3.0 GVAR TRANSMISSION FORMAT

3.1 Introduction

This section defines the structure and content of the GVAR data transmission format used to broadcast meteorological data measured by the independent GOES I-M Imager and Sounder instruments. Included in the format are Imager and Sounder telemetry and calibration data. In addition, the format provides a capability to insert auxiliary data products into the GVAR stream. These secondary products include text messages, spacecraft navigation support data, etc.

The GVAR format has its origins in the Operational VAS Mode AAA (Triple A) format used with the previous generation, two-axis stabilized GOES spacecraft. The AAA format consisted of a repeating sequence of twelve fixed-length equal size blocks, transmitted in a synchronous fashion at the spin rate of the satellite (i.e., one complete 12-block sequence per spacecraft rotation). In contrast, starting with the GOES I-M series, the GOES satellites are three-axis stabilized, giving the Imager and Sounder a continuous view of the Earth. The GVAR format was developed to permit full use of the capabilities afforded by the new instruments and the continuous Earth view, while maintaining as much commonality with AAA reception equipment as possible.

3.2 Scan Format

The GVAR transmission sequence is depicted in Figure 3-1, and Table 3-1 provides an overview of the GVAR block structures, word lengths, and information fields. The format consists of twelve distinct blocks numbered 0 through 11. Blocks 0–10 are transmitted after the completion of each Imager scan line. Block 10 is then followed by a variable number of Block 11s according to what Sounder scan data, instrument telemetry, and other data are available for transmission.

Block 0 and all varieties of Block 11s are fixed, equal-length structures. Blocks 1 through 10 vary in length in accordance with the length of the Imager scan line (i.e., the width of the commanded frame). The minimum block size for Blocks 1 through 10 is 32,208 bits, while the largest block size is 262,288 bits for a 23^{o}-wide scan. The maximum values indicated in the figure for Blocks 1–10 correspond to the manufacturer's specified maximum scan width of 19.2^{o}. Scans having widths up to 23^{o} are possible with either instrument; however, the radiometric and pointing accuracy degrades for widths above 19.2^{o}. The GVAR format handles scans wider than 19.2^{o} with restrictions on operations (see subsection 3.2.2) to allow for special postlaunch tests. During normal operations the 19.2^{o} limits specified by the manufacturer represent the upper bound.

Table 3-1. GVAR Format

SCAN CHARACTERISTICS	
Period	Variable
Blocks/Imager Scan	11
Bit Rate	2,111,360 bps
BLOCK CHARACTERISTICS	
Period	15.25 to 104.6 ms
Synch Length	10032 bits
Header Word Length	8 bits/word
Header Length (Triple Redundant)	90 words (720 bits)
Information Fields	
BLOCK 0 - DOCUMENTATION BLOCK	
Word Size	8 bits
Field Length	8040 words (64320 bits)
BLOCK 1 - INFRARED BLOCK 1	
Word Size	10 bits
Field Length	68 to 21008 words*
Number of Records	4 per block
Line Documentation	16 words
IR Detector Data	1 to 5236 words
BLOCK 2 - INFRARED BLOCK 2	
Word Size	10 bits
Field Length	51 to 15756 words*
Number of Records	3 per block
Line Documentation	16 words
IR Detector Data	1 to 5236 words
BLOCKS 3 TO 10 - VISIBLE BLOCKS	
Word Size	10 bits
Field Length	20 to 20,960 words*
Number of Records	1 per block
Line Documentation	16 words
Visible Detector Data	4 to 20,944 words
BLOCK 11-Sounder/AUXILIARY DATA	
Word Size	6, 8, or 10 bits
Field Length (words)	10720, 8040, or 6432
Record Types	7
Number of Records	1 to 8
Cyclic Redundancy Check (CRC)	16 bits

* Variable length information fields are subjected to zero packing (filling) to meet the 32,208-bit minimum block length and to satisfy the 16-bit bounding required for the block CRC. Maximum values denote only the data sections resulting from a 19.2^{o} instrument scan.

3.2.1 Imager

The layout of the Imager instrument detectors is depicted in Figure 3-2. The Imager has a total of 22 detectors split into three groups:

- Eight visible detectors, V1 through V8
- Seven primary infrared detectors, P1 through P7
- Seven redundant infrared detectors, R1 through R7.

Each of the 22 detectors is a member of one of five spectral channels. Although physically distinct, the five channels are optically overlaid, as illustrated in Figure 3-3. During imaging operations, the detectors are active in either a side 1 or a side 2 configuration, as illustrated in Figure 3-4. In both configurations the visible detector group (V1–V8) and one of the two infrared groups, either P1–P7 or R1–R7, are active. The resultant swath on the Earth's surface generated by either of these two configurations is misaligned in the IR and visible bands as indicated in Figure 3-5.

The SPS removes the misalignment by lagging data from the appropriate visible detectors and combining these data with detector data from a subsequent scan, forming Earth scan swaths in which the visible and IR detector data are coincident. In the side 1 detector configuration, data from visible detectors V5 through V8 are lagged. These lagged data are combined with IR detector P1 through P7 data and visible detector V1 through V4 data gathered during the next scan to create a GVAR Block 0–10 sequence. This makes V5 the northernmost detector. For the side 2 detector configuration, data from visible detectors V5 through V8 and IR detectors R1 through R7 are lagged. The lagged data are combined with data from visible detectors V1 through V4 gathered during the next scan to create a GVAR Block 0–10 sequence, making V4 the northernmost detector.

The placement of Imager detector data within the Block 0 through 10 structure shown in Figure 3-1 is recorded in the Imager Documentation Block 0. Block 1 contains IR scan data for channels 4 and 5; Block 2 contains IR data for channels 2 and 3; and Blocks 3 through 10 contain visible detector data. The detector data position within the blocks is as follows:

Block 1:	Channel 4, Detector 1 (either P1 or R1)
	Channel 4, Detector 2 (either P2 or R2)
	Channel 5, Detector 1 (either P3 or R4)
	Channel 5, Detector 2 (either P4 or R4)
Block 2:	Channel 2, Detector 1 (either P5 or R5)
	Channel 2, Detector 2 (either P6 or P7)
	Channel 3, Detector 1 (either P7 or R7)
Block 3:	Visible Detector 5
Block 4:	Visible Detector 6
Block 5:	Visible Detector 7
Block 6:	Visible Detector 8
Block 7:	Visible Detector 1
Block 8:	Visible Detector 2
Block 9:	Visible Detector 3
Block 10:	Visible Detector 4.

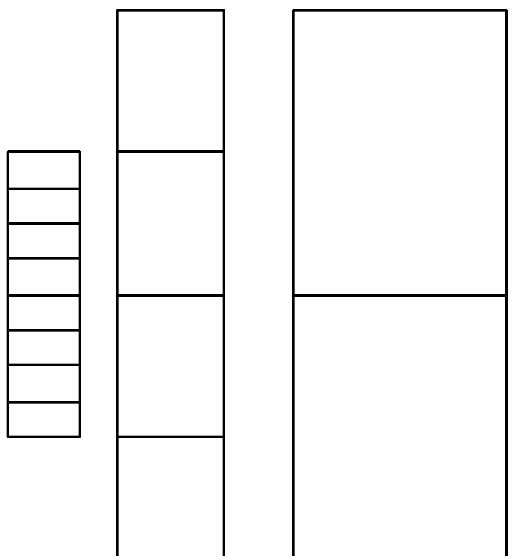
It is important to note that the Imager scans broadcast in GVAR are composed using the IR data to define the output swath. Under some conditions a full complement of detector data is not available for the Block 0–10 sequence. For example, in a side 1 configuration the first scan of a north-to-south frame always lacks visible detector data for the northernmost four lines. In this case, a "half-sided" scan is employed. A full GVAR Block 0–10 sequence is constructed, with fill data (zeros) substituted for the unavailable detector information. The resulting GVAR blocks generated are sized according to the requirements of the imaging frame width, and are denoted as containing fill data via the "Data Valid" flag in the corresponding block headers (see subsection 3.3.2.).

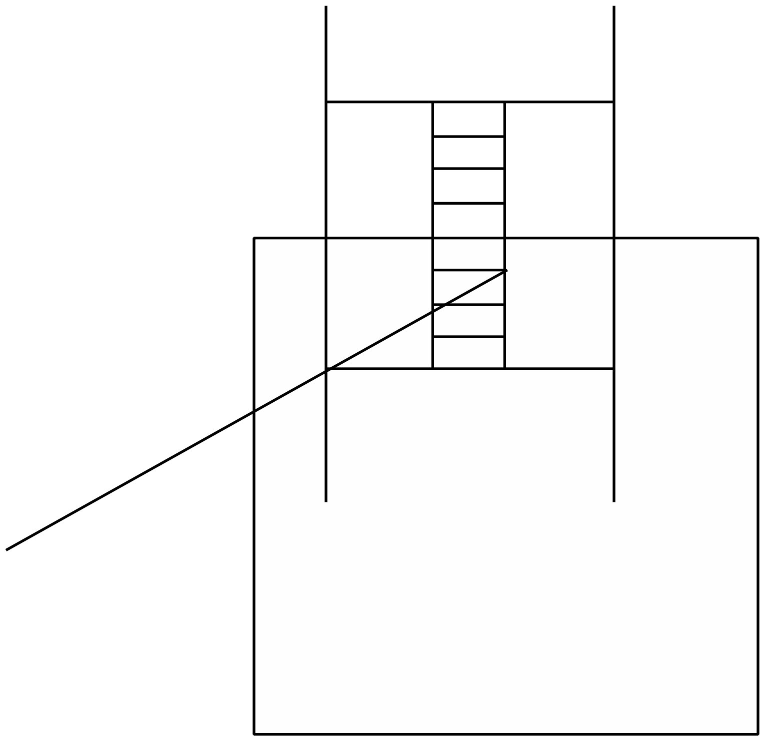
The side 1 start-of-frame, half-sided sequence described above occurs because of a lack of visible detector data to overlay the IR swath fully. The last scan of the same frame has the opposite condition— four extra lines of visible detector data for which an IR swath is never available. In this case the excess visible detector data are trimmed.

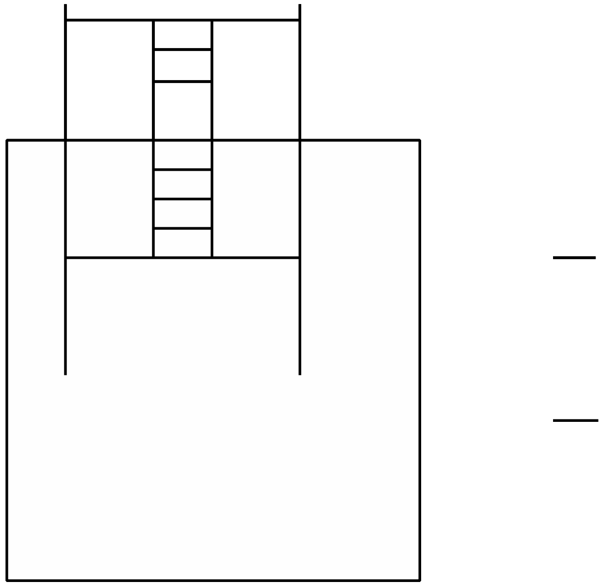
Half-sided Block 0–10 sequences are also generated when data disruptive frame breaks are encountered. These types of frame breaks arise under three conditions: 1) the occurrence of an instrument reset, 2) the loss of raw signal synchronization by the SPS, and 3) the occurrence of a priority frame interrupt. The occurrence of a reset causes the Imager to cancel all current or pending activities, entering a state in which only spacelook and blackbody calibrations are performed. The SPS responds to an instrument reset by dumping any lagged data held as a half-sided scan.

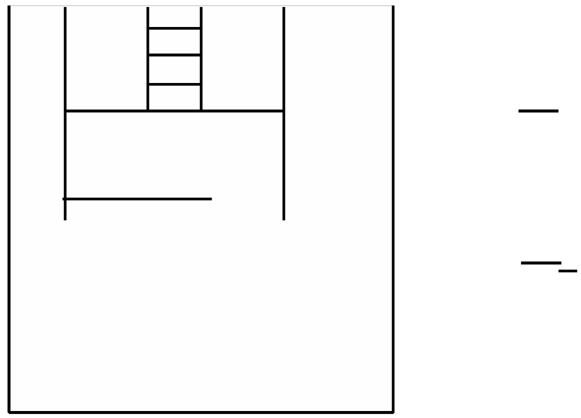
The loss of signal synchronization causes the loss of one or more frame scans. When synchronization is subsequently reestablished, the loss (detected as an excessive step in the north-south scan address) triggers a flushing of the currently held lagged data through a half-sided GVAR Block 0–10 sequence. The newly acquired scan generates a second half-sided sequence, similar to the start of a frame.

In a similar fashion, the interruption of a lower priority frame by a higher priority frame generates two successive half-sided Block 0–10 sequences, one to flush the lower priority lagged data, and one to start the higher priority frame. At the conclusion of the higher priority frame, one more half-sided sequence is generated, marking the restart of the interrupted lower priority frame. Note that half-sided scans are not generated for frame breaks caused by star senses since these do not disrupt the scan data









The above discussion of Imager output scan formation incorporated the assertion that the optical configuration of the IR and visible detectors is invariant. This is a simplification. In actuality, the IR detector arrays move about the optical axis as the plate upon which they are mounted flexes due to thermal distortions caused by thermal gradients within the instrument sun shield. These gradients vary over the course of a day and seasonally.

The magnitude of the IR detector array motion has been characterized in terms of visible detector offsets as follows:

North-south offset:	–8 to +8 lines
East-west offset:	–64 to +64 pixels

To ensure coregistration of the IR and visible data, the GVAR scan formation process is dynamically adjusted to compensate for the offsets. Compensations for the north-south offsets are made by adjustments to the recombination algorithm, increasing or decreasing the lagging applied to the visible detector data. Compensations for the east-west offsets are performed by clipping visible data lying outside the IR imagery, and filling in missing visible data.

3.2.2 Sounder

The physical and optical layout of the 24 Sounder detectors is depicted in Figure 3-6. Unlike the Imager, all of the Sounder's detectors are concurrently active during operations. The Sounder's detectors are split into a radiometric sounding group and a star sense detection group. The star sense detection array contains eight detectors, physically similar to the Imager's visible detector array. The four radiometric detector arrays (4 detectors/array) are physically disjoint but optically coincident and aligned. Three of these arrays work in conjunction with a rotating filter wheel assembly to provide radiometric coverage over 18 distinct IR spectral bands, and the fourth detector array is a visible array. Details concerning the 19 channels (spectral bands) covered by the Sounder's four radiometric arrays are provided in Table 3-2.

Sounder detector data is transmitted in GVAR within a Block 11 format sequence following the end of a Sounder scan line, as tabulated in Figure 3-1. Unlike the Imager, no scan-to-scan data lagging is required for the Sounder. Specific details concerning the internals of the Sounder Scan Data Block 11 format and the associated Sounder scan patterns are provided in subsection 3.3.7.3.

3.2.3 Yaw-Flipped Spacecraft GVAR Generation

By design the GOES N-Q spacecraft will have the capability to rotate 180^{o} about the yaw axis (yaw flip) seasonally to attain lower IR detector patch temperatures and thereby improve IR channel

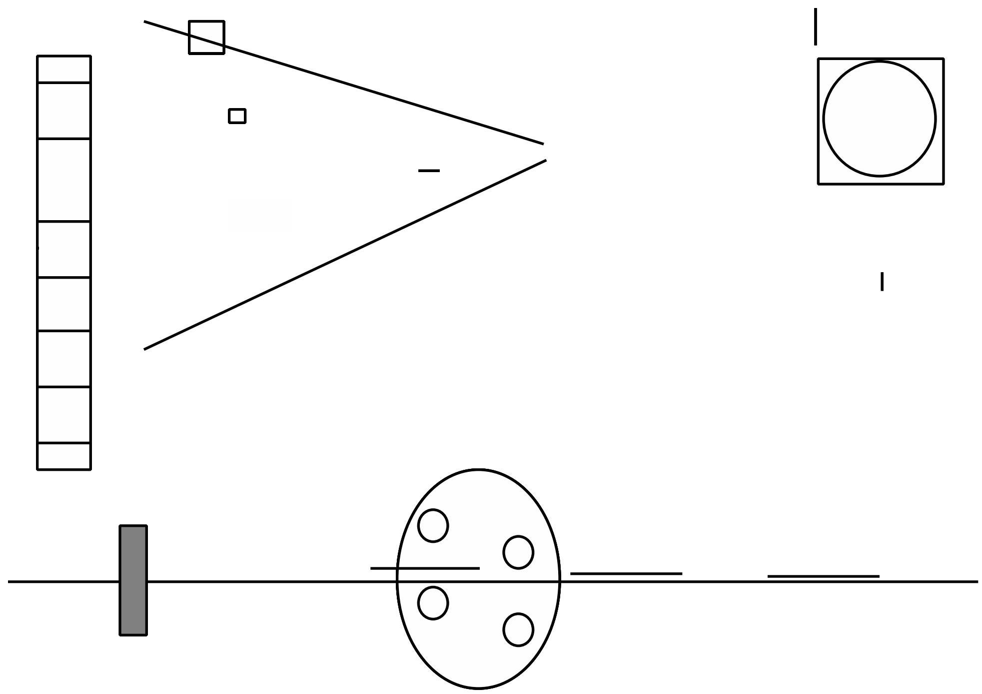


Table 3-2. Sounder Radiometric Channels

Detector	Channel Number	Central Wavelength (microns)	IGFOV (rad)	Purpose
Longwave	1	14.71	224	Temperature
	2	14.37		Sounding
	3	14.06		"
	4	13.64		"
	5	13.37		"
	6	12.66		"
	7	12.02		"
				Surface Temperature
Midwave	8	11.03	224	Surface Temperature
	9	9.71		Total Ozone
	10	7.43		Water Vapor
	11	7.02		Sounding
	12	6.51		"

Shortwave	13 14 15 16 17 18	4.57 4.52 4.45 4.13 3.98 3.74	224	Temperature Sounding " " " Surface Temperature "
Visible	19	.67	224	Cloud

performance. While yaw flipping was never envisioned for the GOES I-M spacecraft, a solar array drive failure on the GOES-10 spacecraft precluded operations in the forward drive direction. Fortunately, solar array operation in the reverse direction was successful. Operation in the reverse direction necessitated a yaw flip so the solar array could properly track the sun. A number of ground system (GIMTACS and the OGE) changes were required to support inverted mode (yaw flipped) operations.

Other than minor changes to algorithms detailed in the *Earth Location User's Guide*, yaw-flipped spacecraft imagery broadcast in GVAR remains in its nominal Earth orientation; that is, images start at the northernmost point on the Earth and scan in a southerly direction. To accomplish this, both the Imager and the Sounder scan from the bottom to the top of their field of view (FOV). The SPS then reverses the order of the physical detectors in the instruments to maintain the north-south ordering, and also reverses the east-west orientation to correct for that yaw flip-induced reversal.

3.2.3.1 Yaw-Flipped Imager – In the reversed (instrument bottom to top) scanning direction, the Imager's visible and IR detectors essentially swap positions relative to those in the normal, upright mode, so that the Earth-oriented, northernmost imagery is processed first. Physical visible detector 8 is swapped with detector 1, 7 with 2, etc. Likewise, physical IR detector 2 is swapped with physical detector 1 in channels 2, 4, and 5. The contents of the GVAR Block 0–10 sequence is then as follows:

Block 1:	Channel 4, IR Detector 2 (either P2 or R2)
	Channel 4, IR Detector 1 (either P1 or R1)
	Channel 5, IR Detector 2 (either P4 or R4)
	Channel 5, IR Detector 1 (either P3 or R4)
Block 2:	Channel 2, IR Detector 2 (either P6 or P7)
	Channel 2, IR Detector 1 (either P5 or R5)
	Channel 3, IR Detector 1 (either P7 or R7)
Block 3:	Visible Detector 4
Block 4:	Visible Detector 3
Block 5:	Visible Detector 2
Block 6:	Visible Detector 1
Block 7:	Visible Detector 8
Block 8:	Visible Detector 7
Block 9:	Visible Detector 6
Block 10:	Visible Detector 5.

3.2.3.2 Yaw-Flipped Sounder – Detector swapping also takes place for the Sounder to process data from north to south. Physical detector 4 is swapped with detector 1 and detector 3 with detector 2. The eight star sense detector array has the same layout as the Imager visible array, with detectors 1 through 4 on the top (or north) side of the optical axis and detectors 5 through 8 on the bottom side. These detectors are swapped in the same manner as the Imager visible detectors: detector 1 with 8, 4 with 5, etc.; and the star sense detector data is formatted in the same detector order as the Imager: 4,3,2,1,8,7,6,5.

3.2.4 Block Sequencing

The block sequence transmitted within the GVAR stream is actively varied by taking into account the priority and availability of each block type. The priority established for a given block type is based primarily on the associated input raw data rates and, to a lesser extent, is assigned so as to maintain sequential consistency with respect to the instrument functions. In general, because of its much higher input raw data rate, the Imager output is assigned a higher priority than the Sounder output. The Block 0 through 10 transmission is followed by a variable number of Block 11s, with Block 11s transmitted in the priority order indicated previously in Figure 3-1.

The Block 11 priority order is followed on a block-by-block output basis. For example, consider a case in which a Sounder Star Sense Statistics and Data Block 11 string comprising 9 blocks is the only GVAR data ready for output. Transmission of the first of the nine Block 11s is initiated. While this block is being transmitted, an Imager scan string (Blocks 0–10) becomes available. The next block transmitted is Block 0, followed by Blocks 1–10 in sequence. While the transmission of Block 10 is underway, the available list is again perused, and if no other higher priority blocks are available, the second of the 9-block Sounder star sense string is queued for output following the Block 10.

The established priorities do not in themselves explain the GVAR block sequencing that occurs for an active GOES satellite. To comprehend the GVAR block sequence, an understanding of the general operation of each instrument is necessary.

As indicated previously, the Imager and Sounder operate independently of one another, and can be commanded to scan variable size frames. While this would seemingly imply fairly random GVAR block sequencing, some aspects of the instruments’ behavior follow a predictable pattern that determines the GVAR block sequence. The Imager performs spacelook calibrations at variable rates ranging from once per second to once every 36.6 seconds, depending on the commanded instrument mode. The spacelook calibrations are reported once every two minutes in GVAR. The Imager performs ECAL and blackbody calibrations every 10 minutes, except when an image scan is in progress. In this case the calibrations are delayed until the end of the image frame. Star senses occur nominally every 30 minutes. These intervals vary somewhat depending on the scanning functions and star senses commanded from the ground. The SPS responds to data generated during these events by generating sequential, fixed sets of Block 11s. As the construction of each set is completed, the SPS places the set in the appropriate priority output queue. For example, the three sequential sets resulting from an Imager spacelook calibration and the four sequential sets from an Imager blackbody calibration are, respectively:

1. 1 Telemetry Statistics Block 11
2. 6 Spacelook Statistics and Data Block 11s
3. 1 Calibration Coefficients and Limits Block 11,

and

1. 2 ECAL Statistics and Data Block 11s
2. 2 Blackbody Statistics and Data Block 11s
3. 1 Calibration Coefficients and Limits Block 11
4. 2 Visible NLUT Block 11s.

The Sounder performs a spacelook calibration every two minutes, an ECAL and blackbody calibration with every 10th spacelook (i.e., every 20 minutes), and a star sense every 30 minutes. As with the Imager, these intervals vary somewhat according to the Sounder commanded scanning functions; but this variability is much less than for the Imager, because the calibration sequences are permitted to interrupt a scan line at raw block boundaries. The GVAR Block 11 set resulting from a star sense consists of nine Star Sense Data and Statistics Block 11s. For a spacelook calibration the Block 11 set comprises:

1. 1 Telemetry Statistics Block 11
2. 5 Spacelook Statistics and Data Block 11s
3. 2 Calibration Coefficients and Limits Block 11s.

The Sounder performs an ECAL in conjunction with blackbody calibrations, with the corresponding GVAR Block 11 set comprising:

1. 3 ECAL Statistics and Data Block 11s
2. 5 Blackbody Statistics and Data Block 11s
3. 2 Calibration Coefficients and Limits Block 11s
4. 9 Visible NLUTs Block 11s.

Figure 3-7 illustrates a typical Sounder scan sequence and the Block 11 output strings the SPS generates, with the effects of Imager and Sounder Compensation and Servo Error Data Block 11s ignored for clarity.

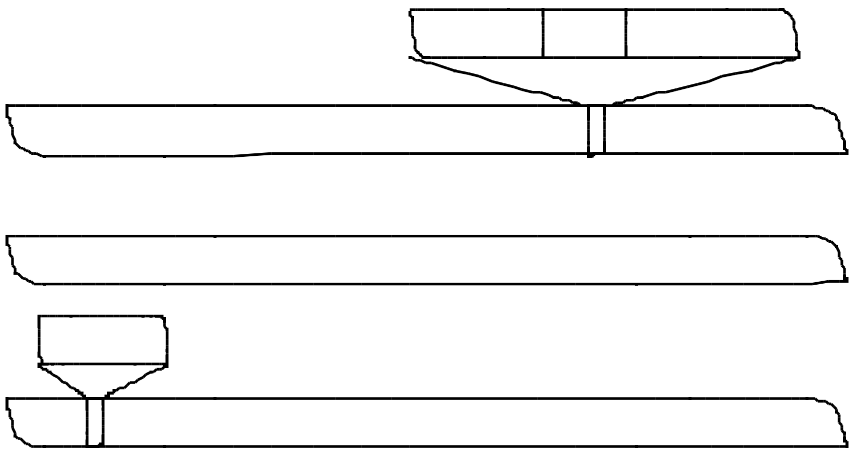
There are three points to note concerning the sets mentioned, which impact the Imager and Sounder GVAR bandwidth usage:

1. Each set can be expected to occur at fairly regular intervals
2. The sets are always generated in a particular sequence
3. Each set is placed in the output queue as it is completed.

3.2.5 Bandwidth Considerations

The output bandwidth available for GVAR is 2,111,360 bps. All of the various GVAR block types must fit within this channel bandwidth without significant delays; otherwise, a data pileup occurs within the SPS, with a concomitant loss of data. The bandwidth requirements can be calculated for each of the instrument block types. For scan related data, the required bandwidth is a function of scan width (frame size). For non-scan data (e.g., calibrations, statistics, NLUTs, star senses), the required bandwidths can be treated as a constant time-dependent overhead. The non-instrument data (messages and auxiliary data) can be characterized indirectly according to the bandwidth of the associated ingest channels.

Table 3-3 provides a synopsis of the equations describing the Imager bandwidth requirements, including the requirements directly related to instrument scan functions (Blocks 0–10 and compensation terms) and the relatively scan-independent Block 11 overheads.



As previously mentioned, Imager Blocks 1–10 vary in length in direct proportion to image scan width, except for a lower limit of 32,208 bits. This block size includes overhead (O/H) consisting of a 10,032-bit block synchronization code, a 720-bit block header, and a 16-bit block CRC. The lower limit ensures a minimum block processing time of 15.25 milliseconds at a GVAR receiver. This equates to a maximum block rate of 65.6 GVAR blocks/second, and forces a minimum data field length (MDFL) of 21,440 bits/block, or one third of the Block 0 and 11 fixed data field length of 64,320 bits. For Imager scan widths of less than approximately 1.9^{o}, this requires GVAR block lengths greater than is warranted by the data contained. The excess space is zero filled. The effect of the MDFL imposition is to raise the bandwidth overhead for small Imager scans.

Table 3-4 provides equations describing the Sounder bandwidth requirements. Since all of the Sounder data is transported via Block 11s, no direct MDFL requirement is involved, although one exists to the extent that the Blocks 11s employed are under-utilized when transporting the various data types.

The equations provided in Tables 3-3 and 3-4 are simplified in that they ignore instrument dead times during which the instruments produce no data for GVAR transmission. These dead times are generally associated with the slewing of the instrument scan mirror to or from a location at which a function is to performed, such as star senses, spacelooks, and blackbody calibrations. The Imager has additional dead times at the frame start or restart after a spacelook, star sense, or priority interruption, during which time it generates three invalid scans before generating a valid one. As a result of these simplifications, the equations provide a conservative (slightly high) value of the bandwidth requirements.

It can be seen that both instruments possess a bandwidth requirement component dependent on the associated frame scan width and a component that is nearly independent of the frame scan width. To assess the GVAR bandwidth utilization, each instrument’s requirements can be computed over the full range of scan widths. The total bandwidth requirement for any combination of frame scan widths can then be computed.

The graph presented in Figure 3-8 is derived using the equations provided in Tables 3-3 and 3-4. It denotes the percentage of the total GVAR bandwidth required as the scanning width is varied from 0.2^{o} to 19.2^{0} for the Imager and Sounder, as well as the total for both. The spare bandwidth is also shown. Since the Imager and Sounder scan widths can be set independently, there are situations where the total bandwidth requirement could exceed the available 2,111,360 bps bandwidth. These regions, or exclusion zones arise from three primary sources of GVAR overhead:

1. The 10,032 bit block synchronization code (13.4% of each Block 11)
2. The 21,440 bit MDFL requirement imposed on small GVAR Blocks 1 through 10
3. The Sounder documentation Block 11 prefixing each Sounder scan line output.

Table 3-3. Imager GVAR Bandwidth Requirements

MDFL	= Minimum Data Field Length (bits)	=	21,440
ISWD	= Scan Width (degrees)	=	0.2^{o} to 19.2^{o}

IRB = Imager Raw Data (raw blocks) = ISWD (17453.29252 â 64)

IST = Imager Scan Time (seconds) = 0.2 + ISWD â 20.02

BOH = Block Overhead (bits) = 10,768

Imager Block 0 through 10 Bandwidth Requirements:

If ISWD = 0, then B0 = B1 = B2 = B3 = 0; otherwise

B0 = Block 0 data length (bits) = 64,320

B1 = Block 1 data length (bits) = MDFL if MDFL > 4(160 + 10 IRB)
else = 4 (160+10 IRB)

B2 = Block 2 data length (bits) = MDFL if MDFL >3 (160 + 10 IRB)
else = 3 (160+10 IRB)

B3 = Block 3 data length (bits) = MDFL if MDFL > (160 + 40 IRB)
else = (160 + 40 IRB)

ISCAN = Total B0 å B10 length (bits) = B0 + B1 + B2 + 8B3 + (11 BOH)

ISTT = GVAR Tx time (seconds) = ISCAN â 2111360

ISTSN = Spare time/scan (seconds) = IST å ISTT

ISTSC = Spare time/second (seconds) = ISTSN â IST

Imager Block 11 Bandwidth Requirements – in Units of Block 11s/second

ICSE = Compensation and Servo Errors = 1 â 4.3

ITLM = Telemetry Statistics = 1 â 120

ISPC = Spacelook Statistics and Data = 6 â 120

IECL = ECAL Statistics and Data = 2 â 600

IBBC = Blackbody Statistics and Data = 2 â 600

ICAL = Cal Coefficients and Limits = 1 â 120 + 1 â 600

INUT = Visible NLUTs = 2 â 600

ISTR = Star Sense Statistics and Data = 9 â 1800

IB11OH = Imager Block 11 Overhead = SUM (ICSE ß ß ISTR) = 0.31589

Notes:

17453.29252 – the number of rads/degree

64 – the number of rads/raw data block

0.2 – the instrument scan reversal time

20.02 – the instrument scan rate in degrees/second.

BOH – the block synch + header + CRC (10,032 + 720 + 16)

Table 3-4. Sounder GVAR Bandwidth Requirements

SSWD	=	Scan Width (degrees)	=	0.2^{o} to 19.2^{o}
SRB	=	Sounder Raw Data (blocks)	=	SSWD (17453.29252 â 280)
SST	=	Sounder Scan Time (seconds)	=	0.1 (SRB + 1)

Sounder Block 11 Bandwidth Requirements – in Units of Block 11s/second

SSCAN	=	Sounder Documentation/Scan	=	(1 + RND(0.4091 + SRB â 11)) â SST
SCSE	=	Compensation/Servo Errors	=	1 â 6.4
STLM	=	Telemetry Statistics	=	1 â 120
SSPC	=	Spacelook Statistics/Data	=	5 â 120
SECL	=	ECAL Statistics/Data	=	3 â 1200
SBBC	=	Blackbody Statistics/Data	=	5 â 1200
SCAL	=	Cal Coefficients/Limits	=	2 â 120 + 2 â 1200
SNUT	=	Visible NLUTs	=	9 â 1200
SSTR	=	Sounder Star Stats/Data	=	9 â 1800
SBOH	=	Sounder Block 11 Overhead	=	SUM (SSCAN ß ß SSTR)

GVAR Bandwidth Requirements - in bps

Imager	=	IBW	=	(1 å ISTSC) 2111360 + 75088 IB11OH
Sounder	=	SBW=		75088 SBOH
Spare	=	2111360 å IBW å SBW		

Notes:

17453.29252	–	the number of rads/degree
280	–	number of rads/raw data block
0.1	–	instrument raw data block time
RND	–	a function rounding to nearest integer
0.4091	–	a factor to force a rounding up if there is one extra raw block
SUM	–	a function summing all included components
2,111,360	–	the available GVAR output rate in bps
75,088	–	the total length of any Block 11 (64,320 + BOH).

For each of three sources of overhead, the most negative effects are found at small scan widths where the overheads outweigh the instrument data being transported. For the Imager, the synchronization code and the MDFL represent over 90% of the bandwidth requirement for a 0.2^{o} scan width. A similar scan width for the Sounder yields 57% of the bandwidth requirement being allocated for non-instrument data. As the instrument scan widths are increased, the percentage of the GVAR output bandwidth allocated to overhead declines, approaching 5% for the Imager visible data, and 13.4% for Sounder scan data.

In addition to the instrument data, the GVAR stream must also provide transport for text messages (from the SPS operator and GIMTACS) and auxiliary data products. The text messages are low rate in the sense that the ingest channel available for their reception at the SPS is narrow, only 9600 bps. Additionally, their expected frequency of occurrence is very small, being occasional in nature. The auxiliary data, on the other hand, has a relatively wide 57,344 bps ingest channel and its expected usage rate is unknown. To provide room for each of these three sources within the GVAR stream, an allocation of one Block 11 per second should be conservatively safe. With this in mind, adequate bandwidth exists to support all functions for both instruments as well as the text and auxiliary data if the following scan width constraints are followed:

Imager: No constraints if Sounder is inactive (not scanning). If the Sounder is active, Imager scan widths should be greater than 0.3^{o}.

Sounder: No constraints if the Imager is inactive. If the Imager is active with a scan width of less than 14.4^{o}, the Sounder scan widths need to be greater than 0.3^{o}. If the Imager scan widths are greater than 14.4^{o}, the Sounder scan widths need to be greater than 0.6^{o}.

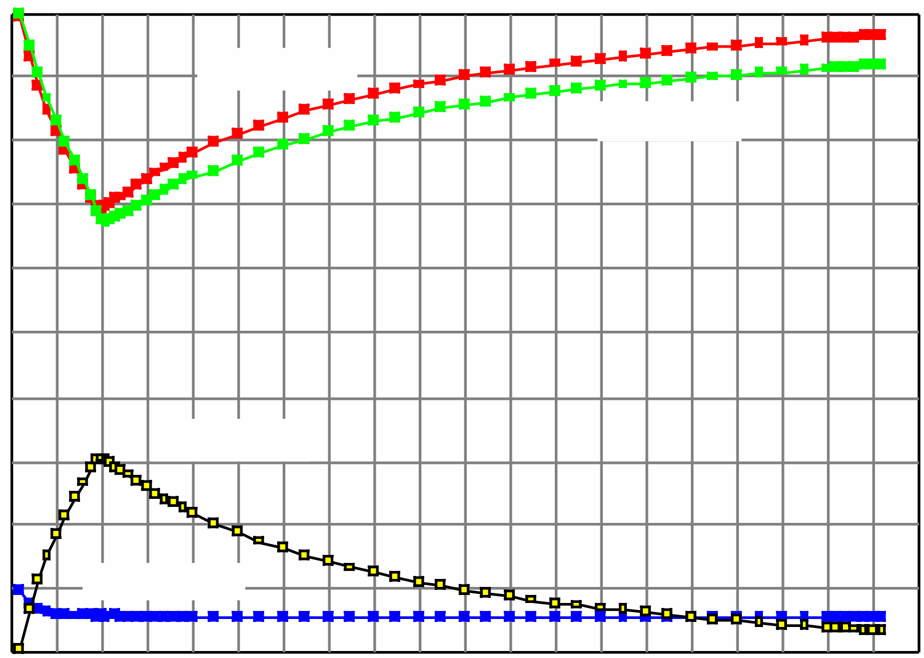
It should be realized that these constraints can be relaxed up to the exclusionary zone boundaries without loss of any instrument data. The only penalty invoked by doing so is to increase the time required to complete the transmission of any text and auxiliary data that may be ready for GVAR output.

3.2.6 Transmission Delays

The GVAR formatted data is received by a user after some variable time delay from the point at which the data was actually measured by the onboard instruments. There are primarily two components in the delay time: transit time and SPS processing time.

Delays caused by signal transit times are in the range from 0.5 to 1.0 seconds and include three stages:

1. Satellite-to-SPS: raw data
2. SPS-to-Satellite: GVAR transmission
3. Satellite-to-user: GVAR transmission.



The largest time delay component occurs in the SPS processing that transforms the raw data into GVAR formatted data. The Imager data contained within Blocks 1–10 is calibrated data ordered in a west-to-east sequence. Calibration is performed on the data after it is received within the SPS and a drift bias measurement has been acquired. The SPS buffers all Imager scan data until it computes the drift bias measurement. The length of time required to obtain the drift bias measurement varies as a function of the current frame type, and can range from approximately one second to 38 seconds. After IR calibration has been performed, the transmission of Blocks 0–10 is enabled.

The SPS performs a similar buffering process is performed on the Sounder data, primarily to permit west-to-east ordering. Sounder data calibration is performed after all of the raw data for a scan has been received. The calibration procedure generates 76 arrays (one array for each Sounder channel-detector) of calibrated pixel information. These arrays, along with the original raw Sounder data blocks, are then sectioned and packaged into the Sounder Scan Data Block 11 format. A full-width (19.2°) single-dwell Sounder scan requires 110 Block 11s for complete transmission. The buffering process for an uninterrupted Sounder scan of the above type can extend to as long as 120 seconds. The subsequent calibration and Block 11 sectioning would take between 10 and 15 seconds to perform. Finally, transmission of the 110 Block 11s could take anywhere from 3.9 to 52.9 seconds depending on the then current GVAR output requirements.

3.2.7 Encoding

Prior to biphase modulation and uplink of the GVAR stream, the GVAR data undergoes three stages of encoding, as described below and illustrated in Figure 3-9:

1. All even numbered eight-bit bytes (regardless of word length) are complemented, with the first byte following initial synchronization being byte number one.

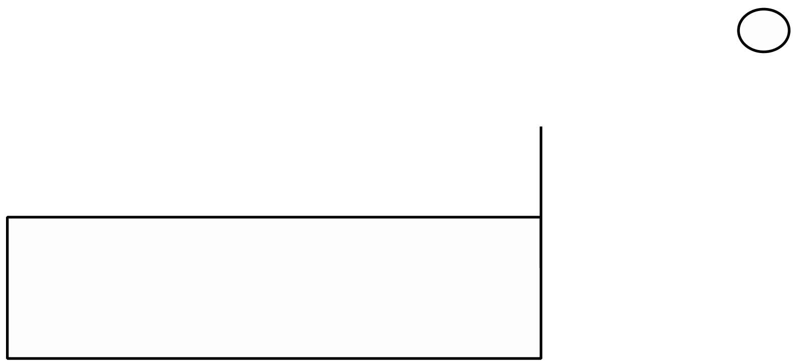
2. Pseudo-random noise (PN) coding with a PN sequence generated by a shift register whose input is the output of an exclusive-OR gate as shown in Figure 3-9. Bits 8 and 15, the MSBs of the shift register, are the inputs to this gate. The output of the gate is combined with a data line using a second exclusive-OR gate.

3. The PN-coded data stream is then passed through an NRZ-S differential encoding process, producing a transition for each logic zero input and none otherwise.

3.3 Block Format

Each GVAR block contains the following primary fields:

1. Block Synchronization Code
2. Header
3. Data Section
4. Cyclic Redundancy Check.



Fields 1, 2, and 4 are fixed in size and have an internal structure identical for all GVAR blocks. Field 3, the Data Section, has an internal substructure dependent on the block type. GVAR Blocks 1–10 have data sections with constant internal structures, but whose sizes vary as a function of the Imager’s scan line length. Blocks 0 and 11 have fixed, equal-length data sections. Block 0 maintains an unchanging structure, and Block 11 has a number of different internal structures defined according to the usage of the block.

The following subsections describe the four primary fields, with the data field presented last because the definitions constitute the bulk of the document.

3.3.1 Block Synchronization Code

Each GVAR block is prefaced with a 10,032-bit code for use in synchronizing receiving equipment. The code is a PN sequence generated as described in subsection 3.2.7 and shown in Figure 3-9. The shift register is preset to 51,665 octal so the contents (15 bits) are a logic one during the final bit period of the initial synchronization sequence.

3.3.2 Block Header

The GVAR header has been defined to maintain compatibility with the AAA format header. It consists of 30 eight-bit words, three copies of which are transmitted in each header field to increase the chances of error-free recovery. An error check field completes each header. Figure 3-10 depicts the header organization, and Table 3-5 describes the header contents.

```
WORD
   |---------------------------------------------|
 1 |           BLOCK IDENTIFICATION              |
   |---------------------------------------------|
 2 |                WORD SIZE                    |
   |                                             |
 3 |                                             |
   |---------------------------------------------|
 4 |                WORD COUNT                   |
   |                                             |
 5 |                                             |
   |---------------------------------------------|
 6 |           PRODUCT IDENTIFICATION            |
   |---------------------------------------------|
 7 |                REPEAT FLAG                  |
   |---------------------------------------------|
 8 |               VERSION NUMBER                |
   |---------------------------------------------|
 9 |               DATA VALID FLAG               |
   |---------------------------------------------|
10 |             ASCII / BINARY FLAG             |
   |---------------------------------------------|
11 |                  SPARE                      |
   |---------------------------------------------|
12 |                RANGE WORD                   |
   |---------------------------------------------|
13 |           VALID BLOCK SEQUENCE              |
   |                                             |
14 |                 COUNTER                     |
   |---------------------------------------------|
15 |                 SPARES                      |
   |                                             |
16 |                                             |
   |---------------------------------------------|
17 |             CURRENT SPS TIME                |
 ! |           (CDA BCD TIME CODE)               |
 ! |                                             |
24 |                                             |
   |---------------------------------------------|
25 |                 SPARES                      |
 ! |                                             |
28 |                                             |
   |---------------------------------------------|
29 |               ERROR CHECK                   |
   |                 FIELD                       |
   |                                             |
30 |---------------------------------------------|
```

Figure 3-10. Header Organization

Table 3-5. Header Contents

WORD	CONTENTS	DESCRIPTION

1 BLOCK ID An 8-bit binary number used to identify a GVAR block as follows:

240	=	GVAR Block 0
1	=	GVAR Block 1
2	=	GVAR Block 2
3	=	GVAR Block 3
4	=	GVAR Block 4
5	=	GVAR Block 5
6	=	GVAR Block 6
7	=	GVAR Block 7
8	=	GVAR Block 8
9	=	GVAR Block 9
10	=	GVAR Block 10
11	=	GVAR Block 11
15	=	Equipment Idle Block[1]

2 WORD SIZE An eight-bit binary number giving the word bit length of the subsequent information field as follows:

6	=	6-bit word size
8	=	8-bit word size
10	=	10-bit word size

3–4 WORD COUNT A 16-bit binary number giving the number of words contained in the subsequent information field plus two. The extra two represents the two 8-bit words containing the block CRC.

5–6 PRODUCT ID A 16-bit binary number used to identify information field data. Numbers used are:

0	=	No Data
1	=	AAA IR Data
2	=	AAA Visible Data
3	=	GVAR Imager Documentation
4	=	GVAR Imager IR Data
5	=	GVAR Imager Visible Data
6	=	GVAR Sounder Documentation
7	=	GVAR Sounder Scan Data
8	=	GVAR Compensation Data
9	=	GVAR Telemetry Statistics
10	=	GVAR Auxiliary Text
11	=	GMACS (GIMTACS) Text

Table 3-5. Header Contents (Cont'd)

WORD	CONTENTS	DESCRIPTION
		12 = P/DU (SPS) Text 13 = AAA Sounding Products 14 = GVAR ECAL Data 15 = GVAR Spacelook Data 16 = GVAR Blackbody Data 17 = GVAR Calibration Coefficients 18 = GVAR Visible NLUTs 19 = GVAR Star Sense Data 20–1000 = Unassigned 1001–65535 = Auxiliary Product Imagery ID
7	REPEAT FLAG	An eight-bit flag that indicates whether the data being transmitted is new data or a repeat of data previously transmitted: 0 = Data Repeat 1 = New Data
8	VERSION NUMBER	An eight-bit binary number that indicates one variation of a product as opposed to another. Range is 0 (baseline version) to 255 (version 255).
9	DATA VALID	An eight-bit flag which indicates whether the transmitted data is usable or only filler: 0 = Filler Data 1 = Valid Data
10	ASCII/BINARY	An eight-bit flag that indicates the format of the data in the data field to be either ASCII or binary: 0 = Binary Data 1 = ASCII Data
11	NONE	Spare word; not currently used.
12	RANGE WORD	An eight-bit word used for ranging functions. The first 4 bits are a binary number identifying the data source spacecraft. The last four digits are always zero except when a ranging function is in progress; then they are set to ones according to the type of ranging function. The first 4 bits have a value as follows: 8 = GOES-I 9 = GOES-J 10 = GOES-K 11 = GOES-L 12 = GOES-M The last 4 bits have the following possible hexadecimal values: 0 = Not a measurement block

Table 3-5. Header Contents (Cont'd)

WORD	CONTENTS	DESCRIPTION
		7 = Satellite ranging measurement block F = Ground path delay measurement block
13–14	BLOCK COUNT	A 16-bit continuous count of GVAR blocks transmitted. Values range from 0 to 65535, inclusive, rolling over to 0 following 65535. Count is incremented by 1 for each successive GVAR block transmitted. Count does not increment for Equipment Idle Blocks.
15–16	NONE	Spare words; not currently used.
17–24	SPS TIME	A 64-bit BCD time code applied at CDA at transmission time.
25–28	NONE	Spare words; not currently used.
29–30	ERROR CHECK	A 16-bit error checking field used to validate transmission accuracy of the header information. This is derived in the same way as the information field error check (CRC). Refer to subsection 3.3.3.

NOTE:

1. The Equipment Idle Block (EIB - Block 15) is generated automatically by the GVAR transmission hardware when no other block definitions are present. The EIB is 32,208 bits in length and includes 21,440 zero data bits.

Two additional fields are defined in the GVAR header in words which are unused in the AAA format. The *range* word was added to support satellite ranging functions. It contains information which is only useful to the OGE. A GVAR block sequence counter has been added to permit a receiver to determine the number of GVAR blocks which have been transmitted. The GVAR variability in block sequence and length prevents usage of a timed counter as was permitted by AAA.

3.3.3 Block Cyclic Redundancy Check (CRC)

The error detection method employed in the GVAR transmission involves a CRC. The process is an algebraic procedure based on modulo-2 division using a polynomial to generate and check the Frame Check Sequence (FCS). At the transmitter, the initial remainder of the division is preset to 16 ones. After the all ones preset, the initial remainder is then modified by division by the generator polynomial. This division is performed on the contents of the field being checked. Upon completion of the division process, the ones complement of the resulting remainder is transmitted as the 16-bit FCS.

The generator polynomial is that specified by CCITT Recommendation V41 and is: $x^{16} + x^{12} + x^5 + 1$.

3.3.4 Block 0 Data Section

The GVAR Block 0 information field is 64,320 bits in length. It consists of 8040 eight-bit words divided into five partitions:

WORDS	DESCRIPTION
1–278	Instrument and Scan Status
279–1626	Instrument Orbit and Attitude (O&A) Data
1627–2306	Scan Reference Data
2307–5386	Grid Data
5387–6304	Scan Reference and Calibration Data
6305–8040	Factory Parameters

The layout and definition of these six partitions is provided in Table 3-6. Supporting commentary is provided in following subsections.

3.3.4.1 Instrument and Scan Status – This partition summarizes the state of the Imager and the current imaging frame. Time tags denoting significant events and identifying various process entities are provided. Additionally, coordinate information locating points are included for the various reference frames.

The flag bits in words 3–6 provide the primary status for the accompanying Block 1–10 data. They denote the presence of normal or priority frame data, and provide frame-start/frame-end indicators. They are also used to denote whether or not a data loss condition has been detected. The detector relevant flags in bits 14–31 are controlled by the OGE operators. They indicate the type of processing performed by the SPS on the raw detector data, such as whether or not visible normalization and IR calibration have been performed. The side 1/side 2 flag denotes which set of IR detectors the SPS currently considers to be active, and hence also indicates the output scan formation approach and database coefficients for conversions. The condition of the imaging detector data (valid, substituted) is also indicated by these flags.

3.3.4.2 Instrument O&A Data – This partition contains the parameters and coefficients currently in use which describe the Imager O&A data. The data in this section is acquired from the OATS. How the data is used depends upon the status of the Image Motion Compensation

(IMC) function. If IMC is active, the O&A data is valid for a fixed period called the registration interval. If IMC is not active, the O&A values only apply to a single point in time. Under these conditions, the O&A information must be translated through time to the desired calculation point.

3.3.4.3 Output Scan Reference Data – This partition provides co-registration table identity and the east-west co-registration offset terms currently available to the SPS. The north-south offsets are contained in the fifth partition (words 6235–6282). The co-registration index (word 1679) denotes which of the 48 offsets is currently in use. If this word is zero, co-registration functions are disabled.

Also contained in this partition are copies of the current and latest lagged raw header and trailer data associated with the output scan contained in GVAR Blocks 1–10. The raw contents of the most recent telemetry data blocks are also provided, including copies of the four command registers. The oldest lagged header and trailer data blocks are included in the fifth partition.

3.3.4.4 Grid Data – The grid data partition provides up to 1024 grid points. A grid point in this context refers to a particular feature of the Earth's surface whose geographic latitude and longitude coordinates are known. If an Imager swath intersects this feature, the particular pixel having the same geographic coordinates is recorded as a grid point. All grid point intersections are associated with the Imager visible data contained in GVAR Blocks 3–10.

The gridding partition contains two sets of two arrays, each set recording up to 512 intersections associated with a particular grid point database. The two arrays comprising a set are parallel in that the i^{th} entry in one denotes the intersecting detector, while the i^{th} entry in the other denotes which pixel for that detector actually intersected the feature.

3.3.4.5 Scan Reference and Calibration Data – This partition starts with the oldest lagged header and trailer data blocks associated with the current output scan. It ends with the north-south co-registration offset array. In between are the IR calibration data sets associated with the output scan.

Each Imager output scan in the GVAR data stream has a specific set of calibration terms assigned to the IR data. These terms (bias, first- and second-order gains, and bias rates) are provided in this partition. Included with the terms are the statistics for the clamped and drift bias measurements from which the bias rates were computed, and interpolated western edge bias terms.

Table 3-6. Imager Documentation Block 0 Format Definition

WORD	NAME	DESCRIPTION
1	SPCID	Spacecraft ID: a binary number identifying the source satellite as follows: 8 = GOES-I valid 9 = GOES-J GVAR 10 = GOES-K assignments 11 = GOES-L 12 = GOES-M
2	SPSID	Sensor Processing System (SPS) Identity: a binary number identifying the source SPS which formatted the GVAR data stream. Values 1–4 are assigned to SPS1–SPS4, respectively.
3–6	ISCAN	Imager Scan status is provided in four words (32 bits); bit 0 is the MSB of word 3, and bit 31 is the LSB of word 6:

Bit		Condition
0	=	1 if frame start
1	=	1 if frame end
2	=	1 if frame break - line(s) lost
3	=	1 if pixel(s) lost
4	=	1 if priority 1 frame data
5	=	1 if priority 2 frame data
6	=	0 if west-to-east scan
	=	1 if east-to-west scan
7	=	0 if north-to-south frame
	=	1 if south-to-north frame
8	=	1 if IMC active
9	=	1 if lost header block
10	=	1 if lost trailer block
11	=	1 if lost telemetry data
12	=	1 if (star sense) time break
13	=	0 if side 1 (primary) active
	=	1 if side 2 (secondary) active
14	=	1 if visible normalization active
15	=	1 if IR calibration active
16	=	1 if yaw flip processing enabled
17–23	=	Correspond to active IR detectors 1–7. A set bit indicates the associated detector data is invalid.
24–31	=	Correspond to visible detectors 1–8. A set bit indicates the associated detector data is invalid.

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	**NAME**	**DESCRIPTION**
7–22	IDSUB	A 16-entry detector substitution matrix. The first entry denotes the number of substitutions in effect (ranges: 0 = none to 15 = all). The last 15 entries sequentially assigned to detectors IR1–IR7, V1–V8). A non-zero value indicates the associated detector data in Blocks 1–10 is substituted data acquired from the detector whose number is entered.

The following 128 words provide CDA time tags for 16 specific events. Each time tag is eight words in length, formatted as follows:

WORD	**BITS**	**BCD FORMATTED CONTENTS**
1	0–3	Year in 1000s
	4–7	Year in 100s
2	0–3	Year in 10s
	4–7	Year in 1s
3	0–3	Day of year (DOY) in 100s; bit 0 = 1 indicates the time code generator is flywheeling
	4–7	DOY in 10s
4	0–3	DOY in 1s
	4–7	Hours in 10s
5	0–3	Hours in 1s
	4–7	Minutes in 1s
6	0–3	Minutes in 1s
	4–7	Seconds in 10s
7	0–3	Seconds in 1s
	4–7	Milliseconds (msec) in 100s
8	0–3	Msec in 10s
	4–7	Msec in 1s

WORD	**NAME**	**DESCRIPTION**
23–30	TCURR	Current SPS time.
31–38	TCHED	Time of current header block.
39–46	TCTRL	Time of current trailer block.
47–54	TLHED	Time of lagged header block.
55–62	TLTRL	Time of lagged trailer block.
63–70	TIPFS	Time of priority frame start.

WORD	**NAME**	**DESCRIPTION**
71–78	TINFS	Time of normal frame start.
79–86	TISPC	Time of last spacelook calibration.

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	NAME	DESCRIPTION
87–94	TIECL	Time of last electronic calibration.
95–102	TIBBC	Time of last blackbody calibration.
103–110	TISTR	Time of last star sense.
111–118	TLRAN	Time of last ranging measurement.
119–126	TIIRT	Time tag of current IR calibration set.
127–134	TIVIT	Time tag of current visible NLUT set.
135–142	TCLMT	Time tag of current Limits set.
143–150	TIONA	Time tag current O&A set implemented.

The following 128 words provide information associated with the Imager's reference frames and the current imaging frame:

WORD	NAME	DESCRIPTION
151–152	RISCT	Relative output scan sequence count since frame start. Ranges 1–1974.
153–154	AISCT	Absolute number of the current output scan. Values of 1 to 1974 correspond to output scans (northernmost to southernmost).
155–156	INSLN	The number of the northernmost visible detector scan line in the current scan. Inclusive values of 1 to 15780 correspond to detector lines (northern-most to southernmost.
157–158	IWFPX	The number of the westernmost visible pixel in the current frame. Inclusive values of 1 to 30677 correspond to the pixels (westernmost to easternmost).
159–160	IEFPX	The number of the easternmost visible pixel in the current frame. Inclusive values of 4 to 30680 correspond to the pixels (westernmost to easternmost).
161–162	INFLN	The number of the northernmost visible detector scan line in the current frame. Inclusive values of 1 to 15780 correspond to detector lines (northernmost to southernmost).

WORD	**NAME**	**DESCRIPTION**
163–164	ISFLN	The number of the southernmost visible detector scan line in the current frame. Inclusive values of 8 to 15787 correspond to detector lines (northernmost to southernmost).
165–166	IMDPX	The number of the visible pixel corresponding to an instrument azimuth of 0^{o}. Nominal value (_ full range) is 15340. This value is an instrument-specific constant.

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

167–168 IMDLN The number of the scan line corresponding to an instrument elevation of 0^o. Nominal value (_ full range) is 7894.This value is an instrument- specific constant.

169–170 IMDCT The number of the output scan corresponding to an instrument elevation of 0^o. Nominal value (_ full range) is 987.This value is an instrument-specific constant.

The following four terms (words 171–182) are computed using the current O&A set. If IMC is active, the terms reflect the reference subsatellite point position. If IMC is off, the terms reflect the actual subsatellite point.

171–172 IGVLNThe number of the visible detector scan line which intersects the subsatellite point.

173–174 IGVPXThe number of the visible pixel which intersects the subsatellite point.

175–178 SUBLA The subsatellite point latitude. Value is a floating point number with units of degrees.

179–182 SUBLO The subsatellite point longitude. Value is a floating point number with units of degrees.

183 CZONE Current compensation zone (0–32) is an 8-bit integer number. A zero value indicates that no compensation is being performed. Values 1–32 denote the latitudinal zone for which corrections are applied.

184 V1PHYThe physical detector number (1–8) assigned to GVAR Block 3.

185–186 G1CNT GRID 1 active entry count (0–512) is a 16-bit integer number. See words 2307–5386.

187–188 G2CNT GRID 2 active entry count (0–512) is a 16-bit integer number. See words 2307–5386.

WORD NAME DESCRIPTION

189–190 PBIAS East-west grid bias (0 Å 12546 pixels) is a signed 15-bit integer number denoting the pixel offset employed for the grid data. A value of zero indicates the grid is not shifted from the locations computed using the current O&A.

191–192 LBIAS North-south grid bias (0 Å 7892 pixels) is similar to east-west grid bias, except in the north-south direction.

193 ISCP1 Odd parity byte computed for ISCAN (words 3–4)

194 Spare – not used.

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	NAME	DESCRIPTION
195–198	IDBER	Current raw data bit error rate is a floating point number denoting most recent measure of raw data error rate. Nominal values are on the order of 1.0E–6.
199–202	RANGE	Most recently computed range – a floating point value denoting number of 50-MHZ clock counts for signal transmission from satellite to ground.
203–206	GPATH	Most recent range calibration ground path delay: a floating point value denoting number of 50-MHZ clock counts that the GVAR signal takes to transit through CDA station equipment.
207–210	XMSNE	The call tower range calibration value – a floating point value denoting the number of 50-MHZ clock counts that the GVAR signal takes to transit the satellite transmission electronics.
211–218	TGPAT	CDA TOD of GPATH measurement, format as provided for words 23–30.
219–226	TXMSN	CDA TOD of XMSNE measurement, format as provided for words 23–30.
227–228	ISTIM	Current line scan time in integer milliseconds computed as TCTRL–TCHED.
229	IFRAM	Current frame counter. Integer ranging from 0 to 255 identifying current frame; rolls over to 0 following 255.
230	IMODE	Current imaging mode. Integer value as follows: 1 = Routine 2 = Rapid scan operation 3 = Super rapid scan operation 4 = Checkout/special short-term operations

The following four floating point values are in units of degrees. Off-earth coordinates have a value of 999999.

WORD	NAME	DESCRIPTION
231–234	IFNW1	Current frame – northwest corner latitude.
235–238	IFNW2	Current frame – northwest corner longitude.
239–242	IFSE1	Current frame – southeast corner latitude.
243–246	IFSE2	Current frame – southeast corner longitude.
247	IG2TN	2nd order gain interpolation table index number. Integer value of 1, 2, or 3 denoting which of the three possible tables is reported in IG2IT (words 6779–7002).
248	ISCP2	Repeat of ISCP1 (word 193)

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

249–250	ISCA2	Repeat of ISCAN (words 3–4)
251–277		Spares – not used.
278		Longitudinal parity (XOR) of words 1–277

The following partition provides the Imager O&A parameters. The format and engineering units of each variable are denoted in parenthesis. The partition is sized to hold the largest expected O&A set. In general, the actual number of parameters in effect is less than the maximum and varies over time. The numeric parameters (words 535–538 and 659–662) are used to denote the number of active terms employed for the roll attitude angle. In a similar fashion, each of the remaining four angles modeled by the O&A set is provided with numeric parameters defining the number of active terms. Inactive terms are not compressed out of the O&A set; their places are occupied by zeroed data words.

WORDS	NAME	DESCRIPTION (Format, Units)
279–282		IMC Identifier (4 ASCII characters)
283–294		Spares – zeros
295–298		Reference Longitude (positive east, R*4, rad)
299–302		Reference radial distance from nominal (R*4, km)
303–306		Reference Latitude (positive north, R*4, rad)
307–310		Reference Orbit Yaw (R*4, rad)
311–314		Reference Attitude: Roll (R*4, rad)
315–318		Reference Attitude: Pitch (R*4, rad)
319–322		Reference Attitude: Yaw (R*4, rad)
323–330		Epoch Date/Time: Standard BCD time format
331–334		IMC set enable time from epoch (R*4, min)
335–338		Spacecraft compensation: Roll (R*4, rad)
339–342		Spacecraft compensation: Pitch (R*4, rad)
343–346		Spacecraft compensation: Yaw (R*4, rad)
347–398		Change in longitude from ref. (13 @ R*4, rad)
399–442		Change in radial distance from ref. (11 @ R*4, km)
443–478		Sine geocentric latitude, total (9 @ R*4, no units)
479–514		Sine orbit yaw, total (9 @ R*4, no units)

Table 3-6. Imager Documentation Block 0 Format Definition (Cont’d)

515–518		Daily solar rate (R*4, rad/min)
519–522		Exponential start time from epoch (R*4, min)
Words 523–742 apply to Roll attitude angle:		
523–526		Exponential magnitude (R*4, rad)
527–530		Exponential time constant (R*4, min)
531–534		Constant, mean attitude angle (R*4, rad)
535–538		Number of sinusoids/Angles (I*4, none)
539–542		Magnitude of 1^{st} order sinusoid (R*4, rad)
543–546		Phase angle of 1^{st} order sinusoid (R*4, rad)
:		
651–654		Magnitude of fifteenth sinusoid (R*4, rad)
655–658		Phase angle of fifteenth sinusoid (R*4, rad)
659–662		Number of monomial sinusoids (I*4, no units)
663–666		Order of applicable sinusoid (I*4, no units)
667–670		Order of first monomial sinusoid (I*4, no units)
671–674		Magnitude of monomial sinusoid (R*4, rad)
675–678		Phase angle of monomial sinusoid (R*4, rad)
679–682		Angle from epoch where monomial is zero (R*4, rad)
683–702		Repeat of 663–682 but for second monomial
703–722		Repeat of 663–682 but for third monomial
723–742		Repeat of 663–682 but for fourth monomial
743–962		Repeat of 523–742 for Pitch attitude angle
963–1182		Repeat of 523–742 for Yaw attitude angle
1183–1402		Repeat of 523–742 for Roll Misalignment angle
1403–1622		Repeat of 523–742 for Pitch Misalignment angle
1623–1624	ISCA3	Repeat of ISCAN (words 3–4)

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	NAME	DESCRIPTION
1625	ISCP3	Repeat of ISCP1 (word 193)
1626		Longitudinal parity (XOR) of words 279–1625.

The terms below are used to adjust the visible Imagery transmitted in GVAR such that it coregisters with the accompanying IR Imagery. If SPS coregistration is enabled, word 1679 has a nonzero index (1–48) indicating which visible correction terms (words 1631–1678 for pixels, 6235–6282 for lines) are being used. If SPS coregistration is disabled, word 1679 is zero.

WORD	NAME	DESCRIPTION
1627–1630		Coregistration Table ID (4 ASCII characters)
1631–1678		(1 x 48) east-west half-hourly correction terms
1679		Index of correction terms currently active
1680–1690		Spares – not used.

In the following, an abbreviated form of the raw header and trailer data blocks associated with the current scan are provided. The downlinked raw data has a 10-bit word length, with each block containing 48 words. The first two words of each block contain a synchronization code and a block ID not included here. Each 10-bit word is embedded in two sequential 8-bit words:

1st word,	bits 0–5: not used – zeros
	bits 6–7: two MSBs of 10-bit word
2nd word,	bits 0–7: eight LSBs of 10-bit word

Specific definitions of the contents of the 10-bit raw data words can be acquired from the *Instrument to OGE Interface Specification*.

WORD	NAME	DESCRIPTION
1691–1782		Current scan raw header data block
1783–1874		Current scan raw trailer data block
1875–1966		Latest lagged scan raw header data block
1967–2058		Latest lagged scan raw trailer data block

The Imager telemetry raw data section which follows consists of 122 10-bit words, each 10-bit word formatted as described above. It contains a copy of each of the four command register status reports, as well as the 78 raw telemetry data words acquired from the most recent 39 telemetry blocks contained in a scan reversal sequence. The notation "B(MSB–LSB)" is used to indicate the bit position of the source data in the downlinked raw data block. Specific definitions of the contents of the status reports, as well as a listing of the telemetry points contained, can be found in reference document SJ–572022.

WORD	NAME	DESCRIPTION
2059–2080		Block 1 command register 1 report, B(20–129)
2081–2102		Block 2 command register 2 report, B(20–129)
2103–2124		Block 3 command register 3 report, B(20–129)

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

2125–2146	Block 4 command register 4 report, B(20–129)
2147–2148	Block 1, telemetry word 1, B(230–239)
2149–2150	Block 1, telemetry word 2, B(470–479)

WORD	**NAME DESCRIPTION**
2151–2152	Block 2, telemetry word 1, B(230–239)
2153–2154	Block 2, telemetry word 2, B(470–479)
:	:
2299–2300	Block 39, telemetry word 1, B(230–239)
2301–2302	Block 39, telemetry word 2, B(470–479)
2303–2305	Spares – not used.
2306	Longitudinal parity (XOR) of words 1691–2305

In the following partition, four arrays are used to provide up to 1024 grid points for the current output scan. The grid points represent two distinct data bases.

2307–2818	Grid (database 1) detector array
2819–3330	Grid (database 2) detector array
3331–4354	Grid (database 1) pixel array
4355–5378	Grid (database 2) pixel array

Each of the GRID arrays above can contain up to 512 entries. The number of entries varies for different output scans as a function of the number of grid points intersected by the scan. For any given scan, the current number of entries is indicated by words 185–188 (G1CNT, G2CNT). Each entry is defined using the formats shown below. A GRID POINT record consists of an entry from both the DETector and the PIXEL arrays.

A DETector entry is an 8-bit (I*1) binary number denoting the logical visible detector which "saw" the grid coordinate. Corresponds to GVAR blocks by:

= 1 for GVAR Block 3
= 2 for GVAR Block 4
= 3 for GVAR Block 5
= 4 for GVAR Block 6
= 5 for GVAR Block 7
= 6 for GVAR Block 8
= 7 for GVAR Block 9
= 8 for GVAR Block 10

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

A PIXEL entry is a 16-bit (I*2) binary number which locates a virtual visible pixel in the DETector- denoted GVAR block. The located pixel corresponds to a particular GRID set coordinate.
Values can range from 0 for no pixel up to a maximum of 25,092. A value of 1 indicates the first pixel in the associated GVAR block, 2 the second, etc.

WORD	NAME	DESCRIPTION
5379–5380		Grid Set #1 Revision level
5381–5382		Grid Set #2 Revision level
5383–5385		Spares – not used
5386		Longitudinal parity (XOR) of words 2307–5385

The following information is used to identify the oldest raw instrument scan that may be providing some of the detector data in the current output GVAR scan. Whether this information is required for the landmarking function is dependent upon three factors:

1. The current frame N-S scan direction
2. The detector electronics side which is active
3. The coregistration terms currently in use.

The format of the header and trailer data is the same as described for words 1691–2058. The time code formats are the same as defined for words 23–150.

WORD	NAME	DESCRIPTION
5387–5478		Oldest lagged scan raw header data block
5479–5570		Oldest lagged scan raw trailer data block
5571–5578	TOHED	Time of oldest lagged header block
5579–5586	TOTRL	Time of oldest lagged trailer block

The IR calibration term arrays in words 5587–5698 below are all in Real*4 format. Each array is sized to hold one term for each of the seven active physical IR detectors. The IWBIAS terms apply to the westernmost IR pixels in the GVAR data stream. The bias term for the N^{th} west-to-east pixel in the line can be computed using the bias-rate terms IBRATE as follows:

BIASn = IWBIAS + (N – 1) IBRATE

WORD	NAME	DESCRIPTION
5587–5614	IWBIAS	(4 x 7) IR calibration bias term
5615–5642	IGAIN1	(4 x 7) IR calibration 1^{st} order gain
5643–5670	IGAIN2	(4 x 7) IR calibration 2^{nd} order gain

WORD	NAME	DESCRIPTION
5671–5698	IBRATE	(4 x 7) IR calibration bias rate

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	NAME	DESCRIPTION
5699–5706		CDA TOD of westernmost IR pixel
	IMAGER IR CLAMPED BIAS STATISTICS	
5707–5714		CDA TOD of clamped bias data
5715–5728		(2 x 7) Total sample size
5729–5742		(2 x 7) Filtered sample size
5743–5756		(2 x 7) Unfiltered minimum value – counts
5757–5770		(2 x 7) Filtered minimum value – counts
5771–5784		(2 x 7) Unfiltered maximum value – counts
5785–5798		(2 x 7) Filtered maximum value – counts
5799–5826		(4 x 7) Unfiltered mean value – counts
5827–5854		(4 x 7) Filtered mean value – counts
5855–5882		(4 x 7) Unfiltered standard deviation – counts
5883–5910		(4 x 7) Filtered sigma – counts
5911–5938		(4 x 7) Filtered sigma – radiance
5939–5966		(4 x 7) Filtered sigma – temperature
5967–5970		Clamp mode and status flags
	IMAGER IR DRIFT BIAS STATISTICS	
5971–5978		CDA TOD of drift bias data
5979–5992		(2 x 7) Total sample size
5993–6006		(2 x 7) Filtered sample size
6007–6020		(2 x 7) Unfiltered minimum value – counts
6021–6034		(2 x 7) Filtered minimum value – counts
6035–6048		(2 x 7) Unfiltered maximum value – counts
6049–6062		(2 x 7) Filtered maximum value – counts
6063–6090		(4 x 7) Unfiltered mean value – counts

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

6091–6118	(4 x 7) Filtered mean value – counts
6119–6146	(4 x 7) Unfiltered standard deviation – counts
6147–6174	(4 x 7) Filtered sigma – counts
6175–6202	(4 x 7) Filtered sigma – radiance
6203–6230	(4 x 7) Filtered sigma – temperature
6231–6234	Clamp mode and status flags
6235–6282	(1 x 48) North-south half-hourly correction terms
6283–6286	(4 x 1) Scan Clamp E/W clipping edge limb offset
6287–6288	IMBOOST – When relativization is active, this is the amount of boost (the arbitrary count level of space)
6289	IRELON – Relativization indication, 1 indicates the function is active
6290–6303	Spares – not used
6304	Longitudinal parity (XOR) of words 5387–6303

The coregistration half-hourly correction terms defined in words 1631–1678 and 6235–6282 formed using 2s complement notation within the 8-bit fields. Valid ranges are –64 to +64 pixels for east-west terms, and –8 to +8 lines for north-south terms.

The two clamp mode and status flag fields defined in words 5967–5970 and 6231–6234 are identically structured within the 32 bits allocated for each. The first word (5967, 6231) identifies the clamp mode active at the time the associated space data was acquired. It takes on one of the following values:

4 = scan clamp mode active
2 = 9.2-second space clamp mode active

WORD **NAME** **DESCRIPTION**

1 = 36.6-second space clamp mode active
0 = mode unknown

The remaining 24 bits (words 5968–5970 and 6232–6234) are used to flag status and alarm conditions associated with the data. These bits are identified as bits 0–23, where the MSB (bit 0) is the left-most bit of the first word (5968, 6232). The bits are set (= 1) if the associated condition is true. They are reset (= 0) if the condition is false. The bits assignments are as follows:

Bit	True Condition
00	Unassigned (always zero)
01	Det 4/1 invalid cal condition (no statistics)

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

02	Det 4/2 invalid cal condition (no statistics)
03	Det 5/1 invalid cal condition (no statistics)
04	Det 5/2 invalid cal condition (no statistics)
05	Det 2/1 invalid cal condition (no statistics)
06	Det 2/2 invalid cal condition (no statistics)
07	Det 3/1 invalid cal condition (no statistics)
08	Unassigned (always zero)
09	Det 4/1 excessive drift rate alarm
10	Det 4/2 excessive drift rate alarm
11	Det 5/1 excessive drift rate alarm
12	Det 5/2 excessive drift rate alarm
13	Det 2/1 excessive drift rate alarm
14	Det 2/2 excessive drift rate alarm
15	Det 3/1 excessive drift rate alarm
16–20	Unassigned (always zero)
21	Space clamp side active (1–East)
22	Excessive interpolation interval
23	Atmospheric exclusion zone activated

In the remaining partition, coefficients and parameters that were measured prior to launch (factory values) are provided. For the most part, these values serve as an historical reference to be used in evaluating the current condition of the imaging detectors. In a few instances, the values are used throughout the life of the instrument as part of the normal calibration functions.

The nadir location of the instrument is measured in terms of cycles and increments (see Section 3.4) in the north/south and east/west directions. Cycles are expressed as an 8-bit integer number ranging from 0 to 127. Increments are expressed as a 16-bit integer number ranging from 0 to 6135.

6305 IOFNC Instrument nadir, north-south cycles

WORD	**NAME**	**DESCRIPTION**
6306	IOFEC	Instrument nadir, east-west cycles
6307–6308	IOFNI	Instrument nadir, north-south increments
6309–6310	IOFEI	Instrument nadir, east-west increments

For each of the 22 detectors (8 visible, 14 IR), two 16-bit integer values provide the X (east-west) and the Y (north-south) radian offset of the detector centroid from the instrument's optical axis:

6311–6312		Visible detector 1 X-offset
:		:
6353–6354		Redundant IR detector 7 X-offset
6355–6356		Visible detector 1 Y-offset
:		:
6397–6398		Redundant IR detector 7 Y-offset

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

A set of characteristic response coefficients is provided for each of the 22 Imager detectors. The characteristic response coefficients are the initial calibration coefficients associated with the detectors. The scaling factors are used to generate a 10-bit value from each calibrated IR pixel. All entries are single precision floating point numbers.

Each of the following arrays contains eight elements, one element per visible detector. The elements are ordered within each array in increasing physical detector number, with element 1 assigned to physical visible detector 1, etc.

WORD	NAME	DESCRIPTION
6399–6430	IVCRB	Visible detectors characteristic response bias coefficients array.
6431–6462	IVCR1	Visible detectors characteristic response 1st order gain coefficients array.
6463–6494	IVCR2	Visible detector characteristic response 2nd order gain coefficients array.
6495–6498	IVRAL	Visible detectors radiance-to-albedo conversion factor, one value for all eight detectors.

In the following arrays the first five each contains 14 elements, one element per IR detector. The first seven elements in each array apply to the seven side 1 (primary) detectors; the last seven, to the side 2 (redundant) detectors. Within each group of seven, the elements are ordered in the same 1–7 sense as follows:

1 – channel 4 north	5 – channel 2 north
2 – channel 4 south	6 – channel 2 south
3 – channel 5 north	7 – channel 3
4 – channel 5 south	

WORD	NAME	DESCRIPTION
6499–6554	IICRB	Characteristic response bias coefficients.
6555–6610	IICR1	Characteristic response 1st order gain coefficients.
6611–6666	IICR2	Characteristic response 2nd order gain coefficients.
6667–6722	IISFB	Scale factors bias coefficients.
6723–6778	IISF1	Scale factors 1st order gain coefficients.
6779–7002	IG2IT	2nd gain interpolation table. This array contains 56 elements, 4 elements for each of the 14 IR detectors. The first 28 elements apply to the side 1 detectors, the last 28 to side 2. Within each group of 28, the elements are sequentially ordered (in groups of four) in the same 1–7 sense defined previously.
7003–7018	IG2BP	2nd gain baseplate temperature interpolation pivot points. Four baseplate temperatures at which IG2IT gains were measured. Access this

		table with baseplate temperature to determine linear interpolation factors to use within IG2IT.
7019–7242	IBBTR	Blackbody temperature-to-target radiance conversion coefficients. An array of 56 elements, 4 elements for each of 14 IR detectors. Elements are ordered in the same manner as described for IG2IT.
7243–7266	IPRNG	Patch temperature control ranges. An array of six elements, two elements for each of the three patch temperature control ranges. Each pair of elements defines the lower and upper temperature limit assigned to a patch control point.
7267–7366		Spares – not used.

In the following section, conversion coefficients are provided for each telemetry point whose engineering units value is used for calibration or alarm monitoring functions by the SPS. Conversion factors of unused telemetry points may be acquired from reference document SJ–572022.

7367–7370	IEL1A	Imager Electronics Temperature side #1 coefficients. Final letter of term name (A–F) denotes type. Usage of terms to convert raw counts to temperature are defined in subsection 3.6.2.1.
7371–7374	IEL1B	
7375–7378	IEL1C	

WORD	**NAME**	**DESCRIPTION**
7379–7382	IEL1D	
7383–7386	IEL1E	
7386–7390	IEL1F	

The A–F naming convention used above with IEL1_ is used for all following thermistor terms:

7391–7414	IEL2_	Electronics #2 thermistor terms
7415–7438	IBP1_	Base plate thermistor #1 terms
7439–7462	IBP2_	Base plate thermistor #2 terms
7463–7486	IBP3_	Base plate thermistor #3 terms
7487–7510	IBP4_	Base plate thermistor #4 terms
7511–7534	IBP5_	Base plate thermistor #5 terms
7535–7558	IBP6_	Base plate thermistor #6 terms
7559–7582	IBB1_	Blackbody thermistor #1 terms
7583–7606	IBB2_	Blackbody thermistor #2 terms

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

WORD	NAME	DESCRIPTION
7607–7630	IBB3_	Blackbody thermistor #3 terms
7631–7654	IBB4_	Blackbody thermistor #4 terms
7655–7678	IBB5_	Blackbody thermistor #5 terms
7779–7702	IBB6_	Blackbody thermistor #6 terms
7703–7726	IBB7_	Blackbody thermistor #7 terms
7727–7750	IBB8_	Blackbody thermistor #8 terms
7751–7774	IOP1_	Scan mirror thermistor terms
7775–7798	IOP2_	Primary mirror thermistor terms
7799–7822	IOP3_	Secondary mirror thermistor #1 terms
7823–7846	IOP4_	Secondary mirror thermistor #2 terms
7847–7870	IOP5_	Baffle thermistor #1 terms
7871–7894	IOP6_	Baffle thermistor #2 terms
7895–7918	IOP7_	Aft optics thermistor terms
7919–7942	IOP8_	Cooler radiator thermistor terms
7943–7966	IOP9_	Wide range IR detector thermistor terms
7967–7990	IOPA_	Narrow range IR detector thermistor terms
7991–8014	ICHT_	Cooler housing thermistor terms

The remaining two telemetry points use a simple linear (gain and bias) mapping to convert raw counts to engineering units.

8015–8022	IPVGB	Patch control voltage gain/bias terms
8023–8030	IICGB	Instrument current gain/bias terms
8031–8039		Spares – not used
8040		Longitudinal parity (XOR) of words 6305–8039

3.3.4.6 Factory Parameters – This partition provides factory measured calibration coefficients for each of the 22 imaging detectors along with the misalignments of the detectors with respect to the instruments optical axis. The coefficients required to convert raw telemetry counts to engineering units are provided for those points employed during formation of GVAR data.

Table 3-6. Imager Documentation Block 0 Format Definition (Cont'd)

3.3.5 Blocks 1 and 2 – Imager IR Data

Imager data from the seven active IR detectors is carried in the information fields of GVAR Blocks 1 and 2. Block 1 carries data for the four long wave detectors (channels 4 & 5), while Block 2 carries data from the remaining three detectors (channels 2 & 3). Data for each of the seven detectors is packaged using the same two-partition record format. The first partition provides line documentation information. The second partition contains the detector data.

The grouping of the detector data records within each block is illustrated in Figure 3-11 along with a depiction of the record layout. Also indicated in the figure is the number (1–7) used by the SPS for each detector in the normal and yaw-flipped modes.

	IR CHANNEL	**NORMAL MODE**		**YAW-FLIPPED MODE**	
		DETECTOR	**SPS IR**	**DETECTOR**	**SPS IR**
GVAR Block 1 Has 4 IR Records	4	1	1	2	2
	4	2	2	1	1
	5	1	3	2	4
	5	2	4	1	3
GVAR Block 2 Has 3 IR Records	2	1	5	2	6
	2	2	6	1	5
	3		7		7

Imager IR Detector Record Layout in Bits	
	LINE DOCUMENTATION – 160 BITS
	Detector Data – from 10 Bits to 52,360 Bits

Figure 3-11. Imager IR Detector Data Order in GVAR

3.3.5.1 Line Documentation – The line documentation segment is used to identify uniquely the detector data segment through the use of a scan line sequence counter, spacecraft code, and detector ID information. A line documentation segment is 160 bits in length, consisting of 16 10-bit words. Table 3-7 defines the contents of a line documentation segment.

3.3.5.2 IR Detector Data – The IR detector data segment contains the scan line data for the associated detector. This segment varies in length directly with the scan line, reaching a maximum nominal length of 52,360 bits (5236 pixels) for a 19.2^{o} wide scan. (A worst case maximum length of 62,730 bits occurs if the full 23^{o} wide FOV of the instrument is scanned.) Data within this segment is always ordered from west-to-east, regardless of the original scan line direction. Each 10-bit pixel within this segment is formatted with the MSB first.

Table 3-7. Blocks 1–10 Line Documentation Definition

WORD	**NAME**	**DESCRIPTION**

1	SPCID	Spacecraft ID – a binary number identifying the source satellite as follows:

8	= GOES-I	valid
9	= GOES-J	GVAR
10	= GOES-K	assignments
11	= GOES-L	
12	= GOES-M	

2	SPSID	SPS ID – a binary number identifying the source SPS which formatted the GVAR stream. Values 1 to 4 denote SPS1 to SPS4, respectively.
3	LSIDE	A binary number denoting the current active detector configuration. A value of 0 indicates side 1 is active; a value of 1023 indicates side 2 is active.
4	LIDET	A binary number denoting the physical detector identified as the data source. Values range from 1 to 8 for the visible channel and from 1 to 7 for the IR channels (see Figure 3-11).
5	LICHA	A binary number identifying the source channel. Values range from 1 to 5 as follows:

Value	Channel	Wavelength
1	01	visible
2	02	3.9 microns
3	03	6.75 microns
4	04	10.7 microns
5	05	12.0 microns

6–7	RISCT	A binary number ranging from 1 to 1974 denoting the relative output scan count since the start of the imaging frame.
8	L1SCAN	Imager scan status word 1: Bits 0–3 are not used. Bits 4–9 are duplicates of bits 2–7 of the ISCAN field are defined in Table 3-6.
9	L2SCAN	Imager scan status word 2: Bits 0–1 are not used. Bits 2–9 are duplicates of bits 8–15 of the ISCAN field are defined in Table 3-6.
10–11	LPIXLS	A binary number denoting the number of pixels contained in the detector data record.

Table 3-7. Blocks 1–10 Line Documentation Definition (Cont'd)

WORD	NAME	DESCRIPTION
12–13	LWORDS	A binary number denoting the number of words contained in the detector record, from word 1 of the line documentation to the last word in the detector data partition. This number, minus the 16 words of line documentation and the number of pixels contained in the detector data partition (words 10–11), denotes the number of zero-valued words appended

to the record for packing purposes. The packing is performed for three reasons:

1. To ensure consistent record bounding for the multi-record GVAR Blocks 1 and 2.
2. To ensure the overall length of the GVAR block information field is a multiple of 16 bits, permitting the proper computation of the block CRC.
3. To ensure the minimum GVAR block size of 32,208 bits is satisfied.

14 LZCOR An 8-bit binary number denoting the value of the zonal correction (pixel offset) employed at the western edge of the scan line.

15 LLAG A binary number (0, 1, or 2) denoting which scan (current, latest lagged, or oldest lagged, respectively) the detector data was acquired from. This information can be used to access Block 0 documentation associated with a particular scan, such as the associated header time tags (TCHED, TLHED, or TOHED, respectively).

16 LSPARSpare – not used.

3.3.6 Blocks 3–10 Imager Visible Data

Image data from the Imager's eight visible detectors is carried in the data section fields of GVAR Blocks 3–10, one detector per block. Each of the GVAR Blocks 3–10 is assigned to a specific logical detector as illustrated in Figure 3-12. This assignment causes the northernmost pixel data to always occur in Block 3, and the southernmost pixel data to be in Block 10. The remaining pixel information is distributed in a North-to-South order across Blocks 4–10.

Figure 3-12 also illustrates the relationship between physical visible detectors and logical visible detectors for the normal and yaw-flipped spacecraft modes. This relationship is the same for both primary (side 1) and redundant (side 2) detector configurations. Note that this mapping of physical to logical detector only holds if the coregistration north-south offset in use is zero. For any active non-zero

Each Imager Visible Detector Record Occupies One GVAR Block

GVAR BLOCK	**NORMAL MODE**		**YAW-FLIPPED MODE**	
	DETECTOR		**DETECTOR**	
	LOGICAL	**PHYSICAL**	**LOGICAL**	**PHYSICAL**
3	1	5	1	4
4	2	6	2	3
5	3	7	3	2

6	4	8	4	1
7	5	1	5	8
8	6	2	6	7
9	7	3	7	6
10	8	4	8	5

Imager Visible Detector Record Layout in Bits	**LINE DOCUMENTATION – 160 BITS**
	Detector Data – from 40 Bits to 209,440 Bits

Figure 3-12. Imager Visible Detector Logical vs. Physical Ordering

offset, the northernmost logical detector in Block 3 will be represented by a physical detector other than 5. Note that this will also be the case for inverted spacecraft. Which physical detector represents the northernmost detector in an output scan is defined in word 184 of the associated Block 0.

Visible detector data is packaged using the same two-partition record format employed for the IR detector data. The first partition provides line documentation, and the second contains the detector data.

3.3.6.1 Line Documentation – The line documentation segment is used to identify uniquely the detector data segment through the use of a scan line sequence counter, spacecraft code, and detector ID information. A line documentation segment is 160 bits in length, consisting of 16 10-bit words. Table 3-7 defines the line documentation segment contents.

3.3.6.2 Visible Detector Data – The visible detector data segment contains the normalized scan line data for the associated detector. This segment varies in length directly with the scan line, reaching a maximum nominal length of 209,440 bits (20,944 pixels) for a 19.2^{o} wide scan. (A worst case maximum length of 250,920 bits occurs if the full 23^{o} wide FOV of the instrument is scanned.) Data within this segment is always ordered from west-to-east, regardless of the original scan line direction. Note that each 10-bit pixel within the segment is ordered with the MSB first.

3.3.7 Block 11 – Sounder/Auxiliary Data

The GVAR Sounder/Auxiliary Data (SAD) Block 11 is a fixed-length block equal in size to the Imager documentation Block 0. The internal structure of a SAD Block 11 depends upon the type of data being transported. The permissible SAD Block data types are:

1. Sounder Documentation Data
2. Sounder Scan Data

3. Instrument Compensation Terms
4. Instrument Space Look Calibration Data
5. Instrument Blackbody Calibration Data
6. Instrument Electronic Calibration Data
7. Instrument Telemetry Statistics
8. Instrument Calibration Coefficients
9. Instrument Normalization Lookup Tables (NLUTs)
10. Instrument Star Sense Data
11. GIMTACS/SPS Text Messages
12. Auxiliary Data
13. Fill Data.

The layout of the 75,088-bit SAD Block 11s is:

FIELD	LENGTH
P/N Synch code	10032
Header	720
Data Section	64320
CRC	16

The PN Synch code, Header, and CRC are described in subsections 3.3.1, 3.3.2, and 3.3.3, respectively.

The 64,320-bit data section is partitioned into two fixed-length regions. The first region is 240 bits in length, and is called the SAD block identifier (SAD ID). The second region, 64,080 bits in length, is defined in accordance with the type of data being transported. The word size employed in the data section also depends on the type of data being transported. Word sizes of 6, 8, and 10 bits are permitted. The number of words for each of the two regions for the various word sizes are as follows:

WORD SIZE (Bits)	REGION 1 (Number of Words)	REGION 2
6	40	10680
8	30	8010
10	24	6408

3.3.7.1 SAD Block ID – The 240-bit SAD block identifier provides a simple means of identifying which type of data is contained within the block. It also provides a data segmentation mechanism permitting transport of strings whose length exceed the capacity of a single block.

The first nine words (seven fields) in a SAD Block ID are always defined in the same fashion regardless of the data type or word length. They are defined in terms of six-bit fields, right-adjusted and bounded within 6-, 8-, or 10-bit words. This insures compatibility with the three word sizes supported by the Block 11 format. These fields, defined in Table 3-8 and illustrated in Figure 3-13, identify the particular data types contained within the block, and also provide the linkage mechanisms for multi-block sequences. Table 3-9 defines the additional fields used to support text messages.

Table 3-8. SAD Block 11 Identifier

WORDS	DESCRIPTION
1	Spacecraft Identity: a binary number identifying the source satellite as follows: 8 = GOES-I — valid 9 = GOES-J — GVAR 10 = GOES-K — assignments 11 = GOES-L 12 = GOES-M
2	SPS ID: a binary number identifying the source SPS which formatted the GVAR data stream. Values 1 to 4 are assigned to SPS1 to SPS4, respectively.
3	Data Identity – a binary number denoting the SAD block type as follows[1]: x '01' = 01 Fill data x '07' = 07 Imager compensation terms x '0E' = 14 Sounder compensation terms x '15' = 21 Imager telemetry statistics x '16' = 22 Imager spacelook data x '19' = 25 Imager cal coefficients and limits x '1A' = 26 Imager ECAL data x '1C' = 28 Imager blackbody data x '1F' = 31 Imager NLUTs data

Table 3-8. SAD Block 11 Identifier (Cont'd)

WORDS	DESCRIPTION
	x '20' = 32 Sounder documentation data x '23' = 35 Sounder scan data x '25' = 37 Sounder telemetry statistics x '26' = 38 Sounder spacelook data x '29' = 41 Sounder cal Coefficients and limits x '2A' = 42 Sounder ECAL data x '2C' = 44 Sounder blackbody data x '2F' = 47 Sounder NLUTs data x '31' = 49 Auxiliary data x '32' = 50 GIMTACS text message x '34' = 52 SPS text message x '38' = 56 Reserved x '3B' = 59 Imager star sense data x '3D' = 61 Sounder star sense data

4 FIRST BLOCK FLAG – a 6-bit flag set to 63 (x ‘3F’) if the SAD Block is the first of a series. Otherwise, the value is set to 0.[2]

5 LAST BLOCK FLAG – a 6-bit flag set to 63 (x ‘3F’) if the SAD Block 11 is the last of a series. Otherwise, the value is set to 0.[2]

6–8 BLOCK COUNT – an 18-bit binary number denoting the number of blocks within a sequence of blocks. Starts as 1 when FIRST BLOCK FLAG is set and increments for each block after until LBF is set.

9 RECORD COUNT – a 6-bit binary count of records in block; 0 to 63 corresponding to 1 to 64 records. Set to 63 (x ‘3F’) for fill data.

21 YAW-FLIP FLAG – a 6-bit flag set to 63 (x ‘3F’) if the satellite is currently yaw-flipped. Otherwise, the value is reset to 0.

22–N Not used.[3]

NOTES:

1. The numbers used in word 3 ensure that single-bit transmission errors do not result in misidentification of the data in the block.

2. If a complete sequence of data is contained in a single SAD Block, both the FIRST and LAST BLOCK FLAGs are set to 63 (x ‘3F’).

3.N = 40, 30, or 24 for 6-, 8-, or 10-bit word sizes, respectively.

WORDS	BITS					6-Bit Words / 8-Bit Words / 10-Bit Words
01					S/C IDENTITY	Words 1–9 and 21–N are always
02					SPS IDENTITY	defined in the same way as for SAD IDs:
03					DATA IDENTITY	6-bit, right-adjusted fields.
04					FIRST BLOCK FLAG	Table 3-8 provides the definitions
05					LAST BLOCK FLAG	
06					BLOCK COUNT	(x = bit not used)
07						(b = bit field open)
08						
09					RECORD COUNT	
10						Words 10–20 are defined according
•						to the application.
•						Table 3-9 provides the definitions.
20						
21					YAW-FLIP FLAG	
22					Spare – not used	
23					Spare – not used	SAD ID has:

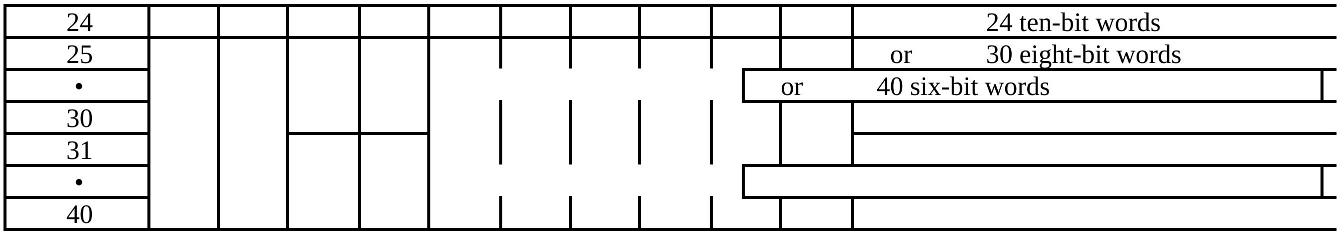


Figure 3-13. SAD Block 11 Identifier

Table 3-9. SAD Block ID Text Message Block 11

WORDS	**DESCRIPTION**
10	SOURCE ID – an 8-bit binary number denoting the message originator: 10 – GIMTACS 20 – SPS 1 21 – SPS 2 22 – SPS 3 23 – SPS 4 no others
11–12	NUMBER OF WORDS – a 16-bit count of the number of characters in the data section that follows.
13–20	TIME QUEUED – a 64-bit BCD-encoded CDA time tag denoting when the Block 11 was queued for transmission. The format of the eight words comprising this tag is the same as that described for words 59–178 in Table 3-10.
21–N	Refer to Table 3-8.

3.3.7.2 Sounder Scan Documentation – The Sounder Scan Documentation Block 11 is analogous in function to the Imager documentation Block 0. It has the same priority as a Sounder Scan Block 11. It is always the first block of a Block 11 sequence constituting a Sounder scan line. It consists of 8040 eight-bit words divided into the following four partitions:

PARTITION	**WORD RANGE**
SAD ID (see subsection 3.3.7.1)	1–30
Instrument and Scan Status	31–306
Sounder O&A parameters	307–1718
Factory Parameters	3005–8040

The SAD ID is described in subsection 3.3.7.1, and its layout specified in Table 3-9. The remaining three partitions are described in the following subsections, and their layout specified in Table 3-10.

3.3.7.2.1 Instrument and Scan Status – This partition summarizes the status of the Sounder, the current sounding frame, and the radiometric detectors. Time tags denoting significant events and identifying various process entities are provided. In addition, coordinate information locating points is provided for the various reference frames.

3.3.7.2.2 Sounder O&A Data – This partition contains the parameters and coefficients describing the Sounder O&A data acquired from the OATS. The usage of the contained information depends upon the status of the IMC function. If IMC is enabled, the O&A data is valid for a fixed period called the registration interval. If IMC is disabled, the O&A values apply only to a single point in time. Under these conditions, the O&A information must be translated through time to the desired calculation point.

3.3.7.2.3 Factory Parameters – This partition provides factory measured calibration coefficients associated with each of the 76 channel-detectors. The detector misalignments with respect to the instrument's optical axis are included. In addition, the coefficients required to convert raw telemetry counts to engineering units are provided for those points employed by the SPS in processing the Sounder data stream.

Table 3-10. Sounder Scan Documentation Block 11 Format

WORD	NAME	DESCRIPTION
31–32	SSCAN	Sounder scan status in two words (16 bits). The MSB is bit 0 of word 1, and the LSB is bit 15 of word 2.

Bits	Value	Condition
0	1	Frame start
1	1	Frame end
2	1	Frame break – line(s) lost
3	1	Line break – pixel(s) lost
4	1	Priority 1 frame data
5	1	Priority 2 frame data
6	0	West-to-east scan
	1	East-to-west scan
7	0	North-to-south frame
	1	South-to-north frame
8	1	IMC enabled
9	1	Dwell mode = 4
10	1	Dwell mode = 2
11	1	Dwell mode = 1
12	1	N-S step mode = double
13	0	Side 1 electronics active
	1	Side 2 electronics active
14	1	Visible normalization enabled
15	1	IR calibration enabled

WORD	NAME	DESCRIPTION
33–42	SDSTA	Detector status in 10 words (80 bits). First 76 bits (9.5 words) correspond to the 76 channel-detectors (CDET) in the Sounder, 1 bit per CDET in increasing CDET (1-1, 1-2, 1-3, 1-4, 2-1,..., 19-4) order. A set bit indicates the data for the associated CDET are suspect or invalid. The last 4 bits of word 12 are not used and are always reset to zeros.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
43–44	SRBCT	Total number of raw scan data blocks included in this scan. Values can range from 1 to a maximum of 1434 (5736 if dwell = 4) for a 23^{o} wide scan.
45–46	SGBCT	Total number of Block 11s comprising the Sounder scan, including the Documentation Block. Values can range from 2 to a maximum of 132 (523 if dwell = 4) for a 23^{o} wide scan with no line breaks.
47–48	SLOCT	Number of line breaks (raw data synchronization losses) contained in this scan.
49–50	SSBRK	Number of the pixel following the 1st star sense break. Ranges from 0–1758; 0 means no break.
51–52	SCBRK	Number of the pixel following the 1st calibration break. Ranges from 0– 1758; 0 means no break.
53	SSCP1	Odd parity byte computed for SSCAN (words 31–32)
54	SRELON	Relativization indication, 1 indicates function is active.
55–56	SNBOOST	With relativization enabled, this is the amount of boost (the arbitrary space count level).
57	YAW FL	Yaw-flip flag; bit 0 = 1 if the satellite is flipped, else = 0.
58		Spare – not used.

The following 120 words provide 8-word CDA time tags for 15 specific events, with each time tag formatted as follows:

Word	Bits	BCD Formatted Contents
1	0–3	Year in 1000s
	4–7	Year in 100s
2	0–3	Year in 10s
	4–7	Year in 1s
3	0–3	Day of year (DOY) in 100s[1]
	4–7	DOY in 10s

Word	Bits	BCD Formatted Contents
4	0–3	DOY in 1s
	4–7	Hours in 10s

[1] Word 3 – bit 0 = 1 indicates the time code generator has lost its external synchronization signal and is operating with an internal oscillator, a mode called "flywheeling."

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION		
		5	0–3	Hours in 1s
			4–7	Minutes in 10s
		6	0–3	Minutes in 1s
			4–7	Seconds in 10s
		7	0–3	Seconds in 1s
			4–7	Milliseconds (msec) in 100s
		8	0–3	Msec in 10s
			4–7	Msec in 1s

WORD	NAME	DESCRIPTION
59–66	TCURR	Current SPS time
67–74	TSCLS	Time of scan line start
75–82	TSCLE	Time of scan line end
83–90	TCSLS	Time of calibration set at line start
91–98	TCSLE	Time of calibration set at line end
99–106	TSPFS	Time of priority frame start
107–114	TSNFS	Time of normal frame start
115–122	TSSPC	Time of last spacelook calibration
123–130	TSECL	Time of last electronic calibration
131–138	TSBBC	Time of last blackbody calibration
139–146	TSSTR	Time of last star sense
147–154	TLRAN	Time of last ranging measurement
155–162	TSVIT	Time Tag of visible NLUTs set used
163–170	TCLMT	Time Tag of current Limits set
171–178	TSONA	Time Tag current O&A set implemented
179–180		Spares – not used

The following 126 words provide information associated with the Sounder's reference frames and the current frame:

WORD	NAME	DESCRIPTION
181–182	RSSCT	Relative output scan sequence count since frame start. Ranges 1–396.
183–184	ASSCT	The current output scan number. Values of 1 to 396 correspond to scan swaths (northernmost to southernmost) in the Sounder's 9-cycle FOV.
185–186	SNSLN	The number of the northernmost visible detector scan line in the current scan. Inclusive values of 1 to 1579 correspond to detector lines (northernmost to southernmost) in the Sounder's 9-cycle FOV
187–188	SWFPX	The number of the westernmost visible pixel in the current frame. Inclusive values of 1 to 1754 correspond to the pixels (westernmost to easternmost) in the instrument's 5-cycle FOV.
189–190	SEFPX	The number of the easternmost visible pixel in the current frame. Inclusive values of 5 to 1758 correspond to the pixels (westernmost to easternmost) in the Sounder's 5-cycle FOV.
191–192	SNFLN	The number of the northernmost visible detector scan line in the current frame. Inclusive values of 1 to 1579 correspond to detector lines (northernmost to southernmost) in the Sounder's 9-cycle FOV.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
193–194	SSFLN	The number of the southernmost visible detector scan line in the current frame. Inclusive values of 4 to 1582 correspond to detector lines (northernmost to southernmost) in the Sounder's 9-cycle FOV.
195–196	SMDPX	The number of the visible pixel corresponding to an instrument azimuth of 0^{o}. Nominal value (1/2 full range) is 879. This value is a constant per instrument.
197–198	SMDLN	The number of the scan line corresponding to an instrument elevation of 0^{o}. Nominal value (1/2 full range) is 791. This value is a constant per instrument.
199–200	SMDCT	The number of the output scan corresponding to an instrument elevation of 0^{o}. Nominal value (1/2 full range) is 198. This value is a constant per instrument.

The following four terms (words 201–214) are computed using the current O&A set. If IMC is on, the terms reflect the reference position subsatellite point. If IMC is off, the terms reflect the actual subsatellite point.

WORD	NAME	DESCRIPTION
201–202	SGVLN	The number of the visible detector scan line intersecting the subsatellite point.
203–204	SGVPX	The number of the visible pixel intersecting the subsatellite point.
205–206		Spares – not used.
207–210	SUBLA	The subsatellite latitude, a floating point number with units of degrees.
211–214	SUBLO	The subsatellite longitude, a floating point number with units of degrees.
215–226		Spares – not used.
227–230	SDBER	Current raw data bit error rate, a floating point number denoting the most recent BER measure with nominal values on the order of 1.0E–6.
231–234	RANGE	Most recently computed range, a floating point value denoting number of 50-MHZ clock counts for signal transmission from satellite to ground.
235–238	GPATH	Most recent range calibration ground path delay, a floating value denoting the number of 50-MHZ clock counts that the GVAR signal takes to transit through CDA station equipment.
239–242	XMSNE	The collimation tower range calibration value, a floating point value denoting the GVAR signal delay through the ground station's antenna feed and the spacecraft's PDR transponder in 50-MHz clock counts.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
243–250	TGPAT	GPATH measurement CDA Time of Day (TOD), in the same format as words 59–66.
251–258	TXMSN	XMSNE measurement CDA TOD, in the same format as words 59–66.
259–260		Spares – not used.
261	SFRAM	Current frame counter, an integer ranging from 0 to 255 identifying current frame. Rolls over to 0 following 255.
262	SMODE	Current sounding mode. Integer value as follows: 1 = routine 2 = rapid scan operation 3 = super rapid scan operation 4 = checkout/special short-term operation

The following 16 words (263–278) contain frame-coordinate floating point values in units of degrees, with off-earth coordinates indicated by a value of 999999.

WORD	NAME	DESCRIPTION
263–266	SFNW1	Current frame's northwest corner latitude
267–270	SFNW2	Current frame's northwest corner longitude
271–274	SFSE1	Current frame's southeast corner latitude
275–278	SFSE2	Current frame's southeast corner longitude
279	SG2TN	2nd order gain interpolation table index number with integer values of 1, 2, or 3 denoting which of three possible tables is reported in SG2IT words 4567–5718.
280	SSCP2	Repeat of SSCP1 (word 53)
281–282	SSCA2	Repeat of SSCAN (words 31–32)
283–305		Spares – not used.
306		Longitudinal parity (XOR) of words 1–305

The O&A partition contains the Sounder O&A parameters being used. The format and engineering units of each variable are denoted in parentheses. The partition is sized to hold the largest expected O&A set. In general, the actual number of parameters in effect is less than the maximum and vary over time. The numeric parameters (words 563–566 and 687–690) denote the number of active terms employed for the roll attitude angle. In a similar fashion, each of the remaining four angles modeled by the O&A set is denoted by numeric parameters defining the number of active terms. Inactive terms are not compressed out of the O&A set; their places are occupied by zeroed data words.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
307–310		IMC Identifier (4 ASCII characters)
311–322		Spares – not used
323–326		Reference Longitude (positive East, R*4, rad)
327–330		Reference radial distance from nominal (R*4, km)
331–334		Reference Latitude (positive North, R*4, rad)
335–338		Reference Orbit yaw (R*4, rad)
339–342		Reference Attitude: Roll (R*4, rad)
343–346		Reference Attitude: Pitch (R*4, rad)
347–350		Reference Attitude: Yaw (R*4, rad)
351–358		Epoch Date/Time: Standard BCD format
359–362		IMC set enable time from epoch (R*4, min)
363–366		Spacecraft compensation: Roll (R*4, rad)
367–370		Spacecraft compensation: Pitch (R*4, rad)
371–374		Spacecraft compensation: Yaw (R*4, rad)
375–426		Change in longitude from ref. (13 @ R*4, rad)
427–470		Change in radial distance from ref. (11 @ R*4, km)
471–506		Sine geocentric latitude, total (9 @ R*4, no units)
507–542		Sine orbit yaw, total (9 @ R*4, no units)
543–546		Daily Solar Rate (R*4, rad/min)
547–550		Exponential Start time from epoch (R*4, min)

Words 551–770 apply to the roll attitude angle:

WORD	NAME	DESCRIPTION
551–554		Exponential Magnitude (R*4, rad)
555–558		Exponential Time Constant (R*4, min)
559–562		Constant, mean attitude angle (R*4, rad)
563–566		Number of Sinusoids/Angles (I*4, none)
567–570		Magnitude of 1st order sinusoid (R*4, rad)
571–574		Phase Angle of 1st order sinusoid (R*4, rad)
:		:
679–682		Magnitude of 15th order sinusoid (R*4, rad)
683–686		Phase Angle of 15th order sinusoid (R*4, rad)
687–690		Number of monomial sinusoids (I*4, no units)
691–694		Order of applicable sinusoid (I*4, no units)
695–698		Order of first monomial sinusoid (I*4, no units)
699–702		Magnitude of monomial sinusoid (R*4, rad)
703–706		Phase Angle of monomial sinusoid (R*4, rad)
707–710		Angle from epoch where monomial is zero (R*4, rad)
711–730		Repeat of 691–710 but for second monomial
731–750		Repeat of 691–710 but for third monomial
751–770		Repeat of 691–710 but for fourth monomial
771–990		Repeat of 551–770 for Pitch attitude angle
991–1210		Repeat of 551–770 for Yaw attitude angle
1211–1430		Repeat of 551–770 for Roll Misalignment angle
1431–1650		Repeat of 551–770 for Pitch Misalignment angle
1651–1652	SSCA3	Repeat of SSCAN (words 31–32)
1653	SSCP3	Repeat of SSCP1 (word 53)
1654–1717		Spares – not used

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
1718		Longitudinal parity (XOR) of words 307–1717
1719–2994		Unused – zeroes
2995–3002	SPSSATTIM	Satellite database modified time (BCD time)
3003–3004	SPSSATVER	Satellite database version number

The factory parameters partition contains the values of various Sounder coefficients and parameters measured prior to launch. For the most part, these values serve as an historical reference useful in evaluating the current condition of the detectors. In a few instances, the values are used throughout the life of the instrument as part of the normal calibration functions.

The nadir location of the instrument is measured in terms of cycles and increments (see section 3.4) in the north-south and east-west directions. Cycles are expressed as 8-bit integers ranging from 0 to 127. Increments are expressed as 16-bit integers ranging from 0 to 2804.

3005	SOFNC	Instrument nadir, top-bottom cycles
3006	SOFEC	Instrument nadir, right-left cycles
3007–3008	SOFNI	Instrument nadir, top-bottom increments
3009–3010	SOFEI	Instrument nadir, right-left increments

For each of the 16 sounding detectors (4 visible, 12 IR), two 16-bit integer values are provided to denote the X (right-left) and Y (top-bottom) radian offset of the detector from the instrument's optical axis. Negative values employ twos complement notation. Values can range from –32768 to +32767.

3011–3012		X-offset Visible detector 1
:		:
3013–3018		X-offset Visible detector 4
3019–3020		X-offset Longwave IR detector 1
:		:
3021–3026		X-offset Longwave IR detector 4
3027–3028		X-offset Midwave IR detector 1
:		:
3033–3034		X-offset Midwave IR detector 4
3035–3036		X-offset Shortwave IR detector 1
:		:
3041–3042		X-offset Shortwave IR detector 4
3043–3074		Y-offsets arranged in same order as x-offsets

A set of characteristic response coefficients is provided for each of the 16 detectors, containing the initial calibration coefficients associated with the detectors. The scaling factors are used to generate a 16-bit value from each calibrated IR pixel. All entries are single-precision floating point numbers.

Each of the three following arrays contain four elements, one element for each 10-km visible detector. Within each array, the elements are ordered 1, 2, 3, 4, where the numbers have the same top-to-bottom sense indicated in Figure 3-15.

3075–3090	SVCRB	Visible detector characteristic response bias coefficients array.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
3091–3106	SVCR1	Visible detector characteristic response 1st order gain coefficients array.
3107–3122	SVCR2	Visible detector characteristic response 2nd order gain coefficients array.
3123–3126	SVRAL	Visible detector radiance-to-albedo conversion factor. Single value for detectors 1–4.

Each of the following five arrays contains 72 elements, sequentially divided into 18 groups of four elements. The first four-element group is assigned to channel 1, the next to channel 2, etc., with the last group assigned to channel 18. Within each group, the four elements are sequentially assigned in a top- to-bottom sense to detectors 1–4.

WORD	NAME	DESCRIPTION
3127–3414	SICRB	IR detector characteristic response bias coefficients array.
3415–3702	SICR1	IR detector characteristic response 1st order gain coefficients array.
3703–3990	SICR2	IR detector characteristic response 2nd gain coefficients array.
3991–4278	SISFB	IR detector scale factor bias coefficients array.
4279–4566	SISF1	IR detector scale factor 1st order gain coefficients array.
4567–5718	SG2IT	IR detector 2nd order gain interpolation table containing 288 elements. The elements are sequentially arranged as 72 groups, four elements per group. The first four elements are assigned to CHannel 1-DETector 1, the next four to CH 1-DET 2, and so forth, until the last group of four which is assigned to CH 18-DET 4.
5719–5734	SG2BP	IR detector 2nd order gain baseplate temperature interpolation pivot points. Four baseplate temperatures at which SG2IT gains were measured for each IR detector. Access this table with baseplate temperature to determine interpolation factors to use within SG2IT.
5735–6886	SBBTR	Blackbody temperature-to-target radiance conversion coefficients array. Array of 288 elements, four elements for each of 72 IR channel- detectors. Elements are ordered in the same manner as described for SG2IT.
6887–6910	SPRNG	Patch temperature control ranges, an array of six elements, two elements for each of the three patch temperature control ranges. Each pair of elements defines the lower and upper temperature limits assigned to a patch control point.
6911–6912	SADCP	A constant to correct the positive analog count values for the discontinuity at zero caused by the A–D converter.

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
6913–6914	SADCN	A constant to correct the negative analog count values for the discontinuity at zero caused by the A–D converter.
6915–7342		Spares – not used.

In the following section, conversion coefficients are provided for each telemetry point whose engineering units value is used for calibration or alarm monitoring functions by the SPS. Conversion factors for unused telemetry points may be ascertained from reference document SJ–572022.

WORD	NAME	DESCRIPTION
7343–7346	SCHTA	Sounder Cooler Housing Thermistor coefficients. The final letter of the
7347–7350	SCHTB	term name (A–F) denotes the type. Usage of terms to convert raw
7351–7354	SCHTC	counts to temperature are defined in Section 3.6.2.1.
7355–7358	SCHTD	
7359–7362	SCHTE	
7363–7366	SCHTF	

The A–F naming convention used above with SCHT_ is used for all following thermistor terms:

WORD	NAME	DESCRIPTION
7367–7390	SEL1_	Sounder Electronics Side #1 Thermistor terms
7391–7414	SEL2_	Electronics #2 thermistor terms
7415–7438	SBP1_	Base Plate thermistor #1 terms
7439–7462	SBP2_	Base Plate thermistor #2 terms
7463–7486	SBP3_	Base Plate thermistor #3 terms
7487–7510	SBP4_	Base Plate thermistor #4 terms
7511–7534	SBP5_	Base Plate thermistor #5 terms
7535–7558	SBP6_	Base Plate thermistor #6 terms
7559–7582	SBB1_	Blackbody thermistor #1 terms
7583–7606	SBB2_	Blackbody thermistor #2 terms
7607–7630	SBB3_	Blackbody thermistor #3 terms
7631–7654	SBB4_	Blackbody thermistor #4 terms
7655–7678	SBB5_	Blackbody thermistor #5 terms
7779–7702	SBB6_	Blackbody thermistor #6 terms
7703–7726	SBB7_	Blackbody thermistor #7 terms
7727–7750	SBB8_	Blackbody thermistor #8 terms
7751–7774	SOP1_	Scan Mirror thermistor terms
7775–7798	SOP2_	Primary Mirror thermistor terms
7799–7822	SOP3_	Secondary Mirror thermistor #1 terms
7823–7846	SOP4_	Secondary Mirror thermistor #2 terms
7847–7870	SOP5_	Baffle thermistor #1 terms
7871–7894	SOP6_	Baffle thermistor #2 terms
7895–7918	SOP7_	Aft optics thermistor terms
7919–7942	SOP8_	Cooler radiator thermistor terms
7943–7966	SOP9_	Wide range IR detector thermistor terms
7967–7990	SOPA_	Narrow range IR detector thermistor terms
7991–8014	SOPB_	Filter wheel housing thermistor terms

Table 3-10. Sounder Scan Documentation Block 11 Format (Cont'd)

WORD	NAME	DESCRIPTION
		The remaining three telemetry points use a simple linear gain and bias mapping to convert raw counts to engineering units:
8015–8022	SFVGB	Filter wheel heater gain/bias terms
8023–8030	SPVGB	Patch control voltage gain/bias terms
8031–8038	SICGB	Instrument current gain/bias terms
8039		Spare – not used
8040		Longitudinal parity (XOR) of words 3005–8039.

3.3.7.3 Sounder Scan Data – Sounder data is buffered within SPS memory until an entire scan line of downlinked (raw) Sounder data blocks has been acquired. The number of raw blocks acquired can range from five (for a 0.016^{o} dwell 1 scan) to 4788 (for a 19.2^{o} dwell 4 scan). Each raw block contains all of the data acquired at one aim point, including a sample from each of the 76 channel detectors. Each channel detector output is treated as if it were a separate scan line.

Radiometrically corrected (hereafter termed calibrated) versions of these detector scan lines are then created. The creation process uses all of the calibration coefficient sets that were applicable during the course of the Sounder scan. Which set is applied to a given pixel is determined by comparing the time tag of the pixels' raw data block (see subsection 3.3.7.3.1) with the time tag(s) of the available calibration coefficient sets (see subsection 3.3.7.9). The set(s) applicable at the start and end of the Sounder scan are directly identified in the documentation block (see Table 3-10, words 83–98).

Following this creation, the resulting 76 scan lines and the raw data scan blocks are each divided into segments 11 samples in length in a west-to-east order. The segments are then organized into a number (from 1–436) of groups. Each group consists of a string of 11 raw Sounder data blocks, and an associated 11-pixel subset for each of the 76 calibrated scan lines. A scan line and pixel identifier data structure is then created for each group to cross-reference the grouped information for display functions. Finally, a SAD Block ID is attached to complete the transformation of each group into a Sounder Scan Data Block 11 format.

The SAD ID links multiple Block 11s together to form a complete output scan. The final Block 11 in an output scan is likely to be only partially filled with from 1 to 10 samples. Partially filled Block 11s also occur as a result of line breaks. A line break in the scan is caused by a loss of raw signal synchronization which causes the loss of one or more raw downlink data blocks. The Block 11 in which the line break starts is partially filled with samples acquired up to the break. The next sequential Block 11 is then initiated with samples acquired upon restoration of synchronization. The actual number of samples in a Block 11 are indicated by the associated SAD ID record count (word 9, Table 3-8).

P/N CODE (10,032 bits)
HEADER (720 bits)
SAD ID (240 bits)
SOUNDER DATA RECORDS **11 Records @ 4352 bits Eack** **(47,872 bits)**
LINE and PIXEL LOCATORS **(2832 bits)**
DETECTOR DATA ARRAYS **76 Lines of Calibrated** **Pixels @ 11 Pixels per Line** **(13,376 bits)**
CRC (16 bits)

Physically, the layout of the Sounder Scan Data Block 11 format is always the same, with permanent space allocations for a full 11–sample segment. The data section which results is summarized below and diagramed in Figure 3-14. The SAD block ID is defined in the preceding section. The remaining components of each segment are covered in the following sections.

DATA SECTION COMPONENT	**SIZE WORDS**	**BITS**	**DOCUMENTED IN SUBSECTION**
SAD Block ID	30	240	3.3.7.1
Instrument Data Records	5984	47872	3.3.7.3.1
Line and Pixel Indexes	354	2832	3.3.7.3.2
Detector Data Arrays	1672	13376	3.3.7.3.3.

3.3.7.3.1 Sounder Data Records – Each Sounder data record in a Block 11 is 544 eight-bit words (4352 bits) in length. The first 500 words contain a modified raw downlink Sounder data block. The modifications are performed automatically by the SPS's Sensor Data Interface (SDI). These modifications include replacement of the leading eight-word (64-bit) block synchronization code with a time tag, and the format adjustment of the remaining 492 words (see subsection 3.5.5). The time tag denotes when the synchronization code was received by the SPS. For Sounder scan data, the time tag is used to select the calibration coefficient set to be used for the data record during the scan line creation sequence.

The last 44 words (appended to each raw block by the SPS) provide status and Earth location information. The status data denotes a number of conditions registered by the SDI when the raw block was received. The Earth location data provides the latitude and longitude on the Earth's surface of the aim point used by the Sounder during the collection of the raw data contained within the record and the Earth locations associated with the four channel 8 detectors.

Table 3-11 defines the contents of the 544-word instrument data record constructed by the SPS. Up to 11 of these records are packed into a Block 11 as follows:

WORDS	CONTENTS
1–30	SAD Block ID
31–574	Record 1 (westernmost record in the Block 11)
575–1118	Record 2
1119–4926	Records 3–9
4927–5470	Record 10
5471–6014	Record 11 (easternmost record in the Block 11).

Table 3-11. Sounder Data Records Block 11

WORDS DESCRIPTION

1–500 The 250 16-bit words contained in a raw Sounder data block, with each 16-bit raw data word occupying two sequential eight-bit words. The first four of these 250 data words contain the SPS raw data block arrival time tag, which the SPS substituted for the four-word raw data block synchronization code. The raw data block content is defined in SS/L Specification 572022.

501–504 Raw Sounder data interface status words, two 16-bit words generated at end of each raw block by the receiving hardware providing configuration and data status. The contents are as follows:

Word	Bits	Description
1	0–7	Synchronization code error count
	8	Bit slip sign (1 = negative)
	9	Not used
	10–11	Input channel
	12	Data loss
	13	Clock loss
	14	Sync fault
	15	First frame after synch loss flag
2	0–7	Bit slip magnitude
	8–15	Parity error count.

Table 3-11. Sounder Data Records Block 11(Cont'd)

The remaining 40 words provide the Earth locations in degrees of five reference points in floating point format. If a reference point does not intersect the Earth, 999999.0 is used for both latitude and longitude.

WORDS	DESCRIPTION
505–508	Aim Point Latitude
509–512	Aim Point Longitude
513–516	Channel 8 Detector 1 (Northwest) Latitude
517–520	Channel 8 Detector 1 Longitude
521–524	Channel 8 Detector 2 Latitude
525–528	Channel 8 Detector 2 Longitude
529–532	Channel 8 Detector 3 Latitude
533–536	Channel 8 Detector 3 Longitude
537–540	Channel 8 Detector 4 (Southeast) Latitude
541–544	Channel 8 Detector 4 Longitude

3.3.7.3.2 Line and Pixel Index Arrays – The aim point employed by the Sounder corresponds to its optical axis, approximately the geometric center of the FOV of the scanning detectors. The general form of the relationship is illustrated in Figure 3-15. The instrument operates by settling at a selected aim point, sampling each of the 76 channel-detectors, and then stepping east-west to the next aim point. The resultant raw block generated for each sampling contains pixels asymmetrically distributed with respect to the aim point. When constructing the detector data arrays (subsection 3.3.7.3.3) the SPS "slides" the 76 calibrated scan lines by one another such that the transmitted GVAR Sounder scan data blocks contain calibrated pixel data which is aligned in Earth location with the downlink data blocks. As a result, the 76 scan line segments are aligned in lines of longitude with each other and ready for preliminary display purposes.

The detector lines and pixel locators are provided for the scan line segments to assist the display effort. Table 3-12 defines the format of the information. Note that the scan line and pixel locations are provided in absolute terms (not relative to start-of-frame location). In addition to the line and pixel locators, two flags are provided to indicate the presence of a line break start or end condition.

A line break start indicates one or more raw downlink data blocks are missing from the scan. The last raw block acquired before the onset of the break is included in the Block 11. The remaining (0–10) raw block slots will be unoccupied, as will the associated detector data array locations. The next sequential Block 11 of the scan begins with the scan data acquired when the line break ended, a condition normally associated with the reestablishment of signal synchronization by the SPS.

Table 3-12. Sounder Detector Line and Pixel Locator Block 11

WORD	CONTENTS	DESCRIPTION
6015–6016	ALINENO	16-bit binary number denoting the detector 1 scan line number. The value provides a vertical display reference and ranges from 1 to 1577.
6017–6018	BLINENO	16-bit detector 2 scan line number.
6019–6020	CLINENO	16-bit detector 3 scan line number.
6021–6022	DLINENO	16-bit detector 4 scan line number.
6023–6044	PIXELNO	Eleven pixel numbers, each 16-bits (two words) in length. Each number specifies the instrument relative west-to-east aim point associated with one of the 11 pixels of a single detector data array. The value, ranging from 1 to 1758, is used to provide a horizontal reference for displays. Sequential pixels from multiple dwells will have the same number.
6045	SLOSS	Flag denoting synchronization loss has occurred in this Block 11. Set to zero in case of no loss. Set to 255 (all bits set to 1) if synch has been lost.
6046	SRESTORE	Flag denoting whether synch has been restored in this Block 11. All bits set to 1 (=255) if restore present; else all bits are zero.
6047–6368		Not used – zeroes.

To access the raw data associated with a calibrated pixel, the satellite orientation (normal or yaw-flipped) must be considered, because it affects the relationship of the physical detectors 1–4 to the logical detectors A–D. In the normal satellite orientation, the relationship is:

Physical Detector		**Logical Detector**
1 (top left)	=	A (northwest)
2	=	B
3	=	C
4	=	D (southeast)

In the yaw-flipped mode, the relationship is:

Physical Detector		**Logical Detector**
4 (bottom right)	=	A (northwest)
3	=	B
2	=	C
1	=	D (southwest)

Hence, the calibrated pixel arrays are always ordered north-to-south and west-to-east, regardless of the satellite orientation. A yaw-flip indicator is provided in the SAD ID as well as in word 57 of the Sounder documentation block.

It is important to note that ITT numbers the Sounder detectors differently than SPS does in GVAR. In ITT documentation, detector numbering begins with the bottom right detector as number 1 and the top left detector as number 4.

In addition, the positional alignment discussed previously causes a misalignment with respect to time between the calibrated pixel information and the downlink data blocks. The time aligned raw data associated with the k^{th} calibrated pixel can be located in the i^{th} downlink data block as follows:

for detectors “1” and “2”, i = k + 2 * dmode
for detectors “2” and “4,” i = k – 2 * dmode

where *k* ranges from 1 to 11 and *dmode* is either 1, 2, or 4 according to the current dwell mode. If *i* exceeds 11, the desired downlink block is in the next sequential SAD block, module 11. If *i* is less than 1, the desired downlink data is located in the previous SAD block.

Figure 3-15 depicts a west-to-east scan of 110 km as provided by Sounder channel *n*. The aim points 1 through 11 are each bracketed by a distinct set of four FOVs corresponding to each of the four detectors in a channel. Note that aim point number 3 is the first aim point for which detectors 2 and 4 have data available, while detectors 1 and 3 have no data available after aim point 9.

Figure 3-16 represents the Sounder scan data block resulting from the 110 km scan of Figure 3-15. The relationships between the 11 downlink sensor data blocks and the resultant calibrated detector scan lines is depicted. A scan length of 110 km (11 raw data blocks) was selected to illustrate the boundary conditions at the start and end of a line of pixels using only one Block 11. For longer width scans, the non-present (zero) pixels depicted in Figure 3-16 would occur in only the first (detectors 2 & 4) and last (detectors 1 & 3) Block 11s of the scan sequence.

3.3.7.3.3 Detector Data Arrays – There are 72 calibrated IR detector data arrays and four normalized visible detector data arrays contained in a Sounder sensor data block. Each of these arrays is 11 pixels in length. Each calibrated IR pixel is 16 bits wide, occupying two sequential eight-bit words. Each normalized visible pixel (from channel 19 detectors) is 13 bits wide, left-adjusted and zero-filled within the 16-bit field. The source raw data pixels have 13-bit precision. Part of the calibration process employed involves a scaling operation to provide 16 bits of precision. Pixels whose raw data contain a parity error are assigned a value of zero. A value of zero is also assigned to the two non-present pixels occurring at the start (detectors 2 and 4) and end (detectors 1 and 3) of a scan.

The 76 Sounder channel-detectors (19 x 4) are allocated space within the detector data array as indicated in Table 3-13. The labeling of detectors with numbers (1, 2, 3, 4) is done in the same north-to-south sense indicated in Figure 3-15.

Each of the 76 arrays is aligned with one another such that the k^{th} element of each array corresponds to the same Earth-located line of longitude. The associated aim point coordinates (latitude and longitude) can be obtained by accessing the k^{th} downlink data block.

Table 3-13. Block 11 Sounder Channel-Detector Array Assignments

SOUNDER CHANNEL	**DETECTOR**			
	1	**2**	**3**	**4**
01	6369–6390	6391–6412	6413–6434	6435–6456
02	6457–6478	6479–6500	6501–6522	6523–6544
03	6545–6566	6567–6588	6589–6610	6611–6632
04	6633–6654	6655–6676	6677–6698	6699–6720
05	6721–6742	6743–6764	6765–6786	6787–6808
06	6809–6830	6831–6852	6853–6874	6875–6896
07	6897–6918	6919–6940	6941–6962	6963–6984
08	6985–7006	7007–7028	7029–7050	7051–7072
09	7073–7094	7095–7116	7117–7138	7139–7160
10	7161–7182	7183–7204	7205–7226	7227–7248
11	7249–7270	7271–7292	7293–7314	7315–7336
12	7337–7358	7359–7380	7381–7402	7403–7424
13	7425–7446	7447–7468	7469–7490	7491–7512
14	7513–7534	7535–7556	7557–7578	7579–7600
15	7601–7622	7623–7644	7645–7666	7667–7688
16	7689–7710	7711–7732	7733–7754	7755–7776
17	7777–7798	7799–7820	7821–7842	7843–7864
18	7865–7886	7887–7908	7909–7930	7931–7952
19	7953–7974	7975–7996	7997–8018	8019–8040

3.3.7.4 Compensation and Servo Error Terms – Both the Imager and the Sounder employ two-degree of freedom scan mirrors for which active positioning involves the use of compensation terms. These terms correct for motions caused by cyclical variations in the spacecraft's orbit and attitude as well as short term variations caused by movement of the other instrument. The total compensation employed by each instrument is split into a north-south and an east-west component associated with the two servo-controlled mirror axes. These component compensations, and the associated servo positioning errors, are reported by each of the instruments in the raw downlink data stream containing the imaging data. Samples of the compensation terms, servo errors, instrument location, time, and instrument status are buffered by the SPS for each instrument. As these sampling buffers fill, the SPS places them in an appropriate Block 11 format and transmits them through the GVAR uplink to a PM at the SOCC. The PM, on acquiring the compensation term Block 11, transmits the associated data to the OATS for use in monitoring each instrument's IMC and MMC component terms.

Samples are buffered by the SPS on a per instrument basis. Each instrument buffer is 64 samples in length and is transmitted when either of the following conditions occur:

1. Buffer fills (64^{th} sample acquired)
2. More than 120 seconds of non-productive instrument activity (e.g., Imager off) has elapsed.

Each 22-word group is made up of 11 pairs of 8-bit words corresponding to the 11 pixel locations for the indicated channels (1–19) and detectors (1–4).

The second condition above can result in partial buffer transmissions. The number of samples contained in a block is indicated by the RECORD COUNT field of the SAD ID (see Table 3-8). The Block 11 format employed for the Imager and Sounder compensation terms uses the record format detailed in Table 3-14.

For the Imager samples (ICSE records) are generated at a constant rate of 15 samples/second, whether a data function is active or not. These functions are always prefaced by a header block in the raw downlink data stream, and include frame scans (normal and priority), calibration events (spacelook and blackbody), and star senses. For these functions, sampling starts on the first downlink data block following a header block, and continues at every 364^{th} data block thereafter. Compensation and servo error terms are acquired directly from the downlinked wideband data blocks. The associated sample time and instrument location are calculated after the fact by interpolation between the header and trailer block end-points.

There are two special conditions to be considered. The first of these is related to the ICSE records generated for a star sense data set. The compensation and servo error terms in these records are the averaged values computed from the sums generated by the Imager SDI hardware. This summation is an unavoidable artifact of the star sense processing by the hardware.

The second special condition concerns the records generated for the intervals in which a data function is not active, that is, when the Imager is generating reversal sequences in the wideband data stream. Imager reversal sequences are generated at a nominal rate of five per second. They occur under a number of conditions, including idle, slew, and settling (at a star sense address, at the blackbody address, or at a frame start address).

Table 3-14. Instrument Compensation Term Records Block 11

WORDS DESCRIPTION

1–2 Instrument status for Sounder record as follows:

Bit	Meaning (If Set)
1	Spacelook in progress
2	ECAL in progress
3	Blackbody calibration in progress
4	Normal frame in progress
5	Priority 1 frame in progress
6	Priority 2 frame in progress
7	East-to-west scan
8	South-to-north frame
9	IMC active
10	Dwell mode = 4
11	Dwell mode = 2
12	Dwell mode = 1
13	N/S step mode = double
14	Side 2 electronics active
15	Star Sense in progress
16	Instrument Slew in progress

1–2 Instrument status for Imager record as follows:

Bit	Meaning (If Set)
1	Spacelook in progress
2	Preclamp scan in progress
3	Blackbody calibration in progress
4	Normal frame in progress
5	Priority 1 frame in progress
6	Priority 2 frame in progress
7	East-to-west scan
8	South-to-north frame
9	IMC active[1]
10	Scan Clamp Mode active

Table 3-14. Instrument Compensation Term Records Block 11 (Cont.)

WORDS DESCRIPTION

Bit	Meaning (If Set)
11	Fast Space Clamp Mode active (9.2 seconds)
12	Slow Space Clamp Mode active (36.6 seconds)
13	Reversal Data
14	Side 2 electronics active[1]
15	Star Sense in progress
16	Instrument Slew in progress

3–10 CDA time tag associated with sample, formatted as described in Table 3-6 for words 23–110.
11–12 Instrument location: east-west cycles.
13–14 East-west increments.

15–16	North-south cycles.
17–18	North-south increments.
19–20	North-south compensation term for instrument.
21–22	East-west compensation term for instrument.
23–24	North-south servo error term for instrument.
25–26	East-west servo error term for instrument.

NOTES:

1.Bits 9 and 14 in word 2 are determined from SPS configuration flags. All other remaining bits are determined directly from the raw downlinked data.

2.The last eight terms (words 11–26) are each 16 bits in length. The corresponding instrument values are right-adjusted and zero-filled within the 16 bits.

3.Up to 64 compensation term records are transmitted in a GVAR Block 11 format, with the actual number of records indicated in the RECORD COUNT field (word 9, Table 3-8) of the SAD ID. Each record is 26 8-bit words long as above. Unused data space within the Block 11 is zero-filled.

4.In the event a record is generated for which no compensation or servo error data is available (e.g., parity errors in Sounder, dead zones in Imager reversals) the corresponding terms in the record are set to zero.

5.In the event an Imager record is generated for which the time tag is estimated by the SPS (inability to acquire hardware status), the flywheel bit of the record is set.

Table 3-14. Instrument Compensation Term Records Block 11 (Cont'd)

6.Every reversal data sequence yields three ICSE records. The time and mirror positions of the first of these records is that of the trailer data block, while the compensation and servo error terms are acquired from the data block immediately following the trailer. The remaining two records generated for an Imager reversal sequence are assigned interpolated time tags and mirror positions. The servo error and compensation terms for these two records are set to zero since there are no corresponding samples available in the wideband data stream.

7.The Sounder compensation and servo error records are much easier to explain. First of all, the sampling rate associated with the Sounder is 10 samples/second. Every single raw downlink data block generates a compensation and servo error record while the SPS is operational. The record's time tag is taken as the time tag of the associated raw data block, while the mirror position is as reported in the block. The east and west compensation terms are taken directly from words 187 and 191, respectively, of the raw data block. The east and west servo error terms are obtained directly from words 181 and 192, respectively, of the same raw data block.

3.3.7.5 Telemetry Statistics – Telemetry data statistics are reported for each instrument via the Block 11 format defined in Table 3-15. Critical alarm and warning flags associated with the statistics are defined in Tables 3-16 and 3-17, respectively. The instrument telemetry points included in the statistics are listed in Tables 3-18 and 3-19 for the Imager and Sounder, respectively.

In general, all telemetry points associated with the quality of the calibration functions are included in the statistics computations, details of which are provided in section 3.6. The interval over which the statistics are accumulated is defined by the SPS time of data clock for the Imager, with every even two-minute mark denoting a completion point. For the Sounder, the telemetry statistics are accumulated between spacelook events, nominally every two minutes. The occurrence of a spacelook calibration event terminates the current telemetry statistics accumulation period, while concurrently initiating a new accumulation set.

Table 3-15. Instrument Telemetry Block 11 Format

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time of first telemetry sample set
39–46	CDA time of current limits set
47–54	CDA time of last telemetry sample set
55–70	(4 x 4) Telemetry Critical Alarm Flags (Table 3-16)
71–198	(2 x 64) Telemetry Warning Flags (Table 3-17)
199–220	Unassigned
221	Electronics Side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221

Table 3-15. Instrument Telemetry Block 11 Format (Cont'd)

WORDS	DESCRIPTION
	Instrument Telemetry Statistics
223–350	(2 x 64) Total sample size
351–478	(2 x 64) Filtered sample size
479–606	(2 x 64) Unfiltered minimum value – counts
607–734	(2 x 64) Filtered minimum value – counts
735–862	(2 x 64) Unfiltered maximum value – counts
863–990	(2 x 64) Filtered maximum value – counts
991–1246	(4 x 64) Unfiltered mean value – counts
1247–1502	(4 x 64) Filtered mean value – counts
1503–1758	(4 x 64) Unfiltered standard deviation – counts
1759–2014	(4 x 64) Filtered standard deviation – counts
2015–2270	(4 x 64) Filtered minimum – engineering units
2271–2526	(4 x 64) Filtered maximum – engineering units
2527–2782	(4 x 64) Filtered mean – engineering units
2783–3038	(4 x 64) Filtered standard deviation – engineering units
3039	Longitudinal parity (XOR) of words 223–3038
3040–8040	Unused

NOTES:

1. Telemetry flag definitions are provided in Tables 3-16 and 3-17. Temperature-critical alarm flag definitions are provided in Tables 3-30 and 3-31 for the Imager and the Sounder, respectively. Telemetry point assignments are provided in Tables 3-18 and 3-19 for the Imager and Sounder.

2. Arrays are sized to handle up to 64 telemetry points. Each of the (N x 64) arrays above is defined in a parallel fashion, in that the K^{th} entry refers to the same telemetry point in all arrays.

3. With the exception of the flag words, the elements of all (2 x 64) arrays are 16-bit positive integer values, right-adjusted and zero-filled within the allocated bit space.

4. The elements of all (4 x 64) arrays are single precision floating point values whose format is described in section 3.5.

Table 3-16. Instrument Telemetry Critical Alarm Flag Definitions

There are four critical alarm flag structures defined for the telemetry points of each instrument as follows:

WORDS	ASSOCIATED CRITICAL ALARM CONDITION
55–58	Insufficient filtered sample size
59–62	Filtered mean below low critical limit
63–66	Filtered mean exceeds high critical limit
67–70	Filtered standard deviation exceeds critical limits.

Each of the four-word critical alarm flag structures has 32 flag bits, numbered 1 to 32, where bit 1 is the MSB of the first word and 32 is the LSB of the fourth word. Each flag bit is set to 1 if the associated condition is true, and reset to 0 if the condition is false. The flags are defined in a parallel fashion within these structures in that the k^{th} entry in each structure refers to the same telemetry point. The assignment of flag bits to telemetry points is as follows:

FLAG	SET TO TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR THE FOLLOWING TELEMETRY POINTS
1	Electronics Temperature #1
2	Electronics Temperature #2
3	Sensor Assy Baseplate Temperature #1
4	Sensor Assy Baseplate Temperature #2
5	Sensor Assy Baseplate Temperature #3
6	Sensor Assy Baseplate Temperature #4
7	Sensor Assy Baseplate Temperature #5
8	Sensor Assy Baseplate Temperature #6
9	Blackbody Target Temperature #1
10	Blackbody Target Temperature #2
11	Blackbody Target Temperature #3
12	Blackbody Target Temperature #4
13	Blackbody Target Temperature #5
14	Blackbody Target Temperature #6
15	Blackbody Target Temperature #7
16	Blackbody Target Temperature #8
17	Scan Mirror Temperature
18	Telescope Primary Temperature
19	Telescope Secondary Temperature #1
20	Telescope Secondary Temperature #2
21	Telescope Baffle Temperature #1
22	Telescope Baffle Temperature #2
23	Aft Optics Temperature
24	Cooler Radiator Temperature

Table 3-16. Instrument Telemetry Critical Alarm Flag Definitions (Cont'd)

FLAG	SET TO TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR THE FOLLOWING TELEMETRY POINTS
25	Wide Range IR Detector Temperature
26	Narrow Range IR Detector Temperature
27	Filter Wheel Housing Temperature (Sounder only)
28–32	Unassigned –always zero

NOTES:

1. The critical alarm flags in words 59–70 are determined with respect to the engineering unit value of each point.

Table 3-17. Instrument Telemetry Warning Flag Definitions

Each of the two-word telemetry warning flag structures has 16 flag bits numbered 1 to 16, where bit 1 is the MSB of the first word and bit 16 is the LSB of the second. Each flag bit is set to 1 if the associated condition is true, and is reset to 0 if the associated condition is false. Flag bits for which no conditions are defined are always 0, as are flag words for which no telemetry point is assigned. The flag bits in each warning flag structure are defined in a parallel fashion in that the k^{th} bit always refers to the same condition, regardless of which telemetry point is referenced. (The telemetry points are each assigned a warning flag structure; Tables 3-18 and 3-19 provide a telemetry point/warning flag cross-reference for the Imager and the Sounder, respectively.) The flag bits definition for each of the warning flag structures is as follows:

FLAG	PRESENT FOR FOLLOWING TELEMETRY POINTS
1	Unassigned – always zero
2	Unassigned – always zero
3	Unassigned – always zero
4	Unassigned – always zero
5	Unassigned – always zero
6	Unassigned – always zero
7	Filtered sample size too small
8	Unfiltered mean value (counts) below low limit
9	Filtered mean value (counts) below low limit
10	Unfiltered mean value (counts) exceeds high limit
11	Filtered mean value (counts) exceeds high limit
12	Unfiltered sigma value (counts) exceeds limit
13	Filtered sigma value (counts) exceeds limit
14	Filtered mean value (engineering units) low
15	Filtered mean value (engineering units) high
16	Filtered sigma value (engineering units) high

Table 3-18. Imager Telemetry Point Assignments

ARRAY ENTRY #	WARNING FLAGS	TELEMETRY POINT DESCRIPTION
1	[71–72]	Electronics Temperature #1
2	[73–74]	Electronics Temperature #2

3	[75–76]	Sensor Assy Baseplate Temperature #1
4	[77–78]	Sensor Assy Baseplate Temperature #2
5	[79–80]	Sensor Assy Baseplate Temperature #3
6	[81–82]	Sensor Assy Baseplate Temperature #4
7	[83–84]	Sensor Assy Baseplate Temperature #5
8	[85–86]	Sensor Assy Baseplate Temperature #6
9	[87–88]	Blackbody Target Temperature #1
10	[89–90]	Blackbody Target Temperature #2
11	[91–92]	Blackbody Target Temperature #3
12	[93–94]	Blackbody Target Temperature #4
13	[95–96]	Blackbody Target Temperature #5
14	[97–98]	Blackbody Target Temperature #6
15	[99–100]	Blackbody Target Temperature #7
16	[101–102]	Blackbody Target Temperature #8
17	[103–104]	Scan Mirror Temperature
18	[105–106]	Telescope Primary Temperature
19	[107–108]	Telescope Secondary Temperature #1
20	[109–110]	Telescope Secondary Temperature #2
21	[111–112]	Telescope Baffle Temperature #1
22	[113–114]	Telescope Baffle Temperature #2
23	[115–116]	Aft Optics Temperature
24	[117–118]	Cooler Radiator Temperature
25	[119–120]	Wide Range IR Detector Temperature
26	[121–122]	Narrow Range IR Detector Temperature
27	[123–124]	Patch Control Voltage
28	[125–126]	Instrument Current
29	[127–128]	Cooler Housing Temperature
30–64	[129–198]	Unassigned

NOTES:

1. Square-bracketed numbers denote the warning flag words associated with the point. The definition of the flag bits within the warning flag words is provided in Table 3-17.

2. Unassigned array locations are set to zero.

Table 3-19. Sounder Telemetry Point Assignments

ARRAY ENTRY #	WARNING FLAGS	TELEMETRY POINT DESCRIPTION
1	[71–72]	Electronics Temperature #1
2	[73–74]	Electronics Temperature #2
3	[75–76]	Sensor Assy Baseplate Temperature #1
4	[77–78]	Sensor Assy Baseplate Temperature #2
5	[79–80]	Sensor Assy Baseplate Temperature #3
6	[81–82]	Sensor Assy Baseplate Temperature #4
7	[83–84]	Sensor Assy Baseplate Temperature #5
8	[85–86]	Sensor Assy Baseplate Temperature #6
9	[87–88]	Blackbody Target Temperature #1
10	[89–90]	Blackbody Target Temperature #2
11	[91–92]	Blackbody Target Temperature #3
12	[93–94]	Blackbody Target Temperature #4
13	[95–96]	Blackbody Target Temperature #5
14	[97–98]	Blackbody Target Temperature #6
15	[99–100]	Blackbody Target Temperature #7
16	[101–102]	Blackbody Target Temperature #8
17	[103–104]	Scan Mirror Temperature
18	[105–106]	Telescope Primary Temperature
19	[107–108]	Telescope Secondary Temperature #1
20	[109–110]	Telescope Secondary Temperature #2
21	[111–112]	Telescope Baffle Temperature #1
22	[113–114]	Telescope Baffle Temperature #2
23	[115–116]	Aft Optics Temperature
24	[117–118]	Cooler Radiator Temperature
25	[119–120]	Wide Range IR Detector Temperature
26	[121–122]	Narrow Range IR Detector Temperature
27	[123–124]	Filter Wheel Housing Temperature
28	[125–126]	Filter Wheel Control Heater Voltage
29	[127–128]	Patch Control Voltage
30	[129–130]	Instrument Current
31	[131–132]	Cooler Housing Temperature
32–64	[133–198]	Unassigned

NOTES:

1. Square bracketed numbers denote the warning flag words associated with the telemetry point. The definition of the flag bits within the warning flag words is provided in Table 3-17.

2. Unassigned array locations are set to zero.

The final statistics are computed and formatted for output at the end of accumulation periods. The final statistics include raw value (counts) and engineering unit quantities. The total sample size (unfiltered) is provided along with the (filtered) sample size remaining after high/low limit checking has been performed. Raw value statistics include the minimum, maximum, mean, and standard deviation in both the unfiltered and filtered states. Engineering unit value statistics are provided for the filtered minimum, maximum, mean, and standard deviations.

Two categories of alarm conditions are provided with the statistics. The warning alarm flags are of lower importance and serve to indicate the existence of outliers within the data. The critical alarm flags are more important because they are used to indicate the existence of a condition that can preclude a successful calibration of the IR detectors.

3.3.7.6 ECAL Statistics and Data – Each instrument periodically performs an ECAL to measure the performance of the signal processing circuitry associated with each radiometric detector. The ECAL consists of applying a known input level to each circuit (at the point where the detector signal would normally be received) and recording the resulting output counts. A total of 16 different input levels (or steps) are sequentially employed to span the full range of the signal processing circuitry. The resulting sets of measured output counts are analyzed (see subsection 3.6.3 for details) on the ground to determine the stability and linearity of the processing circuitry. The results of the analysis as well as the associated raw data are packaged in Block 11 formats for transmission within the GVAR data stream. Table 3-20 defines the two Block 11 formats required for the Imager ECAL data stream. Table 3-21 defines the three Block 11 formats required for the Sounder ECAL data stream.

Table 3-20. Imager ECAL Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time of first header block following ECAL data
39–46	CDA time of current limits set
47–54	Unassigned
55–84	(2 x 15) Insufficient filtered samples/step flags[1]
85–86	(2 x 1) Excessive RMS of residuals warning flags[2]
87–220	Unused
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
	Imager ECAL Statistics Records
223–1566	Seven IR detector records @ 192 words[3]
1567–3102	Eight visible detector records @ 192 words[3]
3103	Longitudinal parity (XOR) of words 223–3102[3]

Table 3-20. Imager ECAL Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION
3104–3198	Unused

Imager ECAL Raw Data Records

3199–5438	Seven 320-word IR detector raw data records[4]
5441–5478	Unused
5479–8038	Visible detectors 1–2, 1280 words of raw data for each[4]
8039–8040	Unused

BLOCK 2 WORDS	**DESCRIPTION**
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221

Imager ECAL Raw Data Records

223–7902	Visible detectors 3–8, raw data @ 1280 words each[4]
7903–8040	Unused

NOTES:

1.Each of the 16 two-word flag structures (words 55–86) contains 16 bits. Each of the 15-step warning flags (words 55–84) is assigned to an active detector. Elements 1–7 correspond to IR detectors 1–7, respectively. Elements 8–15 correspond to visible detectors 1–8, respectively. The 16 bits of each two-word step warning flag are sequentially assigned to each ECAL step, with bit 1 (the MSB) to step 1 and bit 16 (the LSB) to step 16. Flag bits are set to true (1) if too few filtered samples are acquired per given detector at a particular ECAL step, otherwise they are set to 0.

2.The RMS of residuals flag structure (words 85–86) employs bits 1 to 7 (with bit 1 the MSB of word 85) for the IR detectors and bits 8 to 15 (with bit 16 the LSB of word 86) for the visible detectors. Each bit is set true if the RMS of the residuals over the entire 16-step ECAL exceeds a warning limit for the associated detector; otherwise it is zero. Bit 16 (the LSB of word 86) is not used and is always zero.

3.Each of the 15 detector statistics records (words 223–3103) has the following layout in which all elements in (4 x N) arrays are in floating point format:

Table 3-20. Imager ECAL Block 11 Format (Cont'd)

Word	**Description**
1–16	(1 x 16) Total sample size each step
17–32	(1 x 16) Filtered sample size each step
33–96	(4 x 16) Mean Filtered Value each step
97–100	(4 x 1) Least Squares line slope
101–104	(4 x 1) Least Squares line intercept
105–168	(4 x 16) Residuals, each step
169–172	(4 x 1) RMS of residuals
173–192	Unused.

4.Each IR detector raw data record contains 160 samples (10 samples/step) in ascending order from step 1 samples through step 16 samples. Each 10-bit sample is right-adjusted and zero-filled within the 16-bit space provided. Each visible detector raw data record contains 640 samples (40 samples/step), ordered in the same step 1 through step 16 sequence employed in the IR detector records. Each 10-bit visible sample occupies two sequential 8-bit words, packed in the same right-adjusted zero-filled manner as the IR detector data values. Note that all of the ECAL raw data samples are "pure" data, in that no calibration or normalization is present. Also note that, as a result of electronic filter delays, one or more starting samples may be invalid at each step for each channel. The number of leading invalid samples is provided in Table 3-28, words 4387–4430.

Table 3-21. Sounder ECAL Block 11 Format

BLOCK 1 WORDS	**DESCRIPTION**
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time of first ECAL data block
39–46	CDA time of current limits set
47–58	Unused
59–90	(2 x 16) Insufficient filtered samples/step flags[1]
91–92	(2 x 1) Excessive RMS of Residuals warning flags[1]
93–108	(16 x 1) For each of 16 detectors, channel# used
109–220	Unused
221	Electronics Side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
	Sounder ECAL Statistics Records
223–990	Four visible channel detector records @ 192 words[2]
991–1758	Four longwave IR detector records @ 192 words[2]
1759–2526	Four mid wave IR detector records @ 192 words[2]
2527–3294	Four short wave IR detector records @ 192 words[2]

Table 3-21. Sounder ECAL Block 11 Format (Cont'd)

BLOCK 1 WORDS	**DESCRIPTION**
3295	Longitudinal parity (XOR) of words 223–3294
3296–8040	Not used

BLOCK 2 WORDS	DESCRIPTION
1–30	SAD ID (see Section 3.3.7.1.)
	Sounder ECAL Raw Data Records
31–574	ECAL step 1 Sounder data block
575–1118	ECAL step 2 Sounder data block
1119–1662	ECAL step 3 Sounder data block
1663–2206	ECAL step 4 Sounder data block
2207–2750	ECAL step 5 Sounder data block
2751–3294	ECAL step 6 Sounder data block
3295–3838	ECAL step 7 Sounder data block
3839–4382	ECAL step 8 Sounder data block
4383–4926	ECAL step 9 Sounder data block
4927–5470	ECAL step 10 Sounder data block
5471–6014	ECAL step 11 Sounder data block
6015–8040	Unused

BLOCK 3 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
	Sounder ECAL Raw Data Records
31–574	ECAL step 12 Sounder data block
575–1118	ECAL step 13 Sounder data block
1119–1662	ECAL step 14 Sounder data block
1663–2206	ECAL step 15 Sounder data block
2207–2750	ECAL step 16 Sounder data block
2751–8040	Unused

Table 3-21. Sounder ECAL Block 11 Format (Cont'd)

NOTES:

1.Each of the 17 two-word flag structures (words 59–92 above) contains 16 bits. See Block 1 notes for assignments.

2.Each of the 16 detector statistics records (words 223–3294) has the following layout, where all (4 x N) array elements are in floating point format:

Word	Description
1–16	(1 x 16) Total sample size each step
17–32	(1 x 16) Filtered sample size each step
33–96	(4 x 16) Filtered Value each step
97–100	(4 x 1) Least Squares line slope
101–104	(4 x 1) Least Squares line intercept
105–168	(4 x 16) Residuals, each step
169–172	(4 x 1) RMS of residuals

173–192 Unused.

3.Each of the Block 1 step warning flags (words 59–90) is assigned to an active detector as follows:

Elements 1–4 are assigned to visible channel detectors 1–4
Elements 5–8 are assigned to IR longwave channel detectors 1–4
Elements 9–12 are assigned to IR mid wave channel detectors 1–4
Elements 13–16 are assigned to IR short wave channel detectors 1–4

4.The 16 bits of each two-word step warning flag are sequentially assigned to each ECAL step, with bit 1 (the MSB) to step 1 and bit 16 (the LSB) to step 16. The flag bits are set to true (1) if the associated conditions occur for a given detector at a particular ECAL step; otherwise they are reset to zero.

5.The 16 bits of the RMS of residuals flag (words 91–92) are sequentially assigned to each of the 16 channel detectors. The assignments are in the same 1–16 order denoted for the step warning flags. Each bit is set to true if the RMS of the residuals over the entire 16-step ECAL exceeds a warning limit for the associated detector; otherwise it is false (0).

An Imager ECAL is performed on average once every 10 minutes (just prior to a blackbody calibration sequence). At each of the 16 step levels, 40 samples are acquired from each of the eight visible detector circuits. Concurrently, 10 samples are acquired at each step level from each of the seven active IR detector circuits. A number of leading samples are automatically excluded from the analysis at each step level. The number of samples discarded (specified in Table 3-28 as the “leading sample discard count”) varies according to the channel involved, and is a function of the time delay associated with the signal processing circuitry. The samples remaining in each step are filtered using high and low limits specified in Table 3-28 to discard outliers from the analysis. The resulting filtered sample sets are individually averaged at each step level. For each detector circuit, the 16 step averages are fitted with a linear least squares line. The residuals are computed as the difference between each step level average and the step level calculated using the least squares line. The RMS value of the 16 residuals is then computed for each detector.

In the case of the Sounder, an ECAL is performed on average once every 20 minutes, again just prior to a blackbody calibration sequence. Stability and linearity statistics are computed for the 16 10-kilometer detectors representing the four spectral bands (visible, shortwave IR, medium wave IR, and long wave IR). The eight star sensing detectors are ignored. Only one channel is used as the data source for each of the 16 detectors. The available channels associated with each detector are as follows:

SPECTRUM	**CHANNEL #**
4 detectors – visible	19
4 detectors – shortwave IR	13 to 18
4 detectors – medium wave IR	8 to 12
4 detectors – long wave IR	1 to 7

The actual channel used as the data source for each detector is specified in words 93–108 of ECAL Block 1 (see Table 3-21). The sample at each step level is filtered using high and low limits specified in Table 3-29 to discard outliers. For each detector a linear least squares curve is computed for the 16 step samples. The residual differences between the curve and the input step level averages is computed, and an RMS of the residuals is then calculated for each detector.

3.3.7.7 Spacelook Calibration Statistics and Data – Each instrument performs a spacelook calibration sequence at frequent intervals in which the scanning mirror is positioned at an extreme east-west coordinate permitting a view of space. Samples acquired from the imaging detectors while space is being viewed provide the measurements required to compute a new value for the bias term associated with each IR detector. The statistics developed from a spacelook sequence (as well as the underlying raw data) are packaged in Block 11 formats. In the remainder of this section details concerning the spacelook calibration sequence, associated instrument peculiarities, and calibration bias adjustment specifics are presented. Section 3.6 should be referenced for further information concerning the calibration algorithms.

The Imager performs a spacelook calibration sequence at rates which depend upon the current activity of the instrument. The rates can vary from once every second (narrow scan clamp frame) to once every 36.6 seconds (priority 1 space clamp frame). Regardless of the rate, each spacelook has three stages:

1. Preclamp – provides up to 400 raw data blocks
2. Clamp – provides no data
3. Postclamp – provides up to 400 raw data blocks.

During the preclamp stage, space is viewed by the instrument while samples from the imaging detectors are being generated. For the IR detectors, these samples are used to compute the drift bias. The drift bias is used with the previous postclamp bias to compute the bias rate of the detector since the last clamp event.
The clamp operation generates no directly observable samples. Electronic in nature, the clamp serves to dynamically adjust the low-level output of each detector to the common background level represented by space.

The postclamp stage occurs immediately following the clamping operation. Data from the postclamp set is used to compute a new bias term for each IR detector. A separate but identical data analysis is performed on both the preclamp and the postclamp samples. The minimum, maximum, mean, and standard deviation (&) of the spacelook values, both filtered and unfiltered, are computed for each detector. Various warning flags are generated if predefined limits for the various statistics are exceeded.

With the conclusion of the spacelook data set analysis, a check is performed to determine if a two-minute interval has expired since the last GVAR Block 11 report was generated. If one has, a new set of Block 11 spacelook data is constructed and queued for output in GVAR. This format includes one full set of preclamp and postclamp information (statistics and raw data) and summary statistics for all of the intervening clamp events since the last 2-minute report. The six Block 11s used to transport this information are defined in Table 3-22. The warning flags included with the statistics are defined in Table 3-23.

At the same time, computation of the updated calibration bias terms for the IR detectors may be performed using the filtered mean values generated by the spacelook data analysis. If as a result of filtering too few samples are included in a detector's mean value, no calibration bias term update is performed for that detector. Results of the calibration are reported in the Block 11 format described in subsection 3.3.7.9.

Table 3-22. Imager Spacelook Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA formatted time tag of spacelook header block
39–46	CDA time of current limits set
47–50	(2 x 2) Preclamp scan line and western pixel number
51–54	(2 x 2) Postclamp scan line and western pixel number
55–84	(2 x 15) Spacelook warning flags (see Table 3-23)
85–114	(2 x 15) Preclamp warning flags (see notes)
115–117	Spacelook critical alarm flags (see notes)
118	Spare
119–126	CDA time tag for preclamp data
127–134	CDA time tag for postclamp data
135–220	Spare – not used
221	Electronics Side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
	Imager Preclamp Statistics
223–252	(2 x 15) Total sample size
253–282	(2 x 15) Filtered sample size
283–312	(2 x 15) Unfiltered minimum value – counts
313–342	(2 x 15) Filtered minimum value – counts
343–372	(2 x 15) Unfiltered maximum value – counts
373–402	(2 x 15) Filtered maximum value – counts
403–462	(4 x 15) Unfiltered mean value – counts
463–522	(4 x 15) Filtered mean value – counts
523–582	(4 x 15) Unfiltered standard deviation – counts
583–642	(4 x 15) Filtered & – counts
643–670	(4 x 7) Filtered & – radiance (IR only)
671–698	(4 x 7) Filtered & – temperature (IR only)
699–701	Unused
702	Longitudinal parity (XOR) of words 223–701
	Imager Postclamp Statistics
703–732	(2 x 15) Total sample size
733–762	(2 x 15) Filtered sample size
763–792	(2 x 15) Unfiltered minimum value – counts
793–822	(2 x 15) Filtered minimum value – counts
823–852	(2 x 15) Unfiltered maximum value – counts
853–882	(2 x 15) Filtered maximum value – counts
883–942	(4 x 15) Unfiltered mean value – counts

Table 3-22. Imager Spacelook Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION
943–1002	(4 x 15) Filtered mean value – counts
1003–1062	(4 x 15) Unfiltered standard deviation – counts

1063–1122	(4 x 15) Filtered & – counts
1123–1150	(4 x 7) Filtered & – radiance (IR only)
1151–1178	(4 x 7) Filtered & – temperature (IR only)
1179–1181	Unused
1182	Longitudinal parity (XOR) of words 703–1181

<u>Imager Accrued IR Activity</u>

1183–1662	(4 x 120) IR detector 1 preclamp filtered mean – counts
1663–2142	(4 x 120) IR detector 2 preclamp filtered mean – counts
2143–2622	(4 x 120) IR detector 3 preclamp filtered mean – counts
2623–3102	(4 x 120) IR detector 4 preclamp filtered mean – counts
3103–3582	(4 x 120) IR detector 5 preclamp filtered mean – counts
3583–4062	(4 x 120) IR detector 6 preclamp filtered mean – counts
4063–4542	(4 x 120) IR detector 7 preclamp filtered mean – counts
4543–5022	(4 x 120) IR detector 1 postclamp filtered mean – counts
5023–5502	(4 x 120) IR detector 2 postclamp filtered mean – counts
5503–5982	(4 x 120) IR detector 3 postclamp filtered mean – counts
5983–6462	(4 x 120) IR detector 4 postclamp filtered mean – counts
6463–6942	(4 x 120) IR detector 5 postclamp filtered mean – counts
6943–7422	(4 x 120) IR detector 6 postclamp filtered mean – counts
7423–7902	(4 x 120) IR detector 7 postclamp filtered mean – counts
7903–7905	Unused
7906	Longitudinal parity (XOR) of words 1183–7902
7907–8040	Spares – unused

BLOCK 2 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221

<u>Imager Accrued IR Activity</u>

223–702	(4 x 120) IR detector 1 preclamp filtered & – counts
703–1182	(4 x 120) IR detector 2 preclamp filtered & – counts
1183–1662	(4 x 1120) IR detector 3 preclamp filtered & – counts
1663–2142	(4 x 1120) IR detector 4 preclamp filtered & – counts

Table 3-22. Imager Spacelook Block 11 Format (Cont'd)

BLOCK 2 WORDS	DESCRIPTION
2143–2622	(4 x 1120) IR detector 5 preclamp filtered & – counts
2623–3102	(4 x 1120) IR detector 6 preclamp filtered & – counts
3103–3582	(4 x 1120) IR detector 7 preclamp filtered & – counts
3583–4062	(4 x 1120) IR detector 1 postclamp filtered & – counts
4063–4542	(4 x 1120) IR detector 2 postclamp filtered & – counts
4543–5022	(4 x 1120) IR detector 3 postclamp filtered & – counts
5023–5502	(4 x 1120) IR detector 4 postclamp filtered & – counts
5503–5982	(4 x 1120) IR detector 5 postclamp filtered & – counts
5983–6462	(4 x 1120) IR detector 6 postclamp filtered & – counts

6463–6942	(4 x 1120) IR detector 7 postclamp filtered & – counts
6943–6945	Unused
6946	Longitudinal parity (XOR) of words 223–6942
6947–8040	Spares – unused

BLOCK 3 **WORDS**	**DESCRIPTION**
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221
	Imager Accrued IR Activity
223–462	(2 x 120) IR 1 preclamp filtered point count
463–702	(2 x 120) IR 2 preclamp filtered point count
703–942	(2 x 120) IR 3 preclamp filtered point count
943–1182	(2 x 120) IR 4 preclamp filtered point count
1183–1422	(2 x 120) IR 5 preclamp filtered point count
1423–1662	(2 x 120) IR 6 preclamp filtered point count
1663–1902	(2 x 120) IR 7 preclamp filtered point count
1903–2142	(2 x 120) IR 1 postclamp filtered point count
2143–2382	(2 x 120) IR 2 postclamp filtered point count
2383–2622	(2 x 120) IR 3 postclamp filtered point count
2623–2862	(2 x 120) IR 4 postclamp filtered point count
2863–3102	(2 x 120) IR 5 postclamp filtered point count
3103–3342	(2 x 120) IR 6 postclamp filtered point count
3343–3582	(2 x 120) IR 7 postclamp filtered point count
3583–3822	(2 x 120) preclamp event times
3823–4062	(2 x 120) postclamp event times
4063–4542	(4 x 120) clamp mode and status flags
4543	Number of clamp events (1–120)

Table 3-22. Imager Spacelook Block 11 Format (Cont'd)

BLOCK 3 **WORDS**	**DESCRIPTION**
4544–4545	Spares – unused
4546	Longitudinal parity (XOR) of words 223–4545
	Imager IR Preclamp Raw Data Values
4547–5346	(2 x 400) IR detector 1 – counts
5347–6146	(2 x 400) IR detector 2 – counts
6147–6946	(2 x 400) IR detector 3 – counts
6947–7746	(2 x 400) IR detector 4 – counts
7747–8040	Spares – unused

BLOCK 4 **WORDS**	**DESCRIPTION**
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused

222	Longitudinal parity (XOR) of words 1–221

Imager IR Preclamp Raw Data Values

223–1022	(2 x 400) IR detector 5 – counts
1023–1823	(2 x 400) IR detector 6 – counts
1823–2622	(2 x 400) IR detector 7 – counts

Imager IR Postclamp Raw Data Values

2623–3422	(2 x 400) IR detector 1 – counts
3423–4222	(2 x 400) IR detector 2 – counts
4223–5022	(2 x 400) IR detector 3 – counts
5023–5822	(2 x 400) IR detector 4 – counts
5823–6622	(2 x 400) IR detector 5 – counts
6623–7422	(2 x 400) IR detector 6 – counts
7423–8040	Spares – unused

BLOCK 5 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221

Table 3-22. Imager Spacelook Block 11 Format (Cont'd)

BLOCK 5 WORDS	DESCRIPTION

Imager IR Postclamp Raw Data Values

223–1022	(2 x 400) IR detector 7 – counts

Imager Visible Preclamp Data Values

1023–1822	(2 x 400) Visible detector 1 – counts
1823–2622	(2 x 400) Visible detector 2 – counts
2623–3422	(2 x 400) Visible detector 3 – counts
3423–4222	(2 x 400) Visible detector 4 – counts
4223–5022	(2 x 400) Visible detector 5 – counts
5023–5822	(2 x 400) Visible detector 6 – counts
5823–6622	(2 x 400) Visible detector 7 – counts
6623–7422	(2 x 400) Visible detector 8 – counts
7423–8040	Spares – unused

BLOCK 6 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221

Imager Visible Postclamp Data Values

223–1022	(2 x 400) Visible detector 1 – counts
1023–1822	(2 x 400) Visible detector 2 – counts
1823–2622	(2 x 400) Visible detector 3 – counts
2623–3422	(2 x 400) Visible detector 4 – counts
3423–4222	(2 x 400) Visible detector 5 – counts
4223–5022	(2 x 400) Visible detector 6 – counts
5023–5822	(2 x 400) Visible detector 7 – counts
5823–6622	(2 x 400) Visible detector 8 – counts
6623–8040	Spares – unused

NOTES:

1.Warning flags for pre-clamp data words 85–114 of Block 1 are parallel to the spacelook definitions provided in Table 3-23.

Table 3-22. Imager Spacelook Block 11 Format (Cont'd)

2.Critical Alarm flags (words 115–117 of Block 1) are duplicated from words 57–59 of Table 3-28 to simplify message logic in the PMs.

3.The event times provided in block 3 (words 3583–4062) are 16-bit positive integers having units of 10 milliseconds (a value of 23 denotes 230 milliseconds). The time denotes the interval from the preceding two-minute mark of the preclamp or postclamp.

4.The clamp mode and status flags provided in words 4063–4542 of block 3 are defined in exactly the same way as the scan documentation Block 0 (Table 3-6) clamp mode and status flags in words 5967–5970 and 6231–6234.

5.With four exceptions, all block 1 statistics arrays are 15 entries in length. The first 7 entries in each of these arrays are sequentially assigned to the seven active IR detectors. The last 8 entries of each array are assigned to the eight visible detectors. The four exceptions are each 7 entries in length, with each entry sequentially assigned to the seven IR detectors.

6.Arrays sized as 2 x N whose units are in counts contain a right-adjusted 10-bit value. The most significant 6 bits of each two-word entry are zeroes. Arrays sized as (4 x N) are floating point value arrays, each entry occupying four sequential words.

Table 3-23. Imager Spacelook and Blackbody Warning Flag Definitions

WORDS	**DESCRIPTION**
55–56	IR detector 1 warning flags
57–58	IR detector 2 warning flags
59–60	IR detector 3 warning flags
61–62	IR detector 4 warning flags
63–64	IR detector 5 warning flags
65–66	IR detector 6 warning flags
67–68	IR detector 7 warning flags
69–70	Visible detector 1 warning flags
71–72	Visible detector 2 warning flags
73–74	Visible detector 3 warning flags
75–76	Visible detector 4 warning flags

77–78	Visible detector 5 warning flags
79–80	Visible detector 6 warning flags
81–82	Visible detector 7 warning flags
83–84	Visible detector 8 warning flags

NOTES:

1.Visible detector flag words 69–84 are used only for spacelook calibration.

Table 3-23. Imager Spacelook and Blackbody Warning Flag Definitions (Cont'd)

2.Each of the two-word structures has 16 bits numbered 1 to 16, where bit 1 is the MSB of the first word and bit 16 is the LSB of the second word. Each flag bit is set to 1 if the associated condition is true, and set to 0 otherwise. Warning flags are defined as follows:

Flag	**Set True (1) For Condition**
1	Unassigned (always 0)
2	Unassigned (always 0)
3	Unassigned (always 0)
4	Unassigned (always 0)
5	Unassigned (always 0)
6	Unassigned (always 0)
7	Filtered sample size too small
8	Unfiltered mean value (counts) below low limit
9	Filtered mean value (counts) below low limit
10	Unfiltered mean value (counts) exceeds high limit
11	Filtered mean value (counts) exceeds high limit
12	Unfiltered & value (counts) exceeds limit
13	Filtered & value (counts) exceeds limit
14	Unassigned (always 0)
15	Filtered IR & value (radiance) exceeds limit
16	Filtered IR & value (temperature) exceeds limit.

3.Flags 15 and 16 are not applicable for the visible detectors.

The Sounder performs a spacelook calibration sequence at a fixed nominal rate of once every two minutes. During a Sounder spacelook calibrations, 40 raw Sounder data blocks are acquired at the spacelook coordinates. Unlike the Imager, there is no defined preclamp or clamp Sounder activity. Each raw Sounder data block yields a single spacelook sample for each of the 76 channel-detectors.

A data analysis similar to that performed for the Imager spacelook data is performed for the Sounder spacelook data. The resulting statistics, warning flags, and raw data are packaged in five Sounder Block 11 formats, described in Table 3-24; and the associated warning flags are defined in Table 3-25.

Table 3-24. Sounder Spacelook Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time tag of first spacelook data block
39–46	CDA time of current limits set
47–48	Prespacelook scan position line number
49–50	Prespacelook scan position pixel number
51–52	Spacelook scan position line number
53–54	Spacelook scan position pixel number
55–206	(2 x 76) Spacelook warning flags (see Table 3-25)
207–216	Spacelook Critical Alarm flags (see notes)
217–219	Unused
220	Spacelook side active: 0 = west, 255 = east
221	Electronics Side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
	Sounder Spacelook Statistics
223–374	(2 x 76) Total sample size
375–526	(2 x 76) Filtered sample size
527–678	(2 x 76) Unfiltered minimum value – counts
679–830	(2 x 76) Filtered minimum value – counts
831–982	(2 x 76) Unfiltered maximum value – counts
983–1134	(2 x 76) Filtered maximum value – counts
1135–1438	(4 x 76) Unfiltered mean value – counts
1439–1742	(4 x 76) Filtered mean value – counts
1743–2046	(4 x 76) Unfiltered standard deviation – counts
2047–2350	(4 x 76) Filtered standard deviation – counts
2351–2638	(4 x 72) Filtered & – radiance (IR only)
2639–2926	(4 x 72) Filtered & – temperature (IR only)
2927	Longitudinal parity (XOR) of words 223–2926
2928–8040	Unused

BLOCK 2 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1)
	Sounder Raw Data Records
31–574	Spacelook data block 1
575–1118	Spacelook data block 2
1119–1662	Spacelook data block 3

Table 3-24. Sounder Spacelook Block 11 Format (Cont'd)

BLOCK 2 WORDS	DESCRIPTION
1663–2206	Spacelook data block 4
2207–2750	Spacelook data block 5

2751–3294	Spacelook data block 6
3295–3838	Spacelook data block 7
3839–4382	Spacelook data block 8
4383–4926	Spacelook data block 9
4927–5470	Spacelook data block 10
5471–6014	Spacelook data block 11
6015–8040	Unused

BLOCK 3,[4] WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
	Sounder Raw Data Records
31–574	Spacelook data block 12 ,[23]
575–1118	Spacelook data block 13 ,[24]
1119–1662	Spacelook data block 14 ,[25]
1663–2206	Spacelook data block 15 ,[26]
2207–2750	Spacelook data block 16 ,[27]
2751–3294	Spacelook data block 17 ,[28]
3295–3838	Spacelook data block 18 ,[29]
3839–4382	Spacelook data block 19 ,[30]
4383–4926	Spacelook data block 20 ,[31]
4927–5470	Spacelook data block 21 ,[32]
5471–6014	Spacelook data block 22 ,[33]
6015–8040	Unused

BLOCK 5 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
	Sounder Raw Data Records
31–574	Spacelook data block 34
575–1118	Spacelook data block 35
1119–1662	Spacelook data block 36
1663–2206	Spacelook data block 37

Table 3-24. Sounder Spacelook Block 11 Format (Cont'd)

BLOCK 5 WORDS	DESCRIPTION
2207–2750	Spacelook data block 38
2751–3294	Spacelook data block 39
3295–3838	Spacelook data block 40
3039–8040	Unused

NOTES:

1.Spacelook critical alarm flags (words 207–216, block 1) are duplicates of words 63–72, Table 3-29. They are provided here to simplify the message logic in the PMs.

2.All arrays sized (2 x 76) in the statistics section of block 1 contain positive integer values, right- adjusted and zero-filled. The (4 x N) arrays contain floating point values.

3.Blocks 3 and 4 have the same format, with the block 4 contents indicated by the umbers in brackets.

4.The format of the raw data spacelook records (1–40) contained in the 2nd – 5th Block 11s is defined in Table 3-11.

Table 3-25. Sounder Spacelook and Blackbody Warning Flag Definitions

WORDS	DESCRIPTION
55–56	Channel 1 detector 1 warning flags
57–58	Channel 1 detector 2 warning flags
59–60	Channel 1 detector 3 warning flags
61–62	Channel 1 detector 4 warning flags
63–70	Channel 2 detector 1–4 warning flags
71–78	Channel 3 detector 1–4 warning flags
79–86	Channel 4 detector 1–4 warning flags
87–94	Channel 5 detector 1–4 warning flags
95–102	Channel 6 detector 1–4 warning flags
103–110	Channel 7 detector 1–4 warning flags
111–118	Channel 8 detector 1–4 warning flags
119–126	Channel 9 detector 1–4 warning flags
127–206	Channels 10–19 detector 1–4 warning flags

Table 3-25. Sounder Spacelook and Blackbody Warning Flag Definitions (Cont'd)

NOTES:

1.Each of the 76 two-word structures above has 16 flag bits numbered 1–16, where bit 1 is the MSB of the first word and bit 16 is the LSB of the second. Each flag bit is set to 1 if the associated condition is true. Warning flags are defined as follows:

Flag	**Set True (1) for Condition**
1	Unassigned (always 0)
2	Unassigned (always 0)
3	Unassigned (always 0)
4	Unassigned (always 0)
5	Unassigned (always 0)
6	Unassigned (always 0)
7	Filtered sample size too small
8	Unfiltered mean value (counts) below low limit
9	Filtered mean value (counts) below low limit
10	Unfiltered mean value (counts) exceeds high limit
11	Filtered mean value (counts) exceeds high limit
12	Unfiltered & value (counts) exceeds limit
13	Filtered & value (counts) exceeds limit
14	Unassigned (always 0)
15	Filtered IR & value (radiance) exceeds limit
16	Filtered IR & value (temperature) exceeds limit

2.Flags 15 and 16 are not applicable for the four channel 19 visible detectors (words 199–206) during a spacelook report. During a blackbody report, none of the visible detector flags apply and words 199–206 will always be zero.

3.3.7.8 Blackbody Calibration Statistics and Data – At periodic intervals of 10 minutes (nominal) for the Imager and 20 minutes (nominal) for the Sounder, a blackbody calibration sequence is initiated. During a blackbody calibration sequence the scanning mirror is rotated in the north-south direction through an angle of approximately 180 mechanical degrees to present a view of the blackbody surface to the imaging detectors. The blackbody surface is actively maintained in thermal equilibrium at a nominal temperature of 290 Kelvins. The surface is instrumented with eight temperature measuring thermistors. The purpose in viewing a known relatively high temperature scene is to provide a means of computing (see Section 3.6) the 1st order gain coefficients associated with the IR detectors.

Once the scanning mirror has settled on the blackbody scene, the Imager generates 1000 raw data blocks of imaging data. This provides 1000 pixels for each IR detector. The analysis proceeds in the same fashion described for the spacelook data analysis. Minimum, maximum, mean, and standard deviation (&) of the blackbody values (both filtered and unfiltered) are computed for each IR detector. In addition, warning flags are generated if predefined limits for the various statistics are exceeded. The resulting statistics, warning flags, and raw data are packaged into two Block 11s for inclusion in the GVAR data stream. Table 3-26 provides the Block 11 format definitions employed. The warning flags for the Imager blackbody calibration are defined in Table 3-23.

During a Sounder blackbody calibration 40 raw Sounder data blocks are acquired after the scanning mirror has settled on the blackbody scene. Each raw Sounder data block yields a single blackbody sample for each of the 72 IR channel-detectors.

A data analysis similar to that performed for the Imager blackbody data is provided for the Sounder data. The resulting statistics, warning flags, and raw data, are packaged in Block 11 formats for inclusion in the GVAR output data stream. The formats employed for the five Block 11s used to transport the Sounder blackbody information are delineated in Table 3-27. The warning flags employed for a Sounder blackbody are defined in Table 3-25.

Table 3-26. Imager Blackbody Block 11 Format

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA formatted time tag of blackbody header block
39–46	CDA time of current limits set
47–48	Preblackbody scan position line number
49–50	Preblackbody scan position pixel number
51–52	Blackbody scan position scan count number
53–54	Blackbody scan position pixel number
55–68	(2 x 7) Blackbody warning flags (see Table 3-23)
69–114	Spares
115–117	Blackbody critical alarm flags (see notes)
118	Spare
119–126	CDA time of preblackbody postclamp data
127–134	CDA time of blackbody data
135–142	CDA time of postblackbody spacelook data
143–220	Spares
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
	Imager Preblackbody Postclamp Statistics
223–236	(2 x 7) Total sample size
237–250	(2 x 7) Filtered sample size
251–264	(2 x 7) Unfiltered minimum value – counts
265–278	(2 x 7) Filtered minimum value – counts
279–292	(2 x 7) Unfiltered maximum value – counts

Table 3-26. Imager Blackbody Block 11 Format (Cont'd)

BLOCK 1

WORDS	DESCRIPTION
293–306	(2 x 7) Filtered maximum value – counts
307–334	(4 x 7) Unfiltered mean value – counts
335–362	(4 x 7) Filtered mean value – counts
363–390	(4 x 7) Unfiltered standard deviation – counts
391–418	(4 x 7) Filtered & – counts
419–446	(4 x 7) Filtered & – radiance
447–474	(4 x 7) Filtered & – temperature
475–505	Unused
506	Longitudinal parity (XOR) of words 223–505
	Imager Blackbody Statistics

507–520 (2 x 7) Total sample size
521–534 (2 x 7) Filtered sample size
534–548 (2 x 7) Unfiltered minimum value – counts
549–562 (2 x 7) Filtered minimum value – counts
561–576 (2 x 7) Unfiltered maximum value – counts
577–590 (2 x 7) Filtered maximum value – counts
591–618 (4 x 7) Unfiltered mean value – counts
619–646 (4 x 7) Filtered mean value – counts
647–674 (4 x 7) Unfiltered standard deviation – counts
675–702 (4 x 7) Filtered & – counts
703–730 (4 x 7) Filtered & – radiance
731–758 (4 x 7) Filtered & – temperature
759–78 (4 x 7) Interpolated spacelevel at blackbody – counts
787–789 Unused
790 Longitudinal parity (XOR) of words 507–789

Imager Postblackbody Spacelook Statistics

791–804 (2 x 7) Total sample size
805–818 (2 x 7) Filtered sample size
819–832 (2 x 7) Unfiltered minimum value – counts
833–846 (2 x 7) Filtered minimum value – counts
847–860 (2 x 7) Unfiltered maximum value – counts
861–874 (2 x 7) Filtered maximum value – counts
875–902 (4 x 7) Unfiltered mean value – counts
903–930 (4 x 7) Filtered mean value – counts
931–958 (4 x 7) Unfiltered standard deviation – counts
959–986 (4 x 7) Filtered & – counts
987–1014 (4 x 7) Filtered & – radiance

Table 3-26. Imager Blackbody Block 11 Format (Cont'd)

BLOCK 1

WORDS	DESCRIPTION
1015–1042	(4 x 7) Filtered & – temperature
1043–1073	Unused
1074	Longitudinal parity (XOR) of words 791–1073

Imager Blackbody Raw Data Values

1075–3074	(2 x 1000) IR detector 1 raw data – counts
3075–5074	(2 x 1000) IR detector 2 raw data – counts
5075–7074	(2 x 1000) IR detector 3 raw data – counts
7075–7874	(2 x 400) IR detector 4 raw data – counts
7875–8040	Unused – spares

BLOCK 2

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–221	Unused
222	Longitudinal parity (XOR) of words 1–221

Imager Blackbody Raw Data Values

223–1422	(2 x 600) IR detector 4 raw data – counts
1423–3422	(2 x 1000) IR detector 5 raw data – counts
3423–5422	(2 x 1000) IR detector 6 raw data – counts
5423–7422	(2 x 1000) IR detector 7 raw data – counts
7423–8040	Unused

NOTES:

1. Formats and array layouts parallel the definitions provided in Table 3-22 for Imager spacelook data, except that only IR detectors are processed during a blackbody calibration.

2. Critical Alarm flags (words 115–117) are duplicates of words 60–62 of Table 3-28 to simplify message logic in the Product Monitors.

Table 3-27. Sounder Blackbody Block 11 Format

BLOCK 1

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time tag of blackbody header block
39–42	CDA time of current limits set
47–48	Preblackbody scan position line number
49–50	Preblackbody scan position pixel number
51–52	Blackbody scan position line number
53–54	Blackbody scan position pixel number
55–198	(2 x 72) Blackbody warning flags (see Table 3-25)
199–206	Unused
207–216	Blackbody critical alarm flags (see notes)
217–220	Unused
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221

Sounder Blackbody Statistics

223–366	(2 x 72) Total sample size
367–510	(2 x 72) Filtered sample size
511–654	(2 x 72) Unfiltered minimum value – counts
655–798	(2 x 72) Filtered minimum value – counts
799–942	(2 x 72) Unfiltered maximum value – counts
943–1086	(2 x 72) Filtered maximum value – counts
1087–1374	(4 x 72) Unfiltered mean value – counts
1375–1662	(4 x 72) Filtered mean value – counts
1663–1950	(4 x 72) Unfiltered standard deviation – counts
1951–2238	(4 x 72) Filtered standard deviation – counts
2239–2526	(4 x 72) Filtered standard deviation – radiance
2527–2814	(4 x 72) Filtered standard deviation – temperature
2815	Longitudinal parity (XOR) for words 223–2814
2816–8040	Unused

BLOCK 2

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)

Sounder Raw Data Records

31–574	Blackbody data block 1
575–1118	Blackbody data block 2
1119–1662	Blackbody data block 3

Table 3-27. Sounder Blackbody Block 11 Format (Cont'd)

BLOCK 2 WORDS	DESCRIPTION
1663–2206	Blackbody data block 4
2207–2750	Blackbody data block 5
2751–3294	Blackbody data block 6
3295–3838	Blackbody data block 7
3839–4382	Blackbody data block 8
4383–4926	Blackbody data block 9
4927–5470	Blackbody data block 10
5471–6014	Blackbody data block 11
6015–8040	Unused

BLOCK 3,[4] WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)

Sounder Raw Data Records

31–574	Blackbody data block 12 ,[23]
575–1118	Blackbody data block 13 ,[24]
1119–1662	Blackbody data block 14 ,[25]
1663–2206	Blackbody data block 15 ,[26]
2207–2750	Blackbody data block 16 ,[27]
2751–3294	Blackbody data block 17 ,[28]
3295–3838	Blackbody data block 18 ,[29]
3839–4382	Blackbody data block 19 ,[30]
4383–4926	Blackbody data block 20 ,[31]
4927–5470	Blackbody data block 21 ,[32]
5471–6014	Blackbody data block 22 ,[33]
6015–8040	Unused

BLOCK 5 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)

Table 3-27. Sounder Blackbody Block 11 Format (Cont'd)

BLOCK 5 WORDS	**DESCRIPTION**
	Sounder Raw Data Records
31–574	Blackbody data block 34
575–1118	Blackbody data block 35
1119–1662	Blackbody data block 36
1663–2206	Blackbody data block 37
2207–2750	Blackbody data block 38
2751–3294	Blackbody data block 39
3295–3838	Blackbody data block 40
3839–8040	Unused

NOTES:

1. Blackbody critical alarm flags (words 207–216 of Block 1) are duplicates of words 73–82, Table 3-29. They are provided here to simplify the message logic in the PMs.

2. All arrays sized (2 x 72) in the statistics section of block 1 contain positive integer values, right- adjusted and zero-filled. The (4 x 72) arrays contain floating point values.

3. The format of the raw data blackbody records (1–40) contained in the 2^{nd} – 5^{th} Block 11s is defined in Table 3-11.

3.3.7.9 IR Calibration Coefficients and Limits Format – The IR calibration coefficients employed for each instrument are updated following each space look and blackbody calibration event. Specific details concerning the calibration algorithms are provided in Section 3.6. The updated coefficients are reported via the Block 11 formats defined in Tables 3-28 and 3-29 for the Imager and Sounders, respectively. Included in these formats are the warning and critical alarm limits associated with each instrument for the four statistics computation sequences (telemetry statistics, ECAL, space look calibration, blackbody calibration).

The IR calibration coefficients are identified as a specific set through the use of a CDA time tag reflecting the time they were calculated and subsequently implemented within the SPS. This time tag is included in the documentation associated with each instrument's scan data to permit positive identification of the calibration coefficients employed to generate the pixel Imagery. In a similar sense, the warning and critical alarm limits are uniquely identified by a CDA time tag indicating when the last update was made to the limits set in use. This time tag accompanies each of the reports made for the statistics computation sequences so that the limits employed in their generation can be ascertained.

Included with each IR calibration coefficients set is a series of critical alarm flags. The flags are used to denote the occurrence of any condition which prohibits the normal calibration computation sequence for one or more detectors. These flags are defined in Tables 3-30 and 3-31 for the Imager and Sounder, respectively.

Table 3-28. Imager Calibration and Limits Block 11 Format

WORDS	**DESCRIPTION**

1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time IR coefficients calculated
39–46	CDA time of current limits set
47–54	CDA time current visible NLUTs created
55–56	Not used
57–59	Spacelook Data Critical Alarm Flags (Table 3-30)
60–62	Blackbody Data Critical Alarm Flags (Table 3-30)
63–64	Temperature Data Critical Alarm Flags (Table 3-30)
65–71	IR detector M Gain Alarm Flags (see Table 3-30)
72	Blackbody temperature gradient alarm flag (= x ‘FF’ if & of 8 BB temperatures is excessive)
73	Scan mirror temperature out-of-range at BBCAL (= 255 if true)
74–209	Not used
210	Triggering event: 0 = spacelook, 255 = blackbody
211–218	CDA time of triggering event (see notes)
219–220	Not used
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221

Imager Calibration Data

223–250	(4 x 7) Current IR detector biases
251–278	(4 x 7) Current IR detector 1st order gains
279–306	(4 x 7) Current IR detector 2nd order gains (q’s)
307–310	(4 x 11) Current weighted mean blackbody temperature
311–314	(4 x 11) Current weighted mean baseplate temperature
315–318	(4 x 11) Current smoothed patch temperature
319–322	(4 x 11) Current & of 8 blackbody temperatures
323–326	(4 x 11) Current & tolerance for 8 BB temperatures
327–350	(4 x 16) Baseplate thermistor weighing factors
351–382	(4 x 18) Blackbody thermistor weighing factors
383–386	(4 x 11) Current A weight for M-history file

Table 3-28. Imager Calibration and Limits Block 11 Format (Cont’d)

WORDS	DESCRIPTION
387–390	(4 x 11) Current B weight for M-history file
391–394	(4 x 11) Current C weight for M-history file
395–398	(4 x 11) Current D weight for M-history file
399–414	(2 x 8) Blackbody thermistor filtered sample size
415	Blackbody thermistor window size N (see subsection 3.6.2.1)
416	Current patch temperature control level {1:7}
417	IR Calibration B (bias) Mode {1:1}
418	IR Calibration M (1st order gain) Mode {1:7}
419	IR Calibration Q (2nd order gain) Mode {1:3}
420	Visible reference normalization detector
421	M-history window width in hours {1–24}
422	M-history window depth in days {1–10}
423–448	(1 x 26) M-history regression optical selectors
449	Unused
450	E-W correction enabled/disabled (0 = disabled, 255 = enabled)
451–454	(4 x 11) Scan mirror temperature at blackbody calibration

455–470 (4 x 14) Current *a* emissivity coefficients (intercept)
471–486 (4 x 14) Current *b* emissivity coefficients (1st order)
487–502 (4 x 14) Current *c* emissivity coefficients (2nd order)
503–733 Not used (set to zeros)
734 Longitudinal parity (XOR) of words 223–733

Imager Telemetry Warning Limits

735–862 (2 x 64) Minimum filtered sample size limits
863–990 (2 x 64) Low pass filter limit – counts
991–1118 (2 x 64) High pass filter limit – counts
1119–1374 (4 x 164) Unfiltered mean low limit – counts
1375–1630 (4 x 164) Filtered mean low limit – counts
1631–1886 (4 x 164) Unfiltered mean high limit – counts
1887–2142 (4 x 164) Filtered mean high limit – counts
2143–2398 (4 x 164) Unfiltered & high limit – counts
2399–2654 (4 x 164) Filtered & high limit – counts
2655–2910 (4 x 164) Filtered mean low limit – engineering units
2911–3166 (4 x 164) Filtered mean high limit – engineering units
3167–3422 (4 x 164) Filtered & high limit – engineering units

Imager Telemetry Critical Alarm Limits

3423–3486 (2 x 32) Minimum filtered sample size limits
3487–3614 (4 x 132) Filtered mean low limits – engineering units
3615–3742 (4 x 132) Filtered mean high limits – engineering units

Table 3-28. Imager Calibration and Limits Block 11 Format (Cont'd)

WORDS DESCRIPTION

3743–3870 (4 x 132) Filtered & limits – engineering units
3871–4061 Unused
4062 Longitudinal parity (XOR) of words 735–4061

Imager ECAL Warning Limits

4063–4066 (4 x 11) Excessive residual RMS limit (all detectors)
4067–4098 (2 x 16) Channel 1 low filter limits/step – counts
4099–4130 (2 x 16) Channel 2 low filter limits/step – counts
4131–4162 (2 x 16) Channel 3 low filter limits/step – counts
4163–4194 (2 x 16) Channel 4 low filter limits/step – counts
4195–4226 (2 x 16) Channel 5 low filter limits/step – counts
4227–4258 (2 x 16) Channel 1 high filter limits/step – counts
4259–4290 (2 x 16) Channel 2 high filter limits/step – counts
4291–4322 (2 x 16) Channel 3 high filter limits/step – counts
4323–4354 (2 x 16) Channel 4 high filter limits/step – counts
4355–4386 (2 x 16) Channel 5 high filter limits/step – counts
4387–4430 (2 x 22) Leading sample discard count/detector
4431–4474 (2 x 22) Minimum filtered samples limit/detector
4475–4573 Unused
4574 Longitudinal parity (XOR) of words 4063–4573

Imager Spacelook Warning Limits

4575–4618	(2 x 22) Minimum filtered sample size limits
4619–4662	(2 x 22) Low filter limit – counts
4663–4706	(2 x 22) High filter limit – counts
4707–4794	(4 x 122) Unfiltered mean low limit – counts
4795–4882	(4 x 122) Filtered mean low limit – counts
4883–4970	(4 x 122) Unfiltered mean high limit – counts
4971–5058	(4 x 122) Filtered mean high limit – counts
5059–5146	(4 x 122) Unfiltered & high limit – counts
5147–5234	(4 x 122) Filtered & high limit – counts
5235–5322	(4 x 122) Filtered & high limit – radiance
5323–5410	(4 x 122) Filtered & high limit – temperature

Imager Spacelook Critical Limits

5411–5454	(2 x 22) Minimum filtered sample size/detector
5455–5597	Unused
5598	Longitudinal parity (XOR) of words 4575–5597

Table 3-28. Imager Calibration and Limits Block 11 Format (Cont'd)

WORDS DESCRIPTION

Imager Preclamp Warning Limits

5599–5642	(2 x 22) Minimum filtered sample size limits
5643–5686	(2 x 22) Low filter limit – counts
5687–5730	(2 x 22) High filter limit – counts
5731–5818	(4 x 122) Unfiltered mean low limit – counts
5819–5906	(4 x 122) Filtered mean low limit – counts
5907–5994	(4 x 122) Unfiltered mean high limit – counts
5995–6082	(4 x 122) Filtered mean high limit – counts
6083–6170	(4 x 122) Unfiltered & high limit – counts
6171–6258	(4 x 122) Filtered & high limit – counts
6259–6346	(4 x 122) Filtered & high limit – radiance
6347–6434	(4 x 122) Filtered & high limit – temperature
6435–6621	Unused
6622	Longitudinal parity (XOR) of words 5599–6621

Imager Blackbody Warning Limits

6623–6650	(2 x 14) Minimum filtered sample size limits
6651–6678	(2 x 14) Low filter limit – counts
6679–6706	(2 x 14) High filter limit – counts
6707–6762	(4 x 114) Unfiltered mean low limit – counts
6763–6818	(4 x 114) Filtered mean low limit – counts
6819–6874	(4 x 114) Unfiltered mean high limit – counts
6875–6930	(4 x 114) Filtered mean high limit – counts
6931–6986	(4 x 114) Unfiltered & high limit – counts
6987–7042	(4 x 114) Filtered & high limit – counts
7043–7098	(4 x 114) Filtered & high limit – radiance
7099–7154	(4 x 114) Filtered & high limit – temperature

Imager Blackbody Calibration Critical Limits

7155–7182	(2 x 14) Minimum filtered sample size/detector

Imager Calibration Critical Limits

7183–7186	(4 x 11) Maximum baseplate temperature for gain LUT
7187–7190	(4 x 11) Minimum baseplate temperature for gain LUT
7191–7192	(2 x 1) Minimum filtered sample size/BB thermistor
7193–7194	Unused – zeros
7195–7206	(4 x 13) Maximum bias interpolation interval (msec)
7207–7234	(4 x 7) Maximum space level rate/detector (counts/sec)

Table 3-28. Imager Calibration and Limits Block 11 Format (Cont'd)

WORDS	DESCRIPTION
7235–7262	(4 x 7) Maximum M (1st order gain) rate in M mode 2
7263–7266	(4 x 11) Maximum percentage of outliers permitted in M modes 3 & 5
7267–7294	(4 x 7) Maximum SEE for M modes 4 & 5
7295–7322	(4 x 7) Maximum RSS error for M modes 6 & 7
7323–7326	(4 x 11) N-& tolerance for M-history filtering
7327–7330	(4 x 11) Maximum number of iterations M-history filtering
7331–7334	(4 x 11) Minimum minutes between blackbody calibrations
7335–7338	(4 x 11) M recomputation interval (2-minute units)
7339–7342	(4 x 11) Minimum delta patch temperature for M mode 2
7343–7370	(4 x 7) Minimum delta gain for M mode 2
7371–7398	(4 x 7) Minimum rate (slope) in M mode 2
7399–7401	Unused – zeros
7402	Longitudinal parity (XOR) of words 6623–7401
7403–8040	Unused – zeros

NOTES:

1. This Block 11 format is produced following every spacelook and blackbody calibration sequence. The trigger time in words 211–218 is the time associated with the raw data header block of the triggering event (word 210 – spacelook or blackbody).

2. All arrays sized as (4 x N) are floating point value arrays.

3. All arrays sized as (2 x N) are integer value arrays.

4. All limit arrays sized as (N x 22) contain data for all 22 imaging detectors as follows:

1 to 8	–	Visible detectors 1–8
9 to 15	–	Primary IR detectors 1–7
16 to 22	–	Redundant IR detectors 1–7.

5. All limit arrays for blackbody calibration (sized Nx14) contain data for the 14 IR detectors only, as follows:

1 to 7	–	Primary IR detectors 1–7
8 to 14	–	Redundant IR detectors 1–7.

Table 3-29. Sounder Calibration and Limits Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time IR calibration coefficients calculated
39–46	CDA time of current limits set
47–54	CDA time current visible NLUTs created
55–62	CDA time of latest linear regression
63–72	Spacelook data critical alarm flags
73–82	Blackbody data critical alarm flags
83–84	Temperature critical alarm flags
85–94	Standard error of estimate (SEE) critical alarm flags
95–104	(2 x 5) IR detector M gain rate alarms
105–114	(2 x 5) IR detector M gain outlier alarms
115–124	(2 x 5) IR detector M gain SEE alarms
125–134	(2 x 5) IR detector M gain RSS alarms
	(see Table 3-31 for definitions of alarm flags in words 63–134 above)
135	Filter Wheel period alarm (= x 'FF' if a synch loss occurred since the last report)
136	Blackbody temperature gradient alarm flag (=x 'FF' if excessive & in 8 BB temperatures)
137–146	(2 x 5) IR detector M gain rate low alarms
147	Scan mirror temperature out-of-range at BBCAL (= 255 if true)
148–209	Not used
210	Triggering event: 0 = spacelook, 255 = blackbody
211–218	CDA time of triggering event (see notes)
219	Not used
220	Spacelook side active: 0 = west, 225 = east
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221

Sounder Calibration Data

223–510	(4 x 72) IR detector biases
511–798	(4 x 72) IR detector 1st order gains
799–1086	(4 x 72) IR detector 2nd order gains
1087–1374	(4 x 72) IR detector bias regression slopes (k's)
1375–1662	(4 x 72) IR detector bias regression intercepts (h's)
1663–1950	(4 x 72) IR detector bias standard error of estimates
1951–1954	(4 x 11) Weighted mean blackbody temperature
1955–1958	(4 x 11) Weighted mean baseplate temperature
1959–1962	(4 x 11) Weighted mean optics temperature
1963–1966	(4 x 11) Smoothed patch temperature
1967–1970	(4 x 11) Average filter wheel rate (revs/second)
1971–1974	(4 x 11) Current & of 8 blackbody temperatures
1975–1978	(4 x 11) Current & tolerance for blackbody

Table 3-29. Sounder Calibration and Limits Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION
1979–2010	(4 x 18) Blackbody thermistor weighing factors

2011–2034 (4 x 16) Baseplate thermistor weighing factors
2035–2062 (4 x 7) Optics temperature weighing factors
2063–2066 (4 x 11) Current *a* weight for M-history data
2067–2070 (4 x 11) Current *b* weight for M-history data
2071–2074 (4 x 11) Current *c* weight for M-history data
2075–2078 (4 x 11) Current *d* weight for M-history data
2079–2094 (2 x 8) Blackbody thermistor filtered sample size
2095 Blackbody thermistor window size N (see subsection 3.6.2.1)
2096 Current patch temperature control level [1:7]
2097 IR calibration B (bias) mode [1:2]
2098 IR calibration M (1^{st} order gain) mode [1:7]
2099 IR calibration Q (2^{nd} order gain) mode [1:3]
2100 Visible reference normalization detector
2101 M-history window width in hours [1:24]
2102 M-history window depth in days [1:10]
2103–2129 M-history regression optical component selectors
2130 E-W correction enabled/disabled (0 = disabled, 255 = enabled)
2131–2134 (4 x 11) Scan mirror temperature at blackbody calibration
2135–2206 (4 x 118) Current *a* emissivity coefficients (intercept)
2207–2278 (4 x 118) Current *b* emissivity coefficients (1^{st} order)
2279–2350 (4 x 118) Current *c* emissivity coefficients (2^{nd} order)
2351–2781 Not assigned (set to zeros)
2782 Longitudinal parity (XOR) of words 223–2781

Sounder Telemetry Warning Limits

2783–2910 (2 x 64) Minimum filtered sample size limit
2911–3038 (2 x 64) Low pass filter limit – counts
3039–3166 (2 x 64) High pass filter limit – counts
3167–3422 (4 x 164) Unfiltered mean low limit – counts
3423–3678 (4 x 164) Filtered mean low limit – counts
3679–3934 (4 x 164) Unfiltered mean high limit – counts
3935–4190 (4 x 164) Filtered mean high limit – counts
4191–4446 (4 x 164) Unfiltered & high limit – counts
4447–4702 (4 x 164) Filtered & high limit – counts
4703–4958 (4 x 164) Filtered mean low limit – engineering units
4959–5214 (4 x 164) Filtered mean high limit – engineering units
5215–5470 (4 x 164) Filtered & high limit – engineering units

Sounder Telemetry Critical Alarm Limits

5471–5534 (2 x 32) Minimum filtered sample size limits
5535–5662 (4 x 132) Filtered mean low limits – engineering units
5663–5790 (4 x 132) Filtered mean high limits – engineering units
5791–5918 (4 x 132) Filtered & limits – engineering units

Table 3-29. Sounder Calibration and Limits Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION
5919	Longitudinal parity (XOR) of words 2783–5918
5920–6110	Unused – zeroes

Sounder Ecal Warning Limits

6111–6114	(4 x 11) Excessive residual RMS limit (all detectors)
6115–6146	(2 x 16) Visible low limits/step – counts
6147–6178	(2 x 16) IR Long wave low limits/step – counts
6179–6210	(2 x 16) IR Medium wave low limits/step – counts
6211–6242	(2 x 16) IR Shortwave low limits/step – counts
6243–6274	(2 x 16) Visible high limits/step – counts
6275–6306	(2 x 16) IR Long wave high limits/step – counts
6307–6338	(2 x 16) IR Medium wave high limits/step – counts
6339–6370	(2 x 16) IR Short wave high limits/step – counts
6371–6402	(2 x 16) Minimum filtered samples limit/detector (=1)
6403–6418	(1x16) Channel assigned as data source/detector
6419	Longitudinal parity (XOR) of words 6111–6418
6420–8040	Unused – zeroes

BLOCK 2 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time IR coefficients calculated
39–46	CDA time of current limits set
47–54	CDA time current visible NLUTS created
55–222	Not used

Sounder Spacelook Warning Limits

223–374	(2 x 76) Minimum filtered sample size limit
375–526	(2 x 76) Low filter limit – counts
527–678	(2 x 76) High filter limit – counts
679–982	(4 x 76) Unfiltered mean low limit – counts
983–1286	(4 x 76) Filtered mean low limit – counts
1287–1590	(4 x 76) Unfiltered mean high limit – counts
1591–1894	(4 x 76) Filtered mean high limit – counts
1894–2198	(4 x 76) Unfiltered & high limit – counts
2199–2502	(4 x 76) Filtered & high limit – counts
2503–2790	(4 x 72) Filtered IR & high limit – radiance
2791–3078	(4 x 72) Filtered IR & high limit – temperature

Sounder Spacelook Critical Limits

3079–3230	(2 x 76) Minimum filtered sample size/detector
3231	Longitudinal parity (XOR) of words 223–3230
3232–3538	Unused – zeroes

Table 3-29. Sounder Calibration and Limits Block 11 Format (Cont'd)

BLOCK 2 WORDS	DESCRIPTION

Sounder Blackbody Warning Limits

3539–3682	(2 x 72) Minimum filtered sample size limits

3683–3826	(2 x 72) Low filter limit – counts
3827–3970	(2 x 72) High filter limit – counts
3971–4258	(4 x 72) Unfiltered mean low limit – counts
4259–4546	(4 x 72) Filtered mean low limit – counts
4547–4834	(4 x 72) Unfiltered mean high limit – counts
4835–5122	(4 x 72) Filtered mean high limit – counts
5123–5410	(4 x 72) Unfiltered & high limit – counts
5411–5698	(4 x 72) Filtered & high limit – counts
5699–5986	(4 x 72) Filtered & high limit – radiance
5987–6274	(4 x 72) Filtered & high limit – temperature

Sounder Blackbody Calibration Critical Limits

6275–6418	(2 x 72) Minimum filtered sample size/channel-detector

Sounder Linear Regression Critical Limit

6419–6422	(4 x 11) Maximum Standard Error of Estimate

Sounder Calibration Critical Limits

6423–6426	(4 x 11) Maximum baseplate temperature for gain LUT
6427–6430	(4 x 11) Minimum baseplate temperature for gain LUT
6431–6432	(2 x 1) Minimum filtered sample size/BB thermistor
6433–6434	Unassigned – zeros
6435–6722	(4 x 72) Maximum rate in M mode 2
6723–6726	(4 x 11) Maximum percentage of outliers in M modes 3 & 5
6727–7014	(4 x 72) Maximum standard error in M modes 4 & 5
7015–7302	(4 x 72) Maximum RSS error in modes 6 & 7
7303–7306	(4 x 11) N-& tolerance for M-history filtering
7307–7310	(4 x 11) Maximum number of history data iterations
7311–7314	(4 x 11) Minimum number of minutes between BB cals
7315–7318	(4 x 11) M value update interval in 2-minute marks
7319–7322	(4 x 11) Minimum delta patch temperature for M mode 2
7323–7610	(4 x 72) Minimum delta gain for M mode 2
7611–7898	(4 x 72) Minimum rate (slope) in M mode 2
7899–7901	Unassigned – zeros
7902	Longitudinal parity (XOR) of words 3539–7901
7903–8040	Unused – zeroes

Table 3-29. Sounder Calibration and Limits Block 11 Format (Cont'd)

NOTES:

1. This Block 11 format sequence is produced following every spacelook and blackbody calibration sequence. The trigger time in words 211–218 is the time associated with the first raw data block of the triggering event (spacelook or blackbody).

2. All arrays of size (4 x N) are floating point value arrays.

3. All arrays of size (N x 72) apply to the IR channel/detector groups and are ordered channel 1, detector 1 to channel 18, detector 4, respectively. Arrays having a size of (N x 76) include data for the channel 19 (visible) detectors 1–4.

4. Detector 1, as identified in GVAR , refers to the top left detector in the radiometric detector array (see Figure 3-6). (Note that in ITT documentation detector 1 refers to the bottom-right detector and detector 4 refers to the top-left detector.

Table 3-30. Imager Calibration Critical Alarm Flag Definitions

Critical alarm flags for Imager spacelook (words 57–59) and blackbody calibration (words 60–62) data are defined as follows:

FLAG	SET TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR FOLLOWING:
1	Visible detector 1 insufficient samples
2	Visible detector 2 insufficient samples
3	Visible detector 3 insufficient samples
4	Visible detector 4 insufficient samples
5	Visible detector 5 insufficient samples
6	Visible detector 6 insufficient samples
7	Visible detector 7 insufficient samples
8	Visible detector 8 insufficient samples
9	Unassigned (always 0)
10	IR side 1 detector 1 insufficient samples
11	IR side 1 detector 2 insufficient samples
12	IR side 1 detector 3 insufficient samples
13	IR side 1 detector 4 insufficient samples
14	IR side 1 detector 5 insufficient samples
15	IR side 1 detector 6 insufficient samples
16	IR side 1 detector 7 insufficient samples
17	Unassigned (always 0)
18	IR side 2 detector 1 insufficient samples
19	IR side 2 detector 2 insufficient samples
20	IR side 2 detector 3 insufficient samples
21	IR side 2 detector 4 insufficient samples
22	IR side 2 detector 5 insufficient samples
23	IR side 2 detector 6 insufficient samples
24	IR side 2 detector 7 insufficient samples

Table 3-30. Imager Calibration Critical Alarm Flag Definitions (Cont'd)

NOTES:

1.The flag bits are numbered 1 to 24, where bit 1 is the MSB of the first word and bit 24 is the LSB of the third word. Each flag bit is set to 1 if the associated condition is true and 0 otherwise.

2.Only one instrument side (either 1 or 2) can be active at any one time, as indicated by word 221 of Table 3-28. The inactive side flag bits above are always reset to zero.

3.A Block 11 formatted according to Table 3-28 can result from either a spacelook or a blackbody event, as indicated in word 210. If word 210 indicates a spacelook trigger, the blackbody critical alarm flags in words 60–62 are not used and are set to zeros. If word 210 indicates a blackbody event, the critical alarm flags in words 57–59 are not used and set to zeros.

4.Note that the visible detector flags (bits 1–8) do not apply for blackbody calibration (words 60–62) and are always set to zero.

Critical alarm flags for Imager temperature values which affect detector calibration (words 63–64) are defined as follows:

FLAG	SET TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR FOLLOWING:
1	Blackbody Thermistor 1 insufficient samples
2	Blackbody Thermistor 2 insufficient samples
3	Blackbody Thermistor 3 insufficient samples
4	Blackbody Thermistor 4 insufficient samples
5	Blackbody Thermistor 5 insufficient samples
6	Blackbody Thermistor 6 insufficient samples
7	Blackbody Thermistor 7 insufficient samples
8	Blackbody Thermistor 8 insufficient samples
9	Baseplate Temperature too low for LUT usage
10	Baseplate Temperature too high for LUT usage
11–16	Not used

Table 3-30. Imager Calibration Critical Alarm Flag Definitions (Cont'd)

NOTES:

1.The critical alarm flag bits are numbered 1 to 16, with bit 1 the MSB of the first word and bit 16 the LSB of the second word. Each flag bit is set to 1 if the associated condition is true, and is reset to 0 otherwise. The limits defined in words 7183–7192 of Table 3-28 are employed in the determination of the above temperature alarms.

2. The blackbody thermistor flag bits are enabled only for a report triggered by a blackbody calibration; they are always reset to 0s for reports triggered by a spacelook. The samples referenced by these bits are maintained in a moving window within the SPS, and are not directly reported within the GVAR stream. The samples are evaluated at the occurrence of a blackbody calibration sequence.

3. The baseplate temperature flag bits are enabled only for a report triggered by a spacelook calibration; they are always be set to zeros for reports triggered by a blackbody event. The baseplate temperature filtered mean values reported in the telemetry statistics Block 11 associated with the spacelook are used to form a weighted mean baseplate temperature. This weighted mean value is used in controlling the temperature flag bits.

Critical alarm flags for 1st order gain computations (words 65–71) are defined as follows:

FLAG	SET TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR FOLLOWING:
1	Maximum gain rate exceeded, mode 2
2	Maximum percentage of outliers exceeded, modes 3, 5
3	Maximum standard error exceeded, modes 4, 5
4	Maximum RSS error exceeded, modes 6, 7
5	Gain rate below minimum, mode 2
6–8	Unassigned – always zero.

NOTES:

1. The critical alarm flag bits are numbered 1–8, with bit 1 assigned to the MSB of the word and bit 8 to the LSB. Each flag bit is set to one if the associated condition is true, and is set to zero otherwise.

2. The seven flag words (65–71) are sequentially assigned to the seven active IR detectors using the mapping defined in Figure 3-11.

Table 3-31. Sounder Calibration Critical Alarm Flag Definitions

Critical Alarm flags for Sounder spacelook (words 63–72) and blackbody data (words 73–82) are defined as follows:

Spacelook words	[63–64],[65–66],[67–68],[69–70],[71–72]
Blackbody words	[73–74],[75–76],[77–78],[79–80],[81–82]

FLAG	SET TRUE (1) IF AN INSUFFICIENT SAMPLES CONDITION IS PRESENT FOR
1	1 detector – Channels [1],[5],[9],[13],[17]
2	2 detector – Channels [1],[5],[9],[13],[17]
3	3 detector – Channels [1],[5],[9],[13],[17]
4	4 detector – Channels [1],[5],[9],[13],[17]
5	1 detector – Channels [2],[6],[10],[14],[18]
6	2 detector – Channels [2],[6],[10],[14],[18]
7	3 detector – Channels [2],[6],[10],[14],[18]
8	4 detector – Channels [2],[6],[10],[14],[18]
9	1 detector – Channels [3],[7],[11],[15],[19]
10	2 detector – Channels [3],[7],[11],[15],[19]
11	3 detector – Channels [3],[7],[11],[15],[19]
12	4 detector – Channels [3],[7],[11],[15],[19]
13	1 detector – Channels [4],[8],[12],[16]
14	2 detector – Channels [4],[8],[12],[16]
15	3 detector – Channels [4],[8],[12],[16]
16	4 detector – Channels [4],[8],[12],[16]

NOTES:

1.The above representation may appear confusing, but is actually straightforward. For example, it shows detectors 1–4 for Channels 1, 2, 3, and 4 are assigned to flag bits 1–16 in words 63 and 64 for spacelook data and words 73 and 74 for blackbody data.

2.Note that the four Channel 19 visible detectors are not included as part of the blackbody calibration sequence. As a result, their flag bits (9–12) are always zeroed for the blackbody case, words 81 and 82. Also note that the last four flag bits (13–16 in words 71, 72, 81 and 82) are not used and are always 0.

Table 3-31. Sounder Calibration Critical Alarm Flag Definitions (Cont'd)

Temperature critical alarm flags (words 83–84) are defined as follows:

FLAG	SET TRUE (1) IF CRITICAL CONDITION IS PRESENT FOR FOLLOWING:
1	Blackbody Thermistor 1 insufficient samples
2	Blackbody Thermistor 2 insufficient samples
3	Blackbody Thermistor 3 insufficient samples
4	Blackbody Thermistor 4 insufficient samples
5	Blackbody Thermistor 5 insufficient samples

6	Blackbody Thermistor 6 insufficient samples
7	Blackbody Thermistor 7 insufficient samples
8	Blackbody Thermistor 8 insufficient samples
9	Baseplate Temperature too low for LUT usage
10	Baseplate Temperature too high for LUT usage
11–16	Not used

NOTES:

1. The critical alarm flag bits are numbered 1 to 16, with bit 1 the MSB of the first word and bit 16 the LSB of the second word. Notes and comments associated with the Imager temperature critical alarm flags in Table 3-30 apply, except that the limits used in the temperature alarms are defined in words 6423–6432 of Table 3-29.

Critical alarm flags for bias (B) and 1st order gain (M) computations are defined as follows:

ALARM CONDITION	**WORDS**
B SEE	[85–86], [87–88], [89–90], [91–92], [93–94]
M rate	[95–96], [97–98], [99–100], [101–102], [103–104]
M outliers	[105–106], [107–108], [109–110], [111–112], [113–114]
M SEE	[115–116], [117–118], [119–120], [121–122], [123–124]
M RSS	[125–126], [127–128], [129–130], [131–132], [133–134]

Table 3-31. Sounder Calibration Critical Alarm Flag Definitions (Cont'd)

FLAG	**SET TRUE (1) IF THE SEE TOO HIGH CONDITION IS PRESENT**
1	Detector 1 – Channels [1],[5],[9],[13],[17]
2	Detector 2 – Channels [1],[5],[9],[13],[17]
3	Detector 3 – Channels [1],[5],[9],[13],[17]
4	Detector 4 – Channels [1],[5],[9],[13],[17]
5	Detector 1 Channels [2],[6],[10],[14],[18]
6	Detector 2 – Channels [2],[6],[10],[14],[18]
7	Detector 3 – Channels [2],[6],[10],[14],[18]
8	Detector 4 – Channels [2],[6],[10],[14],[18]
9	Detector 1 – Channels [3],[7],[11],[15]
10	Detector 2 – Channels [3],[7],[11],[15]
11	Detector 3 – Channels [3],[7],[11],[15]
12	Detector 4 – Channels [3],[7],[11],[15]
13	Detector 1 – Channels [4],[8],[12],[16]
14	Detector 2 – Channels [4],[8],[12],[16]
15	Detector 3 – Channels [4],[8],[12],[16]
16	Detector 4 – Channels [4],[8],[12],[16]

NOTES:

1. Note that the last eight flag bits (9–16) assigned to each alarm condition (words 94, 104, 114, 124, and 134) are not used, and are always zero.

3.3.7.10 Visible Detector NLUTs – Data from the Imager and Sounder visible detectors are converted to destriped pixel imagery by the SPS through the use of NLUTs. The NLUTs are generated in the PMs and transmitted to the SPSs at relatively infrequent intervals (on the order of once a week). The instrument NLUTs currently in use are broadcast in GVAR following every blackbody calibration event. The Block 11 formats employed are defined in Tables 3-32 and 3-33 for the Imager and Sounder, respectively. The formats include CDA time tags denoting the NLUT creation time and the time at which the respective NLUT was enabled by the SPS. The creation time tag is reported in the scan documentation blocks to permit positive identification of the NLUT.

Table 3-32. Imager NLUT Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–24	SAD ID (see subsection 3.3.7.1.)
25	Unused – always zero
26–33	CDA time IR coefficients calculated
34–41	CDA time of current limits set
42–49	CDA time current visible NLUTs created
50–57	CDA time current visible NLUTs implemented
58	Reference detector ID (1–8)
59	Longitudinal parity (XOR) of detector 1 NLUT
60	Longitudinal parity (XOR) of detector 2 NLUT
61	Longitudinal parity (XOR) of detector 3 NLUT
62	Longitudinal parity (XOR) of detector 4 NLUT
63	Longitudinal parity (XOR) of words 1–66
64–1021	Not used
1022–2045	Detector 1 NLUT
2046–3069	Detector 2 NLUT
3070–4093	Detector 3 NLUT
4094–5117	Detector 4 NLUT
5118–5125	ASCII NLUT identification
5126–6432	Not used

BLOCK 2 WORDS	DESCRIPTION
1–24	SAD ID (see subsection 3.3.7.1.)
25	Unused – always zero
26–33	CDA time IR coefficients calculated
34–41	CDA time of current limits set
42–49	CDA time current visible NLUTS created
55–57	CDA time current visible NLUTS implemented

Table 3-32. Imager NLUT Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION

58	Reference detector ID (1–8)
59	Longitudinal parity (XOR) of detector 5 NLUT
60	Longitudinal parity (XOR) of detector 6 NLUT
61	Longitudinal parity (XOR) of detector 7 NLUT
62	Longitudinal parity (XOR) of detector 8 NLUT
63	Longitudinal parity (XOR) of words 1–66
64–1021	Not used
1022–2045	Detector 5 NLUT
2046–3069	Detector 6 NLUT
3070–4093	Detector 7 NLUT
4094–5117	Detector 8 NLUT
5118–5125	ASCII NLUT identification
5126–6432	Not used

NOTES:

1. The Imager visible NLUTs use a 10-bit word length. They are broadcast in GVAR following the occurrence of every blackbody calibration. They are sequenced to follow the transmission of the blackbody-triggered calibration Block 11 (see Table 3-28). In the normal course of events, actual changes to the NLUTS occur nominally once per week.

Table 3-33. Sounder NLUT Block 11 Format

WORDS	DESCRIPTION
1–30	ID (sees subsection 3.3.7.1.)
31–38	CDA time IR coefficients calculated
39–46	CDA time of current limits set
47–54	CDA time current visible NLUTs created
55–62	CDA time current visible NLUTs implemented
63	Reference detector ID (1–4)
64	Detector X ID
65–66	Detector X word count
67	Longitudinal parity (XOR) of detector X NLUT
68	Detector Y ID
69–70	Detector Y word count
71	Longitudinal parity (XOR) of detector Y NLUT
72–73	Unused – zeroes
74	Longitudinal parity (XOR) of words 1–73

The Sounder visible detector NLUTs require 16,384 8-bit words of Block 11 transmission space for each detector. Between the four applicable detectors, a total of nine Block 11s are required to completely transfer the NLUTs. Words 1–74 of each of the nine blocks are defined above. Three of the required nine Block 11s contain portions of NLUTs for two detectors. The “X” ID in the header identifies the first detector (1, 2, or 3) along with a count of words. The “Y” ID identifies the second detector (2, 3, or 4) and also indicates the number of words. The longitudinal parity values are always computed over the entire 16,384 words of a detector’s NLUT. The nine Block 11s constituting the Sounder’s NLUTs are broadcast in GVAR following each Sounder blackbody calibration.

BLOCK 11 SEQUENCE #	WORDS	CONTENT DESCRIPTION	
1	75–8040	Detector 1 NLUT words:	1–7966
2	75–8040		7967–15932
3	75–526		15933–16384
3	527–8040	Detector 2 NLUT words:	1–7514
4	75–8040		7515–15480
5	75–978		15481–16384
5	979–8040	Detector 3 NLUT words:	1–7062
6	75–8040		7063–15028
7	75–1430		15029–16384
7	1431–8040	Detector 4 NLUT words:	1–6610
8	75–8040		6611–14576
9	75–1882		14577–16384
9	1883–1890	ASCII NLUT ID	
9	1891–8040	Not used	

3.3.7.11 Star Sense Statistics and Data – Under nominal conditions the Imager and Sounder each performs a star sensing operation at a rate ranging from two to six times an hour. During a star sense the instrument is left positioned at a predetermined coordinate through which a star is expected to pass as the satellite revolves. The passage of the known star through the FOV of one or more of the instrument's 1-kilometer visible detectors at a particular time provides a measurement of the instrument's attitude.

The statistics associated with each star sense are passed to the OATS for use in updating the instrument's O&A estimates. As a diagnostic aid, the star sense statistics, supporting calculation data, and the associated raw detector data are transferred in GVAR to the PM via a sequence of Block 11s. The format of the Imager and Sounder star sense Block 11 sequences is defined in Table 3-34 and Table 3-35, respectively. Section 3.7 details the algorithm employed for the star crossing analysis, providing further information about the terms employed in Tables 3-34 and 3-35.

The star sense Block 11 formats also contain edge detection data for the moon's rim. The edge of the full moon is "bright" in both the visible and IR channels, offering a fine target for measuring the E-W imaging detector misalignments. When moon-shot data is transmitted, the moon flag in word 1087 is non-zero. The channel flag, word 1088, is set to denote which radiometric channel is being transmitted.

Table 3-34. Imager Star Sense Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time star sense interval started
39–42	Interval Duration (milliseconds)
43–44	Instrument Coordinates, north-south cycles
45–46	Instrument Coordinates, north-south increments
47–48	Instrument Coordinates, east-west cycles
49–50	Instrument Coordinates, east-west increments
51–52	W – Sample length of averaging moving window
53–54	FOURM – number of raw pixels/SDI sample
	Star Sense Controls, Statistics, & Results
55–56	(2 x 1) WTC – window thresholding count
57–58	(2 x 1) ETC – event thresholding count
59–74	(2 x 8) DWT – window threshold tolerance/detector
75–90	(2 x 8) DMV – interval mean value/detector
91–106	(2 x 8) WTL – window threshold level/detector
107–122	(2 x 8) events counted/detector
123–124	(2 x 1) number of pixels in each of blocks 2–9
125–126	(2 x 1) data loss flag = 1 if break in star data
127–190	(2 x 32) Hin – start of window raw data index
191–254	(2 x 32) Kin – end of window raw data index
255–318	(2 x 32) WMV – window mean value
319–382	(2 x 32) ETL – event thresholding level
383–446	(2 x 32) Min – start of event raw data index
447–510	(2 x 32) Nin – end of event raw data index
511–574	(2 x 32) EMV – event mean value
575–638	(2 x 32) N-S servo error at event
639–702	(2 x 32) E-W servo error at event
703–766	(2 x 32) TEVi – star pixel event data index
767–1022	(8 x 32) TEVCDA – CDA time of event
1023–1086	(2 x 32) Event duration (milliseconds)
1087	(1 x 1) MOONFLAG (0 = star sense, 255 = moon sense)
1088	(1 x 1) MOONCHAN (0 = star sense, 1 to 5 = moon sense)
1089–1090	Spare–unused

Table 3-34. Imager Star Sense Block 11 Format (Cont'd)

BLOCK 1 WORDS	DESCRIPTION
1091–1122	(4 x 8) DWT – as above, in floating point format
1123–1154	(4 x 8) DMV – as above, in floating point format
1155–1186	(4 x 8) WTL – as above, in floating point format
1187–1314	(4 x 32) WMV – as above, in floating point format
1315–1442	(4 x 32) ETL – as above, in floating point format

1443–1570	(4 x 32) EMV – as above, in floating point format
1571–1698	(4 x 32) SDIMAX – maximum raw value
1699–1826	(4 x 32) SDIFWHM – full width half maximum value
1827	Longitudinal parity (XOR) of words 1–1826
1828–8040	Not used

BLOCKS [2–9]

WORDS	**DESCRIPTION**
1–24	SAD ID (see subsection 3.3.7.1.)
25–32	CDA start time (from words 31–38 of block 1)
33–6432	Detector [1–8] star pixel data

NOTES:

1. Block 1 uses an 8-bit word format. With the exception of the CDA formatted time tags, all values in block 1 are unsigned integers.

2. Blocks 2 through 9 use 10-bit word formats. Star pixel data in blocks 2–9 has 10 significant bits in the 10-bit words and is time-ordered with the oldest pixel first (word 33) in each array.

Table 3-35. Sounder Star Sense Block 11 Format

BLOCK 1 WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA time star sense interval started
39–42	Interval duration (milliseconds)
43–44	Instrument coordinates, north-south cycles
45–46	Instrument coordinates, north-south increments
47–48	Instrument coordinates, east-west cycles
49–50	Instrument coordinates, east-west increments
51–52	W – Sample length of averaging moving window
53–54	Unused – zeroes
	Star Sense Controls, Statistics, & Results
55–56	(2 x 1) WTC – window thresholding count
57–58	(2 x 1) ETC – event thresholding count
59–74	(2 x 8) DWT – window threshold tolerance/detector
75–90	(2 x 8) DMV – interval mean value/detector
91–106	(2 x 8) WTL – window threshold level/detector
107–122	(2 x 8) events counted/detector
123–124	(2 x 1) number of pixels in each of blocks 2–9
125–126	(2 x 1) data loss flag = 1 if break in star data
127–190	(2 x 32) Hin – start of window raw data indice
191–254	(2 x 32) Kin – end of window raw data indice
255–318	(2 x 32) WMV – window mean value
319–382	(2 x 32) ETL – event thresholding level
383–446	(2 x 32) Min – start of event raw data indice
447–510	(2 x 32) Nin – end of event raw data indice
511–574	(2 x 32) EMV – event mean value
575–638	(2 x 32) N-S Servo Error at event
639–702	(2 x 32) E-W Servo Error at event
703–766	(2 x 32) TEVi – star pixel event data index
767–1022	(8 x 32) TEVCDA – CDA time of event
1023–1086	(2 x 32) Event duration (milliseconds)
1087	(1 x 1) MOONFLAG (0 = star sense, 255 = moon sense)
1088	(1 x 1) MOONCHAN (0 = star sense, 1 to 20 = moon channel)
1089–1090	spare – unused
1091–1122	(4 x 8) DWT – as above, in floating point format
1123–1154	(4 x 8) DMV – as above, in floating point format
1155–1186	(4 x 8) WTL – as above, in floating point format
1187–1314	(4 x 32) WMV – as above, in floating point format
1315–1442	(4 x 32) ETL – as above, in floating point format

Table 3-35. Sounder Star Sense Block 11 Format (Cont'd)

BLOCK 1
WORDS DESCRIPTION

1443–1570	(4 x 32) EMV – as above, in floating point format
1571–1698	(4 x 32) SDIMAX – maximum raw value
1699–1826	(4 x 32) SDIFWHM – full width half maximum value
1827	Longitudinal parity (XOR) of words 1–1826
1828–8040	Not used

BLOCKS [2–9]

WORDS	DESCRIPTION
1–30	SAD ID (see subsection 3.3.7.1.)
31–38	CDA start time from words 31–38 of block 1
39–54	Not used
55–5174	Detector [1–8] star pixel data
5175–8040	Not used

NOTES:

1. All Sounder star sense Block 11s use an 8-bit word format. Star pixel data (Blocks 2–9) is ordered with oldest pixel first. Each star pixel has 13 significant bits right-adjusted and zero-filled within a two-word 16-bit field.

3.3.7.12 GIMTACS/SPS Text Message Format – A Block 11 format is also provided for transmission of GIMTACS and SPS operator text messages to users. The format uses 8-bit words and the record format is straight 8-bit ASCII strings, one message per record. The record count in the SAD ID indicates the number of messages in the Block 11. Included at the beginning of each message is a 16-byte time tag formatted by the SPS as follows:

1 1111

1 1

byte#:	1	2	3 4 567 89 0 1234	5	6
contents:	<CR>	<LF>	DDD:HH:MM:SS	<CR>	<LF>

where <CR> and <LF> indicate a carriage return and line feed character, respectively.

GIMTACS passes text messages to the SPS via a serial synchronous X.25 interface. GIMTACS text messages may be up to 11,866 characters i n length, including the time tag. Large messages spanning more than one Block 11 are indicated by the first and last block flags and the block count in the SAD ID.

The SPS operator enters text messages via a keyboard using the SEND command. This command permits entry of messages that are up to 74 ASCII characters in length. The SPS normally sends the message via a Block 11 transfer as soon as entry is completed. The record length for SPS text messages is 90 characters, with the actual operator entered message (74 characters maximum) left-adjusted and blank filled following the 16-byte time tag. A limit of 10 SPS message Block 11s is observed.

Table 3-9 defines the SAD Block ID fields specifically related to the text message Block 11.

3.3.7.13 Fill Data Format – A fill data block is transmitted by the SPS whenever no other data blocks are ready for transmission. The fill data is nothing more then a block of 64,080 bits, each set to zero. This is packaged with an appropriate 240-bits SAD Block ID for transmission in the GVAR stream.

3.4 Coordinate Systems

The scan mirror positioning for both instruments is controlled by two servo motors, one for the north-south elevation angle (outer gimbal motor), and one for the east-west scanning azimuth angle (inner gimbal motor). Each servo motor has an associated inductosyn to measure the mechanical shaft rotation angle. The position of the scanning mirror, and hence the coordinate system employed for the instrument, is measured in terms of the inductosyn outputs.

The inductosyn outputs are expressed in terms of cycles and increments. Cycles ,denoted C_x for east- west and C_y for north-south, are coarse measures of the shaft rotation angles. One cycle equals 2.8125^o of mechanical rotation, or 128 cycles for one full 360^o mechanical shaft revolution. Increments, denoted I_x for east-west and I_y for north-south, are finer shaft rotation angle measures, and are different for each instrument. For the Imager each cycle contains 6136 increments, each of which is equal to approximately 8.0 (actually 7.999899) radians of mechanical rotation. For the Sounder each cycle contains 2805 increments, each of which is equal to approximately 17.5 (actually 17.499959) rads of mechanical rotation.
As a result of the manner in which the scanning mirrors have been gimbaled, the relationship between a given shaft mechanical angle and the corresponding image optical angle is not the same in both axes. In the north-south direction, the mechanical shaft angle is equal to the

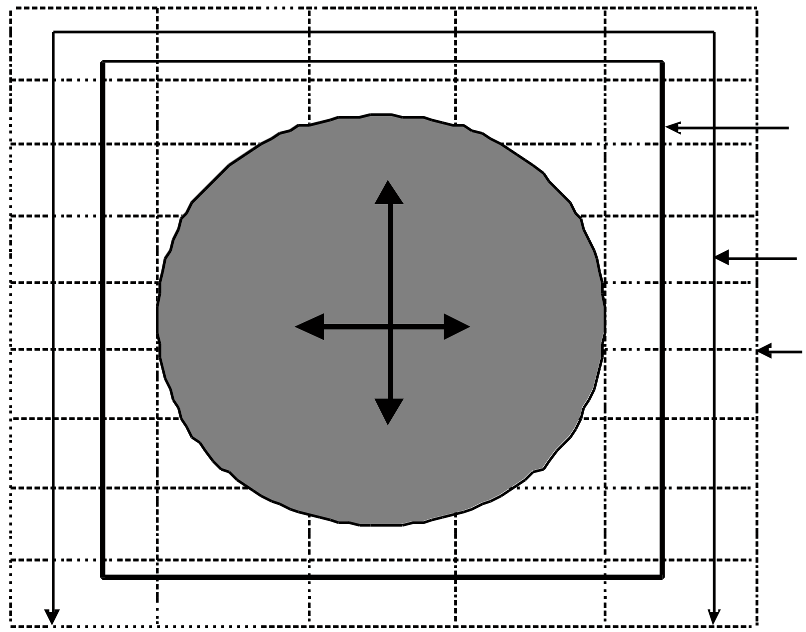
mirror's optical angle, i.e., a mechanical shaft rotation of 1 increment results in a one-increment change in the mirror's elevation angle. In the east-west direction, however, a shaft angle change has a doubling effect upon the mirror's optical angle. This doubling effect means that a single increment of mechanical rotation causes a two-increment change in the scanning mirror's scan angle.

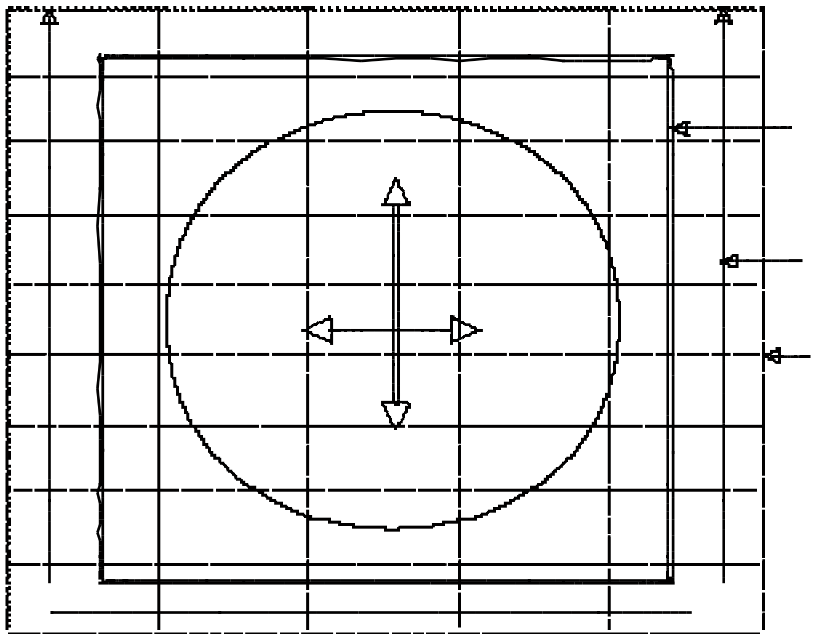
Figure 3-17 illustrates the mapping between cycles and increments for the Imager's FOV. The origin of the coordinate system (zero cycles, zero increments) is defined to be the northwest corner. At a nominal geosynchronous O&A the Earth is positioned in the frame as indicated in the figure. Under these conditions instrument nadir corresponds to the subsatellite point, and has the coordinates denoted in Figure 3-17. The actual of nadir coordinate values may vary somewhat according to the results of the factory alignment. The true values are reported in the factory parameters section of the scan documentation block (see Table 3-6).

The Imager mechanical limits (shown for the west, north, and east sides) are enforced by the presence of physical stops. The north and west stops prevent the instrument from ever reaching the origin point. On the south side the scanning mirror is not constrained until 183^{o} from nadir, permitting rotation of the mirror for blackbody viewing.

Figure 3-18 illustrates the mapping between cycles and increments and the Sounder's FOV. The origin of the coordinate system (zero cycles, zero increments) is defined to be the southwest corner. At a nominal geosynchronous O&A, the Earth is positioned in the frame as indicated in Figure 3-18. Under these conditions instrument nadir corresponds to the subsatellite point, and has the coordinates denoted in Figure 3-18. As with the Imager, the true nadir coordinates may differ slightly from those indicated according to the results of the factory alignment. The actual values are reported in the factory parameters section of the Sounder scan documentation block (see Table 3-10).

The Sounder mechanical limits (shown for the west, south, and east sides) are enforced by the presence of physical stops. The south and west stops prevent the instrument from ever reaching the origin point. On the north side the scanning mirror is not constrained until 183^{o} from nadir, permitting rotation of the mirror for blackbody viewing.





3.5 Bits, Words, and Formats

3.5.1 Bit Transmission Order

Every GVAR block transmitted consists of a similar sequence of four basic components:

1. 10,032-bit synchronization code
2. 720-bit header section
3. N-bit information field
4. 16-bit information field CRC.

The number of bits in the information field varies according to the type of GVAR block involved. Figure 3-19 illustrates the rules governing the order in which the bits of a GVAR block are transmitted (and subsequently received by a user), focusing on the bit sequence associated with a GVAR Block 11 header. The first 10,032 bits transmitted (and received) correspond to the block synchronization code. These are followed sequentially by the 720-bit header section, the 64,320-bit information field, and finally the 16-bit information field CRC. As shown, the 720-bit header section contains three sequential 240-bit segments, each an identical copy of the 240-bit block header (illustrated in Figure 3-10 and defined in Table 3-5).

In general, the transmission of any GVAR block segment always starts with the first word of the segment. The transmission proceeds in a sequential fashion through all of the words in the segment. For any given word, the left-most or MSB is transmitted first. Transmission of the word proceeds in a sequential fashion through the remainder of the bits, with the right-most or LSB transmitted last.

3..5.2 Longitudinal Parity (XOR) Words

Every transmitted GVAR block is terminated by a 16-bit CRC code (see subsection 3.3.3) that detects the presence of bit errors in the associated information field at the GVAR receiver. An additional level of error detection capability is provided for some GVAR block types in the form of embedded longitudinal parity words. The embedded longitudinal parity word is assigned to a portion or segment of the block's information field. If the block CRC denotes that an error is present in the received information field, the longitudinal parity words can be used to isolate the error(s) to a particular segment.

A longitudinal parity word may be either 6-, 8-, or 10-bits in length. The word length employed is the same as the word length used for the rest of the information data field. The word is formed by the cumulative eXclusive OR'ing (XOR) of all of the data words in the segment. The resulting XOR word is assigned a one or a zero in each bit position such that each bit position across all words in the segment has an even number of ones and zeros. Two examples are provided below showing the XOR word for a four-word and a five-word segment. An eight-bit word length is used for the four-word segment and 10 bits for the five-word segment.

Data words	1:	0 0 0 0 1 0 1 0	1:	1 0 0 0 0 0 1 1 0 1
	2:	0 0 1 0 0 1 1 0	2:	1 1 0 0 0 0 0 0 1 0
	3:	0 0 0 0 1 1 1 1	3:	1 1 1 0 0 0 1 0 0 0
	4:	0 0 0 1 1 1 1 1	4:	1 1 1 1 0 0 1 1 0 0
			5:	1 1 1 1 1 0 1 1 1 0

`XOR word: 0 0 1 1 1 1 0 0 1 0 1 0 1 0 0 1 0 1

3.5.3 Integer Formats

All integer values transmitted in the GVAR format are right adjusted and zero filled within their allocated bit space. The size of the bit space (number of bits) allocated for a particular integer value is generally a function of the word size used in the block information field and the expected range of the value. A total of seven different bit lengths are employed in the GVAR format for integer values. The following list denotes the range of values available for each bit length. It also provides a reference to an occurrence of their use in GVAR:

Length	Value Range	Examples of Where Used
6 bits	0 to 63	Table 3-8 word 9
8 bits	0 to 255	Table 3-10 word 261
8 bits	–128 to 127	Table 3-6 words 6235–6282
10 bits	0 to 1023	Table 3-7 word 3
16 bits	–32768 to 32767	Table 3-6 words 6311–6312
18 bits	0 to 262143	Table 3-8 words 6–8

Negative integer values in the GVAR format are formed using a twos complement notation, and are only permitted for the 8-, 16-, and 32-bit lengths. All other bit lengths always represent a zero or positive integer value. Note that in the current GVAR format the only integer terms currently expected to indicate negative quantities are the coregistration correction terms for the

Imager (Table 3-6, words 1631–1678 and 6235–6282), the Imager grid bias terms (Table 3-6, words 189–192), and the instrument detector offsets (Imager: Table 3-6, words 6311–6398; and Sounder: Table 3-10, words 3011–3074).

Two special cases exist for 16-bit integer values which do not employ twos complement arithmetic. The first case involves the GVAR block header block sequence counter (Table 3-5, words 13–14). The second case involves the Sounder detector data arrays defined in subsection 3.3.7.3.3. In both of these cases the 16-bit integers take on values ranging from 0 to 65535.

3.5.4 Floating Point Format

All floating point numbers used in GVAR are 32 bits in length, and are transported via four sequential 8-bit words. Each is a single precision floating point value formatted for the Gould/SEL computer. This format employs a sign bit, a 7-bit exponent, and a 24-bit fractional mantissa, defined as follows:

word	1	2	3	4
bits	1 8	1 8	1 8	1 8
	SEEEEEEE	**MMMMMMMM**	**MMMMMMMM**	**MMMMMMMM**
		MSB ------------------	24-bit Mantissa	---------------------- LSB

WORD	BIT	DESCRIPTION
1	1	**S**ign bit – set to 1 if negative quantity, set to 0 if positive. Negative quantities employ a twos complement notation for the entire 32 bits.
1	2–8	**E**xponent – is biased at 64 (x ‘40’) for a null shift of the binary point. The binary point is shifted 1 hexadecimal digit (4 bits) for each exponent increment, right for positive increments (>x ‘40’), left for negative increments (<x ‘40’).
2	1–8	**M**antissa – first eight bits. Bit 1 is the MSB of the 24-bit mantissa. The Binary point is positioned to the left of bit 1.
3	1–8	**M**antissa – second eight bits.
4	1–8	**M**antissa – last eight bits. Bit 8 is the LSB of the 24-bit mantissa.

Following are examples illustrating the relationship between a decimal value and the associated floating point format:

DECIMAL VALUE	FLOATING POINT FORMAT HEXADECIMAL VALUE
–1.0	x ‘BEF00000’
–0.1640625	x ‘BFD60000’
0.0	x ‘00000000’
0.1640625	x ‘402A0000’
1.0	x ‘41100000’
100.1640625	x ‘42642A00’

3.5.5 Sounder Raw Data Word Format

The GOES I-M Sounders generate one raw data block every 100 milliseconds. These raw data blocks contain 250 16 bit-words of information each for a total block length of 4000 bits. The word formats and their arrangement in the blocks is defined in reference document SJ–572022. The SPS performs a number of operations on the received raw Sounder data blocks, including the following:

1. Replacing the first 64 bits (synchronization code) with a time tag

2. Reformatting each of the remaining 246 16-bit words into 492 8-bit words (two 8-bit words for each original 16-bit word)

3. Appending Earth location information.

The final result of these operations is the Sounder data record transmitted in the GVAR stream. This record is defined in Table 3-11, and consists of 544 8-bit words. The first 500 words of this record correspond to the original raw data block generated by the Sounder.

The reformatting of the original 16-bit words into two 8-bit words includes two primary operations:

1. The SPS changes the 16th bit (LSB) of the original word, which is an odd parity bit, to a bad parity indicator. The bit is set to 1 if the parity of the original word is bad, and to 0. if the parity is good.

2. The bad parity indicator bit is then moved from the LSB position to the MSB position of the word. The 15 remaining data bits are shifted right one position to accommodate the move.

Following these two operations, the SPS views the resulting 16-bit word is simply viewed for GVAR transmission purposes as two sequential 8-bit words. The transformation described of above is diagramed as follows for the Mth word of the original raw Sounder data block:

Original 16-bit word M

MSB													**LSB**			
			d	d	d	d	d	d	d	d	d	d	d	d	d	d
													d	O		
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	D	
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	D	

SPS transformed 16-bit word M

MSB													**LSB**		
B	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d
A	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
D	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5

SPS transmitted 8-bit words

word (2*M – 1)								word (2*M)							
MSB							**LSB**	**MSB**					**LSB**		
B	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d
A	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
D	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5

3.6 Visible Channel Processing, Detector Calibrations, Modes, and Conversion Algorithms

The OGE performs relativization, normalization and calibration of the Imager and Sounder detector data, as well as routine monitoring of calibration and telemetry data. The monitoring functions provide extensive statistics computation on spacelook data, blackbody calibration data, and selected telemetry points. Monitoring also includes a verification of the linearity of the detector electronics based on ECAL data received at each blackbody calibration occurrence. The following paragraphs describe the relativization, normalization, calibration, and linearity verification functions in detail.

3.6.1 Visible Channel Processing

No calibration is applied to either the Imager and Sounder visible channel data. Instead, the visible detector data are subjected to two processes, termed relativization and normalization, described below.

3.6.1.1 Relativization – The SPS relativization process adjusts the outputs of each visible channel detector to the *difference* between the detector's output signal for the target and the detector's space (black) reference signal, rather than the *absolute* detector signals. The resultant signal is thus relative to space. For the Imager the primary objective is to eliminate image banding caused by noise in the space clamps. For the Sounder, which does not execute space clamps, the primary objective is to eliminate the effects of drifts, thermal and otherwise.

Relativization is applied to the counts from each pixel in a two-step process. First, the mean count value from the most recent spacelook is subtracted from the pixel counts. (For the Imager, the spacelook data are from the postclamp following the preceding spacelook.) Second, the constant BOOST is added back in. Without the second step, relativization would have two unfortunate consequences. First, when space itself is the target, the distribution of the data would be approximately Gaussian with a mean of zero. Half of the distribution would have count values less than zero and would be lost, since GVAR does not transmit negative integers. Second, the overall brightness of the image would change significantly between the relativization off and relativization on states.

The value of BOOST is set at 29 for all eight visible channel detectors of all Imagers. It is set to 920 for all four visible channel detectors of all Sounders. Since these are the nominal values for space in the absence of relativization, little change in overall image brightness will occur between the relativization off and on states. Note, however, that the two steps in the relativization process do not cancel each other out; because the mean space value and BOOST are not necessarily equal. The mean spacelook value varies from event to event, affected by noise in the case of the Imager and noise and drift in the case of the Sounder. BOOST, on the other hand is invariant.

For the Sounder, the SPS applies the two relativization steps in sequence, followed by normalization, which is described below. For the Imager, the SPS applies relativization and normalization in one operation. The on/off relativization status and the values of BOOST are transmitted in GVAR in the Block 0s (see Tables 3-6 and 3-10).

3.6.1.2 Normalization – The SPS normalizes Imager and Sounder visible detector data with NLUTs generated by the PM. Normalization can be applied to relativized or non-relativized image data. However, if an NLUT is optimal for relativized data, it will, in general, not be optimal for non-relativized data, and vice-versa.

The NLUTs are calculated directly through the use of a histogram-matching technique which involves a comparison of the cumulative histograms of the reference and target detectors. NLUTs are generated by iterating through the range of radiance values expressed in counts of the target detector's cumulative histogram as follows:

1. A percentage of population value is determined for the current target detector radiance value *R(target)* expressed in counts from the target detector's cumulative histogram.

2. The reference detector radiance *R(reference)* expressed in counts, which corresponds to the percentage of population value determined in step a, is obtained from the reference detector's cumulative histogram. This value then becomes the look-up value for the target radiance *R(target)* expressed in counts in the target detector's NLUT.

3. Steps 1 and 2 are repeated until the NLUT is completed.

Once a complete NLUT set has been calculated and approved, it is sent to all SPSs via the ground-based X.25 network linking the OGE subsystems to GIMTACS. Upon reception of a complete NLUT, the SPS stores the NLUT on disk in the appropriate satellite's database. The SPS currently handling the associated satellite data stream enables the newly received NLUT for activation, either by SPS operator or GIMTACS directive. At the start of the next instrument scan, the SPS retrieves the directed Imager or Sounder NLUT from the configured satellite's database and uses this NLUT for the remainder of the current frame and for all subsequent frames until otherwise directed. The NLUTs in current use are sent to users in GVAR Block 11s after each blackbody calibration event (see subsection 3.3.7.10).

ITT (factory) measured characteristic response coefficients for Imager and Sounder visible detectors are also provided in the Imager and Sounder Documentation blocks, respectively. These coefficients are never actually applied to visible detector data by the OGE, but are provided to the user for conversion of visible detector counts to radiance. Included in each instrument's documentation block is the conversion factor required to obtain the albedo from the visible radiance. Refer to Tables 3-6 and 3-10 for a detailed Documentation Block description for the Imager and Sounder, respectively.

3.6.2 IR Calibration

Calibration of retransmitted Imager and Sounder IR data by the SPS is a real-time process of data conversion to theoretical target radiance based on detector response characteristics derived by the OGE from a combination of: 1) factory measured detector response characteristics, and 2) in-flight measurements made while viewing space and blackbody targets. The correspondence between output counts and target radiance for each Imager IR detector and Sounder detector-channel combination is represented by a 2nd order polynomial based on the relationship

$$R = b + m\,C + q\,C^2 \quad (3.6.2\text{-}1)$$

where R is radiance, C is the measured counts, b is the intercept (bias factor), m the slope (gain factor), and q the coefficient of the quadratic (2nd order) term. The nominal values of b, m, and q for each detector and detector-channel are the result of prelaunch factory measurements, and are provided to the user in the Imager and Sounder documentation blocks (Tables 3-6 and 3-10, respectively).

In-flight changes are expected to occur to detector response characteristics due to aging of and temperature variations in the instrument components. In addition, the IR detectors are subject to a low frequency random drift. This phenomena is labeled 1/*f* drift. It has a pronounced affect upon the bias terms (*b* terms) of the medium and longwave IR detectors of the Imager. The Sounder avoids these effects by high frequency (every 100 milliseconds) clamping of the IR detectors to the filter wheel.

The OGE calibration algorithms allow for recomputation of the detector response coefficients (*b*, *m*, and *q*) based on temperature, spacelook, and blackbody calibration measurements. In addition, IR bias terms for the Imager are dynamically adjusted for each pixel to counter the effects of the 1/*f* drift.

Every time a space or blackbody look occurs, a new calibration set is generated. For the Sounder, the new set is transmitted automatically in GVAR within a Calibration Coefficient and Limits Block 11 (see subsection 3.3.7.9). For the Imager, new sets are transmitted for each output scan in the Scan Documentation Block (see subsection 3.3.4.5). In addition, a Calibration Coefficient and Limits Block 11 (subsection 3.3.7.9) is transmitted following each blackbody calibration event, and following each two-minute interval spacelook event. Each calibration set includes the latest coefficients for all detectors (Imager) or detector-channel combinations (Sounder), along with a time tag which can be used to correlate the calibration set to the sensor data to which it applies.

Scaling factors are applied to a new calibration set before the set is actually enabled within the SPS. Hence, the IR scan line data transmitted in GVAR is also scaled. The scaling factors are used to expand calibrated data into a range of 0–1023 for the Imager and 0–65535 for the Sounder to maximize the dynamic range of the retransmitted data. The scaling factors used are provided to the user in the Imager and Sounder Scan Documentation Blocks. With these factors included, the form of the equation relating input raw counts to retransmitted scaled radiance becomes:

$$SR = SB + SG\,(b + m\,C + q\,C^2) \qquad (3.6.2\text{-}2)$$

where *SR* is the scaled radiance, *SB* is the scaling bias, and *SG* is the scaling gain. To conserve precision and increase computational efficiency, the above equation is implemented within the SPS in the following form:

$$SR = B + C\,(M + Q\,C) \qquad (3.6.2\text{-}3)$$

where,

$B = SB + SG ß\, b$
$M = SG\, ß\, m$
$Q = SG\, ß\, q$

The calibration sets transmitted in GVAR (the *b*, *m*, and *q* terms) are always in their unscaled forms.

The following sections describe distinct operator-selectable IR calibration modes. The different modes allow enough flexibility so that observation and analysis of detector response as related to instrument telemetry can be used to select the most useful algorithms for the IR calibration process.

3.6.2.1 Standard IR Calibration – In the standard algorithm, the 2nd order terms of the detector response equations are not expected to change significantly; therefore, the factory measured values are used. The 1st order gain and bias terms are expected to vary as detectors age and with temperature, however, and are therefore recomputed based on in-flight space and blackbody measurements.

Blackbody measurements are used to determine detector response characteristics (specifically, gain and bias) based on an established relationship between blackbody temperature and equivalent target radiance as measured by each detector or detector-channel combination. This relationship between equivalent target radiance and blackbody temperature is represented by a cubic polynomial of the form:

$$R(T) = R0 + a\,T + b\,T^2 + c\,T^3 \qquad (3.6.2.1\text{-}1)$$

where $R(T)$ is the equivalent radiance, T is the blackbody temperature in K, and $R0$, a, b and c are the factory-measured polynomial coefficients. These coefficients are provided to the user in the Imager and Sounder documentation blocks (Tables 3-6 and 3-10).

The determination of detector response gain and bias following a blackbody calibration measurement is carried out in several steps. First, a moving window's worth of the latest N (operator-adjustable) blackbody thermistor samples is quality-checked and averaged into one value for each thermistor. These individual thermistor values are then converted to temperatures using factory measured polynomial coefficients relating measured thermistor output in counts to actual blackbody temperature. The polynomial is as follows:

$$(1/T) = A + B \ln X + C(\ln X)^3 \qquad (3.6.2.1\text{-}2).$$

where,

T	=	thermistor temperature in K
A, B, and C	=	thermistor characteristic terms
X	=	thermistor resistance computed as:

$$X = (D + E\,G)/(F + G) \qquad (3.6.2.1\text{-}3)$$

where,

D, E, F	=	amplifier characteristic terms
G	=	raw counts in base 10

The coefficients (A–F) above are provided in the Factory Parameters section of the Imager and Sounder documentation blocks. The blackbody temperature is calculated as the weighted mean of the calibrated thermistor values. (If for any one thermistor the number of samples which passed the quality-check filter is below a specified minimum and the affected thermistor's weighing factor is not zero, a critical alarm is reported and new IR calibration coefficients are not computed.)

A target radiance is then computed for each Imager detector or Sounder detector-channel combination using the computed blackbody temperature as an input to the polynomialsabove relating blackbody temperature T to target radiance $R(T)$.

The next step is to compute an average blackbody measurement in counts for each detector (or detector-channel combination) using the downlinked blackbody measurement samples (1000 for the Imager and 40 for the Sounder). The downlinked samples are first filtered using low- and high-reasonableness limits to eliminate noise-induced outliers. Next, the filtered samples are averaged. If the number of samples passing the reasonableness limits is below a specified minimum for any detector, a critical alarm is reported and new IR calibration coefficients are not computed for that detector or detector-channel. Gain is then computed for each detector or detector-channel using:

(3.6.2.1-4)

where m is the 1st order gain and q is the factory-measured 2nd order term. For the Sounder, the space level counts are the filtered mean values acquired from the spacelook immediately preceding the blackbody event. (A spacelook is performed prior to each blackbody calibration sequence, and the data samples are filtered and averaged as was described for blackbody data.)

The SPS uses interpolated spacelevel values for the Imager. The Imager performs a clamping operation prior to blackbody events and a spacelook following the blackbody events. The filtered mean values acquired from these two operations serve as the end points between which the SPS computes an interpolated spacelevel value, with the interpolation ratios computed using the time differences between the three events.

A new bias factor is computed for each detector (detector-channel for Sounder), using the new gains and the associated space levels. The equation is:

$$b = -(q\, slc^2 + m\, slc) \qquad (3.6.2.1\text{-}5)$$

where, for each detector, b is the new bias, q is the factory-measured 2nd order term, m is the newly computed gain, and slc is the space level counts value used to compute the 1st order gain term m.

The new bias factors, new gain factors, and 2nd order terms used for all the Imager detectors or Sounder detector-channel combinations constitute a new calibration set. The calibration set is time-tagged and transmitted in GVAR Block 11s (see subsection 3.3.7.9.) along with the following information:

1. Weighted mean blackbody temperature
2. Blackbody thermistor weighing factors
3. Blackbody thermistor sample window size (N)
4. Qquality/reasonableness limits
5. Sample size minimums
6. Critical alarms (if any).

Spacelooks are performed at a higher frequency than blackbody calibration sequences are. The bias terms of the detector response coefficients are adjusted after each spacelook, using the spacelook data and the latest computed gain from the most recent blackbody calibration. The equation is the same one used for the bias computation following calculation of a new gain (3.6.2.1-5). For the Sounder the new bias factors are automatically transmitted in a Calibration Coefficients and Limits Block 11 sequence along with all the unchanged information from the previous blackbody calibration.

For the Imager, the Block 11 sequence is only generated at two-minute intervals. However, any new sets that end up being applied to a scan are reported in the Scan Documentation Block 0 preceding each scan. The bias term applied to a raw Imager IR pixel is dynamically adjusted to compensate for the $1/f$ drift effects mentioned earlier. The adjustment performed relies upon the assumed linearity of the $1/f$ drift over short time intervals. A bias value term $b0$ is first computed from postclamp spacelook measurements using:

$$b0 = -(q\, slc^2 + m\, slc) \qquad (3.6.2.1\text{-}6)$$

where q and m are as described previously, and slc is the filtered mean postclamp spacelook count value. The results from this computation are held by the SPS, along with all scans occurring afterwards, until the next spacelook event occurs. The preclamp spacelook data acquired from this next event is used to form the drifted spacelook filtered mean count level $dslc$ from which a drift bias value bd is computed using:

$$bd = -(q\ dslc^2 + m\ dslc) \quad (3.6.2.1\text{-}7)$$

Using the bias values, drift bias values, and the midpoint times of the two data sets, a bias rate is then computed for each IR detector:

(3.6.2.1-8)

In the above equation *prate* is a conversion term nominally fixed at 5460 IR pixels/second used to convert the bias rate from change per second to change per pixel.

If any intervening scans are being held by the SPS, a sequence is entered in which the bias terms *bw* associated with the westernmost pixel in each scan are computed by linear interpolation between the postclamp bias values *b0* and the preclamp drift bias values *bd*. The times *tw* of the westernmost pixels of each scan are used to establish the interpolation ratios, as follows:

(3.1.2.1-9)

Using *bw* and *ibrate*, the bias term *bn* for the n^{th} IR pixel of a scan is computed from:

$$bn = bw + (n - 1)\ ibrate\ ß\ dir \quad (3.1.2.1\text{-}10)$$

where *dir* is +1 for a west-to-east scan and –1 for an east-to-west scan. The calibration coefficients provided in the Imager Scan Documentation Block 0 include *bw*, *m*, *q*, and *ibrate ß dir* for each IR detector. Also included in Block 0 are *t0*, *td*, *tw*, and the statistics associated with the postclamp and drift bias data sets.

Statistics are computed on detector spacelook data and transmitted with the raw data in GVAR Spacelook Block 11s as described in subsection 3.3.7.7. Similarly, statistics are computed on detector blackbody calibration data and transmitted with the raw blackbody data in GVAR Blackbody Calibration Block 11s (subsection 3.3.7.8). Telemetry Statistics Block 11s, described in subsection 3.3.7.5, are generated following each reported spacelook event.

3.6.2.2 Modifications to Correct for East-West Variation in Scan Mirror Reflectance – A modification to the standard IR calibration equations is required to correct for errors caused by the east-west variation in the reflectivity of the Imager and Sounder scan mirrors. The modified equations use the scan mirror temperature and emissivity as a function of instrument address. After each blackbody event, a table of emissivity vs. instrument address   is generated for each detector from the polynomial:

$() = a + b + c^2$ (3.6.2.2-1)

The Imager table has 7670 values, and the Sounder table has 1758 values. The coefficients *a*, *b*, and *c* are generated off line by NOAA engineers and may be updated on an infrequent basis. Their values are transmitted in GVAR in the Imager and Sounder Calibration and Limits Block 11s (see Tables 3-28 and 3-29).

The instrument address is related to the absolute increments number by:

$= \; (\textit{increments} + 3)/4 \quad \textit{(Imager)}$

and

= (*increments* + 7)/8 *(Sounder)*

The basic calibration equation 3.6.2-1 is modified to become:

(3.6.2.2-2)

where R, b, m, q, and C are defined as in equation 3.6.2-1. The variable

() is the emissivity at the address of the target;

(sp) is the emissivity at the address of the spacelook; and R_M is the radiance of the scan mirror, which is calculated from its temperature by equation 3.6.2.1-1.

Corresponding changes are made in the scaling equations 3.6.2-2 and 3.6.2-3. However, the user still derives radiances from GVAR counts exactly as before, by subtracting the scaling bias and dividing by the scaling gain.

Equation 3.6.2.1-4, the computation of gain, is replaced by:

(3.6.2.2-3)

where the subscripts *sp* and *bb* refer to the spacelook and blackbody data, respectively. The quantity r_{bb} is given by:

(3.6.2.2-4)

where *R(T)* is the radiance of the blackbody and is computed from its temperature as described in subsection 3.6.2.1. The quantity $R_{M,bb}$ is the radiance of the scan mirror computed via equation 3.6.2.1-1 from a window-average temperature at the time of the blackbody event. The window-average temperature of the scan mirror is computed in the same exact way as that of the blackbody's, as described in subsection 3.6.2.1. The value of $R_{M,bb}$ is transmitted in GVAR in the Imager and Sounder Calibration and Limits Block 11s (see Tables 3-28 and 3-29). The quantities *[bb]* and

[sp] are the scan mirror's emissivity at the blackbody and spacelook addresses, respectively.

Equation 3.6.2.1-5 remains unchanged, although it is understood that *m* is now computed as in the preceding paragraph.

With *m* and *b* computed as just described, the calibration is applied to the counts at each address according to equation 3.6.2.2-2. In this equation, R_M is computed by equation 3.6.2.1-1 from the most recent two-minute average temperature of the scan mirror. As before, the Imager drift correction time interpolates *b* between the spacelooks preceding and following the address. For the Sounder, the value of *b* is the value computed at the spacelook preceding the address.

3.6.2.3 IR Calibration Extensions – There are nine extensions to the standard IR calibration algorithms. These extensions can be selected separately or in combination. The currently active calibration algorithms are reported in the Calibration and Limits Block 11s in words 417–419 (Table 3-28) for the Imager, and words 2097–2099 (Table 3-29) for the Sounder. These words denote the calibration mode currently active for the three calibration terms *b*, *m*, and *q*. For the standard algorithms defined in the preceding section, each of these words is set to one. The following subsections provide a description of each extended calibration mode.

3.6.2.3.1 Bias Vs. Optics Temperatures (BMODE = 2) – This extension is available only for Sounder data. The algorithm uses a rotating history of times, biases, and optical component weighted mean temperature accumulated over the previous 24 hours. The seven optical temperatures used to form the weighted mean are measured at the scan mirror, the primary mirror, the secondary mirror, the baffle mounted on the primary mirror, and the aft optics.

The bias variation between spacelooks for each detector-channel is estimated from its correlation with the optics temperature. The correlation takes the form:

$$b = kT + h$$

where *b* is a bias value and *T* is the associated weighted mean optics temperature. The *k* and *h* terms are determined by performing a linear regression on the spacelook bias *b* and mean-weighted optics temperature *T* histories. The size of the subset of information included in the regression can be varied by the SPS operator to include the entire or a fraction of the file. The rate at which the regression is performed to determine new values of *k* and *h* can also be varied. The maximum time interval between regressions is once every 24 hours. The minimum period causes a regression to occur after every blackbody calibration event. The *k* coefficients determined by the regression are used between spacelooks to estimate a new bias (for each detector-channel) from:

$$b = b_0 + k(T - T_0)$$

where *b* is the new value of the bias factor to be used for IR calibration and *T* is the current weighted mean optics temperature. The terms b_0 and T_0 are the bias and mean weighted optics temperature determined at the most recent spacelook.

New bias values are estimated in this way nominally every 1.1 seconds while the BMODE = 2 algorithm is active. The values of *k*, *h*, the Standard Error of Estimate (SEE) determined by the most recent linear regression, and the current weighted mean optics temperature and optics temperature weighting factors are reported in the Sounder Calibration Coefficients and Limits Block 11s following each spacelook and blackbody calibration. A critical alarm is generated if any detector-channel combination's SEE exceeds a specified maximum. In this case, the newly computed values of *k* and *h* exceeding the specified maximum are discarded. In their place values of *k* and *h* from the last successful linear regression are retained.

3.6.2.3.2 1st Order Gain Versus Patch Temperature (MMODE = 2) – This extension, available for both instruments, adjusts the IR 1st order gain terms between blackbody measurements as a function of changes in patch temperature. The IR detectors are mounted on a flat plate called the patch, which is affixed to the north (top) spacecraft panel. The patch is used to provide a controlled thermal environment for the detectors, radiating excess heat to space or warming them through the use of internal heating elements. The temperature of the patch (and by implication, the detectors) is reported in the wideband telemetry. The SPS monitors the patch temperature, reporting statistics and averaged values every 2 minutes.
The standard calibration algorithm computes each IR detector's instantaneous 1st order gain at each blackbody event. These instantaneous gains are retained by the SPS, along with the time and temperatures present at the event. The SPS uses the information from two consecutive blackbody events to compute the relation between instantaneous 1st order gain and patch temperature. The computation determines the slope of the line defined by the two gain-temperature points provided by the blackbody events.

When MMODE 2 is enabled, the SPS determines a new value of 1st order gain for each IR detector at the two-minute intervals between blackbody events. The new value *m'* is computed using the following equation:

$$m' = m0 + A\,(t' - t0)$$

where *m0* and *t0* are the instantaneous gain and patch temperatures provided by the most recent blackbody event, *t'* is the current smoothed patch temperature, and *A* is the slope of the gain-patch temperature line determined at the most recent blackbody event. Note that the results *m'* of the two 2- minute computations are reported in the Calibration and Limits Block 11s (Tables 3-28 and 3-29) along with the current smoothed patch temperature.

3.6.2.3.3 1st Order Gain – Diurnal Filtering (MMODE = 3)

TBP

3.6.2.3.4 1st Order Gain – Temperature Regression (MMODE = 4)

TBP

3.6.2.3.5 1st Order Gain – Combined Modes 3 and 4 (MMODE = 5)

TBP

3.6.2.3.6 1st Order Gain – Linear Fit of History (MMODE = 6)

TBP

3.6.2.3.7 1st Order Gain – Curved Fit of History (MMODE = 7)

TBP

3.6.2.3.8 2nd Order Gain Versus Patch Temperature (QMODE = 2) – This extension, available for both instruments, computes the IR 2nd order gain terms at two-minute intervals as a function of patch temperature. The 2nd order gain terms are factory measurements taken for each IR detector at three distinct patch temperatures. Tables of these terms and the associated temperature ranges are available to the SPS. When QMODE 3 is enabled, the SPS compares the current smoothed patch temperature to the three available ranges. If a match is detected, the 2^{nd} order gain terms are taken directly from the associated gain table. If the current patch temperature lies outside of the defined ranges, the SPS performs a linear interpolation (or extrapolation) of a new 2^{nd} order gain using the new nearest tabled values. The option selected by the SPS is denoted by the patch temperature control level reported in word 416 (Table 3-28) or word 2096 (Table 3-29) of the Calibration and Limits Block 11s.

3.6.2.3.9 2^{nd} Order Gain Versus Baseplate Temp (QMODE = 3) – This extension, available for both instruments, uses the baseplate temperature to compute the IR 2^{nd} order gain terms at two-minute intervals. A LUT containing values of q at different baseplate temperatures is defined for each IR detector. A separate table is provided for each of three distinct patch temperatures. The table values are derived from factory measurements, and are provided in the Imager and Sounder documentation blocks. An effective baseplate temperature is calculated at two-minute intervals from telemetry as the weighted mean of six baseplate temperatures. The current value of q is determined from the effective baseplate temperature by interpolation in the LUT. Which of the three available LUTs is used for this interpolation is determined by the current smoothed patch temperature. If the current patch temperature lies outside of the defined table ranges, the two nearest tables are accessed with the effective baseplate temperature to generate two intermediate values of q. An interpolation (or extrapolation) is then performed using these two values, the associated patch temperature ranges, and the current patch temperature value to generate the new value of q.

Regardless of the calibration mode, the current weighted mean baseplate temperature, smoothed patch temperature, and the thermistor weighting factors are reported in the Calibration and Limits Block 11s along with the new values of the 2^{nd} order gains. A critical alarm is generated (and reported in the Block 11) if the effective baseplate temperature is out of the range of the LUTs. In this case, the values of q are extracted directly from the LUT by selection of the nearest entry corresponding to the effective baseplate temperature.

3.6.3 ECAL Linearity Verification

Each blackbody calibration sequence on the Imager and the Sounder is prefaced by an ECAL to measure the performance of the signal processing circuitry associated with each detector. The resulting 16 steps of measured output counts are received at the SPS and analyzed as described in the following paragraph.

First, all ECAL data is passed through high- and low-reasonableness filters; the filtered data is then averaged into one value per step per each of the 15 Imager detectors or 16 Sounder detectors (distinction between Sounder channels is not required in this case). Linearity verification is performed for each detector by fitting the mean values at the 16 steps to a line using the method of least squares, and then computing the 16 individual residuals and their RMS.

The results of the filtering and the least squares fit for each detector, the slope and intercept of each computed line, and the associated residuals and RMS are reported in the GVAR ECAL Block 11s (as described in subsection 3.3.6.7). A warning is generated and reported in the ECAL Block 11s if the RMS exceeds a specified limit for any detector or there are insufficient filtered samples for a particular step. The RMS limits, sample/step minimums, and high/low filters are reported in the Calibration Coefficients and Limits Block 11s.

*** NOTE ***

Filter delays in the Imager data result in several invalid samples being downlinked to the SPS preceding the valid ECAL data. These invalid samples are discarded. The number of samples to be discarded for each Imager detector is specified by the “leading sample discard count/detector” array in the Imager Calibration Coefficients and Limits Block 11s.

3.7 Star Sense Analysis Algorithm

3.7.1 Problem Description

At intervals determined by ground command, the scanning mirror slews to a coordinate through which a star is expected to pass. A space clamp is performed at this coordinate, and the detector amplifier gains for each of the 8 visible star sense detectors are increased from 108 to 432 (nominal). The scanning mirror settles at this location to await the start of the star sense data sequence, which begins 2.0 seconds later.

Passage of a star through the detector FOV is accomplished by normal in-orbit rotation of the satellite (0.25^{o} /minute). The star senses last from 1 to 64 seconds as commanded by the ground. While a star sense data sequence is underway, no corrections for image rotation are performed by the instrument. The instrument's optical system provides a diffraction-limited blur spot diameter of approximately 10–15 rads in the visible spectrum of the sensing detectors. The point spread function associated with the blur spot intensity follows a *sin x/x* distribution.

At the conclusion of a star sense, the instrument slews back to the coordinate occupied prior to the initiation of the star sense to continue the previously active operation. The detector amplifier gains are restored to a value of 108, and the nominal space clamp value employed initially is reestablished.

3.7.2 Analysis

A detector is assumed to act as an integrator, providing an output proportional to the total incident illumination and intensity. As a result, the output of a detector for a *sin x/x* blur spot resembles a flattened pyramid whose base width is composed of three parts:

1. Up staircase
2. Plateau
3. Down staircase

The up and down staircases are generated as the blur spot enters and leaves the detector FOV. The step effects, caused by the *sin x/x* intensity lobes, will be unequal as the bulk of the incident energy is contained in the central lobe. The overall width of each staircase will be equal to the width of the incident blur spot divided by the rotation rate. The plateau begins when the bulk of the blur spot is incident on the detector. It represents the peak detector response. The plateau remains in effect as the spot traverses the face of the detector until at the far edge, the spot staircases out of the FOV. The height of the plateau is a function of the intensity, wavelength, and apparent spot diameter of the target star, and is not characterized further. The width of the plateau is a function of the blur spot diameter and detector width. The time characteristics associated with a star sensing use the following terms:

r = Earth's rotation rate = 0.25 deg/min = 72.722 rad/sec
w = detector width = 28 rad
d = star blur spot diameter = 10 rad (example)
t_1 = up staircase interval in seconds
t_2 = plateau interval in seconds
t_3 = down staircase interval in seconds.

The total time of a star crossing can be computed as the time required to sweep through the detector width and the star blur spot diameter:

t_t = (w + d)/r = 38/72.722 = 0.5225 seconds
= $t_1 + t_2 + t_3$

Because of the symmetry of the *sin x/x* intensity function, the up and down staircases are equivalent and equal in time to the sweep rate applied to the blur spot diameter:

t_1 = t_3 = d/r = 0.1375 seconds

The resulting plateau time is:

t_2 = 0.5225 – 0.1375 – 0.1375 = 0.2475 seconds

The Sounder generates pixels at a rate of 40 pixels/second (10 frames/second x 4 pixels/frame) for each of eight star sense detectors. Other than stripping this information from the original downlink data block and repacking it into eight time-ordered arrays, no preprocessing of this information occurs prior to the software analysis. Since the star sense interval can range from 4 to 64 seconds in duration, the number of pixels included in the analysis of each detector can range from 160 to 2560 pixels. The occurrence of a star crossing event involves approximately 21 pixels from a particular array, 10 of which will be registering a plateau while the remaining 11 are split between the up and down staircases.

The analysis performed on the Sounder star sense arrays is described using the terms defined in Table 3-36 (given at the end of this section). In addition to the eight time-ordered sample arrays S_i, a ninth array of CDA time stamps T_i is provided as a primary input to the analysis. The time stamp for each raw Sounder data block is assigned to the first of the four associated star sense samples. The remaining three samples are stamped by the cumulative addition of 25-millisecond increments to the initial CDA time stamp. In the remainder of this discussion, an analysis algorithm is presented from the viewpoint of a single detector.

The star sense pixel array P_i is formed by use of a moving window averaging filter operating on the input sample array S_i. The database term *W* specifies the number of raw input samples to be included in the window, and is constrained to be a positive integer. The number of star sense pixels generated by the moving window filter is a function of the input sample size *N* and the window size *W*, and is equal to $N - W + 1$. The intent of the moving window averaging filter is to improve the signal-to-noise ratio of the data prior to analysis. The resulting star sense pixel array P_i is employed in the remainder of the computations.

The mean value registered by the detector during the star sense interval *DMV* is computed as the average value of the detector pixel array P_i. An incremental database value *DWT* is added to the *DMV* to compute a threshold level *WTL* for the detector. The value of *DWT* can be tailored for each of the eight detectors. Its primary function is to provide a 1^{st} order filtering of noise effects that may be present in the pixel data. The window threshold level *WTL* that results is used to select the subset(s) or window(s) of pixels within array P_i that may contain star information.

The database constant *WTC* denotes the number of pixels that must exceed the window threshold before a star crossing is defined to have started. The *WTC* criteria is also applied in a reverse transit through the pixel array to determine the end location of the window(s).
Once a windowed set of pixels has been selected, the mean value *WMV* of the pixels contained within the window is computed. Next, an event threshold level *ETL* is computed as the level

halfway between *WTL* and *WMV*. This level, in conjunction with the database constant *ETC*, is used to locate the pixels at which the windowed event is defined to begin and end.

The value of *ETC* specifies the number of sequential pixels with values exceeding *ETL* that defines the edge of a star crossing event. Two passes are made through each set of windowed pixels: one in the forward direction to locate the rising edge of the event, and one in the reverse direction to locate the falling edge of the event. In the forward pass, the last of the *ETC* pixels defines the start of the event; and, similarly, in the reverse pass, the last (i.e., the point in time when the detected signal starts to fall) of the *ETC* pixels defines the end of the event.

The CDA time of the event *TEV* is computed as the mid-point time of the inclusive pixel set. The above analysis is repeated for each windowed subset of pixels in the detector's array. The entire analysis is repeated for each of the remaining seven detector arrays.

With some variations, the preceding analysis described for the Sounder also applies to the Imager star sense data. The applicable Imager data analysis terms are defined in Table 3-37. The primary difference between the two analyses lies in the formation of the star sense pixel array P_i.

The Imager generates 21,840 pixels per second from each of the eight star sense detectors, and can perform a simple star sense of up to 64 seconds in length. Extended star sense intervals exceeding 64 seconds can also be performed if the star sequence mode has been commanded. Thus, preprocessing of the Imager star sense data by the SPS's SDI hardware is required to reduce the volume of Imager data generated to a manageable size. To accomplish this reduction, the SDI hardware sums 4*M* raw pixels to generate each input sample S_i. The summation is performed by prior to entry of the sample into the SPS's memory. *M* is an operator-modifiable database constant that specifies the number of Imager data blocks to be included in the sum, and is restricted to a range of 2–1024. The nominal value of *M* is 55, yielding an input sample timing resolution of 10.07 milliseconds.

Each Imager raw data block provides four pixels from each of the eight star sensing detectors, corresponding to a pixels per sample sum of from 8 to 4096 generated by the SDI. For the default case of *M* = 55, the SDI would generate about 99 input samples per second for each detector. Assuming a 10- rad blur spot star event, 51 samples would be involved with the event, 24 registering a plateau and the remaining 27 split between the up and down staircases.

The Imager sample time array T_i contains the CDA time tags associated with the last raw block included in each sample sum generated by the SDI. The star sense pixel array P_i for each visible detector is formed using a moving window averaging filter similar to the one described for the Sounder star sense. The difference between the two is that the Imager version includes the factor 1/4*M* in the averaging algorithm to compensate for the effects of the summing operation performed by the SDI.

Table 3-36. Sounder Star Crossing Analysis Terms

input sample array (160 œ N œ 2560)
expanded input time array
star sense pixel value (W is integer: {1,2,3,..})
detector mean value
detector relative window threshold (separate value each detector)
window threshold level
window threshold count used with WTL to locate window start (h) and end (k) indices
window mean value

Table 3-36. Sounder Star Crossing Analysis Terms (Cont'd)

event threshold level

event threshold count used with ETL to
locate event start (m) and end (n) indices

event mean value

time of event

Table 3-37. Imager Star Crossing Analysis Terms

input sample array (100 œ N œ 6400)

input time array

star sense pixel value
(W is integer: {1,2,3,..})
(2 œ M œ 1024)

Table 3-37. Imager Star Crossing Analysis Terms (Cont'd)

detector mean value

detector-relative window threshold
(separate value each detector)

window threshold level

window threshold count used with WTL to
locate the window start (h) and end (k) indexes

window mean value

event threshold level

event threshold count used with ETL to
locate event start (m) and end (n) indices

event mean value

time of event