PRELIMINARY

SOFTWARE REQUIREMENTS SPECIFICATION

FOR THE

DSPSE

GUIDANCE, NAVIGATION, AND CONTROL CSCI

Prepared by

Space Applications Corporation

6/8/92
1 SCOPE

1.1 IDENTIFICATION

1.2 OVERVIEW

This specification provides the requirements for the DSPSE flight software identified as the Guidance, Navigation, and Control (GNC) CSCI. This CSCI will control the attitude of the spacecraft and perform all associated guidance, navigation, and sensor processing functions. Specific functions to be performed include:

- Attitude Determination
- Attitude Control
- Orbit Propagation
- Autonomous Navigation
- Terminal Guidance and Navigation (for the asteroid encounter)
- Sensor Control and Data Processing
- Delta V Control
- Solar Array Control

Details of these functions are provided in Section 3. The algorithms for these functions are documented separately in TBD.

1.3 SPECIFICATION CONTENTS
2 APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

- Command and telemetry ICD
- Algorithms document

2.2 NON GOVERNMENT DOCUMENTS
3 REQUIREMENTS

3.1 EXTERNAL INTERFACE REQUIREMENTS

The external interfaces can be separated into 3 categories. Those associated with: command and telemetry; sensors; and spacecraft hardware.

3.1.1 Command and Telemetry Interfaces

The command and telemetry interface includes commands and data which are sent from the ground to the spacecraft, and telemetry data about GNC functions that is sent from the spacecraft to the ground. Details of the command and telemetry interface are found in ICD TBD.

3.1.1.1 Inputs from Command and Telemetry

- Spacecraft epoch (position and velocity in TBD inertial coordinates at specified time)
- Asteroid epoch (position and velocity in TBD inertial coordinates at specified time)
- Delta V command: time of execution; desired attitude at time of firing; velocity increment to be achieved
- Attitude mode command: time; attitude mode; if applicable, desired attitude
- Filter wheel positions and camera gains for UV/visual, SWIR, and LWIR sensors
- Requests for image data collection for UV/visual, SWIR, and LWIR sensors
- Enable/disable commands: autonomous navigation; autonomous terminal guidance and control; autonomous scheduling; solar array control; momentum dumping; automatic gain control of sensor cameras

3.1.1.2 Outputs to Command and Telemetry

Periodic outputs are (rates are TBD):
- Estimated spacecraft attitude
- Computed spacecraft position and velocity
- Autonomous navigation updates to spacecraft position and velocity

Aperiodic outputs are:
- Attitude control mode transitions
- Actual delta V's achieved
- Software detected errors and anomalous conditions
- Autonomous updates to asteroid position and velocity

3.1.2 Sensor Interfaces

The specific sensors considered here are: UV/visual; SWIR; LWIR; LIDAR; star tracker; and IMU.

3.1.2.1 Inputs from Sensors

- Image data from UV/visual, SWIR, LWIR, LIDAR, and star tracker sensors (pixel by pixel intensity)
- Attitude and velocity increments from IMU (3 components of each for changes from inertial reference to spacecraft fixed reference)

3.1.2.2 Outputs to Sensors

- Image collection commands to UV/visual, SWIR, LWIR, LIDAR, and star tracker sensors
- Filter wheel and camera gain commands to UV/visual, SWIR, and LWIR sensors

3.1.3 Spacecraft Hardware Interfaces

3.1.3.1 Inputs from Spacecraft Hardware

- Reaction wheel speed
- TTI rocket firing and separation flags
- Propellant tank pressure (if necessary to adjust control system parameters)

3.1.3.2 Outputs to Spacecraft Hardware

- Reaction wheel speed commands
- Attitude control jets on/off commands
- Delta V thruster on/off commands
- Solar array rotation commands

3.2 DETAILED FUNCTIONAL REQUIREMENTS

The GNC CSCI consists of eight functions. The main purpose of each function is given below. Details are given in subsequent subsections.
GNC Executive: coordinates requests for attitude control and pointing; generates desired spacecraft attitude; if enabled, schedules attitude control based on on-board estimates of spacecraft position and mission phase; monitors reaction wheel status for momentum dumping.

Attitude Determination: uses data from IMU and star tracker to estimate spacecraft attitude; during spin-stabilized flight, estimates spin rate and nutation.

Attitude Control: operates reaction wheels and control jets to control spacecraft attitude; operates in a variety of modes to satisfy mission requirements.

Navigation: propagates spacecraft and asteroid orbits from uploaded epoches; determines line-of-sight vectors from spacecraft to earth, sun, moon, and asteroid; does autonomous navigation processing.

Terminal Guidance and Control: determines updated asteroid position from sensor image data; if enabled, determines delta V to improve asteroid fly up geometry; updates predicted asteroid trajectory and pointing data for asteroid encounter.

Sensor Processing and Control: processes image data to extract objects in field of view (stars or asteroid); controls camera gains and filter wheel position.

Delta V Control: requests proper attitude for delta V maneuver; uses IMU data to terminate thruster firing at proper time; reports actual delta V achieved.

Solar Array Control: rotates solar array to maintain proper orientation relative to the sun.

3.2.1 GNC Executive

The GNC Executive Function coordinates requests for attitude control and pointing; generates desired spacecraft attitude; if enabled, schedules attitude control based on on-board estimates of spacecraft position and mission phase; monitors reaction wheel status for momentum dumping.

3.2.1.1 GNC Executive Inputs

External inputs are:

- Attitude control mode request (from ground)
- Pointing direction (from ground)
- Autonomous scheduling enable/disable (from ground)
- Mission phase (from ground)
- Reaction wheel speed
- Flags for translunar rocket burn and separation

Inputs internal to the GNC CSCI are:

- Line-of-sight vectors and rates from spacecraft to earth, sun, and moon (from Navigation Function)
- Attitude control mode request and pointing direction (from Navigation, Delta V Control, or Terminal Guidance and Control Functions)
- Slew maneuver request (from Terminal Guidance and Control Function)
- Attitude control jet firing durations (from Attitude Control Function)
- Delta V thruster firing durations (from Delta V Control Function)
- Imaging flag, sensor imaging or not (from Sensor Processing and Control Function)

3.2.1.2 GNC Executive Processing

The GNC Executive shall process all attitude control mode requests. Mode switching logic shall be that shown in Figure TBS. Requests which would result in an illegal mode transition shall be ignored but their occurrence shall be reported as an error message in the telemetry at the earliest possible time.

The GNC Executive shall modify attitude control parameters, e.g. gains, as necessary for mode changes and changes to spacecraft inertial properties. Updated estimates of spacecraft mass, c.g., and moments of inertia shall be maintained from: firing of the translunar rocket; separation of the spent rocket; firing of the attitude control jets; and firing of the delta V thruster.

The GNC Executive shall monitor reaction wheel speed to determine the need for momentum dumping or failure of a reaction wheel. Momentum dumping shall be done when either of the following conditions is met:

a. The speed of any one reaction wheel exceeds TBD while the attitude control mode is one of the following: TBD.

b. The speed of any one reaction wheel exceeds TBD while the attitude control mode is one of the following: TBD. Note: the speed limit for a will be smaller than for b but will have a more restrictive set of control modes.
If a reaction wheel failure is detected by TBD logic or indicated by the ground, a flag shall be set so that the Attitude Control Function is aware of the failure and the event shall be reported as an error message in the telemetry as soon as possible.

The GNC Executive shall supply the desired attitude and rate to the Attitude Control Function except when the attitude control mode is Active Nutation Control, Despin, or Lifeboat.

When the capability is enabled, the GNC Executive shall schedule the attitude control modes passed on the Spacecraft/Earth/Sun/Moon geometry and the mission phase. This logic is TBD.

The GNC Executive Function shall be performed TBD times per second.

3.2.1.3 GNC Executive Outputs

Outputs internal to the GNC CSCI are:

- Attitude control mode (to Attitude Control, Attitude Determination, Delta V Control, and Solar Array Control Functions)
- Desired attitude and rate (to Attitude Control Function)
- Attitude control parameters (to Attitude Control Function)
- Reaction wheel failure flags (to Attitude Control Function)

External outputs are:

- Error messages (to telemetry)

3.2.1.4 Algorithms

Algorithms for the following will be supplied by Paul DeLaHunt:

- Attitude control parameter changes as a function of inertial properties
- Logic to determine if a reaction wheel has failed.

Algorithms for the following will be supplied by TBD:

- Variations in inertial properties as a function of delta V thruster and attitude control jet firings
- Autonomous scheduling logic.

Preliminary definitions of all algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93.

3.2.2 Attitude Determination
The Attitude Determination Function uses data from the IMU and star tracker to estimate spacecraft attitude; during spin-stabilized flight, it estimates spin rate and nutation.

### 3.2.2.1 Inputs to Attitude Determination

External inputs are:

- Delta rotation data (from IMU)

Inputs internal to the GNC CSCI are:

- Attitude control mode (from GNC Executive Function)
- Star tracker data: image time, star locations in sensor frame, star intensities, and star tracker ID (from Sensor Processing and Control Function)

### 3.2.2.2 Attitude Determination Processing

Attitude Determination shall process IMU and star tracker data at the frequencies shown in the following table.

<table>
<thead>
<tr>
<th>Attitude Control Mode</th>
<th>IMU Rate (Hz)</th>
<th>Star Tracker Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spin Up</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Active Nutation Control</td>
<td>TBD</td>
<td>N/A</td>
</tr>
<tr>
<td>Spinning</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Despin</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Acquisition</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Earth Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Sun Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Moon Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Asteroid Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Slew</td>
<td>TBD</td>
<td>N/A</td>
</tr>
<tr>
<td>Delta V Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Arbitrary Pointing</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Momentum Dump</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Lifeboat</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

The IMU data shall be processed to estimate spacecraft angular velocity relative to inertial space (3 components in spacecraft-fixed frame) and attitude relative to TBD inertial frame (quaternions).

Star locations and intensities shall be correlated with an internal star catalog to determine sensor attitude at the time the image was taken. Sensor attitude shall be converted to spacecraft attitude according to which star tracker was used to collect the data.

The star tracker data shall be used to update the attitude and gyro drift estimates. As the star tracker data will define attitude as
it was some short time ago, it shall be necessary to maintain a suitable time history of attitude estimates. Upon completion of a star tracker attitude estimate, that estimate shall be compared with the appropriate value from the time history. If the difference is within TBD limit, the current estimate will be updated by TBD logic. If the difference exceeds the limit, the star tracker estimate will be ignored and an error message will be output to the telemetry.

After entering the Despin Mode, the estimated attitude will be reset to that obtained from the star tracker as soon as the total angular velocity is less than TBD.

3.2.2.3 Outputs from Attitude Determination

Outputs internal to the GNC CSCI are:

- Attitude (to Attitude Control, Terminal Guidance and Control, Delta V Control, Sensor Processing and Control, and Solar Array Control Functions)

- Body-fixed rates (to Attitude Control Function)

- Star tracker data request (to Sensor Processing and Control Function)

External outputs are:

- Attitude, body-fixed rates, and gyro drifts (to telemetry)

- Error messages (to telemetry)

3.2.2.4 Algorithms

Algorithms for the following will be provided by Paul DeLaHunt:

- IMU processing to get body-fixed rates and attitude

- Updating attitude and gyro drift estimates from star tracker measurement of attitude.

Preliminary versions of these algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93.

Algorithms for the following will be provided by Don Horan:

- Computation of attitude from star tracker data.

It is presumed that these algorithms will be those already implemented in software by LLNL or Ball Aerospace. Copies of the code and design documentation should be provided no later than the system PDR. Copies of test documents should be provided no later than 11/2/92.
3.2.3 Attitude Control

The Attitude Control Function operates reaction wheels and control jets to control spacecraft attitude in a variety of different attitude control modes. Various modes satisfy different mission requirements.

3.2.3.1 Inputs to Attitude Control

External inputs are:
- None

Inputs internal to the GNC CSCI are:
- Attitude control mode (from GNC Executive Function)
- Attitude and body-fixed rates (from Attitude Determination Function)
- Desired attitude and rates (from GNC Executive Function)
- Spin rate, nutation angle, and phasing (from Attitude Determination Function)
- Attitude control parameters, e.g. gains (from GNC Executive Function)
- Reaction wheel failure flags (from GNC Executive Function)

3.2.3.2. Attitude Control Processing

Attitude Control Processing shall execute the attitude control laws for each of the control modes described below.

Spin Up: Spins the spacecraft in preparation for the translunar rocket firing. Desired spin axis is along spacecraft longitudinal axis. Spin orientation in inertial space will be defined by upload from ground. Control is via attitude control jets.

Active Nutation Control: Reduces nutation after spacecraft has been spun up but before firing the translunar rocket. Control is via attitude control jets.

Spinning: No active control during translunar rocket firing.

Despin: Recover from spin stabilized mode or launch vehicle tip-off rates. Goal is zero angular rotation rate. Control is via attitude control jets and/or reaction wheels depending on magnitude of initial rates.

Acquisition: Initial attitude acquisition after launch; recover from spin stabilization; or large attitude transition (e.g. from
Earth Pointing to Sun Pointing). During attitude transitions, the TBD axis of the spacecraft shall not be pointed within TBD degrees of the sun. Control will be via the reaction wheels.

Earth Pointing: the high gain antenna is pointed at the center of the earth. Control is via the reaction wheels.

Sun Pointing: the TBD axis of the spacecraft is pointed at the sun. Control is via the reaction wheels.

Moon Pointing: the TBD axis of the spacecraft is pointed at the center of the moon. Control is via the reaction wheels.

Asteroid Pointing: the TBD axis of the spacecraft is pointed at the asteroid. Control is via the reaction wheels.

Slew: used during the asteroid flyby to rapidly repoint the sensors after the time of closest approach. Control is via the control jets.

Delta V Pointing: controls spacecraft attitude during firing of the delta V thruster. Control is via the attitude control jets.

Arbitrary Pointing: points the spacecraft in an arbitrary, ground commanded, direction. Control is via the reaction wheels.

Momentum Dump: despins reaction wheels by firing attitude control jets to generate opposing torques while maintaining spacecraft attitude. Dump is complete when all reaction wheel speeds are below TBD.

Lifeboat: quasi inactive mode which is used to preserve resources (power and control jet fuel). Body axis rates are maintained between broad limits of: TBD.

If a reaction wheel failure is indicated, the control logic shall utilize the corresponding control jet instead.

3.2.3.3 Outputs from Attitude Control

Outputs internal to the GNC CSCI are:
- Control jet firing duration (to GNC Executive Function)

External outputs are:
- Reaction wheel speed increase/decrease commands
- Attitude control jet on/off commands

3.2.3.4 Algorithms

All algorithms for this function will be provided by Paul DeLaHunt.
Preliminary versions of the algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93. Test cases should be provided by 2/1/93.

3.2.4 Navigation

The Navigation Function propagates the spacecraft orbit from an uploaded epoch; determines line-of-sight vectors from the spacecraft to the earth, sun, and moon; and does autonomous navigation processing.

3.2.4.1 Inputs to Navigation

External inputs are:

- Spacecraft epoch (from ground)
- Autonomous navigation enable/disable flag (from ground)

Inputs internal to the GNC CSCI are:

- Actual achieved delta $V$ (from Delta $V$ Control Function)
- Autonomous navigation measurement (from Sensor Processing and Control Function)
- Asteroid position update (from Terminal Guidance and Control Function)

3.2.4.2 Navigation Processing

The spacecraft and asteroid orbits shall be propagated from epochs supplied by the ground and possibly modified by the Terminal Guidance and Control Function. The spacecraft orbit shall be corrected for all actual delta $V$ maneuvers. Positions of the earth, sun, and moon shall be computed from TBD algorithms.

LOS vectors and rates from spacecraft to earth, sun, and moon shall be computed.

The autonomous navigation subfunction shall have 3 states: disabled; test; and enabled. In the disabled state, no autonomous navigation calculations shall be done. In the test or enabled state, the autonomous navigation algorithms will be computed and in the enabled state, the results shall be incorporated into the on-board estimate of spacecraft ephemeris.

The autonomous navigation subfunction shall determine the type of sensor measurement it wants and the specific sensor it wants to make the measurement. The measurements will be the angular separation between a star specified by this function and either the lunar limb, lunar centroid, or earth centroid. Once a measurement has been identified, autonomous navigation shall request an attitude change to point the spacecraft in the proper direction.
After the spacecraft has stabilized in that direction, autonomous navigation shall issue a request for the measurement. Upon receipt of the measurement it shall cancel its attitude request.

3.2.4.3 Outputs from Navigation

Outputs internal to the GNC CSCI are:

- LOS vectors and rates from spacecraft to earth, sun, and moon (to the GNC Executive and the Sensor Processing and Control Functions)
- Spacecraft/sun LOS (to Solar Array Control Function)
- Attitude mode request and desired attitude (to GNC Executive Function)
- Autonomous navigation measurement request (to Sensor Processing and Control Function)

External outputs are:

- Spacecraft position and velocity in TBD inertial frame (to telemetry)
- Autonomous navigation estimates of position and velocity (to telemetry)

3.2.4.4 Algorithms

All algorithms for this function will be supplied by NRL code 8103. Preliminary versions of the algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93 and test cases by 2/1/93. If 8103 develops engineering versions of these algorithms, that code would be useful in developing the flight software but separate documentation of the algorithms will still be required. The engineering code can be used to provide test cases for checking the flight code.

3.2.5 Terminal Guidance and Control

Terminal Guidance and Control Function includes all special processing associated with the asteroid flyby. Initial calculations will be based on an upload from the ground of the relative spacecraft/asteroid position and velocity. When the spacecraft gets close enough to detect the asteroid on its sensors, the spacecraft/asteroid relative motion estimates will be updated. This will result in an update to the spacecraft pointing to track the asteroid.

As the spacecraft nears the asteroid, the LOS rates may become too great for the spacecraft to maintain pointing. If this happens, this function will command a slew maneuver which produce a rapid
spacecraft rotation such that the asteroid image can be recaptured after the closest approach.

This same function can be used to track the upper stage after separation by uploading the appropriate relative position and velocity estimate. The primary difference is that the relative range will always be increasing and the slew maneuver will be unnecessary.

3.2.5.1 Inputs to Terminal Guidance and Control

External inputs are:
- Target relative position and velocity (from ground)
- Autonomous operations enable/disable (from ground)

Inputs internal to the GNC CSCI are:
- Target location (from Sensor Processing and Control Function)
- Attitude (from Attitude Determination Function)

3.2.5.2 Terminal Guidance and Control Processing

A simple propagator shall be used to predict the target relative motion. When the estimated range reaches TBD, a request for sensor tracking of the target shall be issued. When such tracking data is received, it shall be used to update the relative motion estimator.

Predictions shall be made of the maximum angular rates and accelerations to be expected as the spacecraft passes the target. If the rates or accelerations will exceed the spacecraft capabilities, a slew maneuver shall be commanded. The slew maneuver shall be computed so that the target can be reacquired after the closest approach and that the non-tracking portion of the flyby shall be equally spaced before and after the closest approach.

3.2.5.3 Outputs from Terminal Guidance and Control

Outputs internal to the GNC CSCI are:
- Request for target data (to Sensor Processing and Control Function)
- Attitude mode request and desired attitude (to GNC Executive Function)
- Slew maneuver request (to GNC Executive Function)

External outputs are:
- Reports of autonomous operations (to telemetry)
3.2.5.4 Algorithms

All algorithms for this function will be supplied by NRL code 8103. Preliminary versions of the algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93 and test cases by 2/1/93. If 8103 develops engineering versions of these algorithms, that code would be useful in developing the flight software but separate documentation of the algorithms will still be required. The engineering code can be used to provide test cases for checking the flight code.

3.2.6 Sensor Processing and Control

This function provides the interface to all the imaging sensors. It activates the sensors to collect an image and, if requested by another function, processes that image to extract celestial objects (stars and the asteroid) or make autonomous navigation measurements. If enabled, it monitors image intensity and controls camera gain. It also passes filter wheel position commands on to the sensors.

3.2.6.1 Inputs to Sensor Processing and Control

External inputs are:
- Filter wheel position commands (from the ground)
- Automatic gain control enable/disable (from the ground)
- Manual camera gain settings (from the ground)
- Requests for image data (from scheduler)
- Camera image data (from sensors)

Inputs internal to the GNC CSCI are:
- Star tracker data request (from Attitude Determination Function)
- Autonomous navigation data request (from Navigation Function)
- Target data request (from Terminal Guidance and Control Function)
- Spacecraft to sun, earth, and moon LOS vectors (from Navigation Function)
- Attitude (from Attitude Determination Function)

3.2.6.2 Sensor Processing and Control Processing

Upon request for data from a particular sensor, that sensor shall be commanded to collect an image. As soon as image data is
available, it shall be processed to provide the desired outputs as identified below:

- Star tracker data request: positions in sensor coordinates of 5 brightest stars; intensities; and star tracker ID

- Autonomous navigation data request: angle between specified star and either the lunar limb, lunar centroid, or earth centroid as specified in the request

- Target data request: target intensity and position in sensor coordinates.

If the image request was for star tracker data but did not indicate which of the two star trackers to use, this function shall select the star tracker whose FOV is less obscured by the sun, earth, and moon. The logic for this selection is TBD.

When requested to track the asteroid, sensor images shall be obtained at least TBD. As soon as the target can be detected from the star background, the target position shall be reported to the requesting function. Position updates shall be continued at the above rate.

Requests to collect an image, manually set a camera gain, or change filter wheel position shall be passed on to the appropriate sensor.

When automatic gain control is enabled, the image data from that sensor will be processed to adjust the camera gain.

3.2.6.3 Outputs from Sensor Processing and Control

Outputs internal to the GNC CSCI are:

- Star position and intensity data, star tracker ID (to Attitude Determination Function)

- Autonomous navigation measurement (to Navigation Function)

- Target position (to Terminal Guidance and Control Function)

- Imaging flag, sensors imaging or not (to GNC Executive and Solar Array Control Functions)

External outputs are:

- Filter wheel position (to sensor and telemetry)

- Image collection commands

- Camera gain settings (to sensor and telemetry)

3.2.6.4 Algorithms
All algorithms for this function will be supplied by Don Horan.

It is presumed that most of these algorithms will be those already implemented in software by LLNL or Ball Aerospace. Copies of the code and design documentation should be provided no later than the system PDR. Copies of test documents should be provided no later than 11/2/92. For those algorithms not already coded by LLNL or Ball Aerospace, preliminary versions should be provided immediately after the system PDR. Final versions should be provided by 1/4/93.

3.2.7 Delta V Control

This function controls all delta V maneuvers except the translunar injection which is done with a solid rocket. All other delta V's use a liquid propellant thruster. This function will accomplish delta V maneuvers which are requested by the ground. It will request the attitude control system to point the spacecraft in the proper direction, turn the thruster on, monitor the actual delta V achieved from the IMU accelerometer data, and turn the thruster off. The actual delta V which was achieved is reported in the telemetry.

3.2.7.1 Inputs to Delta V Control

External inputs are:

- Delta V maneuver request: magnitude, direction, and time (from ground)
- IMU accelerometer outputs

Inputs internal to the GNC CSCI are:

- Attitude control mode (from GNC Executive Function)
- Attitude (from Attitude Determination Function)

3.2.7.2 Delta V Control Processing

Delta V Control shall initiate an attitude change sufficiently prior to a delta V maneuver to allow for the attitude to change and stabilize. It shall monitor spacecraft attitude to insure it is within TBD before turning on the delta V thruster.

During the thruster firing, Delta V Control shall monitor the IMU accelerometer outputs and the spacecraft attitude at a TBD rate. Based on a TBD algorithm, it shall modify the commanded spacecraft attitude and turn off the thruster at the proper time so as to achieve the desired velocity correction.

The actual acceleration and attitude time histories shall be reported in the telemetry.

3.2.7.3 Outputs from Delta V Control
Outputs internal to the GNC CSCI are:

- Attitude mode request and desired attitude (to GNC Executive Function)
- Actual delta V magnitude and direction (to Navigation Function)
- Thruster firing duration (to GNC Executive Function)

External outputs are:

- Thruster on/off commands
- Actual delta V: on time, off time, and body-fixed acceleration and attitude time histories (to telemetry)

3.2.7.4 Algorithms

All algorithms for this function will be provided by NRL code 8103 unless they delegate the responsibility to the propulsion people (A. Kudlach). Preliminary versions of the algorithms should be provided immediately after the system PDR. Final versions should be provided by 1/4/93.

3.2.8 Solar Array Control

Solar Array Control rotates the solar array to minimize the solar incidence angle. It has two modes: fine and coarse. The fine mode is used when solar array motion will have no adverse effects on the mission and the array rotation is kept within a small tolerance of the optimum. The coarse mode is used when it is desirable not to move the solar array unless the incidence angle is far from the minimum.

3.2.8.1 Inputs to Solar Array Control

External inputs are:

Inputs internal to the GNC CSCI are:

- Imaging flag, sensors imaging or not (from Sensor Processing and Control Function)
- Spacecraft/sun LOS (from Navigation Function)
- Attitude (from Attitude Determination Function)
- Attitude control mode (from GNC Executive Function)

3.2.8.2 Solar Array Control Processing
The solar array control mode shall be selected as a function of the imaging flag and the attitude control mode in accordance with the TBD table.

The optimum solar array rotation angle shall be computed from the spacecraft/sun LOS and the spacecraft attitude. If the difference between the optimum and current angles is greater than the TBD (mode dependent) limits, the array shall be commanded to the optimum angle.

3.2.8.3 Outputs from Solar Array Control

Outputs internal to the GNC CSCI are:
- None

External outputs are:
- Solar array rotation command

3.2.8.4 Algorithms

All algorithms for this function will be provided by the Electrical Power Subsystem people (W. Baker). These algorithms should be provided by 10/5/93.