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NOSS Altimeter Algorithm Specifications

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SS	Significant slope
SSH	Sea surface height
SWH	Significant waveheight
SWH_{alt}	Real-time SWH
SWH_c	Corrected SWH
TBD	To be determined
TM	Telemetry mode
T_{JD}	Time expressed as Julian date
T_o	Surface atmospheric temperature
t	Local time
t_a	Time of current leading edge
t_b	Time of current trailing edge
t_o	Uncorrected time tag
t_1	Corrected time tag
V_s	Current velocity
WFC	Wallops Flight Center
W_{10}	Wind speed estimate
X	General variable
$\bar{X}$	Mean of X
y	Altitude observation residual
α	Spacecraft attitude
α_{alt}	Instrument attitude
β	Ionospheric parameter supplied by Goldstone and Armidale
Γ_A	Altimeter designation flag
Γ_{AGC}	Quality flag for AGC gate
Γ_{ANG}	Quality flag for noise gate
Γ_{AR}	Adaptive resolution step size flag
Γ_{CM}	Cal mode flag
Γ_{Cl}	Subsatellite point classification flag

Γ_{C2}	Subsatellite point classification flag
Γ_{DATA}	Quality flag for data validity
Γ_{DFB}	Quality flag for DFB temperature
Γ_{EPH}	Ephemeris file quality flag
Γ_{FN}	FNWC data flag
Γ_{h}	Quality flag for height rate
Γ_{L}	LAMMR data quality flag
Γ_{MTU}	Quality flag for MTU temperature
Γ_{R1}	Rain gate quantity flag
Γ_{R2}	Rain gate quality flag
Γ_{SSH}	Sea surface height retrack quality flag
Γ_{TM}	Track mode flag
Γ_{TWT}	Quality flag for TWT collector temperature
Γ_{WP}	Waveform processor convergence flag
Γ_{Z}	Zone flag
Γ_{α}	Quality flag for attitude
$\Gamma_{\sigma_{AGC}}$	Quality flag for AGC standard deviation
Γ_{σ_h}	Quality flag for σ_h
$\Gamma_{\sigma_{SWH}}$	Quality flag for SWH standard deviation
Γ_{σ_1}	Sigma naught correction method flag
Γ_{σ_2}	Sigma naught correction quality flag
$\delta_{AGC_{cm}}$	AGC cal mode correction
δh	Current height anomaly
δh_{WP}	Altitude correction from waveform processor
δL	Horizontal distance across current
δh_{cm}	Altitude correction for cal mode
$\delta h_{1,1}$	Altitude correction for cal zone bias
$\delta h_{1,2}$	Altitude correction for center gravity offset
$\delta h_{1,3}$	Altitude correction for cal mode bias

INTRODUCTION

This document contains the detailed specifications for the NOSS altimeter algorithms and data sets. The algorithm/data set numbering scheme is

X.Y(S) - N.{n}

X - Sensor
- A = Altimeter
- C = CZCS
- L = LAMMR
- S = Scatterometer

Y - Type
- A = Algorithm
- D = Data Set

S - Source
- A = Altimeter
- C = CZCS
- L = LAMMR
- S = Scatterometer
- M = Mission Contractor

N - Level
- 1 = Level 1
- 2 = Level 2

{n} - Algorithm/Data Set Number
(As many levels of this number as needed may be used - e.g. X.Y(S) - $N.n_1.n_2.n_3$)

Alternative algorithms or data are indicated by a letter after the number (e.g. X.Y.(S) - 1.2A; X.Y(S) - 1.2B).

It should be noted that many coefficients and table entries presented in this document are taken from the documentation of the SEASAT-1 software and are therefore subject to change as the NOSS instrument package is developed.

MANAGEMENT SUMMARY

The altimeter Level 1 processing will provide quality altimeter parameters to research oceanographic users. The Level 1 processor converts the data to engineering units and applies first order corrections to the data for known sensor variations. Also Level 1 quality control monitoring is done in the calibration module and the health status module. Both of these modules produce reports that require engineering evaluation. No calibration tables are automatically modified because users require a constant data set with updates only when significant changes have occurred. Required external inputs to Level 1 are the ephemeris data and world surface map data. Some of the table entries will be determined post-launch calibration experiments. The calibration trend file is an important internal file to be maintained to allow for the analysis of sensor characteristics over long periods. The resulting Level 1 output file contains all altimeter data at full rate, all corrections applied and status flags on instrument health. By removing the corrections and knowing the conversion factors, the original data can be recovered if needed.

The Level 2 processor provides quality geophysical measurements derived from altimeter parameters to both production and research oceanographic users. In addition it will provide ice sheet measurements to the ice research community. Its data rate and content will be compressed to nominally one per second. The altimeter main parameters, significant waveheight, wind speed and surface height, are basically direct calculations. Additional products will be ocean surface elevation distribution skewness, dominant wavelength, significant slope, rain rate, ocean backscatter, sea ice boundary and limited area ocean currents. Ice sheet height, surface slope, and roughness will be calculated over ice sheets. In order to provide quality products, some of the corrections require iterative processing and several external files are required as input to determine the best corrections. The files are the LAMMR Level 2 pathlength correction, FNWC atmospheric pressure, SCATT sigma naught correction, ionospheric electron density, geoid and tide. The resulting Level 2 output file contains only geophysical data and their associated corrections. By maintaining the corrections on file, an individual user may apply variations from their own research.

OVERVIEW

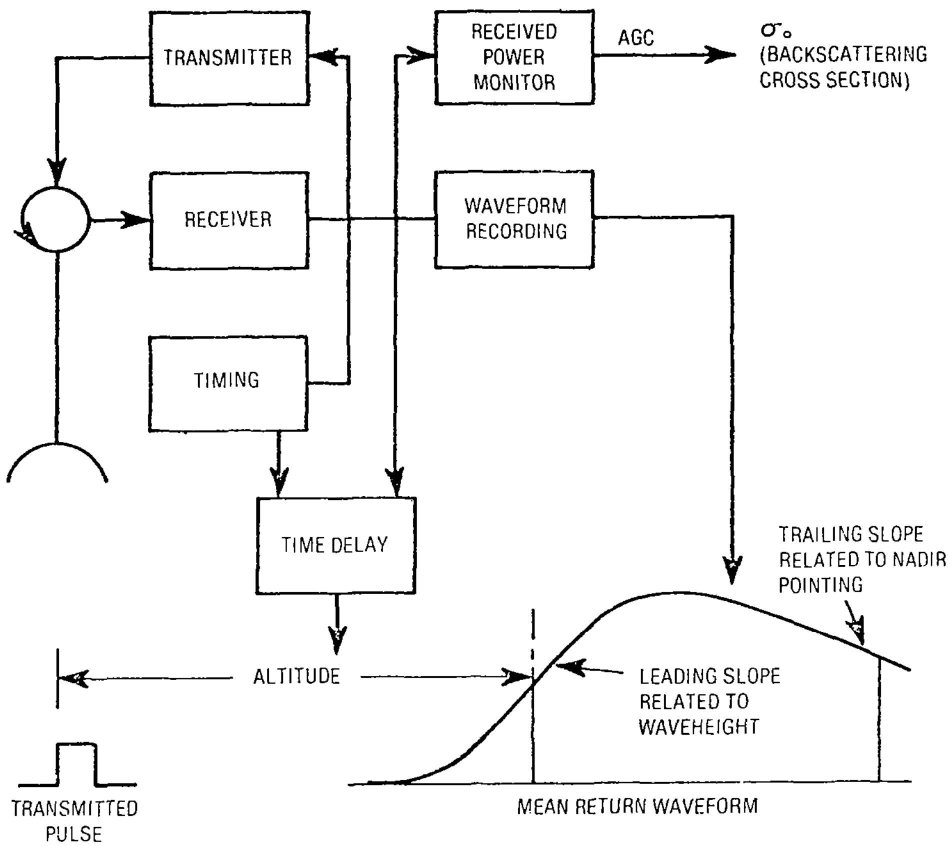
Functionally, the altimeter measures the spacecraft height above mean sea level (MSL), and the significant wave height (SWH) and backscatter coefficient (σ°) of the ocean surface beneath the spacecraft (Ref. 1). The sensor consists of a 13.5 GHz monostatic radar system that tracks in range only using a 1 m parabolic antenna pointed at the satellite nadir. One of its unique features is the microprocessor implementation of the closed-loop range tracking, automatic gain (AGC), and real-time estimation of SWH. Additionally, a linear FM transmitter with 320 MHz bandwidth yields a 3.125 ns time-delay resolution. This high resolution, coupled with a high transmitted pulse rate of 926 Hz, permits the realization of the desired 10 cm altitude precision.

The Skylab S-193 Altimeter was the first in the series of satellite altimeters that were planned to progressively achieve this goal. This altimeter was designed primarily for obtaining the radar measurements necessary for designing improved altimeters. The GEOS-3 Altimeter, second in the series of satellite altimeters, was launched on April 9, 1975, and was the first globally applied altimeter system. The Advanced Applications Flight Experiments (AAFE) Altimeter, an aircraft system which first collected data in October 1975, was a developmental effort directed at bridging the technology gap between the capabilities of the GEOS-3 Altimeter and the rather stringent requirements imposed on the SEASAT-1 Altimeter as well as providing surface truth in support of SEASAT-1 Altimeter calibration activities. The SEASAT-1 Altimeter, launched June 27, 1978, third in the series of satellite altimeters, was part of an ocean-dedicated satellite instrumentation system and represented the first attempt to achieve 10 cm precision from orbit. It is conceptually identical to the AAFE Altimeter. The NOSS Altimeter is identical to the SEASAT-1 Altimeter with modifications to aid ice sheet tracking by adding adaptive resolution. Also there will be two altimeters per spacecraft for the long life requirement.

The basic idea behind altimetry is to utilize the highly stable platform provided by a satellite as a moving reference system from which vertical measurements to the ocean surface are made (Ref. 2). Referring to Figure 1, existing altimeter systems essentially provide three measurements:

(1) Altitude - The elapsed time between the time of transmission of an RF pulse of energy to its reception back at the altimeter, after having been scattered from the ocean surface below, is essentially a measurement of the height of the satellite above mean sea level. When merged with accurate orbital information, the results can be related to changes in mean sea level due to such spatially varying quantities as gravity anomalies and such time varying quantities as tides, winds, and currents.

(2) Return Pulse Shape - The slope and time extent of the leading edge of the return pulse can be related to the significant wave height of the ocean surface below. Additionally, through a deconvolution process the surface height distribution can be recovered including the skewness thereof. It has been shown (Ref. 3) that skewness can then be related to such additional oceanographic parameters as dominant wavelength, swell/sea ratio, etc. Finally, the slope and time extent of the trailing edge of the return pulse can be related to the attitude (angle



APPLICATIONS

$\sigma°$	ICE EDGES PERCENT ICE COVER WIND SPEED
WAVEFORMS	LAND SURFACE ROUGHNESS WAVE HEIGHTS (SWH) SWELL FREQUENCY SPECTRA INFORMATION SATELLITE POINTING
ALTITUDE	STORM SURGES AND TIDES OCEAN GEOID OCEAN CURRENTS LAND AND ICE CONTOUR MAPS CROP INFORMATION

Figure 1. Block Diagram Depicting Satellite Altimetry Concept and Potential Applications.

of the measurement axis with respect to the subsatellite point) of the satellite.

(3) Return Pulse Amplitude - The amplitude of the return pulse, which is determined from the AGC used to normalize the incoming waveform, can be related to the backscatter coefficient (σ_o) of the surface below, which in turn, can be related to wind speed over the ocean as well as certain ice related parameters.

The NOSS Altimeter baseline characteristics are given in Figure 2.

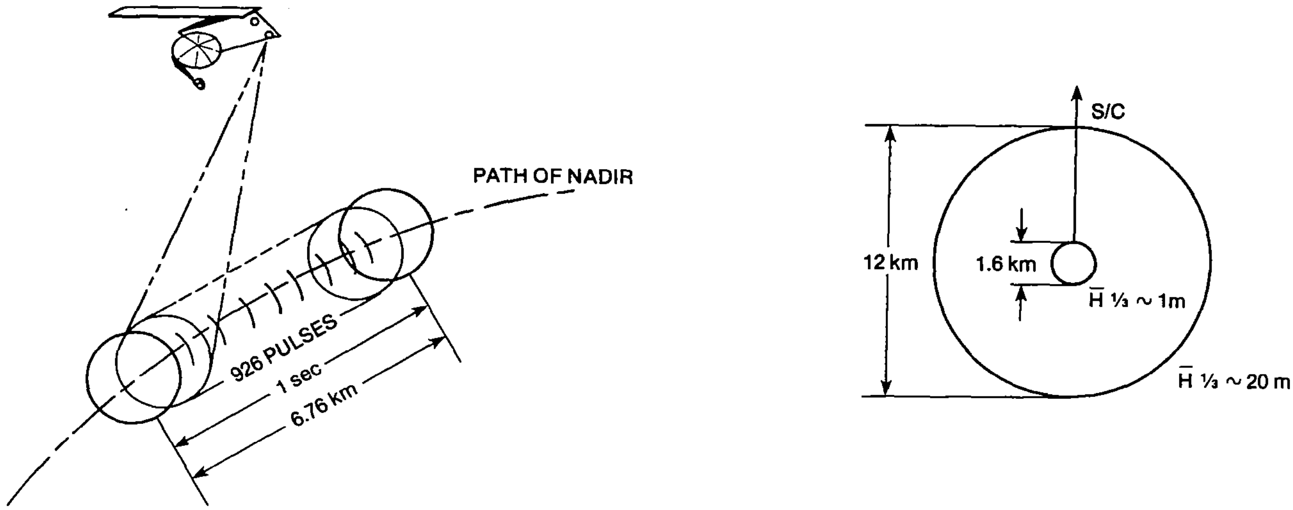
Background

The NOSS Altimeter Level 1 and 2 algorithms provide oceanographic data from the altimeter ready for use in prediction models and research data bases for studying ocean processes including sea state, storm surges, wind currents and geoid. Because of the strong similarity between the SEASAT-1 Altimeter and the NOSS Altimeter, the processing required is well established and there is also an established data user community. A number of the algorithms are inherited from the SEASAT Sensor Data Record (SDR), Sensor File (SF), Geophysical Data Record (GDR), and the Wallops Engineering Assessment Processing Systems. Those that did not come from these systems mainly come from SEASAT-1 research. Both the SEASAT-1 production and research algorithms drew from the GEOS-3 Altimeter system which in turn had inheritance from the Skylab Altimeter.

The engineering units conversion and health status will be very similar to that of the SDR and Wallops SEASAT preprocessor. The equivalent of Level 1 altitude module, data compression, quality control, and sigma naught were done in the SF. The terrain/ocean/ice classification, ephemeris merge, atmospheric module except rain gate, wind speed and Level 2 altitude module except electromagnetic (EM) bias were done in the GDR. The calibration module, except for the trend file processing, was done at Wallops. The waveform processor, ice sheet and ocean current were done in both GEOS-3 and SEASAT-1 research. Adaptive resolution is a new enhancement for Level 1 processing and will be similar to the altitude module with different tables for each step. The new modules for NOSS consist of contaminations, waveform products, rain gate, and EM bias and are being designed and analyzed utilizing SEASAT and aircraft data.

Objectives

The objective of the entire altimeter processing is to provide high quality altimeter derived geophysical data that will help meet the predicted NOSS system capability as given in Table I. The specific altimeter capabilities are given in Table II and will be achieved



PERFORMANCE

Real time one second significant waveheight (H 1/3) measurement accuracy - ± 0.5 m or 10% whichever is greater for H 1/3 from 1 to 20 m.

Sixty-eight percent (1σ) of one second altitude measurements to lie within ± 10 cm of the fitted mean.

Backscatter measurement precision within ± 0.5 dB for wind speed determination.

TECHNICAL CHARACTERISTICS

Orbital Altitude	700 km
Two Altimeters (redundant for 3-year total design life)	
Frequency	13.56 GHz
Pulse Width (uncompressed)	3.2 μsec
Transmit Time ÷ Total Time	3.3×10^{-3}
Pulse Repetition Rate	926 Hz
Compressed Pulse Width*	3.125, 6.25, 12.5 25, 50 ns
Chirp Rate*	100, 50, 25, 12.5, 6.25 MHz/μs
Adaptive Bandwidth*	20, 40, 80, 160, 320 MHz
Antenna Beamwidth	1.6°
Antenna Polarization	Linear
Antenna Gain	40.8 dB
System Noise Temp. Figure	11 dB
Receiver Gain	95 dB
Receiver Dynamic Range	63 dB

Receiver Power Ranges	-85 to -22 dBm
Footprint Diameter	
Beam Limited	20 km
Pulse Limited ($H_{1/3} \approx 1$ m)	1.6 km
Pulse Limited ($H_{1/3} \approx 20$ m)	12 km
Range Gates	
For Pulse Form Definition	63 ea
For Rain**	3 ea
Output Data Rate	20 kbps
Dimensions (each altimeter)	
Signal Processor	34 x 51 x 25 cm
Antenna and rf Section	100 x 80 cm
Weight (each altimeter)	100 kg
Average Power (each altimeter)	
Standby Power	102 W
Operating	177 W
Peak rf Transmit Power	2 kW
Average rf Transmit Power	4.5 W

* The five level adaptive resolution is tentatively included pending cost and engineering impact determination.
** Under study.

Figure 2. Altimeter Baseline Description.

TABLE I. PREDICTED NOSS SYSTEM CAPABILITY

Parameter	Detectable Change	Accuracy	Range	Horizontal Resolution	Instrument
Wind					
Speed	1.5 m/s	±2 m/s or ±10% (whichever is greater)	0 to 50 m/s	17 km	LAMMR
Speed	1.5 m/s	±2 m/s or ±10% (whichever is greater)	4 to > 24 m/s	50 km/25 km*	SCATT
Direction	10°	±20°	0 to 360°	50 km/25 km*	SCATT
Speed (Nadir only)	1.5 m/s	±2 m/s or ± 10% (whichever is greater)	4 to 24 m/s	< 12 km	ALT
Sea Surface Temperature					
Global	1.0°	±1.5°c	-2 to 35°C	25 km**	LAMMR (C-band)
Local	0.2°C	±2.0°C	-2 to 35°C	1.0 km	CZCS/II
Waves (Sea State)					
Sign. Wave Ht.	0.5 m	±0.5 m or 10%	1 to 20 m	< 10 km	ALT
Ice					
Cover	5%	±15%	0 to 100%	9 km	LAMMR
Thickness	2 m	±2 m	0.25 to 50 m	9 km	LAMMR
Age	1st yr, multi-yr	1st yr, multi-yr	two levels	9 km	LAMMR
Sheet Height and Boundaries	0.5-m ht. change	±2-m height change	-5 to +5 m/yr	~10 km	ALT
Water Mass Definition					
Pigment Concentration	10% (mg/m^3)	Within factor of 2	0.1 to 100 mg/m^3	1.0 km	CZCS/II
Diffuse Attenuation Coef (k)	10% m^{-1}	Within factor of 2	.01 - 6 m^{-1}	1.0 km	CZCS/II
				(Length Scale)	
Geostrophic Currents					
Speed	15 cm/s	±15 cm/s	> 15 cm/s	50 km	ALT
Direction	20°	±20°	0 to 360°	50 km	ALT
Water Vapor					
Integrated Atm. Water Vapor Content	0.2 g/cm^2	±0.2 grams/cm^2	0 - 6 grams/cm^2	9 km	LAMMR

*50 km global resolution; 25 km resolution in selected storm regions.
** Avenues are being explored to improve this resolution.

TABLE II. NOSS ALTIMETER CAPABILITIES

Sea State Range of Operation	1 m $\leq$ SWH $\leq$ 20 m
Sea State Measurement Accuracy	< ± 10% of SWH or < ± 0.5 m (whichever is greater)
Ocean Height Measurement Resolution (1 second average)	< 10 cm RMS
Ice Sheet Height Accuracy	± 2 m
σ_o Measurement Accuracy	< ± 1.0 dB
Wind Speed Accuracy (Range 4 to 24 m/s)	± 10% or 2 m/s
Geostrophic Current Accuracy (Speed > 15 cm/s)	± 15 cm/s
Acquisition Time	< 5 seconds

after Level 1 and Level 2 processing. The resultant data allows the oceanographic user community to take the Level 2 output tape directly and proceed with their application or research without concern on how to translate data into corrected geophysical products.

Key Assumptions

In the development of the altimeter processing algorithms, the following key assumptions have been made:

1. Because of the similarity between the proposed NOSS altimeter instrument and the SEASAT-1 altimeter instrument and because many of the altimeter algorithms required by the NOSS processing software were developed for SEASAT-1 and verified in an operational (although not real-time) environment, many of the SEASAT-A altimeter algorithms have been adopted for use by the NOSS altimeter processing software. Additionally, the similarity between SEASAT software and the NOSS software has been used in determining resource requirements.
2. The similarity between the NOSS altimeter and the SEASAT-A altimeter allows for the adoption of SEASAT calibration and processing tables for use as a starting point in the development of those tables for the NOSS altimeter. All tables and constants, whether determined from SEASAT-1 documentation, from documentation of other altimeter instruments (i.e., GEOS-3), or from some other source, must be flexible until the final NOSS values are determined. A few of these table entries will not be defined until well after the launch of the spacecraft.
3. All data required from the input files (i.e., ephemeris file, FNWC file, LAMMR Level 2 file, etc.) must be available and current as the altimeter processing software requires it. Failure to supply certain of the input files will result in the abnormal termination of the altimeter processing software.
4. All input data files required by the altimeter processing software (except the altimeter data itself), as well as all output reports generated by the altimeter processing software will be maintained on permanent data storage devices for a minimum of one week on a daily rotating basis. The trend file will be maintained for one year on a monthly rotating basis.
5. Since the spacecraft is designed to have two altimeters which, although physically identical will have slightly different electronic characteristics, all software must have the capability for processing two independent altimeters. This will require two sets of input tables, two sets of output reports, and documentation of which of the two altimeters was used in taking the data. The problems associated with the possible processing of data from more than one spacecraft have not been addressed in this investigation.

6. The prefix "instrument", as used in this report, relates to altimeter parameters that are supplied directly from the spacecraft. For example, the "instrument current" is the altimeter current as detected by the spacecraft monitor.
7. All processing of altimeter data will be handled using data stored "in core." This will mean that a Level 0 input data record will be read into core and modified as the appropriate altimeter processing algorithms are accessed. After all modules have been processed, the data record will be transferred from core to the output file.
8. For file sizing, and resource requirements, the 20 per second telemetry data rate has been used.
9. Adaptive resolution has only been scoped. However CW mode data will be processed as part of the adaptive resolution module.
10. Subsystem interfaces are handled by the mission contractor such that the required data from one system are time colocated to the requirements of the other system.
11. Mission contractor supplied functions:
    a. There will be an overall control module that is supplied to control flow through the algorithms, error processing, and subsystem interfaces.
    b. Level 0 data will be provided, decommend in counts.
    c. Ephemeris, World Surface Map, Ionospheric, and FNWC file data update processor and interface to the data.
    d. Required data retrieval from other sensor files will be supplied (i.e., CZCS, SCATT, LAMMR).
    e. Knowledgeable personnel will monitor output reports for characteristic changes and health status.

SUBSYSTEM DESCRIPTION

This section summarizes the logic of the altimeter Level 1 and Level 2 subsystem software. Included are the altimeter subsystem flowcharts, a narrative description of each of the major modules, and a description of the subsystem interfaces with other PPF software. An index to the Level 1 and Level 2 modules is given in Tables III and IV, respectively.

TABLE III. LEVEL 1 MODULE

Algorithms	
A.A-1.1	Engineering Units Conversion
A.A-1.2	Level 1 Altitude Module
A.A-1.2.1	Time Tag Correction
A.A-1.2.1.1	Constant Time Tag Correction
A.A-1.2.1.2	Variable Time Tag Correction
A.A-1.2.2	Cal Zone Bias
A.A-1.2.3	Center of Gravity Offset
A.A-1.2.4	Cal Mode Bias
A.A-1.3	Cal Mode Module
A.A-1.3.1	Cal Mode Monitor
A.A-1.3.1.1	Cal I Processing
A.A-1.3.1.2	Cal II Processing
A.A-1.3.2	Trend File Processing
A.A-1.4	Adaptive Resolution
A.A-1.5	Location Classification
A.A-1.6	Health/Status Monitor
Internal Files	
A.D-1.71	Trend File
Input Files	
A.D(M)-1.81	Level 0 Data File
A.D(M)-1.82	Spacecraft Ephemeris File
A.D(M)-1.83	World Surface Map File
A.D(L)-1.84	LAMMR Update File
Output Files/Reports	
A.D-1.91	Cal Report
A.D-1.92	Trend Report
A.D-1.93	Altimeter Diagnostics
A.D-1.94	Level I Output File

TABLE IV. LEVEL 2 MODULE

Algorithms	
A.A-2.1	Data Compressing
A.A-2.2	Contamination Processing
A.A-2.3	Waveform Module
A.A-2.3.1	Waveform Processor
A.A-2.3.2	Corrections From Waveform
A.A-2.3.2.1	SWH Correction for Attitude and SWH
A.A-2.3.2.2	Altitude Correction for Attitude, SWH, and $\ddot{h}$
A.A.2.3.3	SWH Bias
A.A.2.3.4	Waveform Products
A.A-2.3.4.1	Mean Squared Slope and Percent Smoothness
A.A-2.3.4.2	Significant Slope and Dominant Wavelength
A.A-2.4	Atmospheric Module
A.A-2.4.1	Rain Gate
A.A-2.4.2	Barotropic Effects
A.A-2.4.3A	Ionospheric Refraction (Sunspot Model)
A.A-2.4.3B	Ionospheric Refraction (Faraday Model)
A.A-2.4.4	Dry Tropospheric Refraction
A.A-2.4.5	Wet Tropospheric Refraction
A.A-2.4.5.1	LAMMR Wet Tropospheric Refraction
A.A-2.4.5.2	FNWC Wet Tropospheric Refraction
A.A-2.4.6	Sigma Naught Correction
A.A-2.5	Wind Speed Module
A.A-2.5.1	Sigma Naught
A.A-2.5.2	Wind Speed
A.A-2.6	Level 2 Altitude Module
A.A-2.6.1	Geoid Height
A.A-2.6.2	Tide Height
A.A-2.6.3	Solid Earth Tide Height
A.A-2.6.4	EM Bias
A.A-2.6.5	Sea Surface Height, Altitude Residual
A.A-2.7	Ice Sheet Height
A.A-2.8	Ocean Currents
A.A-2.9	Quality Control Module

TABLE IV. LEVEL 2 MODULE (continued)

Internal Files	
A.D-2.71	Geoid File
A.D-2.72	Tide File
A.D-2.73	5' x 5' Geoid File
Input Files	
A.D(M)-2.81	FNWC File
A.D(M)-2.82	Ionospheric Data File
A.D(L)-2.83	LAMMR Level 2 File
A.D(S)-2.84	SCATT Level 2 File
Output Files	
A.D-2.91	Level 2 Output File
A.D-2.92	Wind/Sigma Naught File

General Subsystem Flowchart

The NOSS altimeter processing software subsystem flowcharts for Level 1 and Level 2 are presented in Figures 3 and 4, respectively. A brief description of each of the software modules follows in the Narrative Description and a more detailed description of each of the modules and submodules is presented in the Data Description and Module Description. More detailed flowcharts for Level 1 and Level 2 showing the submodules are presented in Figures 5 and 6, respectively.

Narrative Description

A general description of each of the modules of the NOSS altimeter processing software, indexed by the algorithm identifier numbers (see Tables III and IV) follows.

A.A-1.1 Engineering Unit Conversion. - The altimeter processing software will convert the counts in the telemetry data stream to engineering (functional) units. The input to this module will be the raw (Level 0) altimeter telemetry data and the output will be altimeter parameters and housekeeping data, expressed in engineering units, to be used by the other modules of the altimeter processing software.

The method of conversion to engineering units will vary with different parameters. Some conversions will simply require a table lookup or a temperature correction, while

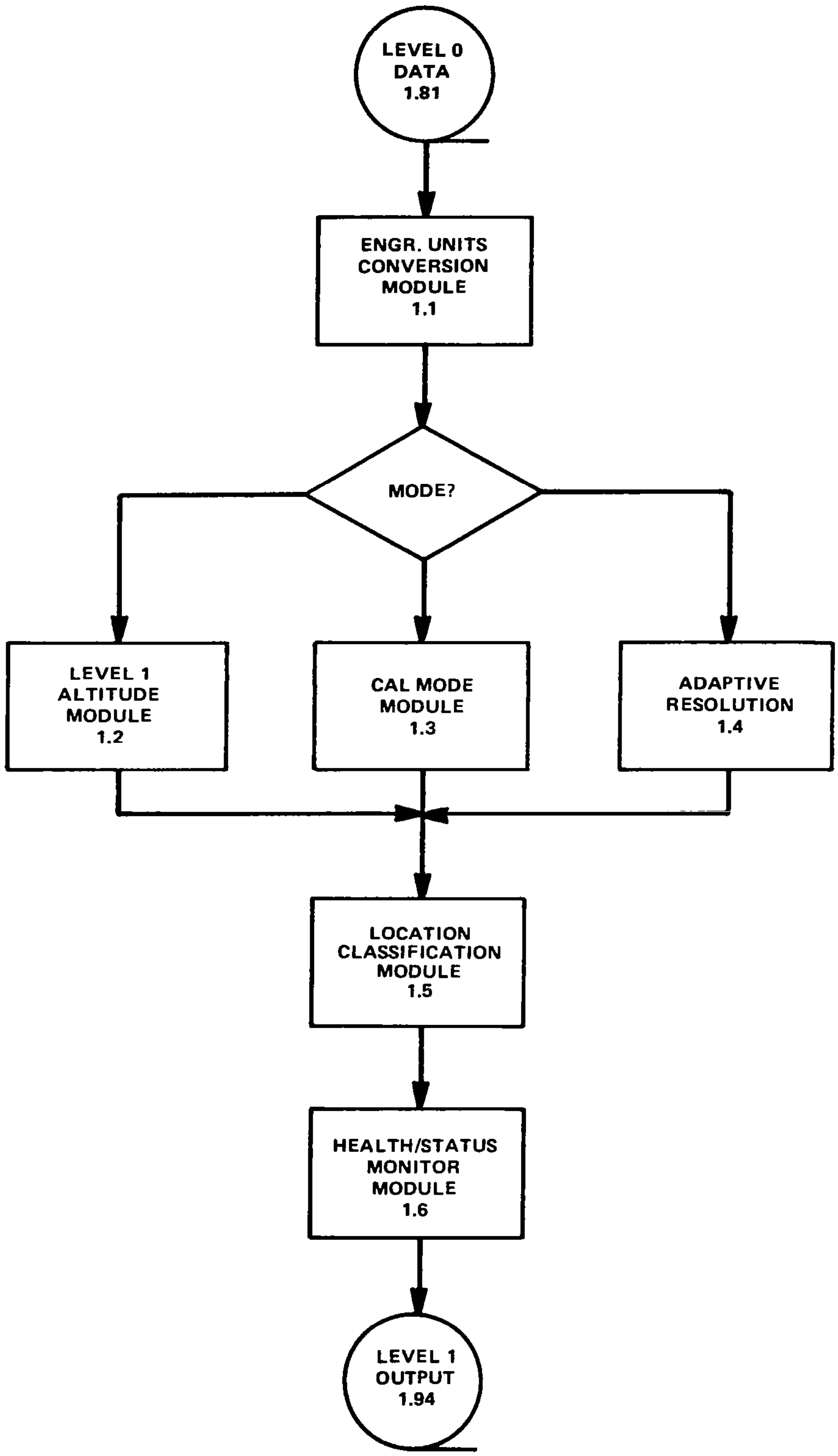


Figure 3. Altimeter Subsystem Level 1 Flowchart.

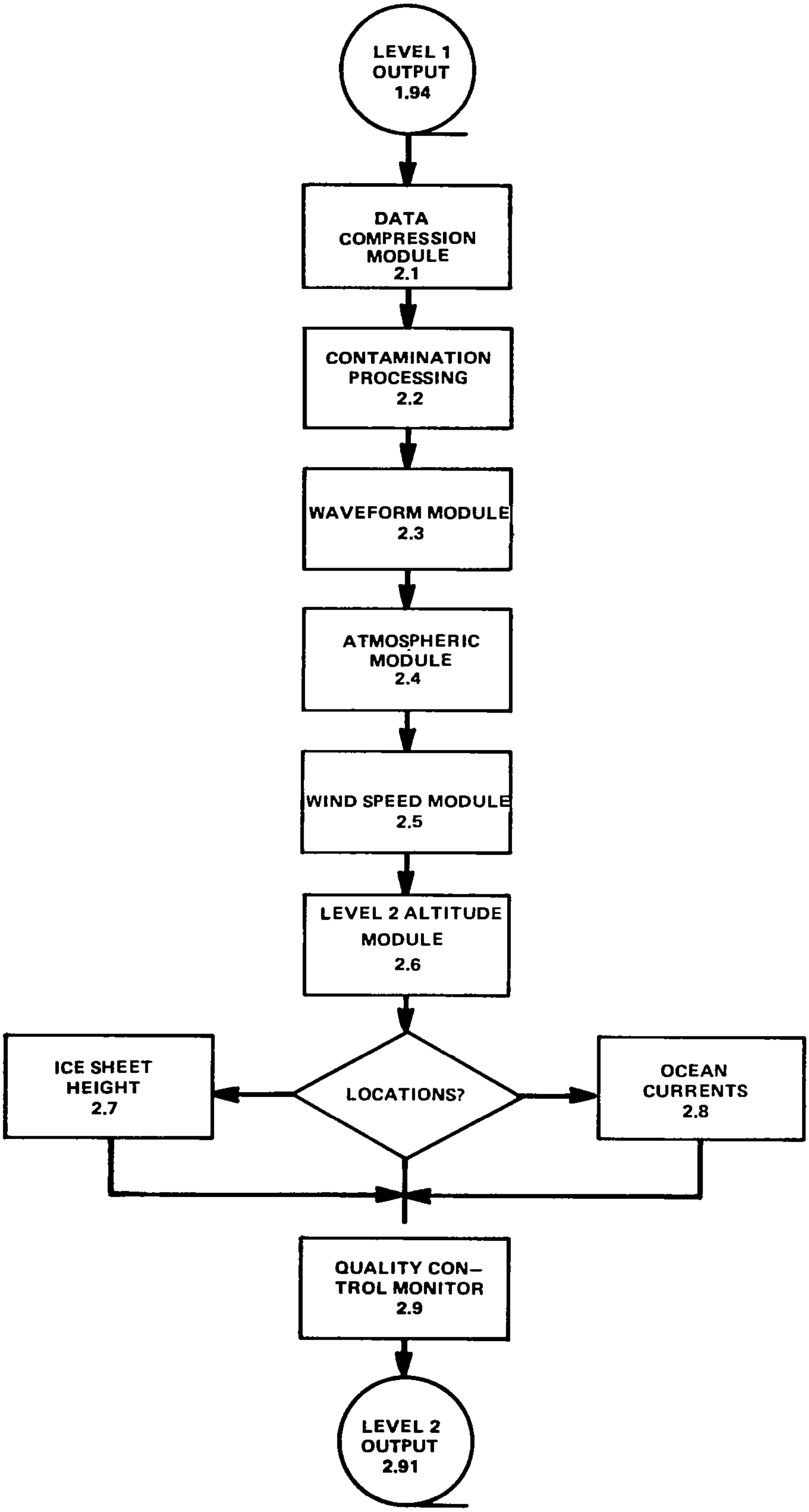


Figure 4. Altimeter Subsystem Level 2 Flowchart.

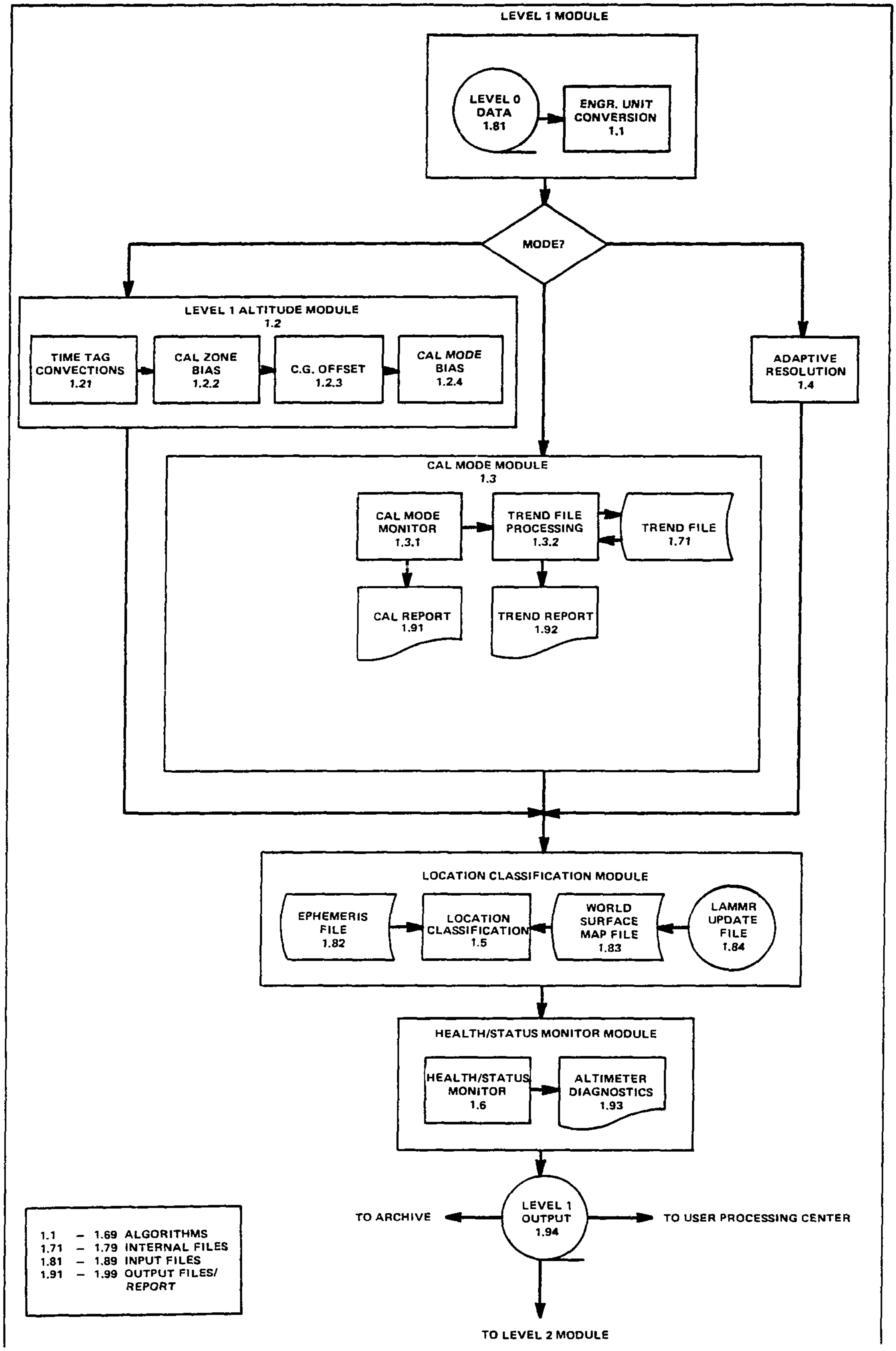


Figure 5. Altimeter Subsystem Detailed Level 1 Flowchart.

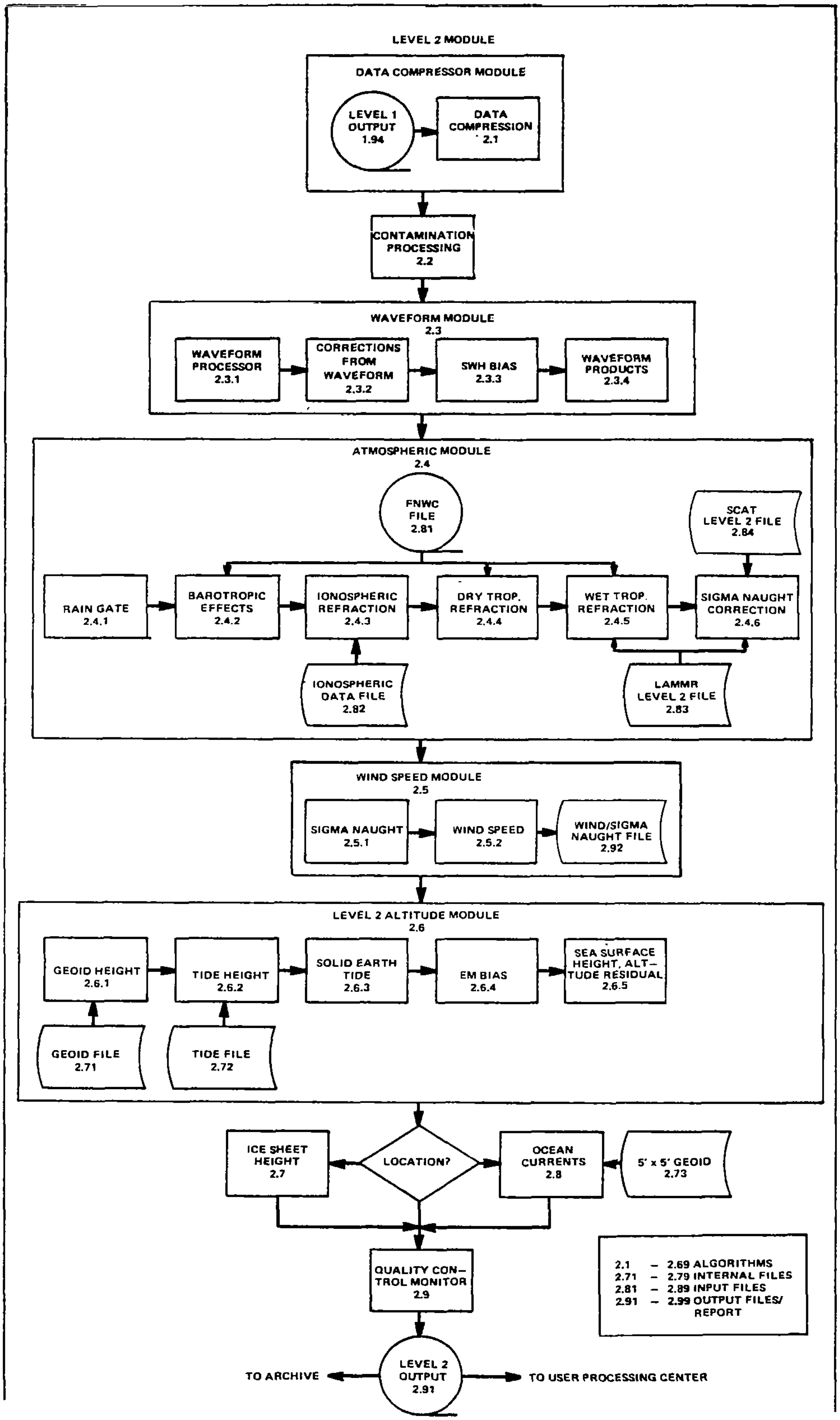


Figure 6. Altimeter Subsystem Detailed Level 2 Flowchart.

others will require the evaluation of a polynomial. It should be noted however that not all parameters in the telemetry stream require conversion to engineering units, since some parameters are merely flags whose bits are used to determine a status or mode of operation.

A.A-1.2 Level 1 Altitude Module. - The altimeter processing software will calculate certain sensor-related corrections to the altitude and AGC. These corrections are:

1. altitude time tag corrections
2. altitude cal zone bias
3. altitude center of gravity offset
4. altitude and AGC cal mode bias

The altitude time tag corrections compensate for altimeter differences in track mode and altitude. The cal zone bias will correct the altitude measurements to a common datum using data which is taken directly over laser tracking stations in the calibration area. The center of gravity offset will account for the expenditure of the onboard fuel. The cal mode bias compensates for differences determined by comparing calibration mode data with preflight tables.

It should be noted that the time tag corrections must be performed immediately after the engineering unit conversion so that all ephemeris data will be correctly interpolated in the Location Classification Module.

A.A-1.3 Cal Mode Module. - The altimeter processing software will monitor all calibration mode data in this module, which contains two submodules:

1. Cal Mode Monitor
2. Trend File Processor

The altimeter has internal calibration modes to detect changes in altitude, AGC, and other parameters due to aging, temperature and voltage fluctuation, etc. This mode will be employed for 60 seconds about once per day. The Cal Mode Monitor will process the calibration mode data, generating calibration reports of comparisons with preflight nominal calibrations. These reports will require human interpretation when flagged changes are significant enough to cause updates to the Cal Mode Bias submodule tables.

The Trend File Processor is designed to identify long range trends in the calibration mode data. To this end, a file of trends will be automatically maintained by the altimeter processing software and significant changes in altimeter parameters will be calculated and flagged. A human decision of the appropriate action to be taken to correct the flagged parameters will be required.

A.A-1.4 Adaptive Resolution. - Adaptive resolution is a mode where the altimeter has detected surface slope changes and automatically switched to a wider pulse width and different track constants to maintain lock. This will primarily occur over ice sheets and land. This module will correct time tags, AGC, and altitude in the adaptive resolution mode for offsets due to the selected pulse width and tracker characteristics. These corrections will make the Level 1 output products consistent with the normal track mode.

A.A-1.5 Location Classification Module. - The Level 1 altimeter processing software will classify the subsatellite point as either land, water, or ice based upon a world surface map. The ice fields of the world surface map will be updated by the LAMMR subsystem. Additionally, this module will merge and interpolate the satellite ephemeris data, which will be necessary in order to calculate the latitude and longitude of the subsatellite point.

A.A-1.6 Health/Status Monitor. - The altimeter processing software will automatically monitor critical instrument parameters and set off system alarms when a potentially damaging or dangerous condition is observed. This module will set quality flags for altitude, temperature, voltage, and current to be output to the Health/Status Monitor Report and to the Level 1 output data file. The analysis of this output will require human interpretation and interaction.

A.A-2.1 Data Compression. - The altimeter Level 1 output data rate is ten frames per second. The data compression software will smooth the data to a selectable rate. Nonproduction data modes such as cal mode, trigger kill, and standby will be culled. The software will also calculate standard deviations for most parameters for later quality analysis.

A.A-2.2 Contamination Processing. - The altimeter processing software will classify the nature of the subsatellite point as either land, water, or ice. This classification, which is derived from analysis of the altimeter data with a resolution of approximately 1 km, should not be confused with the classification performed in the Location Classification Module, which is derived from a world surface map and has a resolution of approximately 10 km. The software will estimate the time and location of land/water and ice/water interfaces. Additionally, a flag will be set to indicate if the data is appropriate for processing by the Waveform Module.

A.A-2.3 Waveform Module. - The altimeter Level 2 software will process waveform data in order to calculate SWH, attitude, and skewness, as well as altitude corrections and certain ocean wave parameters. The calculation of the SWH, attitude and skewness parameters requires an iterative calculation of a best fit solution to the waveform data. That calculation is the convolution of the antenna pattern, surface distribution, and radar pulse. If the solution fails to converge, then the instrument SWH will be used with backup table bias corrections to SWH and altitude.

A.A-2.4 Atmospheric Module. - The altimeter processing software will calculate the atmospheric corrections to the spacecraft altitude and the radar backscatter coefficient. It will also process data from the rain gate. The altitude corrections from this module consist of the combined effects of ionospheric refraction, wet and dry tropospheric refraction, and atmospheric pressure. The prime wet tropospheric refraction correction will employ data from a file built by LAMMR algorithms. FNWC data will be used when LAMMR data is not available.

The radar backscatter coefficient correction accounts for the effects of the atmosphere on return power. This will be based upon data from a file built by SCAT algorithms. The rain gate processing detects the presence of rain at the subsatellite point.

A.A-2.5 Wind Speed Module. - The altimeter processing software will calculate the radar backscatter coefficient and the ground wind speed. The calculated radar backscatter coefficient, sigma naught, is a function of AGC, altitude, and attitude, and the wind speed is a function of sigma naught. Note that the atmospheric correction to sigma naught will be applied before the wind speed is calculated.

A.A-2.6 Level 2 Altitude Module. - The altimeter processing software will correct the altitude measurements for EM bias which accounts for the difference between the radar observed sea surface height distribution and the geometrical sea surface height distribution. The module will also calculate the sea surface height and the altimeter residual. In order to calculate these two parameters, it is necessary to evaluate the geoid height, the tide height, and the solid earth tide height.

A.A-2.7 Ice Sheet Height. - This module will be employed only when over areas of ice sheet interest. The altimeter data will be corrected for waveform shape changes that cause track point shifts. This will be done by a software retracking process designed for ice sheet processing and then the surface height will be calculated.

A.A-2.8 Ocean Currents. - The altimeter processing software will calculate the location of major geostrophic ocean currents and their velocity components perpendicular to the ground track by noting deviations from the steady state measurements of sea surface height near open ocean areas. Since geoidal features are critical to the removal of current locations from the height data, and since the currents must be located to within 2 or 3 kilometers, the standard 1° x 1° geoid will not be sufficient. For the purposes of ocean current detection, a 5' x 5' geoid will be needed in the areas where currents are to be located. It should be noted that the geoid must be a gravimetric geoid and not an altimeter geoid. This is because the current height magnitude is already included in the altimeter geoid.

A.A-2.9 Quality Control Monitor. - As a final step in the Level 2 processing, the altimeter software will analyze the contents of the Level 2 output file in an attempt to classify the quality of the data. The data will be flagged as being of questionable quality when prescribed standard deviation tolerances are exceeded, when the number of rejected points in the various smoothing algorithms exceeds acceptable limits, or when operational threshold limits are exceeded.

Summary of Subsystem Interfaces

This section describes the subsystem interfaces between the altimeter processing software and other NOSS PPF software. These interfaces are in the form of input files and output files and reports, which are described in more detail in the Data Description.

The subsystem interfaces are as follows:

1. A.D(M)-1.81 Level 0 Data File. This file is supplied to the altimeter software from the PPF and contains all of the raw altimeter data in counts.
2. A.D(M)-1.82 Spacecraft Ephemeris File. This file is supplied by the contractor and contains the spacecraft ephemeris information needed to accurately identify the position of the spacecraft.
3. A.D(M)-1.83 World Surface Map File. This file is supplied to the altimeter software by the PPF and contains the locations of the land/ water and ice/water boundaries. The file is updated by the LAMMR update file A.D(L)-1.84.
4. A.D(L)-1.84 LAMMR Update File. This file is supplied by the LAMMR instrument and updates the ice field locations on the World Surface Map File. The mission contractor will handle the interfacing between A.D(L)-1.84 and A.D(M)-1.83.
5. A.D-1.91 Calibration Report. This report is generated by the altimeter processing software to summarize the cal mode data for human interpretation to analyze if any requirements exist to update parameter calibration tables.
6. A.D-1.92 Trend Report. This report is generated by the altimeter processing software to identify long range trends in the altimeter data for human interpretation to analyze if any requirements exist to update parameter calibration tables.
7. A.D-1.93 Altimeter Diagnostics. This report is generated by the altimeter processing software to identify altimeter parameters which have exceeded tolerances and it requires human interpretation to decide if the operation status of an altimeter needs to be modified.
8. A.D-1.94 Level 1 Output File. This file is supplied by the altimeter processing software to the PPF for archiving, level 2 processing and users. It contains all Level 1 altimeter data.
9. A.D(M)-2.81 FNWC File). This file is supplied to the altimeter software by the PPF and contains meteorological data used in calculations of altitude corrections.
10. A.D(M)-2.82 Ionospheric Data File. This file is supplied to the altimeter software by the PPF and contains sunspot or Faraday data for the calculation of ionospheric refraction.

11. A.D(L)-2.83 LAMMR Level 2 File. This file is supplied by the LAMMR level 2 processing and contains data for calculating the wet tropospheric refraction altitude correction and the sigma naught atmospheric correction.
12. A.D(S)-2.84 SCATT Level 2 File. This file is supplied by the SCATT level 2 processing and contains information relating to the sigma naught atmospheric correction.
13. A.D-2.91 Level 2 Output File. This file is supplied to the PPF by the altimeter processing software and contains all Level 2 altimeter data in corrected geophysical form.
14. A.D-2.92 Wind/Sigma Naught File. This file is supplied by the altimeter processing software to SCATT and CZCS and contains wind speed, sigma naught, SWH and rain rate estimates.

DATA DESCRIPTION

This section presents a detailed description of the data sets used or produced by the altimeter processing software. For each data set, the title and reference number, purpose, source, data volume, and description is given.

Input Data Sets

This section describes the input data sets used by the altimeter processing software.

TITLE:	LEVEL 0 DATA FILE	A.D(M)-1.81
FUNCTION:	Provide the basic inputs to the altimeter Level 1 processing for use by module A.A-1.1 engineering units conversion module.	
SOURCE:	Spacecraft telemetry stream	
DATA VOLUME:	The data rate is 10 or 20 frames of 100 ten bit words per second which implies 10 to 20 kilobits per second depending on altimeter telemetry mode. In addition spacecraft data of 264 bytes per second will be included. The amount of data maintained on file and its update frequency will be designed by the mission contractor, however it is expected to be about 100 minutes with updates per orbit. The total file then would be 25,584 kilobytes.	

DESCRIPTION: Table 1.81a gives the expected altimeter telemetry contents and table 1.81b lists the parameters required by the altimeter processing that are in the spacecraft engineering data block. It is assumed that all unpacking of the telemetry stream will be done by the mission contractor and data will be supplied in counts to the altimeter level 1 processor.

TABLE 1.81a

NOSS ALTIMETER TELEMETRY MODE 1 CONTENT (10/S)

1	Time
2	Time
3	Altitude 1
4	"
5	"
6	Altitude 2
7	"
8	"
9	Altitude rate 1
10	" " 2
11	Altitude error 1
12	" " 2
13	SWH
14	AGC word
15	AGC gate
16	Early gate
17	Late gate
18	Middle gate
19	$L_6 - E_6$
20	Noise gate
21	Plateau gate
22	Attitude gate
23	Rain gate 1
24	Rain gate 2
25	Transmit power
26	Cal atten/SACU status
27	Status 1
28	" 2
29	" 3
30	" 4
31	" 5 (Alt 1 or Alt 2, Program version, Tracker type, Resolution steps)
:	
32	Engineering 1 subcom 30 deep
33	Engineering 2 subcom 30 deep
34	Waveform samples (average of 100 PRF's)
	: : : : : :
96	Waveform samples (average of 100 PRF's)
97	Spare
:	:
100	Spare

Table 1.81a (continued)

NOSS ALTIMETER TELEMETRY MODE 2 CONTENT (20/S)

Same content as 10/S except at double rate where altitudes 1 are updated at 20/S and altitudes 2 are zero and waveform samples are average of 50 PRF's.

NOSS ALTIMETER TELEMETRY MODE 3 CONTENT (CW)

Words 1 to 33 will be the same as TM format 1. Words 34 to 96 will be nine groups of seven words containing T_X count, hit count, attitude and AGC.

NOSS ALTIMETER TELEMETRY MODE 4 CONTENT (DUMP)

Same content as TM 3 except words 34 to 96 will contain memory dump data.

NOTES:

1. Time is applied by the spacecraft and inserted with the altimeter TM.
2. Adaptive Resolution uses same format at present, however, after more design work it may require a different format.

TABLE 1.81b

ALTIMETER RELATED SPACECRAFT ENGINEERING DATA (1/S)

Name	Length, Bytes
Time	8
Instrument attitude	8
Baseplate temperature	120
Instrument currents	16
Instrument voltages	8
Instrument heater status	8
Altimeter analog channels	96
	264

Note: Information is always available on both altimeters.

TITLE: EPHEMERIS FILE A.D(M)-1.82

FUNCTION: To supply the spacecraft height above the reference ellipsoid and the latitude and longitude of the subsatellite point as a function of time. It will be read and interpolated by the Location Classification Module (A.A-1.5).

SOURCE: Mission contractor

DATA VOLUME: Each record will contain 36 bytes (see DESCRIPTION). The record frequency will be once per minute. One weeks data will be kept on a rotating basis. Therefore the total size of this file will be 362,880 bytes.

DESCRIPTION: Each record will contain

T_{JD} = double precision time in Julian date form (8 bytes) in (d,0.000001)

ϕ = double precision latitude of the subsatellite point (8 bytes) in (deg,0.0001)

λ = double precision longitude of the subsatellite point (8 bytes) in (deg,0.0001)

H = double precision height above the reference ellipsoid (8 bytes) in (m,0.001)

$\phi_{\odot}$ = geodetic latitude of the sun (4 bytes) in (deg,0.0001)

TITLE: WORLD SURFACE MAP FILE A.D(M)-1.83

FUNCTION: To classify a given surface location as land, water, or ice. The file will be read by the Location Classification Module (A.A-1.5).

SOURCE: Mission contractor, with update from the LAMMR Update File (A.D(L)-1.84)

DATA VOLUME: Since the resolution required is approximately 10 kilometers (about 1/10 degree), the maximum number of entries would be (10x360)x(10x180) = 648,000,000. However, some mechanism should be found so that large areas of land, water, or ice can be identified without the necessity of having a data point every 10 km. This should decrease the actual required size to approximately 1,000,000 entries.

DESCRIPTION: Each record will contain

ϕ = latitude (4 bytes) in (deg,0.01)

λ = longitude (4 bytes) in (deg,0.01)

Γ_{Cl} = classification flag (1 byte)
- 1 for water
- 2 for ice
- 3 for land
- 4 for altimeter calibration zone

TITLE: LAMMR UPDATE FILE A.D(L)-1.84

FUNCTION: To provide ice field location updates to the World Surface Map File (A.D(M)-1.83).

SOURCE: LAMMR

DATA VOLUME: See LAMMR Algorithm Freeze Report, Section 4.3.

DESCRIPTION: The mission contractor will supply the capability to utilize this file to maintain the latest estimate of the ice field extension on file A.D(M)-1.83.

TITLE: FNWC FILE A.D(M)-2.81

FUNCTION: To provide FNWC weather data so that the height atmospheric corrections can be calculated. The FNWC file is read by the Atmospheric Module submodules and used for Barotropic Effects (A.A-2.4.2), Dry Tropospheric Refraction (A.A-2.4.4), and FNWC Wet Tropospheric Refraction (A.A-2.4.5.2).

SOURCE: Fleet Numerical Weather Center (FNWC)

DATA VOLUME: Each record will contain

P = surface atmospheric pressure (4 bytes)

e = surface water vapor pressure (4 bytes)

T_o = surface atmospheric temperature (4 bytes)

DESCRIPTION: The data will be made available 2 hours after synoptic time (0000Z, 0300Z, 1200Z, and 1800Z). A near real-time data link to FNWC must be established in order to maintain this file. One weeks worth of data will be maintained on a rotating basis.

TITLE: IONOSPHERIC DATA FILE (SUNSPOT MODEL) A.D-2.82A

FUNCTION: To provide input data to the Ionospheric Refraction Correction Module (A.A-2.4.3A), which calculates the altitude correction.

SOURCE: National Oceanic and Atmospheric Administration (Boulder, CO)

DATA VOLUME: The file consists of 1728 coefficients (each 4 bytes) for each month. It will require updates once per month by card deck available from NOAA. All data should be archived; however only two months of data should be required on active file. Therefore, the total size would be 3,456 bytes.

DESCRIPTION: See Ref. 4.

TITLE: LAMMR LEVEL 2 FILE A.D(L)-2.83

FUNCTION: To provide the LAMMR estimates of the wet tropospheric refraction height correction to the Wet Tropospheric Refraction Module (A.A-2.4.5).

SOURCE: LAMMR

DATA VOLUME: Each input record will contain 17 bytes (see DESCRIPTION). The input rate will be every 3 seconds.

DESCRIPTION: Each record will contain

(1) Time in Julian date form (8 bytes)

(2) Wet tropospheric refraction correction in meters (4 bytes)

(3) Correction quality flag (1 byte)

(4) Rain rate estimate (4 bytes)

The magnitude of the time will be on the order of 2,450,000, the range of the wet tropospheric refraction correction will be 0.0 to 3.0, and the range of the quality flag will be 1 to 5. One weeks worth of data will be maintained on a rotating basis.

TITLE: SCATT LEVEL 2 FILE A.D(S)-2.84

FUNCTION: To provide the atmospheric correction to sigma naught computed by the scatterometer. The file is read by the Sigma Naught Correction Module (A.A-2.4.6).

SOURCE: Scatterometer

DATA VOLUME: Each input record will contain 14 bytes (see DESCRIPTION). The input rate will be once per second.

DESCRIPTION: Each record will contain

(1) Time in Julian date form (8 bytes)
(2) Sigma naught atmospheric correction in dB (4 bytes)
(3) Correction method flag (1 byte)
(4) Correction quality flag (1 byte)

The magnitude of the time will be on the order of 2,450,000, the range of the sigma naught correction will be -2 to 2, and the ranges of the correction method and quality flags will be 1 to 5. One weeks worth of data will be maintained on a rotating basis.

Internal Data Files

This section describes the internal data files used by the altimeter processing software.

TITLE: TREND FILE A.D-1.71

FUNCTION: To maintain a history file of the calibration mode data in order to assist in the identification of long range trends in that data. The file will be read from and written to by the Trend File Processor (A.A-1.3.2).

SOURCE: All input will originate in the Cal Mode Module (A.A-1.3), which is responsible for the processing of the calibration mode data.

DATA VOLUME: Each cal mode produces approximately 5000 bytes. Cal mode data will be taken on an average of once per day and 365 days worth of data will be maintained by the file.

DESCRIPTION: Statistics will be maintained for altitude and AGC during each cal mode step and for engineering parameters over the entire mode.

TITLE:	GEOID FILE	A.D-2.71

FUNCTION: To provide global geoid height estimates to be written on the Level 2 Output File (A.D-2.91) and used in the calculation of the altimeter residual (A.A-2.6.5). The file is read by the Geoid Height Module (A.A-2.6.1).

SOURCE: Numerous geoid models are currently available with more expected by the launch of the spacecraft. Most of the geoid models which are currently accepted as the most accurate have been generated by and are available from GSFC.

DATA VOLUME: The geoid file will contain geoid heights on a 1°x1° grid over the entire earth's surface (360x180 = 64,800). Each entry could be described in 4 bytes, for a total of 259,200 bytes. The file will be permanent and will therefore require no updates.

DESCRIPTION: Each entry will be the modeled geoid height at a given latitude and longitude, expressed in meters. The range of the data will be from -150 m to 100 m.

TITLE:	TIDE HEIGHT	A.D-2.72

FUNCTION: To provide global ocean tide height estimates to be written on the Level 2 Output File (A.D-2.91) and used in the calculation of the altimeter residual (A.A-2.6.5). The file is read by the Tide Height Module (A.A-2.6.2).

SOURCE: E. W. Schwiderski, Naval Surface Weapons Center, Dahlgren, Va.

DATA VOLUME: The tide file will contain tide amplitude and phase magnitudes on a 1°x1° grid over the entire earth's surface (2x360x180 = 129,600 entries). Each entry could be described in 4 bytes, for a total of 518,400 bytes. The file will be permanent and will therefore require no updates.

DESCRIPTION: At every latitude and longitude, the tide amplitude (expressed in meters) and phase angle (expressed in degrees) will be supplied. The amplitude range will be -10 m to 10 m and the phase angle range will be -180 deg to 180 deg.

TITLE:	5'x5' GEOID FILE	A.D-2.73
FUNCTION:	To provide geoid height estimates to be used by the Ocean Currents Module (A.A-2.8).	
SOURCE:	TBD	
DATA VOLUME:	The 5'x5' geoid file will contain geoid heights on a 5'x5' grid in selected areas where ocean currents are to be located. The number and dimensions of these grids will be determined at a later date.	
DESCRIPTION:	Each entry will be the modeled geoid height at a given latitude and longitude, expressed in meters. Care must be taken to ensure that the geoid is a gravimetric geoid and not an altimeter geoid. The range of the data will be from -150 m to 100 m.	

Output Data Sets

This section describes the output data sets produced by the altimeter processing software.

TITLE:	CAL REPORT	A.D-1.91
FUNCTION:	To summarize the statistics of the calibration mode data.	
SOURCE:	The report is written by the Cal I Processor (A.A-1.3.1.1) and the Cal II Processor (A.A-1.3.1.2).	
DATA VOLUME:	The report will be 14 printed pages. One week's worth of data will be kept on a rotating basis.	
DESCRIPTION:	The report will contain means, standard deviations, maximums, and minimums for All waveform samples Altitude Altitude error AGC gate amplitude Noise gate amplitude	

DESCRIPTION (continued)

Plateau gate amplitude
Attitude gate amplitude
Rain gate amplitude
Transmit power
AGC word
Unit temperatures
Power supply voltages

as well as flags on data outside specified tolerances. The above output will be generated for both Cal I and Cal II calibration mode data.

TITLE: TREND REPORT A.D-1.92

FUNCTION: To summarize the output of the Trend File Processor (A.A-1.3.2) and display long range trends in the calibration mode data so that a human decision can be made if appropriate action needs to be taken.

SOURCE: Trend File Processor (A.A-1.3.2)

DATA VOLUME: The report, which is produced daily, will be a maximum of 5 printed pages and will be kept on file for one month on a rotating basis.

DESCRIPTION: The report will identify those calibration data parameters which are exhibiting long range trends. Specific values will be printed and a graphic display of the trend will be generated.

TITLE: ALTIMETER DIAGNOSTICS A.D-1.93

FUNCTION: To display the magnitudes of critical instrument parameters and flag potentially damaging or dangerous conditions.

SOURCE: Health/Status Monitor (A.A-1.6)

DATA VOLUME: The report will be a maximum of 5 printed pages per day. It will be kept on file for one month on a rotating basis.

DESCRIPTION: Means and standard deviations will be calculated and printed for all critical instrument parameters and data outside nominal preflight tolerances will be flagged for human interpretation.

TITLE:	LEVEL 1 OUTPUT FILE	A.D-1.94
FUNCTION:	Provide altimeter data in user units first order corrected for archive, level 2 processing and research users.	
SOURCE:	Altimeter level 1 processor	
DATA VOLUME:	The output data rate is 10 to 20 data records per second depending on the altimeter telemetry mode and 1 spacecraft engineering record per second. Each record is 270 bytes and each spacecraft engineering record is 264 bytes which implies 5664 bytes per second. The amount of data maintained on file and its update frequency will be designed by the mission contractor; however,it is expected to be about 100 minutes with an update per orbit. The total file would then be 33,984 kilobytes.	
DESCRIPTION:	Table 1.94 list the contents of the altimeter level 1 output data record. Also data in Table 1.81b is output once per second. Each parameter is in user units and, where necessary, corrected for temperature and operating mode effects. All parameter corrections are carried on the output file in order that the original data can be recovered. A header record will contain the software version data.	

TITLE:	LEVEL 2 OUTPUT FILE	A.D-2.91
FUNCTION:	Provide fully corrected altimeter geophysical data for archive and users.	
SOURCE:	Altimeter level 2 processor	
DATA VOLUME:	The normal output data rate is one record per second, however the compression factor will be selectable from 20 to 1/5 records per second. Each record is 200 bytes. The amount of data maintained on file and the update frequency will be designed by the mission contractor. It is expected to be 100 minutes with an update per orbit. The total file would then be 1200 kilobytes.	

TABLE 1.94

ALTIMETER LEVEL 1 OUTPUT RECORD CONTENT

Name	Length, Bytes
Time	8
Orbit Number	4
Latitude	4
Longitude	4
Orbit Altitude	8
Solar Latitude	2
Instrument Attitude	2
World Classification	1
Zone Flag	2
Altimeter Number/Mode	1
Health Flags	6
Altitude 1 and 2	16
Altitude Rate 1 and 2	8
Altitude Error 1 and 2	8
SWH	2
AGC	2
Delta Time	2
Delta Altitude for CG	2
Delta Altitude for CZ	2
Delta Altitude for CM	2
Delta AGC for CM	2
Delta Altitude for AR	2
Delta AGC for AR	2
TM Words 13 to 94	164
Spare	14
	270

DESCRIPTION: Table 2.91 lists the contents of the altimeter level 2 output record. All parameters have been corrected for instrument and physical by induced errors. Each delta correction is carried in the output so that if a correction is in question by an individual user, he may remove it. The data is in geophysical units ready for the application user data base. A header record will contain software version number and compression rate.

TITLE: WIND/SIGMA NAUGHT FILE A.D-2.92

FUNCTION: To provide the altimeter estimates of wind speed and sigma naught to the processing software of the other instruments.

SOURCE: Wind Speed Module (A.A-2.5)

TABLE 2.91

ALTIMETER LEVEL 2 OUTPUT RECORD CONTENTS

Name	Length, Bytes
Time	8
Orbit Number	4
Latitude	4
Longitude	4
Orbit Altitude	8
Solar Latitude	2
Instrument Attitude	2
World Classification	1
Zone Flag	2
Altimeter Number/Mode	1
Quality Flags	6
Contamination Flag	2
Number of Frames Compressed	2
Altitude	8
Altitude Sigma Scatter and Correction	4
Delta Altitude Corrections (16)	32
Atmospheric Measurements	8
SWH	2
SWH Sigmas	4
Delta SWH Corrections	4
Ocean Backscatter σ_o	2
Delta σ_o Correction/Method	4
Windspeed	2
Rain Rate/Quality	4
AGC	2
AGC Sigma	4
Rain Gate 1 and 2	4
Waveform Amplitude	2
Waveform Baseline	2
Waveform Attitude	2
Skewness	2
Waveform Products	8
Sea Surface Height	2
Altitude Residual	2
EM Bias	2
Geoid Height	2
Tide Height	2
Solid Earth Tide	1
Current Area/Quality	1
Current Speed/Direction	4
Ice Boundary/Quality	1
Mean Square Slope	2
Percent Smoothness	2
Ice Delta Height Correction	2
Ice Delta AGC Correction	2
Ice Surface Slope	2
Ice Surface Roughness	2
Spares	14
	200

DATA VOLUME: Each output record will contain 24 bytes (see DESCRIPTION). The output data rate will be once per second and one weeks worth of data will be kept on file on a rotating basis.

DESCRIPTION: Each record will contain

(1) Time in Julian date form (8 bytes)
(2) Wind speed in m/sec (4 bytes)
(3) Sigma naught in dB (4 bytes)
(4) SWH in meters (4 bytes)
(5) Rain rate in mm/hr (2 bytes)
(6) Rain rate quantity flag (1 byte)
(7) Rain rate quality flag (1 byte)

The magnitude of the time will be on the order of 2,450,000, the range of the wind speed will be 0 to 50 m/sec, the range of sigma naught will be 0 to 20 dB. The range of SWH will be 0 to 20 m, and the range of the rain rate will be 0 to 20 mm/hr. One weeks worth of data will be maintained on a rotating basis.

Alternative Data Sets

This section describes the alternative data sets used or produced by the altimeter processing software.

TITLE: IONOSPHERIC DATA FILE (FARADAY MODEL) A.D-2.82B

FUNCTION: To provide input data to the Ionospheric Refraction (Faraday Model) module, A.A-2.4.3B.

SOURCE: Goldstone and Armidale tracking stations

DATA VOLUME: Each station provides 16 bytes per day (see DESCRIPTION) and one weeks worth of data will be kept on file on a rotating basis.

DESCRIPTION: Each record contains

date (4 bytes)
$E_{c,min}$ (4 bytes)
$E_{c,max}$ (4 bytes)
β (4 bytes)

MODULE DESCRIPTIONS

This section contains the detailed descriptions of the altimeter processing algorithms.

Baseline Description

The functional requirements and general logic for each module of the altimeter processing algorithms is provided in this section. For each module the title and reference number, function, inputs and outputs, special tables, and processing is presented. Unless noted otherwise, the flexibility of the algorithm is considered to require no changes. Also, unless noted, quality control output is not a portion of that algorithm.

TITLE:	ENGINEERING UNIT CONVERSION	A.A-1.1
FUNCTION:	To convert the counts in the telemetry data stream to engineering (functional) units. The input to this module will be the raw (Level 0) altimeter telemetry data and the output will be altimeter parameters and housekeeping data, expressed in engineering units, to be used by the other modules of the altimeter processing software.	
INPUTS:	Level 0 altimeter telemetry data file (A.D-1.81)	
OUTPUTS:	Altimeter data expressed in engineering units	
SPECIAL TABLES:	Table 1.1, a sample for types of engineering unit conversions	
PROCESSING:	The method of conversion to engineering units will vary with different parameters. Some conversions will simply require a table lookup or a temperature correction, while others will require the evaluation of a polynomial. (See Table 1.1 for the specific conversion method required by each parameter.)	
FLEXIBILITY:	The coefficients need to be easily changeable since the final set will not be available until after all spacecraft tests are completed.	

TABLE 1.1 EU Conversion

Parameter	Telemetry Designation	EU Conversion/Bit Description	Units
Course Height	AL 700	$h_c = 2.398459587 \times 10^{-1}(AL\ 700) + 734.5282485$	Km
Medium Height	AL 701	$h_m = 2.342245691 \times 10^{-4}(AL\ 701)$	Km
Fine Height	AL 702	$h_f = 2.287349307 \times 10^{-7}(AL\ 702)$	Km
Altitude Rate	AL 703(1)	$h = 2.332946976 \times 10^{-1}(AL\ 703)$	m/s
Height Error	AL 704(2)	$\Delta h = 2.342245691 \times 10^{-1}(AL\ 704)$	cm
AGC Gate	AL 705		Counts
Early Gate	AL 706		Counts
Late Gate	AL 707		Counts
Middle Gate	AL 708		Counts
$L_6 - E_6$	AL 709		Counts
Noise Gate	AL 710	$NG = 2.03264 \times 10^{-3}(AL\ 711)$	Volts
Plateau Gate	AL 711	$PG = 2.03264 \times 10^{-3}(AL\ 712)$	Volts
Attitude Gate	AL 712	$AG = 2.03264 \times 10^{-3}(AL\ 713)$	Volts
Transmit Power	AL 713	$TP = 1.47961997 \times 10^{-8}(AL\ 713)^3 - 2.127214274 \times 10^{-5}(AL\ 713)^2 + 1.224979136 \times 10^{-2}(AL\ 713) - 1.08317283605$	Kw
Command Parity	AL 714		Counts
Memory Dump	AL 715	= 0 for dump off = 1 for dump on	
Cal III Mode	AL 716	= 0 for Cal III off = 1 for Cal III on	
Cal I, II Mode	AL 717	= 0 for Cal I, II off = 1 for Cal I, II on	
Command Mode	AL 718	= 0 for standby = 1 for calibrate = 2 for trigger kill = 3 for track 1 = 4 for track 2 = 5 for track 3 = 6 for track 4 = 7 for TWT fault reset = 8 for test 1 = 9 for test 2	

Table 1.1 EU Conversion (continued)

Parameter	Telemetry Designation	EU Conversion/Bit Description	Units
		= 10 for test 3	
		= 11 for test 4	
Tracker Initialize	AL 719	= 0 for initialize	
		= 2 for no initialize	
Not Used	AL 720		
Engineering Data KSB's	AL 721		Counts
TWT Beam Current	AL 722	BC = 0.006352A(AL 722)	Amps
TWT Cathode Voltage	AL 723	T_c = -0.059(AL 723) + 0.250	Kw
TWT HVPS Temperature	AL 724	(3)	°C
TWT Collector Temperature	AL 725	(3)	°C
No Data	AL 726		
Receiver Temperature	AL 727	(3)	°C
Noise Gate	AL 728	NG = 0.006352(AL 728)	Volts
Plateau Gate	AL 729	PG = 0.006352(AL 729)	Volts
Attitude Gate	AL 730	AG = 0.006352(AL 730)	Volts
Transmit Power	AL 731	$TP = 4.515441884\times10^{-7}(AL\ 731)^3$	Kw
		$- 2.077357689713\times10^{-4}(AL\ 731)^2$	
		$+ 3.82805979971\times10^{-2}(AL\ 731)$	
		$- 1.08317283605$	
UCFM Temperature	AL 732	(3)	°C
DDL Temperature	AL 733	(3)	°C
DDL ASSY Temperature	AL 734	(3)	°C
HSWS Temperature	AL 735	(3)	°C
DFB #1 Temperature	AL 736	(3)	°C
ATU #1 Temperature	AL 737	(3)	°C
ATU #2 Temperature	AL 738	(3)	°C
ICU Temperature	AL 739	(3)	°C
SACU Temperature	AL 740	(3)	°C
LVPS Temperature	AL 741	(3)	°C
LVPS 38V Current	AL 742	+38V = 0.0162(AL 742)	Amps
+28V S/C Bus	AL 743	S/C = 0.1452(AL 743)	Volts
.	.		.
.	.		.
.	.		.
.	.		.

Table 1.1 EU Conversion (continued)

Parameter	Telemetry Designation	EU Conversion/Bit Description	Units
Calibration Attenuator	AL 784	= 59.5 for AL 784 = 5	dB
		= 55.6 for AL 784 = 6	
		= 50.0 for AL 784 = 7	
		= 43.7 for AL 784 = 8	
		= 36.1 for AL 784 = 9	
		= 30.3 for AL 784 = 10	
		= 24.2 for AL 784 = 11	
		= 18.2 for AL 784 = 12	
		= 12.2 for AL 784 = 13	
		= 6.2 for AL 784 = 14	
		= 0.0 for AL 784 = 15	
Spare	AL 785		
High Voltage on Status	AL 786	= 0 for on	
		= 1 for off	
High Voltage Ready Status	AL 787	= 0 for not ready	
		= 1 for ready	
TWT Fault Status	AL 788	= 0 for no fault	
		= 1 for fault	
Gate Width	AL 789		Counts
ACQ/TRK	AL 790	= 0 for track	
		= 1 for acquisition	
.	.		.
.	.		.
.	.		.
Waveform Samples	AL 807		Counts
.	.		.
.	.		.
.	.		.
.	.		.
Waveform Samples	AL 869		Counts
CW Word Count	AL 870		Counts
CW Hit Count	AL 871		Counts
CW Height Fine	AL 872	$h_f = 2.927807114 \times 10^{-5}(AL\ 872)$	Km
CW Height Medium	AL 873	$h_m = 7.495186212 \times 10^{-3}(AL\ 873)$	Km
CW Height Course	AL 874	$h_c = 1.918767670(AL\ 874) + 730.6670565$	Km

Table 1.1 EU Conversion (continued)

Parameter	Telemetry Designation	EU Conversion/Bit Description	Units
CW AGC Fine	AL 875	$AGC_f = 1.953125 \times 10^{-3}$(AL 875)	dB
CW AGC Course	AL 876	$AGC_c = 0.5$(AL 876)	dB
AGC Word Fine	AL 900	AGC = 0.0625(AL 900)	dB

Explanatory Footnotes:

(1) Expressed in 2's complement notation.

(2) 6 bits: Mag. (2's complement); 4 bits: Scale; (AL 704) = Mag x 2^{-scale}

(3) $TEMP = 2.9787362 \times 10^{-10}\,(counts)^5 - 1.680493 \times 10^{-7}\,(counts)^4 + 4.237109 \times 10^{-5}\,(counts)^3 - 5.6777236 \times 10^{-3}\,(counts)^2 + 7.2703893 \times 10^{-1}\,(counts) - 2.4794246 \times 10^{1}$

TITLE: LEVEL 1 ALTITUDE MODULE A.A-1.2

FUNCTION: To calculate certain sensor-related corrections to the altitude and AGC. These corrections are:

1. altitude time tag corrections
2. altitude cal zone bias
3. altitude center of gravity offset
4. altitude and AGC cal mode biases

The inputs to the module are the raw Level 1 altitude and AGC and the above corrections, which are computed by submodules. The corrections are summed and then applied to the altitude and AGC. The outputs of the module are the corrected altitude and AGC. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: t_o = altitude measurement time tag in (s,0.0001)

h_o = raw altitude measurement in (m,0.001)

INPUTS (continued)	AGC_o	= raw AGC in (dB,0.01)
	Δt	= time tag correction from A.A-1.2.1 in (s,0.0001)
	ΔAGC	= cal mode bias AGC correction from A.A-1.2.4 in (dB,0.01)
	$\delta h_{1,1}$	= cal zone bias altitude correction from A.A-1.2.2 in (m,0.001)
	$\delta h_{1,2}$	= c.g. offset altitude correction from A.A-1.2.3 in (m,0.001)
	$\delta h_{1,3}$	= cal mode bias altitude correction from A.A-1.2.4 in (m,0.001)
	$\sigma_{\delta h_{1,1}}$	= standard deviation of $\delta h_{1,1}$ from A.A-1.2.2 in (m,0.001)
	$\sigma_{\delta h_{1,2}}$	= standard deviation of $\delta h_{1,2}$ from A.A-1.2.3 in (m,0.001)
	$\sigma_{\delta h_{1,3}}$	= standard deviation of $\delta h_{1,3}$ from A.A-1.2.4 in (m,0.001)
OUTPUTS:	t_1	= corrected altitude measurement time tag in (s,0.0001)
	h_1	= corrected altitude measurement in (m,0.001)
	AGC_1	= corrected AGC in (dB,0.01)
	σ_{h_1}	= standard deviation of h_1 in (m,0.001)
SPECIAL TABLES:	None	
PROCESSING:	Perform calculations in submodules A.A-1.2.1, A.A-1.2.2, A.A-1.2.3, and A.A-1.2.4	

$$t_1 = t_o + \Delta t$$

$$AGC_1 = AGC_o + \Delta AGC$$

$$\Delta h_1 = \delta h_{1,1} + \delta h_{1,2} + \delta h_{1,3}$$

$$h_1 = h_o + \Delta h_1$$

$$\sigma_{h_1} = \sqrt{\sigma^2_{\delta h_{1,1}} + \sigma^2_{\delta h_{1,2}} + \sigma^2_{\delta h_{1,3}}}$$

TITLE: TIME TAG CORRECTION A.A-1.2.1

FUNCTION: To control the calculation of the total altitude measurement time tag correction. The correction consists of two components:

1. constant time tag correction
2. variable time tag correction

The inputs to the module are the time tag corrections, which are computed by submodules. The output of the module is the sum of the time tag corrections. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: δt_1 = constant time tag correction from A.A-1.2.1.1 in (s,0.0001)

δt_2 = variable time tag correction from A.A-1.2.1.2 in (s,0.0001)

OUTPUTS: Δt = net time tag correction in (s,0.0001)

SPECIAL TABLES: None

PROCESSING: Perform computations in submodules A.A-1.2.1.1 and A.A-1.2.1.2

$$\Delta t = \delta t_1 + \delta t_2$$

TITLE: CONSTANT TIME TAG CORRECTION A.A-1.2.1.1

FUNCTION: To calculate the constant portion of the altitude measurement time tag correction. The input to the module is a flag indicating the track mode. The output of the module is the constant time tag correction. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: Γ_{TM} = track mode flag

OUTPUTS: δt_1 = constant altitude measurement time tag correction in (s,0.0001)

SPECIAL TABLES:

Γ_{TM}	δt_1
1	-0.0794
2	--
3	--
4	-0.0794

Table 1.2.1.1 Γ_{TM} vs δt_1

PROCESSING: Table lookup using Γ_{TM} and Table 1.2.1.1

TITLE: VARIABLE TIME TAG CORRECTION A.A-1.2.1.2

FUNCTION: To calculate the variable portion of the altitude measurement time tag correction. The input to the module is the spacecraft altitude and the output of the module is the variable time tag correction. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: h_o = raw altitude measurement in (m,0.001)

OUTPUTS: δt_2 = variable altitude measurement time tag correction in (s,0.0001)

SPECIAL TABLES: None

PROCESSING: k = 1 (by default)

$$\delta t_2 = k \times h_o \times 10^{-9} \div 2$$

TITLE: CAL ZONE BIAS A.A-1.2.2

FUNCTION: To calculate the altimeter measurement cal zone bias. The cal zone bias selected will maximize the absolute accuracy of the height measurement. The correction will be based upon the evaluation of passes which pass directly over laser tracking stations and will therefore be computed after launch. The input to the module will be the Julian date and the output of the module will be the altimeter cal zone bias. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: T_{JD} = time as Julian date in (d,1.0)

OUTPUTS: $\delta h_{1,1}$ = altitude cal zone bias in (m,0.001)

$\sigma_{\delta h_{1,1}}$ = standard deviation of $\delta h_{1,1}$ in (m,0.001)

SPECIAL TABLES: Table 1.2.2, a table of $\delta h_{1,1}$ and $\sigma_{\delta h_{1,1}}$ as a function of T_{JD} (not presently available). There will be a maximum of five table entries of T_{JD}, $\delta h_{1,1}$, and $\sigma_{\delta h_{1,1}}$.

PROCESSING: Table lookup using T_{JD} and Table 1.2.2. If several sets of T_{JD}, $\delta h_{1,1}$, and $\sigma_{\delta h_{1,1}}$ are available, then linear interpolation and extrapolation may be used to calculate the outputs.

FLEXIBILITY: Table 1.2.2 may need an update at the end of each laser tracking set calibration effort.

TITLE: CENTER OF GRAVITY OFFSET A.A-1.2.3

FUNCTION: To calculate the center of gravity offset correction to the altitude measurement. This correction will depend upon the expenditure of the onboard fuel and the position of each of the altimeters with respect to the center of gravity of the spacecraft. The position of the altimeters will be determined at some time in the future and the expenditure of fuel will occur at specified times after insertion into orbit so that a table of corrections as a function of time will need to be developed as the fuel is expended. The inputs to the module will be the Julian date and a flag to identify which altimeter is being used. The output of the module will be the center of gravity offset correction to the altitude measurement. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS: T_{JD} = time as Julian date in (d,1.0)

Γ_A = altimeter designation flag

OUTPUTS: $\delta h_{1,2}$ = altitude c.g. offset in (m,0.001)

$\sigma_{\delta h_{1,2}}$ = standard deviation of $\delta h_{1,2}$ in (m,0.001)

SPECIAL TABLES: Table 1.2.3, a table of $\delta h_{1,2}$ and $\sigma_{\delta h_{1,2}}$ as a function of T_{JD} for each of the two altimeters (not presently available). There will be a maximum of ten table entries of T_{JD}, $\delta h_{1,2}$, and $\sigma_{\delta h_{1,2}}$ for each of the two altimeters.

PROCESSING: Table lookup using T_{JD}, Γ_A, and Table 1.2.3.

FLEXIBILITY: Any movement of the center of gravity caused by the spacecraft design will have to be described.

TITLE:	CAL MODE BIAS	A.A-1.2.4

FUNCTION: To calculate the cal mode bias altitude and AGC correction. The biases are relative corrections to maintain consistent output products. After launch of the spacecraft, calibration mode data will be analyzed and compared to preflight tables to determine the altitude and AGC cal mode biases. The inputs to the module will be the Julian date and a flag to identify which altimeter is being used. The outputs of the module will be the cal mode altitude and AGC biases. Data in calibration mode or adaptive resolution mode will not be processed by this module.

INPUTS:

T_{JD} = time as Julian date in (d,1.0)

Γ_A = altimeter designation flag

OUTPUTS:

$\delta h_{1,3}$ = altitude cal mode bias in (m,0.001)

ΔAGC = AGC cal mode bias in (dB,0.01)

$\sigma_{\delta h_{1,3}}$ = standard deviation of $\delta h_{1,3}$ in (m,0.001)

SPECIAL TABLES: Table 1.2.4, a table of $\delta h_{1,3}$, ΔAGC, and $\sigma_{\delta h_{1,3}}$ as a function of T_{JD} for each of the two altimeters (not presently available). There will be a maximum of five table entries of T_{JD}, $\delta h_{1,3}$, ΔAGC, and $\sigma_{\delta h_{1,3}}$ for each of the two altimeters.

PROCESSING: Table lookup using T_{JD}, Γ_A, and Table 1.2.4.

If several sets of T_{JD}, Γ_A, $\delta h_{1,3}$, ΔAGC, and $\sigma_{\delta h_{1,3}}$ are available, then linear interpolation and extrapolation may be used to calculate the outputs.

FLEXIBILITY: Table 1.2.4 will require easy updates. The updates are determined by analysis of A.D-1.91 and A.D-1.92 output reports.

TITLE: CAL MODE MODULE A.A-1.3

FUNCTION: To control the processing and evaluation of all calibration mode data. The module consists of two submodules:

1. Cal Mode Monitor
2. Trend File Processor

The altimeter has internal calibration modes to detect changes in altitude, AGC, and other parameters due to aging, temperature and voltage fluctuation, etc. This mode will be employed for 60 seconds about once per day. The Cal Mode Monitor processes all calibration mode data and generates reports of comparisons with preflight nominal calibrations. The Trend File Processor identifies long range trends in the calibration mode data and maintains a file of trend information. All inputs and outputs are processed by the submodules. Non-calibration mode data will not be processed by this module.

INPUTS: None

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: Each submodule is processed in turn:

1. Cal Mode Monitor (A.A-1.3.1)
2. Trend File Processor (A.A-1.3.2)

TITLE: CAL MODE MONITOR A.A-1.3.1

FUNCTION: To process all calibration mode data, generating reports of comparisons with preflight nominal calibrations. These reports will require human interpretation when flagged changes are significant enough to cause updates to the Cal Mode Bias submodule in the Level 1 Altitude Module. The reports are produced by two submodules:

1. Cal I Processor
2. Cal II Processor

which process the two types of calibration mode data. The input to this module is a flag which identifies which of the two calibration modes is being processed. The outputs are the (possibly required) calibration mode altitude and

FUNCTION (continued)

AGC biases, which require human interpretation of validity before use in submodule A.A-1.2.4. Non-calibration mode data will not be processed by this module.

INPUTS: Γ_{CM} = Cal mode flag (1 for Cal I or 2 for Cal II)

OUTPUTS: $\delta h_{1,3}$ = altitude cal mode bias in (m,0.001)

ΔAGC = AGC cal mode bias in (dB,0.01)

SPECIAL TABLES: None

PROCESSING: The appropriate submodule is processed, depending upon the value of Γ_{CM} and the estimated bias updates are computed.

QUALITY CONTROL: The outputs are considered quality control products.

TITLE: CAL I PROCESSOR A.A-1.3.1.1

FUNCTION: To process all Cal I calibration mode data. Cal I data is designed to measure transmitter/receiver power and RF path-length changes and to verify the shape of the transmitted pulse. It will occur during the first 44 seconds of the calibration mode and will be divided into 11 steps of four seconds each, corresponding to 11 AGC settings:

Step #	AGC
1	0
2	6
3	12
4	18
5	24
6	30
7	36
8	42
9	48
10	54
11	60

The input to the module is the Cal I calibration mode data and the output is the Cal I Calibration Report. Only Cal I calibration data will be processed by this module.

INPUTS: Cal I calibration mode data.

OUTPUTS: Cal I Calibration Report (A.D-1.91).

SPECIAL TABLES: Table 1.3.1.1a, a table of calibration data tolerances (not presently available). There will be a maximum of 25 table entries for each of two altimeters.

Table 1.3.1.1b, a table of preflight nominal calibration data for comparison (not presently available). There will be a maximum of 25 table entries for each of the two altimeters.

PROCESSING: Means, standard deviations, maximums, and minimums for each step will be calculated and printed and flags on data outside specified tolerances will be set for

- All waveform samples
- Altitude
- Altitude error
- AGC gate amplitude
- Noise gate amplitude
- Plateau gate amplitude
- Attitude gate amplitude
- Rain gate amplitude
- Transmit power
- AGC word
- Unit temperatures
- Power supply voltages

Mean and standard deviations will be calculated using the following formulae:

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

$$\sigma_X = \sqrt{\frac{n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i \right)^2}{n(n-1)}}$$

QUALITY CONTROL: The output report is for quality control usage.

TITLE: CAL II PROCESSOR A.A-1.3.1.2

FUNCTION: To process all Cal II calibration mode data. Cal II data is designed to determine the noise characteristics of the system. It will occur during the last 16 seconds of the calibration mode. The input to the module is the Cal II calibration mode data and the output is the Cal II Calibration Report. Only Cal II calibration mode data is processed by this module.

INPUTS: Cal II calibration mode data.

OUTPUTS: Cal II Calibration Report.

SPECIAL TABLES: Table 1.3.1.2, a table of preflight nominal calibration data for comparison (not presently available). There will be a maximum of 25 table entries.

PROCESSING: Means, standard deviations, maximums, and minimums will be calculated and printed and flags set for

- All waveform samples
- Altitude
- Altitude error
- AGC gate amplitude
- Noise gate amplitude
- Plateau gate amplitude
- Attitude gate amplitude
- Rain gate amplitude
- Transmit power
- AGC word
- Unit temperatures
- Power supply voltages

Means and standard deviations will be calculated using the following formulae:

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

$$\sigma_X = \sqrt{\frac{n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2}{n(n-1)}}$$

QUALITY CONTROL: The output report is for quality control usage.

TITLE:	TREND FILE PROCESSOR	A.A-1.3.2

FUNCTION: To identify long range trends in the calibration mode data. A file of trends will be automatically maintained and significant changes in altimeter parameters will be calculated and flagged. A human decision of the appropriate action to be taken to correct the flagged parameters will be required. The inputs to the module will be the Cal Report and the Trend File and the outputs will be the updated Trend File and a display of flagged parameters. Calibration mode data will not be processed by this module.

INPUTS: Cal Report (A.D-1.91)

Trend File (A.D-1.71)

OUTPUTS: Updated Trend File (A.D-1.71)

Trend Report (A.D-1.92)

SPECIAL TABLES: Table 1.3.2, a table of tolerances (not presently available). The maximum number of table entries will be 100.

PROCESSING: The input cal report statistics will be compared with previous calibration mode summaries. A curve fit technique will be employed to determine if any long range trends are present. If significant long range trends are found, the parameters involved will be flagged and displayed for human interpretation and reaction.

QUALITY CONTROL: The Trend Report is for quality control usage. The possible reaction will be to update the cal mode bias tables in A.A-1.2.4.

TITLE: ADAPTIVE RESOLUTION A.A-1.4

FUNCTION: To process all adaptive resolution mode data. Adaptive resolution is a mode where the altimeter has detected surface slope changes and automatically switched to a wider pulse width and different track constants to maintain lock. It will primarily occur over ice sheets and land. The corrections made by this module will make Level 1 output products consistent with the normal track mode processed by A.A-1.2. The input to the module will be the Level 1 altimeter data and the output will be modified altitudes, AGC, and time tags. Non-adaptive resolution mode data will not be processed by this module.

INPUTS: Level 1 altimeter data.

OUTPUTS:

h_1 = modified altitude in (m,0.001)

AGC_1 = modified AGC in (dB,0.01)

t_1 = modified altitude time tag in (s,0.0001)

SPECIAL TABLES: Tables for each resolution step similar to those in A.A-1.2 submodules (not presently available).

PROCESSING: Correct altitude, AGC, and time tags for offsets due to the selected pulse width and tracker characteristics. This will generally be a table lookup indexed by pulse width (5 possible steps).

TITLE: LOCATION CLASSIFICATION MODULE A.A-1.5

FUNCTION: To classify the subsatellite point as either land, water, or ice. To accomplish this, the latitude and longitude of the subsatellite point will be determined and a world surface map will be accessed. The inputs to the module will be the time in Julian date form and the world surface map and spacecraft ephemeris files. The outputs will be the interpolated spacecraft latitude, longitude, and height above the reference ellipsoid and a flag indicating the classification of the subsatellite point. The resolution of the world surface classification map will be approximately 10 km.

INPUTS: The world surface classification map file (A.D-1.83)

The spacecraft ephemeris file (A.D(M)-1.82)

T_{JD} = time as Julian date in $(d, 1.0\times10^{-8})$

OUTPUTS: ϕ = interpolated spacecraft latitude in (deg,0.001)

λ = interpolated spacecraft longitude in (deg,0.001)

H = interpolated spacecraft height above the reference ellipsoid in (m,0.001)

Γ_{C1} = subsatellite point classification flag (1 for water, 2 for ice, 3 for land, 4 for unknown)

Γ_Z = zone flag

Γ_{EPH} = ephemeris file quality flag (1-5)

SPECIAL TABLES: Table 1.5, a zone map (not presently available). The maximum number of table entries will be 32.

PROCESSING: The latitude, longitude, and height above the reference ellipsoid will be interpolated from the spacecraft ephemeris file to time T_{JD}.

The world surface classification map will be evaluated at the latitude and longitude of the subsatellite point and the classification flag set.

TITLE: HEALTH/STATUS MONITOR A.A-1.6

FUNCTION: To monitor critical instrument parameters and set off system alarms when a potentially damaging or dangerous condition is observed. This module will also set quality flags for altitude, temperature, voltage, and current to be output to the Health/Status Monitor Report and to the Level 1 output data file. The input to the module is the Level 1 altimeter data and the output is the Health/Status Monitor Report. Calibration mode data will not be processed by this module.

INPUTS: Level 1 altimeter data

OUTPUTS: Health/Status Monitor Report (A.D-1.93)

Data quality flags (see A.D-1.93)

SPECIAL TABLES: Nominal preflight values of tolerances and standard deviations (size TBD)

PROCESSING: All input data will be compared with nominal preflight values and, if significant deviations are located, then the parameters involved will be flagged and displayed for human interpretation and reaction. In addition, means and standard deviations will be calculated and quality flags set for altitude, AGC, and waveform data. Means and standard deviations will be calculated using the following formulae:

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

$$\sigma_X = \sqrt{\frac{n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i \right)^2}{n(n-1)}}$$

QUALITY CONTROL: Data quality flags are computed for the Level 1 output file (A.D-1.94). The output report requires human interpretation of those flags for appropriate action.

TITLE: DATA COMPRESSION A.A-2.1

FUNCTION: To compress the Level 1 output to a selectable rate. Non-production data modes, such as cal mode, trigger kill, and standby will be culled. The module will also calculate standard deviations for most parameters for later quality analysis. The input to the module is the Level 1 altimeter and the output is the Level 2 altimeter data.

INPUTS: Level 1 output file (A.D-1.94) at full rate

ΔT = compression interval in (s,0.01)

OUTPUTS: Level 2 altimeter data at selected rate, with non-production data modes culled.

SPECIAL TABLES: None

PROCESSING: All parameters will be smoothed to the selected compression interval using a linear fit. Means and standard deviations will be calculated using the following formulae:

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

$$\sigma_X = \sqrt{\frac{n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i \right)^2}{n(n-1)}}$$

QUALITY CONTROL: The number of accepted points as well as the standard deviations are used as quality control checks.

TITLE: CONTAMINATION PROCESSING A.A-2.2

FUNCTION: To classify the nature of the subsatellite point as either land, water, or ice. This classification, which is derived from analysis of the altimeter data with a resolution of approximately 1 km, should not be confused with the classification performed in the Location Classification Module, which is derived from a world surface map and has a resolution of approximately 10 km. The module will estimate the time and location of land/water and ice/water interfaces. Additionally, a flag will be set to indicate if the data is appropriate for processing by the Waveform Module.

INPUTS:

Γ_{AR} = adaptive resolution step flag

Γ_{C1} = subsatellite point classification flag from A.A-1.5

Δh = height error in (m/s,0.01)

AGC = AGC in (dB,0.01)

APG = plateau gate in (mv,0.01)

ATG = attitude gate in (mv,0.01)

SWH = significant waveheight in (m,0.01)

$\ddot{h}$ = altitude rate in (m/s^2,0.01)

OUTPUTS:

Γ_{C2} = subsatellite point classification flag (1 for water, 2 for ice, 3 for land, 4 for unknown)

SPECIAL TABLES: None

PROCESSING: TBD

EXCEPTIONS: None

TITLE: WAVEFORM MODULE A.A-2.3

FUNCTION: To process the altimeter waveform data in order to calculate SWH, attitude, and skewness, as well as significant slope, dominant wavelength, mean square shape, and percent smoothness. If the solution fails to converge, then the instrument SWH will be used with a backup table of bias corrections to SWH and altitude.

INPUTS:

SWH = computed SWH from A.A-2.3.1 in (m,0.001)

SWH_{alt} = real-time SWH in (m,0.01)

ΔSWH = SWH cal bias from A.A-2.3.3 in (m,0.01)

δSWH = SWH correction for attitude and SWH from A.A-2.3.2.1 in (m,0.01)

Γ_{WP} = waveform processor convergence flag from A.A-2.3.1

OUTPUTS: SWH_c = corrected SWH

SPECIAL TABLES: None

PROCESSING: Each submodule is called in turn:

1. Waveform Processor (A.A-2.3.1)
2. Correction from Waveforms (A.A-2.4.2)
3. SWH Bias (A.A-2.4.3)
4. Waveform Products (A.A-2.4.4)

If $\Gamma_{WP} = 0$, set $SWH_c = SWH + \Delta SWH$

If $\Gamma_{WP} = 1$, set $SWH_c = SWH_{alt} + \Delta SWH + \delta SWH$

TITLE:	WAVEFORM PROCESSOR	A.A-2.3.1

FUNCTION: To compute the SWH, attitude, skewness, and height correction for SWH, attitude, and $\ddot{h}$. These calculations require an iterative computation of a best fit solution to the convolution of the antenna pattern, the surface distribution, and the radar pulse. The six parameters fitted as necessary descriptors of the system-observed mean return waveform are:

1. amplitude
2. time origin track point
3. composite rise time
4. baseline
5. composite skewness
6. attitude

For a detailed description and derivation of the mathematical algorithm see Hayne, "Wallops Waveform Analysis of SEASAT-1 Radar Altimeter Data," 1980 (NASA CR-156869).

INPUTS: 63 waveform samplers in (counts,0.1)

α_{alt} = instrument attitude in (deg,0.01)

SWH_{alt} = real-time SWH in (m,0.01)

N = number of points from the Compression Module (A.A-2.1)

OUTPUTS: Γ_{WP} = convergence flag (0 for convergence, 1 for nonconvergence)

SWH = SWH estimate in (m,0.01)

α = refined attitude estimate in (deg,0.01)

λ_s = skewness estimate

A = waveform amplitude estimate

δh_{WP} = height correction in (m,0.001)

B = baseline estimate

SPECIAL TABLES: Table 2.3.1a, a table of waveform gain corrections (not presently available). The size of this table will be 2x63.

Table 2.3.1b, the point-target response table (not presently available). This table will contain 63 entries.

PROCESSING: The received return waveform is given by convolution

$$W(t) = P_{FS}(t) \cdot q_s(t) \cdot s_r(t)$$

where from Hayne (Ref. 5) it is assumed that the correct mean waveform from a typical radar altimeter can be obtained from the convolution of the following three terms:

1. The average impulse response function of the quasi-calm ocean surface (flat sea)
2. The ocean surface elevation distribution function for the "effective radar scattering elements"
3. The radar system point-target response function.

The first term, $P_{FS}(t)$ the quasi-calm ocean impulse response function, looks somewhat like a unit step function with a subsequent "plateau" behavior which is a function of the antenna beamwidth and off-nadir angle.

The second term, $q_s(t)$, is the radar-observed surface elevation probability density function (pdf), and, in past work, it has been assumed that the radar-observed elevation pdf is the same as the true, geometrical surface elevation pdf. For the work in this report, it is sufficient to assume that there is some distribution varying with SWH and to put off these more serious questions of what distribution until later.

The third term, $s_r(t)$, is the system point-target response and is the radar altimeter's transmitted pulse shape as sampled at the receiver by the 63 waveform samplers. The phrase "system point-target response" is used here rather than the more casually used "radar pulse shape," because what is meant is the transmitted radar pulse as modified by receiver effects. For ease of physical interpretation, the reader might prefer to think of the point-target response as the transmitted pulse, and this is nearly correct.

The function W(t) is then fit using a least squares technique to solve for the six descriptors named previously.

QUALITY CONTROL: Γ_{WP} is a quality control parameter used to select or bypass other modules.

TITLE: CORRECTIONS FROM WAVEFORM A.A-2.3.2

FUNCTION: To compute the waveform corrections to the altitude and the SWH. All computations are performed by the submodules and all inputs and outputs are processed by the submodules.

INPUTS: None

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: Each submodule is processed in order:

1. SWH correction for attitude and SWH (A.A-2.3.2.1)
2. Altitude correction for attitude, SWH, and $\ddot{h}$ (A.A-2.3.2.2)

TITLE: SWH CORRECTION FOR ATTITUDE AND SWH A.A-2.3.2.1

FUNCTION: To compute the SWH correction for attitude and SWH when the Waveform Processor fails to converge. This module is used only as a backup to the Waveform Processor and is not called when convergence is achieved by the Waveform Processor. The inputs to the module are the spacecraft estimate of attitude, the real-time SWH and the Waveform Processor convergence flag. The output is the SWH correction for attitude and SWH.

INPUTS:

α = attitude in (deg,0.01)

SWH = significant waveheight in (m,0.01)

Γ_{WP} = Waveform Processor convergence flag (0 for convergence, 1 for non-convergence)

OUTPUTS: δSWH = SWH correction for attitude and SWH in (m,0.001)

SPECIAL TABLES: Table 2.3.2a

PROCESSING: When the Waveform Processor has failed to converge, compute the SWH correction for attitude and SWH by table lookup using Table 2.6.5a.

TABLE 2.3.2a. ALTITUDE AND SWH CORRECTIONS DUE TO ATTITUDE AND SWH EFFECTS

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
0.0	0.00	0.56	–0.56	–4.35
0.0	0.05	0.56	–0.56	–4.33
0.0	0.10	0.56	–0.56	–4.23
0.0	0.15	0.56	–0.56	–4.06
0.0	0.20	0.56	–0.56	–3.85
0.0	0.25	0.56	–0.56	–3.57
0.0	0.30	0.64	–0.64	–3.24
0.0	0.35	0.64	–0.64	–2.85
0.0	0.40	0.64	–0.64	–2.41
0.0	0.45	0.72	–0.72	–1.90
0.0	0.50	0.72	–0.72	–1.34
0.0	0.55	0.72	–0.72	–0.76
0.0	0.60	0.80	–0.80	–0.20
0.0	0.65	0.80	–0.80	0.48
0.0	0.70	0.88	–0.88	1.20
0.0	0.75	0.88	–0.88	1.96
0.5	0.00	0.72	–0.22	–3.89
0.5	0.05	0.72	–0.22	–3.86
0.5	0.10	0.72	–0.22	–3.76
0.5	0.15	0.72	–0.22	–3.61
0.5	0.20	0.72	–0.22	–3.40
0.5	0.25	0.72	–0.22	–3.12
0.5	0.30	0.80	–0.30	–2.78
0.5	0.35	0.80	–0.30	–2.41
0.5	0.40	0.80	–0.30	–1.96
0.5	0.45	0.88	–0.38	–1.47
0.5	0.50	0.88	–0.38	–0.96
0.5	0.55	0.88	–0.38	–0.33
0.5	0.60	1.00	–0.50	0.26
0.5	0.65	1.00	–0.50	0.90

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
0.5	0.70	1.08	–0.58	1.62
0.5	0.75	1.08	–0.58	2.30
1.0	0.00	1.08	–0.08	–3.01
1.0	0.05	1.08	–0.08	–2.98
1.0	0.10	1.08	–0.08	–2.89
1.0	0.15	1.16	–0.16	–2.74
1.0	0.20	1.16	–0.16	–2.53
1.0	0.25	1.16	–0.16	–2.26
1.0	0.30	1.16	–0.16	–1.95
1.0	0.35	1.16	–0.16	–1.55
1.0	0.40	1.16	–0.16	–1.16
1.0	0.45	1.24	–0.24	–0.69
1.0	0.50	1.24	–0.24	–0.18
1.0	0.55	1.24	–0.24	0.39
1.0	0.60	1.40	–0.40	0.99
1.0	0.65	1.56	–0.56	1.62
1.0	0.70	1.56	–0.56	2.29
1.0	0.75	1.64	–0.64	3.01
1.5	0.00	1.56	–0.06	–2.28
1.5	0.05	1.56	–0.06	–2.25
1.5	0.10	1.56	–0.06	–2.18
1.5	0.15	1.56	–0.06	–2.03
1.5	0.20	1.56	–0.06	–1.83
1.5	0.25	1.64	–0.14	–1.56
1.5	0.30	1.64	–0.14	–1.26
1.5	0.35	1.64	–0.14	–0.91
1.5	0.40	1.72	–0.22	–0.49
1.5	0.45	1.72	–0.22	–0.05
1.5	0.50	1.72	–0.22	0.48
1.5	0.55	1.88	–0.38	1.01
1.5	0.60	1.88	–0.38	1.59
1.5	0.65	1.96	–0.46	2.20

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
1.5	0.70	1.96	–0.46	2.86
1.5	0.75	2.12	–0.62	3.53
2.0	0.00	1.96	0.04	–1.74
2.0	0.05	1.96	0.04	–1.73
2.0	0.10	1.96	0.04	–1.65
2.0	0.15	2.12	–0.12	–1.51
2.0	0.20	2.12	–0.12	–1.31
2.0	0.25	2.12	–0.12	–1.06
2.0	0.30	2.12	–0.12	–0.75
2.0	0.35	2.12	–0.12	–0.40
2.0	0.40	2.28	–0.28	–0.01
2.0	0.45	2.28	–0.28	0.45
2.0	0.50	2.28	–0.28	0.93
2.0	0.55	2.44	–0.44	1.44
2.0	0.60	2.44	–0.44	2.00
2.0	0.65	2.44	–0.44	2.62
2.0	0.70	2.60	–0.60	3.25
2.0	0.75	2.60	–0.60	3.94
2.5	0.00	2.60	–0.10	–1.35
2.5	0.05	2.60	–0.10	–1.32
2.5	0.10	2.60	–0.10	–1.25
2.5	0.15	2.60	–0.10	–1.12
2.5	0.20	2.60	–0.10	–0.94
2.5	0.25	2.60	–0.10	–0.69
2.5	0.30	2.60	–0.10	–0.40
2.5	0.35	2.72	–0.22	–0.05
2.5	0.40	2.72	–0.22	0.34
2.5	0.45	2.72	–0.22	0.78
2.5	0.50	2.72	–0.22	1.26
2.5	0.55	2.88	–0.38	1.74
2.5	0.60	3.20	–0.70	4.80
2.5	0.65	3.20	–0.70	5.96

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA H 1/3 (m)	HEIGHT ERROR (cm)
2.5	0.70	3.36	–0.86	7.23
2.5	0.75	3.36	–0.86	8.48
3.0	0.00	2.96	0.04	–1.97
3.0	0.05	2.96	0.04	–1.93
3.0	0.10	2.96	0.04	–1.75
3.0	0.15	2.96	0.04	–1.50
3.0	0.20	2.96	0.04	–1.14
3.0	0.25	2.96	0.04	–0.66
3.0	0.30	3.20	–0.20	–0.10
3.0	0.35	3.20	–0.20	0.58
3.0	0.40	3.20	–0.20	1.34
3.0	0.45	3.36	–0.36	2.20
3.0	0.50	3.36	–0.36	3.11
3.0	0.55	3.36	–0.36	4.10
3.0	0.60	3.60	–0.60	5.16
3.0	0.65	3.60	–0.60	6.29
3.0	0.70	3.84	–0.84	7.49
3.0	0.75	3.84	–0.84	8.78
3.5	0.00	3.36	0.14	–1.53
3.5	0.05	3.36	0.14	–1.47
3.5	0.10	3.60	–0.10	–1.32
3.5	0.15	3.60	–0.10	–1.06
3.5	0.20	3.60	–0.10	–0.69
3.5	0.25	3.60	–0.10	–0.25
3.5	0.30	3.60	–0.10	0.32
3.5	0.35	3.60	–0.10	0.97
3.5	0.40	3.84	–0.34	1.71
3.5	0.45	3.84	–0.34	2.54
3.5	0.50	3.84	–0.34	3.44
3.5	0.55	4.08	0.58	4.40
3.5	0.60	4.08	–0.58	5.50
3.5	0.65	4.28	–0.78	6.60

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA H 1/3 (m)	HEIGHT ERROR (cm)
3.5	0.70	4.28	–0.78	7.78
3.5	0.75	4.52	–1.02	9.04
4.0	0.00	4.08	–0.08	–1.16
4.0	0.05	4.08	–0.08	–1.10
4.0	0.10	4.08	–0.08	–0.97
4.0	0.15	4.08	–0.08	–0.71
4.0	0.20	4.08	–0.08	–0.35
4.0	0.25	4.08	–0.08	0.12
4.0	0.30	4.08	–0.08	0.66
4.0	0.35	4.28	–0.28	1.30
4.0	0.40	4.28	–0.28	2.02
4.0	0.45	4.28	–0.28	2.84
4.0	0.50	4.52	–0.52	3.71
4.0	0.55	4.52	–0.52	4.67
4.0	0.60	4.52	–0.52	5.74
4.0	0.65	4.76	–0.76	6.82
4.0	0.70	4.76	–0.76	7.97
4.0	0.75	4.76	–0.76	9.17
5.0	0.00	5.08	–0.08	–0.56
5.0	0.05	5.08	–0.08	–0.52
5.0	0.10	5.08	–0.08	–0.37
5.0	0.15	5.08	–0.08	–0.11
5.0	0.20	5.08	–0.08	0.23
5.0	0.25	5.08	–0.08	0.68
5.0	0.30	5.08	–0.08	1.20
5.0	0.35	5.08	–0.08	1.82
5.0	0.40	5.40	–0.40	2.52
5.0	0.45	5.40	–0.40	3.28
5.0	0.50	5.40	–0.40	4.14
5.0	0.55	5.40	–0.40	5.07
5.0	0.60	5.80	–0.80	6.03
5.0	0.65	6.24	–1.24	14.44

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA H 1/3 (m)	HEIGHT ERROR (cm)
5.0	0.70	6.24	−1.24	16.62
5.0	0.75	6.24	−1.24	18.93
6.0	0.00	5.88	0.12	0.14
6.0	0.05	5.88	0.12	0.20
6.0	0.10	5.88	0.12	0.52
6.0	0.15	5.88	0.12	0.97
6.0	0.20	5.88	0.12	1.61
6.0	0.25	6.24	−0.24	2.45
6.0	0.30	6.24	−0.24	3.45
6.0	0.35	6.24	−0.24	4.67
6.0	0.40	6.24	−0.24	6.00
6.0	0.45	6.64	−0.64	7.49
6.0	0.50	6.64	−0.64	9.11
6.0	0.55	6.64	−0.64	10.86
6.0	0.60	7.04	−1.04	12.73
6.0	0.65	7.04	−1.04	14.76
6.0	0.70	7.04	−1.04	17.00
6.0	0.75	7.52	−1.52	19.13
7.0	0.00	7.04	−0.04	0.88
7.0	0.05	7.04	−0.04	0.97
7.0	0.10	7.04	−0.04	1.26
7.0	0.15	7.04	−0.04	1.73
7.0	0.20	7.04	−0.04	2.36
7.0	0.25	7.04	−0.04	3.14
7.0	0.30	7.04	−0.04	4.13
7.0	0.35	7.52	−0.52	5.28
7.0	0.40	7.52	−0.52	6.55
7.0	0.45	7.52	−0.52	8.00
7.0	0.50	7.52	−0.52	9.58
7.0	0.55	8.00	−1.00	11.29
7.0	0.60	8.00	−1.00	13.14
7.0	0.65	8.00	−1.00	15.04

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
7.0	0.70	8.44	–1.44	17.11
7.0	0.75	8.44	–1.44	19.33
8.0	0.00	8.00	0.00	1.61
8.0	0.05	8.00	0.00	1.69
8.0	0.10	8.00	0.00	1.95
8.0	0.15	8.00	0.00	2.38
8.0	0.20	8.00	0.00	2.99
8.0	0.25	8.00	0.00	3.75
8.0	0.30	8.44	–0.44	4.67
8.0	0.35	8.44	–0.44	5.78
8.0	0.40	8.44	–0.44	7.04
8.0	0.45	8.44	–0.44	8.45
8.0	0.50	8.44	–0.44	9.94
8.0	0.55	9.00	–1.00	11.63
8.0	0.60	9.00	–1.00	13.47
8.0	0.65	9.00	–1.00	15.33
8.0	0.70	9.60	–1.60	17.30
8.0	0.75	9.60	–1.60	19.44
9.0	0.00	9.00	0.00	2.22
9.0	0.05	9.00	0.00	2.30
9.0	0.10	9.00	0.00	2.60
9.0	0.15	9.00	0.00	3.00
9.0	0.20	9.00	0.00	3.63
9.0	0.25	9.00	0.00	4.30
9.0	0.30	9.00	0.00	5.23
9.0	0.35	9.60	–0.60	6.29
9.0	0.40	9.60	–0.60	7.50
9.0	0.45	9.60	–0.60	8.82
9.0	0.50	9.60	–0.60	10.31
9.0	0.55	9.60	–0.60	11.90
9.0	0.60	10.24	–1.24	13.64
9.0	0.65	10.24	–1.24	15.43

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
9.0	0.70	10.24	–1.24	17.40
9.0	0.75	10.24	–1.24	19.39
10.0	0.00	10.24	–0.24	2.80
10.0	0.05	10.24	–0.24	2.91
10.0	0.10	10.24	–0.24	3.15
10.0	0.15	10.24	–0.24	3.57
10.0	0.20	10.24	–0.24	4.10
10.0	0.25	10.24	–0.24	4.84
10.0	0.30	10.24	–0.24	5.72
10.0	0.35	10.24	–0.24	6.74
10.0	0.40	10.24	–0.24	7.88
10.0	0.45	10.92	–0.92	9.19
10.0	0.50	10.92	–0.92	10.60
10.0	0.55	10.92	–0.92	12.18
10.0	0.60	10.92	–0.92	13.86
10.0	0.65	10.92	–0.92	15.58
10.0	0.70	11.80	–1.80	17.46
10.0	0.75	11.88	–1.88	38.90
12.0	0.00	11.88	0.12	8.48
12.0	0.05	11.88	0.12	8.62
12.0	0.10	11.88	0.12	9.06
12.0	0.15	11.88	0.12	9.81
12.0	0.20	11.88	0.12	10.84
12.0	0.25	11.88	0.12	12.10
12.0	0.30	12.88	–0.88	13.70
12.0	0.35	12.88	–0.88	15.61
12.0	0.40	12.88	–0.88	17.64
12.0	0.45	12.88	–0.88	20.04
12.0	0.50	12.88	–0.88	22.60
12.0	0.55	12.88	–0.88	25.45
12.0	0.60	14.08	–2.08	28.42
12.0	0.65	14.08	–2.08	31.70
12.0	0.70	14.08	–2.08	35.20

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
12.0	0.75	14.08	–2.08	38.59
14.0	0.00	14.08	–0.08	10.24
14.0	0.05	14.08	–0.08	10.36
14.0	0.10	14.08	–0.08	10.73
14.0	0.15	14.08	–0.08	11.43
14.0	0.20	14.08	–0.08	12.43
14.0	0.25	14.08	–0.08	13.61
14.0	0.30	14.08	–0.08	15.10
14.0	0.35	14.08	–0.08	16.85
14.0	0.40	15.32	–1.32	18.83
14.0	0.45	15.32	–1.32	21.02
14.0	0.50	15.32	–1.32	23.46
14.0	0.55	15.32	–1.32	26.15
14.0	0.60	15.32	–1.32	28.94
14.0	0.65	15.32	–1.32	31.98
14.0	0.70	16.80	–2.80	35.13
14.0	0.75	16.80	–2.80	38.47
16.0	0.00	16.80	–0.80	11.80
16.0	0.05	16.80	–0.80	11.95
16.0	0.10	16.80	–0.80	12.37
16.0	0.15	16.80	–0.80	12.96
16.0	0.20	16.80	–0.80	13.88
16.0	0.25	16.80	–0.80	15.05
16.0	0.30	16.80	–0.80	16.41
16.0	0.35	16.80	–0.80	18.04
16.0	0.40	16.80	–0.80	19.92
16.0	0.45	16.80	–0.80	21.93
16.0	0.50	16.80	–0.80	24.20
16.0	0.55	18.52	–2.52	26.68
16.0	0.60	18.52	–2.52	29.43
16.0	0.65	18.52	–2.52	32.18
16.0	0.70	18.52	–2.52	35.12
16.0	0.75	18.52	–2.52	38.27

TABLE 2.3.2a. (Continued)

MODEL SWH	ATTITUDE	COMPUTED SWH	DELTA SWH	HEIGHT ERROR (cm)
18.0	0.00	18.52	–0.52	13.24
18.0	0.05	18.52	–0.52	13.36
18.0	0.10	18.52	–0.52	13.71
18.0	0.15	18.52	–0.52	14.38
18.0	0.20	18.52	–0.52	15.21
18.0	0.25	18.52	–0.52	16.29
18.0	0.30	18.52	–0.52	17.55
18.0	0.35	18.52	–0.52	19.11
18.0	0.40	18.52	–0.52	20.77
18.0	0.45	18.52	–0.52	22.75
18.0	0.50	19.92	–1.92	24.83
18.0	0.55	19.92	–1.92	27.19
18.0	0.60	19.92	–1.92	29.65
18.0	0.65	19.92	–1.92	32.33
18.0	0.70	19.92	–1.92	35.15
18.0	0.75	19.92	–1.92	38.08
20.0	0.00	19.92	0.08	14.57
20.0	0.05	19.92	0.08	14.72
20.0	0.10	19.92	0.08	14.99
20.0	0.15	19.92	0.08	15.56
20.0	0.20	19.92	0.08	16.32
20.0	0.25	19.92	0.08	17.36
20.0	0.30	19.92	0.08	18.56
20.0	0.35	19.92	0.08	19.95
20.0	0.40	19.92	0.08	21.61
20.0	0.45	19.92	0.08	23.43
20.0	0.50	20.00	0.00	25.41
20.0	0.55	20.00	0.00	27.58
20.0	0.60	20.00	0.00	29.94
20.0	0.65	20.00	0.00	32.48
20.0	0.70	20.00	0.00	35.04
20.0	0.75	20.00	0.00	37.81

TITLE: ALTITUDE CORRECTION FOR ATTITUDE, SWH, AND $\ddot{h}$ A.A-2.3.2.2

FUNCTION: To compute the altitude correction for attitude, SWH, and $\ddot{h}$ when the Waveform Processor fails to converge. This module is used only as a backup to the Waveform Processor and is not called when convergence is achieved by the Waveform Processor. The inputs to the module are the spacecraft estimate of attitude and the real-time SWH, and the software estimate of $\ddot{h}$. The output is the altitude correction for attitude, SWH, and $\ddot{h}$.

INPUTS:

α = attitude in (deg,0.01)

SWH = significant waveheight in (m,0.01)

$\ddot{h}$ = height acceleration in (m/s^2,0.01)

Γ_{TM} = track mode flag

OUTPUTS:

$\delta h_{2,6}$ = height correction for attitude, SWH, and $\ddot{h}$ in (m,0.001)

$\sigma_{\delta h_{2,6}}$ = standard deviation of $\delta h_{2,6}$ in (m,0.001)

SPECIAL TABLES: Table 2.3.2a and Table 2.3.2b

Track Mode	TC
1	0.28284
2	0.2
3	0.4
4	0.28284

Table 2.3.2b Track Mode vs TC

Table 2.3.2a is a table of altitude and SWH corrections due to the effects of attitude and SWH and consists of 2 entries for each of 20 sea states and 16 attitudes (640 entries).

PROCESSING:

(1) Compute altitude correction for attitude and SWH, $\delta h_{\alpha,SWH}$ by table lookup using Table 2.3.2.a

(2) Compute altitude correction for $\ddot{h}$, $\delta h_{\ddot{h}}$, by table lookup using Table 2.3.2b

$$\delta h_{\ddot{h}} = 2 \times \ddot{h} \times TC^2$$

(3) $\delta h_{2,6} = \delta h_{\alpha,SWH} + \delta h_{\ddot{h}}$

$\sigma_{\delta h_{2,6}} = 0$ (by default)

TITLE: SWH CAL BIAS A.A-2.3.3

FUNCTION: To apply the SWH cal bias. The correction will be based upon comparisons of the calculated SWH with ground truth measurements from buoys and aircraft and will therefore be computed after launch. The input to the module will be the Julian date and the output will be the SWH cal zone bias.

INPUTS: Γ_{C2} = subsatellite point classification flag from A.A-2.2

T_{JD} = time as Julian date in (d,1.0)

SWH = significant waveheight in (m,0.01)

OUTPUTS: ΔSWH = SWH cal zone bias in (m,0.001)

SPECIAL TABLES: Table 2.3.3, a table of ΔSWH as a function of T_{JD} and SWH (not presently available). There will be a maximum of 20 table entries of SWH and ΔSWH for each of a maximum of five T_{JD} (100 table entries).

PROCESSING: For data over water, a table lookup of ΔSWH will be made. Linear interpolation and extrapolation may be used to calculate the output.

FLEXIBILITY: Table 2.3.3 will not be available until postlaunch inflight data are compared and analyzed against ground truth data. This table may be updated during the mission.

TITLE: WAVEFORM PRODUCTS A.A-2.3.4

FUNCTION: This module controls which of the submodules is utilized based on the terrain classification and the waveform processor converging.

INPUTS: Γ_{C2} = classification flag

Γ_{WP} = waveform processor flag

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: If over ocean and the waveform processor converged then module A.A-2.3.4.2 is used; otherwise A.A-2.3.4.1 is used.

TITLE: MEAN SQUARE SHAPE AND PERCENT SMOOTHNESS A.A-2.3.4.1

FUNCTION: To estimate the two ice related quantities mean square slope and percent smoothness.

INPUTS:

α_{SWH} = instrument attitude

AGC = AGC

AAG = attitude gate

APG = plateau gate

P_T = transmitted power

63 waveform samples

OUTPUTS:

MSS = mean square slope

F = Fresnel power reflection coefficient

PCS = percent smoothness

SPECIAL TABLES: None

PROCESSING: These parameters were calculated on GEOS-3 (Ref. 6) and appeared to correlate with the Dwyer-Godin index (Ref. 7). They are based on interpretation of the physics of radar scattering whereas the Dwyer-Godin index is an ad hoc ice index.

$$X = 10 \log_{10} \left(\frac{AAG}{APG}\right) + (AGC-P_T)$$

$$MSS = \exp(a_o + a_1 X + a_2 X^2 + a_3 X^3)$$

$a_o = -0.289242X10^4$

$a_1 = -0.636628X10^2$

$a_2 = -0.469585$

$a_3 = -0.115927X10^{-2}$

$$Y = b_o + b_1 X + b_2 X^2 + b_3 X^3$$

$b_o = 9.00817X10^3$

$b_1 = 2.0088X10^2$

$b_2 = 1.47968$

$b_3 = 3.65289X10^{-3}$

PROCESSING (continued)

$$Z = 10 \log_{10}\left(-10^{\frac{Y}{10}} + 10^{\frac{AGC-P_T}{10}}\right)$$

$$PCS = 10^{(.05Z + 6.3849)}$$

F is computed on a relationship of the peak waveform amplitude and the mean square slope.

TITLE: SIGNIFICANT SLOPE AND DOMINANT WAVELENGTH A.A-2.3.4.2

FUNCTION: To compute the upper ocean dynamics measurements of significant slope and dominant wavelength.

INPUTS:

SWH = significant wave height in (m,0.01)

λ_s = skewness estimate

OUTPUTS:

SS = significant slope

λ_D = dominant wavelength

N_D = dominant frequency

C_D = dominant phase speed

K_D = dominant wave number

SPECIAL TABLES: None

PROCESSING: The extracting of significant slope and dominant wavelength has been described by Huang (Ref. 3). The following equations are given to show the relationship established between the parameters.

$$SS = \lambda_s/8\pi$$

$$\lambda_D = \frac{SWH}{2SS}$$

$$N_D = (2\pi g/\lambda_D)^{\frac{1}{2}}$$

$$C_D = (g\ \lambda_D/2\pi)^{\frac{1}{2}}$$

$$K_D = 2\pi/\lambda_D$$

TITLE:	ATMOSPHERIC MODULE	A.A-2.4

FUNCTION: To calculate the atmospheric corrections to the spacecraft altitude and the radar backscatter coefficient. The module will also process data from the rain gate. The altitude correction from this module consists of the combined effects of ionospheric refraction, wet and dry tropospheric refraction, and atmospheric pressure. The radar backscatter coefficient correction accounts for the effects of the atmosphere on return power and the rain gate processing detects the presence of rain at the subsatellite point. All inputs and outputs are processed by submodules.

INPUTS: None

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: Each submodule is called in turn:

1. Rain Gate (A.A-2.4.1)
2. Barotropic Effects (A.A-2.4.2)
3. Ionospheric Refraction (A.A-2.4.3)
4. Dry Tropospheric Refraction (A.A-2.4.4)
5. Wet Tropospheric Refraction (A.A-2.4.5)
6. Sigma Naught Correction (A.A-2.4.6)

TITLE:	RAIN GATE	A.A-2.4.1

FUNCTION: To provide nadir rain rate estimates. In addition, two flags, indicating the quantity and quality of the rain fall estimate, will be set to facilitate processing of possible altitude rain rate corrections.

INPUTS: ARG_1 = rain gate #1 in (dB,0.001)

ARG_2 = rain gate #2 in (dB,0.001)

OUTPUTS: R = rain rate in (mm/hr,0.1)

Γ_{R1} = rain rate quantity flag
1 for light ($0 < \dot{R} \leq 2$)
2 for mild ($2 < \dot{R} \leq 6$)
3 for medium ($6 < \dot{R} \leq 10$)
4 for heavy ($10 < \dot{R}$)

OUTPUTS (continued)	Γ_{R2}	= rain rate estimate quality flag 0 for good 1 for questionable

SPECIAL TABLES:

Table 2.4.1a, a table of $\dot{R}$ as a function of the difference between the two rain gates (not presently available). The maximum number of entries in this table is 2x20.

Table 2.4.1b, a table of rain rate as a function of rain gate magnitude for low rain rates (not presently available). The maximum number of entries in this table is 2x10.

Table 2.4.1c, a table of nominal rain gate operational tolerances (not presently available). The maximum number of entries in this table is 4.

PROCESSING:

1) $\Delta ARG = |ARG_2 - ARG_1|$
2) If magnitude of ΔARG lies within limits of Table 2.4.1a, use this table to estimate $\dot{R}$. If not, use Table 2.4.1b to estimate $\dot{R}$.
3) Set $\Gamma_{\dot{R}1}$ to value appropriate for the $\dot{R}$ estimate.
4) Compare ARG_1 and ARG_2 with preflight nominal tolerances. If within acceptable range, set $\Gamma_{\dot{R}2} = 0$; otherwise set $\Gamma_{\dot{R}2} = 1$.

A filtering algorithm may be required to smooth the estimates of $\dot{R}$.

The hardware design is not complete but it may be possible to determine the sigma naught atmospheric correction from the rain gate data. If such is the case the altimeter would not require LAMMR/CZCS data for this correction. For the present the SCATT algorithm for σ_0 atmospheric correction will be used and if the rain gate design produces a correction the SCATT algorithm correction will be used for quality control.

QUALITY CONTROL:

For $\Gamma_{\dot{R}1} = 2$ or 3, minor altitude corrections may be needed.

For $\Gamma_{\dot{R}1} = 4$, altitude, SWH, and wind data will be invalid.

TITLE:	BAROTROPIC EFFECTS	A.A-2.4.2

FUNCTION: To compute the altitude correction due to the effects of atmospheric pressure.

INPUTS:

P = sea surface atmospheric pressure from A.D(M)-2.81 in (mb,0.1)

Γ_{FN} = FNWC data flag (0 for FNWC data available, 1 for FNWC data not available)

OUTPUTS:

$\delta h_{2,1}$ = atmospheric pressure altitude correction in (m,0.001)

$\sigma_{\delta h_{2,1}}$ = standard deviation at $\delta h_{2,1}$ in (m,0.001)

SPECIAL TABLES: Table 2.4, a table of monthly averages of atmospheric pressure, temperature, and vapor pressure for each 5 degrees of latitude (not presently available). The size of the table will be approximately 3x12x30.

PROCESSING: If the surface atmospheric pressure (P) is not available from FNWC, Table 2.4 will be linearly interpolated to calculate P.

$\delta h_{2,1}$ = -0.009948 (P-1013.3)

$\sigma_{\delta h_{2,1}}$ = 0 (by default)

TITLE:	IONOSPHERIC REFRACTION (SUNSPOT MODEL)	A.A-2.4.3A

FUNCTION: To compute the altitude correction necessitated by the effects of ionospheric refraction using the sunspot model. A preliminary comparison of A.A-2.4.3A with A.A-2.4.3B indicates:

1) Estimates of the ionospheric refraction correction are comparable in accuracy and resources required.
2) A.A-2.4.3A is more easily implemented in a real-time environment due to the frequency of the input data required by A.A-2.4.3B.

A further comparison of the two methods is planned for FY81.

INPUTS:

T_{JD} = time expressed as Julian date in (d,0.000001)

ϕ = latitude of the subsatellite point in (deg,0.001)

λ = longitude of the subsatellite point in (deg,0.001)

ionospheric data file (A.D-2.82)

OUTPUTS: $\delta h_{2,2}$ = ionospheric refraction altitude correction in (m,0.001)

$\sigma_{\delta h_{2,2}}$ = standard deviation of $\delta h_{2,2}$ in (m,0.001)

SPECIAL TABLES: None

PROCESSING: See Ref. 4.

TITLE: IONOSPHERIC REFRACTION (FARADAY MODEL) A.A-2.4.3B

FUNCTION: To compute the altitude correction due to the effects of ionospheric refraction using the Faraday model. This module does not allow for easy real-time usage because of the difficulty in obtaining Goldstone and Armidale data.

INPUTS:

ϕ = geodetic latitude in (rad,0.01)

ϕ_m = geomagnetic latitude in (rad,0.01)

$\phi_\odot$ = geodetic latitude of the sun in (rad,0.01)

f = transmitter frequency

t = local time in (hours,0.1)

$E_{c,min}$ = supplied by Goldstone and Armidale daily

$E_{c,max}$ = supplied by Goldstone and Armidale daily

β = supplied by Goldstone and Armidale daily

OUTPUTS: $\delta h_{2,2}$ = ionospheric refraction altitude correction in (m,0.001)

$\sigma_{\delta h_{2,2}}$ = standard deviation of $\delta h_{2,2}$ in (m,0.001)

SPECIAL TABLES: None

PROCESSING:

$$B(t) = 0.25\sqrt{\sin(t-11)/18}\quad,\quad 0 \leq t < 5,\ 11 < t < 24$$

$$= 0\quad,\quad 5 \leq t \leq 11$$

$$A(\phi_m,t) = 1 - B(t)[1.15\sin(35\pi|\phi_m|)^{\frac{1}{2}}/(35\pi|\phi_m|)^{\frac{1}{2}}-0.146]\quad,\quad |\phi_m| < \pi/6$$

$$= 1\quad,\quad |\phi_m| \geq \pi/6$$

PROCESSING (continued)

$HA_{\odot} = t - 12 - 11\left(\frac{t-11}{18}\right)^r \quad 0 \leq t < 5,\ 11 < t < 24$

$= t - 12 \quad 5 \leq t \leq 11$

$r = 1.75 - 0.75 \cos^{10}\phi_m$

$\cos\chi = \cos\phi \cos\phi_{\odot} \cos HA_{\odot} + \sin\phi \sin\phi_{\odot}$

$E_1 = E_{c,min} + (E_{c,max} - E_{c,min})(\cos \chi)^{\beta}$

$E_2 = A(\phi_m,t)(1 + \cos^2 \phi_m)$

$E_3 = A(\phi_m^{STA},t)(1 + \cos^2 \phi_m^{STA})$

$\delta h_{2,2} = 40.3\ (E_1 \times E_2/E_3)/f^2$

$\sigma_{\delta h_{2,2}}$ = 0 (by default)

TITLE: DRY TROPOSPHERIC REFRACTION A.A-2.4.4

FUNCTION: To compute the altitude correction due to the effects of dry tropospheric refraction.

INPUTS:

P = surface atmospheric pressure from A.D(M)-2.81 in (mb,0.1)

ϕ = spacecraft latitude in (deg,0.001)

Γ_{FN} = FNWC data flag (0 for FNWC data available, 1 for FNWC data not available)

OUTPUTS:

$\delta h_{2,3}$ = dry tropospheric refraction altitude correction in (m,0.001)

$\sigma_{\delta h_{2,3}}$ = standard deviation of $\delta h_{2,3}$ in (m,0.001)

SPECIAL TABLES: Table 2.4, a table of monthly averages of atmospheric pressure, temperature, and vapor pressure for each 5 degrees of latitude (not presently available). The size of the table will be approximately 3x12x30.

PROCESSING: If the surface atmospheric pressure (P) is not available from FNWC, Table 2.4 will be linearly interpolated to calculate P.

$\delta h_{2,3} = P(2.277-0.011 \cos \phi) \times 10^{-3}$

$\sigma_{\delta h_{2,3}}$ = 0 (by default)

TITLE: WET TROPOSPHERIC REFRACTION A.A-2.4.5

FUNCTION: This module controls which of the submodules is utilized for wet tropospheric refraction based upon the availability of LAMMR data.

INPUTS: Γ_L = LAMMR data quality flag

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: If Γ_L indicates that LAMMR data is present and of good quality, then A.A-2.4.5.1 is called. Otherwise, A.A-2.4.5.2 is called.

TITLE: LAMMR WET TROPOSPHERIC REFRACTION A.A-2.4.5.1

FUNCTION: To compute the altitude correction due to the effects of wet tropospheric refraction. The inputs to this module are the Level 2 LAMMR data file and the time. The output is the altitude wet tropospheric refraction correction.

INPUTS: LAMMR Level 2 data file (A.D-2.83)

Γ_L = LAMMR data quality flag

T_{JD} = time expressed as Julian date in (d,0.00001)

$\Gamma_{\dot{R}1}$ = rain rate quantity

$\Gamma_{\dot{R}2}$ = rain rate quality

$\dot{R}$ = rain rate

OUTPUTS: $\delta h_{2,4}$ = wet tropospheric refraction altitude correction in (m,0.001)

$\sigma_{\delta h_{2,4}}$ = standard deviation of $\delta h_{2,4}$ in (m,0.001)

SPECIAL TABLES: None

PROCESSING: If $2 \leq \Gamma_{\dot{R}1} \leq 3$ and $\Gamma_{\dot{R}2} = 0$ then

$$\delta h_{2,4} = K_1\dot{R} + K_2\dot{R}^2$$

$$\sigma_{\delta h_{2,4}} = K_3\dot{R}$$

$$K_1, K_2, K_3 = \text{TBD}$$

Else access LAMMR Level 2 data and linearly interpolate to time T_{JD}. When LAMMR data are not available, use A.A-2.4.5.2.

TITLE: FNWC WET TROPOSPHERIC REFRACTION A.A-2.4.5.2

FUNCTION: To compute the FNWC altitude correction for wet tropospheric refraction. When LAMMR data is available, A.A-2.4.5.1 is used.

INPUTS:

e = sea surface water vapor pressure from A.D(M)-2.81 in (mb,0.1)

T_o = sea surface atmospheric temperature from A.D(M)-2.81 in (deg.K,0.01)

Γ_{FN} = Fleet Numerical Weather Center data flag

OUTPUTS:

$\delta h_{2,4}$ = wet tropospheric refraction altitude ocrrection in (m,0.001)

$\sigma_{\delta h_{2,4}}$ = standard deviation of $\delta h_{2,4}$ in (m,0.001)

SPECIAL TABLES: Table 2.4, a table of monthly averages of atmospheric pressure, temperature, and vapor pressure for each 5 degrees of latitude (not presently available). The size of the table will be approximately 3x12x30.

PROCESSING:

$$\delta h_{2,4} = 2.277\times10^{-3}(0.05+1255/T_o)e$$

$$\sigma_{\delta h_{2,4}} = 0 \text{ (by default)}$$

When the surface water vapor pressure, e, and/or the surface temperature, T_o, is not available from FNWC, then Table 2.4 will be linearly interpolated in order to calculate them.

TITLE: SIGMA NAUGHT CORRECTION A.A-2.4.6

FUNCTION: To compute the atmospheric correction to sigma naught. The correction will be computed using parameters supplied by the Level 2 SCATT file, unless the rain gate detects the presence of rain at a rate greater than 2 mm/hr. The inputs to the module are the time, the rain rate estimate, the rain rate quantity and quality flags, and the Level 2 SCATT file. The output will be the sigma naught atmospheric correction.

INPUTS: T_{JD} = time expressed as Julian date in (d,0.000001)

h_1 = corrected level 1 attitude (m,0.001)

ARG_1 = altimeter rain gate 1 (dB,.001)

ARG_2 = altimeter rain gate 2 (dB,.001)

$\dot{R}$ = rain rate from A.A-2.4.1 in (mm/hr,0.1)

$\Gamma_{\dot{R}1}$ = rain rate quantity flag from A.A-2.4.1

$\Gamma_{\dot{R}2}$ = rain rate quality flag from A.A-2.4.1

Level 2 SCATT file (A.D(S)-2.84)

OUTPUTS: $\Delta\sigma^\circ$ = sigma naught atmospheric correction in (dB,0.01)

SPECIAL TABLES: None

PROCESSING:

1) If $\Gamma_{\dot{R}1} = 1$ or $\Gamma_{\dot{R}2} = 1$, go to 4)
2) $\Delta\sigma^\circ = |ARG_2 - ARG_1| * K * h_1$

   where K = TBD
3) Return
4) Linear interpolation of SCATT file, evaluating at time T_{JD}.

TITLE: WIND SPEED MODULE A.A-2.5

FUNCTION: To calculate the radar backscatter coefficient (sigma naught) and the ground wind speed. The module consists of two submodules: sigma naught and wind speed. Sigma naught is a function of AGC, altitude, and attitude, and wind speed is a function of sigma naught. Note that the atmospheric correction to sigma naught will be applied before the wind speed is calculated. All inputs and outputs for this module are processed by the submodules.

INPUTS: None

OUTPUTS: None

SPECIAL TABLES: None

PROCESSING: Each submodule is processed in turn:

1. Sigma Naught (A.A-2.5.1)
2. Wind Speed (A.A-2.5.2)

TITLE:	SIGMA NAUGHT	A.A-2.5.1

FUNCTION: To compute the radar backscatter coefficient ($\sigma°$), which is a measure of how well the surface reflects radar. This could be used to determine many surface characteristics including wind speed. The inputs to this module are the AGC, altitude, attitude, and sigma naught atmospheric correction and the output is $\sigma°$.

INPUTS:

AGC = AGC in (dB,0.01)

h = altitude in (m,0.001)

α = attitude in (deg,0.01)

$\Delta\sigma°$ = $\sigma°$ atmospheric correction from A.A-2.4.6 in (dB,0.01)

OUTPUTS:

$\sigma°$ = sigma naught in (dB,0.01)

SPECIAL TABLES:

k	AGC_k(dB)
8	16.58
9	24.15
10	30.30
11	35.67
12	42.27
13	48.07
14	54.52
15	60.58

Table 2.5.1a
AGC vs Attenuator

K	Cal_K(dB)
8	43.7
9	36.1
10	30.3
11	24.2
12	18.2
13	12.2
14	6.2
15	0.0

Table 2.5.1b
Cal Attenuator Value

Attitude	L_{att}(dB)	Attitude	L_{att}(dB)
0.00	0.0161	0.40	1.4904
0.05	0.0391	0.45	1.8826
0.10	0.1081	0.50	2.3212
0.15	0.2231	0.55	2.8066
0.20	0.3842	0.60	3.3386
0.25	0.5914	0.65	3.9178
0.30	0.8449	0.70	4.5430
0.35	0.9445	0.75	5.2158

Table 2.5.1c Attitude Loss

PROCESSING: (1) Set K to the particular k which minimizes $|\Delta_k|$ where

$$\Delta_k = AGC_k - AGC$$

(2) Interpolate Table 2.5.1c to get $L_{att}(\alpha)$.

(3) $\sigma° = \sigma_A - Cal_K - \Delta_K + L_{att} + 30 \log_{10} (\frac{h}{h_o}) + \Delta\sigma°$

where

h_o = 796440 m

σ_A = 39.93 dB

The attitude produced by Waveform Processor is used if available.

FLEXIBILITY: Table 2.5.1b may require changes during the mission.

TITLE: WIND SPEED A.A-2.5.2

FUNCTION: To calculate the magnitude of the wind speed at the sub-satellite point and at an elevation of 10 meters. The algorithm was derived by Brown (Ref's 8 and 9). The A and B coefficients were estimated empirically by comparing GEOS-3 data with hindcast windspeed estimates. The input to this module is σ° (with the atmospheric correction applied) and the output is wind speed.

INPUTS: σ° = σ° from A.A-2.5.1 in (dB,0.01)

OUTPUTS: W_{10} = wind speed at 10 meter altitude in (m/s,0.1)

SPECIAL TABLES:

	$\sigma° \geq 10.9$	$10.9 > \sigma° \geq 10.12$	$10.12 > \sigma°$
A	0.015950	-0.039893	-0.080074
B	0.017215	-0.031996	-0.124651

Table 2.5.2 A and B vs σ°

PROCESSING:

$$x = (\sigma° + 2.1)/10$$

$$W_{10} = \exp[(10^{-x} - B)/A]$$

If the computed value of W_{10} exceeds 16 meters/second, then the following polynomial will be used to compute a corrected estimate:

$$z = W_{10}$$

$$W_{10} = 2.087799z - 0.3649928z^2 + 0.04062421z^3 - 1.904952\times10^{-3}z^4 + 3.288189\times10^{-5}z^5$$

TITLE: LEVEL 2 ALTITUDE MODULE A.A-2.6

FUNCTION: To correct the altitude measurement for EM bias and to calculate the sea surface height and altitude residual. In order to calculate these two parameters, it is necessary to calculate the geoid height, the tide height, and the solid Earth tide height. The inputs to the module are the Level 1 corrected altitude and the Level 2 altitude corrections supply by submodules and by the Atmospheric Module. The output is the Level 2 corrected altitude.

INPUTS:

h_1 = Level 1 corrected altitude from A.A-1.2 in (m,0.001)

$\delta h_{2,1}$ = altitude correction for barotropic effects from A.A-2.4.2 in (m,0.001)

$\delta h_{2,2}$ = altitude correction for ionospheric refraction from A.A-2.4.3 in (m,0.001)

$\delta h_{2,3}$ = altitude correction for dry tropospheric refraction from A.A-2.4.4 in (m,0.001)

$\delta h_{2,4}$ = altitude correction for wet tropospheric refraction from A.A-2.4.5 in (m,0.001)

$\delta h_{2,5}$ = altitude correction for EM bias from A.A-2.6.4 in (m,0.001)

$\delta h_{2,6}$ = altitude correction for α, SWH, and $\ddot{h}$ from A.A-2.3.1 or A.A-2.3.2.2 in (m,0.001)

σ_{h_1} = standard deviation of h_1 from A.A-1.2 in (m,0.001)

$\sigma_{\delta h_{2,1}}$ = standard deviation of $\delta h_{2,1}$ from A.A-2.4.2 in (m,0.001)

$\sigma_{\delta h_{2,2}}$ = standard deviation of $\delta h_{2,2}$ from A.A-2.4.3 in (m,0.001)

$\sigma_{\delta h_{2,3}}$ = standard deviation of $\delta h_{2,3}$ from A.A-2.4.4 in (m,0.001)

$\sigma_{\delta h_{2,4}}$ = standard deviation of $\delta h_{2,4}$ from A.A-2.4.5 in (m,0.001)

$\sigma_{\delta h_{2,5}}$ = standard deviation of $\delta h_{2,5}$ from A.A-2.6.4 in (m,0.001)

$\sigma_{\delta h_{2,6}}$ = standard deviation of $\delta h_{2,6}$ from A.A-2.3.1 or A.A-2.3.2.2 in (m,0.001)

OUTPUTS: h_2 = Level 2 corrected altitude in (m,0.001)

σ_{h_2} = standard deviation of h_2 in (m,0.001)

SPECIAL TABLES: None

PROCESSING: Each submodule is processed in turn:

1. Geoid Height (A.A-2.6.1)
2. Tide Height (A.A-2.6.2)
3. Solid Earth Tide Height (A.A-2.6.3)
4. EM Bias (A.A-2.6.4)

$$h_2 = h_1 + \delta h_{2,1} + \delta h_{2,2} + \delta h_{2,3} + \delta h_{2,4} + \delta h_{2,5} + \delta h_{2,6}$$

$$\sigma_{h_2} = \sigma^2_{h_1} + \sigma^2_{\delta h_{2,1}} + \sigma^2_{\delta h_{2,2}} + \sigma^2_{\delta h_{2,3}} + \sigma^2_{\delta h_{2,4}} + \sigma^2_{\delta h_{2,5}} + \sigma^2_{\delta h_{2,6}}$$

Then the sea surface height and altitude residual are computed by processing A.A-2.6.5.

TITLE: GEOID HEIGHT A.A-2.6.1

FUNCTION: To calculate the geoid height at the subsatellite point. To compute the geoid height, the geoid file (A.D-2.71) must be linearly interpolated. The inputs to the module are the latitude and longitude of the subsatellite point and the geoid file. The output is the geoid height.

INPUTS: ϕ = satellite latitude in (deg,0.01)

λ = satellite east longitude ($0° \leq \lambda < 360°$) in (deg,0.01)

Geoid file (A.D-2.71)

OUTPUTS: h_G = geoid height in (m,0.001)

SPECIAL TABLES: None

PROCESSING:

(1) Compute

$\lambda_1 = [\lambda]$

$\lambda_2 = \lambda_1 + 1$

$\phi_1 = [\phi]$

$\phi_2 = \phi_1 + 1$

where [] indicates the largest integer function

(2) Obtain the two geoid file records for longitudes λ_1 and λ_2

(3) Compute h_G using a four-point bi-linear interpolation with corner points

$$(\lambda_1,\phi_1),\ (\lambda_1,\phi_2),\ (\lambda_2,\phi_1),\ (\lambda_2,\phi_2)$$

and evaluating at (λ,ϕ)

TITLE: TIDE HEIGHT (SCHWIDERSKI M2 MODEL) A.A-2.6.2A

FUNCTION: To compute the magnitude of the ocean tide height. The model used is the Swiderski M2 model. The inputs to the module are the Julian date and the latitude and longitude of the subsatellite point. The output is the tide height.

INPUTS:

T_{JD} = time expressed as Julian date in (d,0.00001)

IYR = year (i.e., 1980)

ϕ = latitude of the subsatellite point in (deg,0.01)

λ = longitude of the subsatellite point in (deg,0.01)

Tide file (A.D-2.72)

OUTPUTS: h_T = ocean-tide height in (m,0.001)

SPECIAL TABLES: None

PROCESSING:

1) FODAY = DMOD(T_{JD},1.0D+00) * 86400.0D+00

IYR1 = IYR - 1975

IYR2 = (IYR1+2) / 4

IDOY = $T_{JD} - T_{JD_o}$

IDOY1 = IDOY + 365*IYR1 + IYR2

2) T = (T1*IDOY + T0) / 36525.0D+00

H = H2*T*T + H1*T + H0

S = S3*T*T*T + S2*T*T + S1*T + S0

X = 2.0 * (H-S)

H_T = AMP * COS(SIGO*FODAY + (X-PHASE) * 3.14159/180.0)

where

H_0 = 279.69668D+00

H_1 = 36000.768930485D+00

H_2 = 0.000303D+00

T_o = 27392.500528D+00

T_1 = 1.0000000356D+00

SIGO = 1.40519D-04

S_0 = 270.434358D+00

S_1 = 481267.88314137D+00

S_2 = -0.001133D+00

S_3 = 1.9D-06

and T_{JD_o} is the Julian date at the beginning of the year and AMP and PHASE are computed by linearly interpolating the tide file.

TITLE: TIDE HEIGHT (SEASAT MODEL) A.A-2.6.2B

FUNCTION:

INPUTS: TBD

OUTPUTS:

SPECIAL TABLES:

PROCESSING:

Awaiting publication of SEASAT geophysical processing documentation.

TITLE: SOLID EARTH TIDE HEIGHT A.A-2.6.3

FUNCTION: To calculate the magnitude of the solid Earth tide height at the subsatellite point. The inputs to the module are the latitude and longitude of the subsatellite point and the output is the solid Earth tide height.

INPUTS:

ϕ = geodetic latitude of the subsatellite point in (deg,0.01)

ϕ' = geocentric latitude of the subsatellite point in (deg,0.01)

λ = longitude of the subsatellite point in (deg,0.01)

OUTPUTS: h_E = solid Earth tide height in (m,0.001)

SPECIAL TABLES: Table 2.6.3, a table of constants for use in the solid Earth tide algorithm (not presently available).

PROCESSING:

$$\Delta h_b = h_2 \frac{M_b}{M_e} \frac{r^4}{D^3} (3/2 \cos^2\theta_b - 1/2)$$

$$\Delta h_c = 0.202(3/2 \sin^2\phi' - 1/2)h_2$$

$$h_E = \Delta h_b - \Delta h_c$$

where h_2 is the second order Love number, M_b is the mass of the tide-generating body, M_e is the mass of the Earth, r is the radius of the Earth, D is the distance from the Earth to the tide-generating body, and θ_b is the angle between a line from the subsatellite point to the center of the Earth and a line from the center of the Earth to the center of the tide-generating body. Tidal effects of the sun and the moon will be calculated.

TITLE:	EM BIAS	A.A-2.6.4

FUNCTION: To provide a correction for the electromagnetic (EM) bias effect in which the relative radar cross section tends to increase below mean sea level (MSL) and decrease above MSL in the presence of waves. Its effect is to shift the centroid of the radar return away from MSL towards the troughs so that the altimeter tracks long. Recent experimental data from the surface contour radar (SCR) at 36 GHz and the NRL 10 GHz adaptive radar altimeter (ARA) indicate that the electromagnetic bias is in the range of 0 to 3% of the SWH. The data indicate that the magnitude of the effect may increase with waveheight. A theoretical development (Ref. 10) using a one-dimensional model of the sea surface indicated that there should be a linear dependence of the EM bias on the skewness of the height distribution. A recent two-dimensional computer simulation (D. E. Barrick) indicates a reduced magnitude of the skewness effect predicted by Ref. 10. Preliminary analysis of very recent SCR data (E. J. Walsh) indicates that the EM bias effect may also be wind-speed dependent.

INPUTS:

SWH = significant waveheight from A.A-2.3 in (m,0.01)

λ_s = ocean wave skewness from A.A-2.3

W_{10} = wind speed from A.A-2.5.2 in (m/s,0.1)

OUTPUTS:

$\delta h_{2,5}$ = height correction for EM bias in (m,0.001)

$\sigma_{\delta h_{2,5}}$ = standard deviation of $\delta h_{2,5}$ in (m,0.001)

SPECIAL TABLES: Table 2.6.4, a table of constants K_1, K_2, K_3, and K_4 (not presently available).

PROCESSING:

$$\delta h_{2,5} = \left[K_1 + K_2*SWH + K_3*\lambda_s + K_4*W_{10}^{\frac{1}{2}}\right] * SWH$$

if $\delta h_{2,5} < 0$, then set $\delta h_{2,5} = 0$

$\sigma_{\delta h_{2,5}}$ = 0 (by default)

TITLE:	SEA SURFACE HEIGHT, ALTITUDE RESIDUAL	A.A-2.6.5

FUNCTION: To compute the sea surface height and the altitude residual. The sea surface height is the difference between the ellipsoid height and the corrected altitude measurement and as such is an estimate of the altimeter geoid. The altitude residual is the difference between the corrected altitude measurement and the modeled altitude measurement and is used in estimation and orbit determination. The inputs to the module are the Level 2 corrected altitude, the ellipsoid height, and the geoid, tide, and solid Earth tide heights. The outputs are the sea surface height and the altitude residual.

INPUTS:

h_2 = Level 2 corrected altitude (from A.A-2.6) in (m,0.001)

H = satellite height above the reference ellipsoid in (m,0.001)

h_G = geoid height (from A.A-2.6.1) in (m,0.001)

h_T = tide height (from A.A-2.6.2) in (m,0.001)

h_E = solid Earth tide height (from A.A-2.6.3) in (m,0.001)

OUTPUTS:

SSH = sea surface height in (m,0.001)

y = altitude residual in (m,0.001)

SPECIAL TABLES: None

PROCESSING:

$$h_{modeled} = H - h_G - h_T - h_E$$

$$y = h_2 - h_{modeled}$$

$$SSH = H - h_2$$

TITLE:	ICE SHEET HEIGHT	A.A-2.7

FUNCTION: To correct sea surface height estimates over ice sheet (and possibly over all non-ocean surfaces) for non-ocean return characteristics.

INPUTS:

SSH = sea surface height from A.A-2.6.5 in (m,0.001)

63 waveform samples in (counts,0.1)

AGC = AGC in (db,0.01)

$\ddot{h}$ = height rate in (m/s,0.01)

α = spacecraft instrument altitude in (deg,0.01)

Δh = height error in (m,0.001)

Γ_{AR} = adaptive resolution step size flag

OUTPUTS:

SSH = corrected sea surface height in (m,0.001)

ΔSSH = sea surface height correction in (m,0.001)

MSR = mean surface roughness in (dimensionless,0.1)

M = mean surface slope in (deg,0.01)

Γ_{SSH} = sea surface height retrack estimate quality flag (0 for good, 1 for questionable)

SPECIAL TABLES: Table 2.7, a table of threshold tracker constants as a function of Γ_{AR} (not presently available). There will be a maximum of 25 entries in this table.

PROCESSING: Utilize the threshold tracker to obtain ΔSSH corrections for the real-time tracker response lag and waveform fluctuations. Then a fit routine similar to the one used by the Waveform Processor (A.A-2.3.1) and based upon ice sheet slope and roughness models will be employed to extract surface roughness and mean surface slope estimates. A more refined definition of the processing will result from FY81 studies.

TITLE: OCEAN CURRENTS A.A-2.8

FUNCTION: To calculate the ocean current location, its height anomaly, and its cross track velocity component by noting deviations from the steady state measurements of sea surface height near open ocean areas. Since geoidal features are critical to the removal of current locations from the height data, and since the currents must be located to within 2 or 3 kilometers, the standard 1°x1° geoid will not be sufficient. For the purposes of ocean current detection, a 5'x5' geoid will be needed in the areas where currents are to be located. It should be noted that the geoid must be a gravimetric geoid and not an altimeter geoid. This is because the current height magnitude is already included in the altimeter geoid. The inputs to this module are the time, the Level 2 corrected altitude, the ellipsoid height, the geoid and tide heights, and the latitude and longitude of the subsatellite point. The outputs are the cross track component of the current velocity and the time, latitude, and longitude of the leading and trailing edge of the current. Data lying outside the selected current investigation areas will not be processed by this module.

INPUTS:

h_2 = Level 2 corrected altitude (from A.A-2.6) in (m,0.001)

H = satellite height above the reference ellipsoid in (m,0.001)

h_G = geoid height (from A.A-2.6.1) in (m,0.001)

h_T = tide height (from A.A-2.6.2) in (m,0.001)

t = altitude measurement time in (s,0.0001)

ϕ = satellite latitude in (deg,0.01)

λ = satellite east longitude ($0° \leq \lambda < 360°$) in (deg,0.01)

5'x5' geoid file (A.D-2.73)

OUTPUTS:

t_a = time of encounter with current leading edge in (s,0.0001)

t_b = time of encounter with current trailing edge in (s,0.0001)

λ_a = east longitude of current leading edge in (deg,0.01)

λ_b = east longitude of current trailing edge in (deg,0.01)

ϕ_a = latitude of current leading edge in (deg,0.01)

ϕ_b = latitude of current trailing edge in (deg,0.01)

V_s = cross track component of current velocity in (cm/s,0.01)

SPECIAL TABLES: None

PROCESSING:

(1) In region of currents, compute height deviation from geoid:

$$\Delta h = (H - h_2) - h_G - h_T$$

(2) Edit spurious points

(3) Smooth data to reduce effects of random measurement noise

(4) Filter data to further suppress the measurement noise

(5) Fit a line through open ocean area and remove this line from entire pass

(6) Locate current by looking for a slope deviation with a duration of approximately 10 to 15 seconds

(7) Compute cross-track velocity:

$$V_s = \frac{g}{2\Omega \sin\phi} \quad \frac{\delta h}{\delta L}$$

g = 980

Ω = 7.29×10^{-5}

δh = height anomaly across the current

δL = horizontal distance across the current

(8) Compute the cross track current direction

TITLE: QUALITY CONTROL MONITOR A.A-2.9

FUNCTION: To classify the quality of the Level 2 Output File (A.D-2.91) The data will be flagged as being of questionable quality when prescribed standard deviation tolerances are exceeded, when the number of rejected points in the various smoothing algorithms exceeds acceptable limits, or when operational threshold limits are exceeded.

INPUTS: Level 2 altimeter data

OUTPUTS: The following data quality flags are set

Γ_{σ_h} = quality flag for σ_h

$\Gamma_{\dot{h}}$ = quality flag for height rate

$\Gamma_{\sigma_{AGC}}$ = quality flag for AGC standard deviation

Γ_{α} = quality flag for attitude

Γ_{MTU} = quality flag for MTU temperature

Γ_{DFB} = quality flag for DFB temperature

Γ_{ANG} = quality flag for noise gate

Γ_{AGC} = quality flag for AGC gate

Γ_{TWT} = quality flag for TWT collector temperature

$\Gamma_{\sigma_{SWH}}$ = quality flag for SWH standard deviation

Γ_{DATA} = quality flag for data validity

Values of 0 indicate acceptable quality; values of 1 indicate questionable quality.

SPECIAL TABLES: Table 2.9, a table of preflight nominal tolerances to be used in setting the data quality flags (not presently available). The maximum number of entries in this table is 25.

PROCESSING: Level 2 output parameters are compared with Table 2.9 and the output flags are set to the appropriate values. Limits on standard deviations are compared after a decay filter is employed to remove spurious points.

OTHER CONSIDERATIONS

This section summarizes the additional considerations required for developing the software for the altimeter processing.

Program Limitations

The following program limitations are repeated here from the Key Assumptions.

1) All data required from the input files (i.e., ephemeris file, FNWC file, LAMMR Level 2 file, etc.) must be available and current as the altimeter processing software requires it. Failure to supply certain of the input files will result in the abnormal termination of the altimeter processing software.
2) The requirements associated with the possible processing of data from more than one spacecraft have not been addressed in this report.

Expected Types of Future Changes/Updates

The following modules will require future updates.

1. A.A-1.1 Engineering Units Conversion. The conversion constants provided in this report are SEASAT values. NOSS values will replace these constants as they become available. Additionally, other data modes will be defined.
2. A.A-1.2.1.1 Constant Time Tag Correction. The table entries in this module are based upon SEASAT values. NOSS values will replace them as they become available.
3. A.A-1.2.2 Cal Zone Bias. The table of cal zone bias corrections will be added after the launch of the spacecraft.
4. A.A-1.2.3 Center of Gravity Offset. The table of center of gravity offsets will be added after the geometry of the spacecraft is defined and updated after launch as fuel is expended.
5. A.A-1.2.4 Cal Mode Bias. The table of altitude and AGC cal mode biases will be added after the launch of the spacecraft.
6. A.A-1.3.1 Cal Mode Monitor. The calibration mode data base constants will be supplied before the launch of the spacecraft. The cal mode will be expanded for better measurement of the received pulse shape and to cover the adaptive resolution calibration requirements. The latter may mean a similar cal mode is run five times, once for each step.

7. A.A-1.3.1.1 Cal I Processor. The calibration data tolerances and nominal comparison data will be supplied before the launch of the spacecraft.
8. A.A-1.3.1.2 Cal II Processor. The calibration nominal comparison data will be supplied before the launch of the spacecraft.
9. A.A-1.3.2 Trend File Processor. The curve fit technique and the display requirements will be specified prior to the launch of the spacecraft.
10. A.A-1.4 Adaptive Resolution. This is a new mode for the altimeter. Therefore the algorithms will be in the development stage for the next year.
11. A.A-2.2 Contamination Processing. Investigations are being made into the best algorithms to use for contamination processing. Therefore the final algorithms will not be defined for several months.
12. A.A-2.3.1 Waveform Processor. The waveform processor is currently being developed at WFC. The algorithms are expected to be fully developed during the next year.
13. A.A-2.3.3 SWH Cal Zone Bias. The table of cal zone biases will be added after the launch of the spacecraft.
14. A.A-2.3.4 Mean Square Slope and Percent Smoothness. This module was developed for GEOS-3 data and will be modified for NOSS during the coming year.
15. A.A-2.4 Atmospheric Module. Work will be done during the next year to determine the ionospheric module to use and provide more descriptions. The interface to other subsystems and external data will be developed as part of the overall system.
16. A.A-2.4.1 Rain Gate. This is a new product for the altimeter. Therefore the algorithms will be in the development stage for the next year.
17. A.A-2.6.4 EM Bias. This is a new product for the altimeter. Therefore the algorithms will be in the development stage for the next year.
18. A.A-2.7 Ice Sheet Height. The processing of this module will be similar to that of the Waveform Processor (A.A-2.3.1) but related to adaptive resolution and will therefore be developed during the coming years.
19. A.A-2.8 Ocean Currents. This module will use the techniques developed for GEOS-3 and used on SEASAT-1 but will be modified during the coming year to accommodate real-time processing requirements. Additionally, the 5'x5' geoid file will need to be developed in current areas.

The altimeter processing is designed as a logical system within itself (i.e., all atmospheric related parameters are in one module). However for an overall satellite system that requires sensor data interchange between sensor processors, there are some altimeter flow changes that may help the overall system. An example would be to compute the sigma naught correction and wind speed using instrument attitude before the waveform processor. This would allow the σ_0/wind file to be produced considerably earlier in the time line which might help the data flow in the CZCS and SCATT processors.

Resources Requirements

The memory/storage and timing requirements of the altimeter processing software are given in Table V. Although the NOSS altimeter processing modules have not yet been coded as a system and executed, the estimates of the resource requirements given by this table are believed to be accurate to about 25 percent. In addition, the totals of the resource requirements do not take the potential of overlaying into account, so that the total of core words required (323.5 K) is considered to be conservatively large.

The fact that the NOSS altimeters will essentially be copies of the SEASAT altimeter and many of the SEASAT sensor and geophysical algorithms have been adopted for use by the NOSS processing software has somewhat simplified the task of estimating the resource requirements. Accordingly, the memory and timing requirements given in Table V are based upon the resource requirements of existing SEASAT altimeter processing software as described below:

1) The SEASAT Sensor File Processor performed essentially the same calculations as modules A.A-1.2, A.A-2.1, A.A-2.3.2, A.A-2.3.3, A.A-2.5.1, and A.A-2.9. Additionally, module A.A-1.4 will have essentially the same resource requirements as the sum of modules A.A-1.2 and A.A-2.3.2 and will only be accessed when A.A-1.2 and A.A-2.3.2 are not accessed. Therefore, the total resource requirements of these modules should be similar to the resource requirements of the SEASAT Sensor File Processor, which required 45.5K words and 5.5 CPU minutes per orbit (converted to 360/91 time).
2) The SEASAT Geophysical Data Record Processor performed essentially the same calculations as modules A.A-1.5, A.A-2.4, A.A-2.5.2, and A.A-2.6 with the exceptions of submodules A.A-2.4.1, A.A-2.4.6, and A.A-2.6.4. The resource requirements of these exceptions are considered to be insignificant when compared to the other modules listed here. Therefore, the total resource requirements of these modules should be similar to the resource requirements of the SEASAT Geophysical Data Record Processor, which required 119.0 K words and 1.9 CPU minutes per orbit (converted to 360/91 time).
3) The SSPREP program, which was developed at WFC, performed essentially the same calculations as modules A.A-1.1 and A.A-1.6. Therefore, the total resource requirements of these modules should be similar to the resource requirements of the SSPREP program, which required 32.0 K words and 2.2 CPU minutes per orbit (converted to 360/91 time).
4) The SEASAT Cal Mode Monitor performed essentially the same calculations as submodule A.A-1.3.1. Since submodule A.A-1.3.2 can be estimated to have the same resource requirements as A.A-1.3.1, the sum of the resource requirements for these two submodules, or equivalently the resource requirement for module

TABLE V. ALTIMETER MODULE RESOURCE REQUIREMENTS

Modules		Core Words	CPU Min/Orbit
A.A-1.2	or A.A-1.4		
A.A-2.3.2			
A.A-2.1		45.5 K	7.7
A.A-2.3.3			
A.A-2.5.1			
A.A-2.9			
A.A-1.5			
A.A-2.4			
A.A-2.5.2		119.0 K	1.9
A.A-2.6			
A.A-1.1		32.0 K	4.4
A.A-1.6			
A.A-1.3		38.0 K	0.002
A.A-2.8		27.0 K	11.25
A.A-2.2			
A.A-2.3.1		31.0 K	60.0
A.A-2.3.4			
A.A-2.7		31.0 K	20.0
		323.5 K	105.3

A.A-1.3, should be twice that of the SEASAT Cal Mode Monitor, which required 19 K words and 0.001 CPU minutes per orbit (converted to 360/91 time and assuming 60 seconds of Cal data per day).

5) The Dynamic Ocean Current Sensing Program, which was also developed at WFC, performed the same types of calculations as will be performed by module A.A-2.8. Accordingly, that module is projected to require the same resources as the Dynamic Ocean Current Sensing program which uses 27.0 K words and 11.25 CPU minutes per orbit (converted to 360/91 time and assuming one orbit in twelve will have current information for a duration of 3 minutes).

6) The SEASAT Waveform Processor Program developed at WFC performs the same calculations as submodule A.A-2.3.1. In addition, the related submodules A.A-2.2 and A.A-2.3.4 can be combined with A.A-2.3.1 for the purpose of the assessment of resource requirements since both are assumed to be insignificant in storage and execution time when compared to A.A-2.3.1. Accordingly, the combined resource requirements of submodules A.A-2.2, A.A-2.3.1, and A.A-2.3.4 is assumed to be that of the SEASAT waveform processor. Those requirements are 31.0 K words and 60.0 CPU minutes per orbit (converted to 360/91 time and assuming 75% of the altimeter data will be over water).

7) Module A.A-2.7 is assumed to be similar in types of calculations to module A.A-2.3.1. Therefore the resource requirements of this module are also determined from the resource requirements of the SEASAT waveform processor. Those requirements are 31.0 K words and 1.6 CPU minutes per orbit (converted to 360/91 time and assuming 25% of the NOSS data will be processed by this module).

The above resource requirements can be separated into the combined requirements for Level 1 and for Level 2 processing. To accomplish this, it was assumed that the requirements of module A.A-1.2 would be 40% of the requirements of the SEASAT Sensor File Processor and that the requirements of module A.A-1.5 would be 10% of the requirements of the SEASAT Geophysical Data Record Processor. With these assumptions, Table VI gives the resource requirements of the NOSS altimeter processing software separated into Level 1 and Level 2.

TABLE VI. ALTIMETER PROCESSOR LEVEL RESOURCE REQUIREMENTS

Processor Level	Core Words	CPU Min/Orbit
1	100.1 K	9.0
2	223.4 K	96.3

It should be noted that in estimating the amount of CPU time required, processing time from different computer systems had to be transformed to IBM 360/91 time. The conversion formulae used were:

$$\frac{\text{IBM 360/75 time}}{\text{IBM 360/91 time}} = \frac{2}{1}$$

$$\frac{\text{Univac 1108 time}}{\text{IBM 360/91 time}} = \frac{2}{1}$$

$$\frac{\text{HW 625 time}}{\text{IBM 360/91 time}} = \frac{10}{1}$$

For the sake of completeness, Table VII is included to provide sizing information of the data files and reports. More specific information concerning the input or output rate of each is contained in the Data Description.

The following are not included in the resource requirements:

1. Processing time for file updates and data access by the processor.
2. Overhead for any overlay or subsystem communication.
3. Input/output loads for archive, and user.
4. Data catalog functions and storage.

Alternative algorithms and files are given for the calculation of the ionospheric refraction height correction. Although the choice of the ionospheric refraction module has not been made, it is not expected to impact core or execution time requirements.

TABLE VII. ALTIMETER PROCESSOR FILE AND REPORT SIZES

File	Size in Bytes
A.D-1.71	1825 K
A.D(M)-1.81	25,584 K
A.D(M)-1.82	362 K
A.D(M)-1.83	9000 K
A.D(L)-1.84	See LAMMR Algorithm Freeze Report
A.D-1.91	588 K
A.D-1.92	900 K
A.D-1.93	900 K
A.D-1.94	33,984 K
A.D-2.71	259.2 K
A.D-2.72	518.4 K
A.D-2.73	518.4 K
A.D(M)-2.81	21,772.8 K
A.D(M)-2.82	3.4 K
A.D(L)-2.83	3427.2 K
A.D(S)-2.84	8467.2 K
A.D-2.91	1200 K
A.D-2.92	14,515.2 K

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15. Supplementary Notes

16. Abstract

This report scopes the data processing algorithm requirements for producing the altimeter products predicted for the National Oceanic Satellite System (NOSS). The report was required by the NOSS project to provide a basis for detailed Primary Processing Facility (PPF) computer system design and cost planning. A description of all algorithms required for altimeter processing is given. Each description includes title, description, inputs/outputs, general algebraic sequences and data volume. All required input/output data files are described and the computer resources required for the entire altimeter processing system is estimated.

This report scopes the majority of the data processing requirements for any radar altimeter of the SEASAT-1 type. Additions and deletions could be made for the specific altimeter products required by other projects.

After review by the NOSS project and modification to its guidelines, the report will be reissued by the project as the Altimeter Algorithm Freeze Report for use by the NOSS study phase contractors. That report should be utilized for the official NOSS position.

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