NASA Reference Publication 1066

NASA Wallops Flight Center GEOS-3 Altimeter Data Processing Report

H. R. Stanley and R. E. Dwyer

NOVEMBER 1980

NASA

NASA Reference Publication 1066

NASA Wallops Flight Center GEOS-3 Altimeter Data Processing Report

H. R. Stanley
Wallops Flight Center
Wallops Island, Virginia

R. E. Dwyer
Computer Sciences Corporation
Wallops Island, Virginia

National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1980

NASA WALLOPS FLIGHT CENTER GEOS-3 ALTIMETER DATA PROCESSING REPORT

by

H. R. Stanley
NASA Wallops Flight Center
Wallops Island, VA 23337

and

R. E. Dwyer
Computer Sciences Corporation
Wallops Island, VA 23337

INTRODUCTION

This document describes to the users the content of the GEOS-3 data tapes and to explain the processes and algorithms used to produce the data. A brief GEOS-3 project description and the technical parameters of the radar altimeter are also provided.

GEOS-3 Mission

The purpose of the GEOS-3 mission was to design, develop, and launch a geodetic satellite and to perform experiments in support of the application of geodetic satellite techniques to geosciences, that is, solid earth physics and oceanography. The GEOS-3 mission objectives in priority order at the time of launch were as follows:

a. To perform an in-orbit satellite altimeter experiment to:

   (1) Determine the feasibility and utility of a spaceborne radar altimeter to map the topography of the ocean surface with an absolute accuracy of ± 5 meters and with a relative accuracy of 1-2 meters.

   (2) Determine the feasibility of measuring the deflection of the vertical at sea.

   (3) Determine the feasibility of measuring wave height.

   (4) Contribute to the technology leading to a future operational altimeter-satellite system with a 10 cm measurement capability.

b. To further support the calibration of NASA's and other agencies' ground C-band radar systems by providing a spaceborne coherent C-band transponder system, to assist in locating these stations in a unified earth-centered reference system, and to provide tracking coverage in support of the radar-altimeter experiment.

c. To perform a satellite-to-satellite tracking experiment with the ATS-6 spacecraft using an S-band transponder subsystem to directly measure the short period accelerations imparted to GEOS-3 by the gravity field and to determine the position of GEOS-3.

d. To further support the intercomparison of new and established geodetic and geophysical measuring systems including the radar altimeter, satellite-to-satellite, and C-band, S-band, laser, and Doppler tracking.

e. To investigate solid-earth dynamic phenomena such as polar motion, fault motion, earth rotation, earth tides, and continental drift theory with precision satellite tracking systems such as laser and Doppler ground systems.

f. To further refine orbit-determination techniques, the determination of inter-datum ties, and gravity models with a spacecraft equipped with laser retroreflectors, C-band and S-band transponders, and Doppler beacons.

g. To support the calibration of the S-band stations in the STDN by providing a spaceborne S-band transponder to assist in positioning the network stations in a world reference tracking system, and to assist in evaluating the S-band system as a tool for geodesy and precision orbit determination.

The GEOS-3 satellite was launched on April 9, 1975, from the Air Force Western Test Range. The achieved orbit parameters are mean altitude 843 Km, inclination 114.98°, and eccentricity 0.001. After completing attitude capture maneuvers and initial system testing, mission data collection began on April 21, 1975. Altimeter data was acquired from that date through December 8, 1978. Table I summarizes the total altimeter data set.

TABLE I. DATA SUMMARY.

	GLOBAL	INTENSIVE	
	Low Data Rate	Low Data Rate	High Data Rate
Time (Min)	6699	46065	30251
Segments	714	4415	3510

GEOS-3 Investigations

Proposals from the scientific community were solicited by the NASA for GEOS-3 investigations in the following categories:

1. Ocean Geoid

2. Ocean Tides
3. Sea State
4. Quasi-stationary Departures from the Marine Geoid
5. Gravity Model Improvement
6. Geological Investigations
7. Solid Earth Dynamics
8. Intercomparison, Evaluation, and Calibration
9. Ground Truth
10. Tracking Station Location
11. Orbit Determination
12. Data Management/Information Processing

The results of these investigations have provided overwhelming evidence as to the success of the GEOS-3 project. In each of the categories of investigation, with the possible exception of ocean tides, the GEOS-3 data have been successfully utilized both to further scientific knowledge and to provide real and practical applications of remotely sensed altimeter data.

To date, only a small portion of the total GEOS-3 data set has actually been used. The purpose of this final distribution is to make available the complete set to the community at large.

GEOS-3 RADAR ALTIMETER SYSTEM DESIGN

System design information is presented here for each major altimeter subsystem; i.e., transmitter, antenna, receiver, signal processor, and the built-in test/calibration system (BIT/CAL). This information, though engineering in nature, is expected to aid the investigator in understanding the altimeter data.

Transmitter

The transmitter section contains two transmitters: a magnetron transmitter for the long pulse (global) mode and a TWT transmitter for the short pulse (intensive) mode.

A Magnetron tube was chosen with a peak power of two kilowatts for the global mode in order to meet input power constraints. With a peak power constraint of two kilowatts, a 200 nanosecond pulse width was necessary to provide adequate single pulse signal-to-noise ratio for tracking. A one-microsecond pulse width for acquisition gives a high single pulse signal-to-noise ratio which is used to provide a fast, high probability acquisition system. A pulse-burst waveform for tracking was selected to improve the altitude estimate accuracy over a single pulse for a fixed bandwidth tracking loop. The burst waveform effectively provides a higher pulse repetition frequency and yet allows the altimeter to operate in an unambiguous manner. The pulse spacing in the 16 pulse-burst was chosen to assure that successive return pulses are statistically independent. The burst repetition rate of 100 per second assures unambiguous operation at the maximum satellite altitude. This results in an effective pulse repetition rate of 1600 pulses per second.

For the intensive data mode, a TWT with a peak power of 2.5 kilowatts is used for the transmitter tube. To meet the performance requirements on the height measurement, the average impulse response measurement, and the wave height measurement, an effective narrow pulse width of approximately 12 nanoseconds is necessary. With a peak power constraint of 2.5 kilowatts and the requirements for an effective narrow pulse, a linear frequency (chirp) pulse compression capability is utilized to obtain adequate single pulse signal-to-noise ratio for tracking.

Transmitter subsystem parameters are as follows:

Characteristic	Global Mode	Intensive Mode
Output Tube:	Magnetron	TWT
Peak Power of Tube:	2 KW min.	2.5 KW min
Frequency:	13.9 GHz	13.9 GHz ± 100 MHz
Pulse Type:	Rectangular	Linear FM Coded Pulses
Pulse Repetition Rate		
Acquisition:	100 pulses per sec	100 pulses per sec
Tracking:	100 pulse burst per sec	100 pulses per sec
	A pulse burst is 16 pulses separated by 204.8 usec	
Transmit Loss:	Less than 1.0 dB	Less than 2.4 dB
Pulse Width (PW)		
Acquisition:	1 usec	Uncompressed 1.2 usec min
Tracking:	200 nsec	Compressed 12.5 nsec nominal
Tracking Pulse Shape:	200 nsec PW	1 usec PW
Rise Time (10-90%):	20 nsec max	20 nsec max
Fall Time (90-10%):	200 nsec max	200 nsec max
Pulse Compression Ratio:	N/A	100:1 nominal
Pulse Expander	N/A	Dispersive delay line at IF of 300 MHz in transmitter chain
Pulse Compressor:	N/A	Dispersive delay line at IF of 300 MHz in receiver chain

Antenna

The physical constraints and performance requirements are:

Type	Paraboloid Reflector
Diameter	.61 meters
Peak Gain	+36 dB min
3 dB Beamwidth	2.6° min

The minimum beamwidth constraint is imposed because of the possible spacecraft attitude error of one degree. With a possible attitude error of one degree, the antenna beamwidth should not be less than two degrees. Due to the long pulse width of the GEOS-3 global mode altimeter, significant altitude bias can be introduced as a function of off-nadir pointing angle (see Fig. 1). The intensive mode altimeter is also effected by off-nadir pointing; however, due to the short pulse width, these errors are estimated at only a few centimeters.

Receiver

The receiver is coherent with the transmitter and has direct down conversion in the front end without preamplification. An IF center frequency of 300 MHz is used because the dispersive delay lines required in the pulse compression system are readily available at this frequency.

The receiver subsystem parameters are as follows:

(1) Front End

Type:	Coherent with direct down conversion
Mixer/Preamp Noise Figure:	7 dB max
Receiver Loss:	1.0 dB max
Receiver Dynamic Range:	56 dB min
AGC Dynamic Range:	50 dB min
AGC Linearity:	Linear with ± 1 dB over 50 dB range

(2) IF Section

IF Center Frequency	300 MHz
IF Filter Bandwidths	
Long Pulse Mode:	150 MHz Pre; 40 MHz Post
Short Pulse Mode:	100 MHz min - Preamp 57 MHz nom - Postamp

(3) Detector

Type:	Square-law
Square-Law Range:	20 dB min

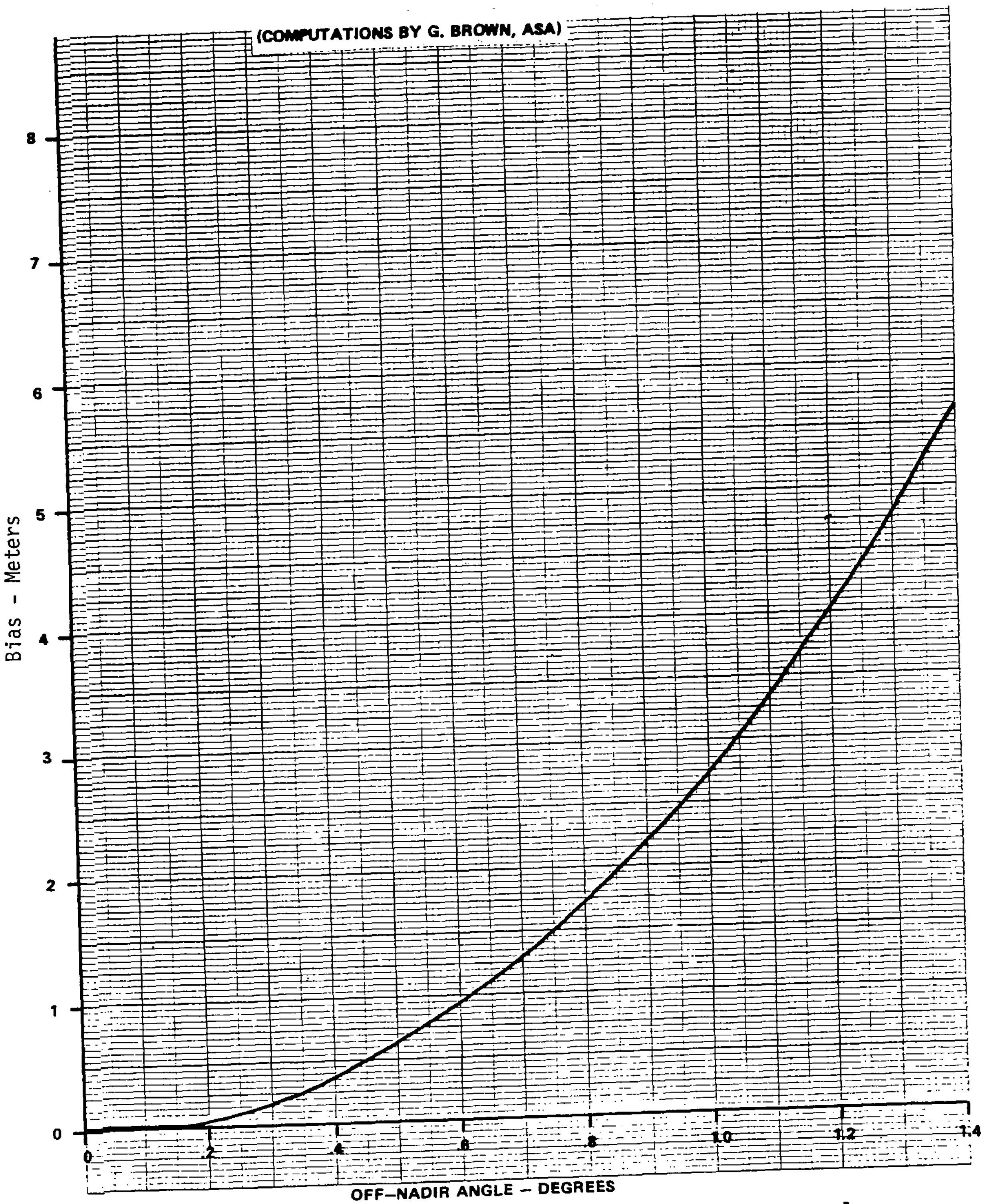

Figure 1. GEOS-3 Global mode altitude bias variation with off-nadir angle.

(4) Video Section

Long Pulse Mode

Video (Post-Detection) Bandwidth:	5 MHz min one sided

Short Pulse Mode

Bandwidth of AGC Loop:	1.6 Hz
Bandwidth of Tracking Loop:	4 Hz
Bandwidth of Waveform Samples:	100 MHz min
Video Signal Dynamic Range to Waveform sampler:	-0.2 volt to +4.0 volt

Signal Processor

The time discrimination function is performed using a set of tracking gates. To meet the performance requirement on height measurement, it is necessary to use tracking gates matched to the mean detected waveform in each mode. This means that a different time discriminator for each mode is required.

Altitude processing provides either average or instantaneous altitude outputs. The system includes the capability to average a number of successive pulse-to-pulse two-way range delay values to obtain a best estimate of the average two-way range delay over a specified time interval. The length of the averaging interval is 0.1024 seconds for both the long and short pulse mode. Ten successive two-way range delay values are averaged to provide 0.1024 second average altitude outputs. When TM format three is commanded, instantaneous altitude data is available from the spacecraft at a rate of 100 per 1.024 seconds. Telemetry format three data was obtained only a few times during the GEOS-3 mission, and, for the purpose of final data distribution, the instantaneous altitudes have been processed to provide only the average (0.1024 second) outputs.

The tracking loop is designed so that the correlation of the random error on successive average altitude outputs is less than 0.25 for both the long pulse and short pulse mode. The standard deviation of the random error on the average altitude output is less than one meter in the long pulse mode and less than 0.6 meter in the short pulse mode.

A receiver automatic gain control (AGC) is necessary to normalize the mean detected return pulses for acquisition and tracking. For acquisition, a peak detector AGC system is used. For each transmit pulse, this system detects the largest peak of return signal, which occurs during a gate covering the two-way range delay uncertainty and adjusts the receiver gain to hold an average of these peaks over many successive pulses equal to a constant. For tracking, the AGC control signal is derived from the tracking plateau gate output. The receiver gain is adjusted to hold an average of the plateau gate outputs over many pulses equal to a constant.

In normal operation of the altimeter, the range tracking loop must be initialized and locked onto the return signal before altitude data can be obtained. This process of initializing the loop and bringing it into a locked condition is commonly called "acquisition." The function of the acquisition system is to locate the time position of the return signal accurately enough so that the tracking loop can pull-in and lock to the return signal.

The acquisition scheme for each mode involves several steps: coarse acquisition, acquisition search, and tracking loop pull-in. The coarse acquisition search steps are based on determining the occurrence time of threshold crossings caused by the return signal. Upon completion of the acquisition search step, the tracking gates and return signals are close enough that the tracking loop can pull into lock.

In the short pulse mode, a waveform sampling system consisting of 16 sampling gates is included to provide information concerning the shape of the average impulse response of the ocean surface and concerning the amplitude probability distribution of the echo energy. Sixteen sample gates are provided in order to have sufficient spread to obtain the complete leading edge of the average impulse response for ten meter wave heights without having to move the time position of these gates. The time position of the 16 gates is fixed with respect to the tracking gates and the capability exists to select all 16 gates simultaneously, the eight even numbered gates, or no gate sampling.

In TM format two, the 16 sample gate outputs are available from the spacecraft at the PRF rate. In all TM formats, averages of the 16 sample gate outputs over many pulses are available from which the average impulse response of the ocean surface can be obtained and the wave height estimated. Only the average sample gates are provided in the final data distribution. Samples at the PRF rate are not provided.

The signal processor subsystem parameters are as follows:

(1) Tracking Loop

Characteristic	Long Pulse (Global) Mode	Short Pulse (Intensive) Mode
Type Loop:	Digital with split gates for tracking	Digital with split gates for tracking
Tracking Gate Configuration:	Ramp and plateau gates for tracking	Ramp and plateau gates for tracking
Ramp Gate Width:	T (200 nsec)	T_e (12.5 nsec)
Plateau Gate Width:	T (200 nsec)	T_e (12.5 nsec)
Separation:	T/2 (100 nsec)	4 T_e (50 nsec)
Feedback Loop Design		
Closed-Loop Type:	1	1

Open Loop Transfer Function:	$A(S) = \frac{(t_1S + 1)}{S(t_2S + 1)}$	$A(S) = \frac{(t_1S + 1)}{S(t_2S + 1)}$
Closed Loop Bandwidth:	4.0 ± 0.4 Hz	4.0 ± 0.4 Hz
Velocity Error Coefficient:	Greater than 1000; 1/sec	Greater than 1000; 1/sec
Acceleration Error Coefficient:	Greater than 273, $1/sec^2$	Greater than 273, $1/sec^2$
Phase Margin:	Greater than 45°	Greater than 45°
Gain Margin:	Stable for any gain	Stable for any gain
Altitude Output		
Normal Operations:	0.1 sec average of two-way range delay	0.1 sec average of two-way range delay
Averaging Process:	10 altitude words per second are accumulated, each word being 23 bits in length	10 altitude words per second are accumulated, each word being 23 bits in length
Output Word:	32-bit buffer stores the accumulated altitude words	32-bit buffer stores the accumulated altitude words
Altitude Word Readout:	Serial readout of the 32-bit buffer by GEOS-3 before updating at 10 per second rate	Serial readout of the 32-bit buffer by GEOS-3 before updating at 10 per second rate
Value of LSB		
100 pps:	6.25 nsec	1.56 nsec
10 pps:	.625 nsec	.156 nsec
Altitude Errors		
Random Error-Height Measurement Performance (1.0 sec average):	Less than 0.6 m	Less than 0.2 m
Random Error Correlation Between Successive (.1 sec) Average Altitude Outputs:	Less than 0.25	Less than 0.25

(2) Automatic Gain Control (AGC) Loop

Concept:	AGC for acquisition peak on return signals peaks during gate covering two-way range delay uncertainty	AGC for tracking derive AGC control signal from tracking plateau gate output
Peak Detector Response Time:	Less than 5 nsec	Less than 5 nsec
Type Loop:	0	0
Loop Bandwidth:	1.6 Hz	1.6 Hz
Loop Filter:	$H(S) = \frac{(t_1S + 1)}{(t_2S + 1)\ (t_3S + 1)}$	$H(S) = \frac{(t_1'S + 1)}{(t_2'S + 1)\ (t_3'S + 1)}$

Gain Margin:	Stable for any gain	Stable for any gain
Phase Margin:	Greater than 45°	Greater than 45°

(3) Acquisition System

Requirement:	Acquire and lock in less than 5 sec
Concept:	Use time location of return signal threshold crossings to position tracking gates within loop pull-in range of return signal
Acquisition for Long Pulse Mode:	5-step process
Step 1 - Acquisition AGC Control Established:	0.1 sec after start of acquisition transmissions
Step 2 - Coarse Acquisition:	Determine initial two-way range delay by counting to return signal threshold crossings: 0.1 sec
Step 3 - Fine Acquisition Sweep:	Search with narrow gate ± 3 usec about initial delay. Locate return signal to within ± 200 nsec; 1.0 sec
Step 4 - Tracking Loop Pull-In:	0.1 sec
Step 5 - Track Lock Indicator:	0.1 sec
Max Acquisition Time (assuming no miss detections):	1.4 sec
Acquisition for Short Pulse Mode:	8-step process
Step 1 - Acquisition AGC Control Established:	0.1 sec after start of transmissions
Step 2 - Coarse Acquisition:	Determine initial two-way range delay by counting to return signal threshold crossing: 0.1 sec
Step 3 - Acquisition Search:	Search with narrow gate ± 3 usec about initial delay. Locate return signal to within ± 200 nsec; 1.0 sec
Step 4 - First Tracking Loop Pull-In:	Lock with long pulse mode tracking gates; 0.1 sec
Step 5 - First Track Lock Indicator:	0.1 sec
Step 6 - Fine Acquisition Search:	Search with narrow gate from leading edge of ramp gate. Locate signal to within ± 12.5 nsec; 1.0 sec
Step 7 - Second Tracking Loop Pull-In:	Lock with short pulse mode tracking gates; 1.0 sec
Step 8 - Second Track Lock Indicator:	0.1 sec
Max Acquisition Time (assuming no miss detections):	2.6 sec

(4) Waveform Sampling System

Long Pulse Mode

Signal to be Sampled:	Square-law detected pulse

Type Sampling:	Integrate and hold
Non-Selectable Sample Gate:	
Configuration and Gate Width:	Noise gate - 200 nsec Ramp gate - 200 nsec Plateau gate - 200 nsec Attitude/Specular gate - 200 nsec
Gate Spacing:	100 nsec
RC Time Constant:	800 nsec
Short Pulse Mode	
Non-Selectable Sample Gate	
Configuration and Gate Width:	Noise gate - 200 nsec Ramp - 12.5 nsec Plateau gate - 12.5 nsec
Gate Spacing:	See Figure 2
RC Time Constant:	4 times gate width
Selectable Waveform	
Sampling System	
Signal to be Sampled:	Square-law detected pulse
Type Sampling:	Point value
Sample Gate Width:	12.5 nsec nominal
Number of Sampling Gates:	0, 8, or 16 depending on GEOS-3 command
Sample Gate Spacing:	6.25 nsec nominal
Reference Signal for Sampling Gates:	Tracking gate signal
Bandwidth of Sampling Channel:	Video 100 MHz min
Sample Gate Outputs:	1. Instantaneous. Value of sample gate power 2. Sample gate power averaged over many successive pulses (2 sec)
RC Time Constant of Instantaneous Sample Gate Outputs:	3.0 nsec
RC Time Constant of Smoothing Filter for Averaged Outputs:	2.0 sec

Built-In Test Calibration System

The major calibrations considered necessary are: time delay (bias), AGC/ gain, and waveform calibration. Internally generated signals are provided for calibration. Each mode has a predetermined calibration cycle which includes a test for each of the above three functions. A time delay (bias) test is performed in each mode to determine the bias to within the required one meter. In each mode, a two-point AGC/gain calibration is obtained using IF reference pulses. For waveform calibration (tracking bias) in the long pulse mode, controlled video waveforms are used which correspond to the expected average return pulse. In the short pulse mode, controlled video waveforms are used which include some wave height effects.

The BIT/CAL subsystem parameters are as follows:

Concept:	Provide internally generated signals for time delay, AGC/gain, and waveform calibration. Calibration test cycle for each mode
Time Delay Calibration:	Both modes
Time Required:	10 sec
Accuracy:	Less than 1 m throughout mission lifetime
AGC/Gain Calibration:	2 cal points each mode
Signal Used:	IF reference pulse
Time Required:	2 seconds for each point (IF1 - 12 sec) (IF2 - 6 sec)
Waveform Calibration:	
Long Pulse Mode Tracking Test Signals Used:	Video waveforms
Time Required:	6 sec for each waveform
Short Pulse Mode Wave Height and Tracking:	
Signals Used:	Video waveforms; two different shapes
Time Required:	2 sec for each waveform

GEOS-3 TELEMETRY AND TIMING

The GEOS-3 spacecraft has no capability to store acquired data; therefore, the telemetry system is used for data retrieval only during real-time passes of GEOS-3 over the various ground telemetry stations. The telemetry system, measurements to be extracted from the telemetry system, and timing considerations are discussed in this section.

General

Data telemetered from GEOS-3 to ground stations are in a PCM format. Data from some experiments are in digital form, such as altitude measured by the altimeter, and system status indicators; however, most of the data originate as analog quantities, and are digitized in the telemetry subsystem. Telemetry bit rate and subsystem timing are controlled by an on-board stable oscillator. Spacecraft timing is provided by the telemetry time code generator (TCG) and the format and frame identification word (FFID), and their relationship to UTC is determined by detecting the time of arrival at the ground of a particular bit in the corresponding telemetry frame. The TCG effectively updates at a rate of about once per two seconds, and does not repeat for more than one year. Altimeter data timing is synchronized with the telemetry format and therefore the timing of altimeter data points is determined to an accuracy of better than ± 600 microseconds.

The telemetry system format is represented as a PCM split-phase bit stream. Two bit-rates are incorporated, a low rate for housekeeping and altimetry data acquisition, and a high rate for housekeeping and concentrated altimetry data acquisition. Each of these telemetry rates are phase-modulated on the spacecraft 136.32 MHz VHF telemetry carrier for reception at the ground VHF telemetry stations operated by both NASA and DoD. In addition both rates are also available for phase-modulation on the 2247 MHz S-band transponder downlink carrier for reception at the STDN S-band sites. Another method of telemetry data retrieval is through the same S-band carrier but, in this case, spacecraft antennas are switched to communicate through the ATS-6 satellite to an ATS earth terminal. Because of signal-to-noise limitations, the low data rate communications is prime in the ATS data relay mode.

The telemetry system operates in various modes and is utilized for both spacecraft housekeeping functions and for altimeter data collection. The two basic altimeter data rates are:

(1) Low Data Rate for altimetry data collection and spacecraft engineering parameters at a telemetry bit rate of 1.56 Kbps.

(2) High Data Rate for high rate altimetry data collection and spacecraft engineering parameters at a telemetry bit rate of 15.6 Kbps.

Table II depicts the nominal parameters of the GEOS-3 telemetry system. Selection of either bit rate does not preclude the selection of any of the altimeter modes.

TABLE II. NOMINAL PARAMETER VALUES FOR GEOS-C TELEMETRY SYSTEM.

PARAMETER	LOW DATA RATE VALUE	HIGH DATA RATE VALUE	UNITS
TRANSMISSION RATE	1,562.42	15,624.2	BITS/SEC
WORD LENGTH	8.	8.	BITS
MINOR FRAME LENGTH	100.	100.	WORDS
MINOR FRAME PERIOD	.5120256	.05120256	SEC
MAJOR FRAME LENGTH	4.	64.	MINOR FRAME
MAJOR FRAME PERIOD	2.048102	3.276964	SEC

Altimeter Data and Sampling Rates

Tables III to V define in detail the parameters and their respective data rates available in each telemetry format. Each parameter in the table is further defined in the following subparagraphs. Finally, Tables VI and VII define the altimeter status (AS) for the short pulse and long pulse modes, respectively.

Instantaneous Return Samples (IRS1-16). - Voltages to monitor the instantaneous value of each of the waveform samples. The samples are positioned in relation to the ramp and plateau tracking gates. For the ideal return pulse and tracking gate positioning shown in Figure 2, time T_0 represents the beginning of the return pulse ramp and the beginning of the ramp tracking gate. Waveform sample 8 always corresponds to the amplitude of the return at the beginning of the ramp tracking gate. Each sample gate is 12.5 nanoseconds in duration and the array of 16 gates provides sample spacing of 6.25 ± 0.5 nanoseconds. The samples represent point values on the square-law detected return signal video pulse and measures, within one percent the amplitude of the pulse at the instant of sample gate shut-off. The specified locations of the gates with respect to the beginning of the ramp tracking gate (referenced as time = T_0) is given below, along with corrections to these locations determined post launch (time in nsec):

Output Signals	Specification	Calibration Correction to Specification
Waveform Sample #1	± 1% Sample of Waveform @ t_0 - 43.75	+ 3.56
Waveform Sample #2	± 1% Sample of Waveform @ t_0 - 37.50	+ 3.50
Waveform Sample #3	± 1% Sample of Waveform @ t_0 - 31.25	- 0.38
Waveform Sample #4	± 1% Sample of Waveform @ t_0 - 25.00	- 0.50
Waveform Sample #5	± 1% Sample of Waveform @ t_0 - 18.75	- 1.06
Waveform Sample #6	± 1% Sample of Waveform @ t_0 - 12.50	- 0.38
Waveform Sample #7	± 1% Sample of Waveform @ t_0 - 6.25	+ 1.13
Waveform Sample #8	± 1% Sample of Waveform @ t_0	- 0.31
Waveform Sample #9	± 1% Sample of Waveform @ t_0 + 6.25	- 1.13
Waveform Sample #10	± 1% Sample of Waveform @ t_0 + 12.50	- 0.50
Waveform Sample #11	± 1% Sample of Waveform @ t_0 + 18.75	- 0.25
Waveform Sample #12	± 1% Sample of Waveform @ t_0 + 25.00	- 0.31
Waveform Sample #13	± 1% Sample of Waveform @ t_0 + 31.25	- 4.06
Waveform Sample #14	± 1% Sample of Waveform @ t_0 + 37.50	+ 0.19
Waveform Sample #15	± 1% Sample of Waveform @ t_0 + 43.75	- 0.06
Waveform Sample #16	± 1% Sample of Waveform @ t_0 + 50.00	+ 0.38

Instantaneous Plateau Gate Energy (IPG). - A voltage to monitor the peak instantaneous value of the sampled plateau gate energy.

TABLE III. ALTIMETER DATA SAMPLING IN TM FORMAT 1 (LOW DATA RATE).

PARAMETER MNEMONIC	PARAMETER DEFINITION	ALTIMETER MODES/SAMPLES PER SECOND (See Note)									
		POWER OFF	AWAKE	LONG PULSE STANDBY	LONG PULSE OPERATE	LONG PULSE TEST/CALIBRATE	SHORT PULSE STANDBY	SHORT PULSE OPERATE 0 WAVEFORMS	SHORT PULSE OPERATE 8 WAVEFORMS	SHORT PULSE OPERATE 16 WAVEFORMS	SHORT PULSE TEST/CALIBRATE
IRS 1,3, ... 15	INSTANTANEOUS RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	0	0
IRS 2,4, ... 16	INSTANTANEOUS RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	0	0	0
IPG	INSTANTANEOUS PLATEAU GATE POWER	0	0	0	10	10	0	10	10	10	10
RSE	RANGE SERVO ERROR VOLTAGE	0	0	0	10	10	0	10	10	10	10
CALT	ALTITUDE (cumulative) (32 bits)	0	0	0	10	10	0	10	10	10	10
AS	ALTIMETER STATUS (8 bits)	10	10	10	10	10	10	10	10	10	10
RAGC	AUTOMATIC GAIN CONTROL VOLTAGE	0	0	10	10	10	10	10	10	10	10
RTP	TRANSMIT POWER MONITOR VOLTAGE	0	0	0	2.0	2.0	0	2.0	2.0	2.0	2.0
ANG	AVERAGE NOISE GATE POWER	0	0	0	2.0	2.0	0	2.0	2.0	2.0	2.0
ARG	AVERAGE RAMP GATE POWER	0	0	0	2.0	2.0	0	2.0	2.0	2.0	2.0
APG	AVERAGE PLATEAU GATE POWER	0	0	0	2.0	2.0	0	2.0	2.0	2.0	2.0
AASG	AVG. ATTITUDE/SPECULAR GATE POWER	0	0	0	2.0	2.0	0	2.0	2.0	2.0	2.0
ARS 1,3, ... 15	AVERAGE RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	0.5	0.5
ARS 2,4, ... 16	AVERAGE RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	0.5	0.5	0.5
VTA	VIDEO TEST SIGNAL AMPLITUDE	0	0	0	0	0.5	0	0	0	0	0.5
RSA	REFERENCE SIGNAL AMPLITUDE	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
IFTA	IF TEST SIGNAL AMPLITUDE	0	0	0	0	0.5	0	0	0	0	0.5
RMI	RECEIVER MIXER CURRENT	0	0	0	0.5	0.5	0	0.5	0.5	0.5	0.5
BCT	BIT/CAL TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RTT	TRANSMITTER TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RRT	RECEIVER TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
GTT	GLOBAL TRACKER TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
ITT	INTENSIVE TRACKER TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
WST	WAVEFORM SAMPLER TEMPERATURE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RAGCHI	HIGH RANGE AGC	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

NOTE: THESE SAMPLE RATES ARE BASED ON A LOW–MAJOR–FRAME DURATION OF 2.0 SECONDS. ACTUAL FRAME RATE WILL BE ABOUT 2.5% LONGER IN DURATION; THEREFORE, THE ACTUAL SAMPLE RATES WILL BE ABOUT 2.5% LESS THAN SHOWN.

TABLE IV. ALTIMETER DATA SAMPLING IN TM FORMAT 2 (HIGH DATA RATE).

PARAMETER MNEMONIC	PARAMETER DEFINITION	ALTIMETER MODES/SAMPLES PER SECOND (See Note)									
		POWER OFF	AWAKE	LONG PULSE STANDBY	LONG PULSE OPERATE	LONG PULSE TEST/CALIBRATE	SHORT PULSE STANDBY	SHORT PULSE OPERATE 0 WAVEFORMS	SHORT PULSE OPERATE 8 WAVEFORMS	SHORT PULSE OPERATE 16 WAVEFORMS	SHORT PULSE TEST/CALIBRATE
IRS 1,3, ... 15	INSTANTANEOUS RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	100	100
IRS 2,4, ... 16	INSTANTANEOUS RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	100	100	100
IPG	INSTANTANEOUS PLATEAU GATE POWER	0	0	0	0	0	0	0	0	0	0
RSE	RANGE SERVO ERROR VOLTAGE	0	0	0	100	100	0	100	100	100	100
CALT	ALTITUDE (cumulative) (32 bits)	0	0	0	10	10	0	10	10	10	10
AS	ALTIMETER STATUS (8 bits)	20	20	20	20	20	20	20	20	20	20
RAGC	AUTOMATIC GAIN CONTROL VOLTAGE	0	0	10	10	10	10	10	10	10	10
RTP	TRANSMIT POWER MONITOR VOLTAGE	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ANG	AVERAGE NOISE GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ARG	AVERAGE RAMP GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
APG	AVERAGE PLATEAU GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
AASG	AVG. ATTITUDE/SPECULAR GATE PWR.	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ARS 1,3, ... 15	AVERAGE RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	0.31	0.31
ARS 2,4, ... 16	AVERAGE RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	0.31	0.31	0.31
VTA	VIDEO TEST SIGNAL AMPLITUDE	0	0	0	0	0.31	0	0	0	0	0.31
RSA	REFERENCE SIGNAL AMPLITUDE	0	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
IFTA	IF TEST SIGNAL AMPLITUDE	0	0	0	0	0.31	0	0	0	0	0.31
RMI	RECEIVER MIXER CURRENT	0	0	0	0.31	0.31	0	0.31	0.31	0.31	0.31
BCT	BIT/CAL TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RTT	TRANSMITTER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RRT	RECEIVER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
GTT	GLOBAL TRACKER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
ITT	INTENSIVE TRACKER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
WST	WAVEFORM SAMPLER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RAGCHI	HIGH RANGE AGC	0	0	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

NOTE: THESE SAMPLE RATES ARE BASED ON A LOW–MAJOR–FRAME DURATION OF 2.0 SECONDS. ACTUAL FRAME RATE WILL BE ABOUT 2.5% LONGER IN DURATION; THEREFORE, THE ACTUAL SAMPLE RATES WILL BE ABOUT 2.5% LESS THAN SHOWN.

TABLE V. ALTIMETER DATA SAMPLING IN TM FORMAT 3 (HIGH DATA RATE).

PARAMETER MNEMONICS	PARAMETER DEFINITION	ALTIMETER MODES/SAMPLES PER SECOND (See Note)									
		POWER OFF	AWAKE	LONG PULSE STANDBY	LONG PULSE OPERATE	LONG PULSE TEST/CALIBRATE	SHORT PULSE STANDBY	SHORT PULSE OPERATE 0 WAVEFORMS	SHORT PULSE OPERATE 8 WAVEFORMS	SHORT PULSE OPERATE 16 WAVEFORMS	SHORT PULSE TEST/CALIBRATE
IRS 1,3, ... 15	INSTANTANEOUS RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	0	0
IRS 2,4, ... 16	INSTANTANEOUS RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	100	100	100
IPG	INSTANTANEOUS PLATEAU GATE POWER	0	0	0	100	100	0	100	100	100	100
RSE	RANGE SERVO ERROR VOLTAGE	0	0	0	100	100	0	100	100	100	100
ALT	ALTITUDE (instantaneous) (32 bits)	0	0	0	100	100	0	100	100	100	100
AS	ALTIMETER STATUS (8 bits)	20	20	20	20	20	20	20	20	20	20
RAGC	AUTOMATIC GAIN CONTROL VOLTAGE	0	0	10	10	10	10	10	10	10	10
RTP	TRANSMIT POWER MONITOR VOLTAGE	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ANG	AVERAGE NOISE GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ARG	AVERAGE RAMP GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
APG	AVERAGE PLATEAU GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
AASG	AVG. ATTITUDE/SPECULAR GATE POWER	0	0	0	2.5	2.5	0	2.5	2.5	2.5	2.5
ARS 1,3, ... 15	AVERAGE RETURN SAMPLES 1,3,5,7,9,11,13,15	0	0	0	0	0	0	0	0	0.31	0.31
ARS 2,4, ... 16	AVERAGE RETURN SAMPLES 2,4,6,8,10,12,14,16	0	0	0	0	0	0	0	0.31	0.31	0.31
VTA	VIDEO TEST SIGNAL AMPLITUDE	0	0	0	0	0.31	0	0	0	0	0.31
RSA	REFERENCE SIGNAL AMPLITUDE	0	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
IFTA	IF TEST SIGNAL AMPLITUDE	0	0	0	0	0.31	0	0	0	0	0.31
RMI	RECEIVER MIXER CURRENT	0	0	0	0.31	0.31	0	0.31	0.31	0.31	0.31
BCT	BIT/CAL TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RTT	TRANSMITTER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RRT	RECEIVER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
GTT	GLOBAL TRACKER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
ITT	INTENSIVE TRACKER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
WST	WAVEFORM SAMPLER TEMPERATURE	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
RAGCHI	HIGH RANGE AGC	0	0	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

NOTE: THESE SAMPLE RATES ARE BASED ON A LOW–MAJOR–FRAME DURATION OF 2.0 SECONDS. ACTUAL FRAME RATE WILL BE ABOUT 2.5% LONGER IN DURATION; THEREFORE, THE ACTUAL SAMPLE RATES WILL BE ABOUT 2.5% LESS THAN SHOWN.

TABLE VI. VALID ALTIMETER STATUS WORD FORMULATIONS - SHORT PULSE MODE.

ALTIMETER STATUS WORD (AS)			TRACKER REGIME (SEE NOTE)	FUNCTION	NUMBER OF ACTIVE WAVEFORM SAMPLERS	MODE
DECIMAL	OCTAL	BINARY				
003	003	0000 0011	PD	VIDEO TEST NO. 1	16	SHORT PULSE
007	007	0000 0111	CS			
011	013	0000 1011	FS			
015	017	0000 1111	AT			
019	023	0001 0011	PD	VIDEO TEST NO. 2	16	
023	027	0001 0111	CS			
027	033	0001 1011	FS			
031	037	0001 1111	AT			
035	043	0010 0011	PD	IF TEST NO. 1	16	
039	047	0010 0111	CS			
043	053	0010 1011	FS			
047	057	0010 1111	AT			
051	063	0011 0011	PD	IF TEST NO. 2	16	
055	067	0011 0111	CS			
059	073	0011 1011	FS			
063	077	0011 1111	AT			
064	100	0100 0000	PD	OPERATE	0	
068	104	0100 0100	CS			
072	110	0100 1000	FS			
076	114	0100 1100	AT			
066	102	0100 0010	PD	OPERATE	8	
070	106	0100 0110	CS			
074	112	0100 1010	FS			
078	116	0100 1110	AT			
067	103	0100 0011	PD	OPERATE	16	
071	107	0100 0111	CS			
075	113	0100 1011	FS			
079	117	0100 1111	AT			
084	124	0101 0100	––	WARM–UP	0	
092	134	0101 1100	––	STAND–BY		
094	136	0101 1110	––	TRANSITION (TYPE 1)		
095	137	0101 1111	––	TRANSITION (TYPE 2)		
099	143	0110 0011	PD	BIAS TEST	16	
103	147	0110 0111	CS			
107	153	0110 1011	FS			
111	157	0110 1111	AT			
115	163	0111 0011	––	INITIAL TEST PREPS	16	
119	167	0111 0111	––	FINAL TEST PREPS		
123	173	0111 1011	––	TEST TERMINATION		
124	174	0111 1100	––	––	0	ALERT

NOTE – THE FOLLOWING ABBREVIATIONS ARE USED TO IDENTIFY TRACKER REGIMES:
PD –– PEAK DETECTION PHASE OF ACQUISITION
CS –– COARSE SWEEP PHASE OF ACQUISITION
FS –– FINE SWEEP PHASE OF ACQUISITION
AT –– AUTOMATIC TRACKING

TABLE VII. VALID ALTIMETER STATUS WORD FORMULATIONS - LONG PULSE MODE.

ALTIMETER STATUS WORD (AS) DECIMAL	OCTAL	BINARY		TRACKER REGIME (SEE NOTE)	FUNCTION	NUMBER OF ACTIVE WAVEFORM SAMPLERS	MODE
128	200	1000	0000	PD	VIDEO TEST NO. 1	0	LONG PULSE
132	204	1000	0100	CS			
140	214	1000	1100	AT			
144	220	1001	0000	PD	VIDEO TEST NO. 2	0	
148	224	1001	0100	CS			
156	234	1001	1100	AT			
160	240	1010	0000	PD	IF TEST NO. 1	0	
164	244	1010	0100	CS			
172	254	1010	1100	AT			
176	260	1011	0000	PD	IF TEST NO. 2	0	
180	264	1011	0100	CS			
188	274	1011	1100	AT			
192	300	1100	0000	PD	OPERATE	0	
196	304	1100	0100	CS			
204	314	1100	1100	AT			
212	324	1101	0100	——	WARM—UP	0	
220	334	1101	1100	——	STAND—BY		
224	340	1110	0000	PD	BIAS TEST	0	
228	344	1110	0100	CS			
236	354	1110	1100	AT			
240	360	1111	0000	——	INITIAL TEST PREPS		
244	364	1111	0100	——	FINAL TEST PREP	0	
248	370	1111	1000	——	TEST TERMINATION		
255	377	1111	1111	——	——	0	OFF

NOTE – THE FOLLOWING ABBREVIATIONS ARE USED TO IDENTIFY TRACKER REGIMES:

PD —— PEAK DETECTION PHASE OF ACQUISITION

CS —— COARSE SWEEP PHASE OF ACQUISITION

AT —— AUTOMATIC TRACKING

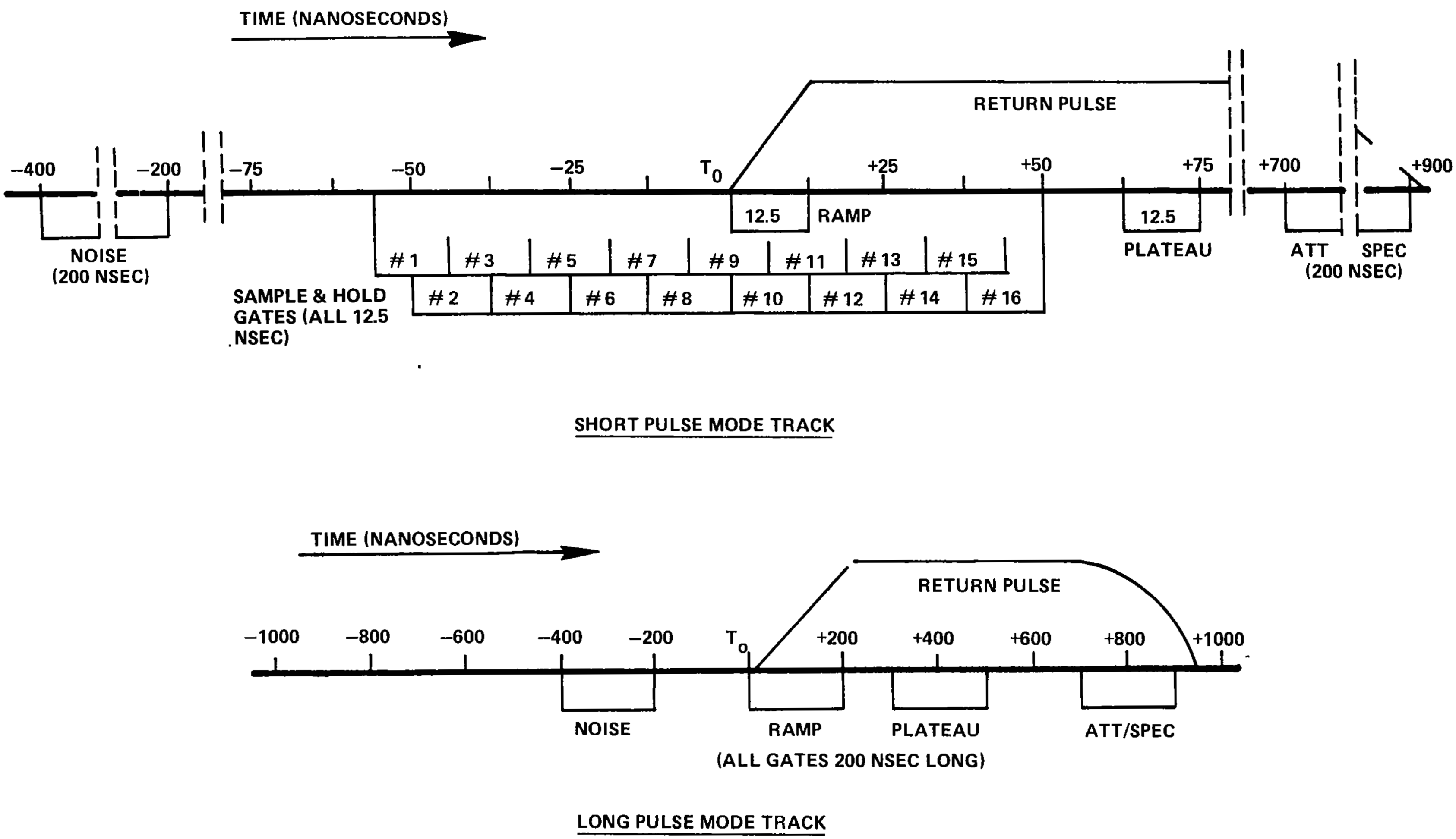

Figure 2. Sampling gate timing and positioning.

Range Servo Error (RSE). - A voltage to monitor the tracking loop error.

Altitude Output (CALT/ALT). - A digital 32-bit word presenting the two-way time delay between time of transmit and time of receipt of a pulse. CALT represents the average measurement over ten transmitted pulses and is available in TM Mode 1 and 2. In Mode 3 telemetry, ALT represents a measurement for each transmitted pulse.

Status Words (AS). - An eight-bit binary word representing the operating mode and state of the altimeter.

Receive Signal Level (RAGC). - An analog voltage proportional to input signal level. This voltage has a stable correspondence to the average received power level within ± 0.5 dB.

Transmit Power (RTP). - An analog voltage proportional to peak output power. This voltage has a stable correspondence to peak output power within ± 1 dB.

Average Video Noise Power (ANG). - A voltage to monitor average noise gate energy. Averaging time is one second.

Average Ramp Gate Energy (ARG). - A voltage to monitor the average value of the return pulse leading edge (ramp). Averaging time is one second.

Average Plateau Gate Energy (APG). - A voltage to monitor the average peak value of the sampled plateau. Averaging time is one second.

Average Attitude/Specular Gate Energy (AASG). - A voltage to monitor average Attitude/Specular Gate Energy. Averaging time is one second.

Average Return Samples (ARS1-16). - Voltages to monitor the average value of the instantaneous waveform samples. Averaging time is two seconds.

Video Test Signal Amplitude (VTA). - A voltage to indicate the presence or absence of the video test signals in the BIT/CAL mode of operation. Not to be used quantitatively.

Reference Signal Amplitude (RSA). - A voltage to indicate the presence of the altimeter 5 MHz reference clock input. Not to be used quantitatively.

IF Test Signal Amplitude (IFTA). - A voltage to indicate the presence or absence of the BIT/CAL 300 MHz input to the receiver. It can be used as a quantitative measurement of the IF Test Signal.

Receiver Mixer Current Monitor (RMI). - A voltage to monitor operation of the down-converter mixer. This will be proportional to the crystal current.

BIT/CAL Temperature (BCT). - Temperature monitored in BIT/CAL module. It is used to further calibrate altimetry data in BIT/CAL.

Transmitter Temperature (RTT). - Temperature monitored in transmitter module. It is used to calibrate the radar transmitter power (RTP).

Receiver Temperature (RRT). - Temperature monitored in the radar receiver module. It is used to further calibrate the RAGC data.

Global Tracker Temperature (GTT). - Temperature monitored in the global tracker portion of the receiver. It is used to calibrate the following gates: ANG, ARG, APG, AASG, and IPG when the long pulse mode is selected, and ANG and AASG when the short pulse mode is selected.

Intensive Tracker Temperature (ITT). - Temperature monitored in the intensive tracker portion of the receiver. It is used to calibrate the following gates: ARG, APG, and IPG when the short pulse mode is selected.

Waveform Sampler Temperature (WST). - Temperature monitored in the waveform sampler module. It is used to further calibrate the IRS and ARS data.

GEOS-3 Timing System

The GEOS-3 timing system and associated ground processing provides spacecraft time correlation to an accuracy of ± 600 microseconds with respect to UTC. Knowledge of spacecraft time to this accuracy is required for precise time labelling of the radar altimeter data. In the spacecraft, both the altimeter and telemetry systems are coherently driven by an ultra-stable 5 MHz oscillator. Precise detection and processing of telemetry time data establishes the time base required in altimeter data processing.

The time of arrival of a selected bit in the GEOS-3 telemetry synchronization pattern is detected at the NASA Spaceflight Tracking and Data Network (STDN). This raw timing data is transmitted to the GEOS-3 Operations Control Center (GOCC) located at NASA Goddard Space Flight Center where it is processed to account for system and propagation delays. After processing, a report is sent to Wallops Flight Center (the Radar Altimeter Data Preprocessing Facility) containing the resultant UTC/GEOS-3 telemetry relationships.

STDN Operations. - Time detection passes were scheduled at the STDN nominally three time per day early in the GEOS-3 mission. In the early lifetime, the GEOS-3 oscillator exhibited a relatively fast drift rate ($> 1 \times 10^{-9}$ per day) and then settled down to a rate of less than one part in 10^{10} per day. The oscillator drift stabilized after about ten days in the space environment and, at that time, the time detection passes at the STDN were dropped to about one per day.

The scheduled STDN station detects the time of arrival of a selected bit in the telemetry synchronization pattern with respect to station time. This is done at a rate of every other frame in the GEOS-3 low data rate and every 20th frame in the high data rate. A nominal ten-minute pass yields about 600 data points. A data point is defined as:

(1) Station day, hours, minute, second.

(2) Microsecond count from (1) to detected frame sync.

(3) TCG number of the detected frame. The TGC (Time Code Generator) is a 24 bit word which updates one binary each major frame (four minor frames) in the low-bit rate.

(4) FFID of the detected frame. The FFID is the minor frame counter and format identifier.

The combination of (3) and (4) above uniquely identifies the detected minor frame for whichever bit rate is used at the time. The data point, then, establishes the station time for the detected minor frame. In addition to the data points described, the station raw data includes the measured ground system delays taken immediately before and after the time detection operation.

GOCC Processing. - GOCC receives the above raw data post-pass for off-line processing. The following factors are applied to each data point to establish time at the spacecraft:

(1) Spacecraft System Delay. A constant measured before launch which is subtracted from each raw time.

(2) Propagation Delay. A variable which is derived from station to spacecraft predicted slant ranges (second by second) and subtracted from corresponding raw times.

(3) Ground System Delay. A constant for the pass being reduced which is derived by taking the average of the reported pre- and post-operation calibration and subtracting it from each raw time.

After the data are processed in GOCC, a time report is teletyped to the Wallops GEOS-3 Data Processing Facility. The report identifies the start time of a given GEOS-3 major frame. These precise times reported day by day are then used in altimeter data processing to time all major frames of data using linear interpolation to time frames falling between the reported times.

Timing Network Schematic. - Figure 3 is a schematic of the timing network for GEOS-3. It shows that the altimeter reference frequency is nominally 4999750 Hz with an altimeter repetition rate of 97.65 Hz. The Major Frame Counter, a 24-bit register, constitutes the Time Code Generator word that is telemetered and allows unambiguous identification (except for ambiguities at intervals of about 398 days) of each and every GEOS-3 major frame of data.

Telemetry Station Locations

The GEOS-3 project utilized four sources of telemetry data to acquire the total altimeter data set. These sources were the NASA STDN VHF telemetry sites, portable DoD VHF facilities positioned at various locations, the NASA STDN S-band telemetry sites, and the NASA ATS-6 satellite telemetry data relay link.

Table VIII summarizes the total data passes and operational dates of each of the NASA telemetry acquisition facilities. Table IX summarizes data obtained through the DoD sites. Figure 4 is a world map showing the total array of sites used to acquire GEOS-3 altimeter data.

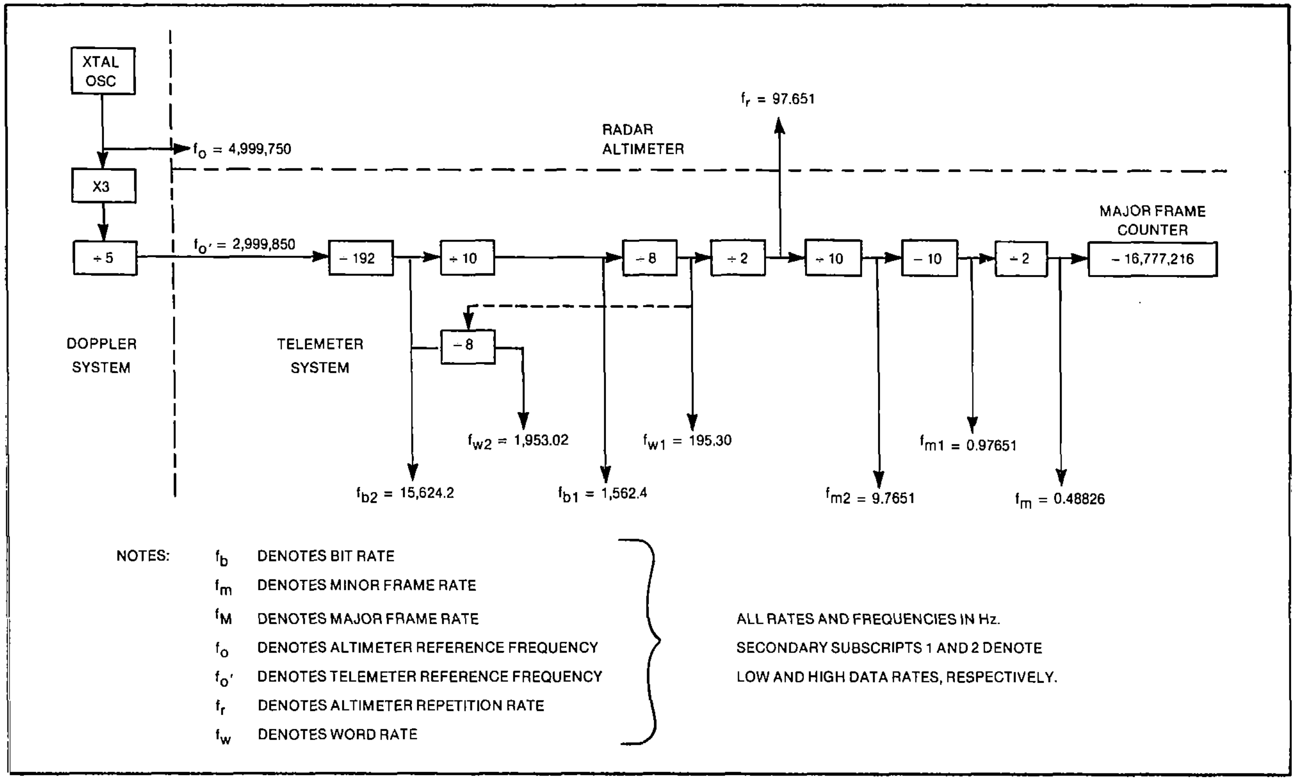

Figure 3. GEOS-3 timing network.

TABLE VIII. NASA TELEMETRY STATIONS

Station	Total Number of Good Passes	Operational Date Start	Stop
Merritt Island, Florida (MIL)	1181	April 10, 1975	Dec. 1, 1978
Rosman, North Carolina (ROS)	641	April 10, 1975	Dec. 1, 1978
Winkfield, United Kingdom (WNK)	1221	April 10, 1975	Dec. 1, 1978
Bermuda Islands (BDA)	398	April 10, 1975	Dec. 1, 1978
Madrid, Spain (MAD)	122	April 10, 1975	Dec. 1, 1978
Ascension (ACN)	457	April 10, 1975	Dec. 1, 1978
Johannesburg (BUR)	118	April 10, 1975	Oct. 31, 1975
Guam (GWM)	410	April 10, 1975	Dec. 1, 1978
Orroral, Australia (ORR)	482	April 10, 1975	Dec. 1, 1978
Hawaii (HAW)	706	April 10, 1975	Dec. 1, 1978
Fairbanks, Alaska (ULA)	1051	April 10, 1975	Dec. 1, 1978
Goldstone, California (GDS)	486	April 10, 1975	Dec. 1, 1978
Quito, Ecuador (QUI)	383	April 10, 1975	Dec. 1, 1978
Santiago, Chile (AGO)	395	April 10, 1975	Dec. 1, 1978
Tananarive, Madagascar (TAN)	12	April 10, 1975	July 11, 1975
Mahe, Seychelles (MAH)	79	March 1, 1976	May 9, 1976
Rosman (via ATS-6 94° West)	78	April 10, 1975	June 12, 1975
Rosman (via ATS-6 140° West)	347	Sept. 3, 1976	Dec. 1, 1978
Madrid, Spain (via ATS-6 34° East)	34	May 26, 1975	Oct. 22, 1976

TABLE IX. DEFENSE MAPPING AGENCY TELEMETRY STATIONS

Station	Total Number of Good Passes	Operational Dates Start	Stop
Herndon, Virginia (HER)		April 20, 1975	July 1, 1975
Perth, Australia (AUS)	82	July 14, 1975	Aug. 17, 1975
Tafuna, Samoa (TAF)	120	Aug. 12, 1975	Nov. 30, 1975
Shemya, Alaska (SHM)	234	Aug. 18, 1975	Dec. 6, 1975
Napier, New Zealand (NEZ)	89	Aug. 29, 1975	Oct. 24, 1975
Easter Island (EAS)	222	Nov. 8, 1975	Feb. 1, 1976
Baja, Mexico (BAJ)	137	Dec. 12, 1975	Feb. 1, 1976
Kerguelen Island (KEG)	137	March 2, 1976	May 16, 1976
Cocos Islands (COC)	113	March 13, 1976	May 26, 1976
Falkland Islands (FLK)	165	April 21, 1976	June 20, 1976
Canary Islands (CYI)	128	July 4, 1976	Sept. 7, 1976
Natal, Brazil (NAT)	63	July 14, 1976	Nov. 15, 1976
Tristan Da Cunha (TDK)	32	Aug. 3, 1976	Oct. 14, 1976
Caribou, Maine (CAR)	546	Sept. 6, 1976	Dec. 11, 1976
Kwajalein (KWA)	37	Jan. 16, 1977	April 17, 1977
Seattle, Washington (SEA)	166	Jan. 18, 1977	April 3, 1977
Rangiroa, Tahiti (TAH)	73	Jan. 22, 1977	Feb. 23, 1977
Townsville, Australia (TOW)	72	March 16, 1977	July 20, 1977
Cyprus (CYP)	161	April 18, 1977	July 22, 1977
Mahe, Seychelles (MAH)	101	Aug. 10, 1977	Nov. 13, 1977
Salalah, Oman (SAL)	233	Aug. 15, 1977	Nov. 25, 1977
Pretoria, South Africa (PRE)	205	Aug. 27, 1977	Nov. 30, 1977
Adak Island, Alaska (ADA)	99	Jan. 20, 1978	March 26, 1978
Kourou, French Guiana (KOU)	62	May 5, 1978	June 20, 1978
Pepeeta, Tahiti (TAH)	9	Dec. 16, 1977	Jan. 20, 1978
Pinang, Malaysia (MAL)	32	May 8, 1978	July 2, 1978
Okinawa (OKI)	48	May 2, 1977	July 24, 1977

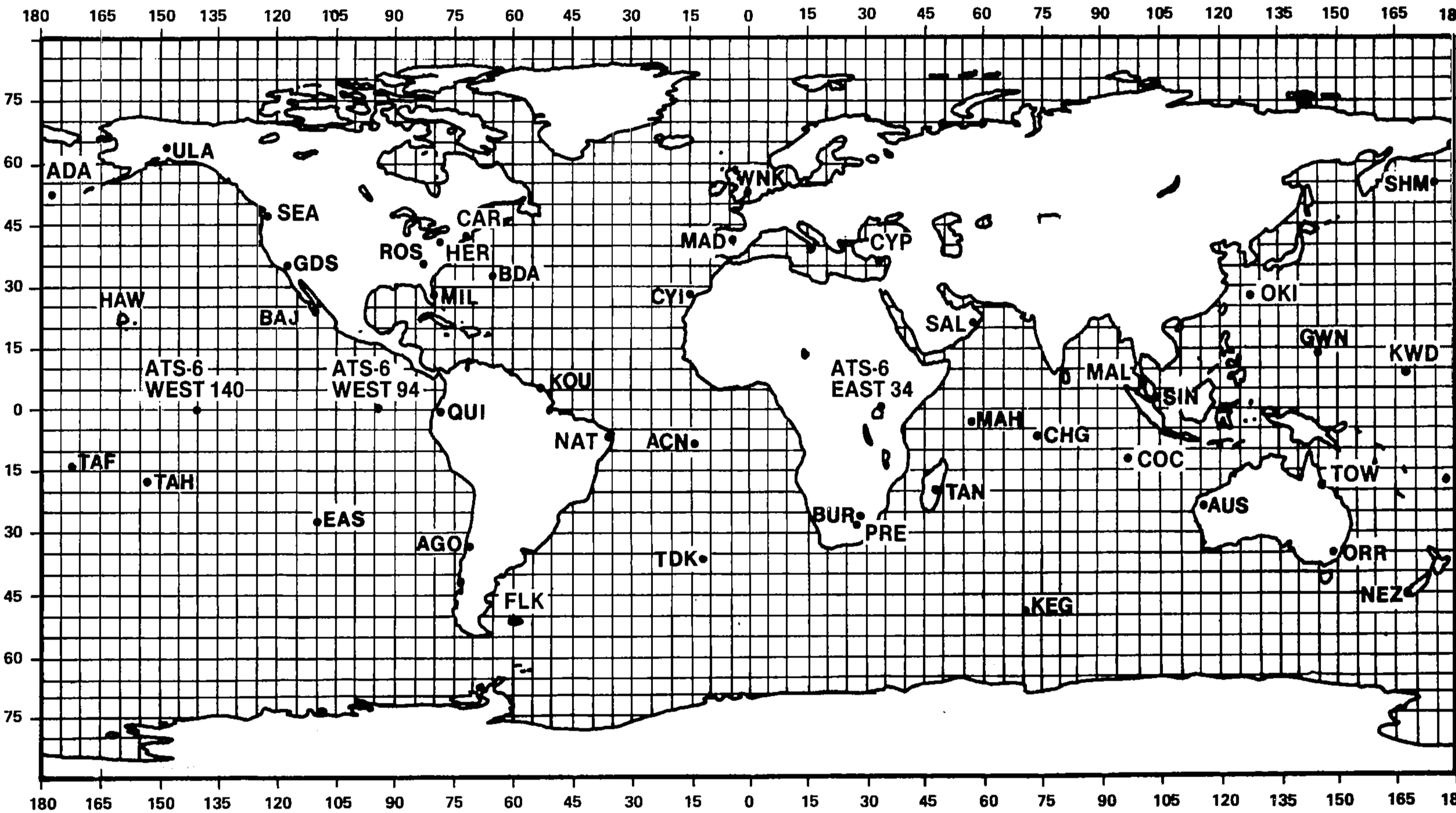

Figure 4. GEOS-3 Telemetry Coverage.

DATA FLOW

Figure 5 displays the flow of raw telemetry data employed during the GEOS-3 mission. Data acquired at the NASA STDN sites (including ROSMAN and Madrid ATS-6 stations) were routed to the NASA Wallops telemetry station either in real-time using data communications, or analog tapes were recorded at the sites and then mailed to Wallops. At the Wallops telemetry station, the data (either real-time or on analog tapes) were digitized to provide a computer compatible tape for further processing in the altimeter data reduction programs. In the case of data acquired at the DoD telemetry sites, these data were digitized by DoD and made available for processing at Wallops in the same altimeter data reduction programs.

Figure 6 displays data handling through the altimeter data processing programs at Wallops. The major steps in the data flow are as follows:

(1) TELEVENT PROGRAM. Digitizes raw telemetry data.

(2) CALIMERGE. Computes time-tag, applies calibration corrections, and time-merges the data.

(3) GAP(GEOS ALTIMETER PREPROCESSOR). Applies further calibration refinements and computes the mean and standard deviations of selected measurements.

(4) ARC(ALTIMETER RESIDUAL COMPUTATION). Computes altimeter residuals, verifies data quality, and plots residuals.

(5) CALTOR. Converts data to user format used in original data distribution.

(6) CORRECTALL. Takes formatted data of original distribution, applies further corrections and algorithms and produces formatted data for final distribution.

The TELEVENT Program utilized an EMR-6130 computer for data digitizing. CALIMERGE through CALTOR was run on an HW-625 computer and CORRECTALL utilized a Data General S200/C300 computer. Additional explanation of each of these processing steps is given in the following sections.

THE TELEVENT PROGRAM

The PCM telemetry data is received in either of two modes: analog tape or land line. The analog tape is mailed directly to the telemetry facility at Building N-162 at Wallops Flight Center. If the data is transmitted via land line, it is recorded on an analog tape using the EMR-6130 computer at Building N-162. The data is then digitized using the EMR-6130 computer.

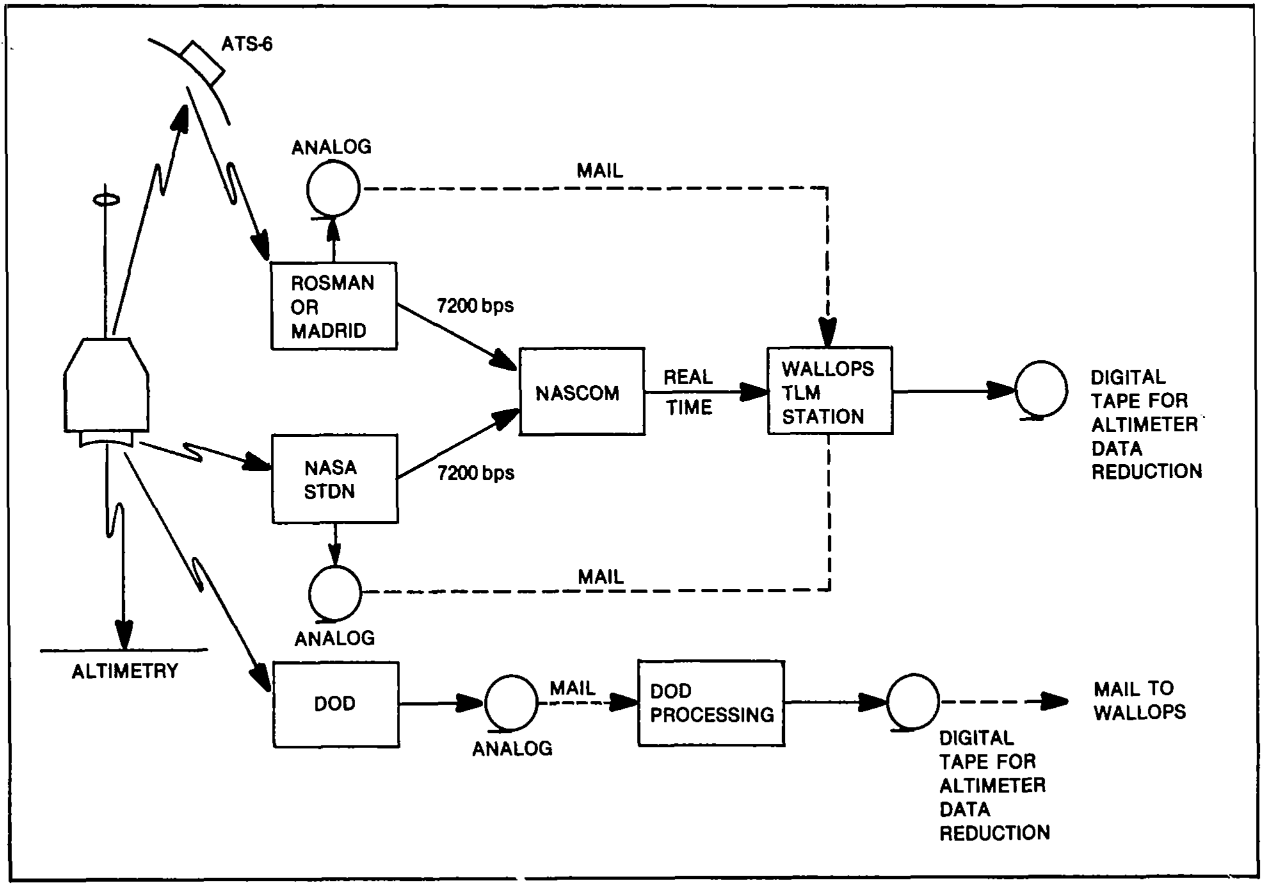

Figure 5. GEOS-3 data flow.

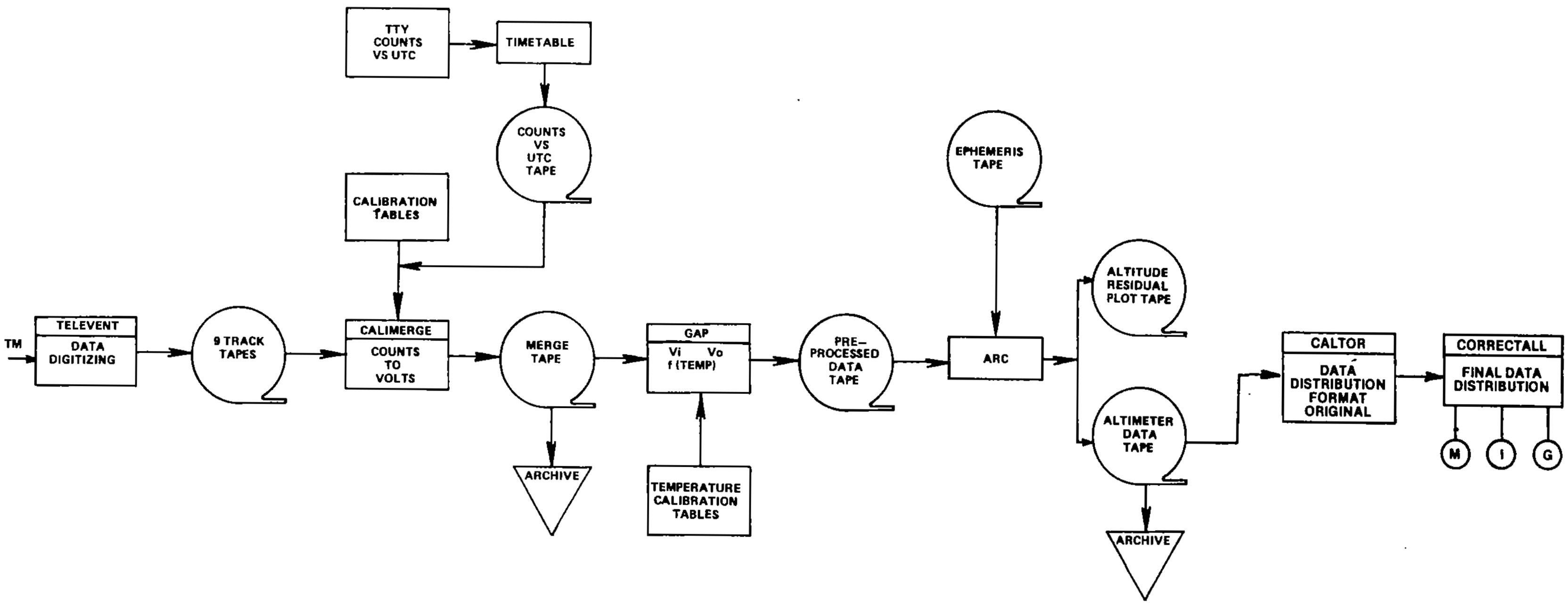

Figure 6. Altimeter data system.

Input

A card deck. The deck which defines the Executive program to be run on the data is required as well as data cards which define the parameters of the telemetry bit stream (e.g., type TM, channels to be digitized, etc.). This deck is mandatory.

Analog data tape. As received from the STDN stations or produced from real-time communications.

Output

Two kinds of output are provided by the Televent Program. They are:

(1) A Digitized Tape. The tape is a nine-track tape, recorded at 800 BPI with odd parity and the word length is 16 bits. Each GEOS-3 telemetry data word (eight bits) is right justified, preceded with eight leading zeroes. Five minor frames are packed per record.

(2) Listing. A list of the first and last values of the time code generator (TCG) printed along with the number of loss of syncs which occurred during processing.

ALTIMETER DATA CALIBRATION AND MERGING - THE CALIMERGE PROGRAM

The CALIMERGE Program is designed to sequence input tapes which have been digitized by the EMR-6130 or as received from DoD. In addition, it will convert altimeter and altimeter related data to functional and/or engineering units, convert TCG counts to UTC time, and perform miscellaneous checks on the quality of the TM data bit stream. The details of the program are described under the headings of Input, Computation, and Output.

Input

Three kinds of input are required by the CALIMERGE Program. They are:

(1) Digitized Data Tapes for Sequencing. These tapes are the nine-track digital magnetic tapes generated by the EMR-6130 computer system or as received from DoD. The format of the tapes is as output by the Televent program. Basically, the eight-bit TM word is placed in a 16-bit word right justified and the three sync words in the TM minor frame format are not used.

(2) UTC/TCG Time Tape. This seven-track tape has the format as written by the TIMTABL program. Parameters included in the format are TCG counts, UTC time (HR-MIN-SEC), number of samples, number of samples used to determine mean time value, and standard deviation of mean time value.

(3) Option Cards. These user-supplied cards instruct the program what to do. Parameters included on input cards are ID, oscillator offset, date of experiment, number of tapes being merged, options for printing the output data, and start and stop TGC numbers for the data tapes being merged, and tape file to operate on.

Computation

Since more than one telemetry station may support a given altimetry mission, a capability to merge data from multiple input tapes is provided. Scale factors and calibration tables used to convert telemetry data from counts to engineering units are presented in Tables X to XII.

A timing header record is written as the first record on tape. The information in this record is sufficient to time tag all data in the data record. All output data buffers are filled with the number -9999 for both fixed point and floating point variables, respectively. In cases where missing frames are encountered, resultant data will contain the nine code for all parameters except AS, which will be set to zero.

The four, eight-bit words that make up the 32 bit CALT and ALT altitude words are each encoded such that the bits of each eight bit word must be reversed prior to forming the 32 bit altitude word. Therefore, the bits are reversed prior to conversion to nanoseconds. The following algorithm is used to convert the two-way range in counts to meters.

$$A_m = \frac{\text{counts}}{2} \quad (SF) \quad (C)$$

where: A_m - measured altitude in meters,
counts - CALT or ALT bits reversed,
SF - scale factor for CALT or ALT in Table X, and
C - velocity of light, 2.997925×10^8 m/sec.

Time is converted from TCG counts to UTC using the calibration time information provided by GSFC via TTY and input to CALIMERGE via the UTC/TCG time tape. A linear interpolation technique is employed to arrive at the UTC frame time using the TCG counts as the independent variable. Minor frames are read and data is converted until four minor frames in the low data rate or 64 minor frames in the high data rate are read. At this

TABLE X. TABLE OF SCALE FACTORS.

PARAMETER		
ALT	$\frac{1}{4\,(160 \times 10^6)\,(1-f \times 10^{-6})} = 1.56257813$ nsec/count	where f is nominally set at 50 Hz
CALT	$\frac{1}{40\,(160 \times 10^6)\,(1-f \times 10^{-6})} = .156257813$ nsec/count	
ARS1	.03245 v/count	
ARS2	.03251 v	
ARS3	.03260 v	
ARS4	.03238 v	
ARS5	.03255 v	
ARS6	.03248 v	
ARS7	.03246 v	
ARS8	.03233 v	
ARS9	.03255 v	
ARS10	.03251 v	
ARS11	.03239 v	
ARS12	.03263 v	
ARS13	.03221 v	
ARS14	.03254 v	
ARS15	.03245 v	
ARS16	.03240 v	
RSE	Counts (.032025) – 4.0844375 v	
RAGC	.03288 v	
IPG	Counts (.032025) – 4.0844375 v	
RTP	.03250 v	
ANG	.03261 v	
ARG	.03247 v	
APG	.03233 v	
AASG	.03250 v	
BCT	Table GE0052	
RTT	Table GE0052	
RRT	Table GE0052	
GTT	Table GE0052	
ITT	Table GE0052	
WST	Table GE0052	
IFTA	.03248 v	
RSA	.03252 v	
VTA	.03257 v	
RMI	Table GE 0210	
IRS(i)	Counts (.032025) – 4.0844375 v i = 1,16	
RAGCHI	.07467 v	

TABLE XI. TEMPERATURE CONVERSION TABLE.

TABLE NAME IS GE0052

120	•	71.9	72.7	73.5	74.3	75.1	76.0	76.9	77.8		
110	•	64.8	65.5	66.2	66.8	67.5	68.2	68.9	69.6	70.4	71.1
100	•	58.9	59.4	60.0	60.6	61.2	61.8	62.3	62.9	63.6	64.2
90	•	53.7	54.2	54.7	55.2	55.7	56.2	56.8	57.3	57.8	58.3
80	•	49.2	49.6	50.0	50.5	50.9	51.4	51.8	52.3	52.8	53.3
70	•	45.0	45.4	45.8	46.3	46.7	47.0	47.5	47.9	48.3	48.7
60	•	41.2	41.6	42.0	42.3	42.7	43.1	43.5	43.9	44.3	44.7
50	•	37.7	38.0	38.4	38.7	39.1	39.4	39.8	40.1	40.5	40.9
40	•	34.4	34.7	35.0	35.3	35.7	36.0	36.3	36.7	37.0	37.3
30	•	31.2	31.5	31.8	32.1	32.4	32.8	33.1	33.4	33.7	34.0
20	•	28.2	28.5	28.8	29.1	29.4	29.7	30.0	30.3	30.6	30.9
10	•	25.3	25.6	25.9	26.2	26.5	26.8	27.0	27.3	27.6	27.9
0	•	22.5	22.8	23.1	23.3	23.6	23.9	24.2	24.5	24.7	25.0
	•				(UNITS ARE DC)						

* *

CTS	0	1	2	3	4	5	6	7	8	9
CTS	0	–1	–2	–3	–4	–5	–6	–7	–8	–9

* *

					(UNITS ARE DC)						
0	•	22.5	22.2	22.0	21.7	21.4	21.1	20.9	20.6	20.3	20.0
– 10	•	19.8	19.5	19.2	19.0	18.7	18.4	18.1	17.9	17.6	17.4
– 20	•	17.1	16.8	16.6	16.3	16.0	15.8	15.5	15.2	15.0	14.7
– 30	•	14.4	14.2	13.9	13.6	13.4	13.1	12.8	12.6	12.3	12.1
– 40	•	11.8	11.5	11.3	11.0	10.7	10.5	10.2	10.0	9.7	9.4
– 50	•	9.2	8.9	8.6	8.4	8.1	7.9	7.6	7.3	7.1	6.8
– 60	•	6.6	6.3	6.0	5.8	5.5	5.2	4.9	4.7	4.4	4.1
– 70	•	3.9	3.6	3.3	3.1	2.8	2.5	2.3	2.0	1.7	1.4
– 80	•	1.1	0.9	0.6	0.3	0.0	–0.3	–0.5	–0.8	–1.1	–1.4
– 90	•	–1.7	–2.0	–2.2	–2.5	–2.8	–3.1	–3.4	–3.7	–4.0	–4.3
–100	•	–4.6	–4.9	–5.2	–5.5	–5.8	–6.1	–6.4	–6.7	–7.0	–7.2
–110	•	–7.5	–7.8	–8.1	–8.5	–8.8	–9.1	–9.4	–9.8	–10.1	–10.4
–120	•	–10.8	–11.1	–11.4	–11.8	–12.1	–12.5	–12.8	–13.2		

TABLE XII. RMI CONVERSION TABLE.

TABLE NAME IS GE0210

120	*	49.0	49.2	49.4	49.6	49.8	50.0	50.2	50.4		
110	•	47.0	47.2	47.4	47.6	47.8	48.0	48.2	48.4	48.6	48.8
100	•	45.0	45.2	45.4	45.6	45.8	46.0	46.2	46.4	46.6	46.8
90	•	43.0	43.2	43.4	43.6	43.8	44.0	44.2	44.4	44.6	44.8
80	•	41.0	41.2	41.4	41.6	41.8	42.0	42.2	42.4	42.6	42.8
70	•	39.0	39.2	39.4	39.6	39.8	40.0	40.2	40.4	40.6	40.8
60	•	37.0	37.2	37.4	37.6	37.8	38.0	38.2	38.4	38.6	38.8
50	•	35.0	35.2	35.4	35.6	35.8	36.0	36.2	36.4	36.6	36.8
40	•	33.0	33.2	33.4	33.6	33.8	34.0	34.2	34.4	34.6	34.8
30	•	31.0	31.2	31.4	31.6	31.8	32.0	32.2	32.4	32.6	32.8
20	•	29.0	29.2	29.4	29.6	29.8	30.0	30.2	30.4	30.6	30.8
10	•	27.0	27.2	27.4	27.6	27.8	28.0	28.2	28.4	28.6	28.8
0	*	25.0	25.2	25.4	25.6	25.8	26.0	26.2	26.4	26.6	26.8
	*				(UNITS ARE MV)						
CTS		0	1	2	3	4	5	6	7	8	9
CTS		0	–1	–2	–3	–4	–5	–6	–7	–8	–9
					(UNITS ARE MV)						
0	•	25.0	24.8	24.6	24.4	24.2	24.0	23.8	23.6	23.4	23.2
– 10	•	23.0	22.8	22.6	22.4	22.2	22.0	21.8	21.6	21.4	21.2
– 20	*	21.0	20.8	20.6	20.4	20.2	20.0	19.8	19.6	19.4	19.2
– 30	•	19.0	18.8	18.6	18.4	18.2	18.0	17.8	17.6	17.4	17.2
– 40	*	17.0	16.8	16.6	16.4	16.2	16.0	15.8	15.6	15.4	15.2
– 50	•	15.0	14.8	14.6	14.4	14.2	14.0	13.8	13.6	13.4	13.2
– 60	*	13.0	12.8	12.6	12.4	12.2	12.0	11.8	11.6	11.4	11.2
– 70	•	11.0	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.4	9.2
– 80	•	9.0	8.8	8.6	8.4	8.2	8.0	7.8	7.6	7.4	7.2
– 90	*	7.0	6.8	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.2
–100	*	5.0	4.8	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2
–110	•	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2
–120	•	1.0	0.8	0.6	0.4	0.2	– 0.0	– 0.2	– 0.4		

time, the entire major frame is written on the output tape. Finally quality control checks such as column parity (CP) monitoring, frame sequence (FFID) monitoring and TCG monitoring are performed. Also, the changes in altimeter status (AS) are monitored, and descriptive temperature statistics are calculated. The associated bits in the preprocessing indicators word will be turned on.

Output

Output is provided by the CALIMERGE program on two different media, listing and magnetic tape, each described in detail below:

(1) Listing. The program lists all of the information read via the option cards. The first AS read and the first TM format code encountered are printed along with the TCG of occurrence. From this point on, whenever AS, or TM format changes, or TCG changes by more than one count, a line is printed defining the time the change occurred and the parameter value changed. The TCG/UTC table values used from the UTC/TCG time tape to correlate time is printed. Also, whenever the CP, TCG, or FFID checks don't satisfy checking criteria, the time of occurrence is printed along with the parameter in question. Temperature statistics are printed at the end of a run. Finally, the first and last times encountered on the output tape are printed.

(2) Tape. A nine-track, binary magnetic tape is generated with all data converted to functional and/or engineering units. All static calibrations have been applied to the data. The tape is written with a time header record written first followed by a physical record for each major frame of TM data.

GEOS-3 ALTIMETER PROCESSOR - THE GAP PROGRAM

GAP is designed to further calibrate the altimeter measurement data by calibrating engineering units to functional units as a function of temperature, flagging altimeter housekeeping data whenever any housekeeping parameter exceeds a given threshold, and calculating the mean and standard deviation of certain altimeter measurements. The details of GAP are described in the following sections of Input, Computations, and Output.

Input

Two kinds of input are necessary for operating the GAP program. These are:

(1) Data tape created by the CALIMERGE program in either of two formats corresponding to the two TM data rates available. A time header record, needed to time tag the parameters included in the file, is written at the beginning of the tape. Following this record, a string of altimeter data records is written.

(2) Option card. The option card supplies descriptive information to the software and instructs the software how to execute. Typical information to be read into the program includes a comment card input file number, and both start and stop time cards.

Computation

The input data tape is read and pre-mission and post-mission BIT/CAL data are analyzed. Parameters to be included in this calibration check include all altimeter measurement parameters and housekeeping parameters.

Table XIII shows the engineering units measurements needed to obtain the necessary functional units. In most cases, the functional units calibration is a function of a temperature parameter.

Table XIV defines the temperature criteria for calibrating engineering unit values to functional unit values.

Once the decision is made to calibrate, the engineering units value is subjected to the following check procedure:

(1) If the engineering units value is -9999., then do not calibrate the engineering units value.

(2) If the engineering units value is not -9999., and not in the range of the calibration table; do not calibrate, add 20 to the engineering units value, and then print the engineering units value with time and present altimeter status.

(3) If the engineering units value is within the range of the calibration table, then calibrate the engineering units value to a functional unit value.

The temperature calibration tables are found in Appendix A.

During the processing of each record of altimeter data, an attempt is made to calculate a smoothed altimeter observation and its associated time, FODAY.

The value of FODAY is given by

FODAY = FRAMTI + 0.923266296 sec. for FORMAT 1

FODAY = FRAMTI + 1.537697016 sec. for FORMAT 2

FODAY = FRAMTI + 1.619621112 sec. for FORMAT 3

TABLE XIII. FUNCTIONAL UNIT PROCESSING

	Functional Unit	Engineering Unit Measurements Required
1.	AVERAGE POST–VIDEO WAVEFORM SAMPLES (VOLTS)	ARS1 THRU ARS16 PLUS WST
2.	INSTANTANEOUS POST–VIDEO WAVE–FORM SAMPLES (VOLTS)	IRS1 THRU IRS16 PLUS WST
3.	TRACKING LOOP JITTER (CM)	RSE
4.	RECEIVED POWER	RAGC AND RRT
5.	TRANSMIT POWER	RTP AND RTT
6.	AVERAGE INTEGRATED NOISE GATE VOLTAGE (VOLTS)	ANG AND GTT
7.	AVERAGE INTEGRATED RAMP GATE VOLTAGE (VOLTS)	
	a. LONG PULSE	ARG AND GTT
	b. SHORT PULSE	ARG AND ITT
8.	AVERAGE INTEGRATED PLATEAU GATE VOLTAGE (VOLTS)	
	a. LONG PULSE	APG AND GTT
	b. SHORT PULSE	APG AND ITT
9.	AVERAGE INTEGRATED ATTITUDE/ SPECULAR GATE VOLTAGE (VOLTS)	AASG AND GTT
10.	INSTANTANEOUS INTEGRATED PLATEAU GATE VOLTAGE (VOLTS)	
	a. LONG PULSE	IPG AND GTT
	b. SHORT PULSE	IPG AND ITT

TABLE XIV. CRITERIA FOR CALIBRATING ENGINEERING UNITS TO FUNCTIONAL UNITS

CONDITION	DECISION
1. PRESENT TEMPERATURE VALUE = –9999. AND NO PREVIOUS GOOD TEMPERATURE IS AVAILABLE.	1. ADD 20. TO ENGINEERING UNITS AND DO NOT CALIBRATE. 2. PRINT PRESENT TEMPERATURE VALUE WITH TIME.
2. PRESENT TEMPERATURE IS NOT WITHIN CALIBRATION TABLE AND NO PREVIOUS GOOD TEMPERATURE IS AVAILABLE.	1. ADD 20. TO ENGINEERING UNITS AND DO NOT CALIBRATE. 2. CHANGE TEMPERATURE VALUE TO –8888. 3. PRINT PRESENT TEMPERATURE VALUE WITH TIME.
3. PRESENT TEMPERATURE IS NOT WITHIN CALIBRATION TABLES AND PREVIOUS GOOD TEMPERATURE IS AVAILABLE.	1. USE PREVIOUS GOOD TEMPERATURE TO CALIBRATE AND SET PRESENT TEMPERATURE EQUAL TO –8888. 2. PRINT PRESENT TEMPERATURE VALUE WITH TIME.
4. PRESENT TEMPERATURE IS WITHIN TABLES AND NOT WITHIN ACCEPTED TEMPERATURE RATE LIMITS* FROM PREVIOUS GOOD TEMPERATURE.	1. USE PRESENT TEMPERATURE TO CALIBRATE AND UPDATE PREVIOUS GOOD TEMPERATURE WITH PRESENT TEMPERATURE. 2. PRINT PRESENT TEMPERATURE VALUE AND PREVIOUS GOOD TEMPERATURES.
5. PRESENT TEMPERATURE IS WITHIN TABLES AND WITHIN ACCEPTED TEMPERATURE RATE LIMITS* FROM PREVIOUS GOOD TEMPERATURE.	1. USE PRESENT TEMPERATURE TO CALIBRATE. 2. UPDATE PREVIOUS GOOD TEMPERATURE WITH PRESENT TEMPERATURE.

*RATE LIMITS FOR ALL TEMPERATURES IS $2^{o}C$/DATA RECORD EXCEPT FOR RTT WHICH HAS A RATE LIMIT OF $5^{o}C$/DATA RECORD.

The smoothing is performed by fitting the best line (best in the sense of least squares) through the individual altitudes and then calculating a standard deviation, ASIGMA, of the data away from that line. The smoothed observation, SMOALT, is calculated by evaluating the value along the line at time, FODAY.

Only observations whose value is between 700 km and 900 km are considered in the smoothing process. The smoothing process will fail if there are less than two points that fall into the above range or if the standard deviation of the points about the line is greater than 100.0. If the smoothing operation fails, SMOALT, FODAY, and ASIGMA will be set to -8888.0.

The GAP program analyzes the status words, AS, to determine whether there are 0, 8, or 16 active sample and hold gates in the current major frame. When any of the 16 gates are inactive, the IRS, ARS, AW, and SAW words corresponding to that gate are set equal to -7777.0 prior to calibration.

After the IRS parameters have been calibrated as a function of Waveform Sampler Temperature, WST, those values not equal to -7777.0 or greater than ten in absolute value, are averaged with equal weighting to yield the AWS, and the standard deviations away from the averages, SAWs, are calculated. If no IRS (i, j) are averaged for gate i, then AW(i) and SAW(i) are set equal to -8888. The following equations are used to make the calculations:

$$AW(i) = \sum_{j=i}^{n_i} \frac{IRS\ (i,j)}{n_i}$$

$$SAW(i) = \left[\sum_{j=1}^{n_i} \frac{IRS^2(i,j) - n_i\ AW^2(i)}{n_i - 1} \right]^{\frac{1}{2}}$$

where IRS (i,j) is the value of the j^{th} good sample of the i^{th} gate and n_i is the total number of good samples of the i^{th} gate.

The AGC varies slightly with altimeter input voltage and the number of waveform gates used. After converting AGC engineering units to functional units as a function of RRT, AGC is further calibrated since it varies slightly with altimeter input voltage and the number of sample gates used. AGC is referenced to a nominal input voltage of 14.7 volts and operation with zero sample gates. Therefore, for operation with each additional eight sample gates, .56 db is subtracted from both RAGC and RAGCHI. That is, .56 db is subtracted for eight active sample gates and 1.12 db is subtracted for 16 active sample gates. Also, for each volt of the experimental bus voltage above 14.7 v, .3 db is subtracted from both RAGC and RAGCHI. Also for each volt of the experimental bus voltage below 14.7 v, .3 db is added to both RAGC and RAGCHI.

The average automatic gain control, is computed by averaging all calibrated RAGC values that are less than ten in absolute value. If all RAGC values in the frame are less than ten in absolute value, then AVRAGC is set equal to -8888. If the RAGCHI value is not less than ten in absolute value, RAGCHI is set equal to -8888.

The radar transmitter power, RTP, is calibrated as a function of temperature to power and then .7 db is subtracted from that power level to account for the transmit power loss from the power detector to the antenna flange.

Sea state is evaluated by computing the value of $H_{1/3}$. The algorithm used is a convolution of a normal distribution and a step function to approximate the waveform shape. A least squares filter technique is used to obtain the coefficients of the curve fit. The resulting value of $H_{1/3}$ is calculated once per major frame. In calculating $H_{1/3}$, if the AS are unequal to 79, or the altimeter is operating in global mode, or any ARS is less than -77776., or a 4 X 4 matrix inversion fails, or the algorithm doesn't converge within ten iterations, then $H_{1/3}$ will be set to -8888.

Output

Two kinds of output are provided by the GAP program, one tape and a listing.

(1) Tape. The nine-track output tape has the same format as the input tape format.

(2) Listing. All input options via cards are printed out on the listing. All BIT/CAL data calculations used for monitoring the altimeter calibration are displayed on the listing in addition to initial housekeeping values and flagged housekeeping data whenever data exceeds threshold values. A typical line of altimeter output will include record number, AS, time, ALT or CALT, RSE, RAGC, and pointing angle. Also displayed will be frame time and the mean and standard deviation of the valid IRS data.

ALTIMETER RESIDUAL COMPUTATION - THE ARC PROGRAM

The ARC program was designed to operate on the altimeter data preprocessed by the GAP program and the ephemeris tape created by the orbit determination program to calculate the remaining parameters not included on the input tape. Basically, ARC calculates the altimeter residuals, sea surface height, and the geophysical parameters needed to further interpret the altimeter data. Nothing is done with the waveform data.

Input

Three kinds of input are needed by the ARC program to execute. These are:

(1) Data tape created by the GAP program. This tape could be written in either of two different record lengths, one for the high data rate format and one for the low data format.

(2) Ephemeris tape created by various organizations.* This tape is used to provide orbital information to ARC for computing altimeter residuals, sea surface height and other orbit related parameters.

(3) Option cards. These cards are used to instruct the ARC program what to do and how to make certain corrections to the data. Typical data to be read in include time intervals, type plots, tropospheric refraction weather data, interpolation order, altimeter bias and edit criterion for plotting.

Computation

The ARC Program has two primary functions. They are:

(1) To compute altimeter residuals and in so doing, verify the quality of altimeter data.

(2) To output a user data tape suitable for the CALTOR Program, and a tape for CALCOMP plotting of ARC results.

The altimeter residuals, R_a, are computed for the i^{th} measurement as

$$R_{ai} = (O_i - r_i + b) - (h_i - g_i - t_i)$$

where
- O = observed altimeter measurement,
- h = computed altimeter height above the referenced ellipsoid,
- r = refraction correction,
- g = geoid height for sub-satellite point,
- t = ocean tide, and
- b = _a priori_ bias, if any.

The ARC observation geometry is depicted in Figure 7.

Timing. - Each of the parameters computed by ARC and written on the output tape (i.e., LAT, LONG, TREF, GHITE, THITE, SATHT, SSHITE, and SMOSSH) has a time of evaluation. The LAT, LONG, TREF, GHITE, THITE, and SMOSSH variables are evaluated at the time of the

* One of the reasons for implementing the final processing step in the GEOS-3 data flow (CORRECTALL) is that quality of orbit ephemeris was not consistent throughout the mission.

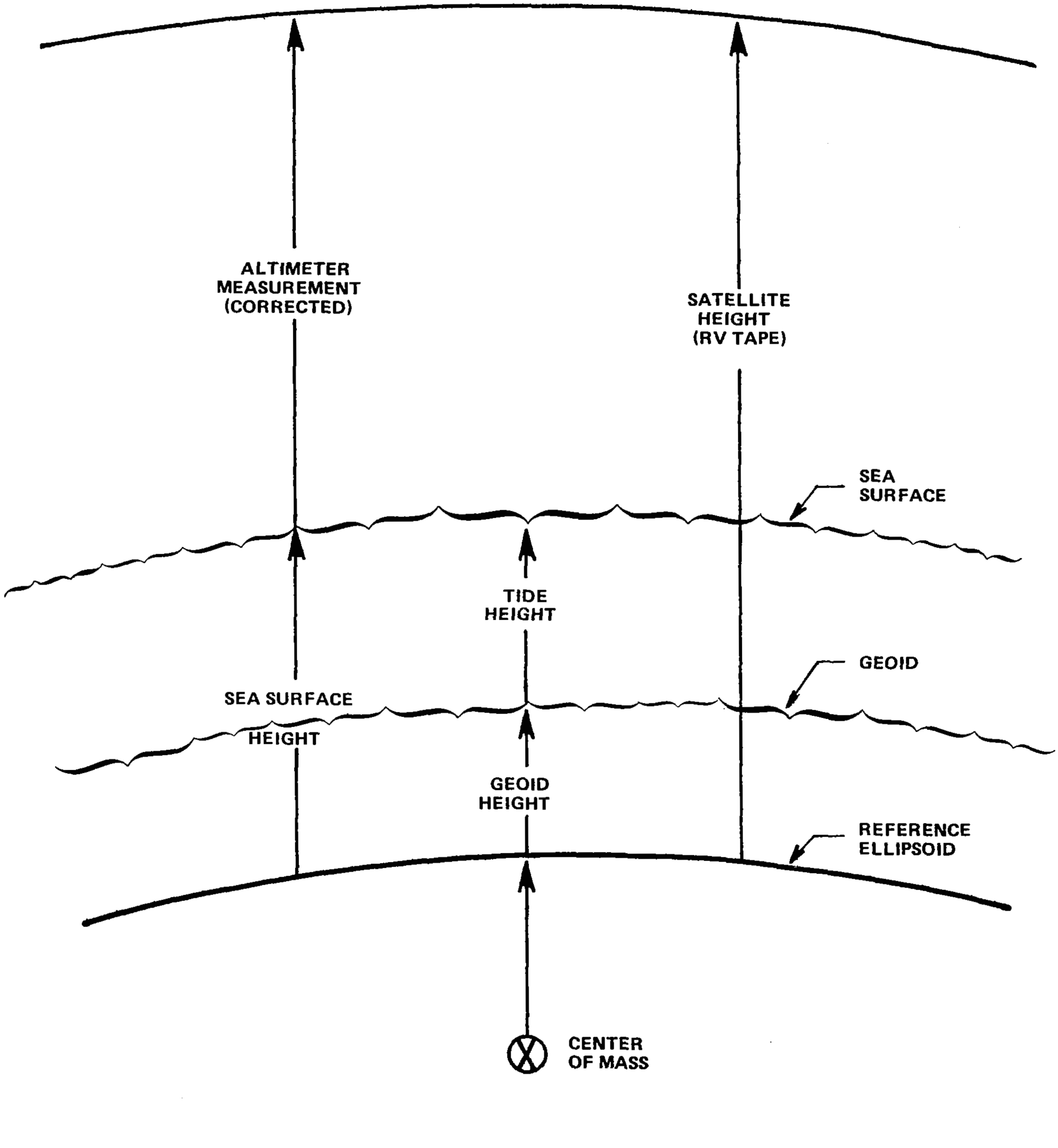

Figure 7. The ARC observation geometry.

smoothed observation (at FODAY). If FODAY is not available from the GAP input tape, it is computed by ARC and LAT, LONG, and SMOSSH are set to -8888.0. SATHT, SSHITE, CALT, ALT, and the observation residuals computed by ARC are time tagged by the following algorithm:

$$t_i = \text{FRAMTI} + T + (i - 1)\ t$$

where t_i is the time of the sample of SATHT, SSHITE, CALT, ALT, T is the amount of time added to the frame time (FRAMTI) to obtain the time of the first sample, and t is the amount of time elapsed between any two adjacent samples occurring in the same frame.

The ARC program computes corrected values of T and t for CALT and ALT and places them in the timing header record. The corrections made are for transit time, filter delay, and tracking loop delay and are defined in the following three equations (Note: Error in CALT and ALT times as indicated in Table XVI are not taken into account below):

TM Mode 1

$$T_{new} = \underset{(T_{old})}{-53\ 186\ 560} + \underset{\text{(transit time)}}{28\ 190\ 000} - \underset{\text{(filter delay)}}{4.5\ (102\ 405\ 120)} - \underset{\text{(tracking loop delay)}}{10\ 000\ 000}$$

$$= -\ 495\ 819\ 600 \text{ sec. x } 10^{10}$$

TM Mode 2

$$T_{new} = \underset{(T_{old})}{-53\ 186\ 560} + \underset{\text{(transit time)}}{28\ 190\ 000} - \underset{\text{(filter delay)}}{4.5\ (102\ 405\ 120)} - \underset{\text{(tracking loop delay)}}{10\ 000\ 000}$$

$$= -495\ 819\ 600 \text{ sec. x } 10^{10}$$

TM Mode 3

$$T_{new} = \underset{(T_{old})}{-155\ 591\ 680} + \underset{\text{(transit time)}}{28\ 190\ 000} - \underset{\text{(tracking loop delay)}}{10\ 000\ 000}$$

$$= -137\ 401\ 680 \text{ sec. x } 10^{10}$$

Tropospheric Refraction Correction. - Each observation processed by the ARC computer program is corrected for tropospheric refraction in calculating SSHITE and SMOSSH although the program does not alter the value of the observation on the data tape. The program makes use of the Saatamoinen tropospheric refraction model as presented in reference 1 with a constant elevation angle of 90° being used. The correction is given by:

$$dr = 0.002277\ (P + (0.05 + 1255.0/T)V)$$

where

P is the surface pressure in mb.,

T is the surface temperature in °K, and

V is the surface vapor pressure in mb.

Table XV contains an array of corrections based upon average values of P, T, and V for each month of the year and in latitude increments of 5° from -65° to +65°. This table is linearly interpolated at one second intervals to obtain the tropospheric refraction correction for the altimeter measurements. The tropospheric refraction correction written on the output tape is evaluated at the latitude of the smoothed observation. If the latitude is greater than 65° in absolute value, the last value calculated by the subroutine is again returned as the correction.

Geoid Height Correction. - The ARC computer program uses the Marsh-Vincent geoid (ref. 2). The geoid height is evaluated by linearly interpolating a table of values given in one-degree latitude by one-degree longitude increments. The interpolation is performed every second for SSHITE. The value written on the output tape is evaluated at the latitude and longitude of the smoothed observation.

Ocean Tide Correction. - The ARC computer program uses the Hendershott tide model (ref. 3) which is evaluated every second for SSHITE. The value written on the output tape is evaluated at the time of the smoothed observation, FODAY.

A Priori Altitude Bias. - Each altitude observation processed by the AGC computer program is corrected for bias while computing SSHITE and SMOSSH; however, no correction is made to the altitude observations on tape. The value of the bias correction is constant and is zero unless supplied by the user. The program accepts separate bias values for the long pulse and short pulse modes.

Method of Ephemeris Interpolation. - In order to calculate sea surface heights, and evaluate the geoid and tide heights, it is necessary to interpolate the satellite latitude, longitude, and height above the reference ellipsoid. The ARC computer program uses a fixed mesh, fixed order Lagrange interpolation scheme, where the order is fixed at three. The satellite latitude and longitude are evaluated every second. The values of latitude and longitude written on the output tape are evaluated at the time of the smoothed observation, FODAY. The height above the reference ellipsoid is evaluated at every observation. The Lagrange interpolation scheme was chosen both because of its accuracy and simplicity (no difference tables are required and interpolation coefficients need only be computed once for a fixed mesh interpolation). However, it should be noted that the interpolation routine is not capable of extrapolating the ephemeris data.

TABLE XV. NOMINAL TROPOSPHERIC REFRACTION CORRECTIONS.

LATITUDE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
-70	2.32	2.32	2.33	2.35	2.37	2.38	2.37	2.37	2.37	2.35	2.32	2.31
-65	2.33	2.33	2.34	2.35	2.38	2.38	2.40	2.41	2.38	2.35	2.35	2.32
-60	2.35	2.36	2.35	2.37	2.39	2.40	2.42	2.42	2.41	2.38	2.37	2.35
-55	2.38	2.38	2.36	2.39	2.41	2.43	2.46	2.46	2.45	2.42	2.40	2.39
-50	2.42	2.40	2.39	2.42	2.43	2.47	2.49	2.50	2.48	2.46	2.44	2.42
-45	2.44	2.43	2.42	2.45	2.46	2.49	2.53	2.53	2.51	2.50	2.47	2.45
-40	2.47	2.46	2.45	2.48	2.48	2.52	2.56	2.55	2.54	2.52	2.50	2.48
-35	2.49	2.48	2.48	2.50	2.51	2.54	2.56	2.57	2.56	2.54	2.52	2.51
-30	2.51	2.49	2.51	2.52	2.53	2.55	2.56	2.57	2.58	2.56	2.54	2.52
-25	2.52	2.50	2.52	2.53	2.53	2.56	2.56	2.57	2.58	2.57	2.56	2.53
-20	2.53	2.52	2.52	2.53	2.54	2.57	2.56	2.58	2.58	2.56	2.57	2.55
-15	2.55	2.52	2.54	2.54	2.54	2.58	2.57	2.58	2.58	2.57	2.58	2.55
-10	2.57	2.56	2.57	2.55	2.55	2.58	2.58	2.57	2.58	2.58	2.57	2.56
-5	2.57	2.57	2.57	2.57	2.58	2.57	2.56	2.56	2.55	2.56	2.56	2.56
0	2.56	2.57	2.57	2.58	2.57	2.56	2.55	2.53	2.54	2.55	2.56	2.56
5	2.56	2.56	2.57	2.58	2.58	2.58	2.55	2.54	2.54	2.57	2.56	2.56
10	2.57	2.58	2.57	2.58	2.57	2.57	2.55	2.55	2.54	2.55	2.56	2.56
15	2.57	2.58	2.57	2.57	2.55	2.55	2.53	2.55	2.53	2.53	2.54	2.56
20	2.56	2.57	2.57	2.54	2.53	2.52	2.51	2.51	2.50	2.50	2.52	2.53
25	2.51	2.53	2.55	2.51	2.50	2.49	2.48	2.48	2.47	2.47	2.48	2.50
30	2.48	2.50	2.50	2.47	2.46	2.46	2.45	2.44	2.44	2.45	2.45	2.47
35	2.44	2.46	2.45	2.43	2.42	2.42	2.41	2.41	2.42	2.42	2.42	2.44
40	2.40	2.41	2.40	2.40	2.38	2.38	2.37	2.37	2.39	2.39	2.39	2.40
45	2.36	2.37	2.36	2.36	2.35	2.34	2.34	2.34	2.35	2.35	2.35	2.35
50	2.32	2.33	2.33	2.32	2.31	2.31	2.31	2.31	2.32	2.32	2.31	2.32
55	2.30	2.30	2.30	2.29	2.28	2.28	2.28	2.28	2.29	2.30	2.29	2.30
60	2.29	2.28	2.28	2.27	2.27	2.27	2.26	2.26	2.26	2.26	2.27	2.29
65	2.28	2.27	2.26	2.25	2.26	2.26	2.26	2.25	2.25	2.25	2.26	2.28

Output

Three outputs are provided by the ARC program: a binary data tape, a plot tape, and a listing.

The Binary Format Tape. - It is output in the same format as the input except that the following quantities are included on the tape.

(1) The calculated geoid/ellipsoid separation.

(2) The calculated tide correction.

(3) The calculated sea surface height.

(4) The calculated tropospheric refraction correction.

(5) Any (user input) altimeter observation bias.

(6) The satellite latitude.

(7) The satellite longitude.

(8) The satellite height.

The Plot Tape. - It is generated by the program and the following plots can be made.

(1) The observation residuals (O-C's) versus time.

(2) The sea surface height versus time.

Listing. - The output listing lists the options which were exercised in the operation of the program. In addition, the time, date, measurement and quantities defined under the binary format are printed on the listing. Finally, a printer plot of sea surface height (SSHITE) and altimeter residuals are displayed on the listing.

THE CALTOR PROGRAM

The CALTOR Program originally provided the formatted data for distribution to the investigators. The CALTOR formats will be fully explained here to retain the information under one cover for use by persons using the originally distributed data. As will be seen in the "CORRECTALL" section of this document, the CALTOR binary formatted data tapes were later used as input to CORRECTALL so that final and complete corrections to the data could be accomplished. It is the output from CORRECTALL which serves as the final archived data release of GEOS-3 data.

The CALTOR program requires the binary altimeter data tape generated by the ARC program for input. Sequentially processing the header record first, and then the successive data records at either the high or low data rates, CALTOR builds a "binary byte oriented" tape.

CALTOR builds the binary tape by packing the binary data from the ARC tape on eight bit/byte boundaries. For example, if altimeter height can be represented by an integer number whose signed binary equivalent can be contained within 30 binary bits, then this value will be stored on the binary output tape in 32 binary bits or four bytes. All fraction portions have been scaled by the program and are integer. The user of the tape needs only to break each word read into the corresponding byte (eight bit) groups, right justify them within the arithmetic register of his computer, and extract the proper binary-integer equivalent of the measurement value.

Input

Input required by the CALTOR program is a data tape created by the ARC program. This tape is defined in the previous section.

Output

The output of CALTOR is a nine-track, 800 BPI tape written with odd parity. The format is composed of two kinds of records, the timing header record (Table XVI), and the data record (Table XVII) both of which are defined in detail in the next few pages for the altimeter data user. The timing header record is a 94 x 23 byte array (plus 34 bytes filler) defining the time tag system to properly time-tag parameters included in the data records. The 92 unique parameters plus a redundant parameter (RSE) and data account for 94 parameters being described. Six fields are required to uniquely define the time tags for each parameter. The six fields require one, five, five, two, five and five bytes, respectively, to provide necessary precision. This totals 23 bytes for each parameter. The first field defines the number of samples of that parameter recorded in the data record for the low data rate. The second field defines the elapsed time in (.1 ns) from the frame time given in the data record, needed to time tag the first sample of that parameter in the data record for the low data rate. The third field defines the time interval in (.1 ns) between samples for that parameter in the data record for the low data rate. The fourth field defines the number of samples of that parameter recorded in the data record for the high data rate. The fifth field defines the elapsed time in (.1 ns) from the frame time given in the data record, needed to time tag the first sample of that parameter in the data record for the high data rate. The sixth field defines the time interval in (.1 ns) between samples for that parameter in the data record for the high data rate.

The algorithm to be used to properly time tag parameters in the data record is as follows:

TABLE XVI. ALTIMETER TIMING HEADER RECORD

	LOW DATA RATE			HIGH DATA RATE		
PARAMETER	NUMBER SAMPLES	TIME FROM FRAME TIME***	TIME WITHIN FRAME	NUMBER SAMPLES	TIME FROM FRAME TIME***	TIME WITHIN FRAME
DATE	1	YYMMDD	0	1	0	0
ALT	0	0	0	320	-155591680**	102405120
CALT	20	-53186560**	1024051200	32	-53186560**	1024051200
AS	20	256012800	1024051200	64	204810240	512025600
ARS1	1	2916561920	0	1	4145423360	0
ARS2	1	3018967040	0	1	4247828480	0
ARS3	1	3121372160	0	1	4657448960	0
ARS4	1	3223777280	0	1	4759854080	0
ARS5	1	3326182400	0	1	5169474560	0
ARS6	1	3428587520	0	1	5271879680	0
ARS7	1	3530992640	0	1	5681500160	0
ARS8	1	3633397760	0	1	5783905280	0
ARS9	1	3940613120	0	1	6193525760	0
ARS10	1	4043018240	0	1	6295930880	0
ARS11	1	4145423360	0	1	6705551360	0
ARS12	1	4247828480	0	1	6807956480	0
ARS13	1	4350233600	0	1	7217576960	0
ARS14	1	4452638720	0	1	7319982080	0
ARS15	1	4555043840	0	1	7729602560	0
ARS16	1	4657448960	0	1	7832007680	0
RSE (Mode 2)	20	254028800	1024051200	320	-155591680	102405120
RSE (Mode 3)	20	254028800	1024051200	320	-53186560	102405120
RAGC	20	766054400	1024051200	32	766054400	1024051200
IPG	20	-155591680	1024051200	320	-53186560	102405120
RTP	4	-53186560	5120256000	8	458839040	4096204800
ANG	4	151623680	5120256000	8	254028800	4096204800
ARG	4	254028800	5120256000	8	1278080000	4096204800
APG	4	356433920	5120256000	8	2302131200	4096204800
AASG	4	458839040	5120256000	8	3326182400	4096204800
BCT	1	17253278720	0	1	26674549760	0
RTT	1	17458088960	0	1	27186575360	0
RRT	1	17662899200	0	1	27698600960	0
GTT	1	17867709440	0	1	28210626560	0
ITT	1	18277329920	0	1	28722652160	0
WST	1	18482140160	0	1	29234677760	0
IFTA	1	2506941440	0	1	3633397760	0
RSA	1	2199726080	0	1	2711751680	0

PARAMETERS	NUMBER SAMPLES	LOW DATA RATE TIME FROM FRAME TIME***	TIME WITHIN FRAME	NUMBER SAMPLES	HIGH DATA RATE TIME FROM FRAME TIME***	TIME WITHIN FRAME
VTA	1	2609346560	0	1	3735802880	0
RMI	1	13976314880	0	1	21963914240	0
SSHITE	20	U*	U*	320	U*	U*
IRS1	0	0	0	320	-53186560	102405120
IRS2	0	0	0	320	-53186560	102405120
IRS3	0	0	0	320	-53186560	102405120
IRS4	0	0	0	320	-53186560	102405120
IRS5	0	0	0	320	-53186560	102405120
IRS6	0	0	0	320	-53186560	102405120
IRS7	0	0	0	320	-53186560	102405120
IRS8	0	0	0	320	-53186560	102405120
IRS9	0	0	0	320	-53186560	102405120
IRS10	0	0	0	320	-53186560	102405120
IRS11	0	0	0	320	-53186560	102405120
IRS12	0	0	0	320	-53186560	102405120
IRS13	0	0	0	320	-53186560	102405120
IRS14	0	0	0	320	-53186560	102405120
IRS15	0	0	0	320	-53186560	102405120
IRS16	0	0	0	320	-53186560	102405120
AW1	0	0	0	1	16331632640	0
AW2	0	0	0	1	16331632640	0
AW3	0	0	0	1	16331632640	0
AW4	0	0	0	1	16331632640	0
AW5	0	0	0	1	16331632640	0
AW6	0	0	0	1	16331632640	0
AW7	0	0	0	1	16331632640	0
AW8	0	0	0	1	16331632640	0
AW9	0	0	0	1	16331632640	0
AW10	0	0	0	1	16331632640	0
AW11	0	0	0	1	16331632640	0
AW12	0	0	0	1	16331632640	0
AW13	0	0	0	1	16331632640	0
AW14	0	0	0	1	16331632640	0
AW15	0	0	0	1	16331632640	0
AW16	0	0	0	1	16331632640	0

PARAMETERS	NUMBER SAMPLES	LOW DATA RATE TIME FROM FRAME TIME***	TIME WITHIN FRAME	NUMBER SAMPLES	HIGH DATA RATE TIME FROM FRAME TIME***	TIME WITHIN FRAME
SAW1	0	0	0	1	16331632640	0
SAW2	0	0	0	1	16331632640	0
SAW3	0	0	0	1	16331632640	0
SAW4	0	0	0	1	16331632640	0
SAW5	0	0	0	1	16331632640	0
SAW6	0	0	0	1	16331632640	0
SAW7	0	0	0	1	16331632640	0
SAW8	0	0	0	1	16331632640	0
SAW9	0	0	0	1	16331632640	0
SAW10	0	0	0	1	16331632640	0
SAW11	0	0	0	1	16331632640	0
SAW12	0	0	0	1	16331632640	0
SAW13	0	0	0	1	16331632640	0
SAW14	0	0	0	1	16331632640	0
SAW15	0	0	0	1	16331632640	0
SAW16	0	0	0	1	16331632640	0
RAGCHI	1	1585295360	0	1	1687700480	0
AVRAGC	1	11006566400	0	1	17150873600	0
ALT*	0	0	0	320	-137401680	102405120
CALT*	20	-495819600	1024051200	32	-495819600	1024051200
SPARE	0	0	0	0	0	0
SPARE	0	0	0	0	0	0

FILLER 34 bytes

* The calculated ALT*, CALT* times corrected for transit time, filter delay, and tracking loop delay will be in error by the sum of the errors described below (i.e., + 102405120 - 208000000 = -105594880). To correct time subtract 10.56 msec from time calculated using frame time and timing header record data in CALTOR (original) distribution.

** Time is in error, add 102405120 to ALT and CALT times shown.

*** Frame time in original distribution is in error, subtract 208000000 from frame time on tape.

U* SSHITE assumes the same time tag as the altitude data corrected for transit time, filter delay, and tracking loop delay (that is, the same time as ALT* and CALT*).

TABLE XVII. GEOS-C BINARY ALTIMETER DATA FORMAT

(Low Data Rate)

NUMBER OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION AND COMMENTS	UNITS
1	2	Record Size less two in Bytes (538)	
1	3	Satellite ID (nnpppqq)	
1	1	Measurement Type (40 or 41)	
1	1	Time System Indicator (nm)	
1	1	Station Number (0)	
1	4	Preprocessing Indicators (Format ID)	
1	3	Modified Julian Date of smooth altitude	
1	5	Seconds of Day Past Midnight	us
1	4	Smooth Altitude	cm
1	3	Satellite Latitude (Geodetic)	Deg. X 10^4
1	3	Satellite Longitude	Deg. X 10^4
1	2	Altitude Measurement Standard Deviation	cm
1	2	Calculated Altitude Bias	cm
1	2	Tropospheric Refraction Correction	cm
1	1	Ionospheric Refraction Correction	cm
1	2	Geoid Height Above Reference Ellipsoid*	cm
1	2	Tide Height Above Mean Sea Level	cm
1	5	Frame Time of Day	us
1	2	Day of Year	
1	1	Year (YY)	
20	4	Cumulative Altitude	cm
20	4	Satellite Height Above Reference Ellipsoid	cm
1	2	Calculated Standard Deviation of Satellite Height	cm
20	2	Altimeter Status	
1	2	Radar Altimeter Average Return Sample No. 1	mv
1	2	Radar Altimeter Average Return Sample No. 2	mv
1	2	Radar Altimeter Average Return Sample No. 3	mv
1	2	Radar Altimeter Average Return Sample No. 4	mv
1	2	Radar Altimeter Average Return Sample No. 5	mv
1	2	Radar Altimeter Average Return Sample No. 6	mv
1	2	Radar Altimeter Average Return Sample No. 7	mv
1	2	Radar Altimeter Average Return Sample No. 8	mv
1	2	Radar Altimeter Average Return Sample No. 9	mv
1	2	Radar Altimeter Average Return Sample No. 10	mv
1	2	Radar Altimeter Average Return Sample No. 11	mv
1	2	Radar Altimeter Average Return Sample No. 12	mv
1	2	Radar Altimeter Average Return Sample No. 13	mv

NUMBER OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION AND COMMENTS	UNITS
1	2	Radar Altimeter Average Return Sample No. 14	mv
1	2	Radar Altimeter Average Return Sample No. 15	mv
1	2	Radar Altimeter Average Return Sample No. 16	mv
20	2	Range Servo Error	cm
20	2	Radar Altimeter Automatic Gain Control Voltage	dbm X 10^2
20	2	Instantaneous Plateau Gate Power	mv
4	2	Radar Altimeter Transmitter Output Power	dbm X 10^2
4	2	Radar Altimeter Average Noise Gate	mv
4	2	Radar Altimeter Average Ramp Gate	mv
4	2	Radar Altimeter Average Plateau Gate	mv
4	2	Radar Altimeter Average Attitude/Specular Gate	mv
1	2	Radar Altimeter Bit/Cal Temperature	°C
1	2	Radar Altimeter Transmitter Temperature	°C
1	2	Radar Altimeter Receiver Temperature	°C
1	2	Radar Altimeter Global Tracker Temperature	°C
1	2	Radar Altimeter Intensive Tracker Temperature	°C
1	2	Radar Altimeter Waveform Sampler Temperature	°C
1	2	Radar Altimeter IF Test Signal Amplitude	mv
1	2	Radar Altimeter Reference Signal Amplitude	mv
1	2	Radar Altimeter Video Test Signal Amplitude	mv
1	2	Radar Altimeter Receiver Mixer Current	mv
20	2	Sea Surface Height*	cm
1	2	Radar Altimeter Automatic Gain Control Voltage (Hi)	dbm X 10^2
1	2	Calculated Average Automatic Gain Control Voltage	dbm X 10^2
1	2	H 1/3	cm
1	2	Smooth Sea Surface Height	cm
14	2	Spare	
1	1	Spare	

* Spheroid height computed based on reference spheroid defined by:

a_e = 6378145.0 Meters

f = 1/298.255

(High Data Rate)

NUMBER OF SAMPLES	BYTES/SAMPLES	PARAMETER DESCRIPTION AND COMMENTS	UNITS
1	2	Record Size less two in Bytes (15190)	
1	3	Satellite ID (nnpppqq)	
1	1	Measurement Type (40 or 41)	
1	1	Time System Indicator (nm)	
1	1	Station Number (0)	
1	4	Preprocessing Indicators (Format ID)	
1	3	Modified Julian Date of Smooth Altitude	
1	5	Seconds of Day Past Midnight	us
1	4	Smooth Altitude	cm
1	3	Satellite Latitude (Geodetic)	Deg. X 10^4
1	3	Satellite Longitude	Deg. X 10^4
1	2	Altitude Measurement Standard Deviation	cm
1	2	Calculated Altitude Bias	cm
1	2	Tropospheric Refraction Correction	cm
1	1	Ionospheric Refraction Correction	cm
1	2	Geoid Height Above Reference Ellipsoid*	cm
1	2	Tide Height Above Mean Sea Level	cm
1	5	Frame Time of Day	us
1	2	Day of Year	
1	1	Year (YY)	
320	4	Altitude*	cm
320	4	Satellite Height Above Reference Ellipsoid	cm
1	2	Calculated Standard Deviation of Satellite Height	cm
64	2	Altimeter Status	
1	2	Radar Altimeter Average Return Sample No. 1	mv
1	2	Radar Altimeter Average Return Sample No. 2	mv
1	2	Radar Altimeter Average Return Sample No. 3	mv
1	2	Radar Altimeter Average Return Sample No. 4	mv
1	2	Radar Altimeter Average Return Sample No. 5	mv
1	2	Radar Altimeter Average Return Sample No. 6	mv
1	2	Radar Altimeter Average Return Sample No. 7	mv

*For Mode 3, instantaneous altitude
For Mode 2, cumulative altitude for first 32 samples, -9999. in last 288 samples

NUMBER OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION AND COMMENTS	UNITS
1	2	Radar Altimeter Average Return Sample No. 8.	mv
1	2	Radar Altimeter Average Return Sample No. 9	mv
1	2	Radar Altimeter Average Return Sample No. 10	mv
1	2	Radar Altimeter Average Return Sample No. 11	mv
1	2	Radar Altimeter Average Return Sample No. 12	mv
1	2	Radar Altimeter Average Return Sample No. 13	mv
1	2	Radar Altimeter Average Return Sample No. 14	mv
1	2	Radar Altimeter Average Return Sample No. 15	mv
1	2	Radar Altimeter Average Return Sample No. 16	mv
320	2	Range Servo Error	cm
32	2	Radar Altimeter Automatic Gain Control Voltage	dbm X 10^2
320	2	Instantaneous Plateau Gate Power (Mode 3)	mv
8	2	Radar Altimeter Transmitter Output Power	dbm X 10^2
8	2	Radar Altimeter Average Noise Gate	mv
8	2	Radar Altimeter Average Ramp Gate	mv
8	2	Radar Altimeter Average Plateau Gate	mv
8	2	Radar Altimeter Average Attitude/Specular Gate	mv
1	2	Radar Altimeter Bit/Cal Temperature	°C
1	2	Radar Altimeter Transmitter Temperature	°C
1	2	Radar Altimeter Receiver Temperature	°C
1	2	Radar Altimeter Global Tracker Temperature	°C
1	2	Radar Altimeter Intensive Tracker Temperature	°C
1	2	Radar Altimeter Waveform Sampler Temperature	°C
1	2	Radar Altimeter IF Test Signal Amplitude	mv
1	2	Radar Altimeter Reference Signal Amplitude	mv
1	2	Radar Altimeter Video Test Signal Amplitude	mv
1	2	Radar Altimeter Receiver Mixer Current	mv
320	2	Sea Surface Height	cm
320	2	Instantaneous Return Sample No. 1 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 2	mv
320	2	Instantaneous Return Sample No. 3 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 4	mv
320	2	Instantaneous Return Sample No. 5 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 6	mv
320	2	Instantaneous Return Sample No. 7 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 8	mv
320	2	Instantaneous Return Sample No. 9 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 10	mv
320	2	Instantaneous Return Sample No. 11 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 12	mv
320	2	Instantaneous Return Sample No. 13 (Mode 2 only)	mv

NUMBER OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION AND COMMENTS	UNITS
320	2	Instantaneous Return Sample No. 14	mv
320	2	Instantaneous Return Sample No. 15 (Mode 2 only)	mv
320	2	Instantaneous Return Sample No. 16	mv
1	2	Calculated Average Waveform No. 1 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 2	mv
1	2	Calculated Average Waveform No. 3 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 4	mv
1	2	Calculated Average Waveform No. 5 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 6	mv
1	2	Calculated Average Waveform No. 7 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 8	mv
1	2	Calculated Average Waveform No. 9 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 10	mv
1	2	Calculated Average Waveform No. 11 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 12	mv
1	2	Calculated Average Waveform No. 13 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 14	mv
1	2	Calculated Average Waveform No. 15 (Mode 2 only)	mv
1	2	Calculated Average Waveform No. 16	mv
1	2	Calculated Sigma Average Waveform No. 1 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 2	mv
1	2	Calculated Sigma Average Waveform No. 3 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 4	mv
1	2	Calculated Sigma Average Waveform No. 5 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 6	mv
1	2	Calculated Sigma Average Waveform No. 7 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 8	mv
1	2	Calculated Sigma Average Waveform No. 9 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 10	mv
1	2	Calculated Sigma Average Waveform No. 11 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 12	mv
1	2	Calculated Sigma Average Waveform No. 13 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 14	mv
1	2	Calculated Sigma Average Waveform No. 15 (Mode 2 only)	mv
1	2	Calculated Sigma Average Waveform No. 16	mv
1	2	Radar Altimeter Automatic Gain Control Voltage (Hi)	dbm X 10^2
1	2	Calculated Average Automatic Gain Control Voltage	dbm X 10^2
1	2	H 1/3	cm
1	2	Smooth Sea Surface Height	cm
12	2	Spare	
1	1	Spare	

$$T_{p,f,n,} = FT + T_{p,f} + nt_{p,f}$$

where $T_{p,f,n}$ = time tag for parameter (p), format (f), and sample (n)

FT = frame time included on data record

$T_{p,f}$ = elapsed time from frame time for parameter (p), and format (f)

n = sample number within data record. n starts with 0 and ranges through N-1, where N is the total number of samples of parameter (p) in the data record.

$t_{p,f}$ = time interval between samples of parameter (p) and format (f).

The derivation of all time tags are based on the data included in Appendix B. It must be noted that Appendix B establishes time at the satellite for the given parameter at the time of a transmitted pulse. Also, in the cases where the parameters are average parameters, Appendix B (and the Timing Header Record) establishes the time of the Last Effective Transmitted Pulse (LETP) that was included in the average. Proper time tagging of average data, then, requires that one start with the timing header record information and, knowing that this represents the last data in the average, subtract time so as to get to the time mid-point of the averaging interval. For instantaneous parameters such as IRS, IPG, RSE, etc., no averaging has been done on-board the satellite therefore the identified LETP time is applied directly.

Two examples are now presented on how to time tag data in the data record.

(1) Time tag sixth sample of CALT in low data rate

$$T_{3,1,5} = FT + T_{3,1} + 5t_{3,1} + [\text{Mid-Point} + \text{Prop} + \text{Lag}]$$

Mid-Point Correction

Since CALT is the average of ten transmitted pulses, the time mid-point of the average is -4.5 interpulse periods (102405120) = -460823040.

Propagation Correction

Transmitted pulses are referenced to time at the satellite, therefore, time propagation for the pulse to reach the earth surface is +28190000.

Lag Correction

The altimeter servo time lag is approximately -10000000.

and,

$$T_{3,1,5} = FT + 49218560^{*} + 5(1024051200) + [-460823040 + 28190000 -10000000]$$

* Corrected for CALT/ALT time error indicated in Table XVI.

(2) Time tag the 10th sample of RSE in high data rate (Mode 2)

$$T_{21,2,9} = FT + T_{21,2} + 9\ t_{21,2}$$

$$T_{21,2,9} = FT + (-155591680) + 9\ (102405120)$$

Time tags in the header record for data calculated by the altimeter processing system (specifically AW1-16, SAW1-16, AVRAGC, $H_{1/3}$, and SSSHITE) take into account the time mid-point of the calculated averages and no further time corrections need to be applied.

The data record contains all altimeter related measurements, calculated parameters and indicators. The data record is recorded in either of two different formats, the Low Data Rate or the High Data Rate format.

Telemetry data recorded in Format Mode 1 is written in the Low Data Rate format and it contains 540 bytes of information. Telemetry data recorded in Format Modes 2 or 3 are written in the High Data Rate format and it contains 15192 bytes of information. The first seven parameters of the data record are described in detail because the description given in the formats is not detailed enough. The other parameters are felt to be described in sufficient detail by the parameter description in the format.

Parameter	Description
1	Record size less two in bytes
2	Satellite ID - This is the international satellite designation nnpppqq where: nn - last two digits of the year in launch (e.g., 1974-74, 1969-69). ppp - order of launch Example - The 25th vehicle launch in a given year is designated with ppp = 025. qq - component identifier (e.g., component a-01, component 1-12, etc.).
3	Measurement type of first measured altitude in data record. 40 = Long Pulse 41 = Short Pulse
4	Time System Indicator (nm) n value — description 0 — Ground Received Time 1 — Satellite Transponder/Transmitter Time 2 — Ground Transmitted Time (Effective Time for Averaged Altimeter Data) 3 — Satellite Receiver Time

m value	Description
0	UT-0
1	UT-1
2	UT-2
3	UTC
4	A.1
5	A.3 (A.T. B.I.H.)
6	A-S (Smithsonian)

5 Station Number

0	Altimeter

6 Preprocessing Indicators/Report

The preprocessing indicators are bit switches packed into four bytes. The rightmost bit (bit 31) is of lowest order and the left most bit (bit 0) is of highest order.

The preprocessing bits are configured as follows:

Bits	Value	Description
1-2		Format Indicator
	1	Format 1
	2	Format 2
	3	Format 3
10-12		Tropospheric Refraction
	0	Data has been corrected
	1	Data has not been corrected
	3	Correction is calculated but not applied to data
13		Ionospheric Refraction
	0	Data has been corrected
	1	Data has not been corrected
20-21		Altimeter Mode
	0	Long Pulse Track Mode
	1	Short Pulse Track Mode
	>1	Not in track mode
26-31		Preprocessing Report
	0	Report not specified
	1	Wallops Flight Center Preprocessing Report
	---	Other values to be assigned later

7 Modified Julian Rate (MJD) of smooth altitude
JD = MJD + 2400000.5

FINAL DISTRIBUTION - CORRECTALL

General

CORRECTALL uses the binary CALTOR data as input and produces the final distribution of GEOS-3 data. CORRECTALL applies all known data corrections to produce a final data base as consistent and accurate as possible. Sea Surface Height (SSHITE) is computed using accurate orbit, refraction and bias calibration data and with all timing corrections applied to the altimeter altitude data, thus providing SSHITE properly referenced in time relative to computed satellite height (SATHT), spheroid height, and latitude/longitude. In addition, CORRECTALL provides the calibrated oceanographic parameters such as sea-state ($H_{1/3}$), surface wind speed, etc., which have been derived during the course of the GEOS-3 program.

Output Products

Because of the volume of GEOS-3 data involved in the final distribution, CORRECTALL was designed to provide three specific types of output. The "G" tapes and "I" tapes constitute the NOAA archived GEOS-3 data base. Each of these series of tapes contain the entire GEOS-3 data set; however, the records are a subset of the full data record. The M-tape series maintains the full data record and constitutes the master set of data. The M-tape series will be stored at Wallops and is not a part of the NOAA archived data.

The contents of the G, I, and M tape records are given in Table XVIII. All tapes are nine-track, 800 BPI, and odd parity. All tapes are recorded binary/NRZI with a standard 3/4-inch inter-record gap. The recording format for the various tapes is as follows (Byte = 8 bits):

	Blocking	Physical Record	Logical Record
M-Tape			
High Rate Data	0.5 Logical per Physical	7596 Bytes	15192 Bytes
Low Rate Data	None	540 Bytes	540 Bytes
I-Tape	None	770 Bytes	770 Bytes
G-Tape	83 Logical per Physical	8134 Bytes	98 Bytes

TABLE XVIII. TAPE CONTENT

PARAMETER DESCRIPTION	SAMPLES PER RECORD G-TAPE LDR	G-TAPE HDR	I-TAPE LDR	I-TAPE HDR	M-TAPE LDR	M-TAPE HDR
REV-GEOS-3 Orbit (Revolution) Number	1	1	1	1	1	1
UNIQ-GEOS-3 Orbit Segment Unique Number	1	1	1	1	1	1
MJDATE-Modified Julian Date of Frame Time	1	1	1	1	1	1
FRAMTI-Frame Time of Day (Past Midnight)	1	1	1	1	1	1
SLAT-Satellite Latitude at SSHITE1	3	4	3	4	3	4
SLON-Satellite Longitude at SSHITE1	3	4	3	4	3	4
SSSHITE1-Smoothed Sea Surface Height (1/GEOS sec.)	3	4	3	4	3	4
STATUS-Status per GEOS second	3	4	3	4	3	4
FRMH3-Average $H_{1/3}$ (Significant Wave Height)	1	1	1	1	1	1
FRMSIGO-Average Sigma Zero	1	1	1	1	1	1
FRMWIND-Average Wind Speed	1	1	1	1	1	1
FRMGAMMA-Swell/Wind Wave Discrimination	1	1	1	1	1	1
FRMPT-Satellite Pointing Angle	1	1	1	1	1	1
FRMMSS-Surface Reflectivity (Mean Squared Slope)	1	1	1	1	1	1
IOTA-Ice Roughness Index	1	1	1	1	1	1
SSSHITE2-Smoothed Sea Surface Height (10/GEOS sec.)			20	32		
SSHITE-Raw Instantaneous Sea Surface Height			20	32	20	32
FRMSTAT-Frame Status			1	1	1	1
NSTAT-Number of Auto Track Statuses in Frame			1	1	1	1
FRMLAT-Satellite Latitude at Frame Time			1	1	1	1
FRMLON-Satellite Longitude at Frame Time			1	1	1	1
ABIAS-Calibrated Altitude Bias			1	1	1	1
TREF-Tropospheric Refraction Correction			1	1	1	1
GHITE-Geoid Height at Frame Time			1	1	1	1
THITE-Tide Height Relative to Mean Sea Level			1	1	1	1
SATHT-Satellite Height above Reference Spheroid			20	32	20	32
ARS1-16-Altimeter Average Return Samples 1-16			1	1	1	1
RAGC-Altimeter Automatic Gain Control Voltage			20	32	20	32
RTPAV-Frame Average Altimeter Transmit Power			1	1	1	1
APG-Altimeter Average Plateau Gate Voltage			4	8	4	8
AASG-Altimeter Average Attitude/Specular Gate Voltage			4	8	4	8
IREF-Ionospheric Refraction Correction					1	1
CALT-Altimeter Raw Average Altitude (CALT)					20	32
AS-Altimeter Status					20	64
IRS1-16-Instantaneous Return Samples 1-16						320[1]
IPG-Instantaneous Plateau Gate					20	320[2]
RSE-Range Servo Error						320
ANG-Average Noise Gate Voltage					4	8
ARG-Average Ramp Gate Voltage					4	8
RAGCHI-Altimeter AGC (extended scale)					1	1
WST-Altimeter Waveform Sampler Temperature					1	1
RTT-Altimeter Transmitter Temperature					1	1
RRT-Altimeter Receiver Temperature					1	1
GTT-Altimeter Global Tracker Temperature					1	1
ITT-Altimeter Intensive Tracker Temperature					1	1

Notes: 1. Only even IRS in Mode 3 TM.
2. Only in Mode 3 TM.

Data Formats and Description

The formats for the G, I, and M Tapes are given in Tables XIX through XXI, respectively. As discussed and illustrated in Table XVIII, the G and I formats are subsets of the Master (M) tape format. The G-tape contains only the products of the mission (i.e., smoothed sea surface height at once per 1.024 seconds and all the oceanographic parameters derived during the mission). The I-tape contains all the information of the G-tape plus the calibrated data used to produce the cited products. In addition, the I-tape contains smoothed sea surface height at a rate of ten per 1.024 seconds. The M-tape contains additional data such as system temperatures that were used to calibrate functional parameters and, in high data rate records, instantaneous samples at the altimeter PRF rate of the 16 waveform gates, the plateau gate, and the range servo error signal. Because of the anticipated small requirement for the added data in the M-tape records, and because of the large volume of these tapes (especially for high data rate), it was decided not to provide M-tapes to the NOAA archive.

Using Table XVIII as a guide, parameters requiring further description are discussed below.

MJDATE. - Modified Julian Date of Frame; MJDATE = true Julian date minus 2400000.5, rounded down.

FRAMTI. - Frame time of day past midnight. FRAMTI is corrected for error cited in CALTOR output data.

SLAT. - Satellite geodetic latitude in degrees at SSSHITE1 (see below).

SLONG. - Satellite geodetic longitude in degrees at SSSHITE1 (see below).

SSSHITE1. - Using raw instantaneous sea surface height (SSHITE) as input data, this parameter is output via a Kalman filter. Each SSSHITE1 sample is located at paired SLAT/SLONG positions described above. Samples are given at time intervals of 1.024 seconds (GEOS second) along the satellite ground track. There are two samples in low data rate (LDR) records and either three or four samples in high data rate (HDR) records. The time of the first SSSHITE in the first record is the frame time (FRAMTI) of the first data record minus .039341 seconds. Succeeding SSSHITE1 (and SLAT/SLONG) are time tagged at 1.0240512 second intervals for the remainder of the pass. For additional information concerning the Kalman filter see "ALTKAL - An Optimum Linear Filter for GEOS-3 Altimeter Data," NASA CR-141429, August 1977.

STATUS. - Status per GEOS second defined as follows:

Bit	State	
1	0	Intensive Mode (I-Mode)
	1	Global Mode (G-Mode)

TABLE XIX. OUTPUT TAPE DESCRIPTION (G-TAPE).

Note: "INTEGER" type signifies 16 bit (2 byte) signed binary fixed point notation; "REAL" and "DOUBLE" precision signify 32 bit (4 byte) 64 bit (8 byte) floating point notation (i.e., a signed 8-bit excess 64 notation exponent and a 24-bit ("REAL") or a 56-bit ("DOUBLE") mantissa).

OCEANOGRAPHIC INFORMATION SECTION

Parameter	Type	No. of Samples	Units	Byte Size	Byte Start	Byte Stop
REV	INTEGER	1		2	1	2
UNIQ	INTEGER	1		2	3	4
MJDATE	REAL	1		4	5	8
FRAMTI	DOUBLE	1	SECS	8	9	16
STATUS	INTEGER	4		2	17	24
SLAT	REAL	4	DEGS	4	25	40
SLON	REAL	4	DEGS	4	41	56
SSSHITE1	REAL	4	METERS	4	57	72
FRMH3	REAL	1	METERS	4	73	76
FRMSIGO	REAL	1	DB	4	77	80
FRMWIND	REAL	1	MTRS/SEC	4	81	84
FRMGAMMA	REAL	1		4	85	88
FRMPT7	REAL	1	DEGS	4	89	92
FRMMSS	REAL	1		4	93	96
IOTA	INTEGER	1		2	97	98

TABLE XX. DISTRIBUTION SYSTEM INTERMEDIATE FORMAT OUTPUT TAPE DESCRIPTION (I-TAPE)

Note: "INTEGER" type signifies 16 bit (2 byte) signed binary fixed point notation; "REAL" and "DOUBLE" precision signify 32 bit (4 byte) 64 bit (8 byte) floating point notation (i.e., a signed 8-bit excess 64 notation exponent and a 24-bit ("REAL") or a 56-bit ("DOUBLE") mantissa).

OCEANOGRAPHIC INFORMATION SECTION

	Parameter	Type	No. of Samples	Units	Byte Size	Byte Start	Byte Stop
1	REV	INTEGER	1		2	1	2
2	UNIQ	INTEGER	1		2	3	4
3	FRMSTAT	INTEGER	1		2	5	6
4	MJDATE	REAL	1		4	7	10
5	FRAMTI	DOUBLE	1	SECS	8	11	18
6	FRMLAT	REAL	1	DEGS	4	19	22
7	FRMLON	REAL	1	DEGS	4	23	26
8	ABIAS	REAL	1	METERS	4	27	30
9	TREF	REAL	1	METERS	4	31	34
10	GHITE	REAL	1	METERS	4	35	38
11	THITE	REAL	1	METERS	4	39	42
12	SATHT(-84000)	REAL	32	METERS	4	43	170
13	NSTAT	INTEGER	1		2	171	172
14	ARS1-16	REAL	16	MV	4	173	236
15	RAGC	REAL	32	DBM	4	237	364
16	RTPAV	REAL	1	MV	4	365	368
17	APG	REAL	8	MV	4	369	400
18	AASG	REAL	8	MV	4	401	432
19	SSHITE	REAL	32	METERS	4	433	560
20	FRMH3	REAL	1	METERS	4	561	564
21	FRMSIGO	REAL	1		4	565	568
22	FRMWIND	REAL	1	MTRS/SEC	4	569	572
23	FRMGAMMA	REAL	1		4	573	576
24	FRMPT	REAL	1	DEGS	4	577	580
25	FRMMSS	REAL	1		4	581	584
26	IOTA	INTEGER	1		2	585	586
		GEODETIC INFORMATION SECTION					
27	STATUS	INTEGER	4		2	587	594
28	SLAT	REAL	4	DEGS	4	595	610
29	SLON	REAL	4	DEGS	4	611	626
30	SSSHITE1	REAL	4	METERS	4	627	642
31	SSSHITE2	REAL	32	METERS	4	643	770

TABLE XXI. M-TAPE DATA FORMAT.

GEOS-3 Packed Decimal Altimeter Data Low Rate Record Contents Description

GEOS-3 Binary Altimeter Data Format

(Low Data Rate)

BYTE LOCATIONS	NO OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION & COMMENTS	UNITS
1-2	1	2	Record Size less two in Bytes (538)	
3-5	1	3	Satellite ID (nnpppqq)	
6-7	1	2	GEOS-3 Orbit (Revolution) Number	
8-9	1	2	GEOS-3 Orbit Segment Unique Number	
10-11	1	2	Frame Status/Quality Indicator	
12	1	1	Number of Operate Auto Track Status in Frame	
13-15	1	3	Modified Julian Date of Frame Time	
16-20	1	5	Seconds of Day Past Midnight (Extraneous Time, do not use)	us
21-22	1	2	Frame H 1/3 (Significant Wave Height)	cm
23-24	1	2	Frame Sigma Zero	db x 10^2
25-27	1	3	Frame Satellite Latitude (Geodetic)	Deg. x 10^4
28-30	1	3	Frame Satellite Longitude (Geodetic)	Deg. x 10^4
31-32	1	2	Frame Wind Velocity	cm/sec.
33-34	1	2	Calculated Altitude Bias	cm
35-36	1	2	Tropospheric Refraction Correction	cm
37	1	1	Ionospheric Refraction Correction	
38-39	1	2	Geoid Height Above Reference Ellipsoid	cm
40-41	1	2	Tide Height Above Mean Sea Level	cm
42-46	1	5	Frame Time of Day (FRAMTI)	us
47-48	1	2	Day of Year	
49	1	1	Year (YY)	
50-129	20	4	Cumulative Altitude	cm
130-209	20	4	Satellite Height Above Reference Ellipsoid	cm
210-211	1	2	Frame Gamma (Swell)	
212-251	20	2	Altimeter Status	
252-253	1	2	Radar Altimeter Average Return Sample No. 1	mv
254-255	1	2	Radar Altimeter Average Return Sample No. 2	mv
256-257	1	2	Radar Altimeter Average Return Sample No. 3	mv
258-259	1	2	Radar Altimeter Average Return Sample No. 4	mv
260-261	1	2	Radar Altimeter Average Return Sample No. 5	mv

BYTE LOCATIONS	NO OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION & COMMENTS	UNITS
262-263	1	2	Radar Altimeter Average Return Sample No. 6	mv
264-265	1	2	Radar Altimeter Average Return Sample No. 7	mv
266-267	1	2	Radar Altimeter Average Return Sample No. 8	mv
268-269	1	2	Radar Altimeter Average Return Sample No. 9	mv
270-271	1	2	Radar Altimeter Average Return Sample No. 10	mv
272-273	1	2	Radar Altimeter Average Return Sample No. 11	mv
274-275	1	2	Radar Altimeter Average Return Sample No. 12	mv
276-277	1	2	Radar Altimeter Average Return Sample No. 13	mv
278-279	1	2	Radar Altimeter Average Return Sample No. 14	mv
280-281	1	2	Radar Altimeter Average Return Sample No. 15	mv
282-283	1	2	Radar Altimeter Average Return Sample No. 16	mv
284-285	1	2	Frame Satellite Pointing Angle (Off-Nadir Angle)	Deg. x 10^3
286-287	1	2	Frame Mean Squared Slope	x10^3
288-293	3	2	"GEOS Second" Status/Quality Indicator	
294-323	15	2	Unused	
324-363	20	2	Radar Altimeter Automatic Gain Control Voltage	dbm x 10^2
364-403	20	2	Instantaneous Plateau Gate Power	mv
404-405	1	2	Radar Altimeter Transmitter Average Output Power	dbm x 10^2
406-407	1	2	Ice Index (IOTA)	
408-409	1	2	Radar Altimeter Automatic Gain Control Voltage (Hi)	dbm x 10^2
410-411	1	2	Unused	
412-419	4	2	Radar Altimeter Average Noise Gate	mv
420-427	4	2	Radar Altimeter Average Ramp Gate	mv
428-435	4	2	Radar Altimeter Average Plateau Gate	mv
436-443	4	2	Radar Altimeter Average Attitude/Specular Gate	mv
444-445	1	2	Radar Altimeter Waveform Sampler Temperature	°C x 10
446-447	1	2	Radar Altimeter Transmitter Temperature	°C x 10
448-449	1	2	Radar Altimeter Receiver Temperature	°C x 10
450-451	1	2	Radar Altimeter Global Tracker Temperature	°C x 10
452-453	1	2	Radar Altimeter Instensive Tracker Temperature	°C x 10
454-513	20	3	Sea Surface Height (Raw Instantaneous)	cm
514-522	3	3	"GEOS Second" Satellite Latitude	Deg. x 10^4
523-531	3	3	"GEOS Second" Satellite Longitude	Deg. x 10^4
532-540	3	3	"GEOS Second" Smoothed Sea Surface Height	cm

GEOS-3 Packed Decimal Altimeter Data High Rate Record Contents Description

GEOS-3 Binary Altimeter Data Format
(High Data Rate)

BYTE LOCATIONS	NO. OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION & COMMENTS	UNITS
1-1	1	2	Record Size Less Two in Bytes (15190)	
3-5	1	3	Satellite ID (nnpppqq)	
6-7	1	2	GEOS-3 Orbit (Revolution) Number	
8-9	1	2	GEOS-3 Orbit Segment Unique Number	
10-11	1	2	Frame Status/Quality Indicator	
12	1	1	Number of Operate Auto Track Status in Frame	
13-15	1	3	Modified Julian Date of Frame Time	
16-20	1	5	Seconds of Day Past Midnight (Extraneous Time, do not use)	us
21-22	1	2	Frame H 1/3 (Significant Wave Height)	cm
23-24	1	2	Frame Sigma Zero	db x 10^2
25-27	1	3	Frame Satellite Latitude (Geodetic)	Deg. x 10^4
28-30	1	3	Frame Satellite Longitude (Geodetic)	Deg. x 10^4
31-32	1	2	Frame Wind Velocity	cm/sec.
33-34	1	2	Calculated Altitude Bias	cm
35-36	1	2	Tropospheric Refraction Correction	cm
37	1	1	Ionospheric Refraction Correction	cm
38-39	1	2	Geoid Height Above Reference Ellipsoid	cm
40-41	1	2	Tide Height Above Mean Sea Level	cm
42-46	1	5	Frame Time of Day (FRAMTI)	us
47-48	1	2	Day of Year	
49	1	1	Year (YY)	
50-177	32	4	Cumulative Altitude	cm
178-1329	288	4	Unused	
1330-1457	32	4	Satellite Height Above Reference Ellipsoid	cm
1458-2609	288	4	Unused	
2610-2611	1	2	Frame Gamma (Swell)	
2612-2739	64	2	Altimeter Status	
2740-2741	1	2	Radar Altimeter Average Return Sample No. 1	mv
2742-2743	1	2	Radar Altimeter Average Return Sample No. 2	mv
2744-2745	1	2	Radar Altimeter Average Return Sample No. 3	mv
2746-2747	1	2	Radar Altimeter Average Return Sample No. 4	mv
2748-2749	1	2	Radar Altimeter Average Return Sample No. 5	mv
2750-2751	1	2	Radar Altimeter Average Return Sample No. 6	mv
2752-2753	1	2	Radar Altimeter Average Return Sample No. 7	mv
2754-2755	1	2	Radar Altimeter Average Return Sample No. 8	mv

BYTE LOCATIONS	NO. OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION & COMMENTS	UNITS
2756-2757	1	2	Radar Altimeter Average Return Sample No. 9	mv
2758-2759	1	2	Radar Altimeter Average Return Sample No. 10	mv
2760-2761	1	2	Radar Altimeter Average Return Sample No. 11	mv
2762-2763	1	2	Radar Altimeter Average Return Sample No. 12	mv
2764-2765	1	2	Radar Altimeter Average Return Sample No. 13	mv
2766-2767	1	2	Radar Altimeter Average Return Sample No. 14	mv
2768-2769	1	2	Radar Altimeter Average Return Sample No. 15	mv
2770-2771	1	2	Radar Altimeter Average Return Sample No. 16	mv
2772-3411	320	2	Radar Servo Error	cm
3412-3475	32	2	Radar Altimeter Automatic Gain Control Voltage	dbm x 10^2
3476-4115	320	2	Instantaneous Plateau Gate Power (Mode 3)	mv
4116-4117	1	2	Radar Altimeter Transmitter Average Output Power	dbm x 10^2
4118-4119	1	2	Ice Index (IOTA)	
4120-4131	6	2	Unused	
4132-4147	8	2	Radar Altimeter Average Noise Gate	mv
4148-4163	8	2	Radar Altimeter Average Ramp Gate	mv
4164-4179	8	2	Radar Altimeter Average Plateau Gate	mv
4180-4195	8	2	Radar Altimeter Average Attitude/Specular Gate	mv
4196-4197	1	2	Radar Altimeter Waveform Sampler Temperature	°C x 10
4198-4199	1	2	Radar Altimeter Transmitter Temperature	°C x 10
4200-4201	1	2	Radar Altimeter Receiver Temperature	°C x 10
4202-4203	1	2	Radar Altimeter Global Tracker Temperature	°C x 10
4204-4205	1	2	Radar Altimeter Intensive Tracker Temperature	°C x 10
4206-4215	5	2	Unused	
4216-4311	32	3	Sea Surface Height	cm
4312-4855	272	2	Unused	cm
4856-5495	320	2	Instantaneous Return Sample No. 1 (Mode 2 only)	mv
5496-6135	320	2	Instantaneous Return Sample No. 2	mv
6136-6775	320	2	Instantaneous Return Sample No. 3 (Mode 2 only)	mv
6776-7415	320	2	Instantaneous Return Sample No. 4	mv
7416-7596	90 1/2	2	Instantaneous Return Sample No. 5 (Mode 2 only) (first 90 samples + first byte of sample 91)	mv
7597-8055	229 1/2	2	Instantaneous Return Sample No. 5 (Mode 2 only)	mv
8056-8695	320	2	Instantaneous Return Sample No. 6	mv
8696-9335	320	2	Instantaneous Return Sample No. 7 (Mode 2 only)	mv
9336-9975	320	2	Instantaneous Return Sample No. 8	mv
9976-10615	320	2	Instantaneous Return Sample No. 9 (Mode 2 only)	mv
10616-11255	320	2	Instantaneous Return Sample No. 10	mv
11256-11895	320	2	Instantaneous Return Sample No. 11 (Mode 2 only)	mv
11896-12535	320	2	Instantaneous Return Sample No. 12	mv
12536-13175	320	2	Instantaneous Return Sample No. 13 (Mode 2 only)	mv
13176-13815	320	2	Instantaneous Return Sample No. 14	mv

BYTE LOCATIONS	NO. OF SAMPLES	BYTES/SAMPLE	PARAMETER DESCRIPTION & COMMENTS	UNITS
13816-14455	320	2	Instantaneous Return Sample No. 15 (Mode 2 only)	mv
14456-15095	320	2	Instantaneous Return Sample No. 16	mv
15096-15097	1	2	Frame Satellite Pointing Angle (Off Nadir Angle)	Deg. x 10^3
15098-15099	1	2	Frame Mean Squared Slope	Deg. x 10^3
15100-15107	4	2	"GEOS Second" Status/Quality Indicator	
15108-15153	23	2	Unused	
15154-15155	1	2	Radar Altimeter Automatic Gain Control Voltage (Hi)	dbm x 10^2
15156	1	1	Unused	
15157-15168	4	3	"GEOS Second" Satellite Latitude	Deg. x 10^4
15169-15180	4	3	"GEOS Second" Satellite Longitude	Deg. x 10^4
15181-15192	4	3	"GEOS Second" Smoothed Sea Surface Height	cm

2	0	No Meaning
	1	Kalman Edit (Modified)
3	0	Low Data Rate
	1	High Data Rate
4	0	All Auto Track Status
	1	Any or All Non Auto Track Status
5	0	No APG/AASG Edit
	1	APG/AASG Edit
6	0	No Kalman Edit
	1	Kalman Edit (original)
7-16	0	Water
	1	Land or Ice

Non-water return wave shape is discriminated when AASG < 35 mv for I-mode or AASG < 33 mv for G-Mode. The ten bit field (bits 7-16) represents locations along the GEOS-3 ground track linearly spaced at .1024 second intervals starting at the time of the first AASG. Land/water bits transition in groups of five in low data rate and in groups of four in high data rate. This is due to the sampling rate of the AASG parameter as shown in the AASG paragraph. Note that in low data rate the last 20 of the land/water bits have no meaning, and in high data rate, the last eight bits have no meaning.

APG/AASG flag (Bit 5) occurs if APG and/or AASG violate the following limits:

35 mv < AASG < 72 mv for I-Mode
33 mv < AASG < 72 mv for G-Mode
88.5 mv < APG <100.5 mv for I-Mode
50.0 mv < APG < 62.0 mv for G-Mode

The Kalman edit flag is set for the following conditions:

(1) A data dropout occurs.
(2) SSHITE data point differs from GHITE by more than 50 meters (i.e., ± 50 meters), data therefore is not input to Kalman.
(3) Filter output diverges from input by more than 3 σ (Intensive 3 σ is 1.8 m Global 3 σ is 4.5 m) for six contiguous data points.

The original Kalman edit flag (Bit 6) was set for the above conditions, however, predicted filter output was permitted over extended periods of no data input (i.e., under conditions (1) and (2) above). This logic was later modified to cause a Kalman reset if any of the above conditions exist for six data points (i.e., approximately 0.61 seconds). Bit 2 was then used to indicate a Kalman flag under the modified logic. The modified logic was implemented for the processing beginning with revolution 11059. However, data are not necessarily processed sequentially, therefore, it is recommended that the user utilize the flag bits to assess the quality of the Kalman output as follows:

Bit 2	Bit 6	
0	0	No Kalman flags, quality good
0	1	Kalman flag, questionable quality (possibly extended periods of predicted data)
1	1	Kalman flags, some data points are predicted, but no more than six in a row.

FRMH3. - Frame estimate of significant wave height, averaged over 21 seconds. Algorithm development is given in Reference 4 and related data in Reference 5.

FRMSIGO. - Frame estimate of sigma zero corrected using pass fit of APG and AASG. For more information see Reference 6.

FRMWIND. - Frame estimate of ground wind speed averaged over three frames and calculated from FRMSIGO. For more information see Reference 7 and Reference 8.

FRMGAMMA. - Frame value of the wave development factor:

$$\gamma = 138.44 \sqrt[3]{\left(\frac{FRMH3}{FRMWIND^2}\right)} \quad .$$

For values under 50, the waves are predominently wind-driven. Conversely, for values over 50, the waves are predominantly swell. For more information see Reference 9.

FRMPT. - Frame estimate of off-nadir pointing angle. For more information see Reference 6.

FRMMSS. - The frame average mean squared slope (FRMSS) is valid only for over-ice operation using the GEOS-3 altimeter intensive (short pulse) mode. Analyses of GEOS-3 data suggests that over-ice radar return waveforms are the sum or superposition of two different types of surface scattering processes: a) a general rough-surface incoherent scattering, varying as the mean squared slope of the surface and giving rise to a return waveform with a relatively slow-decay in the later part of the plateau region, and b) a specular "flat-plate" process giving rise to a near-replica of the transmitted pulse itself. FRMMSS is based on the rough surface incoherent scattering and was developed by G. S. Brown (Reference 10).

Mean squared slope is dimensionless (its units are, in effect, radians squared); it is based on the GEOS-3 attitude/specular gate which samples the return from an annular ring at about one degree off nadir. The calculation assumes an exponential probability density function for ice surface slopes, and assumes that the Fresnel reflection coefficient for ice is $|R(0°)|^2$ = -11 dB. It is also assumed that all specular component effects and all saturation effects are negligible by the time of the attitude/specular gate (AASG) which is about 790 nanoseconds after the leading edge of the radar return. Interpretation of the FRMMSS value over ice is, basically, the rougher the ice surface, the larger the value of FRMMSS.

IOTA. - Frame average value computed as follows:

$$I = \left[\frac{100 + AGC}{100 \times AASG}\right] -10$$

IOTA represents the relative specularity of the target medium and is meaningful in detecting water/ice boundaries and relative ice roughness in both the global and intensive mode. The above algorithm is calibrated to yield a value of zero at the ice edge. Generally, the higher the value of I, the smoother or more nearly specular the target medium. Ambiguities exist in determining if target is ice or land since land is also a specular target. These ambiguities are resolved through evaluation of SLAT/SLONG position. For more information see Reference 11.

SSSHITE2. - Smoothed sea surface height output via the Kalman filter at rate of 10 per GEOS second. The time tag of SSSHITE2 is exactly as described below for SSHITE.

SSHITE. - Raw Sea Surface Height. Twenty samples in low data rate, 32 samples in high data rate. SSHITE is derived as follows:

$$SSHITE = SATHT - [CALT - TREF + ABIAS] .$$

Each SSHITE is referenced to the time of the individual altimeter cumulative altitudes (CALT) measurements. SATHT is also referenced to this same time. The time of each sample (SSHITE, SATHT, CALT) is obtained as follows (all times in μsec):

$$TSAMPLE_n = FRAMTI + TLETP - MDPT + TT - LAG + [(n-1)\ \Delta t]$$

where:

$TSAMPLE_n$	=	Time of n^{th} sample, where n is in range 1 to 20 for low data rate, and 1 to 32 for high data rate.
FRAMTI	=	Frame time.
TLETP	=	Referring to Appendix B, time of last altimeter transmitted pulse that was included in the altimeter accumulator (i.e., the last pulse that was included in the ten pulse average altitude) = 4922 μsec.
MDPT	=	A time interval equal to 4.5 interpulse periods to reflect time to the mid-point of the average altitude = 4.5 (10240.5) = 46082 μsec.
TT	=	Transit time for pulse propagation to surface of earth. Consider 845 km nominal satellite altitude = 2819 μsec.
LAG	=	Accounts for a 1000 μsec altimeter servo lag = 1000 μsec.
Δt	=	Ten interpulse periods to get to next cumulative altitude time = 10 (10240.5) = 102405 μsec.

Example, find time of first SATHT (and therefore first SSHITE and CALT)

$$\begin{aligned} TSATHT_1 &= FRAMTI + 4922 - 46082 + 2819 - 1000 \\ &= FRAMTI - 39341 \ \mu sec. \end{aligned}$$

FRMSTAT. - Frame status; each record represents one frame of GEOS-3 data. This parameter is a 16 bit word with the 0/1 meaning of each bit described in Table XXII.

NSTAT. - Number of altimeter automatic track statuses in frame; maximum 20 for low data rate and 64 for high data rate.

FRMLAT. - Satellite geodetic latitude at FRAMTI in degrees.

FRMLON. - Satellite geodetic longitude at FRAMTI in degrees.

ABIAS. - Calibrated altimeter altitude bias used in derivation of SSHITE; 5.30 m for I-Mode, 3.55 m for G-Mode. For additional calibration information see Reference 12.

TREF. - Tropospheric refraction correction used in derivation of SSHITE. For more information, see Table XV and Reference 13.

GHITE. - Geoid height above reference spheroid for latitude/longitude position at frame time (FRAMTI). Geoid model used is GEM 10 gravimetric geoid (see Reference 14).

THITE. - Tide height above mean sea level for latitude/longitude position at frame time. The model is the Schividerski M-2 tide model (see Reference 15).

SATHT. - Satellite height data is derived from ephemeris tapes produced primarily from laser tracking data with NASA S-band tracking data added as required to strengthen the solution. SATHT is the satellite height above the reference spheroid minus 840000 meters. For the M-tape, the 840000 meter subtraction is not made. The spheroid is defined by Ae = 6378145.0 meters and, f = 1/298.255. There are 20 SATHT in low data rate and 32 in high data rate. Each SATHT is referenced to the time of the individual altimeter cumulative altitude (CALT) measurements.

ARS1-16. - Altimeter Average Return Samples 1 through 16. Referring to Appendix B, it is seen that the last pulse included in these two second average waveform samples occur from .29 to .47 seconds after FRAMTI for low rate data and from .42 to .78 seconds after FRAMTI for high rate data. Average mid-point time of the 16 samples is (time in seconds):

$$\begin{aligned} \text{Format 1} &= \text{FRAMTI} + \left(\frac{.29 + .47}{2}\right) - \left(\frac{\text{2 second ave.}}{2}\right) \\ &= \text{FRAMTI} - .62 \text{ seconds.} \\ \text{Format 2} &= \text{FRAMTI} + \left(\frac{.42 + .78}{2}\right) - \left(\frac{\text{2 second ave.}}{2}\right) \\ &= - .40 \text{ seconds.} \end{aligned}$$

TABLE XXII. FRMSTAT DESCRIPTION

Bit	State	
1	0	TM Rate Lo - TM Format = 1
	1	TM Rate Hi - TM Format = 2
2	0	Altimeter Mode Global
	1	Altimeter Mode Intensive
3	0	All Water
	1	Some Non Water
5	0	All Operate (79 or 204)
	1	Some Non Operate
6	0	Some Operate
	1	All Non Operate (None 79 or 204)
7	0	Original Data Rate Maintained
	1	Original Data Rate was Format 3
8	0	Quality 1 - No Kalman Edit
	1	Quality 2 - Kalman Edit (original)
9	0	Quality 3 - No APG/AASG Edit
	1	Quality 4 - APG/AASG Edit
10	0	Quality 5 - Preceding 1 Frames Good Quality
	1	Quality 6 - Preceding 1 Frames Frames Questionable Quality
11	0	Quality 7 - Succeeding 1 Frames Good Quality
	1	Quality 8 - Succeeding 1 Frames Questionable Quality
12	0	No Meaning
	1	Kalman Edit (Modified)
13	0	
	1	Undefined
14	0	
	1	Undefined
15	0	
	1	Undefined
16	0	
	1	Undefined

The above accurately times the ARS; however, it is possible that the user may desire to simply use FRAMTI as an approximate time of the ARS.

The ARS values are corrected to include amplitude biases which were determined post launch and not included in the first distribution. The bias correction for each gate which has been added to the original ARS value is as follows (values are in mv):

ARS1	+ 2.3	ARS9	+ 1.3
ARS2	- 2.7	ARS10	- 2.0
ARS3	+ 0.8	ARS11	+ 3.6
ARS4	- 1.8	ARS12	+ 1.3
ARS5	+ 2.5	ARS13	+ 0.9
ARS6	- 0.1	ARS14	- 0.5
ARS7	- 0.8	ARS15	- 0.3
ARS8	- 1.2	ARS16	- 4.0

RAGC. - Altimeter Automatic Gain Control Voltage. Low data rate contains 20 samples, high rate contains 32 samples. Each sample is a one-second average produced on-board the spacecraft. Proper timing is as follows for either low or high rate:

$$TAGC_n = \text{FRAMTI} + .077 \text{ sec} - \frac{1.0 \text{ sec ave.}}{2} + .102 \text{ sec } (n-1).$$

Example: Time of 31st RAGC

$$TRAGC_{31} = \text{FRAMTI} + .077 \text{ sec} - 0.5 \text{ sec} + 30\ (.102 \text{ sec})$$

$$= \text{FRAMTI} + 3.087 \text{ seconds.}$$

Note: Relative to the initial distribution, all intensive mode AGC values are increased by + 3.40 db. This corrects signal strength to account for the difference in pre-launch bench calibrations taken with clean and cluttered return signals. The initial distribution used "clean" calibration data. This final distribution corrects the clean values to reflect the measured pre-launch clutter calibration values.

RTRAV. - Frame Average Altimeter Transmitter Output Power. Represents the average of four peak power samples in low rate data and eight samples in high rate data. Proper time of average in low data rate is FRAMTI + .763 sec, and in high data rate is FRAMTI + 1.481 sec.

APG. - Altimeter Average Plateau Gate Voltage. Four samples in low rate data. Eight samples in high rate data. Each sample is a one second average voltage produced on-board the spacecraft. Timing of these samples are as follows:

Low Data Rate (Time in Sec., n = 1, 2, 3, 4)

$$TAPG_n = FRAMTI + .036 - \frac{1.0\ ave.}{2} + (n-1)(.512)$$

High Data Rate (Time in Sec, n = 1 through 8)

$$TAPG_n = FRAMTI + .230 - \frac{1.0\ ave.}{2} + (n-1)(.410)$$

Note: Errors in the calibration of APG which occurred in some passes prior to December 1, 1975, have been corrected in this distribution.

AASG. - Altimeter Average Attitude/Specular Gate Voltage. Four samples in low rate data, eight samples in high rate. Each sample is a one second average produced on-board the spacecraft. Timing is as follows:

Low Rate (Time in Sec, n = 1, 2, 3, 4)

$$TAASG_n = FRAMTI + .046 - \frac{1.0\ ave.}{2} + (n-1)(.512)$$

High Rate (Time in sec, n = 1 through 8)

$$TAASG_n = FRAMTI + .333 - \frac{1.0\ ave.}{2} + (n-1)(.410).$$

IREF. - Ionospheric Refraction Corrections. Value = 0.

CALT. - Altimeter cumulative altitude (average over 10 pulses). CALT is computed as described in the CALIMERGE section of this document. There are 20 CALT's in low data rate, 32 in high. The time tag of each CALT is given under the SSHITE paragraph above.

AS. - Altimeter Status. There are 20 AS in low data rate, 64 in high. All valid altimeter statuses are given in Tables V and VI.

IRS1-16. - Instantaneous Return Samples 1 through 16. Provided only in high data rate and at the altimeter PRF rate. There are 320 samples in each high data rate record. The time of the transmitted pulse to which each IRS1-16 group corresponds is derived as follows (time in μsec):

$$T\ Pulse\ (n^{th}\ IRS\ Group) = FRAMTI - 5319 + (n-1)(10240.5)$$

where n = 1 through 320.

Example: Find the transmitted pulse time for which the 50^{th} IRS1-16 group corresponds.

$$T\ Pulse\ (50^{th}\ IRS\ Group) = FRAMTI - 5319 + (50-1)(10240.5)$$

IPG. - Instantaneous Plateau Gate. There are 20 IPG's in low data rate (i.e., every 10^{th} pulse) and 320 IPG's in high data rate if telemetry was taken in Mode 3. There are no IPG's in Mode 2 high data rate telemetry. The time of the transmitted pulse to which each IPG corresponds is derived as follows (time in μsec):

Low Rate (n = 1 to 20)

$$T \text{ Pulse } (n^{th} \text{ IPG}) = \text{FRAMTI} - 15559 + (n-1)\ (102405)$$

High Rate (n = 1 to 320)

$$T \text{ Pulse } (n^{th} \text{ IPG}) = \text{FRAMTI} - 5319 + (n-1)\ (10240.5).$$

RSE. - Range Servo Error. RSE represents the tracking error in centimeters generated upon receipt of each return pulse. The tracking error is quantized in the altimeter in multiples of 23 centimeters (one way range). It is instructive to establish the time of the transmitted pulse for which (upon its return) the RSE is generated, and also to establish the time of the transmitted pulse at which this error is added to the existing altitude register range to establish a new range estimate.

There are two pulse periods between the time of the pulse for which the RSE is generated and the time the quantized error is included in a range estimate. That is, if pulse n, upon return to the satellite, generates RSE_n, then the estimated range that includes the RSE_n error occurs at pulse n+2. The estimated range dictates the time opening of the tracking and return pulse sampling gates as illustrated in Figure 2.

The time of the transmitted pulse for which the RSE's are generated is derived as follows (time in μsec):

$$T \text{ Pulse } (n^{th} \text{ RSE}) = \text{FRAMTI} - 15559 + (n-1)\ (10240.5)$$

where n = 1 through 320.

For more information on altimeter design and system analysis see Reference 16.

ANG. - Average Noise Gate Voltage. Four samples in low rate data, eight samples in high rate. Each sample is a one second average produced on-board the spacecraft. Timing is as follows:

Low Data Rate (Time in Seconds, n = 1, 2, 3, 4)

$$TANG_n = \text{FRAMTI} + .015 - \frac{1.0 \text{ Ave}}{2} + (n-1)\ (.512)$$

High Data Rate (Time in Seconds, n = 1 through 8)

$$TANG_n = FRAMTI + .025 - \frac{1.0 \text{ Ave.}}{2} + (n-1)\ (.410)$$

ARG. - Average Ramp Gate Voltage. Four samples in low rate data, eight samples in high rate. Each sample is a one second average produced on-board the spacecraft. Timing is as follows:

Low Data Rate (Time in Seconds, n = 1, 2, 3, 4)

$$TARG_n = FRAMTI + .025 - \frac{1.0 \text{ Ave.}}{2} + (n-1)\ (.512)$$

High Data Rate (Time in Seconds, n = 1 through 8)

$$TARG_n = FRAMTI + .128 - \frac{1.0 \text{ Ave.}}{2} + (n-1)\ (.410)$$

All Temperatures. - The value of all temperatures were erroneously truncated in the original distribution. New temperature values have been regenerated using a linear fit of the original data. The corrected temperature values are on the new "M" tapes.

REFERENCES

1. Saastomoinen, J.: Atmospheric Correction for the Troposphere and Stratosphere in Radio Ranging of Satellites, Geophysical Monograph #15, American Geophysical Union, Washington, D.C., 1972.
2. Vincent, S. and Marsh, J. G.: Global Detailed Gravimetric Geoid, NASA Goddard Space Flight Center, NASA-TM-X-70492, Sept. 1973.
3. Hendershott, H. C.: Tide Model Ocean Tides. Transactions of American Geophysical Union, Volume 54, No. 2, Feb. 1973, pp. 76-86.
4. Hayne, G. S.: Initial Development of a Method of Significant Waveheight Estimation for GEOS-III, NASA CR-141425, August 1977.
5. Fedor, L. S., Godbey, T. W., Gower, J. F. R., Guptill, R., Hayne, G. S., Rufenach, C. L., and Walsh, E. J.: "Satellite Altimeter Measurements of Sea State - An Algorithm Comparison," Journal of Geophysical Research, American Geophysical Union, Volume 84, Number B8, July 30, 1979.
6. Brown, G. S., and Curry, W. J.: The Estimation of Pointing Angle and $\sigma°$ from GEOS-3 Radar Altimeter Measurements, NASA CR-141426, August 1977.
7. Brown, G. S.: Correlation of $\sigma°$ (0°) Inferred Wind Speed Estimates with NOAA Hind-cast Data, NASA CR-141437, March 1978.
8. Brown, G. S.: "Estimation of Surface Wind Speeds Using Satellite-Borne Radar Measurements at Normal Incidence," Journal of Geophysical Research, American Geophysical Union, Volume 84, Number B8, July 30, 1979.
9. Parsons, C. L.: "On the Remote Detection of Swell by Satellite Radar Altimeter," Monthly Weather Review, Vol. 107, No. 9, September 1979.
10. Brown, G. S.: Private communication, Applied Science Associates, Apex, NC 27502.
11. Dwyer, R. E., and Godin, R. H.: Determining Sea Ice Boundaries and Ice Roughness Using GEOS-3 Altimeter Data, NASA CR-156862, March 1980.
12. Martin, C. F., and Butler, M. L.: Calibration Results for the GEOS-3 Altimeter, NASA CR-141430, September 1977.
13. Goad, C., and Martin, C. F.: The Wallops Island Tropospheric Refraction Study, NASA WFC Contract No. NAS6-2173, May 1974.
14. Lerch, F. J., Klosko, S. M., Laubscher, R. E., and Wagner, C. A.: Gravity Model Improvement Using GEOS-3 (GEM 9 & 10). GSFC X-921-77-246, September 1977.
15. Schwiderski, E. W.: The Preliminary M_2-Tide Model (A Synoptic Description), Naval Surface Weapons Center, Dahlgren, VA, February 1978.
16. Hofmeister, E. L., Keeney, B. N., Godbey, T. W., and Berg, R. J.: "Data Users Handbook and Design Error Analysis," GEOS-C Radar Altimeter Volume I, General Electric Co., Utica, NY, May 1976.

17. Leitao, C. D., Purdy, C. L., and Brooks, R. L.: Wallops GEOS-C Altimeter Preprocessing Report, NASA TM-X-69357, February 1974.

APPENDIX A

TEMPERATURE CALIBRATION TABLES

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS1		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
-0.2	-3.311	-3.479	-3.231	-3.228
-0.1	-1.595	-1.752	-1.655	-1.596
0.0	.119	0.024	0.017	0.024
0.1	1.867	1.754	1.701	1.765
0.2	3.599	3.457	3.332	3.232
0.3	5.013	4.975	4.949	4.653

REMARKS: TM SYSTEM SATURATES @ ±4 VOLTS

PARAMETER ARS2		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
-0.2	-3.410	-3.417	-3.192	-3.171
-0.1	-1.702	-1.754	-1.630	-1.607
0.0	- .0213	-0.043	-0.026	-0.026
0.1	1.693	1.650	1.622	1.683
0.2	3.396	3.328	3.262	3.165
0.3	5.040	4.808	4.816	4.539

REMARKS: TM SYSTEM SATURATES @ ±4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS3		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
-0.2	-3.307	-3.469	-3.211	-3.181
-0.1	-1.636	-1.754	-1.651	-1.591
0.0	0.013	0.001	-0.001	-0.003
0.1	1.697	1.717	1.680	1.727
0.2	3.372	3.395	3.302	3.188
0.3	4.966	4.916	4.857	4.326

REMARKS: TM SYSTEM SATURATES @ ±4 VOLTS

PARAMETER ARS4		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
-0.2	-3.349	-3.337	-3.098	-3.085
-0.1	-1.667	-1.694	-1.580	-1.569
0.0	-0.0017	-0.015	-0.017	-0.026
0.1	1.709	1.629	1.585	1.644
0.2	3.396	3.278	3.183	3.084
0.3	5.050	4.765	4.705	4.420

REMARKS: TM SYSTEM SATURATES @ ±4 VOLTS

(REV.5/10/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS5	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.241	−3.399	−3.170	−3.188
−0.1	-1.564	−1.721	−1.639	−1.613
0.0	.104	0.034	0.003	−0.008
0.1	1.813	1.738	1.672	1.718
0.2	3.516	3.446	3.317	3.206
0.3	5.038	4.938	4.863	4.554

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS6	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.452	−3.417	−3.175	−3.146
−0.1	-1.739	−1.771	−1.643	−1.625
0.0	- .0453	−0.052	−0.042	−0.047
0.1	1.701	1.634	1.601	1.671
0.2	3.433	3.306	3.240	3.166
0.3	5.078	4.783	4.776	4.528

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS7		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.478	−3.610	−3.367	−3.364
−0.1	-1.856	−1.973	−1.879	−1.829
0.0	- .2127	−0.231	−0.236	−0.241
0.1	1.454	1.456	1.418	1.474
0.2	3.114	3.151	3.062	2.999
0.3	4.772	4.694	4.627	4.287

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS8		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.292	−3.269	−3.029	−3.041
−0.1	-1.638	−1.658	−1.542	−1.535
0.0	- .0013	−0.008	0.000	−0.001
0.1	1.670	1.612	1.583	1.660
0.2	3.349	3.236	3.143	3.061
0.3	4.954	4.661	4.605	4.328

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS9		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.450	−3.610	−3.372	−3.354
−0.1	-1.695	−1.837	−1.751	−1.723
0.0	.0423	−0.026	−0.041	−0.058
0.1	1.808	1.735	1.669	1.746
0.2	3.570	3.468	3.331	3.223
0.3	4.998	4.998	4.940	4.570

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS10		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.424	−3.417	−3.178	−3.153
−0.1	-1.695	−1.732	−1.624	−1.594
0.0	.0220	0.017	0.019	0.006
0.1	1.790	1.728	1.695	1.752
0.2	3.530	3.435	3.347	3.264
0.3	5.028	4.953	4.924	4.658

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS11		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.275	−3.405	−3.194	−3.193
−0.1	-1.593	−1.708	−1.628	−1.599
0.0	.0673	0.069	0.046	0.007
0.1	1.763	1.783	1.717	1.740
0.2	3.451	3.481	3.356	3.225
0.3	5.021	4.964	4.910	4.602

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS12		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.401	−3.349	−3.095	−3.035
−0.1	-1.706	−1.724	−1.600	−1.557
0.0	- .0253	−0.032	−0.020	−0.009
0.1	1.688	1.621	1.597	1.677
0.2	3.418	3.275	3.198	3.145
0.3	5.093	4.770	4.719	4.464

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS13		TEST TEMPERATURE WST		
INPUT: FUNC- TIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.253	−3.376	−3.138	−2.097
−0.1	-1.599	−1.689	−1.599	−1.552
0.0	.069	0.009	0.000	0.096
0.1	1.754	1.666	1.560	1.639
0.2	3.416	3.314	3.178	2.142
0.3	5.013	4.825	4.725	2.264

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS14		TEST TEMPERATURE WST		
INPUT: FUNC- TIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.517	−3.465	−3.214	−3.176
−0.1	-1.769	−1.751	−1.639	−1.584
0.0	.0257	−0.014	−0.006	0.006
0.1	1.739	1.674	1.651	1.735
0.2	3.492	3.359	3.277	3.217
0.3	5.091	4.859	4.840	4.580

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER ARS15		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.357	−3.450	−3.195	−3.122
−0.1	-1.687	−1.772	−1.658	−1.551
0.0	- .0273	−0.009	−0.001	0.030
0.1	1.660	1.690	1.644	1.755
0.2	3.356	3.389	3.282	3.232
0.3	4.984	4.897	4.819	4.589

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

PARAMETER ARS16		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	-3.263	−3.233	−3.004	−2.983
−0.1	-1.598	−1.628	−1.506	−1.457
0.0	.040	0.020	0.029	0.063
0.1	1.705	1.633	1.597	1.716
0.2	3.360	3.218	3.134	3.105
0.3	4.848	4.820	4.592	4.384

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS1	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	− .824	−0.886	−0.821	−0.819
−0.1	− .408	−0.440	−0.421	−0.356
0.0	.036	0.003	0.000	0.008
0.1	.463	0.446	0.429	0.445
0.2	.914	0.876	0.848	0.847
0.3	1.333	1.258	1.248	1.184
0.35	1.504	1.412	1.420	1.288
0.4	1.675	1.567	1.505	1.391
0.45	1.680	1.575	1.539	1.402
0.5	1.686	1.583	1.545	1.413
0.6	1.702	1.600	1.547	1.423

PARAMETER IRS2	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.862	−0.874	−0.815	−0.816
−0.1	−0.431	−0.451	−0.417	−0.405
0.0	0.013	−0.019	0.000	0.000
0.1	0.424	0.417	0.411	0.430
0.2	0.859	0.841	0.825	0.793
0.3	1.277	1.217	1.219	1.159
0.35	1.407*	1.375*	1.412	1.211*
0.4	1.538	1.533†	1.433	1.263
0.45	1.546*	1.533*	1.446†	1.269*
0.5	1.555	1.533†	1.446†	1.275
0.6	1.563	1.533†	1.446†	1.284

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS3		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
–0.2	–0.848	–0.875	–0.812	–0.778
–0.1	–0.410	–0.445	–0.426	–0.400
0.0	0.019	–0.003	0.001	–0.004
0.1	0.449	0.434	0.422	0.429
0.2	0.848	0.860	0.830	0.802
0.3	1.272	1.237	1.228	1.085
0.35	1.434*	1.356 *	1.347	1.118 *
0.4	1.595	1.475 †	1.367 †	1.152
0.45	1.597*	1.475 †	1.367 †	1.155 *
0.5	1.598	1.475 †	1.367 †	1.158 †
0.6	1.600	1.475 †	1.367 †	1.158 †

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS4		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
–0.2	–0.841	–0.848	–0.784	–0.769
–0.1	–0.440	–0.433	–0.400	–0.400
0.0	–0.011	–0.014	–0.015	–0.013
0.1	0.433	0.405	0.396	0.419
0.2	0.850	0.832	0.805	0.780
0.3	1.273	1.196	1.193	1.049
0.35	1.460	1.373 *	1.374	1.148 *
0.4	1.647	1.550	1.434	1.246
0.45	1.665	1.557 *	1.439	1.253 *
0.5	1.684	1.564 †	1.445	1.260
0.6	1.684	1.564 †	1.451	1.264

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS5	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.818	−0.865	−0.806	−0.815
−0.1	−0.399	−0.447	−0.421	−0.407
0.0	0.030	0.012	−0.006	0.019
0.1	0.444	0.444	0.419	0.434
0.2	0.890	0.865	0.837	0.765
0.3	1.303	1.251	1.228	1.142
0.35	1.465*	1.420 •	1.422	1.260 •
0.4	1.627	1.589	1.512	1.378
0.45	1.637*	1.602 *	1.560	1.380 •
0.5	1.646	1.616 †	1.563	1.383 †
0.6	1.653	1.616 †	1.571	1.383 †

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS6	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.885	−0.873	−0.816	−0.809
−0.1	−0.440	−0.455	−0.417	−0.410
0.0	−0.030	−0.008	−0.020	0.013
0.1	0.435	0.408	0.406	0.416
0.2	0.871	0.834	0.823	0.792
0.3	1.299	1.214	1.218	1.153
0.35	1.433*	1.370 *	1.413	1.258 *
0.4	1.567†	1.527	1.503	1.364
0.45	1.567†	1.536 •	1.525 †	1.367 •
0.5	1.567†	1.544 †	1.525 †	1.370 †
0.6	1.567†	1.544 †	1.525 †	1.370 †

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS7	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.881	−0.913	−0.856	−0.904
−0.1	−0.474	−0.501	−0.471	−0.446
0.0	−0.068	−0.046	−0.054	−0.167
0.1	0.368	0.363	0.354	0.368
0.2	0.779	0.797	0.771	0.748
0.3	1.205	1.188	1.168	1.086
0.35	1.384*	1.376*	1.357	1.132*
0.4	1.563	1.563	1.491	1.177
0.45	1.587*	1.580*	1.510†	1.192*
0.5	1.611†	1.596	1.510†	1.208
0.6	1.611†	1.604	1.510†	1.223

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS8	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.833	−0.828	−0.771	−0.778
−0.1	−0.420	−0.415	−0.400	−0.382
0.0	0.006	−0.001	−0.006	−0.001
0.1	0.400	0.405	0.406	0.416
0.2	0.845	0.827	0.799	0.800
0.3	1.250	1.187	1.174	1.099
0.35	1.417*	1.332*	1.324	1.130*
0.4	1.583	1.478†	1.351	1.162†
0.45	1.600*	1.478†	1.359†	1.162†
0.5	1.616	1.478†	1.359†	1.162†
0.6	1.616	1.478†	1.359†	1.162†

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS9		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
–0.2	-0.868	–0.921	–0.852	–0.858
–0.1	-0.444	–0.462	–0.440	–0.444
0.0	-0.001	–0.004	–0.010	–0.009
0.1	0.432	0.439	0.418	0.433
0.2	0.890	0.880	0.838	0.843
0.3	1.306	1.259	1.250	1.153
0.35	1.506*	1.406 •	1.409	1.214 •
0.4	1.705	1.552 †	1.436	1.274
0.45	1.709*	1.552 †	1.452	1.280 •
0.5	1.710	1.552 †	1.459 †	1.285
0.6	1.722	1.552 †	1.459 †	1.291

• INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS10		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
–0.2	-0.867	–0.867	–0.812	–0.809
–0.1	-0.426	–0.444	–0.411	–0.369
0.0	0.020	–0.007	0.003	–0.006
0.1	0.460	0.435	0.423	0.445
0.2	0.883	0.870	0.849	0.817
0.3	1.332	1.245	1.239	1.182
0.35	1.456*	1.411 •	1.452	1.288 •
0.4	1.582	1.577	1.538	1.394
0.45	1.584*	1.582 •	1.555 †	1.408 •
0.5	1.585	1.588 †	1.555 †	1.423 †
0.6	1.593	1.588 †	1.555 †	1.423 †

• INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS11		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.839	−0.867	−0.815	−0.809
−0.1	−0.392	−0.440	−0.411	−0.428
0.0	0.012	0.012	0.008	0.008
0.1	0.444	0.449	0.433	0.445
0.2	0.883	0.876	0.855	0.820
0.3	1.285	1.257	1.242	1.187
0.35	1.450*	1.440 •	1.452	1.281 •
0.4	1.613	1.623	1.551	1.375 †
0.45	1.630*	1.633 •	1.574	1.375 †
0.5	1.645	1.643	1.575	1.375 †
0.6	1.650	1.660	1.584	1.375 †

• INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS12		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.844	−0.844	−0.780	−0.767
−0.1	−0.430	−0.438	−0.396	−0.394
0.0	0.005	−0.010	−0.001	0.006
0.1	0.443	0.408	0.405	0.429
0.2	0.845	0.825	0.811	0.800
0.3	1.289	1.196	1.188	1.164
0.35	1.478*	1.368 •	1.374	1.208 •
0.4	1.669	1.539	1.440 †	1.251
0.45	1.681*	1.541 •	1.440 †	1.256 •
0.5	1.692†	1.544	1.440 †	1.260
0.6	1.692†	1.546	1.440 †	1.262

• INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS13	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	35°	45°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.819	−0.842	−0.810	−0.789
−0.1	−0.411	−0.429	−0.409	−0.397
0.0	0.000	0.017	0.001	−0.001
0.1	0.439	0.416	0.407	0.397
0.2	0.863	0.838	0.806	0.802
0.3	1.259	1.214	1.205	1.188
0.35	1.423*	1.310	1.275	1.231
0.4	1.585†	1.407	1.329	1.254
0.45	1.585†	1.415	1.335	1.262
0.5	1.585†	1.423	1.336	1.271
0.6	1.585†	1.430	1.340	1.275

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS14	TEST TEMPERATURE WST			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.892	−0.875	−0.820	−0.802
−0.1	−0.443	−0.450	−0.413	−0.405
0.0	−0.001	−0.008	0.000	−0.003
0.1	0.434	0.422	0.421	0.426
0.2	0.899	0.847	0.830	0.815
0.3	1.304	1.221	1.221	1.162
0.35	1.446*	1.373 *	1.414	1.219 *
0.4	1.588	1.525 †	1.442 †	1.276
0.45	1.590*	1.525 †	1.442 †	1.278 *
0.5	1.593	1.525 †	1.442 †	1.280 †
0.6	1.593	1.525 †	1.442 †	1.280 †

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETER IRS15		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.858	−0.875	−0.811	−0.791
−0.1	−0.437	−0.445	−0.421	−0.405
0.0	−0.007	−0.007	−0.003	0.002
0.1	0.429	0.422	0.412	0.458
0.2	0.869	0.854	0.827	0.814
0.3	1.255	1.248	1.217	1.163
0.35	1.435*	1.430 *	1.428	1.256 *
0.4	1.616	1.611	1.535	1.350
0.45	1.628*	1.626 *	1.550	1.356 *
0.5	1.640	1.640 †	1.564 †	1.362
0.6	1.640	1.640 †	1.564 †	1.374

• INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

PARAMETER IRS16		TEST TEMPERATURE WST		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	63°
	ENGINEERING UNITS (VOLTS)			
−0.2	−0.832	−0.820	−0.762	−0.766
−0.1	−0.402	−0.412	−0.389	−0.372
0.0	−0.005	0.010	0.003	0.000
0.1	0.415	0.415	0.400	0.434
0.2	0.847	0.814	0.789	0.792
0.3	1.267	1.174	1.170	1.119
0.35	1.456*	1.349 *	1.354	1.178 *
0.4	1.644	1.524	1.414	1.236
0.45	1.664*	1.531 *	1.451 †	1.244 *
0.5	1.686	1.538	1.451 †	1.251
0.6	1.698	1.541	1.451 †	1.267

* INTERPOLATED DATA
† LAST DATA BEFORE REVERSAL

TEMPERATURE CALIBRATION TABLES

PARAMETER RAGC		TEST TEMPERATURE RRT			
INPUT: FUNC-TIONAL (Dbm)	TEMPERATURE °C				
	0.	15.2	25.9	36.4	49.2
	ENGINEERING UNITS (VOLTS)				
−95.	-2.605	−2.922	−3.712	−3.212	−3.724
−89.	-1.481	−1.690	−2.214	−2.122	−2.568
−83.	-0.351	−0.458	−0.716	−1.032	−1.412
−77.	0.580	0.397	0.203	−0.058	−0.374
−71.	1.511	1.242	0.967	0.664	0.330
−65.	2.572	2.090	1.686	1.332	0.947
−59.	3.577	2.889	2.410	1.976	1.557
−53.	4.592	3.699	3.150	2.613	2.164
−47.	5.607	4.509	3.890	3.251	2.772
−41.	6.621	5.319	4.630	3.883	3.379
−17.	10.680	8.559	7.590	6.439	5.810

REMARKS: SHORT PULSE MODE

PARAMETER RAGC		TEST TEMPERATURE RRT			
INPUT: FUNC-TIONAL (Dbm)	TEMPERATURE °C				
	0.	15.3	26.1	36.6	51.4
	ENGINEERING UNITS (VOLTS)				
−95.	-1.088	−1.300	−1.470	−1.950	−2.400
−89.	-0.268	−0.409	−0.588	−0.927	−1.528
−83.	0.520	0.415	0.205	−0.113	−0.648
−77.	1.448	1.216	0.947	0.574	0.045
−71.	2.463	2.025	1.651	1.228	0.656
−65.	3.359	2.783	2.338	1.858	1.241
−59.	4.100	3.483	2.993	2.479	1.825
−53.	4.937	4.210	3.690	3.110	2.385
−47.	5.778	4.930	4.370	3.745	2.955
−41.	6.620	5.650	5.050	4.370	3.520
−17.	9.984	8.530	7.770	6.910	5.805

REMARKS: LONG PULSE MODE

TEMPERATURE CALIBRATION TABLES

PARAMETER RTP		TEST TEMPERATURE RTT		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	−25.0 °C	+25.0 °C	+50.0 °C	+75.0 °C
	ENGINEERING UNITS (VOLTS)			
+54.7	−0.065	0.130	0.158	0.178
57.7	0.285	0.483	0.493	0.500
58.7	0.458	0.644	0.650	0.659
59.7	0.650	0.829	0.807	0.832
60.7	0.860	1.014	1.000	1.020
61.7	1.101	1.240	1.230	1.250
62.7	1.370	1.490	1.450	1.500
63.7	1.680	1.800	1.730	1.790
64.7	2.020	2.120	2.040	2.110
65.7	2.410	2.470	2.480	2.450
66.7	2.810	2.860	2.850	2.830

REMARKS: LONG PULSE MODE

PARAMETER RTP		TEST TEMPERATURE RTT		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	−25.0 °C	+25.0 °C	+50.0 °C	+75.0 °C
	ENGINEERING UNITS (VOLTS)			
+54.7	−0.140	0.072	0.075	0.075
57.7	0.222	0.432	0.403	0.390
58.7	0.385	0.592	0.555	0.540
59.7	0.577	0.784	0.734	0.700
60.7	0.798	0.990	0.930	0.886
61.7	1.032	1.220	1.150	1.101
62.7	1.310	1.490	1.400	1.340
63.7	1.620	1.780	1.700	1.610
64.7	1.960	2.110	2.020	1.930
65.7	2.350	2.390	2.380	2.290
66.7	2.760	2.780	2.750	2.660

REMARKS: SHORT PULSE MODE

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETERS ANG	TEST TEMPERATURE GTT			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	12°	39°	56°
	ENGINEERING UNITS (VOLTS)			
−0.2	−3.629	−3.701	−3.575	−1.134
−0.1	−1.956	−2.054	−1.988	−0.583
−0.0	−0.024	−0.012	−0.009	−0.013
0.1	1.982	2.038	2.022	0.662
0.2	4.001	4.039	3.992	1.236
0.3	4.998	4.998	4.998	1.799
0.35	4.998	4.998	4.998	2.552
0.4	4.998	4.998	4.998	3.305
0.45	4.998	4.998	4.998	3.305
0.5	4.998	4.998	4.998	3.305
0.6	4.998	4.998	4.998	3.305

PARAMETERS AASG	TEST TEMPERATURE GTT			
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	12°	39°	56°
	ENGINEERING UNITS (VOLTS)			
−0.2	−3.758	−3.709	−3.546	−3.437
−0.1	−2.280	−2.233	−2.109	−2.105
0.0	−0.062	−0.043	−0.025	−0.015
0.1	2.208	2.114	2.106	2.244
0.2	4.411	4.191	4.144	4.108

REMARKS: TM SYSTEM SATURATES @ ± 4 VOLTS

(REV. 3/3/76)

TEMPERATURE CALIBRATION TABLES

PARAMETERS APG		TEST TEMPERATURE ITT		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	65°
	ENGINEERING UNITS (VOLTS)			
−0.2	-2.001	−2.054	−1.952	−1.993
−0.1	-1.190	−1.203	−1.121	−1.031
0.0	-0.125	−0.110	−0.086	0.010
0.1	0.990	0.970	0.951	1.088
0.2	1.988	1.945	1.903	1.983
0.3	2.965	2.887	2.926	3.076
0.35	3.495	3.728	3.702	4.037
0.4	4.022	4.570	4.685	4.998

REMARKS: SHORT PULSE MODE

PARAMETERS APG	TEST TEMPERATURE GTT
TEMPERATURE 32.4 °C	
FUNCTIONAL (VOLTS)	ENGINEERING UNITS (VOLTS)
−0.2	−3.295
−0.1	−1.633
0.0	0.045
0.1	1.677
0.2	3.305
0.3	5.000
0.35	5.000
0.4	5.000
0.45	5.000
0.5	5.000

REMARKS: LONG PULSE MODE

TEMPERATURE CALIBRATION TABLES

PARAMETER ARG		TEST TEMPERATURE ITT		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	65°
	ENGINEERING UNITS (VOLTS)			
−0.2	−1.964	−2.047	−1.926	−1.953
−0.1	−1.163	−1.195	−1.093	−0.993
0.0	−0.087	−0.072	−0.031	−0.046
0.1	1.095	1.043	1.059	1.154
0.2	2.014	2.014	2.017	2.042
0.3	2.874	2.897	3.020	3.052
0.35	3.215	3.480	3.531	3.919
0.4	3.558	4.063	4.144	4.786
0.5	4.998	4.998	4.998	4.998

REMARKS: SHORT PULSE MODE

PARAMETER ARG	TEST TEMPERATURE GTT
TEMPERATURE 32.4 °C	
FUNCTIONAL (VOLTS)	ENGINEERING UNITS (VOLTS)
−0.2	−3.233
−0.1	−1.606
0.0	0.017
0.1	1.612
0.2	3.205
0.3	5.000
0.35	5.000
0.4	5.000
0.45	5.000
0.5	5.000
0.6	5.000

REMARKS: LONG PULSE MODE

TEMPERATURE CALIBRATION TABLES

PARAMETER IPG		TEST TEMPERATURE ITT		
INPUT: FUNCTIONAL VOLTS	TEMPERATURE °C			
	0°	20°	45°	65°
	ENGINEERING UNITS (VOLTS)			
–0.2	–0.954	–0.969	–0.924	–0.931
–0.1	–0.537	–0.555	–0.498	–0.426
0.0	–0.004	–0.017	0.026	0.065
0.1	0.536	0.549	0.560	0.603
0.2	1.055	1.048	1.040	1.064
0.3	1.576	1.528	1.541	1.599
0.35	1.845	1.952	1.938	2.161
0.4	2.114	2.376	2.435	2.723
0.45	2.653	2.870	3.087	3.218
0.5	3.191	3.363	3.485	3.714
0.6	3.587	3.659	3.836	4.138

REMARKS: SHORT PULSE MODE

PARAMETER IPG	TEST TEMPERATURE GTT
TEMPERATURE 32.4 °C	
FUNCTIONAL (VOLTS)	ENGINEERING UNITS (VOLTS)
ENGINEERING UNITS (VOLTS)	
–0.2	–1.347
–0.1	–0.750
0.0	–0.004
0.1	1.022
0.2	1.854
0.3	2.719
0.35	2.965
0.4	3.232
0.45	3.320
0.5	3.472
0.6	3.510

REMARKS: LONG PULSE MODE

(REV. 3/3/76)

APPENDIX B

TIMING ANALYSIS DATA

The tables and figures presented in this Appendix were prepared by the Computer Sciences Corporation, Falls Church, Virginia.

Both should be self-explanatory and are organized as follows:

Table 1	-	Mode 1 Telemetry
Table 2	-	Mode 2 Telemetry
Table 2.1	-	Modes 2 and 3, Word 22 (SCS)
Table 2.2	-	Modes 2 and 3, Word 42 (ASCO)
Table 2.3	-	Modes 2 and 3, Word 62 (ASC1)
Table 2.4	-	Modes 2 and 3, Word 82 (ASC3)
Table 3	-	Mode 3 Telemetry
Figure 1	-	Describes Altimeter Parameters on a Minor Frame basis relative to the transmitted pulse to which the parameter corresponds (Mode 1)
Figure 2	-	Same as Figure 1 but for Mode 2
Figure 3	-	Same as Figure 1 but for Mode 3

Comments relative to Figures 1, 2, and 3 are as follows:

- An X in a parameter row indicates the parameter is telemetered each minor frame and corresponds to the indicated transmitted pulse.
- Multiple X's in a parameter row indicate the parameter is telemetered more than once each minor frame (e.g., 5 X's means 5 times per minor frame). Reading left to right, the first X represents the first time the parameter appears in a minor frame, the second X represents the second time, etc. The array of X's are aligned with the transmitted pulses to which they correspond.
- An X with a superscript in a parameter row indicates the parameter is subcommutated and does not appear each minor frame. The superscript number indicates the minor frame in which the parameter does appear. The superscripts run from 0-3 for Mode 1 Telemetry and 0-63 for Modes 2 and 3 Telemetry.
- The tables show the total array of altimeter data that is telemetered on a major frame basis (i.e., minor frames 0-3 for Mode 1 and minor frames 0-63 for Modes 2 and 3) and shows precisely what data is telemetered with respect to a given altimeter transmitted pulse. On a major frame basis, the total array is exactly repetitive.

TABLE 1 - MODE 1 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 1)
4	RTP	LS	T + 5(B1) + 32	T - W1 - 198.4	Average	Use T of LETP	0
5	AS		T + 5(W1)	N/A	Status		
6	ANG	LS	T + 4(W1) + B1 + 32	T + 3(W1) - 198.4	Average	Use T of LETP	2
7							
8	ARG	LS	T + 6(W1) + B1 + 32	T + 5(W1) - 198.4	Average	Use T of LETP	3
9	IPG	HS	T - W1 + 24	T - 3(W1) - 198.4	Instant	Use T of LETP	-1
10	APG	LS	T + 8(W1) + B1 + 32	T + 7(W1) - 198.4	Average	Use T of LETP	4
11	CALTd			T + 1(W1) - 198.4	Cumulative	Use T of LETP	1
12	AASG	LS	T + 10(W1) + B1 + 32	T + 9(W1) - 198.4	Average	Use T of LETP	5
13	CALTc			T + 1(W1) - 198.4	Cumulative	Use T of LETP	1
14	CCSS	LS	T + 12(W1) + B1 + 32	N/A	Average		
15	CALTb			T + 1(W1) - 198.4	Cumulative	Use T of LETP	1
16	CCRR	LS	T + 14(W1) + B1 + 32	N/A	Average		
17	CALTa			T + 1(W1) - 198.4	Cumulative	Use T of LETP	1
18	RAGC	LS	T + 16(W1) + B1 + 32	T + 15(W1) - 198.4	Average	Use T of LETP	8
19	RSE	HS	T + 9(W1) + 24	T + 5(W1) - 198.4	Instant	Use T of LETP, this is loop correction for reference LETP	3

LEGEND

LS Converter Aperture = 2048 μsec
HS Converter Aperture = 280 μsec
W1 = 5120.256 μsec
B1 = 640.032 μsec
T = Minor Frame Start Time

TABLE 1 - MODE 1 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 1)
20	NCSS	LS	T + 18(W1) + B1 + 32	N/A	Average		
21	FFID						
22	NCRR	LS	T + 20(W1) + B1 + 32	N/A	Average		
23	CP						
24	ASCO	LS	T + 22(W1) + B1 + 32	T + 21(W1) - 198.4		AV1 for minor frame (MF) 0, use T of SOA, other MF N/A to RA	11
25	AS		T + 25(W1)	N/A	Status		
26	ASC1	LS	T + 24(W1) + B1 + 32	T + 23(W1) - 198.4		AV2 for MF 0, use T of SOA, other MF N/A to RA	12
27	DSC		T + 27(W1)	N/A	Status	RA on/off for MF 2 (bit 1 of this channel), other MF N/A to RA	
28	ASCO	LS	T + 26(W1) + B1 + 32	T + 25(W1) - 198.4		AV3 for MF0, use T of SOA, ASAD1 for MF1 use SOA, other MF N/A to RA	13
29	IPG	HS	T + 19(W1) + 24	T + 17(W1) - 198.4	Instant	Use T of LETP	9
30	ASC1	LS	T + 28(W1) + B1 + 32	T + 27(W1) - 198.4		AV4 for MF0, use T of LETP, other MF N/A to RA	14
31	CALTd			T + 21 (W1) - 198.4	Cumulative	Use T of LETP	11
32	ASCO	LS	T + 30(W1) - B1 + 32	T + 29(W1) - 198.4		AV5 for MF0, use T of LETP, ASAD2 for MF1 use SOA, other MF N/A to RA	15
33	CALTc			T + 21 (W1) - 198.4	Cumulative	Use T of LETP	11
34	ASC1	LS	T + 32(W1) + B1 + 32	T + 31(W1) - 198.4		RAGC HIV for MF0 use LETP, CCBT for MF3 use SOA	16
35	CALTb			T + 21 (W1) - 198.4	Cumulative	Use T of LETP	11
36	ASC2	LS	T + 34(W1) + B1 + 32	N/A		N/A to RA	
37	CALTa			T + 21 (W1) - 198.4	Cumulative	Use T of LETP	11
38	RAGC	LS	T + 36(W1) + B1 + 32	T + 35(W1) - 198.4	Average	Use T of LETP	18
39	RSE	HS	T + 29(W1) + 24	T + 25(W1) - 198.4	Instant	Use T of LETP, this is loop correction for reference LETP	13

TABLE 1 - MODE 1 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 1)
40	ASCO	LS	T + 38(W1) + B1 + 32	T + 37(W1) - 198.4		RAGC for MF0, use T of LETP; ASAD3 for MF1, use SOA; BCT for MF3, use T of LETP; other MF N/A to RA	19,169
41	TCGa						
42	ASC1	LS	T + 40(W1) + B1 + 32	N/A		N/A to RA, NCBT for MF3 use SOA	
43	DSADa		T - 36(W1)	N/A			
44	ASCO	LS	T + 42(W1) + B1 + 32	T + 41(W1) - 198.4		RTP for MF 0, use T of LETP; RTT for MF 3, use T of LEPT; other MF N/A to RA	21,171
45	AS		T + 45(W1)	N/A	Status		
46	ASC1	LS	T + 44(W1) + B1 + 32	T + 43(W1) - 198.4		RSA for MF 0, use T of LETP; other MF N/A to RA	22
47	DCS		T + 47(W1)		Status	N/A to RA	
48	ASCO	LS	T + 46(W1) + B1 + 32	T + 45(W1) - 198.4		RRT for MF 3, use T of LETP; other MF N/A to RA	173
49	IPG	HS	T + 39(W1) + 24	T + 37(W1) - 198.4	Instant	Use T of LETP	19
50	ASC1	LS	T + 48(W1) + B1 + 32	N/A		N/A to RA	
51	CALTd			T + 41(W1) - 198.4	Cumulative	Use T of LETP	21
52	ASCO	LS	T + 50(W1) + B1 + 32	T + 49(W1) - 198.4		IFTA for MF0, use T of LETP; GTT for MF3, use T of LETP; other MF N/A to RA	25,175
53	CALTc			T + 41(W1) - 198.4	Cumulative	Use T of LETP	21
54	ASC1	LS	T + 52(W1) + B1 + 32	T + 51(W1) - 198.4		VTA for MF 0, use T of LETP; other MF N/A to RA	26
55	CALTb			T + 41(W1) - 198.4	Cumulative	Use T of LETP	21
56	ASC2	LS	T + 54(W1) + B1 + 32	T + 53(W1) - 198.4		RI for MF 2, use T of LETP; other MF N/A to RA	127
57	CALTa			T + 41(W1) - 198.4	Cumulative	Use T of LETP	21
58	RAGC	LS	T + 56(W1) + B1 + 32	T + 55(W1) - 198.4	Average	Use T of LETP	28
59	RSE	HS	T + 49(W1) + 24	T + 45(W1) - 198.4	Instant	Use T of LETP, this is loop correction for reference LETP	23

TABLE 1 - MODE 1 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 1)
60	ASCO	LS	T + 58(W1) + B1 + 32	T + 57(W1) - 198.4		ARS1 for MF 0, use T of LETP; ITT for MF 3, use T of LETP; other MF N/A to RA	29,179
61	TCGb						
62	ASC1	LS	T + 60(W1) + B1 + 32	T + 59(W1) - 198.4		ARS2 for MF 0, use T of LETP; AMT 1 for MF 3, use T of LETP; other MF N/A to RA	30,180
63	DSADb		T - 36(W1)	N/A			
64	ASCO	LS	T + 62(W1) + B1 + 32	T + 61(W1) - 198.4		ARS3 for MF 0, use T of LETP; WST for MF 3, use T of LETP; other MF N/A to RA	31,181
65	AS		T + 65(W1)	N/A	Status		
66	ASC1	LS	T + 64(W1) + B1 + 32	T + 63(W1) - 198.4		ARS4 for MF0, use T of LETP; XMAG for MF2 use SOA; AMT 2 for MF3, use T of LETP; other MF N/A to RA	32,182
67	DSC		T + 67(W1)		Status	N/A to RA	
68	ASCO	LS	T + 66(W1) + B1 + 32	T + 65(W1) - 198.4		ARS5 for MF0, use T of LETP; other MF N/A to RA	33
69	IPG	HS	T + 59(W1) + 24	T + 57(W1) - 198.4	Instant	Use T of LETP	29
70	ASC1	LS	T + 68(W1) + B1 + 32	T + 67(W1) - 198.4		ARS6 for MF0, use T of LETP; YMAG for MF2 use SOA; other MF N/A to RA	34
71	CALTd			T + 61 (W1) - 198.4	Cumulative	Use Tof LETP	31
72	ASCO	LS	T + 70(W1) + B1	T + 69(W1) - 198.4		ARS7 for MF0, use T of LETP; other MF N/A to RA	35
73	CALTc			T + 61 (W1) - 198.4	Cumulative	Use T of LETP	31
74	ASC1	LS	T + 72(W1) + B1 + 32	T + 71(W1) - 198.4		ARS8 for MF0, use T of LETP; ZMAG for MF2 use SOA; other MF N/A to RA	36
75	CALTb			T + 61 (W1) - 198.4	Cumulative	Use T of LETP	31
76	ASC2	LS	T + 74(W1) + B1 + 32	T + 73(W1) - 198.4		RMI for MF2, use T of LETP; other MF N/A to RA	137
77	CALTa			T + 61 (W1) - 198.4	Cumulative	Use T of LETP	31
78	RAGC	LS	T + 76(W1) + B1 + 32	T + 75(W1) - 198.4	Average	Use T of LETP	38
79	RSE	HS	T + 69(W1) + 24	T + 65(W1) - 198.4	Instant	Use T of LETP, this is loop correction for reference LETP	33

TABLE 1 - MODE 1 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 1)
80	ASCO	LS	T + 78(W1) + B1 + 32	T + 77(W1) - 198.4		ARS9 for MF 0, use T of LETP; other MF N/A to RA	39
81	TCGc						
82	ASC1	LS	T + 80(W1) + B1 + 32	T + 79(W1) - 198.4		ARS10 for MF0, use T of LETP; EBV2 for MF1 use LETP; other MF N/A to RA	40,90
83							
84	ASCO	LS	T + 82(W1) + B1 + 32	T + 81(W1) - 198.4		ARS11 for MF 0, use T of LETP; other MF N/A to RA	41
85	AS		T + 85(W1)	N/A	Status		
86	ASC1	LS	T + 84(W1) + B1 + 32	T + 83(W1) - 198.4		ARS12 for MF 0, use T of LETP; other MF N/A to RA	42
87	DSC		T + 87(W1)		Status	Various RA status for MF 3 (bits 0 thru 4 of this channel); other MF N/A to RA	
88	ASCO	LS	T + 86(W1) + B1 + 32	T + 85(W1) - 198.4		ARS13 for MF 0, use T of LETP; other MF N/A to RA	43
89	IPG	HS	T + 79(W1) + 24	T + 77(W1) - 198.4	Instant	Use T of LETP	39
90	ASC1	LS	T + 88(W1) + B1 + 32	T + 87(W1) - 198.4		ARS14 for MF 0, use T of LETP; other MF N/A to RA	44
91	CALTd			T + 81 (W1) - 198.4	Cumulative	Use T of LETP	41
92	ASCO	LS	T + 90(W1) + B1 + 32	T + 89(W1) - 198.4		ARS15 for MF 0, use T of LETP; other MF N/A to RA	45
93	CALTc			T + 81 (W1) - 198.4	Cumulative	Use T of LETP	41
94	ASC1	LS	T + 92(W1) + B1 + 32	T + 91(W1) - 198.4		ARS16 for MF 0, use T of LETP; other MF N/A to RA	46
95	CALTb			T + 81 (W1) - 198.4	Cumulative	Use T of LETP	41
96	ASC2	LS	T + 94(W1) + B1 + 32	N/A		N/A to RA	
97	CALTa			T + 81 (W1) - 198.4	Cumulative	Use T of LETP	41
98	RAGC	LS	T + 96(W1) + B1 + 32	T + 95(W1) - 198.4	Average	Use T of LETP	48
99	RSE	HS	T + 89(W1) + 24	T + 85(W1) - 198.4	Instant	Use T of LETP, this is loop correction for reference LETP	43

TABLE 2 - MODE 2 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 2)
3	RSE	HS	T - W2 + 24	T - 30(W2) - 198.4	Instant	Use T of LETP	-1
4	IRS2	HS	T + 3(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
5	IRS4	HS	T + 4(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
6	IRS6	HS	T + 5(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
7	IRS8	HS	T + 6 (W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
8	IRS10	HS	T + 7(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
9	IRS12	HS	T + 8(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
10	IRS14	HS	T + 9(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
11	IRS16	HS	T + 10(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
12	IRS1	HS	T + 11(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
13	IRS3	HS	T + 12(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
14	IRS5	HS	T + 13(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
15	IRS7	HS	T + 14(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
16	IRS9	HS	T + 15(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
17	IRS11	HS	T + 16(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
18	IRS13	HS	T + 17(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
19	IRS15	HS	T + 18(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0

LEGEND

LS Converter Aperture = 2048 μsec
HS Converter Aperture = 280 μsec
W2 = 512.0256 μsec
B2 = 64.0032 μsec
T = Minor Frame Start Time

TABLE 2 - MODE 2 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 2)
20	CP						
21	FFID						
22	SCS	LS & Dig.	T + 4(B2) + 32	T - 10(W2) - 198.4		See Table 2.1	
23	RSE	HS	T + 19(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
24	IRS2	HS	T + 23(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
25	IRS4	HS	T + 24(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
26	IRS6	HS	T + 25(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
27	IRS8	HS	T + 26(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
28	IRS10	HS	T + 27(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
29	IRS12	HS	T + 28(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
30	IRS14	HS	T + 29(W2) +24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
31	IRS16	HS	T + 30(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
32	IRS1	HS	T + 31(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
33	IRS3	HS	T + 32(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
34	IRS5	HS	T + 33(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
35	IRS7	HS	T + 34(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
36	IRS9	HS	T + 35(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
37	IRS11	HS	T + 36(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
38	IRS13	HS	T + 37(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
39	IRS15	HS	T + 38(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1

TABLE 2 - MODE 2 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 2)
40	AS		T + 40(W2)	N/A	Status		
41	TCGa						
42	ASCO	LS	T + 22(W2) + B2 + 32	T + 10(W2) - 198.4		See Table 2.2	
43	RSE	HS	T + 39(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
44	IRS2	HS	T + 43(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
45	IRS4	HS	T + 44(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
46	IRS6	HS	T + 45(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
47	IRS8	HS	T + 46(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
48	IRS10	HS	T + 47(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
49	IRS12	HS	T + 48(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
50	IRS14	HS	T + 49(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
51	IRS16	HS	T + 50(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
52	IRS1	HS	T + 51(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
53	IRS3	HS	T + 52(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
54	IRS5	HS	T + 53(W2) + 24	T +30(W2) - 198.4	Instant	Use T of LETP	2
55	IRS7	HS	T + 54(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
56	IRS9	HS	T + 55(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
57	IRS11	HS	T + 56(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
58	IRS13	HS	T + 57(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
59	IRS15	HS	T + 58(W2) + 24	T + 30 (W2) - 198.4	Instant	Use T of LETP	2

TABLE 2 - MODE 2 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON-VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP No. (See Fig. 2)
60	CALTd/ CALTb		N/A	See Comments	Cumulative	Even MF = CALTd, use T + 10(W2) - 198.4 Odd MF = CALTb, use T - 90(W2) - 198.4	1 -4
61	TCGB						
62	ASC1	LS	T + 42(W2) + B2 + 32	T + 30(W2) - 198.4		See Table 2.3	
63	RSE	HS	T + 59(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
64	IRS2	HS	T + 63(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
65	IRS4	HS	T + 64(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
66	IRS6	HS	T + 65(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
67	IRS8	HS	T + 66(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
68	IRS10	HS	T + 67(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
69	IRS12	HS	T + 68(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
70	IRS14	HS	T + 69(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
71	IRS16	HS	T + 70(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
72	IRS1	HS	T + 71(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
73	IRS3	HS	T + 72(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
74	IRS5	HS	T + 73(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
75	IRS7	HS	T + 74(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
76	IRS9	HS	T + 75(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
77	IRS11	HS	T + 76(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
78	IRS13	HS	T + 77(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
79	IRS15	HS	T + 78(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3

TABLE 2 - MODE 2 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CON- VERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 2)
80	CALTc/ CALTa		N/A	See Comments	Cumulative	Even MF = CALTc, use T + 10(W2) - 198.4 Odd MF = CALTa, use T - 90(W2) - 198.4	1 -4
81	TCGc						
82	ASC3	LS	T + 62(W2) + 2(B2) + 32	T + 50(W2) - 198.4		See Table 2.4	
83	RSE	HS	T + 79(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
84	IRS2	HS	T + 83(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
85	IRS4	HS	T + 84(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
86	IRS6	HS	T + 85(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
87	IRS8	HS	T + 86(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
88	IRS10	HS	T + 87(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
89	IRS12	HS	T + 88(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
90	IRS14	HS	T + 89(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
91	IRS16	HS	T + 90(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
92	IRS1	HS	T + 91(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
93	IRS3	HS	T + 92(W2) + 24	T + 70(W2) - 198.4	Instant	Use Tof LETP	4
94	IRS5	HS	T + 93(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
95	IRS7	HS	T + 94(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
96	IRS9	HS	T + 95(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
97	IRS11	HS	T + 96(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
98	IRS13	HS	T + 97(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
99	IRS15	HS	T + 98(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4

TABLE 2.1 - MODES 2 AND 3 WORD 22 (SCS)

WORD	MINOR FRAME	MNEMONIC	TYPE PARAMETER	USE T OF:	LETP NO. (See Figure 2 or 3)
22	0,16,32,48	CCSS		SOA	
22	1,9,17,25,33,41,49,57	RTP	Average	LETP	5,45,85,125,165,205,245,285
22	4,20,36,52	CCRR		SOA	
22	5,21,37,53	DSADa	Digital	T-700(W2)-77(W2)	
22	8,24,40.56	NCSS		SOA	
22	12,28,44,60	NCRR		SOA	
22	13,29,45,61	DSADb	Digital	T-1500(W2)-77(W2)	
22	34	DSC-RA on/off (bit 1 of this channel	Digital	T+22(W2)	
22	39	RI		LETP	195
22	43	RMI		LETP	215
22	62	DSC-Various RA Status (bits 0-4 of this channel)		T+22(W2)	

TABLE 2.2 - MODES 2 AND 3, WORD 42 (ASCO)

WORD	MINOR FRAME	MNEMONIC	TYPE PARAMETER	USE T OF:	LETP NO. (See Figure 2 or 3)
42	0	ANG	Average	LETP	1
42	1	AV 1		LETP	6
42	2	AV 3		LETP	11
42	3	AV 5		LETP	16
42	4	RAGC	Average	LETP	21
42	5	RTP	Average	LETP	26
42	7	IFTA		LETP	36
42	8	ARS1	Average	LETP	41
42	9	ARS3	Average	LETP	46
42	10	ARS5	Average	LETP	51
42	11	ARS7	Average	LETP	56
42	12	ARS9	Average	LETP	61
42	13	ARS11	Average	LETP	66
42	14	ARS13	Average	LETP	71
42	15	ARS15	Average	LETP	76
42	16	ARG	Average	LETP	81
42	18	ASAD1		SOA	
42	19	ASAD2		SOA	
42	20	ASAD3		SOA	
42	32	APG	Average	LETP	161
42	48	AASG	Average	LETP	241
42	52	BCT		LETP	261
42	53	RTT		LETP	266
42	54	RRT		LETP	271
42	55	GTT		LETP	276
42	56	ITT		LETP	281
42	57	WST		LETP	286

TABLE 2.3 - MODES 2 AND 3, WORD 62 (ASC1)

WORD	MINOR FRAME	MNEMONIC	TYPE PARAMETER	USE T OF:	LETP NO. (See Figure 2 or 3)
62	0	CCSS		SOA	
62	1	AV2		LETP	7
62	2	AV4		LETP	12
62	3	RAGC HIV	Average	LETP	17
62	5	RSA		LETP	27
62	7	VTA		LETP	37
62	8	ARS2	Average	LETP	42
62	9	ARS4	Average	LETP	47
62	10	ARS6	Average	LETP	52
62	11	ARS8	Average	LETP	57
62	12	ARS10	Average	LETP	62
62	13	ARS12	Average	LETP	67
62	14	ARS14	Average	LETP	72
62	15	ARS16	Average	LETP	77
62	16	CCRR		SOA	
62	28	EBV2		LETP	144
62	32	NCSS		SOA	
62	41	XMAG		SOA	
62	42	YMAG		SOA	
62	43	ZMAG		SOA	
62	48	NCRR		SOA	
62	51	CCBT		SOA	
62	52	NCBT		SOA	
62	56	AMT1		SOA	282
62	57	AMT2		SOA	287

TABLE 2.4 - MODES 2 AND 3, WORD 82 (ASC3)

WORD	MINOR FRAME	MNEMONIC	TYPE PARAMETER	USE T OF:	LETP NO. (See Figure 2 or 3)
82	0, 8, 16, 24, 32, 40, 48, 56	ANG	Average	LETP	3, 43, 83, 123, 163, 203, 243, 283
82	1, 3, 5, 7, 9. . . . 61, 63	RAGC	Average	LETP	8, 18, 28. . . . . 308, 318
82	2, 10, 18, 26, 34, 42, 50, 58	ARG	Average	LETP	13, 53, 93, 133, 173, 213, 253, 293
82	4, 12, 20, 28, 36, 44, 52, 60	APG	Average	LETP	23, 63, 103, 143, 183, 223, 263, 303
82	6, 14, 22, 30, 38, 46, 54, 62	AASG	Average	LETP	33, 73, 113, 153, 193, 233, 273, 313

TABLE 3 - MODE 3 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS)

WORD	MNEMONIC	CONVERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 3)
3							
4	IRS2	HS	T + 3(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
5	IRS4	HS	T + 4(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
6	IRS6	HS	T + 5(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
7	IRS8	HS	T + 6(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
8	IRS10	HS	T + 7(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
9	IRS12	HS	T + 8(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
10	IRS14	HS	T + 9(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
11	IRS16	HS	T + 10(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
12	ALTd		N/A	T - 10(W2) - 198.4	Instant	Use T of LETP	0
13	ALTc		N/A	T - 10(W2) - 198.4	Instant	Use T of LETP	0
14	ALTb		N/A	T - 10(W2) - 198.4	Instant	Use T of LETP	0
15	ALTa		N/A	T - 10(W2) - 198.4	Instant	Use T of LETP	0
16	+CAL	HS	T + 15(W2) + 24	N/A			
17	-CAL	HS	T + 16(W2) + 24	N/A			
18	IPG	HS	T + 17(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0
19	RSE	HS	T + 18(W2) + 24	T - 10(W2) - 198.4	Instant	Use T of LETP	0

LEGEND

LS Converter Aperture = 2018 μsec
HS Converter Aperture = 280 μsec
W2 = 512.0256 μsec
B2 = 64.0032 μsec
T = Minor Frame Start Time

TABLE 3 - MODE 3 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CONVERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 3)
20	CP						
21	FFID						
22	SCS	LS & Dig.	T + 4(B2) + 32	T - 10(W2) - 198.4		See Table 2.1	
23							
24	IRS2	HS	T + 23(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
25	IRS4	HS	T + 24(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
26	IRS6	HS	T + 25(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
27	IRS8	HS	T + 26(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
28	IRS10	HS	T + 27(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
29	IRS12	HS	T + 28(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
30	IRS14	HS	T + 29(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
31	IRS16	HS	T + 30(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
32	ALTd		N/A	T + 10 (W2) - 198.4	Instant	Use T of LETP	1
33	ALTc		N/A	T + 10 (W2) - 198.4	Instant	Use T of LETP	1
34	ALTb		N/A	T + 10 (W2) - 198.4	Instant	Use T of LETP	1
35	ALTa		N/A	T + 10 (W2) - 198.4	Instant	Use T of LETP	1
36	+CAL	HS	T + 35(W2) + 24	N/A			
37	-CAL	HS	T + 36(W2) + 24	N/A			
38	IPG	HS	T + 37(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1
39	RSE	HS	T + 38(W2) + 24	T + 10(W2) - 198.4	Instant	Use T of LETP	1

TABLE 3 - MODE 3 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CONVERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP (See Fig. 3)
40	AS		T + 40(W2)	N/A	Status		
41	TCGa						
42	ASCO	LS	T + 22(W2) + B2 + 32	T + 10(W2) - 198.4		See Table 2.2	
43							
44	IRS2	HS	T + 43(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
45	IRS4	HS	T + 44(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
46	IRS6	HS	T + 45(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
47	IRS8	HS	T + 46(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
48	IRS10	HS	T + 47(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
49	IRS12	HS	T + 48(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
50	IRS14	HS	T + 49(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
51	IRS16	HS	T + 50(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
52	ALTd		N/A	T + 30(W2) - 198.4	Instant	Use T of LETP	2
53	ALTc		N/A	T + 30(W2) - 198.4	Instant	Use T of LETP	2
54	ALTb		N/A	T + 30(W2) - 198.4	Instant	Use T of LETP	2
55	ALTa		N/A	T + 30(W2) - 198.4	Instant	Use T of LETP	2
56	+CAL	HS	T + 55(W2) + 24	N/A			
57	-CAL	HS	T + 56(W2) + 24	N/A			
58	IPG	HS	T + 57(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2
59	RSE	HS	T + 58(W2) + 24	T + 30(W2) - 198.4	Instant	Use T of LETP	2

TABLE 3 - MODE 3 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CONVERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 3)
60							
61	TCGb						
62	ASC1	LS	T + 42(W2) + B2 + 32	T + 30(W2) - 198.4		See Table 2.3	
63							
64	IRS2	HS	T + 63(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
65	IRS4	HS	T + 64(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
66	IRS6	HS	T + 65(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
67	IRS8	HS	T + 66(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
68	IRS10	HS	T + 67(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
69	IRS12	HS	T + 68(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
70	IRS14	HS	T + 69(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
71	IRS16	HS	T + 70(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
72	ALTd		N/A	T + 50 (W2) - 198.4	Instant	Use T of LETP	3
73	ALTc		N/A	T + 50 (W2) - 198.4	Instant	Use T of LETP	3
74	ALTb		N/A	T + 50 (W2) - 198.4	Instant	Use T of LETP	3
75	ALTa		N/A	T + 50 (W2) - 198.4	Instant	Use T of LETP	3
76	+CAL	HS	T + 75(W2) + 24	N/A			
77	-CAL	HS	T + 76(W2) + 24	N/A			
78	IPG	HS	T + 77(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3
79	RSE	HS	T + 78(W2) + 24	T + 50(W2) - 198.4	Instant	Use T of LETP	3

TABLE 3 - MODE 3 TELEMETRY TIMING (ALL TIMES IN MICROSECONDS) (Cont'd)

WORD	MNEMONIC	CONVERTER	START OF APERTURE (SOA)	LAST EFFECTIVE XMITTED PULSE (LETP)	TYPE PARAMETER	COMMENTS	LETP NO. (See Fig. 3)
80							
81	TCGc						
82	ASC3	LS	T + 62(W2) + 2(B2) + 32	T + 50(W2) - 198.4		See Table 2.4	
83							
84	IRS2	HS	T + 83(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
85	IRS4	HS	T + 84(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
86	IRS6	HS	T + 85(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
87	IRS8	HS	T + 86(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
88	IRS10	HS	T + 87(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
89	IRS12	HS	T + 88(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
90	IRS14	HS	T + 89(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
91	IRS16	HS	T + 90(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
92	ALTd		N/A	T + 70 (W2) - 198.4	Instant	Use T of LETP	4
93	ALTc		N/A	T + 70 (W2) - 198.4	Instant	Use T of LETP	4
94	ALTb		N/A	T + 70 (W2) - 198.4	Instant	Use T of LETP	4
95	ALTa		N/A	T + 70 (W2) - 198.4	Instant	Use T of LETP	4
96	+CAL	HS	T + 95(W2) + 24	N/A			
97	-CAL	HS	T + 96(W2) + 24	N/A			
98	IPG	HS	T + 97(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4
99	RSE	HS	T + 98(W2) + 24	T + 70(W2) - 198.4	Instant	Use T of LETP	4

Consider 50 Transmitted Pulses per Minor Frame with No. 1 starting 198.4 μsec before the beginning of Word 1 (Sync 1) - - then the Transmitted Pulse number corresponding to the given parameter is:

PARAMETER	MNEMONIC	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	COMMENTS
RA Transmitted Pwr	RTP		X																					x^0																												x^0 on MF 0 only
Avg. Noise Gate	ANG				X																																															
Avg. Ramp Gate	ARG					X																																														
Inst. Plateau Gate	IPG	X										X										X										X										X									
Avg. Plateau Gate	APG						X																																													
Cum. Alt. (LSB)	CALTd			X									X											X										X										X								
Avg. Alt. Spec. Gate	AASG							X																																												
Cum. Alt. ( )	CALTc			X									X											X										X										X								
Cum. Alt. ( )	CALTb			X									X											X										X										X								
Cum. Alt. (MSB)	CALTa			X									X											X										X										X								
RA AGC	RAGC										X										X	x^0									X										X										X	x^0 on MF 0 only
Range Servo Error	RSE					X										X										X										X										X					
RA Anal. Volt 1	AV 1													x^0																																						Only on MF 0
RA Anal. Volt 3	AV 3															x^0																																				Only on MF 0
RA Anal. Volt 5	AV 5																	x^0																																		Only on MF 0
RA IF Test Sig Ampl	IFTA																											x^0																								Only on MF 0
RA Avg. Ret. Samp. 1	ARS 1																															x^0																				Only on MF 0
RA Avg. Ret. Samp. 3	ARS 3																																	x^0																		Only on MF 0
RA Avg. Ret. Samp. 5	ARS 5																																			x^0																Only on MF 0
RA Avg. Ret. Samp. 7	ARS 7																																					x^0														Only on MF 0
RA Avg. Ret. Samp. 9	ARS 9																																									x^0										Only on MF 0
RA Avg. Ret. Samp. 11	ARS 11																																											x^0								Only on MF 0
RA Avg. Ret. Samp. 13	ARS 13																																													x^0						Only on MF 0
RA Avg. Ret. Samp. 15	ARS 15																																															x^0				Only on MF 0
RA Bit/Cal. Temp.	BCT																					x^3																														Only on MF 3 (Trans Pulse 169)
RA Trans. Temp.	RTT																							x^3																												Only on MF 3 (Trans Pulse 171)
RA Rec. Temp.	RRT																									x^3																										Only on MF 3 (Trans Pulse 173)
RA Glob. Track Temp.	GTT																											x^3																								Only on MF 3 (Trans Pulse 175)
RA Int. Track Temp.	ITT																															x^3																				Only on MF 3 (Trans Pulse 179)
RA Waveform Samp. Temp.	WST																																	x^3																		Only on MF 3 (Trans Pulse 181)
RA Anal. Volt 2	AV 2														x^0																																					Only on MF 0
RA Anal. Volt 4	AV 4																x^0																																			Only on MF 0
RA Ref. Sig. Ampl.	RSA																								x^0																											Only on MF 0
RA Video Test Sig. Ampl.	VTA																												x^0																							Only on MF 0
RA Avg. Ret. Samp. 2	ARS 2																																x^0																			Only on MF 0
RA Avg. Ret. Samp. 4	ARS 4																																		x^0																	Only on MF 0
RA Avg. Ret. Samp. 6	ARS 6																																				x^0															Only on MF 0
RA Avg. Ret. Samp. 8	ARS 8																																						x^0													Only on MF 0
RA Avg. Ret. Samp. 10	ARS 10																																										x^0									Only on MF 0
RA Avg. Ret. Samp. 12	ARS 12																																												x^0							Only on MF 0
RA Avg. Ret. Samp. 14	ARS 14																																														x^0					Only on MF 0
RA Avg. Ret. Samp. 16	ARS 16																																																x^0			Only on MF 0
RA Mount Temp. 1	AMT 1																																x^3																			Only on MF 3 (Trans Pulse 180)
RA Mount Temp. 2	AMT 2																																		x^3																	Only on MF 3 (Trans Pulse 182)
RA Input Current	RI																													x^2																						Only on MF 2 (Trans Pulse 127)
RA Rec. Mixer Current	RMI																																							x^2												Only on MF 2 (Trans Pulse 137)
RA AGC High	RAGCHI																		x^0																																	Only on MF 0

Figure 1 - Mode 1 TM

Consider 5 Transmitted Pulses per Minor Frame with No. 1 starting 198.4 μsec before the beginning of Word 10 (IRS 14) - then the Transmitted Pulse number corresponding to the given parameter is:

PARAMETER	MNEMONIC	-1	0	1	2	3	4
Range Servo Error	RSE	X	X	X	X	X	
Inst. Return Sample 2	IRS 2		X	X	X	X	X
Inst. Return Sample 4	IRS 4		X	X	X	X	X
Inst. Return Sample 6	IRS 6		X	X	X	X	X
Inst. Return Sample 8	IRS 8		X	X	X	X	X
Inst. Return Sample 10	IRS 10		X	X	X	X	X
Inst. Return Sample 12	IRS 12		X	X	X	X	X
Inst. Return Sample 14	IRS 14		X	X	X	X	X
Inst. Return Sample 16	IRS 16		X	X	X	X	X
Inst. Return Sample 1	IRS 1		X	X	X	X	X
Inst. Return Sample 3	IRS 3		X	X	X	X	X
Inst. Return Sample 5	IRS 5		X	X	X	X	X
Inst. Return Sample 7	IRS 7		X	X	X	X	X
Inst. Return Sample 9	IRS 9		X	X	X	X	X
Inst. Return Sample 11	IRS 11		X	X	X	X	X
Inst. Return Sample 13	IRS 13		X	X	X	X	X
Inst. Return Sample 15	IRS 15		X	X	X	X	X
Alt. Alt-Instant (LSB)	ALTd						
Alt. Alt-Instant ( )	ALTc						
Alt. Alt-Instant ( )	ALTb						
Alt. Alt-Instant (MSB)	ALTa						
Inst. Plateau Gate	IPG						
Cum. Alt. (LSB)	CALTd			$X^{0,2,4,\ldots,60,62}$			
Cum. Alt. ( )	CALTc			$X^{0,2,4,\ldots,60,62}$			
Cum. Alt. ( )	CALTb		Note: These parameters occur in $X^{1,3,5,\ldots,61,63}$ and correspond to transmitted pulse -4.				
Cum. Alt. (MSB)	CALTa						
RA AGC	RAGC			X^{4}		$X^{1,3,5,\ldots,61,63}$	
Avg. Noise Gate	ANG			X^{0}		$X^{0,8,16,24,32,40,48,56}$	
Avg. Ramp Gate	ARG			X^{16}		$X^{2,10,18,26,34,42,50,58}$	
Avg. Plateau Gate	APG			X^{32}		$X^{4,12,20,28,36,44,52,60}$	
Avg. Alt. Spec. Gate	AASG			X^{48}		$X^{6,14,22,30,38,46,54,62}$	
Avg. Return Sample 2	ARS 2				X^{8}		
Avg. Return Sample 4	ARS 4				X^{9}		
Avg. Return Sample 6	ARS 6				X^{10}		
Avg. Return Sample 8	ARS 8				X^{11}		
Avg. Return Sample 10	ARS 10				X^{12}		
Avg. Return Sample 12	ARS 12				X^{13}		
Avg. Return Sample 14	ARS 14				X^{14}		
Avg. Return Sample 16	ARS 16				X^{15}		
Avg. Return Sample 1	ARS 1			X^{8}			
Avg. Return Sample 3	ARS 3			X^{9}			
Avg. Return Sample 5	ARS 5			X^{10}			
Avg. Return Sample 7	ARS 7			X^{11}			
Avg. Return Sample 9	ARS 9			X^{12}			
Avg. Return Sample 11	ARS 11			X^{13}			
Avg. Return Sample 13	ARS 13			X^{14}			
Avg. Return Sample 15	ARS 15			X^{15}			
RA Trans. Power	RTP		$X^{1,9,17,25,33,41,49,57}$	X^{5}			
RA Input Current	RI		X^{39}				
RA Rec. Mixer Current	RMI		X^{43}				
RA Analytic Volt 1	AV 1			X^{1}			
RA Analytic Volt 3	AV 3			X^{2}			
RA Analytic Volt 5	AV 5			X^{3}			
RA IF Test Sig. Ampl.	IFTA			X^{7}			
RA Bit/Cal Temp	BCT			X^{52}			
RA Trans Temp	RTT			X^{53}			
RA Rec. Temp	RRT			X^{54}			
RA Global Track Temp	GTT			X^{55}			
RA Int. Track Temp	ITT			X^{56}			
RA Waveform Samp Temp	WST			X^{57}			
RA Analytic Volt 2	AV 2				X^{1}		
RA Analytic Volt 4	AV 4				X^{2}		
RA Ref Sig Ampl	RSA				X^{5}		
RA Video Test Sig Ampl	VTA				X^{7}		
RA Mount Temp 1	AMT 1				X^{56}		
RA Mount Temp 2	AMT 2				X^{57}		
RA AGC High	RAGCH				X^{3}		

Figure 2 - Mode 2 TM

Consider 5 Transmitted Pulses per Minor Frame with No. 1 starting 104.4 μsec before the beginning of Word 10 (IRS 14) - then the Transmitted Pulse number corresponding to the given parameter is:

PARAMETER	MNEMONIC	-1	0	1	2	3	4
Range Servo Error	RSE		X	X	X	X	X
Inst. Return Sample 2	IRS 2		X	X	X	X	X
Inst. Return Sample 4	IRS 4		X	X	X	X	X
Inst. Return Sample 6	IRS 6		X	X	X	X	X
Inst. Return Sample 8	IRS 8		X	X	X	X	X
Inst. Return Sample 10	IRS 10		X	X	X	X	X
Inst. Return Sample 12	IRS 12		X	X	X	X	X
Inst. Return Sample 14	IRS 14		X	X	X	X	X
Inst. Return Sample 16	IRS 16		X	X	X	X	X
Inst. Return Sample 1	IRS 1						
Inst. Return Sample 3	IRS 3						
Inst. Return Sample 5	IRS 5						
Inst. Return Sample 7	IRS 7						
Inst. Return Sample 9	IRS 9						
Inst. Return Sample 11	IRS 11						
Inst. Return Sample 13	IRS 13						
Inst. Return Sample 15	IRS 15						
Alt. Alt-Instant (LSB)	ALTd		X	X	X	X	X
Alt. Alt-Instant ( )	ALTc		X	X	X	X	X
Alt. Alt-Instant ( )	ALTb		X	X	X	X	X
Alt. Alt-Instant (MSB)	ALTa		X	X	X	X	X
Inst. Plateau Gate	IPG		X	X	X	X	X
Cum. Alt. (LSB)	CALTd						
Cum. Alt. ( )	CALTc						
Cum. Alt. ( )	CALTb						
Cum. Alt. (MSB)	CALTa						
RA AGC	RAGC			x^{4}		$x^{1,3,5,\ldots,61,63}$	
Avg. Noise Gate	ANG			x^{0}		$x^{0,8,16,24,32,40,48,56}$	
Avg. Ramp Gate	ARG			x^{16}		$x^{2,10,18,26,34,42,50,58}$	
Avg. Plateau Gate	APG			x^{32}		$x^{4,12,20,28,36,44,52,60}$	
Avg. Alt. Spec Gate	AASG			x^{48}		$x^{6,14,22,30,38,46,54,62}$	
Avg. Return Sample 2	ARS 2				x^{8}		
Avg. Return Sample 4	ARS 4				x^{9}		
Avg. Return Sample 6	ARS 6				x^{10}		
Avg. Return Sample 8	ARS 8				x^{11}		
Avg. Return Sample 10	ARS 10				x^{12}		
Avg. Return Sample 12	ARS 12				x^{13}		
Avg. Return Sample 14	ARS 14				x^{14}		
Avg. Return Sample 16	ARS 16				x^{15}		
Avg. Return Sample 1	ARS 1			x^{8}			
Avg. Return Sample 3	ARS 3			x^{9}			
Avg. Return Sample 5	ARS 5			x^{10}			
Avg. Return Sample 7	ARS 7			x^{11}			
Avg. Return Sample 9	ARS 9			x^{12}			
Avg. Return Sample 11	ARS 11			x^{13}			
Avg. Return Sample 13	ARS 13			x^{14}			
Avg. Return Sample 15	ARS 15			x^{15}			
RA Trans. Power	RTP		$x^{1,9,17,25,33,41,49,57}$	x^{5}			
RA Input Current	RI		x^{39}				
RA Rec Mixer Current	RMI		x^{43}				
RA Analytic Volt 1	AV 1			x^{1}			
RA Analytic Volt 3	AV 3			x^{2}			
RA Analytic Volt 5	AV 5			x^{3}			
RA IF Test Sig Ampl	IFTA			x^{7}			
RA Bit/Cal Temp	BCT			x^{52}			
RA Trans Temp	RTT			x^{53}			
RA Rec. Temp	RRT			x^{54}			
RA Globe Track Temp	GTT			x^{55}			
RA Int. Track Temp	ITT			x^{56}			
RA Waveform Samp Temp	WST			x^{57}			
RA Analytic Volt 2	AV 2				x^{1}		
RA Analytic Volt 4	AV4				x^{2}		
RA Ref Sig Ampl	RSA				x^{5}		
RA Video Test Sig Ampl	VTA				x^{7}		
RA Mount Temp 1	AMT 1				x^{56}		
RA Mount Temp 2	AMT 2				x^{57}		
RA AGC High	RAGCHI				x^{3}		

Figure 3 - Mode 3 TM

1. Report No.
NASA RP-1066

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
NASA WALLOPS FLIGHT CENTER GEOS-3 ALTIMETER DATA PROCESSING REPORT

5. Report Date
November 1980

6. Performing Organization Code

7. Author(s)
H. R. Stanley and R. E. Dwyer

8. Performing Organization Report No.

9. Performing Organization Name and Address
NASA Wallops Flight Center
Wallops Island, VA 23337

10. Work Unit No.

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, DC 20546

13. Type of Report and Period Covered
Reference Publication

14. Sponsoring Agency Code

15. Supplementary Notes
H. R. Stanley: NASA Wallops Flight Center.
R. E. Dwyer: Computer Sciences Corporation, Wallops Island, Virginia.

16. Abstract

The procedures used to process the GEOS-3 radar altimeter data from raw telemetry data to a final user data product are described. In addition, the radar altimeter hardware design and operating parameters are presented to aid the altimeter user in understanding the altimeter data.

This document is an update and replacement of "Wallops GEOS-C Altimeter Preprocessing Report," dated February 1974 (NASA TM-X-69357) and is intended as the reference documentation accompanying the final distribution of GEOS-3 altimeter data.

17. Key Words (Suggested by Author(s))
Radar Altimeter
GEOS-3
Sea Surface Topography
Significant Wave Height
Surface Wind Speed
Ice Boundary

18. Distribution Statement
Unclassified - Unlimited
STAR Category 43

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	130	A07

*For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1980