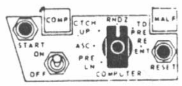
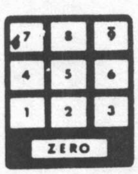
PANEL LOCATION / SECTION I PAGE	NAME AND POSITION	FUNCTION
Pedestal	<u>COMPUTER Control Panel</u> <u>COMPUTER Mode Switch</u> A. PRE LN - (Prelaunch) 	(a) Provides capability to verify computer memory using AGE equipment on the pad. (b) Performs diagnostic check of computer logic function.
	ASC - (Ascent)	(a) Program is automatically started at T = 0 (lift-off). Solves the ascent equations and provides the backup guidance during ascent and insertion. The FDI's can indicate S/C RATES or attitude errors via the computer. (Selected by the secondary guidance switchover.) (b) Automatically displays the ΔV on the Fwd-Aft IVI needed for correct insertion at SSECO + 20 sec for firing the OAMS thrusters, and biases the FDI's to null when the S/C is 0°, 0°, 0°.
	CTCH - UP - (Catch-up)	Enables the computer to provide pointing commands on the FDI's for S/C alignment and velocity information on the IVI's for controlled application of translation maneuvers.

PANEL LOCATION / SECTION I PAGE	NAME AND POSITION	FUNCTION
	RNDZ (Rendezvous	(a) Enables computer to use radar and platform data to compute ΔV's needed for thrusting for rendezvous. ΔV's are displayed on the IVI. (b) Enables computer to drive ΔV display up or down toward zero as a thrusting is being made via closed loop with accelerometer output.
	RE-ENT - (Reentry)	(a) Enables computer to solve reentry equations and will display commanded roll attitude and down range and cross range touchdown point errors with the FDI's. (b) Enables computer to display desired roll attitude on the roll FDI for the desired lift. (c) Enables computer to display on the IVI the ΔV achieved from retrofire. (d) Provides the signals for the ACME reentry attitude control mode (automatic).
	B. START - (Computer Switch)	(a) Initiates CATCH-UP, REENTRY programs and starts "closed loop guidance" computations in RNDZ. (b) Illuminates green COMP light to indicate operation of the computer.

PANEL LOCATION / SECTION I PAGE	NAME AND POSITION	FUNCTION
	COMP - (Computer Green Light)	Illuminated green light indicates that the computer is running, except for short periods in the Rendezvous mode when the light goes off to indicate that the platform should be fine-aligned and illuminates again to indicate that the platform alignment time is over.
	C. RESET Sw (Computer Malfunction Switch)	Release after depression of the malfunction RESET Switch will turn the MALF Light off but does not affect or interrupt the computer program nor correct a mistake or error. Resets the low voltage sensitivity going to the Aux Computer Power Unit (ACPU).
	D. MALF - (Computer Amber Light)	Illuminating of amber light indicates that: (a) A malfunction has occurred during the running of the program. (b) It was turned on by computer diagnostic program. (c) A timing error occurred. (d) Program looping occurred. (e) The computer was turned off by Auxiliary Computer Power Unit (ACPU).

PANEL LOCATION SECTION I PAGE	NAME AND POSITION	FUNCTION
	E. Computer Power Sw	
	ON -	(a) Applies power to the computer and enables it to operate in the selected mode ($1\frac{1}{2}$ sec). (b) Powers the IVI's. (c) Enables the MDU PWR Switch.
	OFF -	(a) Normal controlled shutdown.
Right Astro Panel	Manual Data Readout Unit (MDU) 	The MDU contains a two digit address display and a five digit message display. (a) The two digit address window displays address Supplied from insertion unit (MDU). (See notes 2.5.7) (b) The five digit message window displays quantities either entered thru the MDU or read from the computer.
	PWR Switch ON -	Power from the computer to MDU.
	OFF -	Disables MDU.

PANEL LOCATION SECTION I PAGE	NAME AND POSITION	FUNCTION
	READ OUT -	If a valid two digit address is inserted, depression and release of the read out will cause display of values in the five digit message window. Subsequent read outs of same address may be made by simply depressing READ OUT.
	CLEAR -	Depress and release of the CLEAR button releases all latches for the numbers displayed, but does not affect the visual display.
	ENTER -	Depress and release the button to insert the five digit message from the MDU into the memory of the computer to the address specified in the address window.
Right Astro Panel	<u>Manual Data Insertion Unit (MDU)</u>  	The manual keyboard is used to enter the necessary numbers into the MDU for either entering information into the computer or reading out information from the computer. Insertion of a two digit address for readout or a two digit address and a five digit message for insertion.

Flight Crew Support Division
Spacecraft Operations Branch

Prepared by
Checked by
Approved by

COMPUTER PROGRAM NOTES

MATH FLOW # 6- S/C 7

PRE LN

The prelaunch computer program enables the AGE equipment to verify the memory thru the spacecraft umbilical. Each computer program can be checked out along with the computer malfunction light. If PRE LN is selected in orbit, a diagnostic check including all T/M values for prelaunch and 117 computer multiplex words can be recorded. Since only six of the 117 words are read out every 2.4 seconds, 48 seconds (20 frames) are required to read all 117 words. The memory may be loaded only via DCS or MDU.

ASCENT

The ascent computer program is the onboard secondary guidance during ascent and can provide all of the steering commands to the GLV during the launch phase. The program will provide the crew with the information to correct the insertion velocity conditions with the onboard OAMS translation system. The onboard secondary guidance may be automatically selected by the GLV or manually initiated by selecting IGS on the guidance switch. Primary guidance (RGS) may be reselected if desired. If onboard guidance is activated, there is a fade-in logic that will minimize the forces on the GLV in the event a difference exists between secondary guidance (IGS) and primary guidance (RGS). The max attitude error that can be displayed is 6° regardless of HI or LO range selection.

STAGE I - Lift-Off

The spacecraft platform is aligned and in the FREE position during lift-off and ascent. When the GLV is 1.5 inches off of the launch pad, the Event Timer, the Time Reference System, and the Computer will be started by activation of a lift-off relay that is powered by the APS and IPS busses of the GLV. The Elapsed Time (T_E) is started when the spacecraft is 1.5 inches off of the launch pad. All ascent guidance is based on T_E. The count UP on the Event Timer, if manually initiated, is a backup start for the TRS and Computer at lift-off.

ROLL PROGRAM

The roll program commands a constant roll rate of $\pm 1.25^{\circ}$/sec. The start time is a variable with the termination time fixed at 20.48 seconds. The earliest start time (T_R) for roll program initiation is 4.48 seconds and varies as $T = (20.48 - \Delta\emptyset R/1.25)$ Where $\Delta\emptyset R$ is the roll required to align the pitch of the GLV with the orbital plane. Positive roll is clockwise looking from the rear of the GLV toward the front. Nominal roll duration for S/C 7 is variable due to a variable launch azimuth.

PITCH PROGRAM

A three-step pitch program is provided with pitch rates designed to approximate a gravity turn profile in order to minimize the angle of attack and normal forces on the GLV. The following are the start times and the pitch rates for the three-step pitch program:

Step No.	Initiation Time	Pitch Rate
1	23.04 seconds	-0.609°/second*
2	87.414 seconds*	-0.516°/second*
3	118.134 seconds*	-0.260°/second*

* May be updated via DCS.

FIRST STAGE UPDATES

Two out-of-plane velocity components (azimuth updates) will be received. The first update will be at 105 seconds and the second will be at 145 seconds. The onboard computer can accept four updates. However, the S/C-7 computer will only receive two updates due to Burrough's ground computer limitations. These updates are to correct the platform alignment to within the 3σ limit (45 arc - minutes $=3\sigma$).

STAGE II

INITIATION

The Stage II guidance initiation time for S/C-7 will be loaded via the DCS into computer address 13 and will be 166.072 sec. after lift-off. The approximate location of the spacecraft will be at an altitude of 250,000 feet, a velocity of 9,800 ft/second, a pitch attitude of 20 degrees, and a down range distance of 20 N.M.

STEERING

The Stage II guidance equations determine the attitude commands required to achieve the desired insertion conditions based on computed navigational data. The computed change in velocity error during each computation cycle is used to derive a time-to-go to Second Stage Engine Cutoff (SSECO). Spacecraft will not receive Second Stage updates from the ground.

YAW STEERING

The implicit steering scheme, in which only the out-of-plane velocity is nulled at SSECO, will be used. The onboard computer also provides the capability of explicit yaw steering, in which both the out-of-plane position and velocity are driven to zero at SSECO. Yaw steering will not be used on Gemini VII.

SECO COUNTDOWN

When the time-to-go to Second Stage Engine Cutoff (SSECO) becomes less than 2.3 seconds, the computer enters a fast loop sequence to insure engine cutoff as precise as possible and to command a zero attitude error signal to the GLV autompilot. The SSECO Discrete Input (DI) is transmitted when the time-to-go to SSECO is less than 0.475 seconds which is a time bias to compensate for the thrust tailoff. At this time, the astronauts will be on their right side with their heads toward the south pole.

SECO + 3.5 SECONDS

At SECO + 3.5 seconds, the IVI's are enabled and will go thru a zeroing process. When the IVI's are zeroed or at 23 seconds, whichever occurs first, the zeroing loop is disabled and the ΔV values will count up.

SECO + 30 SECONDS

At SECO + 30 seconds, the SEP SPCFT telelight will be depressed. Nominal ΔV will then be added by firing the aft firing maneuver thrusters.

IVAR

The Insertion Velocity Adjust Routine (IVAR) is automatically entered following a GLV shutdown after $\approx$300 seconds from lift-off. IVAR provides the velocity commands required to obtain a specified orbit. A velocity command is displayed at SECO + 3.5 seconds if zeroing is complete. If zeroing is not complete at SECO + 3.5 seconds, the IVAR commands are displayed when zeroing is complete or SECO + 23 seconds, whichever occurs first. Out-of-plane velocity errors are included in the displayed velocity command. An additional velocity correction at apogee to correct perigee and a time from lift-off to apogee is calculated and available via the MDU. (The apogee correction is made utilizing the Catch-up computer mode.) IVAR will calculate the corrections for either an under-speed or an overspeed condition at booster cutoff. (The IVAR corrections will not be used unless there is no ground solution from GE-Burroughs.)

INSERTION IVAR COMPUTATIONS

IVAR uses the Catch-Up mode logic with the computer mode switch in ASC and takes into consideration the in-plane velocity commands (V_{ga}) and the out-of-plane velocity commands ($\Delta \dot{z}$) to make the insertion velocity corrections. V_{ga} is calculated from the radial velocity error (flight path angle error) the total vehicle velocity error at insertion and the error in radial distance from the earth center. The $\Delta \dot{z}$ error is calculated from the three computed platform velocity components. The out-of-plane command ($\Delta \dot{z}$) is not limited in Math Flow 6 and can be read out of address 60. Address 61 will display radial velocity and Address 72 will display total inertial velocity.
NOTE: The $\Delta \dot{z}$ will limit but not necessarily correct the out-of-plane position errors.

IVAR IVI DISPLAY

The in-plane and out-of-plane velocity commands are displayed in body coordinates. As the spacecraft attitude changes, the computer will maintain the correct ΔV display with respect to instantaneous spacecraft attitudes thru a closed loop with the platform gimbals and accelerometer.

Due to the approximations made in the IVAR equations, the intitial ΔV's displayed on the IVI's are not necessarily the ΔV's that must be applied to the spacecraft to drive the IVI's to zero.

IVAR FDI DISPLAY

The Flight Director Indicators (FDI's) provide pointing commands for alignment of the spacecraft to apply the IVAR velocity corrections. The roll during IVAR will always indicate "zero" roll. The pitch needle will be displaced such that nulling it will align the spacecraft for the in-plane velocity correction. The yaw needle will be displaced such that nulling it will align the spacecraft for the out-of-plane correction. The out-of-plane command is not limited in Math Flow 6.

UNDERSPEED INSERTION

For an underspeed insertion, the FDI's will be in a "Fly-To" polarity in the SEF "Heads-Up" position. The procedure for correcting the underspeed insertion is to null the FDI's and fire the aft-firing maneuver thrusters until 0 ft/second is indicated. If the IVI's go thru "zero," the pitch FDI will peg at the top or bottom limit; also, the FWD light will go out and the AFT light will illuminate.

OVERSPEED INSERTION

When an overspeed exists, the pitch FDI will peg at the top or bottom limit indicating that a pitch up or a pitch down 180° maneuver should be performed. The computer will use a "shortest way to 180° logic" to reach the BEF heads down position. This FDI pitch logic depends on which side of the 0° pitch the spacecraft is orientated. The procedure to be used will be the 180° pitch up attitude maneuver. When at the 90° pitch up position, the aft firing thrusters should be fired for 5 seconds to give S/C-GLV separation. When the 180° pitch over maneuver is complete, the S/C will be "BEF" and in the "Heads Down" position. The FDI's will be in a "Fly To" polarity. The aft firing maneuver thrusters should be fired until 0 feet/second condition is reached.

IVAR APOGEE CORRECTION

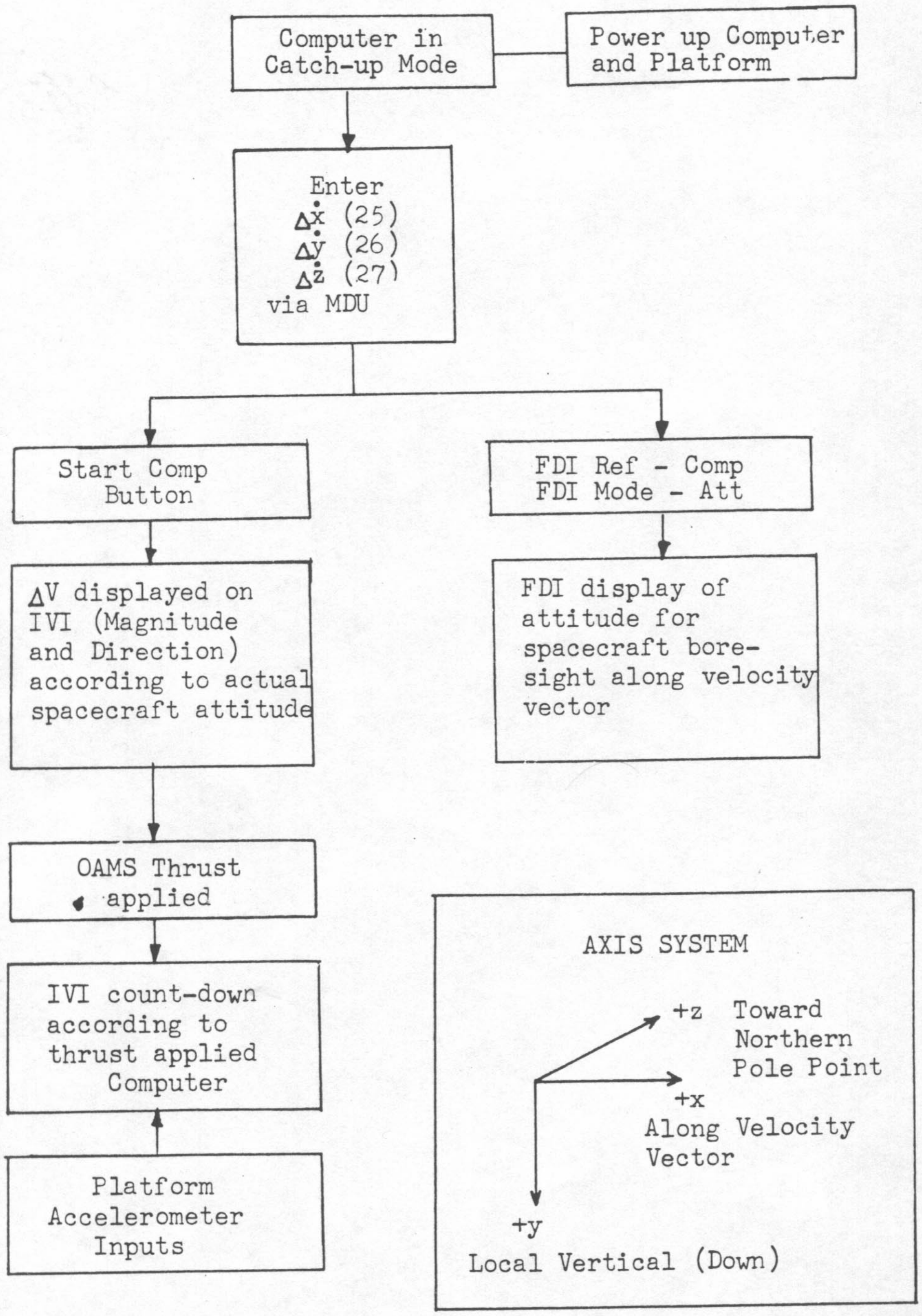
From SECO until switching out of ASCENT mode the horizontal in-plane velocity to be gained at apogee to correct perigee (V_{gp}, computer address 52) and the velocity to be gained at perigee to correct apogee (V_{ga}, computer address 97) are computed. V_{gp} and V_{ga} should be read out of the MDU as soon as insertion thrusting is complete. The time from lift-off to apogee (T_{ap}, address 73) is computed only from SECO to SECO + 20 seconds and only the final computed value can be read out. V_{gp} and V_{ga} are continuously computed taking into consideration central angle travel and thrusting. T_{ap}, V_{gp}, and V_{ga} remain in storage after switching out of Ascent mode and may be read out in other modes when the computer is on.

AFTER IVAR THRUSTING

Read out V_{gp} (computer address 52) and T_{ap} (computer address 73) and record these values. Select PRE LN so that the insertion conditions can be read on T/M.

CATCH-UP MODE

LOGIC FLOW



COMPUTER PROGRAM NOTES

MATH FLOW NO. 6 - S/C 7

CATCH-UP

The CTCH-UP computer mode is used in conjunction with an aligned platform in ORB-RATE or FREE to apply a controlled velocity with the spacecraft OAMS translation system. Astronaut or ground computations must be done to supply the spacecraft computer with velocity components (pointing commands), and the time to initiate thrusting. CATCH UP Velocity Components can be loaded in any computer mode. See CATCH-UP Logic Flow for definition of coordinate systems.

LOADING THE MEMORY

The three velocity vectors ($\Delta\dot{x}$, $\Delta\dot{y}$, $\Delta\dot{z}$) can be loaded into the computer via the DCS or MDU in platform coordinates. The velocity vectors are loaded into addresses 25, 26, and 27 of the computer memory.

Example:

	Address:Message
$\Delta\dot{x}$ = +50 feet/second	25:0050.0
$\Delta\dot{y}$ = +40 feet/second	26:0040.0
$\Delta\dot{z}$ = +30 feet/second	27:0030.0

Negative values may be loaded by using a 9 in the first digit of the Message.

FDI DISPLAYS

When the $\Delta\dot{x}$, $\Delta\dot{y}$, and $\Delta\dot{z}$ values are inserted into the computer, the pitch and yaw FDI will displace to a position such that when they are nulled, the FWD-AFT axis of the spacecraft will be aligned along the resultant velocity vector. The roll FDI is always slaved to the platform roll gimbal; however, the phasing is controlled to maintain a "fly-to" phasing.

As $\pm 90^{\circ}$ yaw is approached, the pitch and roll FDI's become hyper sensitive. Yaw attitudes close to $\pm 90^{\circ}$ must be flown using the "8 ball" or the IVI's as a reference.

The "8 ball" readings at the FDI null position can be calculated from the velocity by using a yaw, then a pitch Euler angle calculation sequence. The yaw angle is measured in the xz (yaw) plane from the x axis. The "8 ball" pitch angle is measured in a plane perpendicular to the yaw plane from the $\Delta\dot{x}$, $\Delta\dot{z}$ resultant to the resultant of the $\Delta\dot{x}$, $\Delta\dot{z}$ and $\Delta\dot{y}$ velocity vectors.

The computer also calculates the pointing angles and they can be read out of the MDU from addresses 56 (yaw) and 57 (pitch). These computer angles are calculated in a different manner than the "8 ball" angles; therefore, they are slightly different. The computer calculates the angles in a pitch, then a yaw Euler angle calculation sequence. The computer pitch angle is measured in the xy (pitch) plane from the x axis. The computer yaw angle is measured from the $\Delta\dot{x}$, $\Delta\dot{y}$ resultant to the resultant of the $\Delta\dot{x}$, $\Delta\dot{y}$ and $\Delta\dot{z}$ velocity vector.

IVI DISPLAY

If the S/C is aligned to the platform and if $\Delta\dot{x}$, $\Delta\dot{y}$ and $\Delta\dot{z}$ values are inserted into the computer, and theSTART computer button is depressed, the velocity values will be displayed in the FWD-AFT IVI windows. The $\Delta\dot{y}$ (address 26) will be displayed in the UP-DN IVI windows. The $\Delta\dot{z}$ (address 27) will be displayed in the L-R IVI windows. As the spacecraft attitude changes, the computer will maintain the correct ΔV display with respect to instantaneous spacecraft attitude thru a closed loop with the platform gimbals. An attitude change will resolve the ΔV components along the 3 vectors of the spacecraft (body coordinates). The ΔV's displayed on the IVI's are also closed loop with respect to spacecraft translation maneuvers thru the platform accelerometer. When the spacecraft is maneuvered in attitude to null the pitch and yaw FDI's, the single velocity resultant will be displayed in the FWD-AFT IVI windows. For each set of IVI windows, there are small green lights indicating the direction in which a spacecraft translation maneuver would be required to drive the IVI's to "zero" if the S/C attitude were to remain constant.

REENTRY

The reentry computer program provides the capability to fly an automatic reentry or to fly a manual reentry by nulling the Roll FDI from 400,000 feet to 80,000 feet altitude.

UPDATES

The reentry computer program can receive DCS updates when the computer is on in any mode up to T_R-120 seconds. After T_R-120 manual updates may be made using the MDIU. The initial conditions of RE-ENT consists of a set of earth centered position coordinates and a velocity fix with respect to $T_R = 0$.

INITIATION

The RE-ENT computer mode can be started by a $T_R = 0$ discrete input (DI) from the Time Reference System (TRS), from the COMP button on the pedestal, or from the MAN FIRE RETRO Telelight Switch. With the COMPUTER mode switch in RE-ENT, the computer will accept and store 10 sec of acceleration data from the platform accelerometers prior to initiation of the RE-ENT mode ($T_R = 0$). If the retro rockets are fired at a time other than $T_R = 0$, the touchdown point will be shifted proportionately.

T_R = 0 to 400,000 feet

At $T_R = 0$ the first retro rocket will fire. The last retro rocket thrust will end at T_R + 22 seconds which includes tailoff time. At $T_R = 0$ the COMP light will illuminate green and the computer will accept acceleration data from the platform accelerometers for 60 seconds. During retrofire and until the 60-sec time period is over, the computer will integrate the acceleration data and display the ΔV from retrofire on the IVI's in body coordinates that are not closed loop with S/C attitudes. T_R + 45 seconds and in retroattitude, the JETT RETRO Telelight will illuminate amber. When depressed, the retro rockets are jettisoned; the BEF bias ("fly to" the FDI's in BEF attitude) is removed; the roll FDI's are locked in the MIX mode regardless of flight director mode switch selection; and the telelight is illuminated green. At T_R + 60 seconds, the computer starts calculating the distance from the S/C to the center of the earth. The HI RANGE for FDI scale deflection should be selected. As long as COMP MODE and ATT REF are selected, the FDI will reference zero regardless of S/C attitude.

400,000 feet to 1.0 ft/sec^2

When a value is calulated indicating that the S/C is at an altitude equal to 400,000 feet above the earth, the computer will start sending pointing commands to the roll FDI. When the roll FDI is nulled, and the proper "fly to" the FDI phasing is obtained, the orientation of the S/C will be at the desired bank angle in the BEF heads down position. This attitude will be held until a reverse bank angle command is received from the computer. When the computer receives a 1.0 ft/sec^2 acceleration from the platform accelerometers, a down range error will be displayed and a cross range signal that is the cross range error divided by cross range capability. The altitude above earth will be 280,000 to 320,000 ft.

1.0 ft/sec^2 to 80,000 feet

When the 1.0 ft/sec^2 acceleration is sensed, the down range error and the cross range error divided by the cross range capability are displayed on the pitch and yaw FDI's. At a time after flying a constant bank angle, when the cross range error is equal to the cross range capability, a reverse bank angle will occur and the spacecraft is rolled thru the heads down position to the Reverse Bank Angle desired. At 80K feet the spacecraft will be heading straight to the toughdown point.

The down range and cross range errors will be displayed on the pitch and yaw FDI's. To calculate these errors, the distance down range to the touchdown point is compared with the distance to the touchdown point that would be obtained if zerolift (rolling reentry) were used.

Full scale deflection from center on the pitch FDI (down range) is $\pm$200 N.M. (HI scale) and $\pm$100 N.M. (LO scale). The cross range displayed is the cross range error divided by the cross range capability remaining. Coriolis effect is included in the calculations.

When the computation (of the distance tothe center of the earth) indicates that the S/C is 80,000 feet above the earth surface, the roll gimbal is check and a signal that is opposite to the roll gimbal angle is commanded, thereby setting any bank signal or roll rate equal to zero. The pitch and yaw FDI's are commanded to zero.

The S/C is now in the proper attitude for drogue deployment.

COMPUTER PROGRAM NOTES

MATH FLOW NO. 6 (S/C 6 & 7)

RENDEZVOUS (Not used S/C 7)

1. When RNDZ is selected, after RDR lock-on is established, the computer will go through an initialization cycle and pick up the $W_T t_{PR}$ (130° for GT-6) and the angular distance between vernier corrections ($\Delta = 48^\circ$ for GT-6).

2. The computer will zero the IVI's and then start cycles to check the RDR until the RDR ready discreate is up. At this time the computer will read the range to the target and the sine of the azimuth and elevation angles of the target with respect to the spacecraft. The computer checks to second that the data is within reliable operating ranges of the RDR. If the data is out of range, it is discarded, and if it is in range, a second set of data is taken and compared to the first range. If the two ranges are within a specific tolerance, the first set of data is accepted. The computer uses this accepted data and the gimbal angle information to compute the position of the spacecraft in target centered navigational coordinates (X, Y & Z) and stores this coordinate data. This process will continue at 100 second intervals until 700 seconds after the first valid RDR sample.

3. If during the RDR interrogation an invalid data point is received, the COMP will interrogate the RDR four times a second until a valid point is received or until 100 seconds have passed. If late data is reveived, it is time tagged with the actual late time and stored. If no valid data is received, then a missed point indicator is stored.

4. 700 seconds after the first valid data point (provided that the last data point is not a missed point), a sequence of calculations is begun using the Clohessy-Wiltshire equations. The data storage table contains 11 spaces for data stowage and the latest data point is always stored in position 11, and earlier data points shifted down toward 1 by one storage space, with any data bit in the first data stowage space being shifted out. At the end of 700 seconds, 8 data points will have been taken and spaces 1, 2 & 3 will have missed data point indicators stored in them. The data point stored in number 11 is compared with the data in 1 through 7. Points 1, 2 & 3 are invalid, therefore, only 4, 5, 6 & 7 are used.

5. The ΔV_T is displayed on the ΔV_X of the IVI for 50 seconds. After that the IVIs are zeroed and remain zero for 50 seconds. During this 100 second interval, the astronauts must determine whether to push start COMP and initiate the closed-loop Rendezvous or wait for another ΔV_T. When a ΔV_T has been selected and the start COMP depressed, the midpoint of the first thrust (T_M) is set at 250 seconds after the last radar point was taken. The ΔV for the initial thrust is calculated, the angles to align the Spacecraft for that thrust are displayed on the FDIs and the IVIs will count up. When the start COMP light comes on, thrust should be initiated.

COMPUTER

NOTES

6. 150 seconds after the midpoint of thrust (T_M + 150), the Spacecraft attitude is computed so that at (T_M + 200 sec.) the Spacecraft can be aligned on the target. At (T_M + 200 sec.), the computer starts taking radar samples at 20 second (not 100 sec.) intervals for 120 seconds (7 samples). (T_M + 200 sec.) + (120 sec.) = T_M + 320 sec. At T_M + 320 seconds, all FDIs are commanded to zero for platform alignment.

7. 80 seconds prior to the first verier correction, the platform alignment is terminated by an indication from the FDIs to re-align on the target. At the end of the 80 seconds for spacecraft-target alignment, one radar data point is taken. This one radar data point, plus the seven data points taken prior to the platform alignment, are used to compute a vernier ΔV. As soon as the ΔV appears on the IVIs, thrusting should begin (line-of-sight).

8. The procedure in the previous paragraph is repeated as many times as necessary.

9. Out-of-plane corrections will be made on the first thrust and on any vernier correction of 90° or less from rendezvous.

10. 150 seconds after the last vernier correction, the start COMP light goes out indicating that the closed-loop rendezvous is complete. At this time, if there is less than 30° orbital travel to rendezvous, the computer will interrogate the radar each 1/8 second and the radar range can be read out or the catchup mode can be selected as it interrogates the radar each 1/8 second.

COMPUTER MDU

NOTES

The Manual Data Unit (MDU) consists of the Manual Data Keyboard and the Manual Data Readout units. The Manual Data Keyboard has ten push buttons for insertion of addresses and data, while the Manual Data Readout has three push buttons for control of manual data functions.

Readout - Insert the two-digit address, the first digit going into the left address window and the second going into the right address window. Depress Readout and any computer function that is going on will stop and the data at the selected address will be displayed in 3.7 seconds. Then the computer will continue on as normal. Holding down the Readout will cause display of updated information, each 3.7 seconds.

Insertion - A two-digit address and a five-digit message must be displayed. If negative data is to be inserted, the number nine key is depressed as the first message digit. This means that the largest positive number that can be inserted by the MDU is 89,999 and the largest negative number that can be inserted is -9,999.

Depress the Enter button and the data in the message windows is entered into the computer memory at the designated address. Each digit of the address and the message is verified by a slight ripple of the display wheels. If a number other than the ones displayed was entered, the ripple will turn the display wheel to the number that was entered. This can happen if the number keys are not held down for approximately 0.5 seconds each.

COMPUTER

NOTES

IVI's

The Incremental Velocity Indicators display the ΔV values from 000 to $\pm$999 ft/sec in any one or all three axes. A value of 0.5 is added to each velocity value to be displayed and the value is rounded to the lower whole number. When a thrust is made while the computer is in Ascent, Catch-up, Rendezvous, or Reentry, the computer will resolve the acceleration data from the platform through the matrices in the computer and drive the ΔV values to these proper settings on the IVI. The ΔV values are displayed with reference to body coordinates of the spacecraft.

Whenever the ΔV values are inserted from the platform through the computer or from the MDU or DCS through the computer, they are closed loop with the spacecraft attitude. Any acceleration change will be sensed and changed to body coordinates and displayed accordingly on the IVI's. The spacecraft can be maneuvered such that all of the ΔV value will be displayed in one axis only.

Insertion of ΔV by the manual insertion knobs are not closed loop because they are not resolved through the computer matrices. The computer automatically zeros the ΔV indicators when turned on and upon changing from one computer mode to another computer mode.

The IVI's provide a display of the required or actual velocity change in each of the three spacecraft axes, as determined by the particular computer mode of operation.

a. Ascent - Display and countdown of insertion velocity correction calculated by the computer. This occurs at SSECO + 20 seconds.

b. Catch-up - Display and countdown catch-up velocity maneuvering which will be inserted via the Digital Command System, the MDU, or set in manually.

c. Rendezvous - Accept radar data, calculate and display ΔV and pointing commands required for rendezvous.

d. Reentry - The display will show the change in velocity, relative to the body reference axes, caused by the firing of retro rockets.

COMPUTER

NOTES

The Auxiliary Computer Power Unit provides power to the computer during periods of varying bus voltage. The Auxiliary Power Unit will supply power for 100 M.S. and, if proper voltage is not restored, will then shut the computer down in a controlled sequence so that no memory data will be erased.

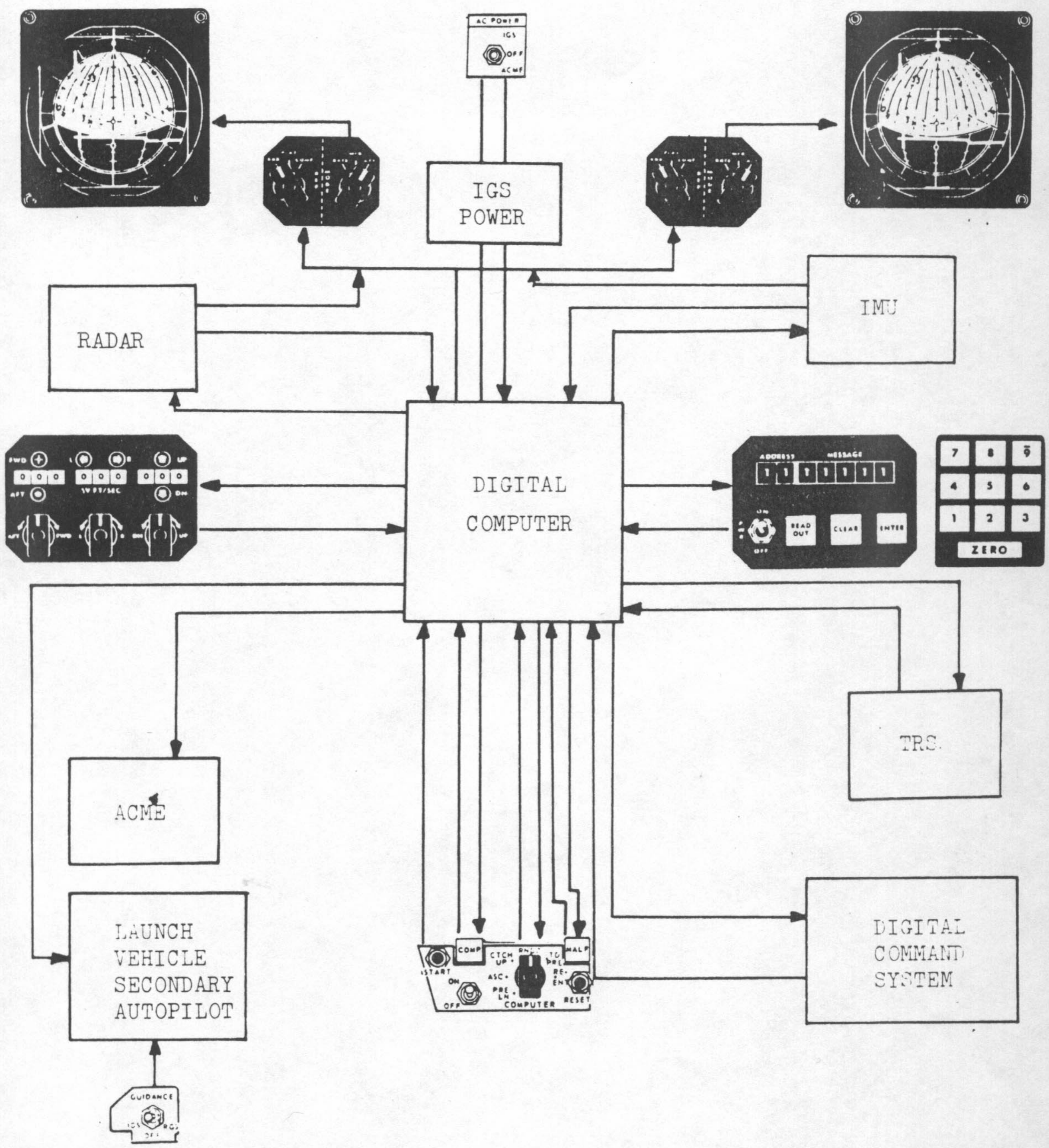
EXTENDED ADDRESS CAPABILITY

The DCS extended address capability is accomplished by sequential use of two DCS addresses (computer addresses 20 and 21) such that the data and an auxilliary address are shared within the two word transmission. The extended address technique is required for any DCS decimal address (computer address) greater than 63. The extended DCS capability permits a greater number of DCS loadable constants as well as providing a 26 bit data word update which eliminates some errors resulting from the DCS 18 bit words.

EXAMPLE

<table>
<tr><td colspan="2">18 of the most significant bits
24 ← 7</td><td>Address 20
6 bits
6 ← 1</td></tr>
<tr><td>8 least significant bits
24 ← 7</td><td>Auxilliary Address
16 ← 7</td><td>Address 21
6 ← 1</td></tr>
</table>

COMPUTER BLOCK DIAGRAM



Prepared by ______ Checked by ______ Approved by ______	Flight Crew Support Division Spacecraft Operations Branch Date 10-27-65	GEMINI OPERATIONS HANDBOOK S/C 7 Rev Orig Section 2.5.7 Pg 15

COMPUTER

NOTES

ADDRESS	(a) The two digits to be inserted if a readout is desired. (b) The first two digits of seven to be inserted if data is to be entered into the computer memory.
QUANTITY	Nomenclature of the addressed memory units.
MODE	Position of computer mode selection switch for the corresponding address.
USED BY DCS	Address and data can be inserted through the DCS system from the ground.
MDU INSERT	The dimensions and units that can be inserted into the computer for each address.
MDU DISPLAY	The dimensions and units that can be displayed by the computer for each address.
RANGE	The maximum and minimum nominal amount that can be inserted into or read out of the computer for each address.

ALL COMPUTER MODES

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Clear display	00	--	--	--	No	All zeros displayed when error in procedure
Time to reset (T_X) DCS Relays	01	Min:Sec	--	0-900 Sec	Yes	Transfers between Computer and TRS occur with the Least Significant Bit (LSB) equal to 1/8sec Max time is 2 hrs 16 min 32 sec
High Order DCS data	20	--	--		Yes	
Extended DCS address and Low Order DCS data	21	--	--		Yes	
Time to go to Retrofire T_R	02	XXX.XX	XXX.XX		Yes	There is a 3.7 sec time delay between READ OUT and the actual display.

PRE-LAUNCH COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Final velocity (V_F*)	22	--	X.XXXX	$1\pm.1$	Yes	Nominal time value of V_F* = .992035 to specify V_F in Cononical units
Pitch gimbal (K_θ) bias	35	--	XXX.XX Deg Min	0-360°	Yes	Desired decimal value = 8.0
Yaw gimbal (K_ψ) bias	36	--	XXX.XX Deg Min	0-360°	Yes	Desired decimal value = 0
Roll gimbal (K_ϕ) bias	37	--	XXX.XX Deg Min	0-360°	Yes	Desired decimal value = 3.0
Misalignment & scale factor matrix	38-46	--	$\pm$.XXXXX	.25	Yes	Matrix data for platform alignment (KX1, KX2, KX3, KY1, KY2, KY3, KZ1, KZ2, KZ3)
Accelerometer bias	47-49	--	$\pm$X.XXX pul/sec	3.6 pul/sec	Yes	Bias for each platform accelerometer (KX4, KY4, KZ4)

ASCENT COMPUTER MODES

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Abort Lat (ϕ_{TA}) Abort Long (θ_{TA})	10 11	$\pm$XX.XX° XXX.XX°	$\pm$XX.XX° XXX.XX°	0$\pm$90° 0-360°	Yes Yes	Touchdown point for computer to navigate to during an abort situation during ASCENT
Separation Velocity (δV_F^*)	12	No	$\pm$XXX.X ft/sec	$\pm$50 ft/sec	Yes	Nominal value = 10 FPS
Final Velocity (V_F^*)	22	--	X.XXXX	1$\pm$ .1	Yes	Nominal value of V_F^* = .992035 to specify V_F in cononical units
Desired X velocity change ($\Delta\dot{X}$)	25	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	
Desired Y velocity change ($\Delta\dot{Y}$)	26	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	Insertion Velocity Adjust Routine (IVAR) is from catch-up equations used in ASCENT to drive FDI's and IVI's for insertion correction
Desired Z velocity change ($\Delta\dot{Z}$)	27	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	
V along guid X-axis (V_{XG})	28	--	XXXXX ft/sec	0-26,000 ft/sec	Yes	
V along guid Y-axis (V_{YG})	29	--	$\pm$XXXX ft/sec	$\pm$4000 ft/sec	Yes	Backup guidance parameters updated at 105, & 145 sec during launch
V along guid Z-axis (V_{ZG})	30	--	$\pm$XXXX ft/sec	$\pm$2000 ft/sec	Yes	
Update command (LC21)	31	--	--	--	Yes	Minus data word results in LC21 (-), LC21 (-) in ascent update loop enabling use of address 28, 29, and 30
Azimuth of Orbit Plane (γ)	32	--	$\pm$XX.XX°	$\pm$10°	Yes	Nominal γ = -.0789318 radians Difference between local S/C azimuth and insertion azimuth at time of platform release.
Sine of the platform angle between launch point & orbit plane ($\sin\int$)	33	--	$\pm$.XXXX	$\pm$.01745	Yes	Nominal $\sin\int$ = -.0076103. $\sin\int$ = angle between platform Y-axis and the normal to the orbit plane at platform release

ASCENT COMPUTER MODES

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Desired roll ($\Delta\phi_R$) maneuver	34	--	$\pm$XX.XX$^\circ$ deg	$\pm 25^\circ$ deg	Yes	Nominal $\Delta\phi_R$ = -.1391497 radians Roll program to place GLV in launch azimuth. Positive for clockwise roll looking from rear.
(LC 31)	50	Yes	$\pm$XXXX	0 to 1400 sec.	Yes	+ for MISSION SIMULATION (NOT USED DURING ASC) - for ACCEPTANCE TEST
ΔV applied at apogee to gain perigee (V_{gp})	52	--	$\pm$XXXX ft/sec	$\pm$300 ft/sec	No	
S/C Y-axis with (C_5) respect to East	55	--	X.XXXX$^\circ$ deg	+4° +6°	Yes	Nominal value of C_5 =.0E4794 radians. Positive C_5 for S/C Y-axis is north of east.
IVAR-out-of-plane ΔV ($V_{\perp f}$)	60	No	$\pm$XXXX ft/sec	$\pm$250 ft/sec	Yes	
Final Targeting Radial Velocity (V_{pf})	61	No	No	-1200 +1000 ft/sec	Yes	
Effective (g_{epf}) gravity at SSECO	62	--	--	$\pm$2 ft/sec^2	Yes	Nominal g_{epf} = -0.233 ft/sec^2
Total Inertial Velocity (V)	72	No	XXXX.X ft/sec	--	No	
Computed time (T_{AP}) from lift-off to apogee	73	--	XXXXX sec	0-10,000 sec.	No	This value computed at SSECO but can not be read out until SSECO + 20. Consideration is not taken for the final 10 ft/sec OAMS insertion thrusting.
Time to stop (T_s)	90	XXXX.X sec	XXXX.X sec			
Start Command (LCS)	91	$\pm$XXXX	$\pm$XXXX			
Orb Radius Rate (V_p)	94	No	$\pm$XXXX ft/sec	-1200 +1000 ft/sec	No	
ΔV applied at perigee to gain apogee (Vga)	97	No	$\pm$XXXX ft/sec	$\pm$400 ft/sec	No	

ASCENT COMPUTER MODES

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Apogee time purturbation constant (CT2)	101	No	No	$\pm$.0001 sec/ (FPS)^3	Yes	-.0000255 sec/(ft sec)^3
Bias used for SSECO delivery (t_K)	102			0.4 to 1.0 sec	Yes	.38802 sec
Final value of (ΔR_F) insertion radius	103					Final value = 21438500 ft
Effective exhaust velocity (C*)	104	--	--	10,080 $\pm$100 ft/sec	Yes	Nominal C* = 10,092 FPS.
Time stage II (t_{STG}) guid initiate	105	--	--	160-170 sec	Yes	166.072 sec
Time pitch step 2 initiate (t_{P2})	106	--	--	50-100 sec	Yes	Nominal value of t_{P2} = 87.41 sec. Use in conjunction with address 109 to approximate a gravity turn profile during first stage of launch
Time pitch step 3 initiate (t_{P3})	107	--	--	100-125 sec	Yes	Nominal value of t_{P3} = 118.13 sec. Used in conjunction with address 110 to approximate a gravity turn profile during first stage of launch
LV pitch rate, step 1 (C_{p1})	108	--	--	-.5 -1.0°/sec	Yes	Nominal pitch rate = -012370844 radiums. Step 1 rate will be initiated at 23.04 sec.
LV pitch rate, step 2 (C_{p2})	109	--	--	0 -.7°/sec	Yes	Nominal pitch rate = -.493°/sec. Used in conjunction with address 106
LV pitch rate, step 3 (C_{p3})	110	--	--	0 -.5°/sec	Yes	Nominal pitch rate =.00410676 -.246°/sec. Used in conjunction with address 107
Final value of (V_{Pf}) radial velocity	112	--	--	$\pm$2000 ft/sec	Yes	Nominal value of V_{Pf} = 0 ft/sec at shutdown.

ASCENT COMPUTER MODES

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Insertion Purtibation Coefficients (KA5)	113	No	No	$\pm$.0006	Yes	KA5 = -.00048281 sec/ft
(A7*)	114	No	No	$\pm$.001	Yes	$A7^* = -\frac{A7}{A6} = -.00089765 \frac{ft/sec}{ft}$
(A9*)	115	No	No	$\pm$.0006	Yes	$A9^* = -\frac{1}{A6} = -.00029268 \frac{ft/sec}{ft}$
Apogee time purtibation constant (CT1)	116	No	No	0 to -4	Yes	CT1 = 3.17 sec/ft/sec
Average Pitch attitude error ($\Delta\theta_{AV}$)	117	No	No	$\pm$ 2 deg.	Yes	$\Delta\theta$AV = 0 rad.

CATCH-UP COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Desired X vel change ($\Delta\dot{X}$)	25	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	ΔV values that can be inserted thru the MDU or DCS to give pointing commands on the FDI's and closed loop velocities on the IVI's with respect to S/C attitude. Also used for IVAR in ASCENT.
Desired Y vel change ($\Delta\dot{Y}$)	26	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	
Desired Z ($\Delta\dot{Z}$)	27	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	Yes	
Command yaw (ψ_{bc})	56	--	XXXXX arc min	+10,800 -9999	No	Vector values from addresses 25, 26, & 27 resolved to body angular coordinates thru the computer matrices. Pitch computed first and resultant used to compute yaw.
Command pitch (θ_{bc})	57	--	XXXXX arc min	+10,800 -9999	No	
Yaw Error ($\Delta\psi_b$)	58	--	$\pm$XXX.X DEG	0 $\pm$ 180°	No	Difference between actual attitude and commanded attitude (displayed on FDI's using Comp Ref) for thruster firing or platform alignment. Pitch computed first and resultant used to compute yaw
Pitch error ($\Delta\theta_b$)	59	--	XXXXX $\pm$XXX.X DEG	0 $\pm$ 180°	No	
Radar Range (R_R)	69	--	XXX.XX N.M.	0-250 N.M.	No	Readout of L-Band Radar Range measurement. Real time read out each time Readout Button is pushed, updated each 1/8 sec. If range is greater than 250 N.M., readout will be 00000.

CATCH-UP COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Desired Velocity Changes (ΔV_{XB})	80	--	$\pm$XXX.X ft/sec		No	Body coordinates that are closed loop with S/C attitude. A reference position must be used.
(ΔV_{YB})	81	--	$\pm$XXX.X ft/sec		No	
(ΔV_{ZB})	82	--	$\pm$XXX.X ft/sec		No	

RENDEZVOUS COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Reciprocal of AFT Thruster Acc. 1/AT	24	X.XXXX sec^2/ft	X.XXXX sec^2/ft		*	*In any mode except rendz.
Desired X vel change ($\Delta\dot{X}$)	25	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	No	ΔV values that can be inserted thru the MDU only to give pointing commands on the FDI's and closed loop velocities on the IVI's with respect to S/C attitude. Also used for IVAR in ASCENT.
Desired Y vel change ($\Delta\dot{Y}$)	26	XXXX.X ft/sec	XXXX.X ft/sec	0-999.9 ft/sec	No	
Desired Z ($\Delta\dot{Z}$)	27	XXXX.X	XXXX.X	0-999.9 ft/sec	No	
Target orbit (T) period	53	XXXX.X sec	XXXX.X sec	5,200 to 6,400 sec	Yes	Nominal value $(T)_d$ = 5403.625248 sec.
Target orbit (r_T) radius	54	XXXXX (100yds)	XXXXX (100yds)	0-26x10^6 ft	Yes	Nominal value (r_T) = 21,888,154 feet. Measured from center of earth.
Command yaw (ψ_{bc})	56	--	XXXXX arc min	10,800 -9999	No	Values from addresses 25, 26, & 27 resolved to body coordinates thru the computer matrices.
Command pitch (θ_{bc})	57	--	XXXXX arc min	10,800 -9999	No	

RENDEZVOUS COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Yaw error ($\Delta\psi_b$)	58	--	XXXXX arc min	10,800 -9999	No	Difference between actual attitudes & commanded attitudes (displayed on FDI's)
Pitch error ($\Delta\theta_b$)	59	--	XXXXX arc min	10,800 -9999	No	
Radar range (R_R)	69	--	XXX.XX N.M.	0-250 N.M.	No	Readout of L-Band Radar Range Updated with each 100 sec radar data point from start of rendz until the 30° Wt corrections. After 30° Wt range is updated each 1/8 sec. For ranges greater than 250 N.M., computer will read 0 N.M.
Total vel incr (ΔV_T) for rendz	70	--	XXXX.X ft/sec	0-999.9 ft/sec	No	The sum of the initially calculated vel correction and the calculated final closing vel ($\Delta V_T = \Delta V_i + \Delta V_F$) displayed automatically on Fwd-Aft IVI each 100 sec starting at end of the 700 sec data acquisition period. Does not include the velocity required at the ΔWt (Address 93) corrections. Used for total fuel estimate for rendezvous.
Initial impulse (ΔV_i) for intercept	71	--	XXXX.X ft/sec	0-999.9 ft/sec	No	ΔV that is calculated for first thrust after a total ΔV has been selected.
Desired velocity changes (ΔV_{XB})	80	No	$\pm$XXX.X	$\pm$540 ft/sec	No	Body coordinates that are closed loop with S/C attitudes. A reference position must be used.
(ΔV_{YB})	81	No	$\pm$XXX.X	$\pm$150 ft/sec	No	
(ΔV_{ZB})	82	No	$\pm$XXX.X	$\pm$150 ft/sec	No	These angles must be selected such that $W_s t dL < 18.17°$ $163.42 < W_s t dL < 196.58°$ $342.71 < W_s t dL$ Other values will cause comp overflow.
Orbital angle to go to RNDZ ($W_t t_{PR}$)	83	XXX.XX deg	XXX.XX deg		No	
Orbital angle between corrections (ΔWt)	93					
Radar angle reject signed (RLO)	92	XXXXX	XXXXX		No	Accept 00000, Reject 99999
Radar Range Tolerance Constant (CR)	111	--	--		Yes	

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REENTRY COMPUTER MODE

PARAMETER	ADDRESS	MDU INSERT	MDU DISPLAY	RANGE	UPDATE BY DCS	REMARKS
Time to go to retrofire (T_R)	02	Min Sec XXX XX	Min Sec XXX XX		Yes	There is a 3.7 sec. time delay between READ OUT and the actual display.
Position coordinates (X_{ER+}) (X_{ER-})	03 63	XXXXX (100yds)	XXXXX (100yds)	$\pm 24 \times 10^6$ ft	Yes	Set of retrofire position inertially fixed orthogonal axis with the origin at the center of the earth, Z_{ER} along the north polar axis, and X_{ER} extending thru a celestial reference lying in the equatorial plane. If the value is negative the computer will change the address and display the correct address and value upon READ OUT.
(Y_{ER+}) (Y_{ER-})	04 64	XXXXX (100yds)	XXXXX (100yds)	$\pm 24 \times 10^6$ ft	Yes	
(Z_{ER+}) (Z_{ER-})	05 65	XXXXX (100yds)	XXXXX (100yds)	$\pm 24 \times 10^6$ ft	Yes	
Velocity components ($\dot{X}_{ER+}$) ($\dot{X}_{ER-}$)	06 66	XXXXX yds/sec	XXXXX yds/sec	$\pm 26 \times 10^3$ ft/sec	Yes	Inertial velocity components of the retrofire position coordinates. If the value is negative, the computer will change the address and display the correct address and value upon READ OUT.
($\dot{Y}_{ER+}$) ($\dot{Y}_{ER-}$)	07 67	XXXXX yds/sec	XXXXX yds/sec	$\pm 26 \times 10^3$ ft/sec	Yes	
($\dot{Z}_{ER+}$) ($\dot{Z}_{ER-}$)	08 68	XXXX.X yds/sec	XXXX.X yds/sec	$\pm 26 \times 10^3$ ft/sec	Yes	
Initial earth longitude of X_E axis ($\Delta\theta_R$)	09	XXX.XX° deg	XXX.XX° deg	0-360° deg	Yes	Angle from X_E axis to Greenwich Meridian at T_R = 0. Update from Goddard SFC is referenced to the first point of Aries.
Target latitude (ϕT)	10	±XX.XX° deg	±XX.XX° deg	0±90° deg	Yes	Can update via MDU until T_R = 0
Target longitude (θT)	11	XXX.XX° deg	XXX.XX° deg	0-360° deg	Yes	Lat and long used during reentry or an ascent abort.
Bank Angle Bias K_{BA}	23	- -	±XX.XX° deg	0 ±15° deg	Yes	Nominal value = 00000
Acceleration threshold (K)	*100*	--	--	0-15 ft/sec²	Yes	Nominal value of K = 1.0 ft/sec²

NOTE: The computer cannot be updated after T_R - 120 SEC via DCS.

T/M OF COMPUTER MODES

NOTES

Prelaunch Mode
T/M (D/T)

1.	Prelaunch selection	0 or +8V
2.	Pitch gimbal	Rev
3.	Yaw gimbal	Rev
4.	Roll gimbal	Rev
5.	Sum of X accel F-X	FPS
6.	Sum of Y accel F-Y	FPS
7.	Sum of Z accel F-Z	FPS
8.	Sum of X accel SF-X	FPS
9.	Sum of Y accel SF-Y	FPS
10.	Sum of Z accel SF-Z	FPS
11.	Pitch error	Deg
12.	Yaw error	Deg
13.	Roll error	Deg
14.	Time in mode	Sec
15.	Flow tag	
16.	Multiplex frame (14 frames)	Diagnostic Check
17.	MDU-DCS Multiplex Word 1	Diagnostic Check
18.	MDU-DCS Multiplex Word 2	Diagnostic Check
19.	MDU-DCS Multiplex Word 3	Diagnostic Check
20.	MDU-DCS Multiplex Word 4	Diagnostic Check
21.	MDU-DCS Multiplex Word 5	Diagnostic Check
22.	MDU-DCS Multiplex Word 6	Diagnostic Check

Ascent Mode
T/M (D/T)

1.	Ascent selection	0 or +8V
2.	Pitch gimbal	Rev
3.	Yaw gimbal	Rev
4.	Roll gimbal	Rev
5.	Sum of X accel	FPS
6.	Sum of Y accel	FPS
7.	Sum of Z accel	FPS
8.	Velocity (X)	FPS
9.	Velocity (Y)	FPS
10.	Velocity (Z)	FPS
11.	Pitch error	Rad
12.	Yaw error	Rad
13.	Roll error	Rad
14.	Time in Mode	Sec
15.	Flow tag	
16.	Z Velocity update	FPS
17.	Pitch rate	Rad/Sec
18.	Position (X)	Ft
19.	Position (Y)	Ft
20.	Position (Z)	Ft
21.	Time to go to SECO	Sec
22.	Radical Velocity	FPS

Catch-up Mode
T/M (D/T)

1.	Catch-up Mode selection	0 or +8V
2.	Pitch gimbal	Rev
3.	Yaw gimbal	Rev
4.	Roll gimbal	Rev
5.	Sum of X accel	FPS
6.	Sum of Y accel	FPS
7.	Sum of Z accel	FPS
8.	Computed IVI (X)	FPS
9.	Computed IVI (Y)	FPS
10.	Computed IVI (Z)	FPS
11.	Pitch command	Rad
12.	Yaw command	Rad
13.	Logic time	Sec
14.	Time in mode	Sec
15.	Flow tag	
16.	Incremental velocity (X)	FPS
17.	Incremental velocity (Y)	FPS
18.	Incremental velocity (Z)	FPS
19.	Time thrust of midpoint	Sec
20.	Radar Range	Ft
21.	Sine radar elevation	Ft
22.	Sine radar azimuth	Ft

Rendezvous Mode
T/M (D/T)

1.	Rendezvous Mode selection	
2.	Pitch gimbal	Rev
3.	Yaw gimbal	Rev
4.	Roll gimbal	Rev
5.	Sum of X accel	FPS
6.	Sum of Y accel	FPS
7.	Sum of Z accel	FPS
8.	Computed IVI (X)	FPS
9.	Computed IVI (Y)	FPS
10.	Computed IVI (Z)	FPS
11.	Pitch command	Rad
12.	Yaw command	Rad
13.	Logic time	
14.	Time in mode	Sec
15.	Flow tag	
16.	Incremental velocity (X)	FPS
17.	Incremental velocity (Y)	FPS
18.	Incremental velocity (Z)	FPS
19.	Time of thrust midpoint	Sec
20.	Radar range	Ft
21.	Sine radar elevation	Ft
22.	Sine radar azimuth	Ft

Reentry Mode
T/M (D/T)

1.	Reentry selection	
2.	Pitch gimbal	Rev
3.	Yaw gimbal	Rev
4.	Roll gimbal	Rev
5.	Sum of X accel	FPS
6.	Sum of Y accel	FPS
7.	Sum of Z accel	FPS
8.	Distance to earth center	Ft
9.	S/C velocity	FPS
10.	Flight path angle	Rad
11.	Down range error	NM
12.	Cross range error	NM
13.	Commanded bank	Rad
14.	Time in mode	Sec
15.	Flow tag	
16.	Longitude	Rad
17.	Latitude	Rad
18.	S/C heading	Rad
19.	Density altitude	
20.	Heading to target	Rad
21.	Range to target	NM
22.	Predicted half lift range	NM