IF
END IF
440 READ (20,*)
       READ (20,120) ATEMP
120 FORMAT (28X,A1)
   IF (ATEMP .EQ. ' ') THEN
      ITIME = 0
   ELSE IF (ATEMP .EQ. '+' ) THEN
ITIME = 2
ELSE
BACKSPACE 20
READ (20,121) TIME

121 FORMAT (28X,F20.8)
ITIME = 1
IF (TIME .LT. 0.0) THEN
WRITE (6,*) 'YOU HAVE ENTERED A NEGATIVE TIME : ', TIME 
STOP
END IF
END IF
DO I = 1,3
POINT(I) = POINT(I)*PI/180.0
RATE(I) = RATE(I)*PI/180.0
ACCEL(I) = ACCEL(I)*PI/180.0
IF (I .LE. 2) THEN
SLEW(I) = SLEW(I)*PI/180.0
ROLL(I) = ROLL(I)*PI/180.0
END IF
END DO
TIME = TIME * 60.0
RETURN
END
SUBROUTINE ROLLER (TIME,PTIME,A,IPOINT,POINT,ROLL,IROLL,IREAD,WP, 1 ISYS)

IMPLICIT REAL*8 (A-H,O-Z)

COMMON /COM3/ PI,TWOP1,PI02
COMMON /COM4/ RBURN
COMMON /COM7/ SANG1,SANG2,STARROT1,STARROT2,SV1(3),SV2(3)

DIMENSION A(3,3),IPOINT(3),POINT(3),ROLL(2),IROLL(2),SV1M(3),
1 SV2M(3)

IF (ISYS .NE. 4) THEN
  CALL GETPROJ (TIME,A, ROT)
ELSE IF (IPOINT(1) .EQ. 2) THEN
  ROLLANG1 = ROT + RBURN
ELSE IF (IPOINT(3) .NE. 0) THEN
  ROLLANG1 = ROT + POINT(3)
ELSE
  ROLLANG1 = 0.0
END IF
ELSE
  IF (IPOINT(1) .EQ. 1) THEN
    SV1M(2) = A(2,1) * SV1(1) + A(2,2) * SV1(2) + A(2,3)
    SV1M(3) = A(3,1) * SV1(1) + A(3,2) * SV1(2) + A(3,3)
    ROT = ATAN2 (SV1M(3),SV1M(2))
    ROLLANG1 = ROT + POINT(1)
  ELSE
    SV2M(2) = A(2,1) * SV2(1) + A(2,2) * SV2(2) + A(2,3)
    SV2M(3) = A(3,1) * SV2(1) + A(3,2) * SV2(2) + A(3,3)
    ROT = ATAN2 (SV2M(3),SV2M(2))
    ROLLANG1 = ROT + POINT(2)
END IF
END IF

ROLLANG = ANG(ROLLANG1)
WRITE (13,*)'ROLLING TO CORRECT ATTITUDE, TIME,ROLLANG=', TIME,ROLLANG

IF (ROLLANG .GT. PI) THEN
  ROLLANG = ROLLANG - TWOPI
  SROLL = -ROLL(1)
  SACCEL = -ROLL(2)
ELSE
  SROLL = ROLL(1)
  SACCEL = ROLL(2)
END IF

IF (IROLL(1) .EQ. 0 .AND. IROLL(2) .EQ. 0) THEN
  CALL ROTATE (A,0.0,0.0,ROLLANG,0,0,1)
ELSE IF (IROLL(1) .EQ. 1 .AND. IROLL(2) .EQ. 0) THEN
  TTS = ROLLANG / SROLL
  IF (TIME + TTS .GT. PTIME) THEN
    ANGTRAV = SROLL * (PTIME-TIME)
    ROLLANG = ROLLANG - ANGTRAV
    WP = SROLL
    TIME = PTIME
    CALL OUTPUT (IREAD,TIME,A,WP,WQ,WR,PTIME)
  GOTO 30
  ELSE
    TIME = TIME + TTS
    WP = 0.0
  END IF
ELSE IF (IROLL(1) .EQ. 1 .AND. IROLL(2) .EQ. 1) THEN
  TEMP1 = (0.5 * WP**2 + ROLLANG * SACCEL)**0.5
  TACC1 = (-WP + TEMP1) / SACCEL

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TACC2 = (-WP - TEMPI) / SACCEL
IF (TACCI .GT. TACC2) THEN
  TACC = TACCI
ELSE
  TACC = TACC2
END IF
IF (TACC .LT. 0.0) THEN
  TACC = 0.0
END IF
WPMAX = WP + TACC * SACCEL
IF (ABS(WPMAX) .GT. ABS(SROLL)) THEN
  TACC = (SROLL-WP) / SACCEL
  WPMAX = SROLL
END IF
IF (TACCI .GT. TACC2) THEN
  TACC = TACCI
ELSE
  TACC = TACC2
END IF
WPMAX = WP + TACC * SACCEL
IF (ABS(WPMAX) .GT. ABS(SROLL)) THEN
  TACC = (SROLL-WP) / SACCEL
  WPMAX = SROLL
END IF
T1 = TIME + TACC
TDEC = TACC + WP/SACCEL
ANGT = WP * TACC + 0.5 * SACCEL * TACC**2 + 0.5 * SACCEL
  + TDEC**2
T2 = T1 + (ROLLANG-ANGT)/SROLL
TTS = T2 + TDEC - TIME
TACCEL = ROLL(1) / ROLL(2)
ANGACC = 0.5 * ROLL(2) * TACCEL**2
ANGDEC = ROLL(2) * TACCEL - ANGACC
IF (ABS(ROLLANG) .LT. ANGACC + ANGDEC) THEN
  TTS = (4.0 * ABS(ROLLANG) / ROLL(2))**0.5
  T1 = TIME + TTS * 0.5
  T2 = T1
ELSE
  TTS = 2.0 * TACCEL + (ABS(ROLLANG) - ANGACC - ANGDEC)
  / ROLL(1)
  T1 = TIME + TACC
  T2 = TIME + TTS - TACCEL
END IF
IF (T1 .GT. PTIMZ) THEN
  ANGTAV = WP * (TIME-TIME) + 0.5 * SACCEL * (TIME-TIME)**2
  WP = WP + SACCEL * (TIME-TIME)
  ROLLANG = ROLLANG - ANGTRAV
  CALL ROTATE (A,0.0,0.0,ANGTRAV,0,0,1)
  TTS = TTS - (TIME-TIME)
  TIME = PTIME
  CALL OUTPUT (IREAD,TIME,A,WP,WQ,WR,PTIME)
  GOTO 40
ELSE IF (T2 .GT. PTIME) THEN
  IF (TIME .LT. TI) THEN
    ANGTAV = WP * (TI-TIME) + 0.5 * SACCEL * (TI-TIME)**2 + WPMAX * (TIME-T1)
  ELSE
    ANGTAV = WPMAX * (TIME-TIME)
  END IF
  WP = WPMAX
  ROLLANG = ROLLANG - ANGTRAV
  TTS = TTS - (TIME-TIME)
  TIME = PTIME
  CALL ROTATE (A,0.0,0.0,0.0,ANGTRAV,0,0,1)
  CALL OUTPUT (IREAD,TIME,A,WP,WQ,WR,PTIME)
  GOTO 40
ELSE IF (TIME + TTS .GT. PTIME) THEN
  IF (TIME .LT. TI) THEN
    ANGTAV = WP * (TI-TIME) + 0.5 * SACCEL * (TI-TIME)**2 + WPMAX * (TIME-T2)
    WP = WPMAX - SACCEL * (TIME-T2)**2
  ELSE IF (TIME .LT. T2) THEN
    ANGTAV = WPMAX * (T2-TIME) - 0.5 * SACCEL * (TIME-T2)**2 + WPMAX * (TIME-T2)
  END IF
END IF
IF (TIME + TTS .GT. PTIME) THEN
  IF (TIME .LT. TI) THEN
    ANGTAV = WP * (TI-TIME) + 0.5 * SACCEL * (TI-TIME)**2 + WPMAX * (TIME-T2)
  ELSE IF (TIME .LT. T2) THEN
    ANGTAV = WPMAX * (T2-TIME) - 0.5 * SACCEL * (TIME-T2)**2 + WPMAX * (TIME-T2)
WP = WPMAX - SACCEL * (PTIME - T2)
ELSE
   ANGTRAV = WP * (PTIME - TIME) - 0.5 * SACCEL * (PTIME - TIME)**2
   WP = WP - SACCEL * (PTIME - TIME)
END IF
ROLLANG = ROLLANG - ANGTRAV
CALL ROTATE (A, 0.0, 0.0, ANGTRAV, 0, 0, 1)
TTS = TTS - (PTIME - TIME)
TIME = PTIME
CALL OUTPUT (IREAD, TIME, A, WP, WP, WP, PTIME)
GOTO 40
ELSE
   TIME = TIME + TTS
   CALL ROTATE (A, 0.0, 0.0, ROLLANG, 0, 0, 1)
   WP = 0.0
END IF
END IF
WRITE (13, *) 'FINISHED ROLLING, TIME=', TIME
RETURN
END
SUBROUTINE ROTATE (A, ANG1, ANG2, ANG3, N1, N2, N3)
IMPLICIT REAL*8 (A-H, O-Z)
DIMENSION A(3,3), B(3,3), N(3), ANGLE(3), SANG(3), CANG(3)
ANGLE(1) = ANG1
ANGLE(2) = ANG2
ANGLE(3) = ANG3
N(1) = N1
N(2) = N2
N(3) = N3
DO I = 1, 3
  SANG(I) = SIN(ANGLE(I))
  CANG(I) = COS(ANGLE(I))
END DO
DO I = 1, 3
  IF (N(I) .EQ. 1) THEN
    B(1,1) = A(1,1)
    B(1,2) = A(1,2)
    B(1,3) = A(1,3)
    B(2,1) = A(2,1) * CANG(I) + A(3,1) * SANG(I)
    B(2,2) = A(2,2) * CANG(I) + A(3,2) * SANG(I)
    B(2,3) = A(2,3) * CANG(I) + A(3,3) * SANG(I)
    B(3,1) = -A(2,1) * SANG(I) + A(3,1) * CANG(I)
    B(3,2) = -A(2,2) * SANG(I) + A(3,2) * CANG(I)
    B(3,3) = -A(2,3) * SANG(I) + A(3,3) * CANG(I)
    DO J = 1, 3
      A(J,K) = B(J,K)
    END DO
  ELSE IF (N(I) .EQ. 2) THEN
    B(1,1) = A(1,1) * CANG(I) - A(3,1) * SANG(I)
    B(1,2) = A(1,2) * CANG(I) - A(3,2) * SANG(I)
    B(1,3) = A(1,3) * CANG(I) - A(3,3) * SANG(I)
    B(2,1) = A(2,1)
    B(2,2) = A(2,2)
    B(2,3) = A(2,3)
    B(3,1) = A(1,1) * SANG(I) + A(3,1) * CANG(I)
    B(3,2) = A(1,2) * SANG(I) + A(3,2) * CANG(I)
    B(3,3) = A(1,3) * SANG(I) + A(3,3) * CANG(I)
    DO J = 1, 3
      A(J,K) = B(J,K)
    END DO
  ELSE IF (N(I) .EQ. 3) THEN
    B(1,1) = A(1,1) * CANG(I) + A(2,1) * SANG(I)
    B(1,2) = A(1,2) * CANG(I) + A(2,2) * SANG(I)
    B(1,3) = A(1,3) * CANG(I) + A(2,3) * SANG(I)
    B(2,1) = -A(1,1) * SANG(I) + A(2,1) * CANG(I)
    B(2,2) = -A(1,2) * SANG(I) + A(2,2) * CANG(I)
    B(2,3) = -A(1,3) * SANG(I) + A(2,3) * CANG(I)
    B(3,1) = A(3,1)
    B(3,2) = A(3,2)
    B(3,3) = A(3,3)
    DO J = 1, 3
      A(J,K) = B(J,K)
    END DO
  END IF
END IF
END DO
RETURN
END
SUBROUTINE SLEWER (TIME, CI2M, ROLLTEMP, ANGTRAV, POINT, IPOINT, ROLL1,
PSI, THT, PHI, A)
IMPLICIT REAL*8 (A-H,O-Z)
COMMON/COM4/RBURN
COMMON/COM6/TR0,TR1,TR2, WPMAX
DIMENSION A(3,3), POINT(3), IPOINT(3), CI2M(3,3)
CALL ROTATE (CI2M, ANGTRAV, 0.0, 0.0, 3, 0, 0)
DO I = 1, 3
   DO J = 1, 3
      A(I,J) = CI2M(I,J)
   END DO
END DO
IF (TR1 .EQ. TR0) THEN
   ROLLT = (TIME-TR0) * WPMAX
ELSE IF (TIME .LT. TR1) THEN
   WPT = WPMAX / (TR1-TR0) * (TIME-TR0)
   ROLLT = 0.5 * (TIME-TR0) * WPT
ELSE IF (TIME .LT. TR2) THEN
   ROLLT = 0.5 * (TR1-TR0) * WPMAX + WPMAX * (TIME-TR1)
ELSE
   WPT = -WPMAX / (TR1-TR0) * (TIME-TR2) + WPMAX
   ROLLT = (TR2-TR0) * WPMAX - 0.5 * (TR2+TR1-TR0-TIME) * WPT
END IF
END IF
ROLLT = ROLL1 + ROLLT
CALL ROTATE (A, 0.0, 0.0, ROLLT, 0, 0, 1)
PSI = ATAN2 (A(1,2), A(1,1))
THT = ASIN (-A(1,3))
PHI = ATAN2 (A(2,3), A(3,3))
RETURN
END
SUBROUTINE SUNV(TIME, RA, DEC)
IMPLICIT REAL*8 (A-H, O-Z)
COMMON/COM2/PINT, TIME0
COMMON/COM3/PI, TWOPI, PIO2
DIMENSION XSUN(3)

DATA DJUL0 /2433282.5/
DATA OBL0 / .40920621/
DATA SOBL0 / .39788120/
DATA COBL0 / .91743695/
DATA OBLD / .6219E-8/
DATA PEQD / .6675E-6/
DATA GHA0 / 1.74664770/
DATA GHADI / .0172027918/
DATA GHADF / .63003881/
DATA ASUN0 / 6.2482947/
DATA ASUND / .01720197/
DATA ECCS0 / .016730108/
DATA ECCSD / -.1148E-8/
DATA XLPS0 / 4.9232341/
DATA XLPSD / .8217E-6/

DJUL = TIME0 + TIME/86400.0
DAYS = DJUL - DJUL0
OBL = OBL0 + OBLD * DAYS
SOBL = SIN(OBL)
COBL = COS(OBL)
ECCSUN = ECCS0 + ECCSD * DAYS
XLPSUN = XLPS0 + XLPSD * DAYS
A = DMOD((ASUN0 + ASUND * (DJUL - DJUL0)), TWOPI)
E = A

1 E = ECCSUN * SIN(E) - A
IF (ABS(E) .LT. 1.E-5) GO TO 5
DBDE = 1. - ECCSUN * COS(E)
E = E - DBDE
GO TO 1

5 TN = SQRT(1. - ECCSUN**2) * SIN(E)
TD = COS(E) - ECCSUN
F = ATAN2(TN, TD)
ANG = XLPSUN + F
SANG = SIN(ANG)
CANG = COS(ANG)
XSUN(1) = CANG
XSUN(2) = SANG * COBL
XSUN(3) = SANG * SOBL
RA = ATAN2(XSUN(2), XSUN(1))
DEC = ATAN2(XSUN(3), (XSUN(1)**2 + XSUN(2)**2)**0.5)
RETURN
END