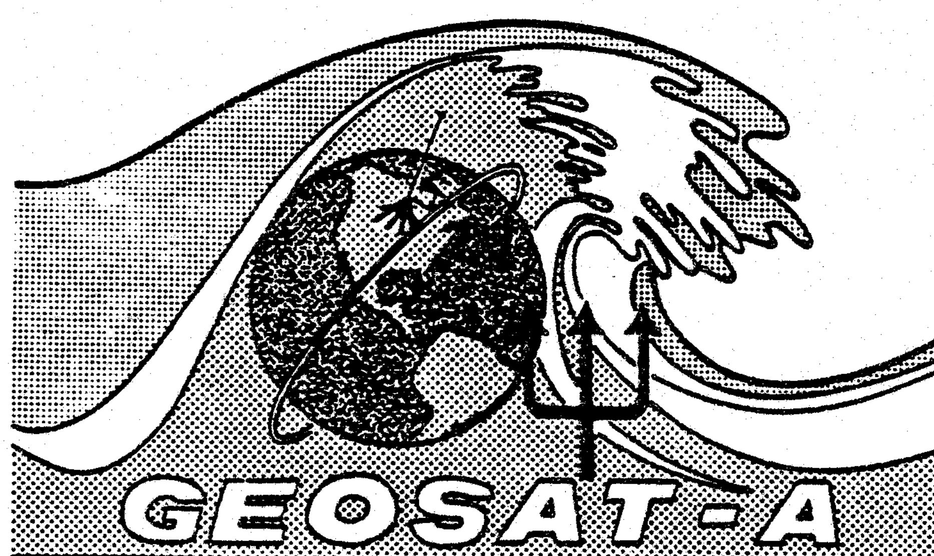
JHU / APL
7292—9510 REV. 1
MAY 1985

GEOSAT-A DATA USERS / GROUND SYSTEM INTERFACE CONTROL DOCUMENT (ICD)



THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY

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GEOSAT-A
DATA USERS / GROUND SYSTEM INTERFACE CONTROL DOCUMENT (ICD)

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Approved by: Charles May

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Johns Hopkins Road, Laurel, Maryland 20707
Operating under Contract N00024-85-C-5301 with the Department of the Navy

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1.0 GEOSAT-A DATA OBJECTIVES

The primary objective to be attained through the GEOSAT-A mission is the acquisition of extremely accurate altimetry data to augment the existing global measurement database. GEOSAT-A altimetry data is acquired from a spaceborne radar altimeter which was launched into a precise earth orbit. In addition to this primary concern, a secondary objective is the evaluation of radar altimetry data to quantify various oceanographic parameters in a near real-time capacity.

Reference 2.1a provides additional background information concerning the GEOSAT-A mission objectives and program description. (Section 2.0 presents references for this document.) The following subsections present the scope of this document and define the two primary data products, the SENSOR DATA RECORD (SDR) and the WAVEFORM DATA RECORD (WDR).

1.1 Document Scope

The complete description of the interface between the GEOSAT-A ground station at The Johns Hopkins University/Applied Physics Laboratory (APL) and the primary GEOSAT-A data users is defined within this document.

The use of "primary data users" in this document means the Naval Surface Weapons Center (NSWC) at Dahlgren for the SDR product and both the Naval Research Laboratory (NRL) and Defense Mapping Agency (DMAAC) for the WDR data product. Initially, the WDR is sent to NRL. After approximately six months of altimeter data collection, the WDR is forwarded to DMAAC for the remainder of the mission.

To fully address the data interfaces, this document contains information concerning the data source as well as the two primary data products. Section 3.0 presents the altimeter data flow from the spacecraft to the GEOSAT-A Ground System Computer System (GSCS) located at APL (Reference 2.1(b)). Appendix D supplements this description of the data source by describing the exact contents and format of the telemetry stream portion dedicated to the altimeter.

The two data products are defined extensively through presentation of contents, format, algorithms, and attendant logistics necessary for the conveyance of these products to the users. Sections 4.0 and 5.0 present this information for the SDR and WDR data products, respectively.

The SDR preprocessing algorithms are documented in Appendix A and are under configuration control as well as this entire document. The current version of this ICD was approved through the submission of two APL memoranda, References 2.2(a) and 2.2(b). Calibration and WDR processing procedures are also under configuration control. Appendix B presents the calibration processing algorithms whereas Section 5.2 describes the WDR algorithms.

In order to clarify the use of estimated bias values and assist in the application of time tagging, Appendix C was written and included in this document. Appendices E and F, respectively, define the SDR and WDR tape formats precisely using the exact (FORTRAN) coding statements responsible for creating the data tapes. These appendices thoroughly define each parameter written to tape. Finally, Appendix G lists the acronyms and symbols used in this document along with attendant definitions.

The secondary data objective of producing an oceanographic data product using altimetry data is the subject of a program denoted GEOSAT-A Ocean Applications Program (GOAP). Particulars relating to the GOAP data product and interface with GOAP data users are presented in Reference 2.3(b). This reference is an Interface Control Document and serves the identical purpose for the GOAP effort as this document does for the GEOSAT-A program. Details pertinent to the GOAP program are reserved for documentation explicitly addressing that program and are not described within this document.

1.2 Data Product Definitions

To support the GEOSAT-A mission, APL processes radar altimetry data to estimate both instrument errors and parameters. In addition, APL ground station data necessary for downstream data processing is acquired and incorporated in the data products.

The design of the data products are such as to permit full data accountability. No data editing of the raw data is performed; instead, the raw measurements are given at their full sampling rate which corresponds to the telemetry frame rate (10.204 samples/sec). The raw data consists of spacecraft computed height (h), altimeter automatic gain control (AGC), onboard computed significant wave height (SWH), and radar return waveform samples (WS) for each of the 63 altimeter gates. The SDR is generated using algorithms derived from the SEASAT mission and from several recently developed techniques involving radar altimetry. The SDR product is a computer compatible tape (CCT) which is forwarded to NSWC/Dahlgren for further processing. The

SDR is considered a SECRET data product as it contains an extended period of precise altimetry data. Each SDR spans a 24-hour measurement period; from midnight to midnight (±1 second).

The WDR is a simpler data product aimed at altimetry research. Primarily, this data product consists of raw waveform samples only. To permit correlation with the SDR product, WDR products cover the same measurement periods. Due to the amount of waveform data accrued during a 24-hour period, the WDR product requires two CCTs whereas the SDR is placed on one. The WDR CCTs are forwarded to NRL or DMAAC (Section 1.1) and are UNCLASSIFIED.

1.3 Data Product Generation Schedule

The nominal schedule used to produce these data products depends on the timeliness of the received data and the GSCS processor load. For both the SDR and the WDR, the data products are available for delivery two weeks after data reception.

Unscheduled maintenance on the GEOSAT-A ground system computer system (GSCS), remedial operation of the spacecraft and/or altimeter, or any similar occurrence might alter data product delivery. In any event, the dump data is recorded on an analog tape (archive tape) during the pass to minimize data loss. (Two analog tapes simultaneously record dump data for redundancy but only one analog tape is saved as an archive tape.)

Due to the processing load on the GSCS, significant reprocessing of the data products is not possible. Thus, if such reprocessing of the SDR tapes generated during the initial measurement period (first month of altimeter operation) is warranted, it must be performed on a separate processor. (Infrequent reprocessing will be accommodated as GSCS scheduling permits.)

During an abnormal spacecraft data dumping scenario, as when data from a missed pass is being recovered, additional preprocessing time is required in order to accomplish data merging. This additional time is required to acquire all of the missed data; consequently, the generation and delivery of the data products (SDR and WDR) may be delayed by up to 4 weeks. The occurrence of abnormal data dump operations has been estimated to total less than 5% of the mission period.

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2.0 DOCUMENTS

2.1 GEOSAT-A Program Documents

The following are formal GEOSAT-A program documents. These documents provide details concerning the GEOSAT-A mission and/or any of the GEOSAT-A subsystems.

(a) SDO-6002.1, "GEOSAT-A Program Plan; Technical Plan."

(b) 7292-9300 "Performance and Interface Specifications for GEOSAT-A Ground System Computer System (GSCS)."

(c) 7292-9400 "Performance and Interface Specifications for Command, Control, and Monitoring Software."

(d) 7292-9500, Performance and Interface Specification for the GEOSAT-A SDR and WDR Preprocessing Software."

(e) 7292-9650, "Security Manual: Standard Practice Procedure Description Document for the GEOSAT-A Ground System Computer System (GSCS)."

(f) 7292-9600, "TEMPEST Plan for the GEOSAT-A Ground Station."

(g) 7292-9000, "Performance and Interface Specification for the GEOSAT-A Ground Station."

2.2 APL Memoranda

The following documents were published as APL internal memoranda and distributed to external GEOSAT-A efforts. These references supplement those listed in Section 2.1; however, these documents are not subject to configuration control. Instead, information concerning GEOSAT-A elements where rapid dissemination was required was documented by the following.

(a) S3C-2-199, "Description of the SDR Format and Content", February 27, 1984.

(b) S3C-2-199, Rev. 1, "Description of the SDR Format and Content - Revision 1"; March 27, 1984.

(c) S3C-2-112, "Time Management Methodology for GEOSAT-A", March 26, 1983.

(d) S2N-82-0072V, "Telemetry List for GEOSAT-A"; November 27, 1984.

(e) S2N-82-0154B, "Change to the GEOSAT-A Telemetry Formats"; January 11, 1983.

2.3 Other References

References not generated by the GEOSAT-A program but directly related are given in this section.

(a) SDO-5232, "SEASAT-A Radar Altimeter Design Description", November 1978.

(b) 7292-9810, "GEOSAT-A Ocean Applications Program Data Link/ NORDA Interface Control Document," February 1984.

(c) "Operations and Maintenance Manual - Model 9300 Digital Tape Transport", Kennedy Co.

2.4 Precedence

With respect to the contents and format of the primary data products, this document takes precedence over all other GEOSAT-A references. Several constants associated with this document were derived from prelaunch calibrations and are subject to change. Constants given herein are best estimates and/or represent nominal values.

3.0 SDR/WDR DATA SOURCE DESCRIPTION

The SDR and WDR are chronological data products derived from GEOSAT-A measurements commencing with operational altimeter tracking and continuing until the end of the GEOSAT-A primary program. These data products are produced in segments corresponding to 24-hour data spans approximately marked by $00^h00^m00^s$ UTC at each end (these spans vary by ±1 second). These data products are arranged into logical records with each record comprising 10 samples of raw data.

3.1 GEOSAT-A Telemetry Stream Format

The source of altimetry data processed in SDR and WDR products is telemetry data that is dumped to the GEOSAT-A ground station from the spacecraft (S/C). This data is recorded on an analog Archive Tape (AT) during each pass selected for data reception (denoted dump pass). The telemetry stream is formatted as 1000 bit minor frames organized as follows:

S/C HOUSKEEPING (HSKP):
- Synch Pattern. . . . . bits 0001-0024
- Format ID. . . . . bits 0025-0032
- Minor Frame Count (mFC). . . . . . bits 0033-0040
- Subcommutated HSKP Data. . . . . . bits 0041-0144

FILL BITS . . . . bits 0145-0150
ALTIMETRY . . . . bits 0151-1000

Detailed information on S/C housekeeping telemetry is documented in References 2.2(d) and 2.2(e). The altimetry portion of the telemetry stream is described further in Appendix D and Reference 2.2(c).

The telemetry stream definitions are as follows:

minor frame - 1000 bit stream representing a sample of a housekeeping and altimetry data channel.

major frame - 32 minor frames; required number of minor frames to fully sample each housekeeping channel at least once.

altimetry frame - 50 minor frames; required number of minor frames to fully sample each altimetry channel at least once.

These definitions indicate how the housekeeping and altimeter functions are subcommutated in order to acquire all of the necessary data. Accompanying each minor frame is a number cycling from 0 to 31 known as the minor frame count (mFC). There is also a number, denoted major frame count (MFC), appearing twice per major frame interval which uniquely identifies every data sample. (MFC occurs on the first and is repeated on the 17th minor frame for each major frame.)

Two successive clusters, nominally 12 hours apart, are recorded on one Archive Tape. A cluster can represent one or more dump passes spaced at ~100 minute intervals (see Section 4.0). Each Archive Tape contains about 24 hours of data but the 24 hour AT period is not necessarily aligned to $00^h00^m00^s$.

3.2 GEOSAT-A Telemetry Stream Characteristics

The storage mechanism for the housekeeping and altimetry data onboard the spacecraft employs flight tape recorders. This affects the characteristics of the dump data as: (a) data transmitted to the ground station is time reversed (last recorded, first playback) and (b) about 12 hours of data must be dumped during a pass (average of 10 minutes) using a data rate higher (833.4 kbps) than that associated with measurement sampling and recording (10.204 kbps). Characteristics of this dump data may demonstrate any of the following:

1) Occasional loss of minor frames of data.

2) Significant data segments out of chronological order.

3) Data overlaps associated with S/C tape recorder operations.

4) Frame counter resets.

These data problems do not exhaust all possibilities but are considered the more pertinent ones impacting SDR/WDR processing.

The SDR and WDR processing code automatically adjusts for these data stream malfunctions to varying degrees in order to produce chronological products. To determine if data is missing, SDR and WDR files are accumulated for up to 10 days as needed, with at most 3 days worth of SDRs and 1.5 days worth of WDRs "active" concurrently. If the missing data does not appear at the ground station during this period, the data is considered lost. This buffering approach permits the repacking of data received into its proper sequence thereby minimizing the appearance of anachronistic data. Data overlaps are handled simply by deletion of the second occurrence when identified. Data gaps, if less than two minutes (1200 minor frames), are zero filled, else they are completely compressed. Finally, coding difficulties resulting from major frame counter resets are not expected to occur frequently, and are resolved manually through interaction with the operator.

3.3 GEOSAT-A Ground System Computer System (GSCS)

The GEOSAT-A data processor located at APL which generates the SDR and WDR data products is based around a SEL 32/77 minicomputer. The 32/77 is a 32-bit architecture computer which implements both single and double precision arithmetic. Most of the SDR and WDR code is FORTRAN 77 with the remainder written in SEL assembly. The operating system used with the Ground System Computer System (GSCS) 32/77 is the Real-Time Monitor (RTM) version 7.2. In addition to RTM, an adjunct system program is used to enhance operating system capabilities and to add accounting functions. (Reference 2.1(b) describes the GSCS in more detail.)

Dump data is played into the GSCS processor through the use of digital hardware located adjacent to the processor. The hardware transfers the dump data from the Archive Tape to the GSCS using a high-speed interface at 833.4 kbps (actually, transfers occur in minor frame blocks). Thus, playback time equals the recording time which elapsed during pass operations.

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4.0 SDR INTERFACE DESCRIPTION

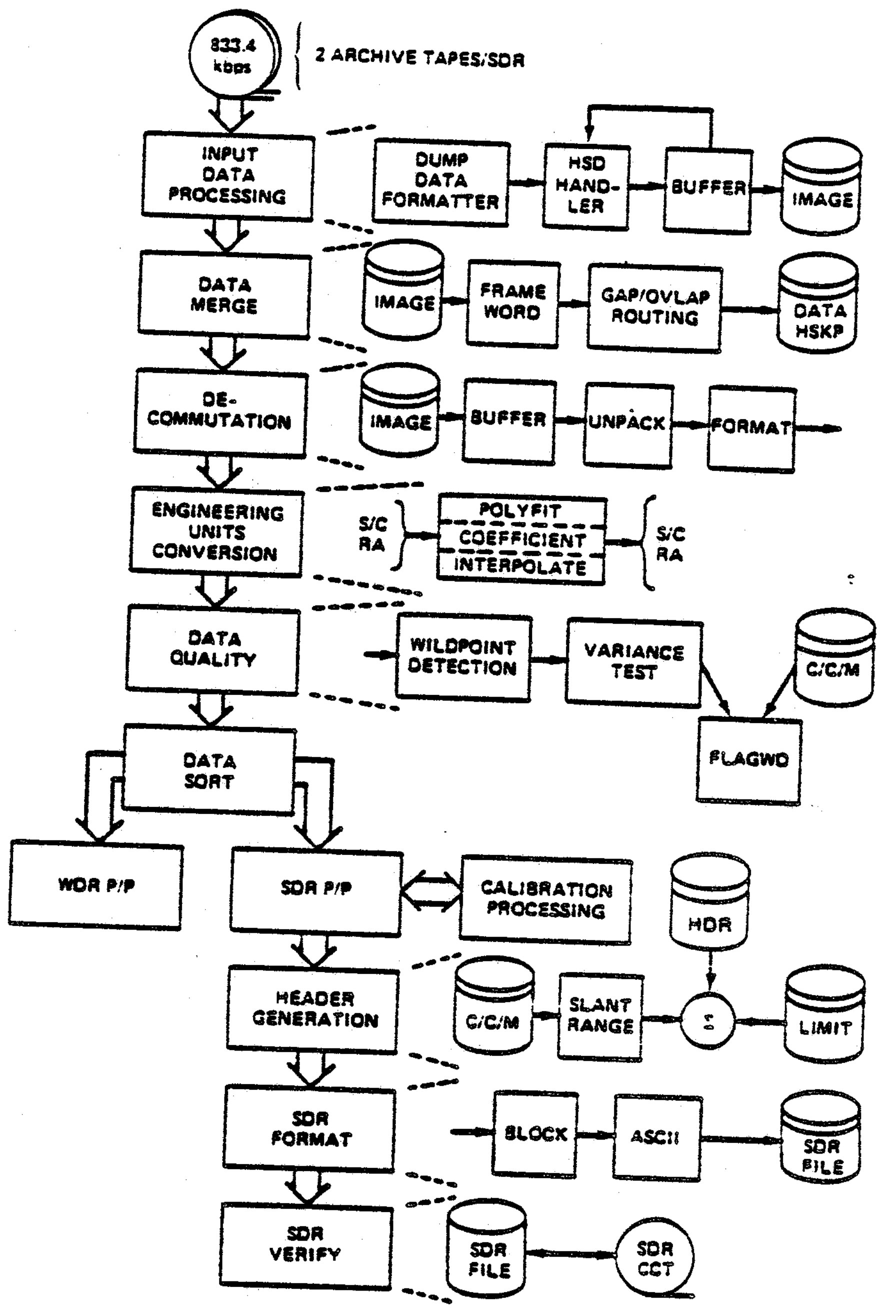
Normally, SDR processing occurs subsequent to each pass cluster. (A pass cluster is defined as a group of spacecraft passes where each pass is separated by an orbit period. Pass clusters occur once every 12 hours on an average. One or more data dumps can be commanded during each cluster, especially during split-pass scenarios.) SDR CCTs are 9-track, 1600 bpi digital tapes and contain 24 hours of processed data.

A functional description of the overall processing is represented in Figure 1 and is subsequently explained. The figure illustrates the major software modules and their respective operations as shown to the right using dotted lines. The three outputs, the WDR data product, CALIBRATION reports, and the SDR data product are produced concurrently. This section discusses the overall SDR processing flow. The WDR processing flow is addressed in Section 5.0 and CALIBRATION processing is presented in Appendix B. Presentation and discussion of the SDR preprocessing (P/P) algorithms themselves are reserved for Appendix A.

Figure 1 is now discussed. An image of the archived raw data is transferred onto the GSCS data disk to commence data processing. This transfer task is performed after each dump data pass using command, control, and monitoring (CCM) software (Reference 2.1(c)). CCM performs this task to permit ready access to the data by all of the dump data processing code including SDR/WDR software.

The SDR and WDR data products require ancillary information which is applicable to the entire data span. Such information includes data identification, time tag measurements, orbital parameters (NAVSPASUR elements, 5 line type), altimeter calibration values, S/C clock frequency, velocity of light and test limits used in the production of the data product. This information is placed at the beginning of each data product in the area denoted as the header file. These header file entries require updating at varying rates, thus a repository of header parameters is maintained and modified as required using the HEADER GENERATION module. The resultant header file is therefore a composition of fixed and updated parameter values.

The use of a Command/Control/Monitoring (CCM) file in the Header Generation process provides a means of archiving header information when the the normal processing schedule is disrupted. CCM saves various files generated during its execution onto digital tapes for both backup and delayed processing scenarios.



1 Altimetry Data Input Flow

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The succeeding SDR/WDR module, MERGE, works on the data image itself. The merge operation checks for data gaps and overlaps to ensure chronological order of the data. Data gaps are identified and are used to search subsequent raw data files to determine if the missing data arrived at the ground station at some later time (limited to 10 days). Unless the missing data can be identified for inclusion, durations of data loss are simply compressed in the SDR unless the gaps are on the order of 2 minutes (≤1200 minor frames) in which case MERGE zero fills the associated SDR record data. Overlaps are simply handled by the deletion of the second occurrence of the redundant data. The MERGE module reports all data gaps, overlaps, and unidentifiable data (e.g., invalid data transfers such as all zeroes).

The Decommutation module parses the merged raw data file into computer oriented data words for input to the Engineering Units Conversion (EUC) module.

EUC translates the telemetry bit stream into engineering words with proper units via application of coefficient(s), and/or tabular interpolation. For example, within this module, height data is converted from a temporal to a metric measurement with accommodation of attendant frequency and timing offsets of the altimeter/spacecraft.

The Data Quality module evaluates the reasonableness and validity of the data. This module uses calculations performed during SDR preprocessing along with a bit error check on predetermined bit patterns within the telemetry stream itself.

The Data Sort module identifies which data to process in the WDR and SDR Preprocessing (P/P) and the Calibration by splitting off the appropriate data words to each.

After the initial data processing (SDR/WDR D/P), which is identical for both SDR and WDR generation, the Data Sort function separates the waveform samples for scaling in order to increase packing efficiency on the WDR CCT (Scaling Process module). The header used by the SDR is copied and used by the WDR except that the tape ID is modified to uniquely identify the WDR CCT volumes. Finally, to compress the WDR records (2 CCTs/24-hour dump data), the WDR file is written onto magnetic tape and verified using binary representation instead of ASCII characters as used for the SDR. (Section 5.0 details the WDR data product.)

The calibration sequence is expected to occur once every 12 hours of operation. During operation, the altimeter will periodically cycle into onboard calibration modes. This portion of the data stream is used as input for the Calibration Processing discussed in Section 6.0.

4.1 SDR Data Contents

Tables 1 and 2 contain the parameters, associated resolutions (precision, not accuracy), and dynamic range for the elements which compose the SDR. A header is generated (Table 1) for each SDR and is intended to contain all constants applicable for the associated 24 hour data span. The SDR entries (Table 2) are placed onto the CCT such that one entry (data record) will represent the minor frame (0.98 second) data span. Therefore, each CCT will store approximately 88,128 SDR data records.

Definitions for the various SDR parameters are presented in Tables 3 and 4. Numbering of the definitions corresponds with that associated with the content tables.

Parameters transferred directly from the S/C telemetry dump data to the CCT (raw data) include:

- Mode word (concatenation of the Status/Mode words #1, #3, #4 as defined in Appendix D) at a 1/sec rate (item 3 of Table 2). Since each data word is 10 bits in length, the mode word requires two fill bits in the MSB positions to complete a GSCS computer word (i.e., right justification). As presented in Appendix E, the mode word is represented as a 10-digit integer on the SDR tape.

- Measurement data (h, SWH, and AGC) at the full (10/sec) data rate (items 5-14, 18-27, and 30-39, respectively). The height measurements (fine, medium, and coarse) are converted in metric units and combined to form nine digit integers. The SWH and AGC measurements are also converted and written to the SDR CCT as four digit floating point numbers.

For further information concerning the telemetry stream, refer to Reference 2.2(d) for housekeeping data and Appendix D for altimetry data. Detailed information associated with the design of SDR parameter processing can be found in Reference 2.1(d).

TABLE 1
SDR CCT HEADER CONTENTS

ITEM	PARAMETER	RESOLUTION	RANGE	TYPE	START BYTE
1	tape ID	NA	(SDRXXYYDDDNN)	A12	1
2	record count	1 record	0→88200	I5	13
3	start FC	1 count	0→2^{29}-1	I9	18
4	stop FC	1 count	0→2^{29}-1	I9	27
5	UTC(1) year	YY (year)	84→90	I2	36
6	UTC(1) day	DDD (day)	001→366	I3	38
7	UTC(1) second	10^{-6} second	0→86400	F12.6	41
8	correlated FC(1)	1 count	0→15x10^{6}	I8	53
9	τ 1,3	1 μs	0→10^{5}	I6	61
10	τ 1,4	1 μs	0→10^{4}	I5	67
11	τ 1,5	1 μs	0→10	I2	72
12	τ 1,6	1 μs	0→10^{4}	I5	74
13	τ 1,7	1 μs	0→10	I2	79
14	τ 1,8	1 μs	0→10^{3}	I4	81
15	SR1	1m	10^{5}→10^{7}	F9.0	85
16	a1	10^{-8} radii	1→1.5	F10.8	94
17	e1	10^{-7}	10^{-4}→10^{-2}	F9.7	104
18	P1	0.0001°	0→360	F8.4	113
19	I1	0.0001°	95→115	F8.4	121
20	MM1	10^{-8} rad/day	0→99	F11.8	129
21	LN1	0.00001°	0→360	F9.5	140
22	PP1	0.00001°/day	-10→10	F9.5	149
23	NP1	0.00001°/day	-10→10	F9.5	158
24	MA1	0.0001°	0→360	F8.4	167
25	date 1	(YDDD)	4000→0367	I4	175
26	epoch 1	10^{-8} MJD	45500→50000	F14.8	179
27	UTC(2) year	YY (year)	84→90	I2	193
28	UTC(2) day	DDD (day)	001→366	I3	195
29	UTC(2) second	10^{-6} second	0→86400	F12.6	198
30	correlated FC(2)	1 count	0→15x10^{6}	I8	210
31	τ 2,3	1 μs	0→10^{5}	I6	218
32	τ 2,4	1 μs	0→10^{4}	I5	224
33	τ 2,5	1 μs	0→10	I2	229
34	τ 2,6	1 μs	0→10^{4}	I5	231
35	τ 2,7	1 μs	0→10	I2	236
36	τ 2,8	1 μs	0→10^{3}	I4	238
37	SR2	1m	10^{5}→10^{7}	F9.0	242
38	a2	10^{-8} radii	1→1.5	F10.8	251
39	e2	10^{-7}	10^{-4}→10^{-2}	F9.7	261
40	P2	0.0001°	0→360	F8.4	270
41	I2	0.001°	95→115	F8.4	278
42	MM2	10^{-8} rad/day	0→99	F11.8	286
43	LN2	0.0001°	0→360	F9.5	297
44	PP2	0.00001°/day	-10→10	F9.5	306

TABLE 1
SDR CCT HEADER CONTENTS (Continued)

ITEM	PARAMETER	RESOLUTION	RANGE	TYPE	START BYTE
45	NP2	0.00001°/day	-10→10	F9.5	315
46	MA2	0.0001°	0→360	F8.4	324
47	date 2	(YDDD)	4000→0366	I4	332
48	epoch 2	10^{-8} MJD	45500→50000	F14.8	336
49	no. calibrations	NA	0→15	I2	350
50	Δh(cal)	1 mm	$-10^3 \rightarrow 10^3$	F5.0	352
51	ΔAGC(cal)	0.01 dB	-10→10	F6.2	357
52	ΔWS(1)	0.0001	0→2	F6.4	363
53	ΔWS(2)	0.0001	0→2	F6.4	369
...	...	...	...	...	...
114	ΔWS(63)	0.0001	0→2	F6.4	735
115	Δh(initial)	1 mm	$-10^3 \rightarrow 10^3$	F6.0	741
116	Δh(cg)	1 mm	$0 \rightarrow 10^4$	F5.0	747
117	ΔSWH(initial)	0.01m	-10→10	F6.2	752
118	ΔAGC(initial)	0.01 dB	-25→25	F6.2	758
119	Δfc	0.01 ppm	$0 \rightarrow 10^4$	F8.2	764
120	c	1 m/s	(2.99792458×10^8)	F10.0	772
121	σh,U	1 mm	$0 \rightarrow 10^4$	F6.0	782
122	σAGC,U	0.01 dB	0→3	F4.2	788
123	σSWH,U	0.01m	0→10	F5.2	792
124	ξ limit	0.01°	0→1	F4.2	797
125	T(MTU,U)	0.1°C	40→110	F5.1	801
126	T(MTU,L)	0.1°C	-30→20	F5.1	806
127	T(DFB,U)	0.1°C	40→110	F5.1	811
128	T(DFB,L)	0.1°C	-30→20	F5.1	816
129	T(TWTA,U)	0.1°C	40→110	F5.1	821
130	T(TWTA,L)	0.1°C	-30→20	F5.1	826
131	T(SACU,U)	0.1°C	40→110	F5.1	831
132	T(SACU,L)	0.1°C	-30→20	F5.1	836
133	T(DCG,U)	0.1°C	40→110	F5.1	841
134	T(DCG,L)	0.1°C	-30→20	F5.1	846
135	h(U)	1 mm	$8 \times 10^8 \rightarrow 8.5 \times 10^8$	F10.0	851
136	h(L)	1 mm	$7.5 \times 10^8 \rightarrow 8 \times 10^8$	F10.0	861
137	AGC(U)	0.01 dB	30→63	F5.2	871
138	AGC(L)	0.01 dB	0→25	F5.2	876
139	SWH(U)	0.01 m	10→20	F5.2	881
140	SWH(L)	0.01 m	0→2	F4.2	886
141	|dh/dt| limit	1 m/s	20→100	F4.0	890
142	RCVT(cal)	0.1°C	-30→110	F5.1	894

BYTE TOTAL = 898

TABLE 2

SDR CCT RECORD (1/s) CONTENTS

ITEM	PARAMETER	RESOLUTION	RANGE	TYPE	START BYTE
1	MFC	1 count	$0 \rightarrow (2^{24}-1)$	I8	1
2	mFC	1 count	$0 \rightarrow 31$	I2	9
3	mode	NA	$0 \rightarrow (2^{30}-1)$	I10	11
4	flagword	NA	$0 \rightarrow (2^{30}-1)$	I10	21
5	h_1	1 mm	$10^8 \rightarrow (10^9-1)$	I9	31
...	...	...	...	...	...
14	h_{10}	1 mm	$10^8 \rightarrow (10^9-1)$	I9	112
15	σh	1 mm	$0 \rightarrow (10^4-1)$	I4	121
16	$\Delta h(SWH \mid \xi)$	1 mm	$-9999 \rightarrow 9999$	I5	125
17	$\Delta h(fm)$	1 mm	$-999 \rightarrow 999$	I4	130
18	SWH_1	0.01 m	$0 \rightarrow 20$	F4.2	134
...	....	...	...	...	...
27	SWH_{10}	0.01 m	$0 \rightarrow 20$	F4.2	170
28	σSWH	0.01m	$0 \rightarrow 2$	F3.2	174
29	$\Delta SWH(SWH \mid \xi)$	0.01m	$-9.99 \rightarrow 9.99$	F4.2	177
30	AGC_1	0.01 dB	$0 \rightarrow 64$	F4.2	181
...	...	...	...	...	...
39	AGC_{10}	0.01 dB	$0 \rightarrow 64$	F4.2	217
40	σAGC	0.01 dB	$0 \rightarrow 64$	F4.2	221
41	$\Delta AGC(SWH \mid \xi)$	0.01 dB	$-9.99 \rightarrow 9.99$	F4.2	225
42	$\Delta AGC(h)$	0.01 dB	$-9.99 \rightarrow 9.99$	F4.2	229
43	$\Delta AGC(T)$	0.01 dB	$-9.99 \rightarrow 9.99$	F4.2	233
44	dh/dt	1 m/s	$-99 \rightarrow 99$	F3.0	237
45	ξ	0.01°	$0 \rightarrow 2$	F3.2	240
46	$\sigma°$	0.01 dB	$0 \rightarrow 64$	F4.2	243
47	W_c	0.1 m/s	$0 \rightarrow 32$	F3.1	247
48	$VATT_t$	0.001v	$0 \rightarrow 3$	F4.3	250
49	$RCVT_o$	0.1°C	$-30 \rightarrow 110$	F4.1	254
50	Spares	NA	NA	3(X)	258

BYTE TOTAL = 260

TABLE 3

SDR AND WDR HEADER DATA CHARACTERISTICS

PARAMETER	DEFINITION (REFERENCE SECTION)
1. Tape ID	A tag to uniquely identify the CCT under question using SDR or WDR sequencing numbers, generation date, and code version identification. SDR identification, SDRXXYYDDDNN, uses the "SDR" prefix, the tape version (XX), year and day of data acquisition on spacecraft (YYDDD), and code version (NN). WDR identification is identical except the "WDR" prefix is used and the tape version indicates if the WDR tape is morning (XX=00) or afternoon (XX=10).
2. No. records	Number of data records contained by the CCT (approx. 88,128). The SDR and WDR are time correlated in that the two products are produced simultaneously from the same raw data file. Note: Each minor frame is <0.1 sec and there are 10 minor frames/record.
3.,4. Start/Stop frame count	These items represent the calculated frame count (FC) values at the start (item 3) and finish (item 4) of the data product (midnight crossings). These counts are unique and are formed using major frame count (MFC) and minor frame count (mFC) in the equation; FC=(MFC*32)+mFC. (Section 3.1 presented definitions for MFC and mFC.)
5.,6.,7. Corrected UTC	UTC, or universal time coordinated, is a time based on GMT which consists of year (item 5), day (item 6) and microseconds into day (item 7). These items along with item 8 provide the capability to assign a highly accurate time to each data record contained on the SDR and/or WDR CCT. UTC(1) is one of the two time measurements given in the header. (Appendix C discusses the two time tag data groups.) The second time tag pair (UTC and correlated frame count) is necessary to perform time assignment to altimetry data to the required

TABLE 3
(Continued)

PARAMETER	DEFINITION (RÉFERENCE SECTION)
	precision. The UTC entries are corrected per Appendix C.
8. Correlated Major Frame Count	The major frame count (MFC) which correlates to the time (UTC) given in items 5.-7. FC(1) will be computed from the equation; FC(1)=MFC (1)*32. Time tagging function is performed by ground hardware at the major frame count (MFC) rate. Thus minor frame count (mFC) will always be zero during time tag measurements. (The time tagging algorithm is described in Appendix C.)
9.-14. Time Corrections	Various time delays were determined during S/C prelaunch tests and are estimated based on pass information. Appendix C details the definition of these timing errors and presents an error budget. Time correction(1,2) is not placed in the header as this term actually depends on height. To perform the correction necessary to account for radar altimeter return time delay, a nominal value for height is used. The six time corrections given are briefly described: TIME CORRECTION 3- (1,3) signal processor delay TIME CORRECTION 4- (1,4) - S/C telemetry system delay TIME CORRECTION 5- (1,5) - S/C transmit delay TIME CORRECTION 6- (1,6) - telemetered data propagation time due to slant range TIME CORRECTION 7- (1,7) - ground station receiver delay TIME CORRECTION 8- (1,8) - ground station digital delay The time tagging accuracy sought is 100 s.
15. Slant Range	Calculated distance from S/C to ground station at UTC/frame count measurement time. Determined via time propagation of spacecraft

TABLE 3
(Continued)

PARAMETER	DEFINITION (REFERENCE SECTION)
	location using ALERT data derived from Kepler elements produced using NAVSPASUR data (items 16. to 26.).
16.-26. NAVSPASUR elements	Ephemeris data received at APL from NAVSPASUR and used to derive Kepler ALERT parameters associated with the time tag measurements for each of the two passes used. The following time tag group 1 elements are stored in the header for reference: a1 - semi-major axis. e1 - eccentricity. P1 - perigee angle. I1 - inclination angle. MM1 - mean motion. LN1 - longitudinal node angle. PP1 - perigee precession. NP1 - nodal precession. MA1 - mean anomaly. date1 - date of pass associated with NAV-SPASUR elements used as time tag group 1. epoch1 - modified Julian date of calculation associated with NAVSPASUR elements.
27.-48. Time Tag Data, Group 2	These parameters follow the definitions given for items 5.-26.; however, these parameters were measured during a pass near the end of the data span covered by this SDR and/or WDR. The requirements on the time tag data are summarized within Appendix C. Basically, to perform time tagging of the altimetry data within a high precision, two time tag measurements using an accurate station clock and the real-time telemetry stream must be available. Reference 2.2(c) describes the hardware and approach to timing measurements via use of APL designed/fabricated Time Management Unit (TMU).
49. No. Calibration Mode Operations	Number of RA calibrations contained on the SDR CCT.
50. Height Calibra-	The height measurement bias as determined by

TABLE 3
(Continued)

PARAMETER	DEFINITION (REFERENCE SECTION)
tion Bias	analysis of onboard RA calibration(s) occurring prior to the time frame covered by the CCT.
51. AGC Calibration Bias	The AGC measurement bias as determined by analysis of onboard RA calibration(s) occurring prior to the time span covered by the CCT.
52.-114. Waveform Sampler Gates Calibration Biases	Sampler gate measurement biases (63) as determined by analysis of onboard RA calibration(s) occurring prior to the CCT-covered time span. This process is a normalization operation.
115.-118. Altimeter Biases	Altimeter measurement biases used to account for systematic bias estimates determined through prelaunch tests. Bias estimates of $\Delta h(cg)$ represent attitude shift due to the change in the cg as fuel is expended and the physical separation between cg and the electrical center of the RA (see Appendix A).
119. Clock Frequency Offset	The onboard S/C clock offset (nominally 80 ppm) used in the ENGINEERING UNITS CONVERSION module to convert height data from temporal units to metric units. The nominal oscillator frequency is 5 MHz.
120. Velocity of Light	Physical constant used in ENGINEERING UNITS CONVERSION and slant range computations.
121.-141. Alarm Thresholds	Various alarm thresholds (upper, lower bounds) used in determining data quality. Includes threshold tests on: • Height word statistic • AGC word statistic • SWH word statistic • Off-nadir angle (S/C calculation) • MTU temperature • DFB temperature • TWTA temperature • SACU temperature

TABLE 3
(Continued)

PARAMETER	DEFINITION (REFERENCE SECTION)
	• DCG temperature • Height word reasonableness checks • AGC word reasonableness checks • SWH word reasonableness checks • Height rate word reasonableness checks
142. Receiver calibration temperature	Reference temperature used in the computation of corrected AGC values during SDR processing. (Appendix A).
143.-146. Spares	Future use.

TABLE 4

SDR CONTENTS DEFINITION

PARAMETER	DEFINITION
1. Major Frame Count	The telemetry (TM) major frame count (telemetry word DSC1; frame words 12-15; 24 bits; repeated twice per frame) corresponding to the first of 10 height word measurement included in any SDR data record.
2. Minor Frame Count	The minor frame identification word (telemetry word FC; frame word 4; 8 bits) used to time tag the first of 10 height words measurement given in any SDR data record.
3. Mode word	The mode flagword indicating the status/mode of radar altimeter operation. The mode word consists of status/mode words #1, #3, and #4 (altimeter TM words 15, 19, and 20, respectively). The three TM words are combined into this single mode word which is written once per SDR record (1/sec). Appendix D defines the various states for each of the three status/mode words. The three data words are concatenated into 4 ASCII (4 bytes) characters using two zero fill bits for the SDR. Mode word #1 indicates the operational status of the altimeter, mode word #1 definitions are: 1 - STANDBY1 9 - TEST MODE 1 2 - CALIBRATE 10 - TEST MODE 2 3 - STANDBY2 11 - TEST MODE 3 4 - TRACK 1 12 - TEST MODE 4 5 - TRACK 2 13 - UNASSIGNED 6 - TRACK 3 14 - UNASSIGNED 7 - TRACK 4 15 - UNASSIGNED 8 - UNASSIGNED 16 - UNASSIGNED (Standby modes are processed similarly as track mode ops.)
4. Data Quality Flagword	Results of data quality tests based on

TABLE 4
(Continued)

PARAMETER	DEFINITION
	loss of any data measurements (h, SWH, or AGC), predetermined thresholds for data statistics, , temperatures of various components, ground derived quality index, and data reasonableness. The flagword is an integer (I10 format) whose value depends upon the outcome of the data quality tests. This integer value is determined via the summation of the weighted tests which failed (a bit is set). The weights and quality tests are equated using the following table:

TEST BIT#	QUALITY TEST DESCRIPTION	WEIGHTING
1	Absence of first datapoint (zero filled)	2**0
2	Absence of second datapoint (zero filled)	2**1
...	...	...
10	Absence of tenth datapoint (zero filled)	2**9
11	h Out of bounds	2**10
12	AGC Out of bounds	2**11
13	SWH Out of bounds	2**12
14	ξ Out of bounds	2**13
15	T(MTU) Out of bounds	2**14
16	T(DFB) Out of bounds	2**15
17	T(TWTA) Out of bounds	2**16
18	T(SACU) Out of bounds	2**17
19	T(DCG) Out of bounds	2**18
20	Bit error in deterministic pattern	2**19
21	h-reasonableness (checks all 10 samples)	2**20
22	AGC-reasonableness (checks all 10 samples)	2**21
23	SWH-reasonableness (checks all 10 samples)	2**22
24	dh/dt-reasonableness (average of 10 samples)	2**23
25	VATT extrapolated (4 minute max.)	2**24

TABLE 4
(Continued)

PARAMETER	DEFINITION
	26 VATT Estimated (item 48); value not available 2**25 27 VATT estimate (item 48); used <60 raw samples 2**26 28 Receiver temperature not available -- 20°C used 2**27 29 Backscatter out of nominal range 2**28
5.-14. Height Words (10)	The height words representing the height word measurements at the full rate (10/s) which are derived from altimeter TM words 1-3.
15. Height Word Statistic	Height word statistic formed using all of the 10 height samples. This parameter is also used in data quality flagging.
16. Height Word Bias (off-nadir, SWH component)	Height word bias resulting from an off-nadir satellite orientation (item 45) and/or SWH presence using table lookup.
17. Height Word Bias (FM crosstalk component)	Height word bias resulting from linear compression of the altimeter pulse. The correction is a function of the compression ratio and the pulse bandwidth. (Doppler shift appears as a range shift.)
18.-27. SWH Words	The SWH word measurements as determined onboard the S/C (TM word 21) at the full rate (10/s).
28. SWH Statistic	SWH word statistic formed using all of the 10 SWH samples. This parameter is also used in data quality flagging.
29. SWH Word Bias (off-nadir, SWH component)	SWH word bias resulting from an off-nadir S/C orientation and/or SWH presence (table lookup).
30.-39. AGC Words	AGC word measurements as determined onboard the S/C (TM word 6) at the full

TABLE 4
(Continued)

PARAMETER	DEFINITION
	rate (10/s).
40. AGC Statistic	AGC word statistic formed using all of the 10 AGC samples. This parameter is also used in data quality flagging.
41. AGC Word Bias (off-nadir, SWH component)	AGC word bias resulting from an off-nadir S/C orientation and/or SWH presence (table lookup). (See description for item 16.)
42. AGC Word Bias (altitude)	In AGC and backscatter computations, signal calibrations performed during the prelaunch period used a simulated height h =796.44 km). Variations of the s/c from this height result in AGC bias.
43. AGC Word Bias (receiver temperature)	An AGC bias results as the temperature of the receiver varies from the nominal calibration temperature of 20°C. This term is used in the backscatter computation.
44. Processed Height Rate	Processed height rate based on full rate (10/sec) $\dot{h}$ (TM word 4) measurements.
45. Off-nadir Angle	The S/C orientation angle as estimated by ground processing of the return waveform trailing edge of appropriate smoothing of waveform samples (TM words 23-82).
46. Backscatter Coefficient	The backscatter coefficient as estimated by ground processing of AGC term and use of average height calculations.
47. Windspeed	Ground processing calculation of windspeed using backscatter coefficient (item 46).
48. Attitude Voltage	Fitted waveform parameter which is proportional to attitude and used to derive the off-nadir angle (item 45) and

TABLE 4
(Continued)

PARAMETER	DEFINITION
	various corrections (Appendix A).
49. Receiver Temperature	Temperature readout of altimeter receiver unit (AL127) to perform temperature correction calculations for AGC ($\Delta AGC(T)$).
50. Spares	Three padding bytes to meet CCT format requirements.

4.2 SDR Format

The SDR data is recorded onto a 1600 bpi, 9-track tape. The CCT representation is standardized (e.g., ASCII) to alleviate data transfer difficulty from the SEL 32/77 (32-bit architecture) to the NSWC CDC7600 (a 60-bit architecture). Although minimal, special output and input software modules are required for both the APL GSCS and NSWC computer. (Appendix E contains the SDR formatting details using FORTRAN descriptors.)

The nominal SDR CCT will consist of 88,128 data records (Table 2) organized into the two file structure depicted in Figure 2. The first file provides the necessary I/O parameters used in creating the CCT on the SEL 32/77 and contains the SDR header information as previously described. The remaining file contains 24 hours of processed dump data records. As a result of the 12:00 AM to 12:00 AM processing. Partial orbit revolutions may exist on each CCT.

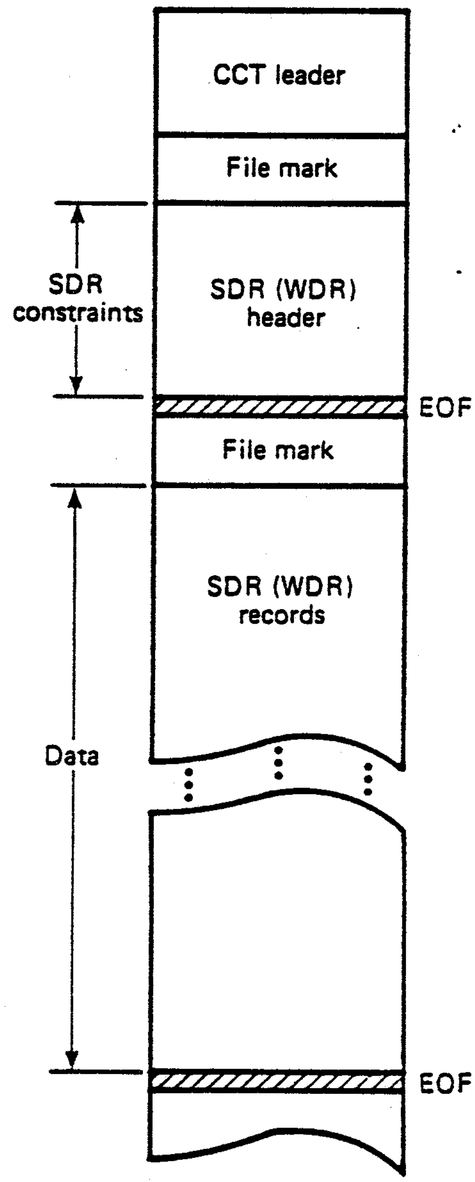
4.3 SDR Transmission Medium

The SDR is classified SECRET and is produced and transmitted following applicable security guidelines. (Processing concerns related to classification are addressed in Reference 2.1(e).) SDR CCT products are forwarded to NSWC via Naval courier on a basis to meet with a timeliness of 2 weeks (4 weeks during "catch-up" mode operations).

In the event of a missed data dump pass, the associated SDR is not generated until all of the data expected to be recovered is collected. As the missing data is acquired, it is intercalated among the received data to be used in producing the affected SDR. Thus, the data merge function performs the following:

- Under normal conditions; all data gaps and overlaps are noted. Two minute (1200 minor frames) gaps are zero filled (as previously described) and overlaps are deleted (second occurrence). Data gaps in excess of two minutes are not expected and if such occurs, the data will not be recoverable in any event. In this latter case, the gaps are simply compressed with no zero filling.

- During catch-up mode conditions; the above process occurs, and missing data is placed within preallocated SDR file locations as it is recovered. This recovery period may extend up to 10 days. After the recovery period, generation of the affected SDR CCTs is performed with data



2 SDR/WDR CCT Structure

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records properly sequenced and gaps/overlaps handled as in normal processing.

The tapes used for transmitting SDR products are certified to 6250 bpi. If an SDR is not properly transferred due to handling problems, another SDR can be produced using a spare SDR which is generated simultaneously with the transferred SDR. The spare SDR is held until tape receipt and validation is acknowledged by NSWC. NSWC validation determines if there are recording problems by copying the SDR. If there are problems experienced downstream whereby a SDR is damaged, archive tapes could be reprocessed to regenerate SDR CCTs on an "as available" schedule. (The archive tapes will be stored at APL for an indefinite period.)

The physical characteristics of the digital tapes to be used are:

- Width, 0.5 inch
- Length, 2400 ft
- Reel diameter, 10.5 inches
- Recording mode, PE (IBM compatible)
- Load point and end of tape reflective strip detection (IBM compatible), infrared sensor.

Additional data concerning the tape drive unit(s) which will be employed in SDR CCT generation are available from Reference 2.3(c).

5.0 WDR INTERFACE DESCRIPTION

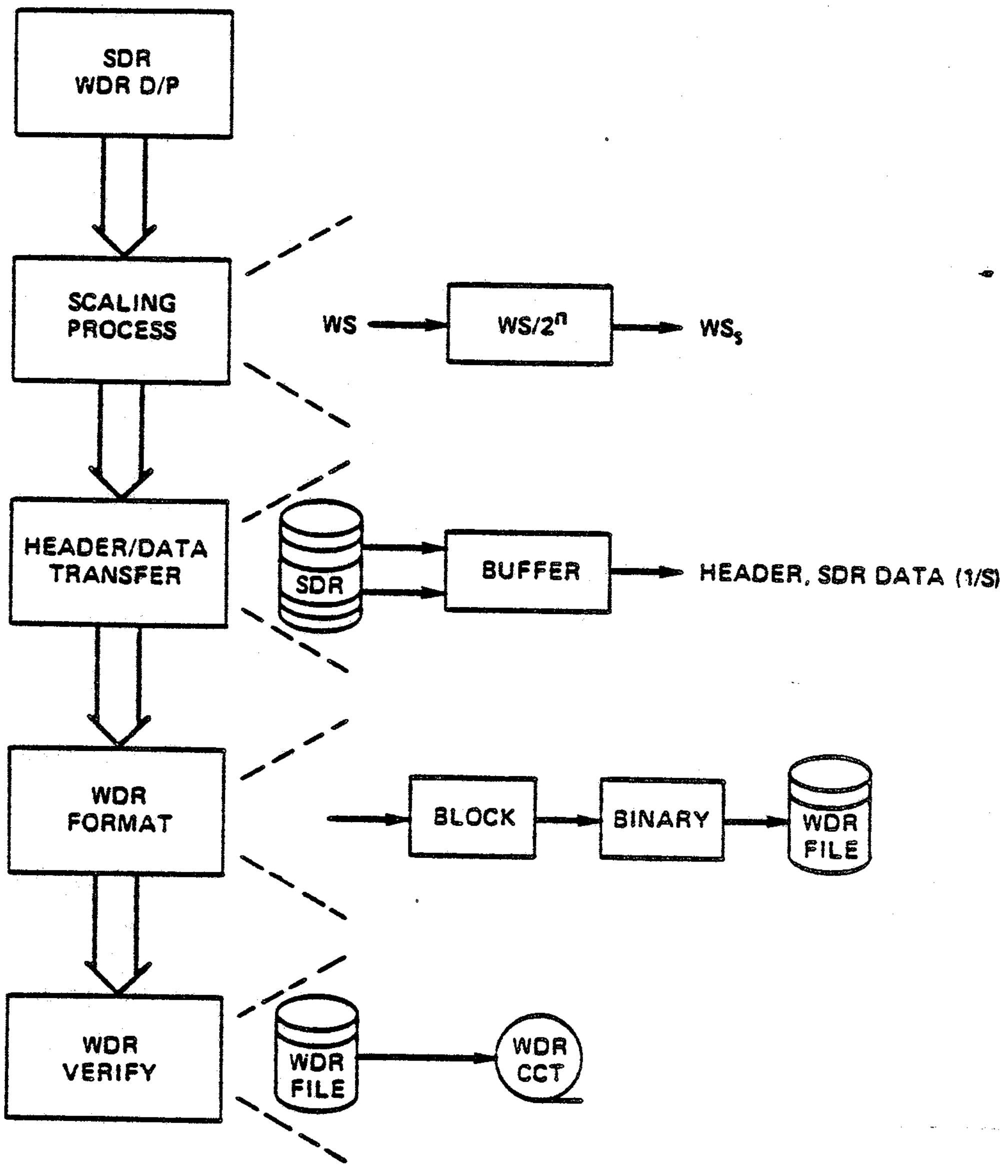
This data product is intended to provide waveform processing techniques under development with the necessary information concerning actual radar altimetry data. The GEOSAT-A altimeter waveform measurements are placed directly on a CCT at the full 10/sec rate. With the exception of scale factoring, neither data processing nor conditioning is performed on the waveform samples.

The WDR processing flow is summarized in Figure 3. The scaling performed is accomplished for each set of 63 waveforms; thus, 10 scale factors result for each CCT data record. (Data records are produced at a 1/sec rate as for the SDR.)

The waveform sample data constitutes 74% of the radar altimeter dump data. Processing waveform samples separately via the WDR reduces the quantity of data used in generating the SDR. For a 24 hour period, there are 881.6 Mbits associated with the radar altimeter dump data; 652.4 Mbits represent waveform samples. Since a 9-track, 1600 bpi CCT can store approximately 36.9 Mbytes, the WDR itself requires ~2 tapes per SDR tape with scaling and binary representation (88,128 WDR data record entries of 660 bytes each). To simplify downstream processing of WDR tapes, a WDR is processed using 12 hour data spans (12:00 AM to 12:00 PM and 12:00 PM to 12:00 AM).

WDR software resides in the GSCS and runs concurrently with SDR software. The WDR header is derived from the SDR header (see Table 1 and Figure 3). The 1/sec WDR data record entry is presented in Table 5.

WDR software is detailed within Reference 2.1(d). WDR CCT parameter definitions are given in Table 6. WDR CCTs for a 12-hour period contain the same header file as the corresponding SDR CCT except that the tape ID parameter specifies a morning or afternoon WDR CCT. (The WDR header is encoded using ASCII as with the SDR header.)



3 WDR Data Preprocessing Flow

TABLE 5

WDR CCT RECORD (1/S) CONTENTS

ITEM	PARAMETER	RESOLUTION	RANGE	TYPE	START BYTE
1	MFC	1 count	$0 \rightarrow (2^{24}-1)$	R3	1
2	mFC	1 count	$0 \rightarrow 31$	R1	4
3	Mode	NA	$0 \rightarrow (2^{30}-1)$	R4	5
4	flagword	NA	$0 \rightarrow (2^{30}-1)$	R4	9
5	WS(1,1)	1 count	$0 \rightarrow 225$	R1	~~10~~ 13
6	WS(2,1)	1 count	$0 \rightarrow 225$	R1	~~11~~ 14
...	...	...	...	...	...
634	WS(63,10)	1 count	$0 \rightarrow 225$	R1	~~639~~ 642
635	SCALE(1)	NA	1,2,4	R1	643
...	...	...	...	...	...
644	SCALE(10)	NA	1,2,4	R1	652
645	SPARES	NA	NA	8(X)	653

BYTE TOTAL = 660

TABLE 6

WDR DATA RECORD CHARACTERISTICS

PARAMETER	DEFINITION
1. Major Frame Count	The major telemetry frame count corresponding to the first waveform sample.
2. Minor Frame Count	The minor telemetry frame count associated with the first waveform sample.
3. Mode Word	See Table 4, entry 3.
4.-633. Scaled Waveform Samples	The waveform samples presented at the full rate (10/s) for each of the 63 gates. The samples are arranged such that all 63 gate values are given for each measurement period (0.1s). The samples are scaled to reduce the bytes necessary for representation.
634. Data Quality Flag Word	See Table 4, entry 4.
635.-644. Scale Factors	The waveform samples scale factor used to reclaim the waveform sample measurements from the scaled waveform sample data. (Each of the 10 waveforms per second have an attendant factor.)
645. Spare	Future use/byte padding.

5.1 WDR Format

The WDR data is placed onto a 1600 bpi, 9-track tape using binary representation. Appendix F contains detailed information concerning the description and layout of WDR records. The WDR header file (Figure 4) differs from the corresponding SDR in that a multi-volume header format is used to identify the particular WDR tape within the two volume set.

5.2 WDR Transmission Medium

The WDR data product is unclassified; it is forwarded to NRL or DMA/AC via the U.S. postal system on a basis to meet a timeliness of 2 weeks during normal operations. A backup CCT copy is generated and held until receipt of the mailed tape is acknowledged by NRL. In the event of a lost CCT or badly recorded volume, the archive tape(s) can be played back for regeneration of the affected WDR CCT volumes on an "as available" GSCS time schedule.

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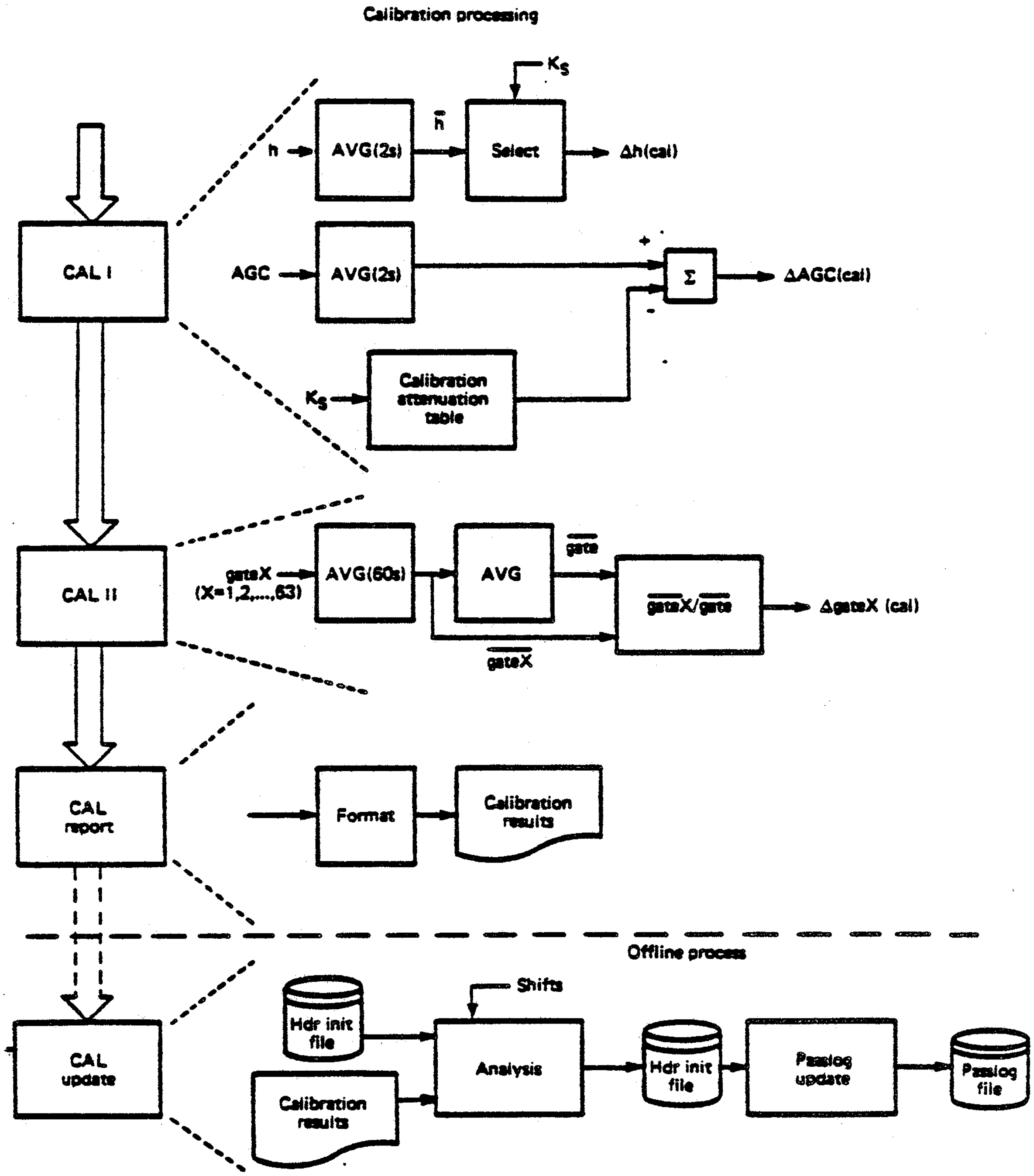
6.0 CALIBRATION PROCESSING

The calibration mode analyses (Figure 4) provides a calibration file (which will be periodically updated) for use in both waveform processing and the SDR/WDR header. (Appendix B presents the calibration processing particulars.) Throughout the mission, the radar altimeter is sequenced through onboard calibrations to determine long-term shifts of the track point (height data). Without this measurement of height drift, the data could appear as an error source in the geoidal model. Upgrades to the SEASAT design were made to GEOSAT-A due to the importance of such onboard calibrations. Such modifications include: reduced calibration mode rf leakage, improved simulation of height rate for CAL II mode (noise only) to enhance waveform sample amplitude calculations, and recording of receiver temperature during calibration for thermal corrections to AGC. Calibration processing produces as end products the following estimates:

- height word bias (CAL I); $\Delta h(cal)$
- AGC word bias (CAL I); $\Delta AGC(cal)$
- waveform sampler (63) gain corrections (CAL II); $\Delta WS(j)$, where $j = -30,-29,\ldots,-1,1,\ldots,29,30,-1.5,0,1.5$.

The attendant calibration tables (AGC lookup table and calibration attenuation table) provide both bias and attenuator corrections necessary to the estimation processing.



4 Calibration Processing

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7.0 SDR/WDR SOFTWARE V&V

To ensure software reliability, stringent verification and validation practices were adhered to during the development/implementation phase. Each module was tested using simulated data and nominal coefficient tables prior to integration into the software packages. In addition, reviews with data users were held periodically to permit feedback concerning software integrity and usage.

Subsequent to the initial completion of the preprocessing software, an end-to-end test was performed wherein SDR CCTs and WDR CCTs were generated. These initial CCTs permitted a preliminary check on the entire software package, the GSCS operational environment, and the ability of transferring the data from APL to NSWC and NRL.

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APPENDIX A

SDR PROCESSING ALGORITHM DESCRIPTION

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Introduction

The following paragraphs describe the SDR Processing Algorithms which are summarized in Figure A-1. These software modules estimate corrections to the altimetry measurements to compensate for GEOSAT-A instrument errors. These corrections along with raw altimetry measurements (height, SWH, AGC) and ancillary data form the primary product, the Sensor Data Record (SDR). In addition to these data, estimates of backscatter coefficient (σ°) and windspeed are calculated and included on the SDR.

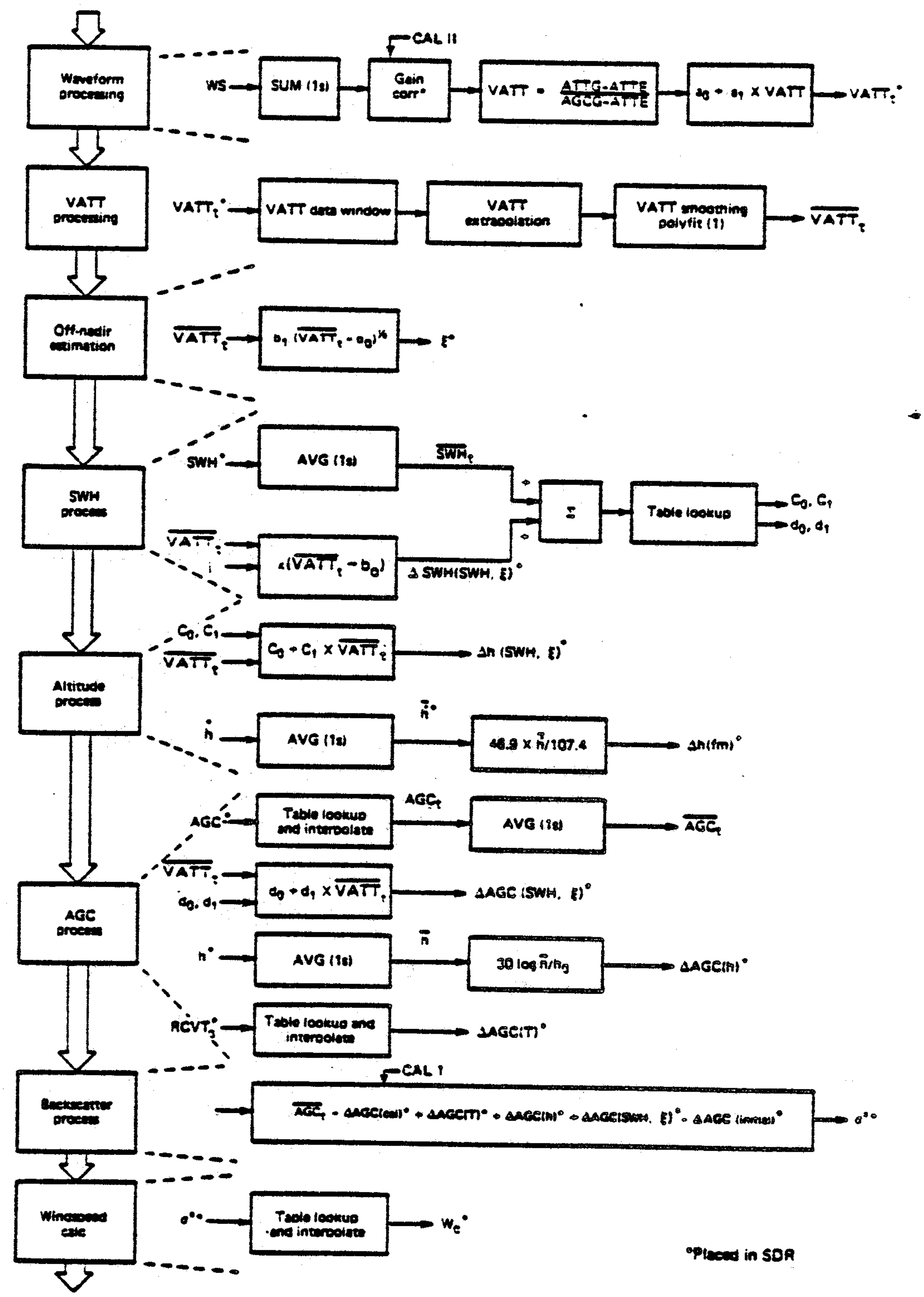
Throughout this Appendix, reference to altimetry channel identifiers (denoted as ALXXX) defined in Appendix D are used. The three digit number (XXX) indicates the altimeter channel of interest.

The SDR is comprised of data records spanning 1 second (approximately) of altimetry measurement. Each record contains 10 altimeter measurements (a measurement is contained in each minor telemetry frame -- thus there are 10 minor frames per SDR record) with associated corrections and estimated parameters computed at the SDR record (1/second) rate. The on-board adaptive tracker has been devised so as to permit Gate Index (AL196) changes to occur at 10 minor frame (1-second) intervals only thus permitting alignment of the SDR records with altimeter parameters dependent upon gate index. The Gate Index (i) refers to one of five gate triplets used by the algorithms for height tracking and determination of significant waveheight (SWH) onboard the spacecraft. In actuality, there are 6 triplets; however, the sixth triplet provides a reference for normalization which alleviates the impact of signal-to-noise variational differences. The Gate index change interval is synchronized with engineering data channels (AL212) 1, 11, 21, 31 and 41. All buffering and filtering of data as part of SDR processing are aligned with these epochs.

Waveform Processing Module

This module accepts waveform samples (AL214 thru AL276) at the 10/second (minor frame) rate. The samples are averaged for 1 second and are then adjusted using individual gain corrections derived from Calibration Processing. The corrected waveform samples (at the 1/s rate) are used to produce a term proportional to attitude (VATT). VATT is required as various bias corrections and the off-nadir angle calculations depend upon this term.

Corrected waveform samples are not placed on the SDR; instead, uncorrected (but scaled) waveform samples are placed on the WDR. Waveform corrections are printed on the calibration



A-1 SDR Processing Flow

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report produced by the Calibration Processing modules (Appendix B).

The VATT parameter (in units of voltage) is computed as the ratio of attitude gate (ATTG) to AGC gate (AGCG) using corrected waveform samples (WSC(j)). This sequence is performed for each second (n) of waveform data. (The interval index, n, is used to denote the specific sample.)

$$ATTG(n) = 1/8 \sum_{j=23}^{30} WSC(j,n) \quad ,$$

$$AGCG(n) = (1/47)* \left[\sum_{j=-24}^{-1} WSC(j,n) + \sum_{j=1}^{24} WSC(j,n) \right]$$

$$ATTGE(n) = (1/8)* \sum_{j=-30}^{-23} WSC(j,n) \text{ , and}$$

$$VATT(n) = [ATTG(n)-ATTGE(n)]/[AGCG(n)-ATTGE(n)] \text{ .}$$

The waveform sample indexing, j, is derived from the SEASAT-1 convention wherein the leading 30 gates are numbered from -30 to -1 and the trailing 30 gates are numbered 1 to 30. The separation between gates -1 and +1 is the same as all other spacings, 3.125 ns (46.9 cm). There are also tracking gates, which are labelled -1.5, 0 and +1.5 with the same spacing. These gates are centered about the midpoint of the interval between gates -1 and +1 and are not used in the VATT calculation process. The tracking gates are responsible for centering the radar return.

Ideally, VATT varies over a range of 1.8099 to 2.0456 as the attitude (off-nadir angle) varies from 0 to 1 degrees. However, there is a VATT dependency upon the significant waveheight (SWH).

This dependency is responsible for the accuracy of the VATT (n) samples being adversely affected by very high waveheights, especially when SWH exceeds 11 meters. The VATT(n) values are a function of SWH. To compensate for the SWH influence, coefficients for adjusting VATT exist. These adjustment coefficients (a_o,

a_1) are based on corrected waveheight samples (SWH_t) and are presented in Table A-1. The coefficients are used in a 1st order equation and are selected based on Gate Index (see Table A-1). Derivation of the coefficients result from prelaunch calibrations and are adjustable as necessary.

Editing of the raw $VATT_t(n)$ samples prior to performing a 1st-order fit involves three tests; this is done to reduce the measurement noise associated with waveform data:

(1) A first difference between the current and preceding $VATT_t(n)$ samples is formed and if the magnitude of this difference exceeds a preset threshold (0.1 volt), the current value is not passed to the fit routine. This test is based on attitude varying slowly and smoothly with gravity gradient stabilization; any abrupt change is evidence that the waveform samples are contaminated by land, rainfall or other nonlinear effects impacting the altimetry measurements.

(2) A test is applied to reject all $VATT_t(n)$ samples that do not fall within the nominal range (includes effect of noise) of 1.7 to 2.2. Samples that fall below 1.7 are indicative of a specular or near-specular ocean return.

(3) Finally, a test which computes an average height velocity is used to reject corresponding VATT(n) samples when $|\dot{h}|$ is less than 1 m/s. This is a result of VATT accuracy depending on the averaging effect provided by the digital filter bank when a reasonable (>1 m/s) height rate exists.

Sample points that remain after the above tests have been applied are passed to a 1st-order fit routine that operates on a variable data span. (The nominal situation is to estimate a central value from ±2 minutes of data (~240 raw VATT values).) Points that deviate from the fit by more than three times the standard deviation about the fit are rejected and the points remaining are fitted again. If the number of samples available to perform the fit falls below a prescribed count (60), the fit is not used and instead an extrapolation using the most recent fit constants is performed.

The fitting process is performed at 1-second intervals resulting in fitted samples of $VATT_t(n)$ at the 1/second rate. These fitted samples of $VATT_t(n)$ are used in subsequent modules to correct for attitude induced biases. The fitting equations assume a first order equations as:

$$\overline{VATT}_t(n) = A * n + B$$

where

$$A = [N*\Sigma(n*VATT_t(n)) - \Sigma n*\Sigma VATT_t(n)]/[N*\Sigma n^2-(\Sigma n)^2],$$

$$B = [\Sigma VATT_t(n)*\Sigma n^2 - \Sigma n*\Sigma(n*VATT_t(n))]/[N*\Sigma n^2-(\Sigma n^2)],$$

and

N = number of $VATT_t(n)$ samples.

TABLE A-1

SDR CORRECTION CONSTANTS

GATE INDEX (AL197)	H-1/3 RANGE (CORRECTED)		c0	c1	d0	d1	a0	a1	SWH BIAS COMPUTATION (SWH, ATTITUDE DEPENDENT)
1	0	.25	33.923	- 16.333	-53.997	30.009			
1	.25	.707	32.092	- 15.922	-53.905	29.960	-.5992	1.3200	-1.23(VATT -b0)
1	.707		41.568	- 20.621	-54.436	30.201			
2		1.34	50.769	- 25.151	-53.111	29.542			
2	1.34	2.16	66.135	- 32.761	-53.887	29.954	-.6740	1.3613	-1.44(VATT -b0)
2	2.16		85.888	- 42.548	-54.926	30.504			
3		3.14	99.464	- 49.335	-52.237	29.083			
3	3.14	4.49	125.790	- 62.407	-53.677	29.848	-.8526	1.4520	-2.67(VATT -b0)
3	4.49		166.308	-82.569	-55.988	31.076			
4		6.51	179.104	- 89.290	-49.041	27.389			
4	6.51	9.42	245.747	-122.757	-53.141	29.574	-1.333	1.7065	-4.47(VATT -b0)
4	9.42		358.862	-180.120	-60.519	33.518			
5		14.64	375.184	-191.578	-52.587	29.276			
5	14.64		953.316	-497.411	-86.415	47.650	-2.087	2.1187	-6.88(VATT -b0)

b0 = 1.8099
b1 = 2.0600

Off-Nadir Estimation Module

As described, the Waveform Processing Module computes a parameter proportional to attitude, $VATT_t(n)$, which is edited and then used in a 1st-order fit. The data span used in the VATT smoothing operation consists of one to four minutes of raw VATT samples centered about the value to be smoothed. The data span width depends on noise exhibited by raw VATT samples and analytic studies of the altimetry data. The fitted points, $\overline{VATT}_t(n)$, are then used to compute the off-nadir angle, $\xi(n)$, according to the expression:

$$\xi(n) = b_1 * (\overline{VATT}_t(n) - b_o)^{1/2}$$

with; n = 1-second sample indice

The constants b_o, b_1 are both derived from pre-launch simulations (see Table A-1 for values).

The off-nadir angle is subsequently passed to the SDR File for inclusion in the CCT, but is not directly used to determine biases. Instead, $\overline{VATT}_t(n)$ is used for reasons that will be apparent when the appropriate modules are subsequently discussed.

VATT samples result from measurements acquired in a noisy environment therefore it is possible to obtain a smoothed VATT value such that

$$\overline{VATT}_t(n) - b_o < 0.$$

If this condition exists, the above difference is set to zero and VATT dependent values for the associated SDR record (1 second interval) are:

$\xi(n) = 0$,

$\Delta h(SWH|\xi,n) = c_o + c_1 * \overline{VATT}_t(n)$,

$\Delta SWH(SWH|\xi,n) = 0$, and

$\Delta AGC(SWH|\xi,n) = d_o + d_1 * \overline{VATT}_t(n)$.

Significant Waveheight Processing Module

This module accepts raw significant waveheight (SWH) data (AL211) at the 10/second rate and applies bias corrections via a look-up table in order to estimate subsequent bias values dependent on corrected SWH. The Gate Index (AL196) is also input to the look-up table since the corrections will depend on the particular on-board adaptive gate width in use. Entries in the table are derived from ground test data, and are modified as required during post-launch calibrations. These minor corrections are required because the on-board SWH estimation uses waveform samples that have not been gain corrected. Thus, particularly at the lower waveheights, a small adjustment is required as was the case with SEASAT-1 data.

The current $\overline{VATT}_t(n)$ sample is used in conjunction with the Gate Index to derive a correction via the equation:

$$\Delta SWH(SWH|\xi,n) = K*(\overline{VATT}_t(n) - b_o)$$

where K is a constant selected on which Gate Index (i) is in use. This correction is subsequently passed to the SDR File.

Height and automatic gain control (AGC) corrections depend on corrected waveheight data. Therefore, an averaged SWH(n) value is computed using 10 raw SWH measurements and the attitude correction $\Delta SWH(SWH|\xi,n)$) to select constants (c_o, c_1, d_o, and d_1) to be used in the Altitude Processing and AGC Processing Modules, as described below (see Table A-1).

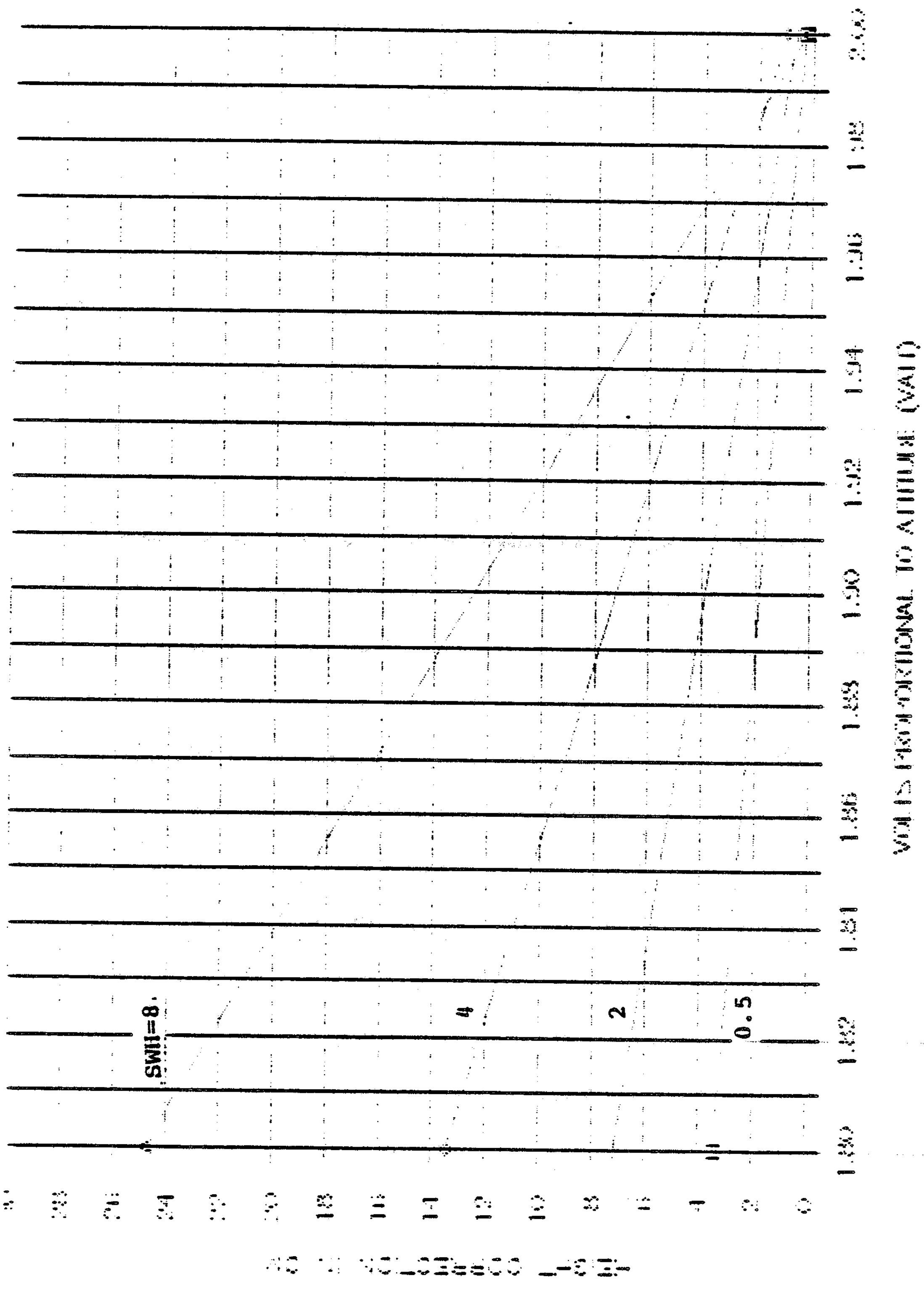
Altitude Processing Module

This module computes three height bias corrections representing attitude induced bias, chirp pulse range/doppler crosstalk, and an offset term due to the distance between the antenna flange and the spacecraft center-of-gravity (cg).

The effect of attitude variation on height bias is shown in Figure A-2 and is based on waveshape/height-error simulations. (The terms, SWH and H-1/3, are both used to represent significant waveheight and are interchangable.) The interesting feature of these curves is the straight-line relationship between $\Delta h(SWH|\xi)$ and $VATT_t$. At a given waveheight, the error can be characterized by a slope and intercept. These are denoted as c_o and c_1, respectively, and are determined within the Significant Waveheight Processing Module. Thus, computation of a height correction involves solution of a linear expression using the current $\overline{VATT}_t$ value. Note on the curve (Figure A-2) that up to about 4 meters for SWH, the total peak-to-peak variation in track point falls within 13 cm over the 0 to 1 degree off-nadir angle (1.8 to 2.0 VATT values) variation.

The implication of the attitude (VATT) measurement precision is presented in Figure A-3. Each waveform sample is assumed to be Rayleigh distributed, thus per sample mean and standard deviation are directly related. Taking an extreme case of SWH=16 meters, which is not shown on Figure A-2, the total change in Δh is 40 cm as attitude varies between 0 and 1 degrees (VATT varies from 1.816 to 1.987). From this result there exists the need to average 55360 samples in order to reduce the noise on $\overline{VATT}_t$ to the point it represents 2 cm. Since the attitude gate is comprised of 8 samples and the altimeter pulse rate is 1020 Hz, the required averaging time is 6.8 seconds. Based on a more stringent requirement imposed by the AGC correction, $\overline{VATT}_t(n)$ actually is computed by fitting at least 60 seconds of data.

The second correction estimated in the Altitude Processing Module relates to the range/doppler crosstalk effect of linear FM waveforms. A doppler frequency, equal to the reciprocal of the uncompressed pulse width (102.4 μsec), results in a height bias equal to one resolution cell, or 3.125 ns (46.9 cm). At the Ku-band wavelength of 2.22 cm, a doppler frequency of 9676 Hz corresponds to a height rate ($\dot{h}$) of 107.4 meters/second. Consequently, it is only necessary to know $\dot{h}$ to a precision of about 1 meter/second in order to make the correction to a precision of better than 0.5 cm. This is easily realized by averaging 10 of the altimeter raw height rate samples (AL103). The least significant bit (LSB) of AL103 is equivalent to 23.34 cm/sec, thus quantization noise does not preclude achieving the desired precision.



A-2 Height Bias vs Attitude

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- Given: H-1/3 = 16M, max h error = 2 cm

$$\frac{\Delta h}{\Delta VATT} = \frac{40\text{ cm}}{1.987 - 1.816} = 234\text{ cm/Volt}$$

$$\therefore \quad 2\text{cm} \approx 8.5 \times 10^{-3}\text{ Volts}$$

$$N \approx \left(\frac{2}{8.5 \times 10^{-3}}\right)^2 = 55360$$

- If Ng = 8 (Attitude gate):

$$Ta = \frac{55360}{8 \times 1020} = 6.8\text{ Sec } (\sigma_h = 2\text{ cm})$$

A-3 Attitude Precision vs Height Error

The smoothed height rate, $\bar{\dot{h}}(n)$, and the FM crosstalk correction, $\Delta h(fm,n)$, are passed to the SDR File and are included in the SDR data.

A caution is in order with respect to this $\dot{h}$ measurement. No correction to the height data to account for on-board tracker lag in the presence of constant acceleration ($\ddot{h}$) is made as part of the SDR processing. If this modification is implemented later, a second order differencing fit to the basic height data would be preferred over a first differencing fit to the height rate data. The 23.34 cm/sec LSB of the height rate word tends to dominate if it is used to estimate acceleration.

The final two bias terms, accounting for antenna delays Δh(initial) and cg offset, $\Delta h(cg)$, are determined off-line by various electrical and mechanical measurements prior to launch. These bias terms are provided to the data products as header elements (items 115 and 116) and are used in the final height correction equation.

AGC Processing Module

The AGC Processing Module accomplishes five functions:

(1) Corrects raw altimeter AGC data (AL192) to account for receiver AGC attenuator ground calibrations,

(2) Estimates attitude induced errors in AGC,

(3) Estimates AGC errors from receiver temperature variations,

(4) Determines corrections to AGC for height variations from prelaunch signal simulation (varies as h^{-3}),

and,

(5) Computes a backscatter coefficient (σ°) by combining all known AGC corrections, including on-board AGC Calibration terms. (This is accomplished in a separate module but is discussed in this section for continuity.)

A 1-second average (10 samples) of AGC, $\overline{AGC}_t(n)$, is then computed for use in subsequent backscatter coefficient processing.

AGC variations as a function of attitude are illustrated in Figure A-4. As with height bias, a straight line dependency of AGC error on $VATT_t$ is observed. This curve is applicable with lower waveheights (SWH); however, above 10 meters the slope will be affected. Therefore, various coefficients (d_o, d_1) are determined in the SWH Correction Module (Table A-1) and are used to solve for the AGC corrections, $\Delta AGC(SWH|\xi,n)$, which is included on the SDR.

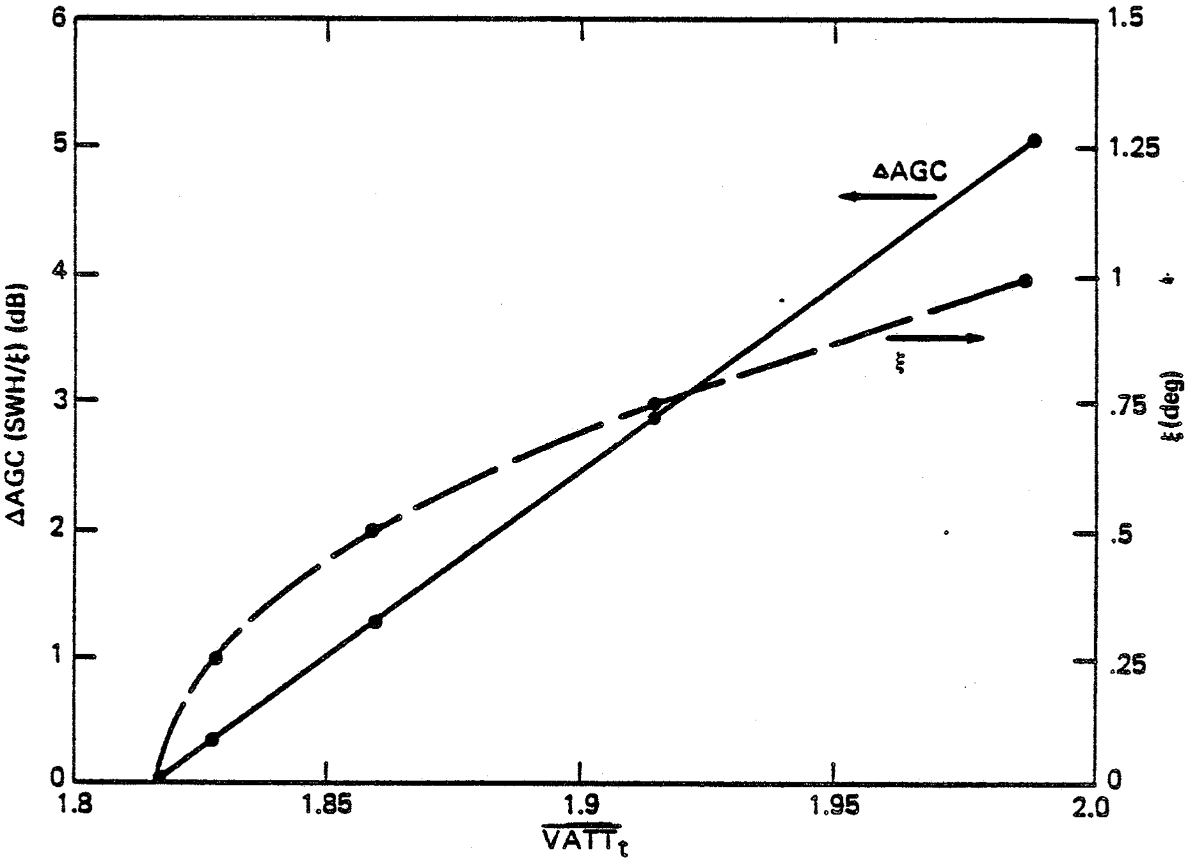
The altimeter receiver gain changes approximately ±2 dB over the full temperature range expected for the receiver. An AGC correction based on receiver temperature (AL127) is required and is implemented using a calibration table. This correction is denoted $\Delta AGC(T,n)$ and is derived from observed receiver temperature variations. If receiver temperature is not available due to data difficulties, temperature is set to 20°C and a data quality flag (SDQRCVT) indicating such is set.

Calibration terms used in SDR processing are derived from off-line analyses of past calibration runs completed during previous SDR periods. These terms are placed in the SDR CCT header since one calibration analysis applies to an entire SDR data span.

A correction to AGC to account for spacecraft height variation from that used during prelaunch testing is made based on 1-second (10 sample) averages of the height data. The height data used is the sum of the three height words (AL100+AL101+AL102) converted to meters (using the speed of light and clock frequency offset as given in the SDR Header). The value of the prelaunch reference height, h_s, is 796.44 km.

The backscatter (σ^o) computation depends upon the current $AGC_t(n)$ value adjusted by the above three AGC corrections as well as a correction derived in the Calibration Processing Module, $\Delta AGC(cal)$. In addition, an initially determined offset, $\Delta AGC(initial)$, is stored in the SDR CCT header and is used to properly adjust the final σ^o result.

The precision required to measure σ^o to a 0.1 dB rms error is derived similarly to the attitude induced height uncertainty (Figure A-5). In this case, the AGC varies 5.15 dB as $VATT_t(n)$ varies from 1.816 to 1.987. To reduce the noise on $VATT_t(n)$ to the equivalent of a 0.1 dB error in σ^o requires the averaging of 362900 independent samples, which results in a 44.5 second averaging time. This is the primary reason for selecting a 60-second minimum data span for the $VATT_t(n)$ fitting process in the VATT Processing Module. (A 0.2 dB error requirement would reduce the required averaging time to 11.1 seconds.) The impact of σ^o precision on windspeed measurement can be examined using equations from the next section.



A-4 Altimeter AGC and Pointing (ξ) Errors vs Attitude Parameter, VATT

- $\frac{\Delta AGC}{\Delta VATT} = \frac{5.15}{1.987 - 1.816} = 30.12$ dB/Volt

  Thus: $0.1 \text{ dB} = 3.32 \times 10^{-3}$ Volts

  And: $N \approx \left(\frac{2}{3.32 \times 10^{-3}}\right)^2 = 362900$

- If Ng = 8 (Attitude gate):

$$Ta = \frac{362900}{8 \times 1020} = 44.5 \text{ Sec } (\sigma_{AGC} = 0.1\text{dB})$$

A-5 Attitude Precision vs AGC (σ°) Error)

Windspeed Calculation Module

Computation of windspeed follows the work of Brown, et al, (IEEE Vol. OE6, No. 2, April 1981). The windspeed algorithm uses a table lookup approach whose entries are calculated as follows:

$$S = 10^{-[\sigma^\circ+2.1]/10}$$

$$W_G = \exp[(S-B)/A]$$

where A and B depend upon the range of σ° as:

1) For $\sigma^\circ > 10.9$ dB;

   A = 0.01595 B = 0.017215

2) For $10.12 < \sigma^\circ \leq 10.9$ dB;

   A = 0.03983 B = -0.031996

3) For $\sigma^\circ \leq 10.12$ dB;

   A = 0.080074 B = -0.124651

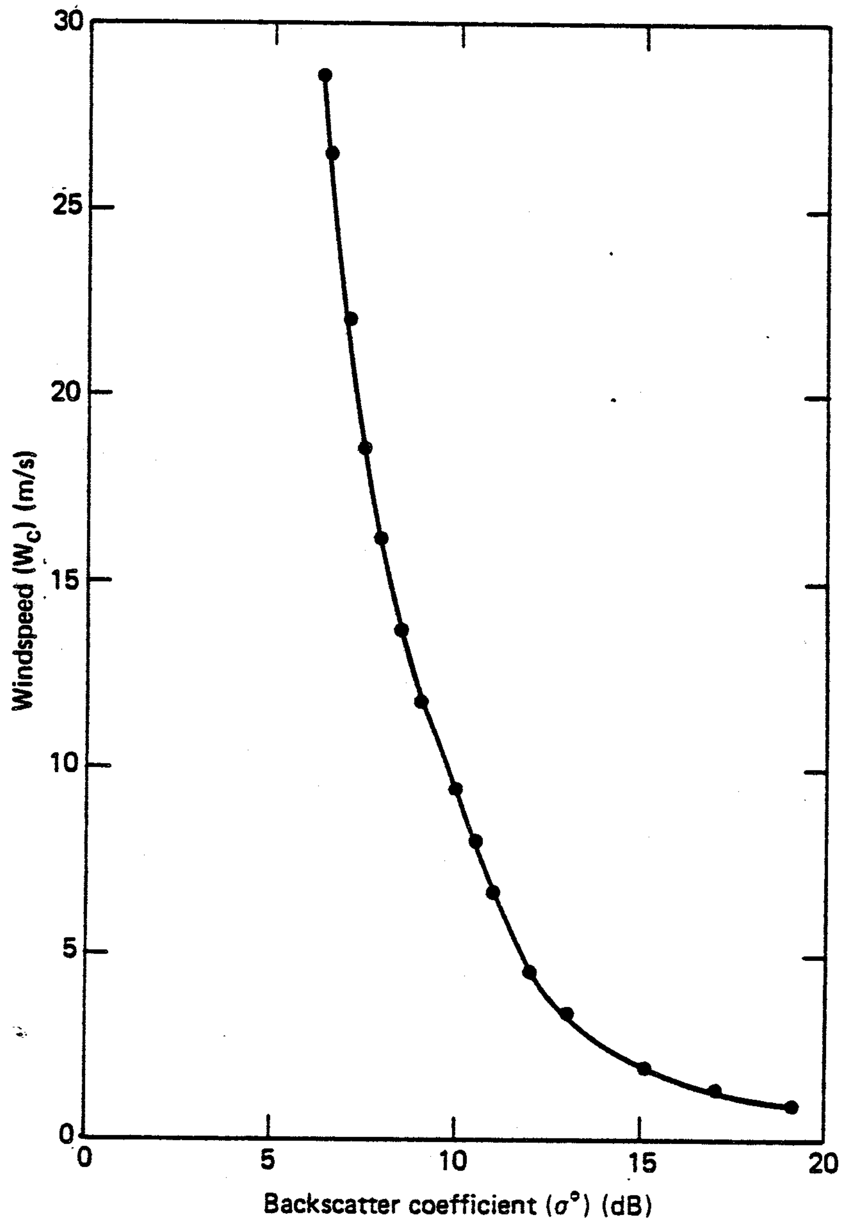
Finally, W_G is corrected to W_C according to the following. For $W_G > 16$ m/s, $W_C = W_G$. For $W_G \leq 16$m/s, the following equation applies:

$$W_C = \sum_{n=1}^{5} a_n (W_G)^n$$

where:

a_1 = 2.087799
a_2 = -0.3649928
a_3 = 4.062421E-2
a_4 = -1.904952E-3
a_5 = 3.288189E-5

A plot of windspeed versus σ° is given in Figure A-6 and is tabulated in Table A-2. Use of the table look-up permits adjustments of the windspeed processing by altering tabular elements. This facilitates use of algorithm different than that from Brown's work if required.



A-6 Windspeed vs Backscatter (σ°) Coefficient

TABLE A-2

WINDSPEED (m/s) VS BACKSCATTER COEFFICIENT (dB)

σ°	W_c	σ°	W_c	σ°	W_c	σ°	W_c	σ°	W_c	σ°	W_c	σ°	W_c
19.0	1.0	18.9	1.1	18.8	1.1	18.7	1.1	18.6	1.1	18.5	1.1	18.4	1.1
18.3	1.1	18.2	1.1	18.1	1.2	18.0	1.2	17.9	1.2	17.8	1.2	17.7	1.2
17.6	1.2	17.5	1.3	17.4	1.3	17.3	1.3	17.2	1.3	17.1	1.3	17.0	1.4
16.9	1.4	16.8	1.4	16.7	1.4	16.6	1.4	16.5	1.5	16.4	1.5	16.4	1.5
16.2	1.5	16.1	1.6	16.0	1.6	15.9	1.6	15.8	1.7	15.7	1.7	15.6	1.7
15.5	1.8	15.4	1.8	15.3	1.9	15.2	1.9	15.1	1.9	15.0	2.0	14.9	2.0
14.8	2.1	14.7	2.1	14.6	2.2	14.5	2.2	14.4	2.3	14.3	2.3	14.2	2.5
14.1	2.5	14.0	2.5	13.9	2.6	13.8	2.7	13.7	2.8	13.6	2.8	13.5	2.9
13.4	3.0	13.3	3.1	13.2	3.2	13.1	3.3	13.0	3.4	12.9	3.5	12.8	3.6
12.7	3.7	12.6	3.8	12.5	3.9	12.4	4.0	12.3	4.2	12.2	4.3	12.1	4.4
12.0	4.6	11.9	4.7	11.8	4.9	11.7	5.1	11.6	5.3	11.5	5.5	11.4	5.7
11.3	5.9	11.2	6.2	11.1	6.5	11.0	6.9	10.9	7.3	10.8	7.5	10.7	7.7
10.6	7.9	10.5	8.1	10.4	8.4	10.3	8.7	10.2	9.0	10.1	9.3	10.0	9.5
9.9	9.7	9.8	9.9	9.7	10.1	9.6	10.3	9.5	10.6	9.4	10.8	9.3	11.1
9.2	11.3	9.1	11.6	9.0	11.9	8.9	12.3	8.8	12.6	8.7	13.0	8.6	13.4
8.5	13.8	8.4	14.2	8.4	14.6	8.2	15.1	8.1	15.6	8.0	16.1	7.9	16.5
7.8	17.0	7.7	17.5	7.6	18.1	7.5	18.7	7.4	19.3	7.3	19.9	7.2	20.6
7.1	21.3	7.0	22.0	6.9	22.8	6.8	23.7	6.7	24.6	6.6	25.6	6.5	26.6
6.4	27.7	6.3	28.8										

NOTES: 1. For values of σ° beyond table limits, σ° is set to its respectful limit:
if σ°>19.0, σ°=19.0, and
if σ°<6.3, σ°=6.3.
2. Values between table entries are determined by linear interpolation.

APPENDIX B

CALIBRATION PROCESSING ALGORITHM DESCRIPTION

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Introduction

The altimeter contains a two-phase onboard calibration. In the first phase (Cal I), a sample of the transmit pulse is coupled via a precise, digitally controlled, attenuator into the receiver. This pulse is tracked as a point return using a modified tracker algorithm to allow long-term drifts in track point and signal strength to be observed. The calibrate signal is stepped thru 11 signal strength levels separated by 6 dB, to insure that a calibration level matching the nominal ocean return signal level is available for subsequent comparison. In the second phase (Cal II), the transmitter is turned off and the altimeter gain control loop is closed as in normal tracking. With uniform front-end receiver noise, all waveform samples should show the same amplitude. Actually, it is expected that small variations attributable to I and Q video filter response ripple exist. The Cal II mode quantifies these waveform sample variations for compensation in the Waveform Processing Module.

The Calibration Processing flow is shown in Figure B-1. Calibration mode corrections are not applied automatically to the related measurements; instead, operator intervention to assess the need to update calibrated terms is required (signified by the offline boxes shown in Figure B-1). This process is supported by calibration reports generated by the SDR/WDR calibration modules; as illustrated in Tables B-1 through B-4 (examples).

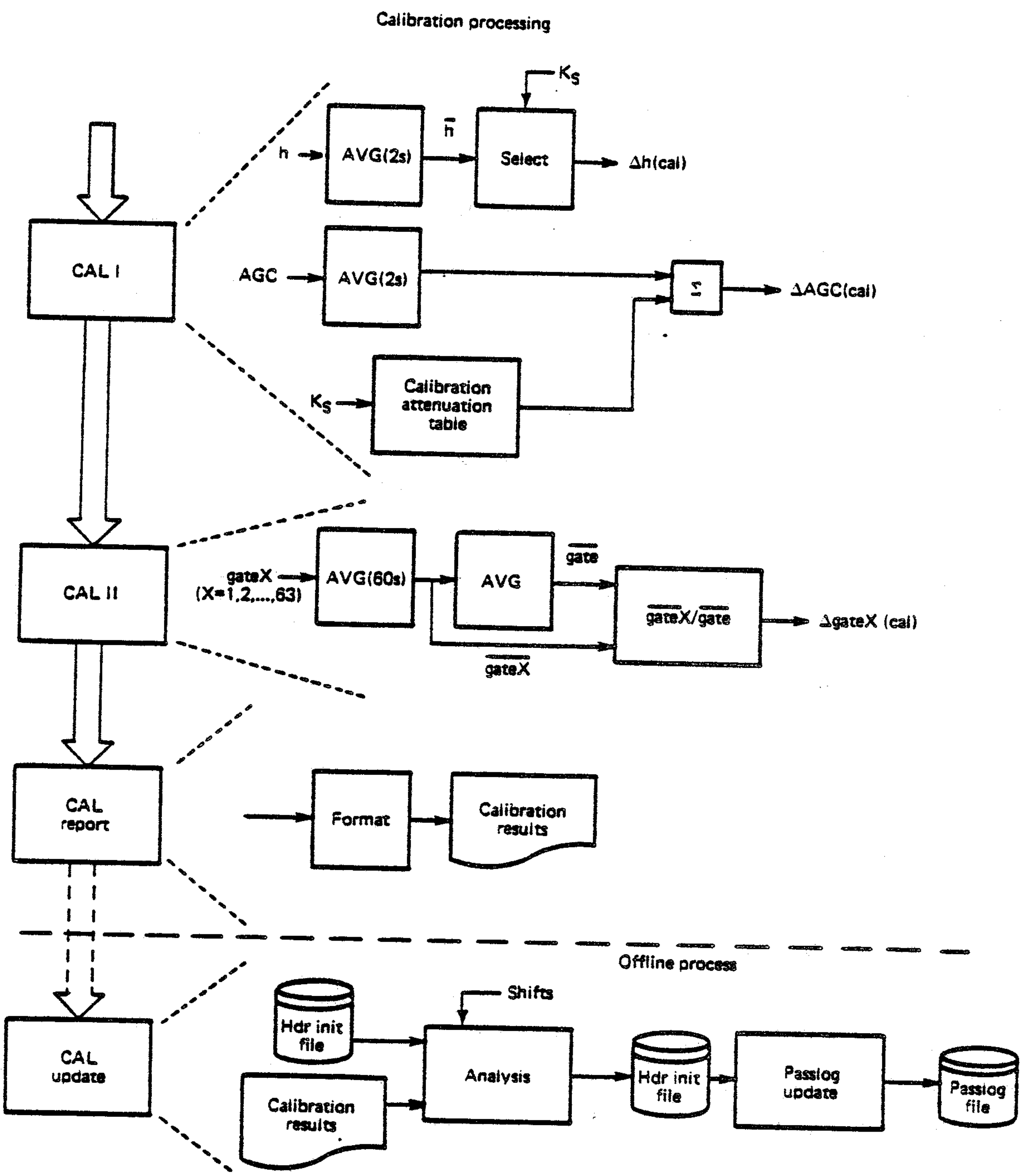
Calibrations are expected to occur at a rate of two each 24-hour period.

Cal I Mode Processing Module

Calibration Mode I is indicated in the telemetry when bit AL207 is set. In this mode the Calibrate Attenuator Step, K_s, will be indicated by a four bit word, AL193. The altimeter remains at each step for 5 seconds. This allows 2 seconds for tracker settling and a minimum of 2 seconds for data averaging.

Height (7 least significant bits of medium height, AL101, and fine height, AL102) and AGC data (AL192) are averaged at each K-step for 2 seconds. Averaged height data at each K-step is printed out in the CALI report and is monitored over time to access the need to update the Δh(cal) term in the header. The resultant averaged height word at a selected K-step is passed to the SDR Header (Δh(cal)). The selected step (K) is the one which most closely matches the average in-flight AGC range according to ground test data.

AGC data is first corrected via a look-up table based on



B-1 Calibration Processing Flow

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ground test data (the same look-up table as used in the AGC Processing Module). The calibration attenuator value for the K-step being processed is then added to the corrected AGC value and the results (calibrated AGC bias) are printed in the CALI report. The corrected AGC result computed using the selected K-step is monitored as with the height calibration values and is periodically updated in the SDR header as ΔAGC(cal). This parameter represents the correction that is used in the σ° computation as presented in the AGC Processing Module description (Appendix A).

Cal II Processing Module

Calibrate Mode II is indicated by AL209=1. The altimeter remains in the Cal II Mode for a minimum of 60 seconds. During this interval, waveform samples are averaged (WS(j), AL214 to AL276) and a waveform mean (WSAVG) of all 63 gates is produced. A correction factor is then derived as the ratio of each individual gate index sample average to the waveform mean:

$$\Delta WS(j) = \overline{WS(j)}/WSAVG.$$

These correction factors are passed to the calibration reports and are subsequently used in the analyses of calibration results and selection of header parameters.

In addition to waveform correction calculations, the CAL II Processing Module produces a parameter similar to VATT (see Appendix A) using the equation below:

$$CALVATT = [(20*CATTGL)-CATTGE]/[(10*CAGCG)-CATTGE].$$

This parameter provides an additional piece of data to the off-line calibration analyses. The gates are computed using corrected waveform samples, WSC(j):

$$CATTGE = (1/8) * \sum_{j=1}^{8} WSC(j) \text{ , (early gate) ,}$$

$$CAGCG = (1/47) * \sum_{j=7}^{54} WSC(j) \text{ , (middle/AGC gate) ,}$$

and

$$CATTGL = (1/8) * \sum_{j=53}^{60} WSC(j) \text{ , late gate.}$$

A note concerning correction factors, $\Delta WS(j)$, where j=1 to 63. The correction factors used for CALVATT are those contained in the SDR header, not those recently computed by the CAL II Processing Module. To form the corrected waveform samples from uncorrected samples (WSC(j)), the following is necessary:

$$WSC(j) = WS(j)/\Delta WS(j).$$

Engineering Data Processing Module

This module will compute the min, max, mean and standard deviation of all engineering data channels. Subcommutated engineering data is contained in telemetry channels AL122 to AL191 (not all of which are active). The Channel Select is given by AL212. These results are saved in the Calibration File and are included in the Calibration Reports (see Table B-3).

TABLE B-1

CALIBRATION REPORT (MODE I); SUMMARY

08/01/84 15:09:14 T70AINFO SYSTEMS REAL-TIME MONITOR-7.X APL/S3C

CALIBRATION REPORT (start frame count = 762521) Page 1 of 4
STATISTICAL SUMMARY CALIBRATION MODE I

SELECTED CALIBRATION STEP (dB)	MEASURED CALIBRATION STEP (dB)	HEIGHT (cm)	AGC (dB)	CORRECTED AGC (dB)	CALIBRATED AGC BIAS (dB)
60.0000	59.5000	64.9815	3.9289	3.6096	63.1096
54.0000	55.6000	70.5911	7.0647	6.5224	62.1224
48.0000	50.0000	86.3402	13.9353	13.6853	63.6853
42.0000	43.7000	87.9261	18.8470	18.4676	62.1676
36.0000	36.1000	88.3772	25.4052	25.1711	61.2711
30.0000	30.3000	88.5878	31.4634	31.2390	61.5390
24.0000	24.2000	68.7195	37.9375	37.8125	62.0125
18.0000	16.2000	88.8433	44.1983	44.0842	62.2842
12.0000	12.2000	88.9742	50.6444	50.3339	62.5339
6.0000	6.2000	88.6130	55.6228	55.3689	61.5689
.0000	.0000	85.1152	55.7455	55.5026	55.5026

TABLE B-2

CALIBRATION REPORT (MODE I); WAVEFORMS

08/01/84 15:09:14 T70AINFO SYSTEMS REAL-TIME MONITOR-7.X APL/S3C

CALIBRATION REPORT (start frame count = 762521) Page 2 of 4
WAVEFORM SAMPLES CALIBRATION MODE I
Calibrate attenuator setting=30dB "selected step"

SAMPLE	MEAN	SAMPLE	MEAN
-30	.3448	1	378.3794
-29	.2069	2	36.6207
-28	.7586	3	15.8276
-27	.4138	4	6.4483
-26	1.5862	5	3.7931
-25	1.0000	6	3.1034
-24	.6207	7	3.3103
-23	.7241	8	1.1724
-22	.6207	9	1.0000
-21	.7586	10	1.1034
-20	.6897	11	1.0345
-19	.8276	12	.5862
-18	.9655	13	.9310
-17	.9655	14	.8276
-16	1.0000	15	.5862
-15	.9310	16	.4483
-14	.9655	17	.4828
-13	1.1034	18	.3448
-12	1.0345	19	.5517
-11	2.9310	20	.4483
-10	1.3448	21	.3448
-9	25.2069	22	1.0690
-8	5.7241	23	.6207
-7	7.0690	24	.4483
-6	3.2414	25	.1034
-5	5.7586	26	.0345
-4	8.7241	27	.1034
-3	17.0000	28	.1724
-2	57.1035	29	.0000
-1	358.5173	30	.1724
-1.5	9.3103		
.0	890.1724		
1.5	10.8276		

TABLE B-3

CALIBRATION REPORT (MODE I); ENGINEERING DATA

08/01/84 15:09:14 T70AINFO SYSTEMS REAL-TIME MONITOR-7.X APL/S3C

CALIBRATION REPORT (start frame count = 762521)

ENGINEERING DATA CALIBRATION MODE I

CHANNEL IDENTIFICATION	UNITS	MINIMUM	MAXIMUM	MEAN	STD	NBR
TWT Cathode Current	mAmps	35.4665	35.4665	35.4665	.0000	11
TWT Helix Voltage	kVolt	4.1740	4.1740	4.1740	.0000	11
TWTA Temperature	Deg C	7.6000	8.4000	7.7455	.2697	11
TWT Collector Temp	Deg C	12.7600	13.1000	12.7909	.1025	11
Receiver Temperature	Deg C	-.9100	-.9100	-.9100	.0000	11
TWTA Bus Current	Amps	2.0055	2.0055	2.0055	.0000	11
TWT Helix Current	mAmps	1.0485	1.0485	1.0485	.0000	11
Transmit Power Amplitude	Watts	22.0300	22.0300	22.0300	.0000	11
UCFM Temperature	Deg C	5.6000	5.6000	5.6000	.0000	11
DCG Temperature	Deg C	10.3400	11.0300	10.7191	.2413	11
MTU Temperature #1	Deg C	4.4000	4.4000	4.4000	.0000	11
WS Temperature	Deg C	32.8600	32.8600	32.8600	.0000	11
CFB Temperature #1	Deg C	51.9000	51.9000	51.9000	.0000	11
ATU #1 Temperature	Deg C	23.4500	23.7900	23.6354	.1776	11
ATU #2 Temperature	Deg C	14.4800	14.4800	14.4800	.0000	11
ICU Temperature	Deg C	22.7600	22.7600	22.7600	.0000	11
SACU Temperature	Deg C	20.0000	20.0000	20.0000	.0000	11
LVPS Temperature	Deg C	23.4500	24.1400	23.7909	.1543	11
LVPS 38V Current	Amps	1.6686	1.7010	1.6863	.0114	11
+28 S/C Bus (Isolated)	Volts	30.9069	31.0548	30.9607	.0746	11
+28 Volts	Volts	28.7552	28.7552	28.7552	.0000	11
+15 Volts	Volts	15.1745	15.1745	15.1745	.0000	11
-15 Volts	Volts	-15.5175	-15.4308	-15.5018	.0351	11
+7 Volts	Volts	6.9089	7.0098	6.9593	.0226	11
-9 Volts	Volts	-9.0896	-9.0402	-9.0492	.0200	11
+5 Volts	Volts	5.2119	5.2437	5.2177	.0129	11
-5.2 Volts	Volts	-5.2429	-5.2429	-5.2429	.0000	11
+1.00 Volt Reference	Volts	1.0000	1.0000	1.0000	.0000	11
+0.657 Volt Reference	Volts	.6600	.6600	.6600	.0000	11
SACU PLO Lock	Volts	2.0200	2.0200	2.0200	.0000	11
MTU Temperature #2	Deg C	5.2000	5.6000	5.4909	.1868	11
CFB Temperature #2	Deg C	45.0000	45.4200	45.3436	.1699	11

TABLE B-4

CALIBRATION REPORT (MODE II); WAVEFORMS

08/01/84 15:09:14 T70AINFO SYSTEMS REAL-TIME MONITOR-7.X APL/S3C

CALIBRATION REPORT (start frame count = 762521) Page 4 of 4

WAVEFORM SAMPLES CALIBRATION MODE II

SAMPLE	MEAN	CORRECTION FACTOR	SAMPLE	MEAN	CORRECTION FACTOR
-30	80.8552	.8991	1	93.9810	1.0450
-29	83.9310	.9333	2	93.3759	1.0383
-28	86.4397	.9612	3	92.0293	1.0233
-27	87.5293	.9733	4	92.1724	1.0249
-26	88.4621	.9836	5	90.9310	1.0111
-25	89.6672	.9970	6	90.6121	1.0075
-24	90.8672	1.0104	7	89.9741	1.0005
-23	90.3121	1.0042	8	89.7448	.9979
-22	91.6138	1.0187	9	89.4569	.9947
-21	90.7879	1.0095	10	88.1431	.9801
-20	90.7224	1.0088	11	88.9655	.9892
-19	90.1983	1.0029	12	88.7534	.9869
-18	90.4293	1.0055	13	88.0741	.9793
-17	90.1414	1.0023	14	88.5172	.9843
-16	89.4879	.9950	15	89.0397	.9901
-15	89.5793	.9961	16	89.5328	.9955
-14	89.7914	.9984	17	89.1431	.9912
-13	90.5017	1.0063	18	90.0000	1.0007
-12	90.3017	1.0041	19	89.9086	.9997
-11	90.2276	1.0033	20	89.7224	.9977
-10	91.2638	1.0148	21	89.9121	.9998
-9	92.1345	1.0245	22	90.0379	1.0012
-8	91.4569	1.0169	23	89.6621	.9970
-7	92.1293	1.0244	24	89.1310	.9911
-6	92.7017	1.0308	25	88.0914	.9795
-5	94.0086	1.0453	26	87.2207	.9698
-4	93.4966	1.0396	27	87.1052	.9686
-3	94.4034	1.0497	28	85.3414	.9489
-2	93.8638	1.0437	29	84.1759	.9360
-1	93.6914	1.0418	30	80.3448	.8934
-1.5	94.0328	1.0456	SUMMATION OF MEANS =		5665.8086
.0	93.8879	1.0440	AGC Average =		12.0537
1.5	93.7966	1.0430	VATT =		2.1174

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APPENDIX C

APPLICATION OF SDR/WDR PROCESSING AND ONBOARD CALIBRATION RESULTS

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This appendix briefly describes how the errors computed during data and calibration processing are to be applied to the SDR and WDR parameters. Table C-1 presents the proper signs and equations to accomplish data correction for instrument/spacecraft errors.

TABLE C-1

SDR/WDR PARAMETER CORRECTION EQUATIONS

SDR/WDR Parameter	Equation
corrected height, hc	$hc(n)=h(n)+\Delta h(fm)-\Delta h(cal) -\Delta h(initial)+\Delta h(cg) +\Delta h(SWH\mid\xi)$
corrected SWH, SWHC	$SWHC(n)=SWH_t(n)+\Delta SWH(SWH\mid\xi) -\Delta SWH(initial)$
corrected AGC, AGCC (same as $\sigma°$)	$AGCC(n)=AGC_t(n)+\Delta AGC(h)+\Delta AGC(T) +\Delta AGC(SWH\mid\xi)-\Delta AGC(cal) -\Delta AGC(initial)$
corrected WS, WSC	$WSC(j,n)=WS(j,n)/\Delta WS(j)$

Error sources are estimated at the SDR (1/sec) rate and are updated for each SDR data record. Thus, to correct the parameters which are recorded onto the SDR and WDR data products at the full rate (10/sec) one would apply the identical error estimates to all 10 samples. For systematic and calibration bias values (Δh(initial), Δh(cg), Δh(cal), ΔAGC(initial), ΔAGC(cal), and ΔSWH(initial)), these terms are slowly varying and may not be updated until substantial downstream processing of data has occurred.

Another parameter contained in the SDR and WDR data products which is corrected at APL/JHU is the universal time coordinate (UTC) time tag (items 5 through 7 in Table 1). The equation to be employed for this process is:

$$UTC = UTC_M - \sum_{i=2}^{8} \tau_i$$

where:

UTC - estimate of correct UTC (Note: UTC must be reconverted into some unified measure such as MJD to be manipulated.)

UTC_M - measured UTC from ground station Time Management Unit

τi - estimates of time corrections resulting from systematic and propagation delays. See items 9-14 of Table 1 for time tag group 1 ($\tau 1,x$) and items 31-36 for group 2 ($\tau 2,x$). $\tau 2$ is based on a nominal trajectory height, h_o, of 810 km. $\tau 6$ is a function of slant range (item 12, Table 1).

Figure C-1 illustrates the various timing corrections and their physical meaning. Table C-2 presents the error budget for these terms. Reference 2.2(c) describes in detail the mechanization of acquiring accurate time tag data.

To perform time tagging of a particular minor frame of data, the following is necessary:

Given:

(1) Time tag data at approximate beginning of the data span; consists of corrected universal time (UTC1) and a correlated frame count (FC1).

(2) Time tag data at approximate conclusion of data span; UTC3 (corrected), FC3.

Find:

Universal time (UTC2) at any altimetry frame count (FC2).

Algorithm:

(1) Compute number of expired unique frame counts;

$$FC2 - FC1 = N$$

(Using major and minor frame counts, MFC and mfc, respectively, this equation assumes FC=MFC*32+mfc).

(2) Compute $\tau 2$ using a nominal height value (h_o) for both corrected values (respectively $\tau(1,2)$ and $\tau(3,2)$):

$$\tau 2 = h_o/c \ .$$

(3) Complete UTC correction via:

$$UTC1 = UTC1-\tau(1,2)$$
and
$$UTC3 = UTC3-\tau(3,2).$$

(4) Compute actual unique frame count (FC) spacing, a:

$$a = (UTC3-UTC1)/(FC3-FC1).$$

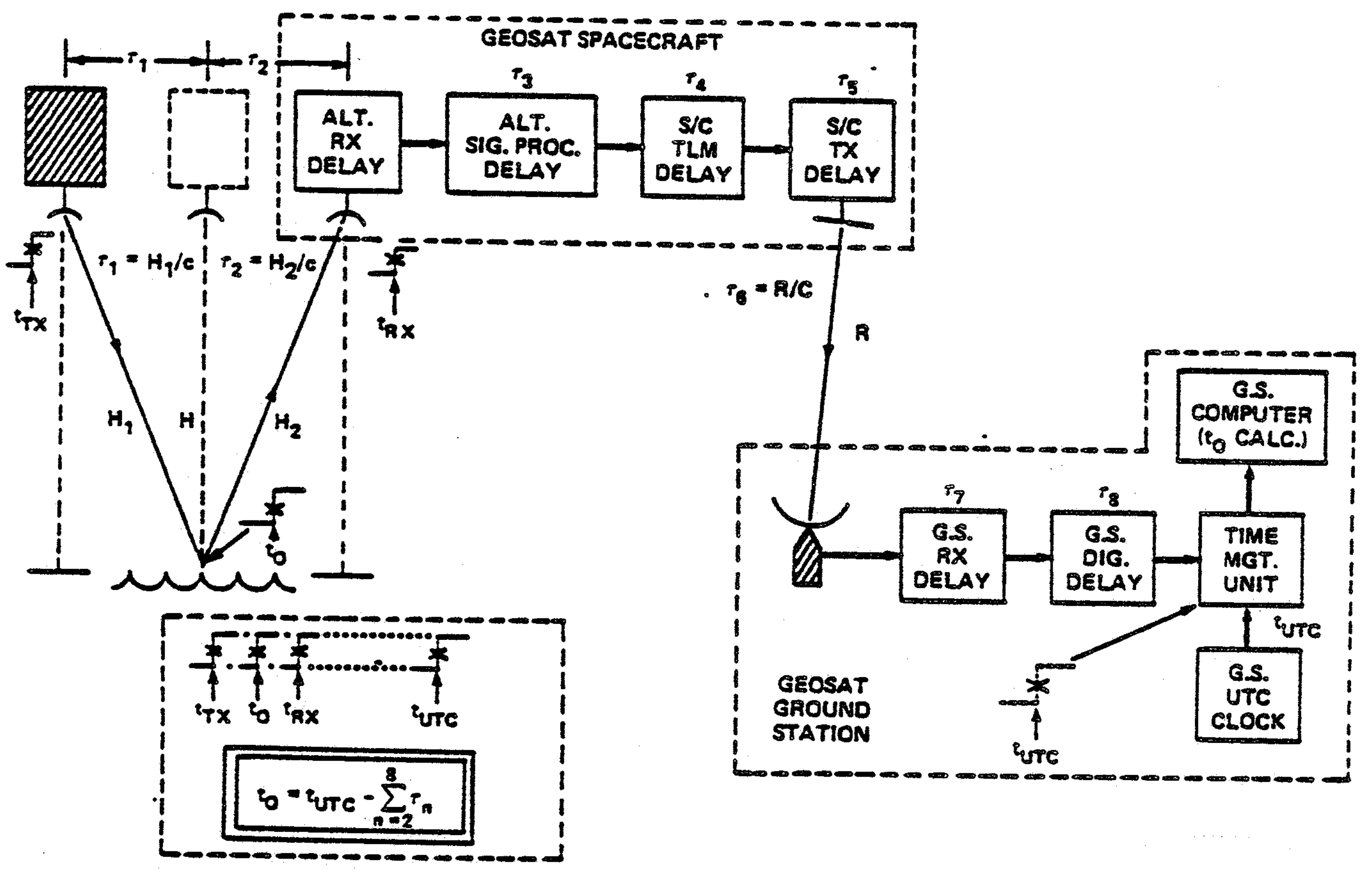
(5) Compute UTC at FC2;

$$UTC2 = UTC1 + (FC2 - FC1) * a.$$

The need to compute the minor frame period, a, is the reasoning for the inclusion of two groups of time tag data in the header. The nominal minor frame period equals 98 ms.

The term, τ_2, is identical for both $\tau(1,2)$ and $\tau(3,2)$. The reason this time correction is separated from the other corrections is that it is possible to perform more precise estimation of τ_2 using estimates of instantaneous height. Height data is not readily processed at APL thus the nominal height, h_o, is suggested - τ_2 is <u>not</u> applied to the corrected UTC placed in the header. Note that the slant range used in the determination of propagation delay is associated with <u>measured</u> UTC; <u>before</u> any corrections are applied.

A spacecraft clock uncertainty of $1:10^7$ corresponds to approximately 100 µs/day. The above procedure avoids the requirement to correct for clock offset. A <u>drift</u> offset of $1:10^{10}$/day is also present; however, it is not significant in comparison to the total clock uncertainty.



C-1 GEOSAT-A Timing Corrections

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TABLE C-2

GEOSAT-A BUDGET FOR TIMING ERROR SOURCES

DESCRIPTION	NOMINAL VALUE	DETERMINED BY	MAX ERROR	NOTES
$\tau 1$ transmission delay to surface (H_1/C)	~2.7 ms	RA measurement	±67 μs[1]	nominal orbit ~810 km
$\tau 2$ transmission delay from surface (H_2/C)	~2.7 ms	RA measurement	±67 μs	~$(H_1+H_2)/2$=height measurement
$\tau 3$ RA signal processor delay	30.38ms	analysis	±10 μs	determined using crossings
$\tau 4$ S/C TLM system delay	0.0	calibration	±9 μs	sync data window is 9 μs.
$\tau 5$ S/C TX delay	5 μs[2]	calibration	±1 μs	includes S/C ant delays
$\tau 6$ slant range propagation delay	~2.7 ms (TCA)[3]	calculation	±30 μs	includes avg of NAVSPASUR elements
$\tau 7$ gnd. station RX delay (avg)	8 μs	calibration	±1 μs	includes avg of g.s. antennae delays
$\tau 8$ gnd. station digital delay	-11859 μs	calibration	±3.5 μs	bit sync delays; time taggin occurs at end of sync word
UTC UTC time code	UTC	measurement	±3 μs	calib. to APL TFS time/freq. std.)
Total MAX Time Tag Error:			124.5 μs[4]	

Notes: (1) not included in total max error
(2) estimate
(3) TCA ~810km
(4) rms total error: 74.8 μs

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APPENDIX D

GEOSAT-A RADAR ALTIMETER TELEMETRY LIST

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The following twelve tables present the radar altimeter telemetry list, engineering data words (TLM word 16), status/mode words (TLM word 15), altimeter transmit power conversion and altimeter temperature conversion. The telemetry list tables contain the following for each entry: altimeter word position, parameter title (and mnemonic), channel, TLM frame location and the conversion units.

TABLE D-1

RADAR ALTIMETRY LIST

Radar Altimeter Telemetry List

RA Word	Full Title (Mnemonic)	Channel	TM Frame Location	Units Conversion
1	Coarse Height (CRSEHT)	AL100	151 : : 160	MSB=819.2 usec : : LSB=819.2/2^9 usec
2	Medium Height (MEDMHT)	AL101	161 : : 170	MSB=819.2/2^10 usec : : LSB=819.2/2^19 usec
3	Fine Height (FINEHT)	AL102	171 : : 180	MSB=819.2/2^20 usec : : LSB=819.2/2^29 usec
4	Height Rate (HTRATE)	AL103	181 : : 190	Two's Complement Sign : : LSB=819.2/2^29 us/PRI
5	Height Error (HTERRO)	AL104	191 : 196 197 : 200	MSB 2's comp magnitude : MSB=sign,LSB=3.125 ns LSB MSB Exponent(power of : two by which to LSB divide magnitude)
6	AGC Gate Amplitude (AGCGTA) (RAM check)*	AL105	201 : : 210	MSB Binary Counts : (DFB outputx100/32) : LSB
7	Early Gate Amplitude (EARGTA) (ROM 0 checksum)*	AL106	211 : : 220	MSB Binary Counts : (DFB outputx100/32) : LSB
8	Late Gate Amplitude (LATGTA) (ROM 1 checksum)*	AL107	221 : : 230	MSB Binary Counts : (DFB outputx100/32) : LSB
9	Middle Gate Amplitude (MIDGTA) (ROM 2 checksum)*	AL108	231 : : 240	MSB Binary Counts : (DFB outputx100/32) : LSB

* Denotes alternate interpretation of Words 6 to 9 when Altimeter is initialized into the Standby I Mode

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TABLE D-2

RADAR ALTIMETER TELEMETRY LIST (Continued)

10	L6-E6 Amplitude (L6E6AM)	AL109	241 : : 250	MSB : : LSB Binary Counts (DFB outputx50/32)
11	Off-Nadir Angle (OFFNAD)	AL110	251 : : 260	MSB=1.28 degrees : : LSB=1.28/2^9 degrees
12	Attitude Volts (ATTV)	AL111	261 : : 270	MSB=2 volts : : LSB=2/2^9 volts
13	Memory Checksum (CKSUM)	AL112	271 : : 280	MSB : : LSB Binary Counts (Value=875)
14	Transmit Power (XMTPWR)	AL113	281 : : 290	MSB : : LSB (Multiply counts by 32/100, then use the Calibration Data in Table I)
15	Status/Mode #1, Last Command Sent			
	-Parity	AL114	291	Even Parity, Bits 291-298
	-Dump Control	AL115	292	1=Memory Dump Command
	-(Unassigned)	AL116	293	
	-(Unassigned)	AL117	294	
	-Mode Command	AL118	295 : 298	(Refer to Table II)
	-Initialize Tracker	AL119	299 300	(Refer to Table II)
	(Unassigned)	AL120		
16	Engineering Data			
	-Frame Start	AL121	301	(1=frame start)
			302	(Not used)
	-Engineering Data (Sub-com)	AL122 to AL191	303 : 310	MSB : LSB (Refer to Table III)
17	AGC Word (AGCWRD)	AL192	311 : : 320	MSB=32 dB : : LSB=0.0625 dB

TABLE D-3

RADAR ALTIMETER TELEMETRY LIST (Continued)

18	Cal Atten/SACU Status			
			321	(Not Used)
			322	(Not Used)
	-Cal Att Setting	AL193	323	MSB=48 dB
			:	: ("0"=Insert Atten)
			326	LSB=6 dB
			327	(Not Used)
	-(Unassigned)	AL194	328	
	-TWTA On	AL195	329	("1"=TWTA On)
			330	(Not Used)
19	Status/Mode #3, ATU Branch Status			
	-Gate Index	AL196	331	MSB
			:	: (Counts)
			333	LSB
	-ACQ Flag	AL197	334	("1"=ACQ Flag Set)
	-ACQ TC Flag	AL198	335	("1"=Using ACQ Alpha/Beta)
	-Attitude Flag	AL199	336	("1"=ATTU Limits Exceeded)
	-Detect Flag	AL200	337	("1"=Detect Flag Set)
	-DHa Flag	AL201	338	("1"=DHa)TDH)
	-LMax Flag	AL202	339	("1"=LMax/4)AGCG)
			340	(Not Used)
20	Status/Mode #4, SACU Mode Command			
			341	(Not used)
			342	(Not used)
	-Chirp/CW	AL203	343	("1"=Chirp)
	-Hi-Volts ON/OFF	AL204	344	("1"=Hi-Volts OFF)
	-(Spare)	AL205	345	
	-TWT-In Inhibit	AL206	346	("1"=Inhibit)
	-Calibrate I	AL207	347	("1"=Calibrate I)
	-TWT-Out Inhibit	AL208	348	("1"=Inhibit)
	-Calibrate II	AL209	349	("1"=Calibrate II)
	-Enter CW Mask	AL210	350	("1"=Enter Mask)
21	Waveheight(H-1/3) (WAVHGT)	AL211	351	MSB=10 meters
			:	:
			358	LSB=.078125 meters
			359	(Not used)
			360	(Not used)
22	Status/Mode #2, Engineering Data Channel/ATU Mode			
	-Channel Select	AL212	361	MSB
			:	: (Counts=Ch1 to Ch50,
			:	: 1-sec epochs begin at
			:	: 1,11,21,31,41 counts)
			366	LSB
	-ATU Mode	AL213	367	(ATU Mode-same as bits 6,
			:	5,4,3 of Word 15, Last
			370	Data Command)

TABLE D-4

RADAR ALTIMETER TELEMETRY LIST (Continued)

23	Waveform Sample -30 (WSA-30)	AL214	371 : 380	MSB : Counts(DFB Outputx100/32) LSB
:	: (AL215 to AL242)			
52	Waveform Sample -1 (WSA-01)	AL243	661 : 670	MSB : Counts(DFB Outputx100/32) LSB
53	Waveform Sample +1 (WSA+01)	AL244	671 : 680	MSB : Counts(DFB Outputx100/32) LSB
:	: (AL245 to AL272)			
82	Waveform Sample +30 (WSA+30)	AL273	961 : 970	MSB : Counts(DFB Outputx100/32) LSB
83	Waveform Sample (-1.5) (WSA-1.5)	AL274	971 : 980	MSB : Counts(DFB Outputx100/32) LSB
84	Waveform Sample (0) (WSA00)	AL275	981 : 990	MSB : Counts(DFB Outputx100/32) LSB
85	Waveform Sample (+1.5) (WSA+1.5)	AL276	991 : 1000	MSB : Counts(DFB Outputx100/32) LSB

Note: If AL 203="0", Words 23-85 will be replaced by nine(9) groups of seven(7) words each containing "super-commutated" CW Mode Data. All CW words will be 8-bits, right adjusted.

23-79 Step7	Pulse Rep Count (PRCNT)	AL277	373-380 443-450 : : 933-940	Counts (MSB=Bits 373,443,...,933)
24-80 Step7	Hit Count (HITCNT)	AL278	383-390 453-460 : : 943-950	Counts (MSB=Bits 383,453,...,943)

TABLE D-5

RADAR ALTIMETER TELEMETRY LIST (Continued)

25-81 Step7	Least Significant Height Word (CWHTLE)	AL279	393-400 463-470 : : 953-960	MSB=25 ns (Bits 393,463,...,953)
26-82 Step7	Medium Height Word (CWHTME)	AL280	403-410 473-480 : : 963-970	MSB=6.4 usec (Bits 403,473,...,963)
27-83 Step7	Most Significant Height Word (CWHTMO)	AL281	413-420 483-490 : : 973-980	MSB=sign(not used) (Bits 413,483,...,973) MSB-1=819.2 usec (Bits 414,484,...,974)
28-84 Step7	Least Significant AGC Word (CWAGCL)	AL282	423-430 493-500 : : 983-990	MSB=32/2^8 dB (Bits 423,493,...,983)
29-85 Step7	Most Significant AGC Word (CWAGCM)	AL283	433-440 503-510 : : 993-1000	MSB=32 dB (Bits 433,503,...,993)

TABLE D-6

ENGINEERING DATA WORD (TM WORD 16)

SubCom Word	Full Title	Channel	TM Frame Location	Units Conversion (N=Counts)	EU
1	TWT Cathode Current	AL122	303-310	TWTACI = -.5264+.21722×N	Ma
2	TWT Cathode Voltage	AL123	303-310	TWTACV= 3.78818+.00322×N	Kv
3	TWTA Temperature	AL124	303-310	TWTATP (Refer to Table IV)	DegC
4	TWT Collector Temperature	AL125	303-310	TWTCTP (Refer to Table IV)	DegC
5	(Spare Current)	AL126	303-310		
6	Receiver Temperature	AL127	303-310	RCVRTP (Refer to Table IV)	DegC
7	TWTA Bus Current	AL128	303-310	TWTABI= .32299+.03127×N	Amps
8	TWT Helix Current	AL129	303-310	TWTAHI= -.17196+.02145×N	Ma
9	(No Data)	AL130			
10	Transmit Power	AL131	303-310	XMTPAM (Refer to Table I)	Watts
11	UCFM Temperature	AL132	303-310	UCFMTP (Refer to Table IV)	DegC
12	DCG Temperature (Digital)	AL133	303-310	DCGDTP (Refer to Table IV)	DegC
13	MTU Temperature #1(Xmt Mon)	AL134	303-310	MTU1TP (Refer to Table IV)	DegC
14	WS Temperature	AL135	303-310	WSAMTP (Refer to Table IV)	DegC
15	DFB Temperature #1	AL136	303-310	DFB1TP (Refer to Table IV)	DegC
16	ATU #1 Temperature	AL137	303-310	ATU1TP (Refer to Table IV)	DegC
17	ATU #2 Temperature	AL138	303-310	ATU2TP (Refer to Table IV)	DegC

TABLE D-7

ENGINEERING DATA WORD (TM WORD 16) (Continued)

18	ICU Temperature	AL139	303-318	ICUTTP (Refer to Table IV)	DegC
19	SACU Temperature	AL140	303-318	SACUTP (Refer to Table IV)	DegC
20	LVPS Temperature	AL141	303-318	LVPSTP (Refer to Table IV)	DegC
21	LVPS 30V Current	AL142	303-318	LVP30I=0.0162xN	Amps
22	+28V S/C Bus (Isolated)	AL143	303-318	+28SCV=0.14788xN	Volts
23	+28 Volts	AL144	303-318	+28VOL=0.16526xN	Volts
24	+15 Volts	AL145	303-318	+15VOL=0.08525xN	Volts
25	-15 Volts	AL146	303-318	-15VOL=-0.08669xN	Volts
26	+7 Volts	AL147	303-318	+7VOLT=0.05043xN	Volts
27	-9 Volts	AL148	303-318	-9VOLT=-0.0494xN	Volts
28	+5 Volts	AL149	303-318	+5VOLT=0.03178xN	Volts
29	-5.2 Volts	AL150	303-318	-5.2VT=-0.02929xN	Volts
30	+1.00 Volt Reference	AL151	303-318	+1VREF=0.02xN	Volts
31	0.657 Volt Reference	AL152	303-318	.657RF=0.02xN	Volts
32	SACU PLO Lock	AL153	303-318	PLOLKV=0.02xN	Volts
33	MTU Temperature #2(Cal Atten)	AL154	303-318	MTU2TP (Refer to Table IV)	DegC
34	(No Data)	AL156			
35	DFB Temperature #2	AL157	303-318	DFB2TP (Refer to Table IV)	DegC

TABLE D-8

ENGINEERING DATA WORD (TM WORD 16) (Continued)

36	(No Data)	AL158		
37	(No Data)	AL159		
38	(No Data)	AL160		
39	(Spare #1)	AL161		
40	(Spare #2)	AL162		
41	LVPS Telltales			
			303-307	(Not Used)
	-TWTA Fault Override	AL163	308	"0"=TWTA Fault Override "1"=TWTA Fault Normal
	-LVPS I Override	AL164	309	"0"=LVPS Current Normal "1"=LVPS Current Override
	-ATU Selection	AL165	310	"0"=ATU#1 "1"=ATU#2
42	(No Data)	AL166		
43	Parameter Select #1	AL166 thru AL169		(Refer to Table VI)
44	Parameter Select #2	AL170 thru AL173		(Refer to Table VI)
45	Parameter Select #3	AL174 thru AL177		(Refer to Table VI)
46	Parameter Select #4	AL178 thru AL181		(Refer to Table VI)
47 thru 50	(No Data) thru (No Data)	AL182 thru AL191		

TABLE D-9

STATUS/MODE WORD (TM WORD 15)

CMD Word No.	Bit Number 10	9	8	7	6	5	4	3	Mode
1	0	0	0	0	0	0	0	0	Standby 1
2	1	0	0	0	0	0	0	1	Calibrate
3	1	0	0	0	0	0	1	0	Standby 2
4	0	0	0	0	0	0	1	1	Track 1
5	1	0	0	0	0	1	0	0	Track 2
6	0	0	0	0	0	1	0	1	Track 3
7	0	0	0	0	0	1	1	0	Track 4
8	1	0	0	0	0	1	1	1	(Unassigned)
9	1	0	0	0	1	0	0	0	Test mode 1
10	0	0	0	0	1	0	0	1	Test mode 2
11	0	0	0	0	1	0	1	0	Test mode 3
12	1	0	0	0	1	0	1	1	Test mode 4
13	0	0	0	0	1	1	0	0	Test mode 5
14	1	0	0	0	1	1	0	1	Test mode 6
15	1	0	0	0	1	1	1	0	Test mode 7
16	0	0	0	0	1	1	1	1	(Unassigned)
	Parity	Memory Dump			Mode Command				

Notes: 1) Bits 2 and 1

1 0 Execute bits 3 through 6 immediately

0 0 First initialize the tracker, then execute bits 3 through 10

0 1 Load memory dump control words, allows 256 data commands

1 1 Load parameter select control words, allows 256 data commands

2) Bits 3 through 10 used for parity. Commands sent with bits 1 and 2 either 01 or 11 will not appear in TM word 15

3) Test Mode 1 - CW
4) Test Mode 2 - Chirp/Freeze
5) Test Mode 3 - Calibrate Freeze (Toggle)
6) Test Mode 4 - Chirp/Sweep Height
7) Test Mode 5 - ACQDH Only
8) Test Mode 6 - TRKDH Only
9) Test Mode 7 - Gate Index Freeze

TABLE D-10

ALTIMETER TRANSMIT POWER CONVERSION

WATTS	S/C ANALOG TELEMETRY (VOLTS)	ALTIMETER DIGITAL TELEMETRY (COUNTS, DECIMAL)
5.01	0.879	44
6.31	1.13	56
7.94	1.465	73
10.0	1.912	95
12.59	2.483	124
15.85	3.251	162
17.82	3.754	187
19.95	4.326	215
20.89	4.591	228
22.03	4.962	247

NOTE:

1. Above data taken with Altimeter RF deck at 20°C in vacuum.

2. The counts in the above table refer to the Transmit Power presented with the subcommutated engineering data in word 16 of the Altimeter telemetry frame. (It is the tenth parameter as identified by the count in word 22.) To use this table for conversion of the Transmit Power as presented in word 14 of each frame, first multiply the count in word 14 by 32/100.

TABLE D-11

ALTIMETER TEMPERATURE CONVERSION

COUNTS	TEMP	COUNTS	TEMP	COUNTS	TEMP
0	-30.00 (-0.1)	51	1.60	102	20.34
1	-25.00	52	2.00	103	20.69
2	-24.17	53	2.40	104	21.03
3	-23.33	54	2.80	105	21.38
4	-22.50	55	3.20	106	21.72
5	-21.67	56	3.60	107	22.07
6	-20.83	57	4.00	108	22.41
7	-20.00	58	4.40	109	22.76
8	-19.44	59	4.80	110	23.10
9	-18.89	60	5.20	111	23.45
10	-18.33	61	5.60	112	23.79
11	-17.78	62	6.00	113	24.14
12	-17.22	63	6.40	114	24.48
13	-16.67	64	6.80	115	24.83
14	-16.11	65	7.20	116	25.17
15	-15.56	66	7.60	117	25.52
16	-15.00	67	8.00	118	25.86
17	-14.44	68	8.40	119	26.21
18	-13.89	69	8.80	120	26.55
19	-13.33	70	9.20	121	26.90
20	-12.78	71	9.60	122	27.24
21	-12.22	72	10.00 (1.45)	123	27.59
22	-11.67	73	10.34	124	27.93
23	-11.11	74	10.69	125	28.28
24	-10.56	75	11.03	126	28.62
25	-10.00	76	11.38	127	28.97
26	-9.55	77	11.72	128	29.31
27	-9.09	78	12.07	129	29.66
28	-8.64	79	12.41	130	30.00 (2.6)
29	-8.18	80	12.76	131	30.36
30	-7.73	81	13.10	132	30.71
31	-7.27	82	13.45	133	31.07
32	-6.82	83	13.79	134	31.43
33	-6.36	84	14.14	135	31.79
34	-5.91	85	14.48	136	32.14
35	-5.45	86	14.83	137	32.50
36	-5.00	87	15.17	138	32.86
37	-4.55	88	15.52	139	33.21
38	-4.09	89	15.86	140	33.57
39	-3.69	90	16.21	141	33.93
40	-3.18	91	16.55	142	34.29
41	-2.73	92	16.90	143	34.64
42	-2.27	93	17.24	144	35.00
43	-1.82	94	17.59	145	35.36
44	-1.36	95	17.93	146	35.71
45	-0.91	96	18.28	147	36.07
46	-0.45	97	18.62	148	36.43
47	0.00 (0.94)	98	18.97	149	36.79
48	0.40	99	19.31	150	37.14
49	0.80	100	19.66	151	37.50
50	1.20	101	20.00 (2.02)	152	37.86

( ) = S/C Analog Telemetry Volts

TABLE D-12

ALTIMETER TEMPERATURE CONVERSION (Continued)

COUNTS	TEMP		COUNTS	TEMP		COUNTS	TEMP	
153	38.21		188	52.85		223	72.31	
154	38.57		189	53.33		224	73.08	
155	38.93		190	53.81		225	73.85	
156	39.29		191	54.29		226	74.62	
157	39.64		192	54.76		227	75.38	
158	40.00	(3.15)	193	55.24		228	76.15	
159	40.42		194	55.71		229	76.92	
160	40.83		195	56.19		230	77.69	
161	41.25		196	56.67		231	78.46	
162	41.67		197	57.14		232	79.23	
163	42.08		198	57.62		233	80.00	(4.69)
164	42.50		199	58.10		234	80.10	
165	42.91		200	58.57		235	80.20	
166	43.33		201	59.05		236	80.30	
167	43.75		202	59.52		237	80.40	
168	44.17		203	60.00	(4.07)	238	80.50	
169	44.58		204	60.59		239	80.60	
170	45.00		205	61.18		240	80.70	
171	45.42		206	61.76		241	80.80	
172	45.83		207	62.35		242	80.90	
173	46.25		208	62.94		243	90.00	
174	46.67		209	63.53		244	91.25	
175	47.08		210	64.12		245	92.50	
176	47.50		211	64.71		246	93.75	
177	47.92		212	65.29		247	95.00	
178	48.33		213	65.88		248	96.25	
179	48.75		214	66.47		249	97.50	
180	49.17		215	67.06		250	98.75	
181	49.58		216	67.75		251	100.00	
182	50.00	(3.64)	217	68.24		252	102.50	
183	50.48		218	68.82		253	105.00	
184	50.95		219	69.41		254	107.50	
185	51.43		220	70.00		255	110.00	(5.12)
186	51.90		221	70.76				
187	52.38		222	71.54				

( ) = S/C Analog Telemetry Volts

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APPENDIX E

SDR RECORD FORMAT

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CODE IDENT NO.	SIZE	
88898	A	7292-9510
SCALE	DO NOT SCALE PRINT	PAGE 96

The SDR records are written onto tapes so that 19 (logical) SDR records of 260 bytes each appear as one contiguous (physical) record of 4940 bytes. (Each SDR contains 257 bytes data and 3 padding byte.) The GSCS SEL can write longer records onto tape, but NRL and NSWC have requested a maximum physical record length of 5120 bytes.

There is room to expand the SDR without changing the spacings suggested by using the three existing padding bytes. Further expansion, if required, would expand to more than 260 characters per logical record. Also, the logical record lengths have been requested by NSWC and NRL to be a multiple of 10 characters, and to make the GSCS processing easier, the logical lengths are also a multiple of 4 characters. Therefore, the next convenient lengths would be 280 and 300 bytes if expansion is necessary. Such expansion beyond 260 bytes per logical record would require restructuring to fewer than 19 logical records per physical record. At present, none of the spares specified in this ICD are encoded.

The SDR has been packed into ASCII format. The following format is suitable for reading one logical SDR record:

```
READ(XX,100)MAJ,MIN,MOD,DATAQ,HEIGHT,SIGH,DELH,DELF,SWH,SIGSWH,
            DELSWH,AGC,SIGAGC,DELAGC,DAGCH,DAGCT,HRATE,OFFNA,
            BACK,WS,VATT,RCVT

100   FORMAT(I8,I2,I10,I10,10(I9),I4,I5,I4,10(F4.2),F3.2,F4.2,
      10(F4.2),F4.2,F4.2,F4.2,F4.2,F3.0,F3.2,F4.2,F3.1,F4.3,F4.1)
```

INTEGER MAJ	Major frame counter at H1
INTEGET MIN	Minor frame counter at H1
INTEGER MOD	Mode word
INTEGER DATAQ	data absent/quality flags
INTEGER HEIGHT(10)	H1..H10 height word
INTEGER SIGH	standard deviation of H0-H9
INTEGER DELH	SWH|ξ
INTEGER DELF	fm crosstalk
REAL SWH(10)	SWH1..SWH10 wave heights
REAL SIGSWH	std dev of SWH1-SWH10
REAL DELSWH	SWH|ξ
REAL AGC(10)	AGC1..AGC10 automatic gain control
REAL SIGAGC	std dev of AGC1-AGC10
REAL DELAGC	AGC bias due to SWH and/or ξ
REAL DAGCH	AGC bias due to h
REAL DAGCT	AGC bias due to receiver temperature
INTEGER HRATE	height rate
REAL OFFNA	off nadir angle
REAL BACK	backscatter coefficient
REAL WS	windspeed

REAL VATT   attitude voltage
REAL RCVT   receiver temperature

The following data quality flags have already been defined (it is possible that others may be added):

SDQH0	=	1	H1, SWH1, or AGC1 were unreasonable.
SDQH1	=	2	H2, SWH2, or AGC2 were unreasonable.
.			
.			
.			
SDQH9	=	512	H10, SWH10, or AGC10 were unreasonable.
SDQSIGH	=	1024	Std. deviation of height is out of bounds.
SDQSIGAG	=	2048	Std. deviation of AGC is out of bounds.
SDQSIGSW	=	4096	Std. deviation of SWH is out of bounds.
SDQOFFNA	=	8192	Off nadir angle is out of bounds or VATT-b_o<0.
SDQTMTU	=	16384	Temp of MTU is out of bounds.
SDQTDFB	=	32768	Temp of DFB is out of bounds.
SDQTTWTA	=	65536	Temp of TWTA is out of bounds.
SDQTSACU	=	131072	Temp of SACU is out of bounds.
SDQTDCG	=	262144	Temp of DCG is out of bounds.
SDQAGCGD	=	524288	Bit error from checked bit pattern (42 bits) and/or frame counter occurred.
SDQH	=	1048576	One of the 10 H is out of bounds.
SDQAGC	=	2097152	One of the 10 AGC is out of bounds.
SDQSWH	=	4194304	One of the 10 SWH is out of bounds.
SDQHRATE	=	8388608	H rate is out of bounds.
SDQVATTE	=	16777216	Smoothed VATT value is estimated (up to 4 minutes from last fit window which spans ±2 minutes maximum).
SDQVATTN	=	33554432	No smoothed VATT values available -- functions based on VATT are zero-filled.
SDQRCVT	=	134217728	Receiver temperature not available for 24000 minor frames (~1/2 orbit); set T= 20°C.
SDQBACK	=	268435456	σ° out of bounds ($\sigma^\circ<6.3$ or $\sigma^\circ\geq19$); see Note 1 of Table A-2.

APPENDIX F

WDR RECORD FORMAT

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The WDR records are written onto tapes so that 7 (logical) WDR records of 660 bytes each appear as one contiguous (physical) record of 4620 bytes. (Each WDR contains 652 bytes data and 8 padding bytes.) The GSCS SEL can write longer records onto the tape, but NRL and NSWC have requested a maximum physical record length of 5120 bytes. There is room to expand the WDR without changing the spacings suggested by using the spares and the padding bytes; further expansion will require more than 660 characters per logical record. NSWC and NRL has also requested that the logical record lengths be a multiple of 10 characters, and to make the GSCS processing easier, the logical lengths should also be multiple of 4 characters. Therefore, the next convenient lengths would be 680, 700, and 720 bytes. Expansion to more than 720 bytes per logical record would require restructuring to 6 logical records per physical record. Expansion would jeopardize the ability to place 24 hours worth of WDRs on two 2400 foot tapes.

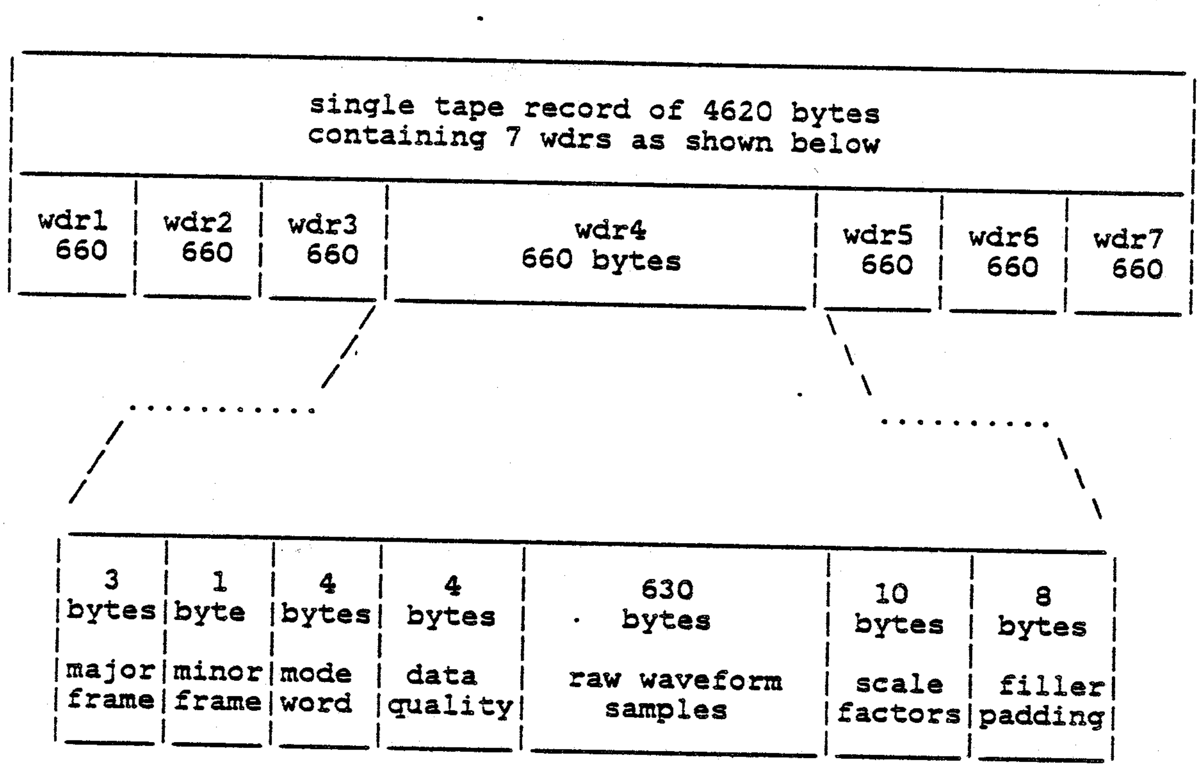
The WDR is packed using binary format. The following format is suitable for reading one logical WDR record:

```
READ(XX,100)MAJ,MIN,MOD,DATAQ,SAM,SCALE

100    FORMAT(R3,R1,R4,R4,630(R1),10(R1),8(X))
```

where: integer MAJ is the major frame counter of the first 63 samples
- integer MIN is the minor frame counter of the first 63 samples
- integer MOD is the mode word for this data record
- integer DATAQ contains the 29 data flags as defined for the SDR (Appendix E)
- integer SAM(630) contains 1 second of waveform samples (SAM(1) to SAM(63) contain the first minor frame of data for example)
- integer SCALE (10) contain the scale factors for the 10 respective sets of values in SAM

Figure F-1 illustrates a typical WDR data record.



F-1 WDR Format

APPENDIX G

ICD NOMENCLATURE

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CODE IDENT NO.	SIZE	
88898	A	7292-9510
SCALE	DO NOT SCALE PRINT	PAGE 104

This Appendix lists the acronyms and symbols used in this document. Definitions and cross-reference nomenclature is provided for each entry. This list is in alphabetical order (more or less).

ACRONYM/SYMBOL	DEFINITION
a	Minor frame period computed using the two time measurements contained in the header of the data products
a_0, a_1, a_2, a_3, a_4, a_5	Coefficients of various equations: a_0 and a_1 are used in the WAVEFORM PROCESSING MODULE to refine the VATT parameter; a_0, a_1, a_2, a_3, a_4, and a_5 are used in the WINDSPEED CALCULATION submodule to determine windspeed from backscatter estimates.
A	Intercept coefficient used in the description of the VATT fitting routine.
AGC	Automatic Gain Control; measurement of altimeter signal strength at the altimeter receiver. These "raw" measurements are recorded at a 10/s rate on the SDR data product. "Raw" means that the data is not processed prior to placement on the SDR.
AGC_t	The adjusted AGC which use raw AGC measurements and apply receiver corrections. Corrections are applied using a tabular look-up/ interpolation routine.
$AGC_t(n)$	Adjusted AGC as a function of discrete time (n). This notation is used when the temporal characteristics of the parameter is of interest.
AGC(U),AGC(L)	Fixed AGC values in the header record that are used in determining AGC reasonableness.

ACRONYM/SYMBOL	DEFINITION
	AGC(U) and AGC(L) denote the upper and lower bounds, respectively.
$AGC_0, \ldots, AGC_9$	These ten elements represent the first through tenth AGC entries in a SDR record.
AGCC	Corrected AGC; uses all of the available bias corrections in combination with the adjusted AGC measurement, AGC_t. (Table C-1 contains the AGCC equation.)
AGCG(n)	AGC gate; consists of the inner 48 waveform gates. AGCG is computed to form the VATT parameter in the WAVEFORM PROCESSING MODULE. (AGCG(n) is a function of discrete time, n. The discrete time steps are 1 second.)
ALXXX	Designates an altimeter telemetry channel (XXX). Appendix D describes the channel entries.
APL	The Johns Hopkins University Applied Physics Laboratory.
AT	The archive tape which is produced in the GEOSAT-A ground station at APL. The AT is an analog recording of real-time and dump data, and, also has an IRIG-B formatted time track. These tapes are archived at APL.
ATTG(n)	Attitude gate; formed using the last 8 wave-form gates. ATTG is formed to compute the VATT parameter within the WAVEFORM PROCESSING MODULE. (ATTG(n) shows time dependency, n.)

ACRONYM/SYMBOL	DEFINITION
ATTGE(n)	Early attitude gate; formed using the first 8 waveform gates of the 63 available. This term is used in the CALIBRATION MODULE to generate a VATT parameter based on calibration data for use in the off-line analyses.
B	Slope term derived from VATT smoothing equations.
b_0, b_1	Coefficients of the off-nadir equation based on the VATT parameter in the OFF-NADIR ESTIMATION submodule. See Table A-1.
BACK	Code parameter containing the backscatter coefficient (Appendix E).
bpi	Bits per inch -- density of the digital magnetic tape. The SDR and WDR products are written onto tape at 1600 bpi.
c	Velocity of electromagnetic radiation (vacuum). Value used is 299792458 m/s.
c_0, c_1	Coefficients used in the ALTITUDE PROCESSING module. These coefficients relate the attitude dependent height bias to the VATT parameter.
CAGCG	AGC gate computed using calibration data. This term is denoted the middle gate and uses the inner 48 waveform gates.
CALI	Refers to calibration mode I (Appendix B). CALI produces an estimate of both height and AGC bias values based on coupling of the transmit pulse directly to the receiver.

ACRONYM/SYMBOL	DEFINITION
CALII	Refers to calibration mode (Appendix B). CALII produces estimates of waveform gate corrections derived from a normalization processing of noise-only receiver input.
CALVATT	The term similar to the VATT parameter but produced using calibration data. This parameter is a function of CATTGE, CATTGL, and CAGCG. It is used in the off-line calibration analyses.
CATTGL	Late attitude gate based on calibration data. Uses the last 8 waveform gates (j=56 to 63).
CATTGE	Early attitude gate based on calibration data. Uses the first 8 waveform gate (j=-63 to -56).
CCT	Computer Compatible Tape; denotes digital magnetic tape generated and readable by digital computers. Assumes standard tape characteristics: 0.5 inch width, 24 ft. length, 10.5 inches reel diameter, and IBM compatible EOT/BOT.
CDR	Critical Design Review -- final technical design review. Formal start of configuration control.
d_0, d_1	Coefficients relating the attitude dependent AGC bias to the VATT parameter. (See Table A-1).
DAGCH	The code variable holding the altitude dependent AGC bias value (Appendix E).
DAGCT	The code variable holding the receiver temperature dependent AGC bias value (Appendix E.)

ACRONYM/SYMBOL	DEFINITION
DATAQ	The code variable holding the data quality flagword.
date1, date2	The parameter that gives the date of the last NAVSPASUR ephemerides. date1 is associated with time tag group 1 whereas date2 relates the time tag group 2.
DCG	Digital Chirp Generator; the hardware sub-system onboard the spacecraft (S/C) responsible for generating the altimeter transmit pulse.
DELAGC	Code variable holding the attitude dependent AGC bias value (Appendix E).
DELF	Code variable holding the fm crosstalk produced altitude bias (Appendix E).
DELH	Code variable holding the attitude dependent altitude bias (Appendix E).
DELSWH	Code variable holding the attitude dependent SWH bias (Appendix E).
ΔAGC(cal)	AGC bias derived from off-line analyses of calibration data. This term is placed in the header and is modified infrequently (>daily).
ΔAGC(h)	AGC bias resulting from height variations about the height simulated during prelaunch calibrations. This term is identical to DAGCH.

ACRONYM/SYMBOL	DEFINITION
ΔAGC(initial)	AGC bias resulting from initial AGC measurements.
ΔAGC(SWH|ξ)	AGC bias dependent on attitude (and SWH). This term is modified to denote time dependency as AGC(SWH|ξ,n). Identical to DELAGC.
ΔAGC(T)	AGC bias dependent on receiver temperature. Time dependency of this term is demonstrated using ΔAGC(T,n). Identical to DAGCT.
Δfc	Frequency offset of reference (5 MHz) oscillator which is responsible for all altimeter timing functions. The onboard S/C clock offset (Δfc) is 79.44 ppm. Due to oscillator drift, it will change about every 100 days.
Δh(cal)	Altitude bias computed from offline analyses of calibration data. This term is placed in the header.
Δh(cg)	Altitude bias based on location and movement of the GEOSAT-A spacecraft center-of-gravity (cg).
Δh(fm)	Altitude bias resulting from fm crosstalk with the altimeter return signal. Time dependency is denoted via Δh(fm,n). Identical to DELF; updated once per SDR record.
Δh(initial)	Altitude bias derived from prelaunch measurements (e.g., antenna focal length/flange propagation distances). This term is placed in the header. May be updated occasionally depending on analyses of collected altimetry data.

ACRONYM/SYMBOL	DEFINITION
$\Delta h(SWH \mid \xi)$	Altitude bias which is dependent on attitude (and SWH). Time dependency shown as $\Delta AGC(SWH \mid \xi, n)$. Identical to DELH; updated once per SDR record.
ΔSWH(initial)	SWH bias derived from prelaunch measurements. This term is placed in the header and may be updated occasionally depending on analyses of collected altimetry data.
$\Delta SWH(SWH \mid \xi)$	SWH bias dependent on attitude (and SWH, itself). Time dependency demonstrated as $\Delta SWH(SWH \mid \xi, n)$. Updated once per SDR record.
$\Delta WS(j)$	Waveform gate corrections for the 63 gates (j=1..63) generated from CAL II return signal samples. Placed in header; updated infrequently based on off-line calibration analyses.
DFB	Digital Filter Bank; altimeter hardware subsystem which generates the waveform samples and produces the return signal track point.
dh/dt	Altitude rate. Identical to HRATE and $\dot{h}$.
DMAAC	Defense Mapping Agency, Aerospace Center, located in St. Louis, MO.
D/P	Data Processing; an abbreviation.
e1,e2	Eccentricity element associated with group 1 (e1) and 2 (e2) NAVSPASUR entries. Placed in header (used in slant range calculation and attendant propagation delay).
epoch1, epoch2	Time associated with group 1 (epoch 1) and 2 (epoch 2) NAVSPASUR elements.

ACRONYM/SYMBOL	DEFINITION
EUC	Engineering Units Conversion; a process which converts telemetry data (in units of counts) to engineering units.
FC	Unique frame count formed from combination of major and minor frame counts. FC(1) and FC(2) denote frame counts at time 1 and 2 -- these terms are used in minor frame computations (Appendix C).
flagword	Data quality flagword contains the data flagging bits based on 29 tests performed on the dump data. Identical to DATAQ; updated once per SDR record.
Gate Index	Gate Index indicates the gate width in effect for return signal processing. There are 5 gate index values available. This term is used to access SDR data correction constants (Table A-1).
GOAP	GEOSAT-A Oceans Application Program, see Reference 2.3(b).
GSCS	GEOSAT-A Ground System Computer System; the ground processor (SEL 32/77) performing command/control/monitoring (CCM) functions and generation of data products.
h	Altitude measurement -- h(n) denotes time dependency and $\overline{h(n)}$ signifies sample smoothing.
h(U),h(L)	Altitude (height) upper (U) and lower (L) bounds used to check altitude data reasonableness for quality flagging. These two values are placed into the header and may be

ACRONYM/SYMBOL	DEFINITION
	modified based on height measurement variations.
$\dot{h}$	Altitude (height) rate; $\dot{h}(n)$ denotes time dependency and $\bar{\dot{h}}(n)$ denotes smoothed height rate (over 1 second). $\bar{\dot{h}}$ is placed in each SDR record and is used to estimate the fm cros-stalk bias component in altitude ($\Delta h(fm)$). Identical to HRATE.
$\ddot{h}$	Altitude acceleration; $\ddot{h}(n)$ denotes time dependency.
$h_0 .. h_9$	Altitude data measurements in SDR record. Denotes each of the 10 raw altitude entries in the SDR record (one/minor frame). The major frame count (MFC) for SDR records correspond to h_0.
h_0	Nominal height (810 km) for time correction 2 ($\tau(1,2)$ and $\tau(2,2)$). h_0 is not on the SDR or WDR products; advised change to this parameter provided by APL/JHU memorandum (see Appendix C).
h_s	Simulated height (796.44 km) for AGC bias ($\Delta AGC(h)$) estimation based on s/c height variation. This parameter is embedded in the SDR/WDR code and represents prelaunch test conditions using the Return Signal Simulator (RSS).
hc	Corrected height using estimated biases (Appendix C, Table C-1). Not performed by APL/JHU.
H-1/3	Significant Wave Height (SWH) nomenclature; H-1/3=SWH. H-1/3 is used in several open references concerning oceanography. (Also,

ACRONYM/SYMBOL	DEFINITION
	$H_{1/3}$.)
HEIGHT	Code variable holding altitude (height). Identical to h. Ten values (h_0..h_9) per SDR record.
HRATE	Code variable holding $\dot{h}$ values.
HSKP	Abbreviation for housekeeping -- refers to S/C and/or altimeter health/status.
i	Gate Index symbol. See Appendix A with respect to Table A-1 and SWH estimation.
I1,I2	Inclination parameter for NAVSPASUR elements (group 1 and 2). Placed in header and used in slant range computations.
I/O	Abbreviation for input/output.
ICD	Interface Control Document; formalized documentation describing an interface between two responsible entities.
K_s	Calibration attenuation step (there are 11 steps); this variable indicates which measurement conditions are in effect during CAL I mode operations. The step values are used in off-line calibration analyses.
LN1,LN2	Longitudal node entries to the group 1 and 2 NAVSPASUR elements. Placed in the header and used as part of slant range/time correction computations.
LSB	Least Significant Bit.

ACRONYM/SYMBOL	DEFINITION
MA1,MA2	Mean anomaly elements for NAVSPASUR group 1 and 2. These terms are placed in the header and are used in the slant range/time correction computations.
MAJ	Code variable holding the major frame count (MFC) values. Placed in each SDR/WDR record -- corresponds to h_0 measurement.
mFC	Minor frame count; altimeter measurements are made and stored in each minor frame. The minor frame period is roughly 0.1 sec; a SDR/WDR record uses 10 minor frames of data. mFC ranges from 0 to 31. The mFC for h_0 is placed in each SDR/WDR record.
MFC	Major frame count; contains 32 minor frames and is used by S/C HSKP to permit multiplexing of s/c and altimeter sensor data. Each SDR/WDR record has a MFC entry corresponding to the h_0 measurement.
MIN	Code variable holding the minor frame count (mFC) values. Placed in each SDR/WDR record -- corresponds to h_0 measurement.
MM1,MM2	Mean motion elements for NAVSPASUR group 1 and 2. These terms are placed in the header and are used in the slant/range time correction computations.
MSB	Most Significant Bit.
MTU	Microwave Transmission Unit; a hardware subsystem associated with the altimeter for routine of rf transmissin/reception signals.

ACRONYM/SYMBOL	DEFINITION
n	Time index; indicates which of an ordered set of samples is involved in various processing algorithms.
N	Number of VATT samples used in fitting equations to produce smooth VATT values.
NP1,NP2	Nodal precession for time tag group 1 and 2. The NP parameter is a NAVSPASUR element and is used in the slant range timing correction algorithm.
NRL	Naval Research Laboratory located in Washington, D.C. NRL receives and processes the WDR data product.
NSWC	Naval Surface Weapon Center located at Dahlgren, VA. NSWC receives and processes the SDR data product.
OFFNA	Code variable that holds the off-nadir angle.
OTA	Procedure of estimation without sufficient information.
P1,P2	Perigee for time tag group 1 and 2, respectively. A NAVSPASUR element used in the slant range timing correction algorithm.
PP1,PP2	Perigee precession for time tag groups 1 and 2, respectively. PP is a NAVSPASUR element used in the slant range time correction algorithm.
P/P	Abbreviation for preprocessing.

ACRONYM/SYMBOL	DEFINITION
P&I	Performance and Interface; specification describing the design of a particular subsystem.
PDR	Abbreviation for Preliminary Design Review -- formal review of program conceptual design.
PE	Phase Encoding method employed for digital tapes at 1600 bpi density.
RA	Abbreviation for Radar Altimeter -- the GEOSAT-A instrument.
RCVT	RA receiver prelaunch calibration temperature (20°C).
RCVT(cal)	RA receiver calibration temperature (postlaunch).
rf	Abbreviation for radio frequency.
RTM	Real Time Monitor; operating system for the GSCS SEL 32/77 (GEOSAT-A ground processor).
SACU	Abbreviation for Synchronization and Calibration Unit -- a RA subsystem (Reference 2.3(a)).
SAM(j)	Code variables (j=1..630) which hold waveform sample values for a WDR record (1 second of 63 gates).
S/C	Abbreviation for spacecraft.

ACRONYM/SYMBOL	DEFINITION
SCALE(j)	Code variables (j=1 to 10) holding the scale factors used for each 0.1 second waveform (produced by 63 gates) in the WDR record (10 waveforms).
SDQ...	The SDQ prefix denotes a quality flag code variable. There are 29 flags. The SDQ suffix identifies the specific test: AGC - AGC reasonableness flag BACL - backscatter reasonableness flag BITER - fixed telemetry pattern bit check flag H - altitude (H) reasonableness flag H0 - height/AGC/SWH; one or more measurement not available ... ... H9 - height/AGC/SWH; one or more measurement not available HRATE - height rate reasonableness flag OFFNA - off-nadir angle reasonableness flag RCVT - receiver temperature not available, used 20°C SIGAG - AGC statistic out of bounds SIGH - height statistic out of bounds SIGSW - SWH statistic out of bounds SWH - SWH reasonableness flag TDCG - DCG temperature out of bounds TDFB - DCB temperature out of bounds TMTU - MTU temperature out of bounds TSACU - SACU temperature out of bounds TTWTA - TWTA temperature out of bounds VATTE - VATT parameter estimated using previous value(s) VATTF - Smoothed VATT from <60 samples VATTN - VATT parameter not available
SDR	Sensor Data Record; primary GEOSAT-A data product containing raw measurements, associated (estimated) bias values, and ancillary data. Product is a CCT and is classified SECRET.
SEL 32/77	System Engineering Laboratories model 32/77

ACRONYM/SYMBOL	DEFINITION
	minicomputer. Used as the GEOSAT-A ground processor (GSCS). See Reference 2.1(b).
SIGAGC	Code variable representing computed AGC statistic (standard deviation).
SIGH	Code variable representing computed altitude statistic.
SIGSWH	Code variable representing computed SWH statistic.
σ^{o}	Symbol representing backscatter coefficient; used in open literature.
σAGC	Symbol for AGC statistic.
σAGC,U	Symbol representing the upper bound for the AGC statistic. Used in data quality testing.
σh	Symbol for altitude statistic.
σh,U	Symbol representing the upper bound for the altitude statistic. Used in data quality testing.
σSWH	Symbol for SWH statistic.
σSWH,U	Symbol representing the upper bound for the SWH statistic. Used in data quality testing.
SR1,SR2	Computed slant range values using time tag group 1 and 2 data, respectively. (Actually, SR computations use associated NAVSPASUR elements. SR results produce propagation

ACRONYM/SYMBOL	DEFINITION
	delays which must be determined to correctly time tag data (Appendix C). SR values are determined at the time of the UTC measurement (NO timing corrections applied).
SWH	Significant Waveheight; raw altimeter data measurement which represents rms waveheight. Also denoted as H-1/3.
SWH_t	Significant Waveheight after applied corrections. Subsequent to launch, SWH is corrected based on collected altimetry data. This correction is performed in the Engineering Units Conversion (EUC) module. $SWH_t(n)$ indicates discrete time dependency.
SWH(U), SWH(L)	Upper (U) and lower (L) bounds for SWH reasonableness checks. These values are changed periodically based on collected data, and they are stored in the header.
$SWH_0 .. SWH_9$	The raw SWH measurements (10) placed in a SDR record.
SWHC	Corrected SWH; the SWH value resulting from the application of all of the estimated SWH biases to the raw measurement (Table C-1 or Appendix C).
τi or τ_i	The timing correction values (i=1 to 8) as presented in Figure C-1 of Appendix C. These terms represent time delays resulting from the altimeter/ground station configuration.
$\tau(1,i)$	The timing corrections associated with time tag Group 1; the pass information closest to the data start time on the data product CCT (i=1 to 8; however, only i=3 to 8 are placed in the header). $\tau 1$ does not impact measurement

ACRONYM/SYMBOL	DEFINITION
	time and $\tau 2$ is dependent on the instantaneous height. $\tau 2$ is computed using either nominal height (h_0) or an estimated height from smoothing of measurements.
T(X,U),T(X,L)	Temperature upper (U) and lower (L) bounds for various spacecraft equipment (X=MTU, DFB, TWTA, SACU, or DCG).
TM,TLM	Abbreviations for telemetry.
TMU	Abbreviation for Time Management unit; hardware which is responsible for time tagging altimetry data. The TMU equipment is located at the ground station (part of the Digital Element).
TWTA	Abbreviation for the Traveling Wave Tube Amplifier associated with the altimeter.
UTC	Abbreviation for Universal Time Coordinated; GMT.
UTC(1),UTC(2)	Measured and corrected UTC for time tag group 1 (pass closes to data start time) and for group 2 (pass closest to data stop time). UTC(1) and UTC(2) are corrected for $\tau(1,i)$ and $\tau(2,i)$ terms, respectively (for i=3 to 8).
UTC_M	Measured (not corrected) UTC.
UTC 1, UTC 2, UTC 3	UTC parameters used to exemplify time tagging of altimetry data (see Appendix C).
VATT	Parameter proportional to attitude which is used to evaluate functions of attitude. VATT is generated using raw waveform data.

ACRONYM/SYMBOL	DEFINITION
$VATT_t$	VATT measurement corrected using prelaunch calibration results.
$VATT_t(n)$	Corrected VATT as a function of discrete time.
$\overline{VATT}_t(n)$	VATT resulting from editing of corrected VATT and application of fitting equations to smooth through measurement data. This term illustrates its dependency on discrete time (see Appendix A).