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 (AUX) data products into the GVAR stream. These secondary products include text messages and spacecraft navigation support data.

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 structure. The format consists of twelve distinct blocks numbered 0 – 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 – 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 – 10 is 32,208 bits, for scan widths less than 1.9°, while the largest block size is 262,288 bits for a 23°-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°. Scans having widths up to 23° are possible with either instrument; however, the radiometric and pointing accuracy degrades for widths above 19.2°. The GVAR format handles scans wider than 19.2° with restrictions on operations to allow for special postlaunch tests (see Section 3.2.2). During normal operations, the 19.2° limits specified by the manufacturer represent the upper bound.

DOC	IR1	IR2	VIS 1	VIS 2	VIS 3	VIS 4	VIS 5	VIS 6	VIS 7	VIS 8	SAD
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**

– Each GVAR Block has the following: 10,032-bit Synchronization Code
720-bit Header
N-bit Information Field
16-bit CRC

– Blocks 0 and 11 have a fixed-length information field of 64,320 bits.

– Blocks 1 – 10 have variable length information fields directly dependent on frame width (scan width), with a minimum length of 21,440 bits.

– A Single Imager Scan generates Blocks 0–10 in sequence.

– Blocks 0–10 may be followed by any number of Block 11s (0–N), depending on what is available.
In priority order, the following Blocks transmitted are:

1. Imager Scan Blocks 0–10
2. Imager Compensation and Servo Errors – 1 Block 11
3. Sounder Compensation and Servo Errors – 1 Block 11
4. Imager Telemetry Statistics – 1 Block 11
5. Imager Spacelook Statistics and Data – 6 Block 11s
6. Imager Calibration Coefficients and Limits – 1 Block 11
7. Imager ECAL Statistics and Data – 2 Block 11s
8. Imager BB Statistics and Data – 2 Block 11s
9. Imager Visible NLUTs – 2 Block 11s
10. Imager Star Sense Statistics and Data – 9 Block 11s
11. Sounder Scan Data – 2–523 Block 11s
12. Sounder Telemetry Statistics – 1 Block 11
13. Sounder Spacelook Statistics and Data – 5 Block 11s
14. Sounder Calibration Coefficients and Limits – 2 Block 11s
15. Sounder ECAL Statistics and Data – 3 Block 11s
16. Sounder BB Statistics and Data – 5 Block 11s
17. Sounder Visible NLUTs – 9 Block 11s
18. Sounder Star Sense Statistics and Data – 9 Block 11s
19. GIMTACS Text Messages – 1–2 Block 11s
20. SPS Text Messages – 1 Block 11
21. AUX Data – 1–N Block 11s
22. Fill Data – 1 Block 11

Figure 3-1. GVAR Format

KEY TO ACRONYMS AND ABBREVIATIONS:			
CRC	Cyclic Redundancy Check	IR n	Infrared Detector n
DOC	Documentation	VIS n	Visible Detector n
ECAL	Electronic Calibration		

Table 3-1. GVAR Format

Parameter	Value
Scan	
Period Blocks and Imager Scan Bit Rate	Variable 11 2,111,360 bps
Block	
Period Synch Length Header Word Length Header Length (Triple Redundant) Data Section	15.25 to 104.6 msec 10,032 bits 8 bits per word 90 words (720 bits)
Data Section (by block type)	
Block 0 - Documentation Block Word Size Field Length	 8 bits 8040 words (64,320 bits)
Block 1 - Infrared Block 1 Word Size Field Length Number of Records Line Documentation IR Detector Data	 10 bits *68 to 21,008 words 4 per block 16 words 1 to 5236 words
Block 2 - Infrared Block 2 Word Size Field Length Number of Records Line Documentation IR Detector Data	 10 bits *51 to 15,756 words 3 per block 16 words 1 to 5236 words
Blocks 3 – 10 - Visible Blocks Word Size Field Length Number of Records Line Documentation IR Detector Data	 10 bits *20 to 20,960 words 1 per block 16 words 4 to 20,944 words
Block 11-Sounder and AUX Data Word Size Field Length (words) Record Types Number of Records	 6, 8, or 10 bits 10720, 8040, or 6432 7 1 to 8
CRC	16 bits

Note:

* 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° instrument scan.

3.2.1 Imager

The Imager is designed to sense radiant and solar energy from various areas of the Earth. The layout of the Imager instrument detectors is depicted in Figure 3-2. The Imager has a total of 22 detectors split into the following three groups:

- Eight visible detectors, V1 – V8
- Seven primary IR detectors, P1 – P7
- Seven redundant IR detectors, R1 – R7

Each of the 22 detectors is a member of one of the 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 IR 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. This forms Earth scan swaths in which the visible and IR detector data coincide. In the side 1 detector configuration, data from visible detectors V5 – V8 are lagged. These lagged data are combined with IR detector P1 – P7 data and visible detector V1 – 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 – V8 and IR detectors R1 – R7 are lagged. The lagged data are combined with data from visible detectors V1 – 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 – 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 – 10 contain visible detector data. The detector data position within the ten 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 R3)
	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 R6)
	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

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 N-S 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 of 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 denoted as containing fill data by way of the Data Valid flag in the corresponding block headers (see Section 3.3.2.).

The side 1 start-of-frame, half-sided sequence described above occurs when there is a lack of visible detector data to fully overlay the IR swath. 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.

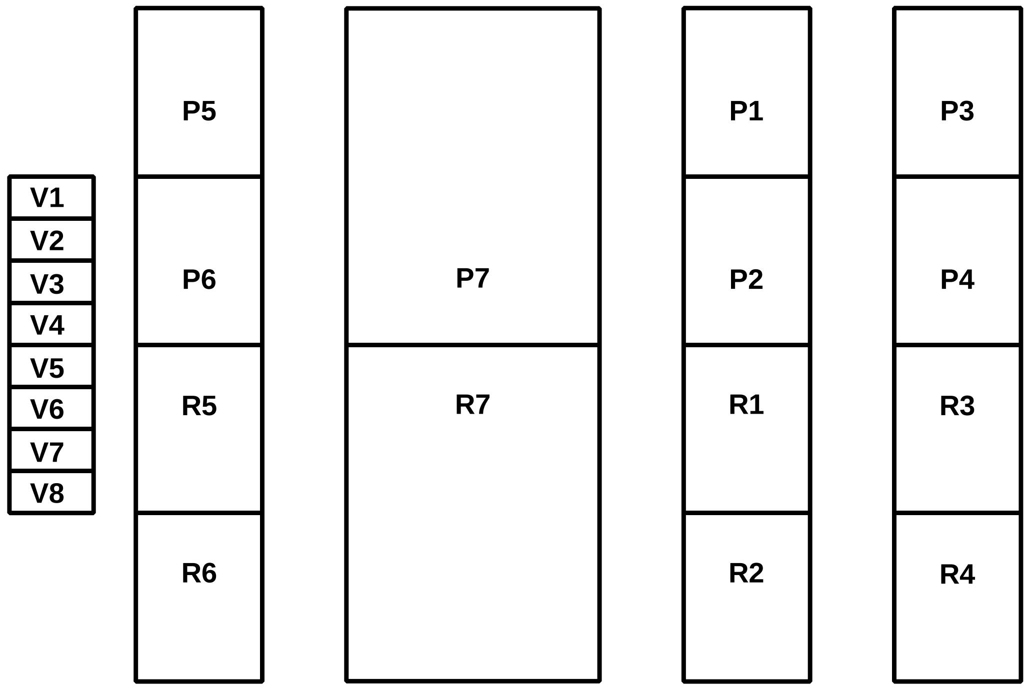
Half-sided Block 0 – 10 sequences are also generated when data disruptive frame breaks are encountered. These frame breaks arise under the following three conditions:

1. An instrument reset
2. The loss of raw signal synchronization by the SPS
3. A priority frame interrupt

The occurrence of an instrument reset causes the Imager to cancel all current or pending activities, entering a state in which only spacelook and BB-Cal 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 N-S 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 sequence.



CHANNEL	**1**	**2**	**3**	**4**	**5**
CENTRAL WAVELENGTH (µm)	**0.65**	**3.9**	**6.75**	**10.7**	**12**
DETECTOR IGFOV (µradians)	**28**	**112**	**224**	**112**	**112**

Notes:
µm – micrometers (microns)
µradians – micro radians
IGFOV – Instantaneous Geometric Field-of-View

Figure 3-2. Imager Detector Physical Configuration

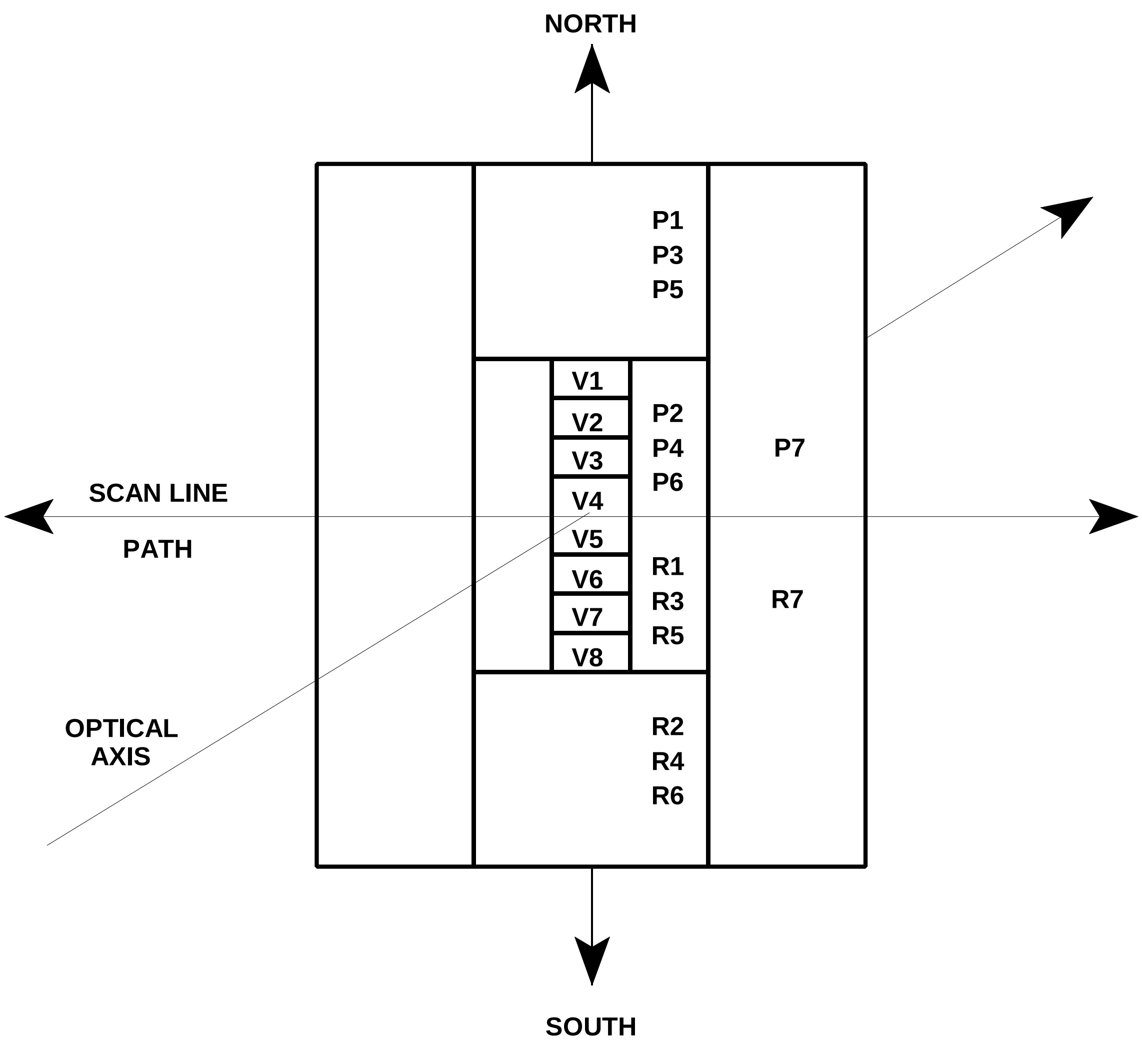


Figure 3-3. Imager Detector Optical Configuration

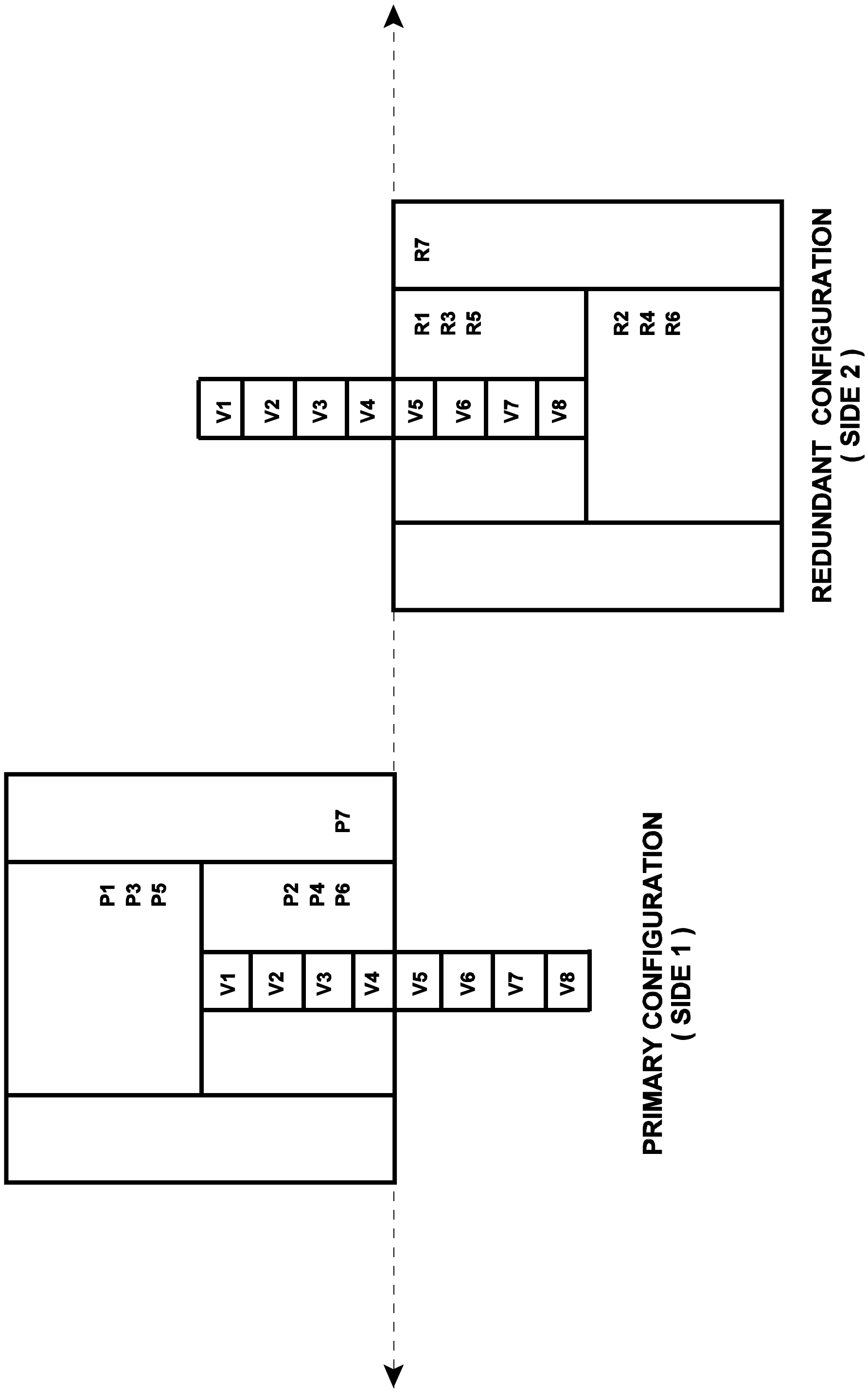
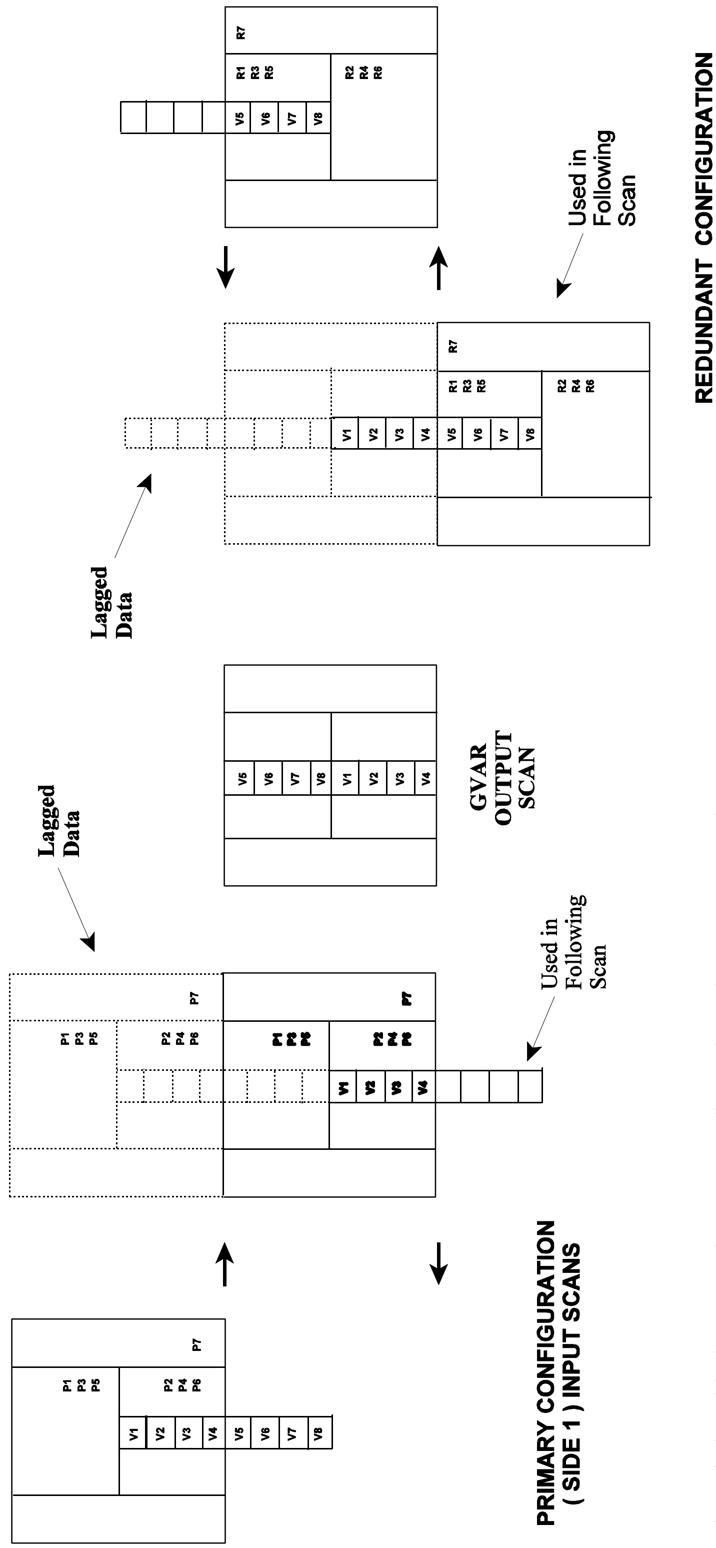


Figure 3-4. Imager Detector Operation Configuration



The relationship between detector configurations, input scans, and output scans is illustrated using two successive input scans. Lagged data from the first scan, solid then dotted, is combined with visible data, solid, from the second scan to construct a complete output scan output in GVAR Blocks 1 – 10.

Figure 3-5. Imager Scan Line Generation

The above discussion of Imager output scan formation assumes the optical configuration of the IR and visible detectors is invariant. This assumption is a simplification. Actually, 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:

- N-S offset: –8 to +8 lines
- E-W 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 N-S offsets are made by adjustments to the recombination algorithm, increasing or decreasing the lagging applied to the visible detector data. Compensations for the E-W offsets are performed by clipping visible data lying outside the IR imagery and filling in missing visible data.

3.2.2 Sounder

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 physical and optical layout of the 24 Sounder detectors is depicted in Figure 3-6. 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. The 19 channels, spectral bands, covered by the Sounder's four radiometric arrays are shown in Table 3-2. The star sense detection array contains eight detectors, physically similar to the Imager's visible detector array.

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 Section 3.3.7.3.

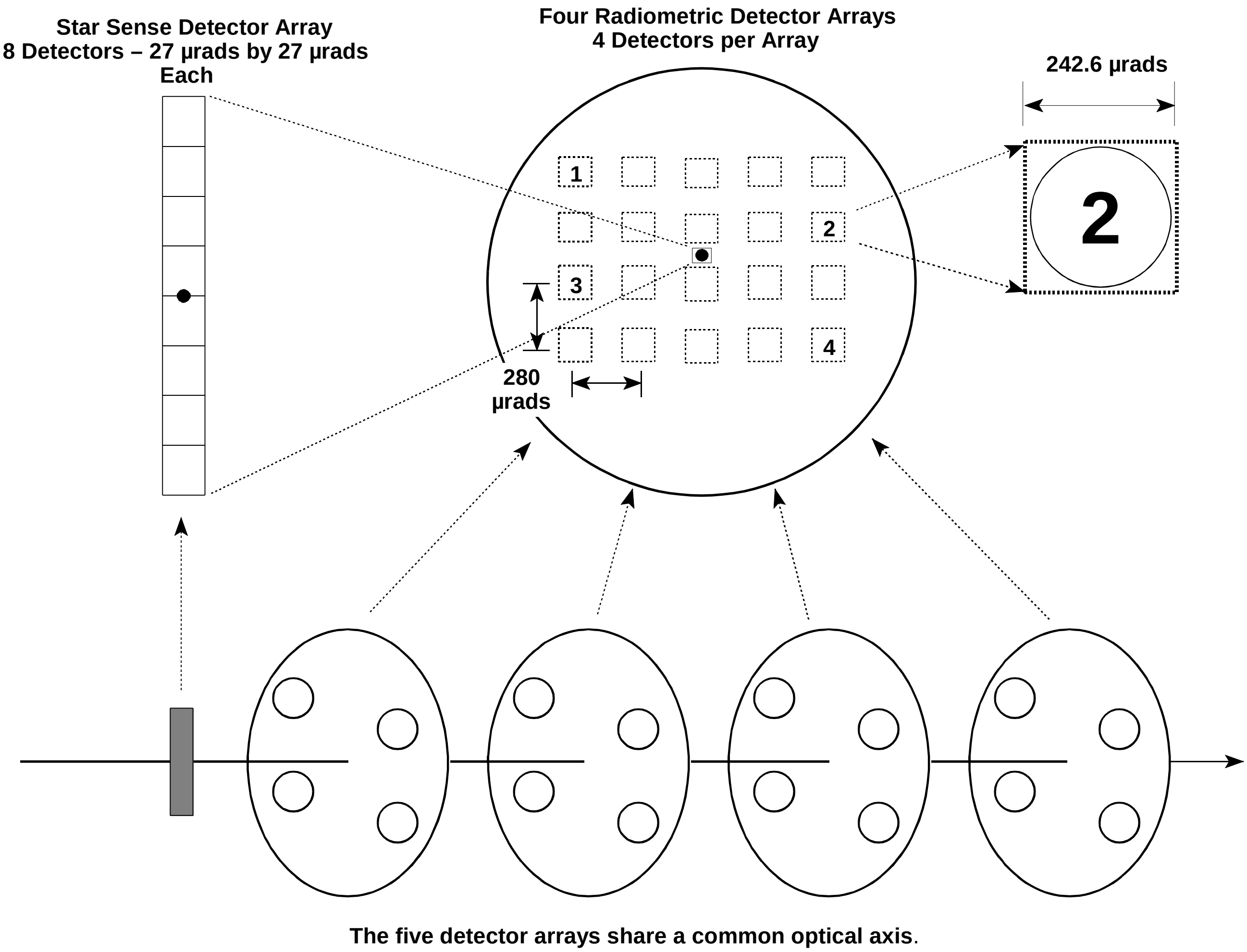


Figure 3-6. Sounder Physical and Optical Detector Configuration

Table 3-2. Sounder Radiometric Channels

Detector	Channel Number	Central Wavelength (microns)	IG Field of View (IGFOV) (µrad)	Purpose
Longwave	1	14.71	224	Temperature Sounding
	2	14.37		Temperature Sounding
	3	14.06		Temperature Sounding
	4	13.64		Temperature Sounding
	5	13.37		Temperature Sounding
	6	12.66		Temperature Sounding
	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		Sounding
Shortwave	13	4.57	224	Temperature Sounding
	14	4.52		Temperature Sounding
	15	4.45		Temperature Sounding
	16	4.13		Temperature Sounding
	17	3.98		Surface Temperature
	18	3.74		Surface Temperature
Visible	19	.67	224	Cloud

3.2.3 Yaw-Flipped Spacecraft GVAR Generation

While the capability of operating the GOES I-M spacecraft in a yaw-flip position (a 180° rotation about the yaw axis) was never envisioned, it was necessitated by a solar array drive failure on the GOES-10 spacecraft. This failure precluded operations in the forward drive direction. To permit proper tracking of the sun while the solar array is moving in the reverse direction, the spacecraft has to be in the yaw-flip position. A number of ground system changes were required to support yaw-flipped operations. By design the GOES N-Q spacecraft will have the capability to rotate seasonally 180° about the yaw axis (yaw-flip) to attain lower IR detector patch temperatures and, thereby, improve IR channel radiometric performance.

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 N-W ordering and also reverses the E-W 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 physical positions relative to those in the normal, upright mode, so the Earth-oriented, northernmost imagery is processed first. Visible detector 8 is swapped with detector 1 and 7 with 2. This pattern continues for the remaining visible detectors. Likewise, IR detector 2 is swapped with physical detector 1 in channels 2, 4, and 5. The contents of the GVAR Block 0 – 10 sequence are 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 R3)
Block 2:	Channel 2, IR Detector 2 (either P6 or R6)
	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 N-S. As shown in Figure 3-6, IR channels 1 – 18 and visible channel 19 have identical 4-detector layouts. 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 – 4 on the top, north side of the optical axis and detectors 5 – 8 on the bottom side. These detectors are swapped in the same manner as the Imager visible detectors, detector 1 with 8 and 4 with 5. The star sense detector data is formatted in the same detector order as the Imager: 4, 3, 2, 1, 8, 7, 6, and 5.

3.2.4 Block Sequencing

The block sequence transmitted within the GVAR stream is actively varied by 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 to maintain sequential consistency with respect to the instrument functions. Since the Imager has a much higher input raw data rate, the Imager output is assigned a higher priority than the Sounder output. The Block 0 – 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 nine blocks is the only GVAR data ready for output. Transmission of the first of the nine Block 11s is initiated. While this block is transmitting, 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. Comprehending the GVAR block sequence requires an understanding of the general operation of each instrument.

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 every two minutes in GVAR. The Imager performs electronic calibration (ECAL) and BB-Cal every 30 minutes, except when an image scan is in progress. When the scan is in progress, 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 BB-Cal are, respectively, as follows:

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

and

1. Two ECAL Statistics and Data Block 11s
2. Two BB Statistics and Data Block 11s
3. One Calibration Coefficients and Limits Block 11
4. Two Visible NLUTs Block 11s

The Sounder performs a spacelook calibration every two minutes, an ECAL and BB-Cal with every tenth spacelook, 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 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. A Block 11 spacelook calibration set is comprised of the following:

1. One Telemetry Statistics Block 11
2. Five Spacelook Statistics and Data Block 11s
3. Two Calibration Coefficients and Limits Block 11s

The Sounder performs an ECAL in conjunction with BB-Cal, with the corresponding GVAR Block 11 set comprised of the following:

1. Three ECAL Statistics and Data Block 11s
2. Five BB Statistics and Data Block 11s
3. Two Calibration Coefficients and Limits Block 11s
4. Nine Visible NLUTs Block 11s

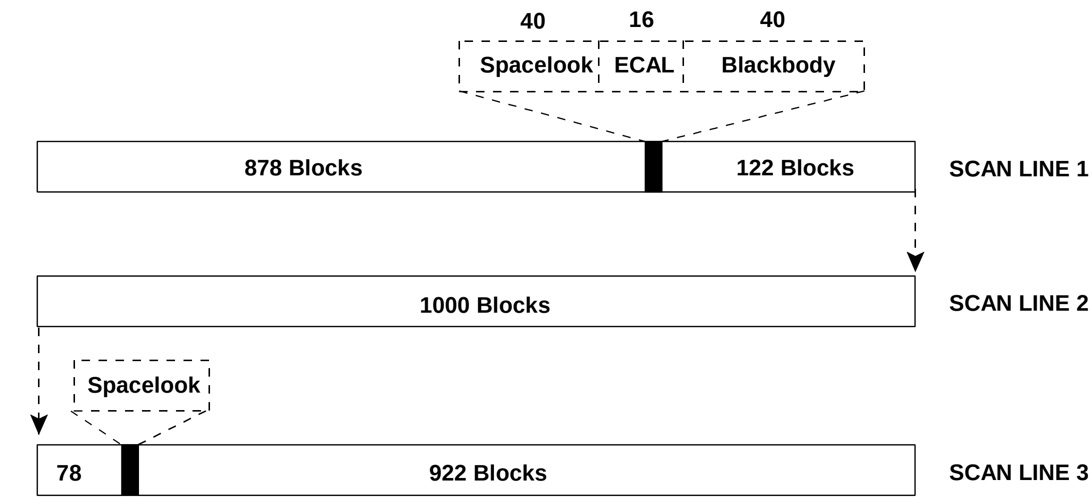
Figure 3-7 illustrates a typical Sounder scan sequence and the Block 11 output strings the SPS generates, with the effects of Imager and Sounder Compensation and Servo Error Data Block 11s ignored for clarity.

The following three points in conjunction with the sets mentioned impact the GVAR bandwidth usage:

1. Each set should 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 including calibrations, statistics, NLUTs, and star senses, the required bandwidths can be treated as a constant time-dependent overhead. The non-instrument data, messages and AUX data can be characterized indirectly according to the bandwidth of the associated ingest channels.



An arbitrary 16° wide sounding (1000 km) generates1000 blocks for each scan line. Spacelook calibrations occur every 2 minutes (i.e., 1200 blocks), interrupting the sounding, as in Scan Line 3. Complete calibration sequences are performed at every tenth spacelook, as shown in Scan Line 1. The resulting GVAR Block 11 sequence is depicted below. 'DOC' indicates a documentation Block 11, and 'SDB' indicates a Sounder sensor data Block 11. Note that the calibration data precedes the scan line data.

TLM Stats 1 SDB	**Spacelook 5 SDBs**	**Cal & Limits 2 SDBs**	**ECAL 3 SDBs**	**BlackBody 5 SDBs**	**Cal & Limits 2 SDBs**	**NLUTS 9 SDBs**

Scan Line 1 DOC + 91 SDBs	**Scan Line 2 DOC + 91 SDBs**	**TLM Stats 1 SDB**	**Spacelook 5 SDBs**	**Cal & Limits 2 SDBs**	**Scan Line 3 DOC + 91 SDBs**

Figure 3-7. Typical Sounder Scan Scenario

Key to Acronyms	
DOC	documentation Block 11
SDB	Sounder sensor data Block 11
TLM	Telemetry

Table 3-3 provides 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 Cyclic Redundancy Check (CRC). The lower limit ensures a minimum block processing time of 15.25 msec at a GVAR receiver. This equates to a maximum block rate of 65.6 GVAR blocks per second and forces a Minimum Data Field Length (MDFL) of 21,440 bits per 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°, 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 for the Sounder bandwidth requirements. Since all of the Sounder data is transported through Block 11s, no direct MDFL requirement is involved. An MDFL requirement 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 ignore instrument dead times. During instrument dead times no data is produced for GVAR transmission. These dead times are generally associated with the slewing of the instrument scan mirror to or from a location where a function is performed; such as star senses, spacelooks, or BB-Cal. The Imager has additional dead times at the frame start and restart, after a spacelook, star sense, and priority interruption. During these times the Imager generates three invalid scans before generating a valid scan. As a result of these simplifications, the equations provide a conservative (slightly high) value of the bandwidth requirements.

It can be assumed that both the Imager and Sounder 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 bandwidth utilized by GVAR transmissions, each instrument's requirements are computed over the full range of scan widths. The total bandwidth requirement for any combination of frame scan widths can then be computed.

Figure 3-8 provides the GVAR bandwidth utilization 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° to 19.2° 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 the following primary sources of GVAR overhead:

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

Table 3-3. Imager GVAR Bandwidth Requirements

General Bandwidth Requirements	Range of Values
MDFL = Minimum Data Field Length (bits)	21,440
ISWD = Imager Scan Width (degrees)	0.2° to 19.2°
IRB = Imager Raw Data (raw blocks)	ISWD (17453.29252 ÷ 64)
IST = Imager Scan Time (seconds)	0.2 + ISWD ÷ 20.02
BOH = Block Overhead (bits)	10,768
Imager Block 0 – 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 – B10 length (bits)	B0 + B1 + B2 + 8B3 + (11 BOH)
ISTT = GVAR Tx time (seconds)	ISCAN ÷ 2111360
ISTSN = Spare time/scan (seconds)	IST – ISTT
ISTSC = Spare time/second (seconds)	ISTSN ÷ IST
Imager Block 11 Bandwidth Requirements – in Units of Block 11s per second	
ICSE = Imager Compensation and Servo Errors	1 ÷ 4.3
ITLM = Imager Telemetry Statistics	1 ÷ 120
ISPC = Imager Spacelook Statistics and Data	6 ÷ 120
IECL = Imager ECAL Statistics and Data	2 ÷ 600
IBBC = Imager BB Statistics and Data	2 ÷ 600
ICAL = Imager Cal Coefficients and Limits	1 ÷ 120 + 1 ÷ 600
INUT = Visible NLUTs	2 ÷ 600
ISTR = Star Sense Statistics and Data	9 ÷ 1800
IB11OH = Imager Block 11 Overhead = SUM (ICSE · · ISTR) = 0.31589	

Notes:

17453.29252 – the number of μrads/degree
64 – the number of μrads/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)
SUM – a function summing all included components

Table 3-4. Sounder GVAR Bandwidth Requirements

General Bandwidth Requirements	Range of Values
SSWD = Sounder Scan Width (degrees)	0.2° to 19.2°
SRB = Sounder Raw Data (blocks)	SSWD (17453.29252 ÷ 280)
SST = Sounder Scan Time (seconds)	0.1 (SRB + 1)
Sounder Block 11 Bandwidth Requirements – in Units of Block 11s per second	
SSCAN = Sounder Documentation/Scan	(1 + RND(0.4091 + SRB ÷ 11)) ÷ SST
SCSE = Sounder Compensation/Servo Errors	1 ÷ 6.4
STLM = Sounder Telemetry Statistics	1 ÷ 120
SSPC = Sounder Spacelook Statistics/Data	5 ÷ 120
SECL = Sounder ECAL Statistics/Data	3 ÷ 1200
SBBC = Sounder BB Statistics/Data	5 ÷ 1200
SCAL = Sounder Cal Coefficients/Limits	2 ÷ 120 + 2 ÷ 1200
SNUT = Sounder Visible NLUTs	9 ÷ 1200
SSTR = Sounder Star Statistics/Data	9 ÷ 1800
SBOH = Sounder Block 11 Overhead	SUM (SSCAN : SSTR)
GVAR Bandwidth Requirements - in bps	
Imager = IBW	(1 − ISTSC) 2111360 + 75088 IB11OH
Sounder = SBW	75088 SBOH
Spare	2111360 − IBW − SBW

Notes:

17453.29252	–	number of µrads/degree
280	–	number of µrads/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)

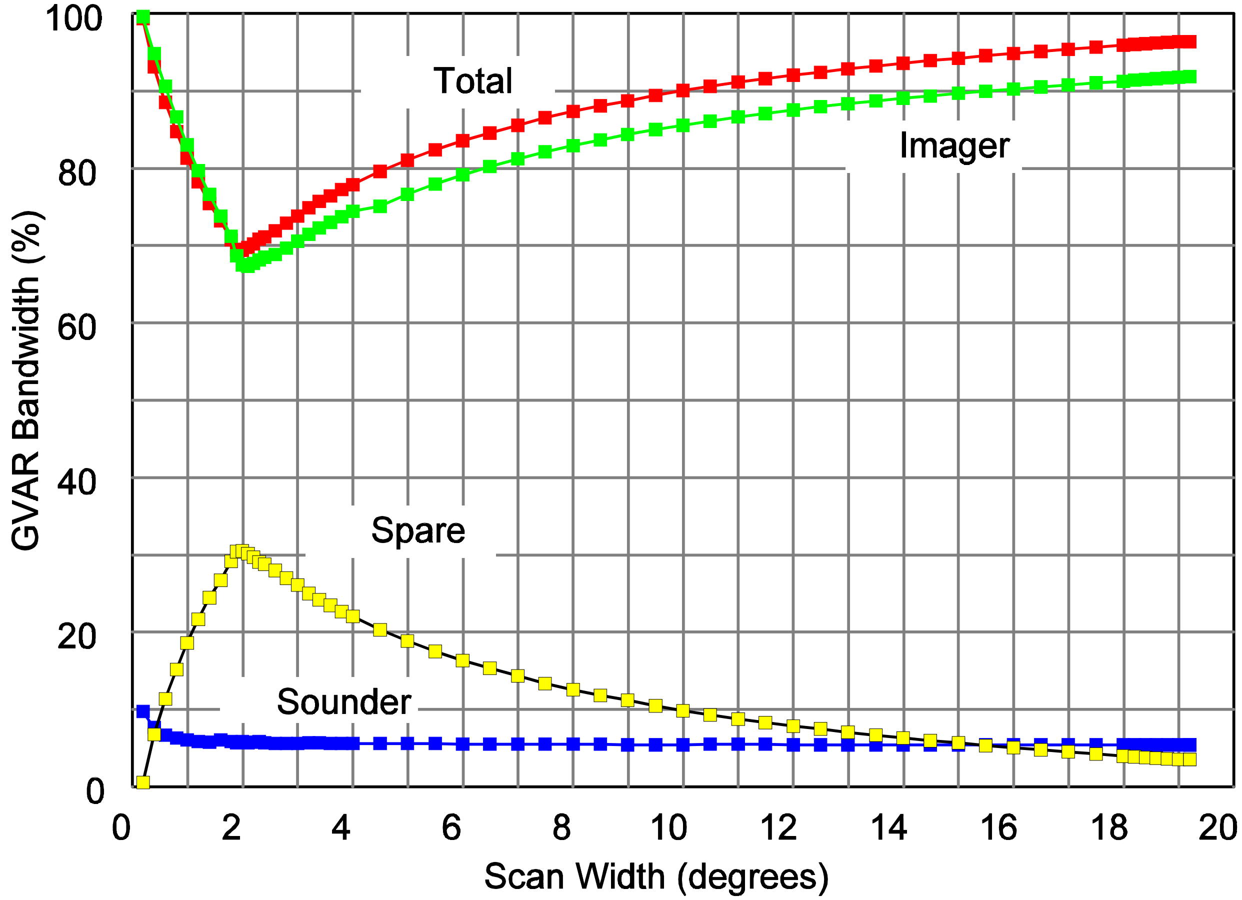


Figure 3-8. GVAR Bandwidth Utilization

Of the 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° 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 AUX 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. The AUX 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 AUX 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°.

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

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 the amount of time required to complete the transmission of any text and AUX 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 two primary 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 the following 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 and data ordered in a W-E 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 time required to obtain the drift bias measurement varies as a function of the current frame type and can range from approximately 1 – 38 seconds. After IR calibration has been performed, the transmission of Blocks 0 – 10 is enabled.

The SPS performs a similar buffering process on the Sounder data, primarily to permit W-E 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 (CDET), 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 – 52.9 seconds, depending on the 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 8-bit bytes, regardless of word length, are complemented; 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 (XOR) gate as shown in Figure 3-9. Bits 8 and 15, the Most Significant Bits (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 XOR gate.

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

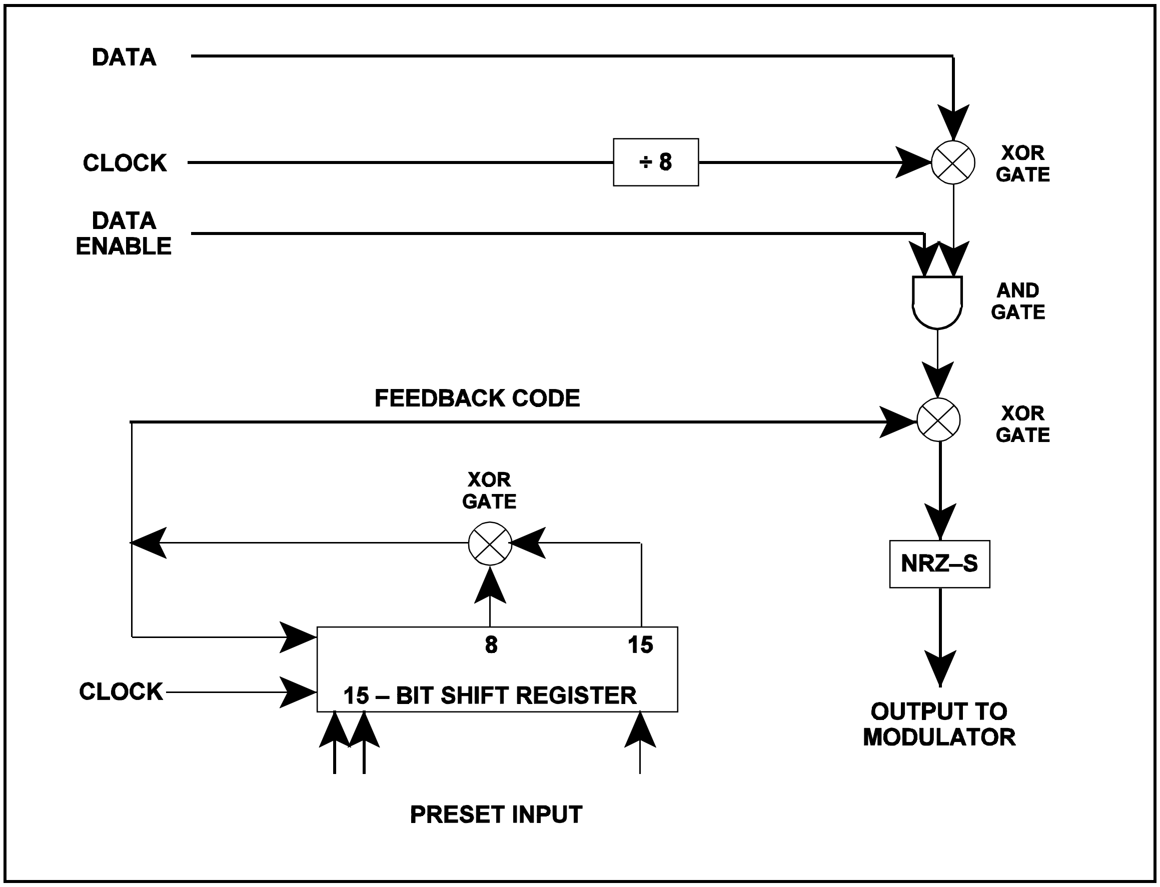


Figure 3-9. GVAR Block Synchronization Preamble Encoding

3.3 Block Format

Each GVAR block contains the following, primary fields:

- Block Synchronization Code
- Header
- Data Section
- Cyclic Redundancy Check

Fields one, two, and four are fixed in size and have an internal structure identical for all GVAR blocks. Field three, 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 sections 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 synchronizing receive equipment. The code is a PN sequence generated as described in Section 3.2.7 and shown in Figure 3-9. The shift register is preset to 51,665 octal so the contents, 15 bits, are logical 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.

Two additional fields are defined in words in the GVAR header that 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.

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

Figure 3-10. Header Organization

Table 3-5. Header Contents (1 of 2)

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*
2	Word Size	An 8-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 as follows: 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 AUX Text 11 = GIMTACS Text 12 = SPS Text 13 = AAA Sounding Products 14 = GVAR ECAL Data 15 = GVAR Spacelook Data 16 = GVAR BB Data 17 = GVAR Calibration Coefficients 18 = GVAR Visible NLUTs 19 = GVAR Star Sense Data 20–1000 = Unassigned

Note:

* 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.

Table 3-5. Header Contents (2 of 2)

Word	Contents	Description
7	Repeat Flag	An 8-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 8-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	The following 8-bit flag which indicates whether the transmitted data is usable or only filler: 0 = Filler Data 1 = Valid Data
10	ASCII/Binary	The following 8-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	Spares–not used
12	Range Word	An 8-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 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 65,535, inclusive, rolling over to 0 following 65,535. Count is incremented by 1 for each successive GVAR block transmitted. Count does not increment for Equipment Idle Blocks.
15-16	None	Spares–not used
17-24	SPS Time	A 64-bit BCD time code applied at CDA at transmission time.
25–28	None	Spares–not 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. See Section 3.3.3.

3.3.3 Block Cyclic Redundancy Check

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 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 of 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 then specified by International Telegraph and Telephone Consultative Committee (CCITT) Recommendation V41 and is as follows:

$$x^{16} + x^{12} + x^5 + 1$$

3.3.4 Block 0 Data Section

The GVAR Block 0 information field is 64,320 bits in length. It consists of 8040 8-bit words divided into the following six partitions:

Words	Description
1–278	Instrument and Scan Status
279–1626	Instrument 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 the 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 or side 2 flag denotes which set of IR detectors the SPS currently considers to be active; and, also indicates the output scan formation approach and database coefficients for conversions. The condition of the imaging detector data, valid or 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 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 Scan Reference Data

This partition provides co-registration table identity and the E-W coregistration offset terms currently available to the SPS. The N-S offsets are contained in the fifth partition, words 6235 – 6282. The coregistration index, word 1679, denotes which of the 48 offsets is currently in use. If this word is zero, coregistration 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 N-S coregistration 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.

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.

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 and 5), while Block 2 carries data from the remaining three detectors (channels 2 and 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.

Table 3-6. Imager Documentation Block 0 Format Definition (1 of 16)

Word	Name	Description
1	SPCID	Spacecraft ID - a binary number identifying the source satellite as follows: 8 = GOES-I 9 = GOES-J 10 = GOES-K 11 = GOES-L 12 = GOES-M
2	SPSID	SPS Identity: a binary number identifying the source SPS which formatted the GVAR data stream. Values 1–5 are assigned to SPS1–SPS5, 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 Least Significant Bit (LSB) of word 6. For each status bit that does not have a bit value of 0 listed below, a value of 0 represents a condition that is the opposite, or negative of the condition associated with a bit value of 1. For example, if bit 0 has a value of 1, a frame start occurred on this scan; if bit 0 has a value of 0, no frame start occurred on this scan. **<u>Bit</u> <u>Value</u> <u>Condition</u>** 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.
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 are 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.

Table 3-6. Imager Documentation Block 0 Format Definition (2 of 16)

Words 23 – 150 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 4-7	Year in 1000s Year in 100s
2	0-3 4-7	Year in 10s Year in 1s
3	0-3 4-7	Day of year (DOY) in 100s bit 0 = 1 indicates the time code generator is flywheeling DOY in 10s
4	0-3 4-7	DOY in 1s Hours in 10s
5	0-3 4-7	Hours in 1s Minutes in 1s
6	0-3 4-7	Minutes in 1s Seconds in 10s
7	0-3 4-7	Seconds in 1s Msec in 100s
8	0-3 4-7	Msec in 10s Msec in 1s

Table 3-6. Imager Documentation Block 0 Format Definition (3 of 16)

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
71-78	TINFS	Time of normal frame start
79-86	TISPC	Time of last spacelook calibration
87-94	TIECL	Time of last ECAL
95-102	TIBBC	Time of last BB-Cal
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 sets
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:		
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 1-1974 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 15,780 correspond to detector lines (northernmost to southernmost).
157-158	IWFPX	The number of the westernmost visible pixel in the current frame. Inclusive values of 1 to 30,677 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 30,680 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 1-15,780 correspond to detector lines (northernmost to southernmost).

Table 3-6. Imager Documentation Block 0 Format Definition (4 of 16)

Word	Name	Description
163-164	ISFLN	The number of the southernmost visible detector scan line in the current frame. Inclusive values of 8 to 15,787 correspond to detector lines (northernmost to southernmost).
165-166	IMDPX	The number of the visible pixel corresponding to an instrument azimuth of 0°. Nominal value, ½ full range, is 15,340. This value is an instrument-specific constant.
167-168	IMDLN	The number of the scan line corresponding to an instrument elevation of 0°. Nominal value, ½ 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°. Nominal value, ½ 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	IGVLN	The number of the visible detector scan line intersecting the subsatellite point.
173-174	IGVPX	The number of the visible pixel intersecting 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	V1PHY	The 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.
189-190	PBIAS	E-W grid bias (0 ± 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	N-S grid bias (0 ± 7892 pixels) is similar to E-W grid bias, except in the N-S direction.
193	ISCP1	Odd parity byte computed for ISCAN (see words 3–4).

Table 3-6. Imager Documentation Block 0 Format Definition (5 of 16)

Word	Name	Description
194		Spare – not used
195–198	IDBER	Current raw data bit error rate (BER) is a floating point number denoting the 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 the 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 the 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 msec 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 or special short-term operations
The following four floating point values are in units of degrees. Off-Earth coordinates have a value of 999999.		
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	Second order gain interpolation table index number. Integer value of 1, 2, or 3 denoting which of the three possible tables is reported in IG2IT (see words 6779–7002).
248	ISCP2	Repeat of ISCP1 (see word 193)
249–250	ISCA2	Repeat of ISCAN (see words 3–4)
251–277		Spares – not used
278		Longitudinal parity XOR of words 1–277

Table 3-6. Imager Documentation Block 0 Format Definition (6 of 16)

Word	Name	Description
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.		
279-282		IMC Identifier (4 ASCII characters)
283-294		Spares – not used
295–298		Reference Longitude (positive east, R*4, radians)
299–302		Reference radial distance from nominal (R*4, kilometers (km))
303–306		Reference Latitude (positive north, R*4, radians)
307–310		Reference Orbit Yaw (R*4, radians)
311–314		Reference Attitude: Roll (R*4, radians)
315–318		Reference Attitude: Pitch (R*4, radians)
319–322		Reference Attitude: Yaw (R*4, radians)
323–330		Epoch Date or Time: Standard BCD time format
331–334		IMC set enable time from epoch (R*4, minutes)
335–338		Spacecraft compensation: Roll (R*4, radians)
339–342		Spacecraft compensation: Pitch (R*4, radians)
343–346		Spacecraft compensation: Yaw (R*4, radians)
347–398		Change in longitude from ref. (13 at R*4, radians)
399–442		Change in radial distance from ref. (11 at R*4, km)
443–478		Sine geocentric latitude, total (9 at R*4, no units)
479–514		Sine orbit yaw, total (9 at R*4, no units)
515–518		Daily solar rate (R*4, radians per minute)
519–522		Exponential start time from epoch (R*4, minutes)
Words 523–742 apply to Roll attitude angle:		
523–526		Exponential magnitude (R*4, radians)
527–530		Exponential time constant (R*4, minutes)
531–534		Constant, mean attitude angle (R*4, radians)
535–538		Number of sinusoids or Angles (I*4, none)

Table 3-6. Imager Documentation Block 0 Format Definition (7 of 16)

Word	Name	Description
539–542		Magnitude of first-order sinusoid (R*4, radians)
543–546		Phase angle of first-order sinusoid (R*4, radians)
547–658		Repeat 539–546 for 2nd – 15th sinusoids (R*4, radians)
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, radians)
675-678		Phase angle of monomial sinusoid (R*4, radians)
679–682		Angle from epoch where monomial is zero (R*4, radians)
683–702		Repeat 663–682 for second monomial
703–722		Repeat 663–682 for third monomial
723–742		Repeat 663–682 for fourth monomial
743–962		Repeat 523–742 for Pitch attitude angle
963–1182		Repeat 523–742 for Yaw attitude angle
1183–1402		Repeat 523–742 for Roll Misalignment angle
1403–1622		Repeat 523–742 for Pitch Misalignment angle
1623–1624	ISCA3	Repeat of ISCAN (see words 3–4)
1625	ISCP3	Repeat of ISCP1 (see word 193)
1626		Longitudinal parity (XOR) of words 279–1625
The terms below are used to adjust the visible Imagery transmitted in GVAR so that it coregisters with the accompanying IR Imagery. If SPS coregistration is enabled, word 1679 has a non-zero 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.		
1627–1630		Coregistration Table ID (4 ASCII characters)
1631–1678		(1 x 48) E-W half-hourly correction terms
1679		Index of correction terms currently active
1680–1690		Spares – not used

Table 3-6. Imager Documentation Block 0 Format Definition (8 of 16)

Word	Name	Description
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: First word: bits 0–5: not used – zeros; bits 6–7: two MSBs of 10-bit word Second 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*.		
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.		
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)
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)
2151–2302		Repeat 2147–2150 for blocks 2 – 39
2303–2305		Spares – not used
2306		Longitudinal parity (XOR) of words 1691–2305

Table 3-6. Imager Documentation Block 0 Format Definition (9 of 16)

Word	Name	Description
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 databases.		
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 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		
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 range from 0 for no pixel up to 25,092. A value of 1 indicates the first pixel in the associated GVAR block and 2 the second. The pixel value continues to rise in conjunction with the associated GVAR block.		
5379–5380		Grid Set No. 1 Revision level
5381–5382		Grid Set No. 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 the following 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.		

Table 3-6. Imager Documentation Block 0 Format Definition (10 of 16)

Word	Name	Description
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.		
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: BIAS(n) = IWBIAS + (N – 1) IBRATE Note for the first-order gain, words 5615–5642, the gain could be computed by modes 1–7 or 8–14, when the Midnight blackbody calibration correction (MBCC) is active (i.e., when the MBCC Indicator (words 503–510) has a value of 1 or 2).		
5587–5614	IWBIAS	(4 x 7) IR calibration bias term
5615–5642	IGAIN1	(4 x 7) IR calibration first-order gain
5643–5670	IGAIN2	(4 x 7) IR calibration second-order gain
5671–5698	IBRATE	(4 x 7) IR calibration bias rate
5699–5706		CDA TOD of westernmost IR pixel

Table 3-6. Imager Documentation Block 0 Format Definition (11 of 16)

Word	Name	Description
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 (σ) – counts
5883–5910		(4 x 7) Filtered σ – counts
5911–5938		(4 x 7) Filtered σ – radiance
5939–5966		(4 x 7) Filtered σ – 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
6091–6118		(4 x 7) Filtered mean value – counts
6119–6146		(4 x 7) Unfiltered σ – counts
6147–6174		(4 x 7) Filtered σ – counts
6175–6202		(4 x 7) Filtered σ – radiance

Table 3-6. Imager Documentation Block 0 Format Definition (12 of 16)

Word	Name	Description
6203–6230		(4 x 7) Filtered σ – temperature
6231–6234		Clamp mode and status flags
6235–6282		(1 x 48) N-S 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 30 minute correction terms defined in words 1631–1678 and 6235–6282 are formed using 2s complement notation within the 8-bit fields. Valid ranges are –64 to +64 pixels for E-W terms and –8 to +8 lines for N-S 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 and 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
1 = 36.6-second space clamp mode active
0 = mode unknown

Table 3-6. Imager Documentation Block 0 Format Definition (13 of 16)

Word	Name	Description
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 to one if the associated condition is true. They are reset to zero if the condition is false. The bits assignments are as follows: **Bit** — **True Condition** 00 — Unassigned (always zero) 01 — Detector 4/1 invalid calibration condition (no statistics) 02 — Detector 4/2 invalid calibration condition (no statistics) 03 — Detector 5/1 invalid calibration condition (no statistics) 04 — Detector 5/2 invalid calibration condition (no statistics) 05 — Detector 2/1 invalid calibration condition (no statistics) 06 — Detector 2/2 invalid calibration condition (no statistics) 07 — Detector 3/1 invalid calibration condition (no statistics) 08 — Unassigned (always zero) 09 — Detector 4/1 excessive drift rate alarm 10 — Detector 4/2 excessive drift rate alarm 11 — Detector 5/1 excessive drift rate alarm 12 — Detector 5/2 excessive drift rate alarm 13 — Detector 2/1 excessive drift rate alarm 14 — Detector 2/2 excessive drift rate alarm 15 — Detector 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 a 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 in the N-S and E-W directions (see Section 3.4). 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, N-S cycles
6306	IOFEC	Instrument nadir, E-W cycles

Table 3-6. Imager Documentation Block 0 Format Definition (14 of 16)

Word	Name	Description
6307–6308	IOFNI	Instrument nadir, N-S increments
6309–6310	IOFEI	Instrument nadir, E-W increments
For each of the 22 detectors (8 visible, 14 IR), two 16-bit integer values provide the X (E-W) and the Y (N-S) µradian offset of the detector centroid from the instrument's optical axis, as follows:		
6311–6312		Visible detector 1 X-offset
6313–6352		Repeat 6311–6312 for 20 detectors
6353–6354		Redundant IR detector 7 X-offset
6355–6356		Visible detector 1 Y-offset
6357–6396		Repeat 6355–6356 for 20 detectors
6397–6398		Redundant IR detector 7 Y-offset
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. This pattern continues for all the elements within each array.		
6399–6430	IVCRB	Visible detectors characteristic response bias coefficients array.
6431–6462	IVCR1	Visible detectors characteristic response first-order gain coefficients array.
6463–6494	IVCR2	Visible detector characteristic response second-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 2 – channel 4 south 3 – channel 5 north 4 – channel 5 south 5 – channel 2 north 6 – channel 2 south 7 – channel 3		
6499–6554	IICRB	Characteristic response bias coefficients
6555–6610	IICR1	Characteristic response first-order gain coefficients
6611–6666	IICR2	Characteristic response second-order gain coefficients
6667–6722	IISFB	Scale factors bias coefficients
6723–6778	IISF1	Scale factors first-order gain coefficients

Table 3-6. Imager Documentation Block 0 Format Definition (15 of 16)

Word	Name	Description
6779–7002	IG2IT	Second 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	Second 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	BB temperature-to-target radiance conversion coefficients. An array of 56 elements, 4 elements for each of the 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 No. 1 coefficients. Final letter of term name (A–F) denotes type. Usage of terms to convert raw counts to temperature are defined in Section 3.6.2.1.
7371–7374	IEL1B	
7375–7378	IEL1C	
7379–7382	IEL1D	
7383–7386	IEL1E	
7387–7390	IEL1F	
The A–F naming convention used above with IEL1_ is also used for the following thermistor terms:		
7391–7414	IEL2_	Electronics No. 2 thermistor terms
7415–7438	IBP1_	Base plate thermistor No. 1 terms
7439–7462	IBP2_	Base plate thermistor No. 2 terms
7463–7486	IBP3_	Base plate thermistor No. 3 terms
7487–7510	IBP4_	Base plate thermistor No. 4 terms

Table 3-6. Imager Documentation Block 0 Format Definition (16 of 16)

Word	Name	Description
7511–7534	IBP5_	Base plate thermistor No. 5 terms
7535–7558	IBP6_	Base plate thermistor No. 6 terms
7559–7582	IBB1_	BB thermistor No. 1 terms
7583–7606	IBB2_	BB thermistor No. 2 terms
7607–7630	IBB3_	BB thermistor No. 3 terms
7631–7654	IBB4_	BB thermistor No. 4 terms
7655–7678	IBB5_	BB thermistor No. 5 terms
7779–7702	IBB6_	BB thermistor No. 6 terms
7703–7726	IBB7_	BB thermistor No. 7 terms
7727–7750	IBB8_	BB thermistor No. 8 terms
7751–7774	IOP1_	Scan mirror thermistor terms
7775–7798	IOP2_	Primary mirror thermistor terms
7799–7822	IOP3_	Secondary mirror thermistor No. 1 terms
7823–7846	IOP4_	Secondary mirror thermistor No. 2 terms
7847–7870	IOP5_	Baffle thermistor No. 1 terms
7871–7894	IOP6_	Baffle thermistor No. 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 or bias terms
8023–8030	IICGB	Instrument current gain or bias terms
8031–8039		Spares – not used
8040		Longitudinal parity (XOR) of words 6305–8039

GVAR Block 1 has 4 IR Records

IR CHANNEL	NORMAL MODE		YAW-FLIPPED MODE	
	DETECTOR	SPS IR	DETECTOR	SPS IR
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 uniquely identify 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° wide scan. A worst case maximum length of 62,730 bits occurs if the full 23° 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 (1 of 2)

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 formats the GVAR stream. Values 1 to 5 denote SPS1 to SPS5, 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 – 8 for the visible channel and from 1 – 7 for the IR channels (see Figure 3-11).
5	LICHA	A binary number identifying the source channel. Values range from 1 –- 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 – 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 and 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 and are defined in Table 3-6.
10–11	LPIXLS	A binary number denoting the number of pixels contained in the detector data record.
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 (see words 10–11), denotes the number of zero-valued words appended to the record for packing purposes. The packing is performed for the following 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.

Table 3-7. Blocks 1–10 Line Documentation Definition (2 of 2)

Word	Name	Description
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	LSPAR	Spare–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 – 9.

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 N-S offset in use is zero. For any active non-zero offset, the northernmost logical detector in Block 3 will be represented by a physical detector other than five. 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.

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 Versus Physical Ordering

3.3.6.1 Line Documentation

The line documentation segment is used to uniquely identify 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° wide scan. A worst case maximum length of 250,920 bits occurs if the full 23° 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 and Auxiliary Data

The GVAR 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 as follows:

- Sounder Documentation Data
- Sounder Scan Data
- Instrument Compensation Terms
- Instrument Spacelook Calibration Data
- Instrument BB-Cal Data
- Instrument ECAL Data
- Instrument Telemetry Statistics
- Instrument Calibration Coefficients
- Instrument Normalization Lookup Tables
- Instrument Star Sense Data
- GIMTACS or SPS Text Messages
- AUX Data
- Fill Data

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

Field	Length
P/N Synch code	10032
Header	720
Data Section	64320
CRC	16

The P/N Synch code, Header, and CRC are described in Sections 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 called the SAD block identifier (SAD ID). The second region is 64,080 bits in length and 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 ID

The 240-bit SAD ID 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 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 ensures 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. The fields also provide a linkage mechanism for multi-block sequences. Table 3-9 defines the additional fields used to support text messages.

Table 3-8. SAD Block 11 Identifier (1 of 2)

Words	Description
1	Spacecraft Identity: a binary number identifying the source satellite as follows: 8 = GOES-I 9 = GOES-J 10 = GOES-K 11 = GOES-L 12 = GOES-M
2	SPS ID a binary number identifying the source SPS which formatted the GVAR data stream. Values 1 – 5 are assigned to SPS1 to SPS5, respectively.
3	Data Identity – a binary number denoting the SAD block type as follows*: 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 calibration coefficients and limits x ‘1A’ = 26 Imager ECAL data x ‘1C’ = 28 Imager BB data x ‘1F’ = 31 Imager NLUTs data 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 calibration Coefficients and limits x ‘2A’ = 42 Sounder ECAL data x ‘2C’ = 44 Sounder BB data x ‘2F’ = 47 Sounder NLUTs data x ‘31’ = 49 AUX 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.†
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.†
6-8	Block Count – an 18-bit binary number representing 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 Last Block Flag 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.

Table 3-8. SAD Block 11 Identifier (2 of 2)

Words	Description
10–20	Used to support text messages. Refer to Table 3-9.
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	Spare–not used**

Notes:

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

† 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'.

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

WORDS	BITS										
					0	1	2	3	4	5	6-Bit Words
			0	1	2	3	4	5	6	7	8-Bit Words
	0	1	2	3	4	5	6	7	8	9	10-Bit Words
01	x	x	x	x	S/C IDENTITY						Words 1–9 and 21–*N* are always defined
02	x	x	x	x	SPS IDENTITY						the same way regardless of the
03	x	x	x	x	DATA IDENTITY						SAD Block 11 data type or word length:
04	x	x	x	x	FIRST BLOCK FLAG						6-bit, right-adjusted fields.
05	x	x	x	x	LAST BLOCK FLAG						Table 3-8 provides the definitions
06	x	x	x	x	BLOCK						(x = bit not used)
07	x	x	x	x	COUNT						(b = bit field open)
08	x	x	x	x							
09	x	x	x	x	RECORD COUNT						
10											Words 10–20 are defined according
•											to the application.
•											Table 3-9 provides the definitions.
20											
21	x	x	x	x	YAW-FLIP FLAG						
22	x	x	x	x	Spare–not used.						
23	x	x	x	x	Spare–not used.						SAD ID has:
24	b	b	b	b	b	b	b	b	b	b	24 ten-bit words
25			b	b	b	b	b	b	b	b	
•											
30			b	b	b	b	b	b	b	b	or 30 eight-bit words
31					b	b	b	b	b	b	
•											
40					b	b	b	b	b	b	or 40 six-bit words

Figure 3-13. SAD Block 11 Identifier

Table 3-9. SAD ID Text Message Block 11

Words	Description
10	Source ID – an 8-bit binary number denoting the following message originator: 10 – GIMTACS 20 – SPS 1 21 – SPS 2 22 – SPS 3 23 – SPS 4 24 – SPS 5 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	See 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. The Sounder Scan Documentation Block 11 is always the first block of a Block 11 sequence constituting a Sounder scan line and consists of 8040 eight-bit words divided into the following four partitions:

Partition	Word Range
SAD ID (see Section 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 Section 3.3.7.1 and its layout specified in Table 3-9. The remaining three partitions are described in the following sections 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 (1 of 10)

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. For each status bit that does not have a bit value of 0 listed below, a value of 0 represents a condition that is opposite or negative of the condition associated with a bit value of 1. For example, if bit 0 has a value of 1, a frame start occurred on this scan; if bit 0 has a value of 0, no frame start occurred on this scan.
		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 / W-E scan
		  / 1 / E-W scan
		7 / 0 / N-S frame
		  / 1 / S-N 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

33–42	SDSTA	Detector status in 10 words, 80 bits. First 76 bits, 9.5 words, correspond to the 76 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 always reset to zeros.
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° 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° 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 first star sense break. Ranges from 0–1758; 0 means no break.
51–52	SCBRK	Number of the pixel following the first calibration break. Ranges from 0–1758; 0 means no break.
53	SSCP1	Odd parity byte computed for SSCAN (see words 31–32).
54	SRELON	Relativization indication, 1 indicates function is active.

Table 3-10. Sounder Scan Documentation Block 11 Format (2 of 10)

Word	Name	Description
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

Words 59 – 178 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	DOY in 100s *
	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 10s
6	0-3	Minutes in 1s
	4–7	Seconds in 10s
7	0-3	Seconds in 1s
	4–7	Msec in 100s
8	0-3	Msec in 10s
	4–7	Msec in 1s

Note:

* 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 (3 of 10)

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 ECAL
131–138	TSBBC	Time of last BB-Cal
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:		
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 – 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 – 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 – 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 – 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 – 1579 correspond to detector lines, northernmost to southernmost, in the Sounder's 9-cycle FOV.
193–194	SSFLN	The number of the southernmost visible detector scan line in the current frame. Inclusive values of 4 – 1582 correspond to detector lines, northernmost to southernmost, in the Sounder's 9-cycle FOV.

Table 3-10. Sounder Scan Documentation Block 11 Format (4 of 10)

Word	Name	Description
195–196	SMDPX	The number of the visible pixel corresponding to an instrument azimuth of 0°. Nominal value, ½ 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°. Nominal value, ½ 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°. Nominal value, ½ 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.		
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 BER, 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 Processed Data Relay (PDR) transponder in 50-MHz clock counts.
243–250	TGPAT	GPATH measurement CDA 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 – 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 or special short-term operation

Table 3-10. Sounder Scan Documentation Block 11 Format (5 of 10)

Word	Name	Description
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.		
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	Second-order gain interpolation table index number with integer values of 1, 2, or 3 denoting which of three possible tables are reported in SG2IT words 4567–5718.
280	SSCP2	Repeat of SSCP1 (see word 53)
281–282	SSCA2	Repeat of SSCAN (see 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.		
307–310		IMC Identifier (4 ASCII characters)
311–322		Spares–not used
323–326		Reference Longitude (positive East, R*4, radians)
327–330		Reference radial distance from nominal (R*4, km)
331–334		Reference Latitude (positive North, R*4, radians)
335–338		Reference Orbit yaw (R*4, radians)
339–342		Reference Attitude: Roll (R*4, radians)
343–346		Reference Attitude: Pitch (R*4, radians)
347–350		Reference Attitude: Yaw (R*4, radians)
351–358		Epoch Date and Time: Standard BCD format
359–362		IMC set enable time from epoch (R*4, minutes)
363–366		Spacecraft compensation: Roll (R*4, radians)
367–370		Spacecraft compensation: Pitch (R*4, radians)
371–374		Spacecraft compensation: Yaw (R*4, radians)

Table 3-10. Sounder Scan Documentation Block 11 Format (6 of 10)

Word	Name	Description
375–426		Change in longitude from ref. (13 at R*4, radians)
427–470		Change in radial distance from ref. (11 at R*4, km)
471–506		Sine geocentric latitude, total (9 at R*4, no units)
507–542		Sine orbit yaw, total (9 at R*4, no units)
543–546		Daily Solar Rate (R*4, radians per minute)
547–550		Exponential Start time from epoch (R*4, minutes)
The following words, 551–770, apply to the roll attitude angle:		
551–554		Exponential Magnitude (R*4, radians)
555–558		Exponential Time Constant (R*4, minutes)
559–562		Constant, mean attitude angle (R*4, radians)
563–566		Number of Sinusoids/Angles (I*4, none)
567–570		Magnitude of first-order sinusoid (R*4, radians)
571–574		Phase angle of first-order sinusoid (R*4, radians)
575–686		Repeat 567–574 for second-order through 15^{th}-order sinusoids (R*4, radians)
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, radians)
703–706		Phase angle of monomial sinusoid (R*4, radians)
707–710		Angle from epoch where monomial is zero (R*4, radians)
711–770		Repeat 691–710 for second – fourth monomials
771–990		Repeat 551–770 for Pitch attitude angle
991–1210		Repeat 551–770 for Yaw attitude angle
1211–1430		Repeat 551–770 for Roll Misalignment angle
1431–1650		Repeat 551–770 for Pitch Misalignment angle
1651–1652	SSCA3	Repeat of SSCAN (see words 31–32)
1653	SSCP3	Repeat of SSCP1 (see word 53)
1654–1717		Spares–not used
1718		Longitudinal parity (XOR) of words 307–1717
1719–2994		Unused – zeroes

Table 3-10. Sounder Scan Documentation Block 11 Format (7 of 10)

<table>
<tr><th>Word</th><th>Name</th><th>Description</th></tr>
<tr><td>2995–3002</td><td>SPSSATTIM</td><td>Satellite database modified time (BCD time)</td></tr>
<tr><td>3003–3004</td><td>SPSSATVER</td><td>Satellite database version number</td></tr>
<tr><td colspan="3">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 in the N-S and E-W directions (see Section 3.4). Cycles are expressed as 8-bit integers ranging from 0 – 127. Increments are expressed as 16-bit integers ranging from 0 – 2804.</td></tr>
<tr><td>3005</td><td>SOFNC</td><td>Instrument nadir, top-bottom cycles</td></tr>
<tr><td>3006</td><td>SOFEC</td><td>Instrument nadir, right-left cycles</td></tr>
<tr><td>3007–3008</td><td>SOFNI</td><td>Instrument nadir, top-bottom increments</td></tr>
<tr><td>3009–3010</td><td>SOFEI</td><td>Instrument nadir, right-left increments</td></tr>
<tr><td colspan="3">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) µradian offset of the detector from the instrument's optical axis. Negative values employ two's complement notation. Values can range from –32,768 to +32,767.</td></tr>
<tr><td>3011–3012</td><td></td><td>X-offset Visible detector 1</td></tr>
<tr><td>:</td><td></td><td>:</td></tr>
<tr><td>3017–3018</td><td></td><td>X-offset Visible detector 4</td></tr>
<tr><td>3019–3020</td><td></td><td>X-offset Longwave IR detector 1</td></tr>
<tr><td>:</td><td></td><td>:</td></tr>
<tr><td>3025–3026</td><td></td><td>X-offset Longwave IR detector 4</td></tr>
<tr><td>3027–3028</td><td></td><td>X-offset Midwave IR detector 1</td></tr>
<tr><td>:</td><td></td><td>:</td></tr>
<tr><td>3033–3034</td><td></td><td>X-offset Midwave IR detector 4</td></tr>
<tr><td>3035–3036</td><td></td><td>X-offset Shortwave IR detector 1</td></tr>
<tr><td>:</td><td></td><td>:</td></tr>
<tr><td>3041–3042</td><td></td><td>X-offset Shortwave IR detector 4</td></tr>
<tr><td>3043–3074</td><td></td><td>Y-offsets arranged in same order as x-offsets</td></tr>
</table>

Table 3-10. Sounder Scan Documentation Block 11 Format (8 of 10)

Word	Name	Description
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 following three arrays contain four elements, one element for each 10-km visible detector. Within each array, the elements are ordered one, two, three, and four, 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.
3091–3106	SVCR1	Visible detector characteristic response first-order gain coefficients array.
3107–3122	SVCR2	Visible detector characteristic response second-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 and the next to channel 2. This pattern continues for all groups until the last group is assigned to channel 18. Within each group, the four elements are sequentially assigned in a top-to-bottom sense to detectors 1 – 4.		
3127–3414	SICRB	IR detector characteristic response bias coefficients array.
3415–3702	SICR1	IR detector characteristic response first-order gain coefficients array.
3703–3990	SICR2	IR detector characteristic response second-order gain coefficients array.
3991–4278	SISFB	IR detector scale factor bias coefficients array.
4279–4566	SISF1	IR detector scale factor first-order gain coefficients array.
4567–5718	SG2IT	IR detector second-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 with the next four to Channel 1-Detector 2, and so on until the last group of four, which is assigned to Channel 18-Detector 4.
5719–5734	SG2BP	IR detector second-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	BB temperature-to-target radiance conversion coefficients array. Array of 288 elements, four elements for each of 72 IR CDET. 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 comprise 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.
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

Table 3-10. Sounder Scan Documentation Block 11 Format (9 of 10)

Word	Name	Description
The following words contain conversion coefficients 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.		
7343–7346	SCHTA	Sounder Cooler Housing Thermistor coefficients. The final letter of the term name (A – F) denotes the type. Usage of terms to convert raw counts to temperature are defined in Section 3.6.2.1.
7347–7350	SCHTB	Refer to 7343–7346 description.
7351–7354	SCHTC	Refer to 7343–7346 description.
7355–7358	SCHTD	Refer to 7343–7346 description.
7359–7362	SCHTE	Refer to 7343–7346 description.
7363–7366	SCHTF	Refer to 7343–7346 description.
The A–F naming convention used above with SCHT_ is also used for the following thermistor terms:		
7367–7390	SEL1_	Sounder Electronics Side No. 1 thermistor terms
7391–7414	SEL2_	Sounder Electronics Side No. 2 thermistor terms
7415–7438	SBP1_	Base Plate thermistor No. 1 terms
7439–7462	SBP2_	Base Plate thermistor No. 2 terms
7463–7486	SBP3_	Base Plate thermistor No. 3 terms
7487–7510	SBP4_	Base Plate thermistor No. 4 terms
7511–7534	SBP5_	Base Plate thermistor No. 5 terms
7535–7558	SBP6_	Base Plate thermistor No. 6 terms
7559–7582	SBB1_	BB thermistor No. 1 terms
7583–7606	SBB2_	BB thermistor No. 2 terms
7607–7630	SBB3_	BB thermistor No. 3 terms
7631–7654	SBB4_	BB thermistor No. 4 terms
7655–7678	SBB5_	BB thermistor No. 5 terms
7679–7702	SBB6_	BB thermistor No. 6 terms
7703–7726	SBB7_	BB thermistor No. 7 terms
7727–7750	SBB8_	BB thermistor No. 8 terms
7751–7774	SOP1_	Scan Mirror thermistor terms
7775–7798	SOP2_	Primary Mirror thermistor terms
7799–7822	SOP3_	Secondary Mirror thermistor No. 1 terms
7823–7846	SOP4_	Secondary Mirror thermistor No. 2 terms

Table 3-10. Sounder Scan Documentation Block 11 Format (10 of 10)

Word	Name	Description
7847–7870	SOP5_	Baffle thermistor No. 1 terms
7871–7894	SOP6_	Baffle thermistor No. 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
The remaining three telemetry points use a simple linear gain and bias mapping to convert raw counts to engineering units, as follows:		
8015–8022	SFVGB	Filter wheel heater gain or bias terms
8023–8030	SPVGB	Patch control voltage gain or bias terms
8031–8038	SICGB	Instrument current gain or 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° dwell 1 scan) to 4788 (for a 19.2° dwell 4 scan). Each raw block contains all of the data acquired at one aim point, including a sample from each of the 76 CDET. Each CDET 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. The set applied to a given pixel is determined by comparing the time tag of the pixels' raw data block (see Section 3.3.7.3.1) with the time tag(s) of the available calibration coefficient sets (see Section 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 W-E order. The segments are then organized into a number of groups from 1–436. 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 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 1 – 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 where 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 is indicated by the associated SAD ID record count (see Table 3-8, word 9).

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 ID is defined in the preceding section. The remaining components of each segment are covered in the following sections:

Data Section Component	Word Size	Bits	Documented in Section
SAD 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

P/N SYNCH CODE	**(10,032 bits)**
HEADER	**(720 bits)**
SAD ID	**(240 bits)**
SOUNDER DATA RECORDS **11 Records at 4352 bits Each**	**(47,872 bits)**
LINE and PIXEL LOCATORS	**(2,832 bits)**
DETECTOR DATA ARRAYS **76 Lines of Calibrated Pixels @ 11 Pixels per Line**	**(13,376 bits)**
CRC	**(16 bits)**

Figure 3-14. Sounder Scan Data Block 11 Format

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 SDI. These modifications include replacing of the leading 8-word (64-bit) block synchronization code with a time tag, and adjusting the format of the remaining 492 words (see Section 3.5.5). The time tag denotes when the synchronization code was received by the SPS. The Sounder, scan data 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 are appended to each raw block by the SPS and 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 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)

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 E-W 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 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 (see Section 3.3.7.3.3) . 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 raw block slots, 0 – 10, 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 3-11. 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 8-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 Space Systems/Loral (SS/L) Specification SJ-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
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.	
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

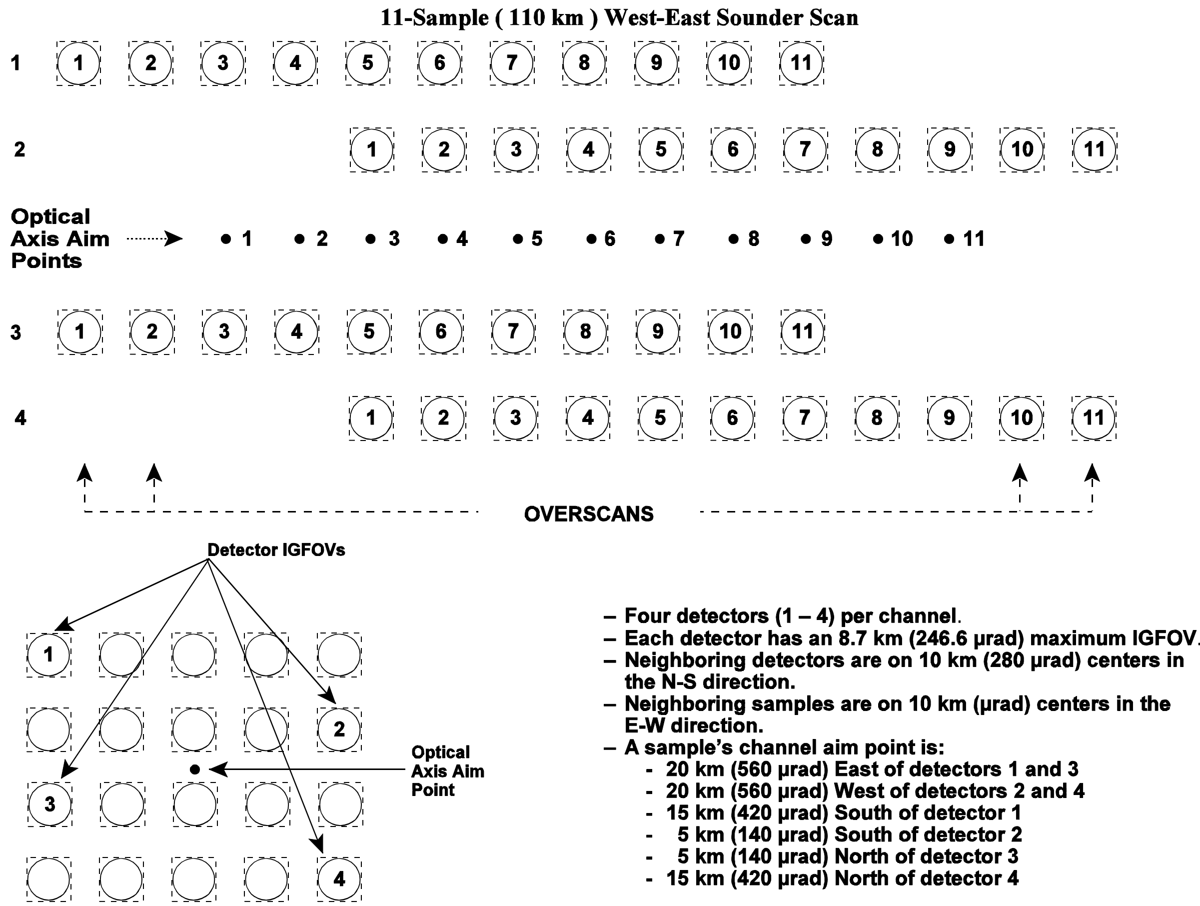


Figure 3-15. Sounder Detector FOV vs. Aim Point

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 – 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 – 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, 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 as follows:

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

In the yaw-flipped mode, the relationship is as follows:

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

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 Industries, Defense Products and Services Segment, Aerospace/ Communicaiton Unit (ITT) numbers the Sounder detectors differently than SPS does in GVAR. In ITT documentation, detector numbering begins with the bottom right detector as number one and the top left detector as number four.

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 – 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. 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 – 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 and 4) and last (detectors 1 and 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, for a total of 76 detector data arrays. Each array is 11 pixels in length. Each calibrated IR pixel is 16 bits wide, occupying two sequential 8-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 at the start (detectors 2 and 4) and end (detectors 1 and 3) of a scan.

The 76 detector data arrays are allocated space within the Block 11 Sounder Channel-Detector array indicated in Table 3-13. Labeling of detectors with numbers 1, 2, 3, and 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.

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 N-S and an E-W 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 transmitted when either of the following conditions occur:

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

SOUNDER DATA RECORD No. 1

Earth Location Aim Point 1

k = 1 544 8-bit words (see Table 3-12)

•
Raw data blocks are ordered by Earth location W-E, such
that sample *n* is always either collocated or west of sample *n* - 1
•

SOUNDER DATA RECORD 11

Earth Location Aim Point 11

k = 11

Display Data (Table 3-13)

1 lines	2 lines	3 lines	4 lines	Line numbers denote absolute scan lines (1–1580) for all channel-detectors 1–4.						
AP No. 1	2	3	4	5	6	7	8	9	10	11

Values denote absolute instrument pixel numbers (1–1758).

Calibrated Sounder Pixel Data (Table 3-14)

CHANNEL	k = 1	2	3	4	5	6	7	8	9	10	11
01	1 (3)	1 (4)	1 (5)	1 (6)	1 (7)	1 (8)	1 (9)	1 (10)	1 (11)	0	0
	0	0	2 (1)	2 (2)	2 (3)	2 (4)	2 (5)	2 (6)	2 (7)	2 (8)	2 (9)
	3 (3)	3 (4)	3 (5)	3 (6)	3 (7)	3 (8)	3 (9)	3 (10)	3 (11)	0	0
	0	0	4 (1)	4 (2)	4 (3)	4 (4)	4 (5)	4 (6)	4 (7)	4 (8)	4 (9)
02 • • 19	1 (3) • • 0	Four Channel 01 arrays are repeated for each of the 18 remaining channels									• • 4 (9)

Figure 3-16. Sounder Raw and Block 11 Data for the Sample 110-km Scan

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

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

The second condition listed 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.

The Imager Compensation and Servo Errors (ICSE) records are generated at a constant rate of 15 samples per 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 BB), and star senses. For these functions, sampling starts on the first downlink data block following a header block and continues at every 364th 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 BB address, or at a frame start address).

3.3.7.5 Telemetry Statistics

Telemetry data statistics are reported for each instrument through 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 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 3-14. Instrument Compensation Term Records Block 11 (1 of 2)

Words	Description
1–2	Instrument status for Sounder record as follows: **Bit** — **Meaning (If Set)** 1 Spacelook in progress 2 ECAL in progress 3 BB-Cal in progress 4 Normal frame in progress 5 Priority 1 frame in progress 6 Priority 2 frame in progress 7 E-W scan 8 S-N 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 BB-Cal in progress 4 Normal frame in progress 5 Priority 1 frame in progress 6 Priority 2 frame in progress 7 E-W scan 8 S-N frame 9 IMC active* 10 Scan Clamp Mode active 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* 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.

Note:

* 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.

Table 3-14. Instrument Compensation Term Records Block 11 (2 of 2)

Words	Description
11–12	Instrument location: E-W cycles
13–14	E-W increments
15–16	N-S cycles
17–18	N-S increments
19–20	N-S compensation term for instrument
21–22	E-W compensation term for instrument
23–24	N-S servo error term for instrument
25–26	E-W servo error term for instrument

Notes:

1. 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.

2. 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 of the SAD ID (see Table 3-8, word 9). Each record is 26 8-bit words long, as above. Unused data space within the Block 11 is zero-filled.

3. If a record is generated and no compensation or servo error data is available, the corresponding terms in the record are set to zero, such as parity errors in Sounder or dead zones in Imager reversals.

4. If an Imager record is generated and the time tag is estimated by the SPS, the flywheel bit of the record is set.

5. Every reversal data sequence yields three ICSE records. The time and mirror positions of the first of these records is 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.

6. The Sounder compensation and servo error records are much easier to explain. First, the sampling rate associated with the Sounder is 10 samples per second. Every 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 E-W compensation terms are taken directly from words 187 and 191 of the raw data block. The E-W servo error terms are obtained directly from words 181 and 192 of the same raw data block.

Table 3-15. Instrument Telemetry Block 11 Format (1 of 2)

Words	Description
1–30	SAD ID (see Section 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 (see Table 3-16)
71–198	(2 x 64) Telemetry Warning Flags (see Table 3-17)
199–220	Unassigned
221	Electronics Side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
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 σ – counts
1759–2014	(4 x 64) Filtered σ – 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 σ – engineering units
Instrument Telemetry Statistics	
3039	Longitudinal parity (XOR) of words 223–3038
3040–8040	Spares–not used

Table 3-15. Instrument Telemetry Block 11 Format (2 of 2)

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 (1 of 2)

Words	Associated Critical Alarm Condition
There are four critical alarm flag structures defined for the telemetry points of each instrument as follows:	
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 σ exceeds critical limits

Flag	Telemetry Points
Each of the four-word critical alarm flag structures has 32 flag bits, numbered 1 – 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 one if the associated condition is true and reset to zero 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:	
1	Electronics Temperature No. 1
2	Electronics Temperature No. 2
3	Sensor Assy Baseplate Temperature No. 1
4	Sensor Assy Baseplate Temperature No. 2
5	Sensor Assy Baseplate Temperature No. 3
6	Sensor Assy Baseplate Temperature No. 4
7	Sensor Assy Baseplate Temperature No. 5
8	Sensor Assy Baseplate Temperature No. 6
9	BB Target Temperature No. 1
10	BB Target Temperature No. 2
11	BB Target Temperature No. 3
12	BB Target Temperature No. 4
13	BB Target Temperature No. 5
14	BB Target Temperature No. 6
15	BB Target Temperature No. 7
16	BB Target Temperature No. 8
17	Scan Mirror Temperature
18	Telescope Primary Temperature
19	Telescope Secondary Temperature No. 1
20	Telescope Secondary Temperature No. 2

Table 3-16. Instrument Telemetry Critical Alarm Flag Definitions (2 of 2)

Flag	Telemetry Points
21	Telescope Baffle Temperature No. 1
22	Telescope Baffle Temperature No. 2
23	Aft Optics Temperature
24	Cooler Radiator Temperature
25	Wide Range IR Detector Temperature
26	Narrow Range IR Detector Temperature
27	Filter Wheel Housing Temperature (Sounder only)
28–32	Unassigned –always zero

Note:

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

Table 3-17. Instrument Telemetry Warning Flag Definitions

Flag	Value for Telemetry Points
Each of the two-word telemetry warning flag structures 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 and 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 or warning flag cross-reference for the Imager and the Sounder, respectively.) The flag-bits definitions for each of the warning flag structures is as follows:	
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 σ value (counts) exceeds limit
13	Filtered σ value (counts) exceeds limit
14	Filtered mean value (engineering units) low
15	Filtered mean value (engineering units) high
16	Filtered σ value (engineering units) high

Table 3-18. Imager Telemetry Point Assignments (1 of 2)

Array Entry No.	Warning Flags	Telemetry Point Description
1	[71–72]	Electronics Temperature No. 1
2	[73–74]	Electronics Temperature No. 2
3	[75–76]	Sensor Assy Baseplate Temperature No. 1
4	[77–78]	Sensor Assy Baseplate Temperature No. 2
5	[79–80]	Sensor Assy Baseplate Temperature No. 3
6	[81–82]	Sensor Assy Baseplate Temperature No. 4
7	[83–84]	Sensor Assy Baseplate Temperature No. 5
8	[85–86]	Sensor Assy Baseplate Temperature No. 6
9	[87–88]	BB Target Temperature No. 1
10	[89–90]	BB Target Temperature No. 2
11	[91–92]	BB Target Temperature No. 3
12	[93–94]	BB Target Temperature No. 4
13	[95–96]	BB Target Temperature No. 5
14	[97–98]	BB Target Temperature No. 6
15	[99–100]	BB Target Temperature No. 7
16	[101–102]	BB Target Temperature No. 8
17	[103–104]	Scan Mirror Temperature
18	[105–106]	Telescope Primary Temperature
19	[107–108]	Telescope Secondary Temperature No. 1
20	[109–110]	Telescope Secondary Temperature No. 2
21	[111–112]	Telescope Baffle Temperature No. 1
22	[113–114]	Telescope Baffle Temperature No. 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

Table 3-18. Imager Telemetry Point Assignments (2 of 2)

Array Entry No.	Warning Flags	Telemetry Point Description
28	[125–126]	Instrument Current
29	[127–128]	Cooler-Housing Temperature
30–64	[129–198]	Unassigned–zeros

Note:

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

Table 3-19. Sounder Telemetry Point Assignments (1 of 2)

Array Entry No.	Warning Flags	Telemetry Point Description
1	[71–72]	Electronics Temperature No. 1
2	[73–74]	Electronics Temperature No. 2
3	[75–76]	Sensor Assy Baseplate Temperature No. 1
4	[77–78]	Sensor Assy Baseplate Temperature No. 2
5	[79–80]	Sensor Assy Baseplate Temperature No. 3
6	[81–82]	Sensor Assy Baseplate Temperature No. 4
7	[83–84]	Sensor Assy Baseplate Temperature No. 5
8	[85–86]	Sensor Assy Baseplate Temperature No. 6
9	[87–88]	BB Target Temperature No. 1
10	[89–90]	BB Target Temperature No. 2
11	[91–92]	BB Target Temperature No. 3
12	[93–94]	BB Target Temperature No. 4
13	[95–96]	BB Target Temperature No. 5
14	[97–98]	BB Target Temperature No. 6
15	[99–100]	BB Target Temperature No. 7
16	[101–102]	BB Target Temperature No. 8
17	[103–104]	Scan Mirror Temperature
18	[105–106]	Telescope Primary Temperature
19	[107–108]	Telescope Secondary Temperature No. 1
20	[109–110]	Telescope Secondary Temperature No. 2
21	[111–112]	Telescope Baffle Temperature No. 1
22	[113–114]	Telescope Baffle Temperature No. 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

Table 3-19. Sounder Telemetry Point Assignments (2 of 2)

Array Entry No.	Warning Flags	Telemetry Point Description
30	[129–130]	Instrument Current
31	[131–132]	Cooler Housing Temperature
32–64	[133–198]	Unassigned–zeros

Note: 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.

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 unfiltered sample size is provided along with the filtered sample size remaining after high or low limit checking has been performed. Raw value statistics include the minimum, maximum, mean, and standard deviation (σ) 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 Electronic Calibration 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 applies a known input level to each circuit (at the point where the detector signal would normally be received) and records 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 set of measured output counts are analyzed on the ground to determine the stability and linearity of the processing circuitry (see Section 3.6.3). 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 (1 of 2)

Block 1 Words	Description
1–30	SAD ID (see Section 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 or step flags*
85–86	(2 x 1) Excessive root mean square (RMS) of residuals warning flags†
87–220	Spares–not used
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 at 192 words**
1567–3102	Eight visible detector records at 192 words**
3103	Longitudinal parity (XOR) of words 223–3102**
3104–3198	Spares–not used
Imager ECAL Raw Data Records	
3199–5438	Seven 320-word IR detector raw data records††
5439–5478	Spares–not used
5479–8038	Visible detectors 1–2, 1280 words of raw data for each††
8039-8040	Spares–not used

Table 3-20. Imager ECAL Block 11 Format (2 of 2)

Block 2 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
222	Longitudinal parity (XOR) of words 1–221
Imager ECAL Raw Data Records	
223–7902	Visible detectors 3–8, raw data at 1280 words each[††]
7903–8040	Spares–not used

Notes:

* Each of the 16 two-word flag structures contains 16 bits (see words 55–86). Each of the 15-step warning flags is assigned to an active detector (see words 55 – 84). 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 2-word step warning flag are sequentially assigned to each ECAL step, with bit 1 to step 1 and bit 16 to step 16. Flag bits are set to true if too few filtered samples are acquired per given detector at a particular ECAL step; otherwise, they are set to zero.

† The RMS of residuals flag structure employs bits 1 – 7 for the IR detectors and bits 8 – 15 for the visible detectors (see words 85–86). Bit 1 is the MSB of word 85 and bit 16 is the LSB of word 86. Each bit is set to true when 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.

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

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	Spares–not used

†† Each IR detector raw data record contains 160 samples (10 samples per 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 per 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 (1 of 3)

Block 1 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA time of first ECAL data block
39–46	CDA time of current limits set
47–58	Spares–not used
59–90	(2 x 16) Insufficient filtered samples per step flags*
91–92	(2 x 1) Excessive RMS of Residuals warning flags*
93–108	(16 x 1) For each of 16 detectors, channel No. used
109–220	Spares–not used
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 CDET records at 192 words†
991–1758	Four long-wave IR detector records at 192 words†
1759–2526	Four mid-wave IR detector records at 192 words†
2527–3294	Four short-wave IR detector records at 192 words†
3295	Longitudinal parity (XOR) of words 223–3294
3296–8040	Spares–not used

Notes:

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

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

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	Spares–not used

Table 3-21. Sounder ECAL Block 11 Format (2 of 3)

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	Spares–not used

Table 3-21. Sounder ECAL Block 11 Format (3 of 3)

Block 3 Words	Description
1–30	SAD ID (see Section 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	Spares–not used

Notes:

1. Each of the Block 1, step-warning flags is assigned to an active detector as follows (see words 59 – 90):
   Elements 1 – 4 are assigned to visible CDET 1 – 4
   Elements 5 – 8 are assigned to IR longwave CDET 1 – 4
   Elements 9 – 12 are assigned to IR mid wave CDET 1 – 4
   Elements 13 – 16 are assigned to IR short wave CDET 1 – 4

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

3. The 16 bits of the RMS of residuals flag are sequentially assigned to each of the 16 CDET (see words 91–92). 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 zero.

An Imager ECAL is performed, on average, once 30 minutes just prior to a BB-Cal 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 varies according to the channel involved (see Table 3-28). The discarding of samples 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 every 20 minutes, again just prior to a BB-Cal sequence. Stability and linearity statistics are computed for the 16 10-km 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 No.
4 detectors – visible	19
4 detectors – shortwave IR	13 – 18
4 detectors – medium wave IR	8 – 12
4 detectors – long wave IR	1 – 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 calculated for each detector.

3.3.7.7 Spacelook Calibration Statistics and Data

Each instrument performs a spacelook calibration sequence at frequent intervals. The spacelook calibration positions the scanning mirror at an extreme E-W 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. The remainder of this section presents the spacelook calibration sequence, instrument peculiarities, and calibration bias adjustment specifics. Section 3.6 should be referenced for further information concerning the calibration algorithms.

The Imager performs a spacelook calibration sequence at rates based on 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 the following 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. The IR detectors use these samples 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 dynamically adjusts 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 2-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 Section 3.3.7.9.

Table 3-22. Imager Spacelook Block 11 Format (1 of 7)

Block 1 Words	Description
1-30	SAD ID (see Section 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–not used
119–126	CDA time tag for preclamp data
127–134	CDA time tag for postclamp data
135–220	Spares–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 σ – counts
583–642	(4 x 15) Filtered σ – counts
643–670	(4 x 7) Filtered σ – radiance (IR only)
671–698	(4 x 7) Filtered σ – temperature (IR only)
699–701	Spares–not used
702	Longitudinal parity (XOR) of words 223–701

Table 3-22. Imager Spacelook Block 11 Format (2 of 7)

Block 1 Words	Description
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
943–1002	(4 x 15) Filtered mean value – counts
1003–1062	(4 x 15) Unfiltered σ – counts
1063–1122	(4 x 15) Filtered σ – counts
1123–1150	(4 x 7) Filtered σ – radiance (IR only)
1151–1178	(4 x 7) Filtered σ – temperature (IR only)
1179–1181	Spares–not used
1182	Longitudinal parity (XOR) of words 703–1181
Imager Accrued IR Activity	
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

Table 3-22. Imager Spacelook Block 11 Format (3 of 7)

Block 1 Words	Description
Imager Accrued IR Activity	
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	Spares–not used
7906	Longitudinal parity (XOR) of words 1183–7902
7907–8040	Spares–not used

Block 2 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares – not used
222	Longitudinal parity (XOR) of words 1–221
Imager Accrued IR Activity	
223–702	(4 x 120) IR detector 1 preclamp filtered σ – counts
703–1182	(4 x 120) IR detector 2 preclamp filtered σ – counts
1183–1662	(4 x 120) IR detector 3 preclamp filtered σ – counts
1663–2142	(4 x 120) IR detector 4 preclamp filtered σ – counts
2143–2622	(4 x 120) IR detector 5 preclamp filtered σ – counts
2623–3102	(4 x 120) IR detector 6 preclamp filtered σ – counts
3103–3582	(4 x 120) IR detector 7 preclamp filtered σ – counts
3583–4062	(4 x 120) IR detector 1 postclamp filtered σ – counts
4063–4542	(4 x 120) IR detector 2 postclamp filtered σ – counts
4543–5022	(4 x 120) IR detector 3 postclamp filtered σ – counts
5023–5502	(4 x 120) IR detector 4 postclamp filtered σ – counts
5503–5982	(4 x 120) IR detector 5 postclamp filtered σ – counts
5983–6462	(4 x 120) IR detector 6 postclamp filtered σ – counts
6463–6942	(4 x 120) IR detector 7 postclamp filtered σ – counts
6943–6945	Spares–not used
6946	Longitudinal parity (XOR) of words 223–6942
6947–8040	Spares–not used

Table 3-22. Imager Spacelook Block 11 Format (4 of 7)

Block 3 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
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)
4544–4545	Spares–not used
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
Imager IR Preclamp Raw Data Values	
6947–7746	(2 x 400) IR detector 4 – counts
7747–8040	Spares–not used

Table 3-22. Imager Spacelook Block 11 Format (5 of 7)

Block 4 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
222	Longitudinal parity (XOR) of words 1–221
Imager IR Preclamp Raw Data Values	
223–1022	(2 x 400) IR detector 5 – counts
1023–1822	(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–not used

Block 5 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
222	Longitudinal parity (XOR) of words 1–221
Imager IR Postclamp Raw Data Values	
223–1022	(2 x 400) IR detector 7 – counts

Table 3-22. Imager Spacelook Block 11 Format (6 of 7)

Block 5 Words	Description
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–not used

Block 6 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
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–not used

Table 3-22. Imager Spacelook Block 11 Format (7 of 7)

Notes:

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

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

3. The event times provided in Block 3 (see words 3583 – 4062) are 16-bit positive integers having units of 10 msec (a value of 23 denotes 230 msec). The time denotes the interval from the preceding 2-minute mark of the preclamp or postclamp.

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

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

2. Each of the two-word structures has 16 bits numbered 1 – 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 one if the associated condition is true; Otherwise, the flag is zero. 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 σ value (counts) exceeds limit
13	Filtered σ value (counts) exceeds limit
14	Unassigned (always 0)
15	Filtered IR σ value (radiance) exceeds limit
16	Filtered IR σ 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 every 2 minutes. During a Sounder spacelook calibration, 40 raw Sounder data blocks are acquired at the spacelook coordinates. Unlike the Imager, the Sounder has no defined preclamp or clamp activity. Each raw Sounder data block yields a single spacelook sample for each of the 76 CDET.

A data analysis is also 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 (1 of 3)

Block 1 Words	Description
1-30	SAD ID (see Section 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	Spares–not used
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 σ – counts
2047–2350	(4 x 76) Filtered σ– counts
2351–2638	(4 x 72) Filtered σ – radiance (IR only)
2639–2926	(4 x 72) Filtered σ – temperature (IR only)
2927	Longitudinal parity (XOR) of words 223–2926
2928–8040	Spares–not used

Table 3-24. Sounder Spacelook Block 11 Format (2 of 3)

Block 2 Words	Description
1–30	SAD ID (Section 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
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	Spares–not used

Block 3, [4] Words	Description
1–30	SAD ID (see Section 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	Spares–not used

Table 3-24. Sounder Spacelook Block 11 Format (3 of 3)

Block 5 Words	Description
1–30	SAD ID (see Section 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
2207–2750	Spacelook data block 38
2751–3294	Spacelook data block 39
3295–3838	Spacelook data block 40
3039–8040	Spares–not used

Notes:

1. Spacelook critical alarm flags, Block 1, words 207–216, are duplicates of Table 3-29, words 63 – 72. The alarm flags 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. The Block 4 contents are indicated by the numbers in brackets.

4. The format of the raw data spacelook records, 1 – 40, contained in the second through fifth 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

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 one 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 σ value (counts) exceeds limit
13	Filtered σ value (counts) exceeds limit
14	Unassigned (always 0)
15	Filtered IR σ value (radiance) exceeds limit
16	Filtered IR σ 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 BB 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

A BB-Cal sequence is initiated every 30 minutes for the Imager and every 20 minutes for the Sounder. During a BB-Cal sequence, the scanning mirror is rotated in the N-S direction through an angle of approximately 180 mechanical degrees to present a view of the BB surface to the imaging detectors. The BB surface is actively maintained in thermal equilibrium at a nominal temperature of 290° Kelvin. 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 the first-order gain coefficients associated with the IR detectors (see Section 3.6).

Once the scanning mirror has settled on the BB 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 BB 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 BB-Cal are defined in Table 3-23.

During a Sounder BB-Cal, 40 raw Sounder data blocks are acquired after the scanning mirror has settled on the BB scene. Each raw Sounder data block yields a single BB sample for each of the 72 IR CDET.

A data analysis similar to that performed for the Imager BB 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 BB information are delineated in Table 3-27. The warning flags employed for a Sounder BB are defined in Table 3-25.

Table 3-26. Imager Blackbody Block 11 Format (1 of 3)

Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA formatted time tag of BB 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	BB scan position scan count number
53–54	BB scan position pixel number
55–68	(2 x 7) BB warning flags (see Table 3-23)
69–114	Spares–not used
115–117	BB critical alarm flags (see notes)
118	Spare–not used
119–126	CDA time of preblackbody postclamp data
127–134	CDA time of BB data
135–142	CDA time of postblackbody spacelook data
143–220	Spares–not used
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

Block 1 Words	Description
279–292	(2 x 7) Unfiltered maximum value – counts
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 σ – counts

Table 3-26. Imager Blackbody Block 11 Format (2 of 3)

Block 1 Words	Description
391–418	(4 x 7) Filtered σ – counts
419–446	(4 x 7) Filtered σ – radiance
447–474	(4 x 7) Filtered σ – temperature
475–505	Spares–not used
506	Longitudinal parity (XOR) of words 223–505
Imager BB Statistics	
507–520	(2 x 7) Total sample size
521–534	(2 x 7) Filtered sample size
535–548	(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 σ – counts
675–702	(4 x 7) Filtered σ – counts
703–730	(4 x 7) Filtered σ – radiance
731–758	(4 x 7) Filtered σ – temperature
759–786	(4 x 7) Interpolated spacelevel at BB – counts
787–789	Spares–not used
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

Table 3-26. Imager Blackbody Block 11 Format (3 of 3)

Block 1 Words	Description
Imager Postblackbody Spacelook Statistics	
931–958	(4 x 7) Unfiltered σ – counts
959–986	(4 x 7) Filtered σ – counts
987–1014	(4 x 7) Filtered σ – radiance
1015–1042	(4 x 7) Filtered σ – temperature
1043–1073	Spares–not used
1074	Longitudinal parity (XOR) of words 791–1073
Imager BB 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	Spares–not used

Block 2 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–221	Spares–not used
222	Longitudinal parity (XOR) of words 1–221
Imager BB 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	Spares–not used

Notes:

1. Format and array layouts parallel the definitions provided in Table 3-22 for Imager spacelook data; except, only IR detectors are processed during a BB-Cal.

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

Table 3-27. Sounder Blackbody Block 11 Format (1 of 3)

Block 1 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA time tag of BB 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	BB scan position line number
53–54	BB scan position pixel number
55–198	(2 x 72) BB warning flags (see Table 3-25)
199–206	Spares–not used
207–216	BB critical alarm flags (see notes)
217–220	Spares–not used
221	Electronics side active: 0 = Side 1, 255 = Side 2
222	Longitudinal parity (XOR) of words 1–221
Sounder BB 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 σ – counts
1951–2238	(4 x 72) Filtered σ – counts
2239–2526	(4 x 72) Filtered σ – radiance
2527–2814	(4 x 72) Filtered σ – temperature
2815	Longitudinal parity (XOR) of words 223–2814
2816–8040	Spares–not used

Table 3-27. Sounder Blackbody Block 11 Format (2 of 3)

Block 2 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
Sounder Raw Data Records	
31–574	BB data block 1
575–1118	BB data block 2
1119–1662	BB data block 3
1663–2206	BB data block 4
2207–2750	BB data block 5
2751–3294	BB data block 6
3295–3838	BB data block 7
3839–4382	BB data block 8
4383–4926	BB data block 9
4927–5470	BB data block 10
5471–6014	BB data block 11
6015–8040	Spares–not used

Block 3, [4] Words	Description
1–30	SAD ID (see Section 3.3.7.1)
Sounder Raw Data Records	
31–574	BB data block 12, [23]
575–1118	BB data block 13, [24]
1119–1662	BB data block 14, [25]
1663–2206	BB data block 15, [26]
2207–2750	BB data block 16, [27]
2751–3294	BB data block 17, [28]
3295–3838	BB data block 18, [29]
3839–4382	BB data block 19, [30]
4383–4926	BB data block 20, [31]
4927–5470	BB data block 21, [32]
5471–6014	BB data block 22, [33]
6015–8040	Spares–not used

Table 3-27. Sounder Blackbody Block 11 Format (3 of 3)

Block 5 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
Sounder Raw Data Records	
31–574	BB data block 34
575–1118	BB data block 35
1119–1662	BB data block 36
1663–2206	BB data block 37
2207–2750	BB data block 38
2751–3294	BB data block 39
3295–3838	BB data block 40
3839–8040	Spares–not used

Notes:

1. BB critical alarm flags, Block 1, words 207 – 216, are duplicates of Table 3-29, words 73 – 82. The alarm flags 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 BB records 1 – 40 contained in the second through fifth 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 spacelook and BB-Cal event. The calibration algorithms are in Section 3.6. The updated coefficients are reported in 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, spacelook calibration, and BB-Cal.

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.

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 on an as needed basis. The instrument NLUTs currently in use are broadcast in GVAR following every BB-Cal 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 3-28. Imager Calibration and Limits Block 11 Format (1 of 6)

Words	Description
1–30	SAD ID (see Section 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	Spares–not used
57–59	Spacelook Data Critical Alarm Flags (see Table 3-30)
60–62	BB Data Critical Alarm Flags (see Table 3-30)
63–64	Temperature Data Critical Alarm Flags (see Table 3-30)
65–71	IR detector M Gain Alarm Flags (see Table 3-30)
72	BB temperature gradient alarm flag (= x 'FF' if σ of 8 BB temperatures is excessive)
73	Scan mirror temperature out-of-range at BB-Cal (= 255 if true)
74–209	Spares – not used
210	Triggering event: 0 = spacelook, 255 = BB
211–218	CDA time of triggering event (see notes)
219–220	Spares–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 first-order gains
279–306	(4 x 7) Current IR detector second-order gains (q's)
307–310	(4 x 1) Current weighted mean BB temperature
311–314	(4 x 1) Current weighted mean baseplate temperature
315–318	(4 x 1) Current smoothed patch temperature
319–322	(4 x 1) Current σ of 8 BB temperatures
323–326	(4 x 1) Current σ tolerance for 8 BB temperatures
327–350	(4 x 6) Baseplate thermistor weighing factors
351–382	(4 x 8) BB thermistor weighing factors
383–386	(4 x 1) Current A weight for M-history file
387–390	(4 x 1) Current B weight for M-history file

Table 3-28. Imager Calibration and Limits Block 11 Format (2 of 6)

Words	Description
391–394	(4 x 1) Current C weight for M-history file
395–398	(4 x 1) Current D weight for M-history file
399–414	(2 x 8) BB thermistor filtered sample size
415	BB thermistor window size *N* (see Section 3.6.2.1)
416	Current patch temperature control level {1:7}
417	IR Calibration B (bias) Mode {1:1}
418	IR Calibration M (first-order gain) Mode {1:7}
419	IR Calibration Q (second-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	Spare–not used
450	E-W correction enabled/disabled (0 = disabled, 255 = enabled)
451–454	(4 x 1) Scan mirror temperature at BB-Cal
455–470	(4 x 4) Current *a* emissivity coefficients (intercept)
471–486	(4 x 4) Current *b* emissivity coefficients (first-order)
487–502	(4 x 4) Current *c* emissivity coefficients (second-order)
503-510	MBCC indicator for 8 detectors: 0 = inactive, 1 = active but not used, 2 = active and used
511-518	MBCC IR calibration for 8 detectors (first-order gain) Mode {1:14}
519–733	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 64) Unfiltered mean low limit – counts
1375–1630	(4 x 64) Filtered mean low limit – counts
1631–1886	(4 x 64) Unfiltered mean high limit – counts

Table 3-28. Imager Calibration and Limits Block 11 Format (3 of 6)

Word	Description
Imager Telemetry Warning Limits	
1887–2142	(4 x 64) Filtered mean high limit – counts
2143–2398	(4 x 64) Unfiltered σ high limit – counts
2399–2654	(4 x 64) Filtered σ high limit – counts
2655–2910	(4 x 64) Filtered mean low limit – engineering units
2911–3166	(4 x 64) Filtered mean high limit – engineering units
3167–3422	(4 x 64) Filtered σ high limit – engineering units
Imager Telemetry Critical Alarm Limits	
3423–3486	(2 x 32) Minimum filtered sample size limits
3487–3614	(4 x 32) Filtered mean low limits – engineering units
3615–3742	(4 x 32) Filtered mean high limits – engineering units
3743–3870	(4 x 32) Filtered σ limits – engineering units
3871–4061	Spares–not used
4062	Longitudinal parity (XOR) of words 735–4061
Imager ECAL Warning Limits	
4063–4066	(4 x 1) 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	Spares–not used
4574	Longitudinal parity (XOR) of words 4063–4573

Table 3-28. Imager Calibration and Limits Block 11 Format (4 of 6)

Words	Description
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 22) Unfiltered mean low limit – counts
4795–4882	(4 x 22) Filtered mean low limit – counts
4883–4970	(4 x 22) Unfiltered mean high limit – counts
4971–5058	(4 x 22) Filtered mean high limit – counts
5059–5146	(4 x 22) Unfiltered σ high limit – counts
5147–5234	(4 x 22) Filtered σ high limit – counts
5235–5322	(4 x 22) Filtered σ high limit – radiance
5323–5410	(4 x 22) Filtered σ high limit – temperature
Imager Spacelook Critical Limits	
5411–5454	(2 x 22) Minimum filtered sample size/detector
5455–5597	Spares–not used
5598	Longitudinal parity (XOR) of words 4575–5597
Imager Pre-clamp 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 22) Unfiltered mean low limit – counts
5819–5906	(4 x 22) Filtered mean low limit – counts
5907–5994	(4 x 22) Unfiltered mean high limit – counts
5995–6082	(4 x 22) Filtered mean high limit – counts
6083–6170	(4 x 22) Unfiltered σ high limit – counts
6171–6258	(4 x 22) Filtered σ high limit – counts
6259–6346	(4 x 22) Filtered σ high limit – radiance
6347–6434	(4 x 22) Filtered σ high limit – temperature
6435–6621	Spares–not used
6622	Longitudinal parity (XOR) of words 5599–6621

Table 3-28. Imager Calibration and Limits Block 11 Format (5 of 6)

Words	Description
Imager BB 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 14) Unfiltered mean low limit – counts
6763–6818	(4 x 14) Filtered mean low limit – counts
6819–6874	(4 x 14) Unfiltered mean high limit – counts
6875–6930	(4 x 14) Filtered mean high limit – counts
6931–6986	(4 x 14) Unfiltered σ high limit – counts
6987–7042	(4 x 14) Filtered σ high limit – counts
7043–7098	(4 x 14) Filtered σ high limit – radiance
7099–7154	(4 x 14) Filtered σ high limit – temperature
Imager BB-Cal Critical Limits	
7155–7182	(2 x 14) Minimum filtered sample size/detector
Imager Calibration Critical Limits	
7183–7186	(4 x 1) Maximum baseplate temperature for gain Lookup Table (LUT)
7187–7190	(4 x 1) 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 3) Maximum bias interpolation interval (msec)
7207–7234	(4 x 7) Maximum space level rate/detector (counts/second)
7235–7262	(4 x 7) Maximum M (first-order gain) rate in M mode 2
7263–7266	(4 x 1) Maximum percentage of outliers permitted in M modes 3 & 5
7267–7294	(4 x 7) Maximum Standard Error of Estimate (SEE) for M modes 4 & 5
7295–7322	(4 x 7) Maximum root sum square (RSS) error for M modes 6 & 7
7323–7326	(4 x 1) N-σ tolerance for M-history filtering
7327–7330	(4 x 1) Maximum number of iterations M-history filtering
7331–7334	(4 x 1) Minimum minutes between BB-Cal

Table 3-28. Imager Calibration and Limits Block 11 Format (6 of 6)

Words	Description
Imager Calibration Critical Limits (Cont.)	
7335–7338	(4 x 1) M recomputation interval (2-minute units)
7339–7342	(4 x 1) 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 BB-Cal sequence. The trigger time in words 211–218 is the time associated with the raw data header block of the triggering event (spacelook or BB) identified in word 210.

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

5. All limit arrays for BB-Cal, sized *N* x 14, contain data for the 14 IR detectors only, as follows:

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

Table 3-29. Sounder Calibration and Limits Block 11 Format (1 of 6)

Block 1 Words	Description
1–30	SAD ID (see Section 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 (See Table 3-31 for definitions of alarm flags in words 63–134)
73–82	BB data critical alarm flags
83–84	Temperature critical alarm flags
85–94	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
135	Filter Wheel period alarm (= x ‘FF’ if a synch loss occurred since the last report)
136	BB temperature gradient alarm flag (= x ‘FF’ if excessive σ in 8 BB temperatures)
137–146	(2 x 5) IR detector M gain rate low alarms
147	Scan mirror temperature out-of-range at BB-Cal (= 255 if true)
148–209	Spares–not used
210	Triggering event: 0 = spacelook, 255 = BB
211–218	CDA time of triggering event (see notes)
219	Spares–not used
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 Calibration Data	
223–510	(4 x 72) IR detector biases
511–798	(4 x 72) IR detector first-order gains
799–1086	(4 x 72) IR detector second-order gains
1087–1374	(4 x 72) IR detector bias regression slopes (ks)
1375–1662	(4 x 72) IR detector bias regression intercepts (hs)

Table 3-29. Sounder Calibration and Limits Block 11 Format (2 of 6)

Block 1 Words	Description
Sounder Calibration Data (Cont.)	
1663–1950	(4 x 72) IR detector bias SEE
1951–1954	(4 x 1) Weighted mean BB temperature
1955–1958	(4 x 1) Weighted mean baseplate temperature
1959–1962	(4 x 1) Weighted mean optics temperature
1963–1966	(4 x 1) Smoothed patch temperature
1967–1970	(4 x 1) Average filter wheel rate (revolutions per second)
1971–1974	(4 x 1) Current σ of 8 BB temperatures
1975–1978	(4 x 1) Current σ tolerance for BB
1979–2010	(4 x 8) BB thermistor weighing factors
2011–2034	(4 x 6) Baseplate thermistor weighing factors
2035–2062	(4 x 7) Optics temperature weighing factors
2063–2066	(4 x 1) Current *a* weight for M-history data
2067–2070	(4 x 1) Current *b* weight for M-history data
2071–2074	(4 x 1) Current *c* weight for M-history data
2075–2078	(4 x 1) Current *d* weight for M-history data
2079–2094	(2 x 8) BB thermistor filtered sample size
2095	BB thermistor window size N (see Section 3.6.2.1)
2096	Current patch temperature control level [1:7]
2097	IR calibration B (bias) mode [1:2]
2098	IR calibration M (first-order gain) mode [1:7]
2099	IR calibration Q (second-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 or disabled (0 = disabled, 255 = enabled)
2131–2134	(4 x 1) Scan mirror temperature at BB-Cal
2135–2206	(4 x 18) Current *a* emissivity coefficients (intercept)
2207–2278	(4 x 18) Current *b* emissivity coefficients (first-order)

Table 3-29. Sounder Calibration and Limits Block 11 Format (3 of 6)

Block 1 Words	Description
Sounder Calibration Data (Cont.)	
2279–2350	(4 x 18) Current *c* emissivity coefficients (second-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 64) Unfiltered mean low limit – counts
3423–3678	(4 x 64) Filtered mean low limit – counts
3679–3934	(4 x 64) Unfiltered mean high limit – counts
3935–4190	(4 x 64) Filtered mean high limit – counts
4191–4446	(4 x 64) Unfiltered σ high limit – counts
4447–4702	(4 x 64) Filtered σ high limit – counts
4703–4958	(4 x 64) Filtered mean low limit – engineering units
4959–5214	(4 x 64) Filtered mean high limit – engineering units
5215–5470	(4 x 64) Filtered σ high limit – engineering units
Sounder Telemetry Critical Alarm Limits	
5471–5534	(2 x 32) Minimum filtered sample size limits
5535–5662	(4 x 32) Filtered mean low limits – engineering units
5663–5790	(4 x 32) Filtered mean high limits – engineering units
5791–5918	(4 x 32) Filtered σ limits – engineering units
5919	Longitudinal parity (XOR) of words 2783–5918
5920–6110	Unused – zeroes

Table 3-29. Sounder Calibration and Limits Block 11 Format (4 of 6)

Block 1 Words	Description
Sounder ECAL Warning Limits	
6111–6114	(4 x 1) 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 Short wave 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 or detector (equals 1)
6403–6418	(1x16) Channel assigned as data source or detector
6419	Longitudinal parity (XOR) of words 6111–6418
6420–8040	Unused – zeroes

Block 2 Words	Description
1–30	SAD ID (see Section 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	Spares–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

Table 3-29. Sounder Calibration and Limits Block 11 Format (5 of 6)

Block 2 Words	Description
Sounder Spacelook Warning Limits (Cont.)	
1895–2198	(4 x 76) Unfiltered σ high limit – counts
2199–2502	(4 x 76) Filtered σ high limit – counts
2503–2790	(4 x 72) Filtered IR σ high limit – radiance
2791-3078	(4 x 72) Filtered IR σ 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
Sounder BB 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 σ high limit – counts
5411–5698	(4 x 72) Filtered σ high limit – counts
5699–5986	(4 x 72) Filtered σ high limit – radiance
5987–6274	(4 x 72) Filtered σ high limit – temperature
Sounder BB-Cal Critical Limits	
6275–6418	(2 x 72) Minimum filtered sample size or CDET
Sounder Linear Regression Critical Limit	
6419–6422	(4 x 1) Maximum SEE
Sounder Calibration Critical Limits	
6423–6426	(4 x 1) Maximum baseplate temperature for gain LUT
6427–6430	(4 x 1) Minimum baseplate temperature for gain LUT
6431–6432	(2 x 1) Minimum filtered sample size/BB thermistor
6433–6434	Unassigned – zeros

Table 3-29. Sounder Calibration and Limits Block 11 Format (6 of 6)

Block 2 Words	Description
Sounder Calibration Critical Limits (Cont.)	
6435–6722	(4 x 72) Maximum rate in M mode 2
6723–6726	(4 x 1) 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 1) N-σ tolerance for M-history filtering
7307–7310	(4 x 1) Maximum number of history data iterations
7311–7314	(4 x 1) Minimum number of minutes between BB-Cal
7315–7318	(4 x 1) M value update interval in 2-minute marks
7319–7322	(4 x 1) 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

Notes:

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

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 CDET 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 (1 of 3)

Critical alarm flags for Imager spacelook, words 57–59, and BB-Cal, words 60–62, data are defined as follows:

Flag	Set True(1) if Critical Condition is Present
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

Notes:

1. The flag bits are numbered 1 – 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 one if the associated condition is true; otherwise, it is set to zero.

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

Table 3-30. Imager Calibration Critical Alarm Flag Definitions (2 of 3)

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

4. Note that bits 1 – 8 are the visible detector flags, are not applicable for BB-Cal and are always set to zero (see words 60 – 62).

Critical alarm flags for Imager temperature values affect detector calibration and are defined as follows (see words 63–64):	
Flag	**Set True(1) if Critical Condition is Present**
1	BB Thermistor 1 insufficient samples
2	BB Thermistor 2 insufficient samples
3	BB Thermistor 3 insufficient samples
4	BB Thermistor 4 insufficient samples
5	BB Thermistor 5 insufficient samples
6	BB Thermistor 6 insufficient samples
7	BB Thermistor 7 insufficient samples
8	BB Thermistor 8 insufficient samples
9	Baseplate Temperature too low for LUT usage
10	Baseplate Temperature too high for LUT usage
11–16	Spares – not used

Notes:

1. Critical alarm-flag bits are numbered 1 – 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 one if the associated condition is true; otherwise, it is set to zero. Limits defined in Table 3-28, words 7183–7192, are employed in determining the above temperature alarms.

2. The BB thermistor flag bits are enabled only for a report triggered by a BB-Cal; they are always reset to zeros 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 BB-Cal sequence.

3. Baseplate temperature flag bits are enabled only for a report triggered by a spacelook calibration; they are always reset to zeros for reports triggered by a BB 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.

Table 3-30. Imager Calibration Critical Alarm Flag Definitions (3 of 3)

Critical alarm flags for first-order gain computations, words 65–71, are defined as follows:

Flag	Set True(1) if Critical Condition is Present
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; otherwise, it is set to zero.

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 (1 of 3)

Critical Alarm flags for Sounder spacelook, words 63–72, and BB data, words 73–82, are defined as follows:

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

Flag	Set True (1) if an Insufficient Sample Condition is Present
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. 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 BB data.

2. The four Channel 19 visible detectors are not included as part of the BB-Cal sequence. As a result, their flag bits, 9 – 12, are always zeroed for the BB case, words 81 and 82. Also, the last four flag bits, 13 – 16, in words 71, 72, 81 and 82, are not used and are always zero.

Table 3-31. Sounder Calibration Critical Alarm Flag Definitions (2 of 3)

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

Flag	Set True (1) if Critical Condition is Present
1	BB Thermistor 1 insufficient samples
2	BB Thermistor 2 insufficient samples
3	BB Thermistor 3 insufficient samples
4	BB Thermistor 4 insufficient samples
5	BB Thermistor 5 insufficient samples
6	BB Thermistor 6 insufficient samples
7	BB Thermistor 7 insufficient samples
8	BB Thermistor 8 insufficient samples
9	Baseplate Temperature too low for LUT usage
10	Baseplate Temperature too high for LUT usage
11-16	Spares–not used

Note:

1. The critical alarm flag bits are numbered 1 – 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 Table 3-29, words 6423 – 6432.

Critical alarm flags for bias (B) and first-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 (3 of 3)

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

Note:

1. 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.

Table 3-32. Imager NLUT Block 11 Format (1 of 2)

Block 1 Words	Description
1–24	SAD ID (see Section 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	Spares–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	Spares–not used

Block 2 Words	Description
1-24	SAD ID (see Section 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 5 NLUT
60	Longitudinal parity (XOR) of detector 6 NLUT
61	Longitudinal parity (XOR) of detector 7 NLUT

Table 3-32. Imager NLUT Block 11 Format (2 of 2)

Block 2 Words	Description
62	Longitudinal parity (XOR) of detector 8 NLUT
63	Longitudinal parity (XOR) of words 1 – 66
64–1021	Spares–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	Spares–not used

Note:

1. The Imager visible NLUTs use a 10-bit word length. They are broadcast in GVAR following every BB-Cal. The NLUTs are sequenced to follow the transmission of the BB-triggered calibration Block 11 (see Table 3-28).

Table 3-33. Sounder NLUT Block 11 Format (1 of 2)

Words	Description
1–30	SAD ID (see Section 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 BB-Cal.

Block 11 Sequence No.	Words	Content Description
1	75–8040	Detector 1 NLUT words 1 – 7966
2	75–8040	Detector 1 NLUT words 7967 – 15932
3	75–526	Detector 1 NLUT words 15933 – 16384
3	527–8040	Detector 2 NLUT words 1 – 7514
4	75–8040	Detector 2 NLUT words 7515 – 15480
5	75–978	Detector 2 NLUT words 15481 – 16384
5	979–8040	Detector 3 NLUT words 1 – 7062
6	75–8040	Detector 3 NLUT words 7063 – 15028
7	75–1430	Detector 3 NLUT words 15029 – 16384
7	1431–8040	Detector 4 NLUT words 1 – 6610

Table 3-33. Sounder NLUT Block 11 Format (2 of 2)

Block 11 Sequence No.	Words	Content Description
8	75–8040	Detector 4 NLUT words 6611 – 14576
9	75–1882	Detector 4 NLUT words 14577 – 16384
9	1883–1890	ASCII NLUT ID
9	1891–8040	Spares–not used

3.3.7.11 Star Sense Statistics and Data

Under nominal conditions the Imager and Sounder each perform 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 km 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 by way of a sequence of Block 11s. The format of the Imager and Sounder star sense Block 11 sequences are 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 the radiometric channel being transmitted.

Table 3-34. Imager Star Sense Block 11 Format (1 of 2)

Block 1 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA time star sense interval started
39–42	Interval Duration (msec)
43–44	Instrument Coordinates, N-S cycles
45–46	Instrument Coordinates, N-S increments
47–48	Instrument Coordinates, E-W cycles
49–50	Instrument Coordinates, E-W increments
51–52	W – Sample length of averaging moving window
53–54	FOURM – number of raw pixels/SDI sample
Star Sense Controls, Statistics, and Results	
55–56	(2 x 1) window thresholding count (WTC)
57–58	(2 x 1) event thresholding count (ETC)
59–74	(2 x 8) window threshold tolerance/detector (DWT)
75–90	(2 x 8) interval mean value/detector (DMV)
91–106	(2 x 8) window threshold level/detector (WTL)
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) window mean value (WMV)
319–382	(2 x 32) event thresholding level (ETL)
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) event mean value (EMV)
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 (msec)

Table 3-34. Imager Star Sense Block 11 Format (2 of 2)

Block 1 Words	Description
Star Sense Controls, Statistics, and Results (Cont.)	
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	Spares–not used
1091–1122	(4 x 8) DWT – in floating point format
1123–1154	(4 x 8) DMV – in floating point format
1155–1186	(4 x 8) WTL – in floating point format
1187–1314	(4 x 32) WMV – in floating point format
1315–1442	(4 x 32) ETL – in floating point format
1443–1570	(4 x 32) EMV – 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	Spares–not used

Blocks 2-9 Words	Description
1–24	SAD ID (see Section 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 – 9 use 10-bit word formats. Star pixel data in blocks 2 – 9 have 10 significant bits in the 10-bit words and are time-ordered with the oldest pixel first (word 33) in each array.

Table 3-35. Sounder Star Sense Block 11 Format (1 of 2)

Block 1 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA time star sense interval started
39–42	Interval duration (msec)
43–44	Instrument coordinates, N-S cycles
45–46	Instrument coordinates, N-S increments
47–48	Instrument coordinates, E-W cycles
49–50	Instrument coordinates, E-W increments
51–52	W – Sample length of averaging moving window
53–54	Unused – zeroes
Star Sense Controls, Statistics, and Results	
55–56	(2 x 1) WTC
57–58	(2 x 1) ETC
59–74	(2 x 8) DWT
75–90	(2 x 8) DMV
91–106	(2 x 8) WTL
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
319–382	(2 x 32) ETL
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
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 (TEV)
1023–1086	(2 x 32) Event duration (msec)
1087	(1 x 1) MOONFLAG (0 = star sense, 255 = moon sense)

Table 3-35. Sounder Star Sense Block 11 Format (2 of 2)

Block 1 Words	Description
Star Sense Controls, Statistics, and Results (Cont.)	
1088	(1 x 1) MOONCHAN (0 = star sense, 1 to 20 = moon channel)
1089–1090	Spares–not used
1091–1122	(4 x 8) DWT – in floating point format
1123–1154	(4 x 8) DMV – in floating point format
1155–1186	(4 x 8) WTL – in floating point format
1187–1314	(4 x 32) WMV – in floating point format
1315–1442	(4 x 32) ETL – in floating point format
1443–1570	(4 x 32) EMV – 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	Spares–not used

Blocks 2-9 Words	Description
1–30	SAD ID (see Section 3.3.7.1)
31–38	CDA start time from Block 1, words 31 – 38
39–54	Spares–not used
55–5174	Detector [1–8] star pixel data
5175–8040	Spares–not used

Note:

1. All Sounder star sense Block 11s use an 8-bit word format. Star pixel data, Blocks 2 – 9, are 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 and SPS Text Message Format

A Block 11 format is also used 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
byteNo. :	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 through a serial synchronous X.25 interface. GIMTACS text messages may be up to 11,866 characters in 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 through 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 by way of 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 messages per Block 11 is observed.

Table 3-9 defines the SAD 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-bit SAD 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 N-S elevation angle, outer gimbal motor, and one for the E-W 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 E-W and C_y for N-S, are coarse measures of the shaft rotation angles. One cycle equals 2.8125° of mechanical rotation, or 128 cycles for one full 360° mechanical shaft revolution. Increments, denoted I_x for E-W and I_y for N-W, are finer shaft rotation angle measures that are different for each instrument. Each Imager cycle contains 6136 increments and is equal to approximately 8.0 (actually 7.999899) µradians of mechanical rotation. Each Sounder cycle contains 2805 increments and is equal to approximately 17.5 (actually 17.499959) µrads of mechanical rotation.

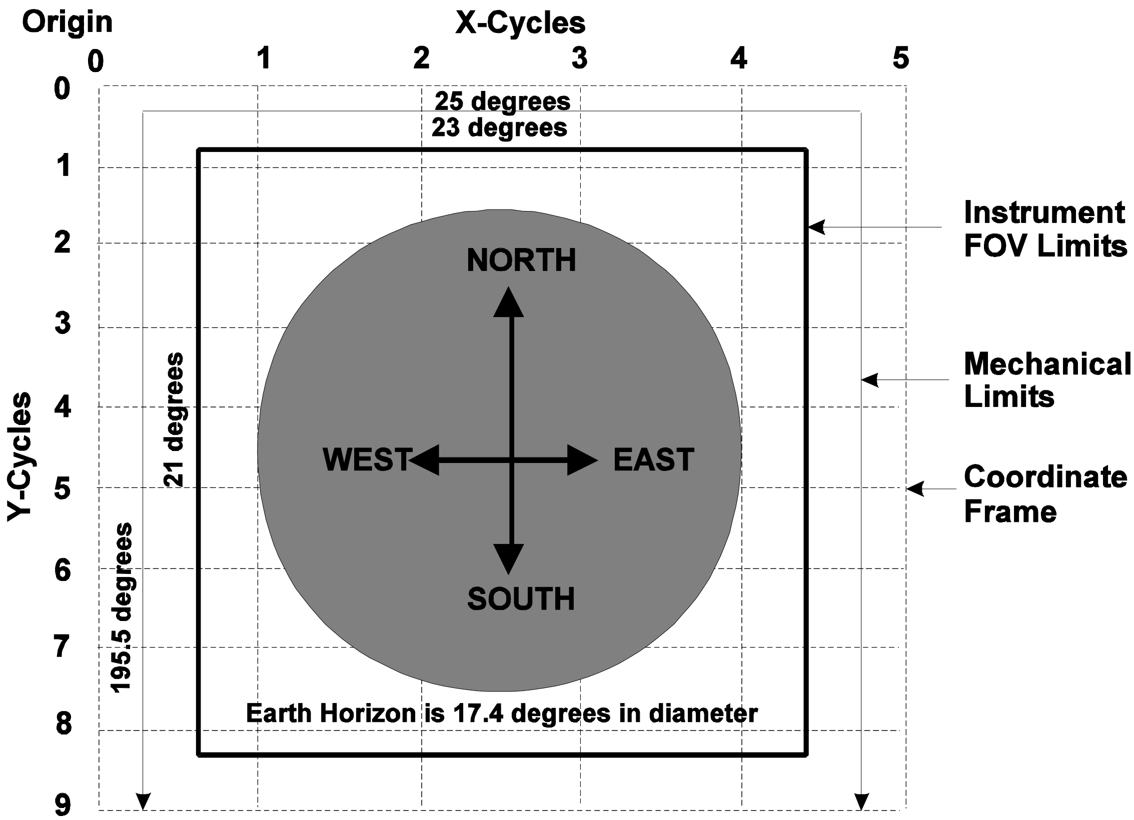
As a result of the manner in which the scanning mirrors have been gimbaled, the relationship between a given shaft mechanical angle, and the corresponding image optical angle is not the same on both axes. In the N-S direction, the mechanical shaft angle is equal to the mirror's optical angle. Thus, a mechanical shaft rotation of one increment results in a one-increment change in the mirror's elevation angle. However in the E-W direction, 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 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° from nadir, permitting rotation of the mirror for BB 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 as 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° from nadir, permitting rotation of the mirror for BB viewing.

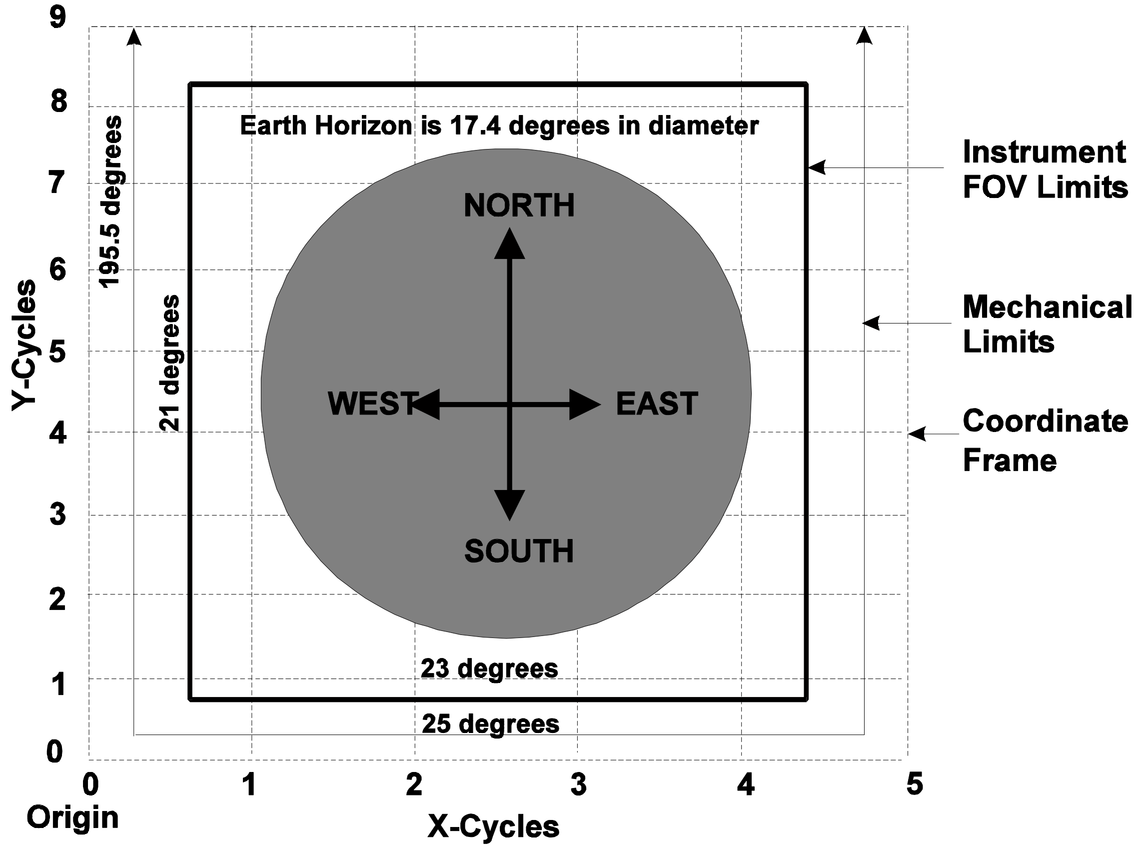


Imager Instrument Nadir

Offset from Origin	E/W	N/S
Mechanical Degrees	7.03125	12.65625
Cycles/Increments	2/3068	4/3068

Imager Increments/Cycle: 0 – 6135

Figure 3-17. Imager Coordinate System



Sounder Instrument Nadir

Offset from Origin	E/W	N/S
Mechanical Degrees	7.03125	12.65625
Cycles/Increments	2/1402	4/1402

Sounder Increments/Cycle: 0 – 2804

Figure 3-18. Sounder Coordinate System

3.5 Bits, Words, and Formats

3.5.1 Bit Transmission Order

Every GVAR block transmitted consists of a similar sequence of the following 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, focusing on the bit sequence associated with a GVAR Block 11 header. The first 10,032 bits transmitted 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 (see Figure 3-10 and 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 that detects the presence of bit errors in the associated information field at the GVAR receiver (see Section 3.3.3). 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 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 4-word and a 5-word segment. An 8-bit word length is used for the 4-word segment and 10 bits for the 5-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

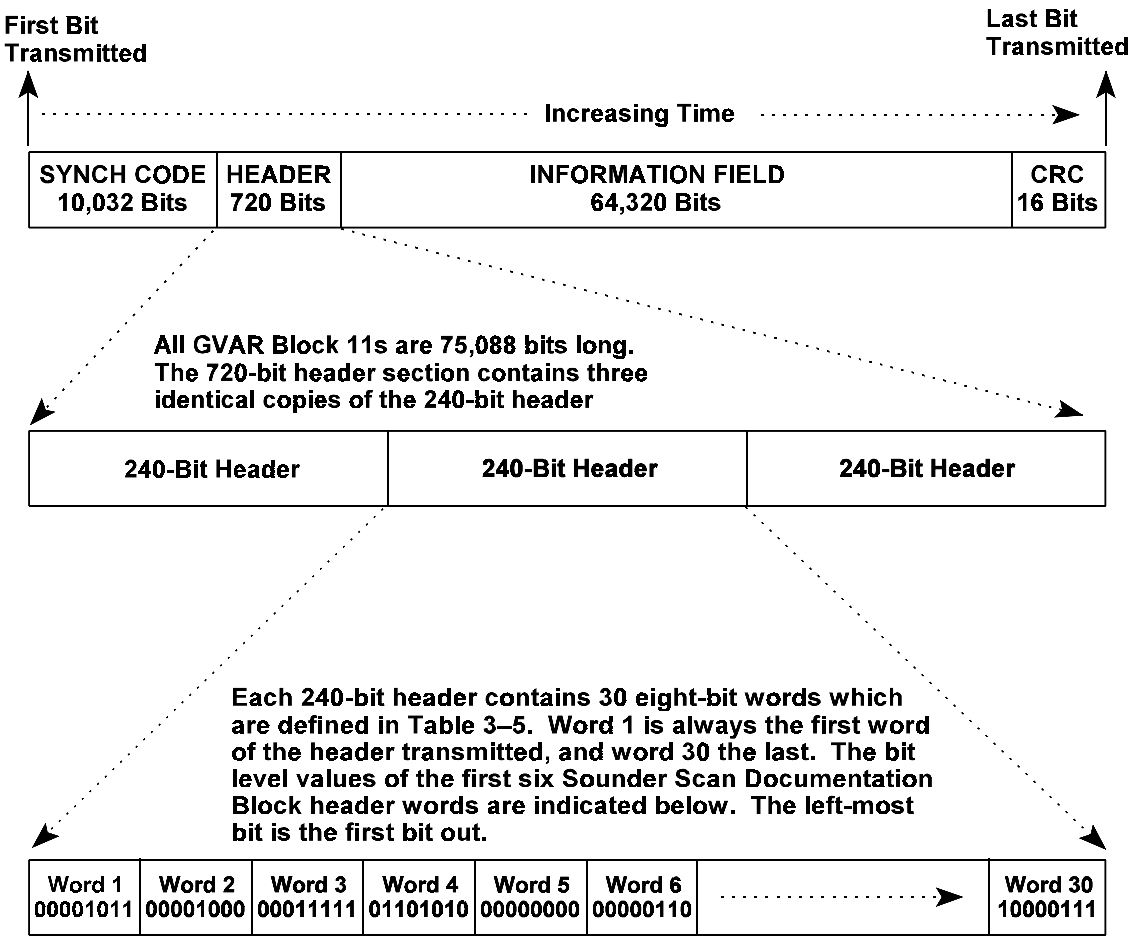


Figure 3-19. GVAR Block Bit Transmission Order

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

Negative integer values in the GVAR format are formed using a twos complement notation and only permitted for the 8-, 16-, and 32-bit lengths. All other bit lengths always represent a zero or positive integer value. The only integer terms currently expected to indicate negative quantities include the coregistration correction terms for the Imager (see Table 3-6, words 1631 – 1678 and 6235 – 6282), the Imager grid bias terms (see Table 3-6, words 189 – 192) and the instrument detector offsets (Imager: see Table 3-6, words 6311 – 6398; and Sounder: see Table 3-10, words 3011 – 3074).

Two special cases exist for 16-bit integer values that do not employ two's complement arithmetic. The first case involves the GVAR block header block sequence counter (see Table 3-5, words 13 – 14). The second case involves the Sounder detector data arrays defined in Section 3.3.7.3.3. In both of these cases, the 16-bit integers take on values ranging from 0 – 65,535.

3.5.4 Floating Point Format

All floating point numbers used in GVAR are 32 bits in length and transported by way of four sequential 8-bit words. Each is a single precision floating point value formatted for the Gould or 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
          - - - - - - - -  - - - - - - - -  - - - - - - - -  - - - - - - - -
          S E E E E E E E  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 two's 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 8 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 8 bits.
4	1–8	**M**antissa – last 8 bits. Bit 8 is the LSB of the 24-bit mantissa.

The following examples illustrate the relationship between a decimal value and 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 msec. These raw data blocks each contain 250 16-bit words of information 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 the following, two primary operations:

1. The SPS changes the 16^{th} bit of the original word, which is an odd parity bit, to a bad parity indicator. The bit is set to one if the parity of the original word is bad and zero 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 as two sequential 8-bit words viewed for GVAR transmission purposes. The transformation described above is diagramed as follows for the M^{th} 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 monitors calibration and telemetry data. The monitoring functions provide extensive statistics computation on spacelook data, BB-Cal data, and selected telemetry points. Monitoring also includes a verification of the linearity of the detector electronics based on ECAL data received at each BB-Cal occurrence. The following sections 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 relative to space. The Imager's primary objective is to eliminate image banding caused by noise in the space clamps. The Sounder does not execute space clamps, and its primary objective is to eliminate the effects of drifts.

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. The Imager's spacelook data is from the postclamp following the preceding spacelook. Second, the constant BOOST is added. 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. However, note 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.

The SPS applies the two relativization steps in sequence, followed by normalization, for the Sounder. The SPS applies relativization and normalization in one operation, for the Imager. The on or 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 1, 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 is calculated and approved, it is sent to all SPSs by 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 BB-Cal event (see Section 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. 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 realtime process of data conversion to theoretical target radiance based on detector response characteristics derived by the OGE from a combination of the following:

1. Factory measured detector response characteristics
2. In-flight measurements made while viewing space and BB targets

The correspondence between output counts and target radiance for each Imager IR detector and Sounder detector-channel combination is represented by a second-order polynomial based on the relationship

$$R = b + m\,C + q\,C^2 \qquad (3.6\text{-}1)$$

where R is radiance, C is the measured counts, b is the intercept (bias factor), m is the slope (gain factor), and q is the coefficient of the quadratic (second-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 (see Tables 3-6 and 3-10).

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 clamping of the IR detectors to the filter wheel every 100 msec.

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

Every time a space or BB look occurs, a new calibration set is generated. The Sounder automatically transmits a new set in GVAR within a Calibration Coefficient and Limits Block 11 (see Section 3.3.7.9). The Imager transmits new sets for each output scan in the Scan Documentation Block (see Section 3.3.4.5). In addition, a Calibration Coefficient and Limits Block 11 is transmitted following each BB-Cal event and each 2-minute interval spacelook event (see Section 3.3.7.9). Each calibration set includes the latest coefficients for all Imager detectors or Sounder detector-channel combinations, along with a time tag. The time tag can be used to correlate the calibration set to the sensor data.

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 – 65,535 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 the following:

$$SR = SB + SG\,(b + m\,C + q\,C^2) \qquad (3.6\text{-}2)$$

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:

$$SR = B + C\,(M + Q\,C) \qquad (3.6\text{-}3)$$

where,

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

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 second-order terms of the detector response equations are not expected to change significantly; therefore, the factory measured values are used. The first-order gain and bias terms are expected to vary as detectors age and temperature changes. However, the terms are recomputed based on in-flight space and BB measurements.

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

$$R(T) = R0 + a\,T + b\,T^2 + c\,T^3 \qquad (3.6\text{-}4)$$

where *R(T)* is the equivalent radiance, *T* is the BB 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 (see Tables 3-6 and 3-10).

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

$$(1/T) = A + B \ln X + C(\ln X)^3 \tag{3.6-5}$$

where,

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

$$X = (D + EG)/(F + G) \tag{3.6-6}$$

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 BB 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 BB temperature as an input to the polynomials above relating BB temperature T to target radiance $R(T)$.

The next step is to compute an average BB measurement in counts for each detector, or detector-channel combination, using the downlinked BB 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 the following:

$$m = \frac{R(T) - Q(Blackbody\ Counts^2 - Space\ Level\ Counts^2)}{(Blackbody\ Counts - Space\ Level\ Counts)} \tag{3.6-7}$$

where m is the first-order gain and q is the factory-measured second-order term. The Sounder uses the space level counts that are the filtered mean values acquired from the spacelook immediately preceding the BB event. A spacelook is performed prior to each BB-Cal sequence, and the data samples are filtered and averaged as was described for BB data.

The SPS uses interpolated spacelevel values for the Imager. The Imager performs a clamping operation prior to BB events and a spacelook following the BB events. The filtered mean values acquired from these two operations serve as the end points between which the SPS computes an interpolated spacelevel value. The interpolation ratios are 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 as follows:

$$b = -(q\, slc^2 + m\, slc) \qquad (3.6\text{-}8)$$

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

The new bias factors, new gain factors, and second-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 along with the following information (see Section 3.3.7.9):

1. Weighted mean BB temperature
2. BB thermistor weighing factors
3. BB thermistor sample window size (*N*)
4. Q quality or reasonableness limits
5. Sample size minimums
6. Critical alarms (if any)

Spacelooks are performed at a higher frequency than BB-Cal sequences. 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 BB-Cal. The equation is the same as the equation used for the bias computation following calculation of a new gain (3.6-8). The Sounder's new bias factors are automatically transmitted in a Calibration Coefficients and Limits Block 11 sequence along with all the unchanged information from the previous BB-Cal.

The Imager's Block 11 sequence is generated every 2 minutes. However, any new sets 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 the following:

$$b0 = -(q\, slc^2 + m\, slc) \qquad (3.6\text{-}9)$$

where *q* is the factory-measured second-order term, *m* is the newly computed gain, and *slc* is the filtered mean postclamp spacelook count value. The computation results and the scans that occur before the next spacelook event are held by the SPS. The preclamp spacelook data acquired from this next event is used to form the drifted spacelook filtered mean count level (dslc). The following equation uses the dslc to compute the drift bias (bd) value:

$$bd = -(q\, dslc^2 + m\, dslc) \qquad (3.6\text{-}10)$$

The following equation uses the bias values, drift bias values, and the midpoint times of the two data sets to compute a bias rate for each IR detector:

$$ibrate = \frac{(bd - b0)}{(td - t0)} \cdot \frac{1}{prate} \qquad (3.6\text{-}11)$$

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

If any intervening scans are being held by the SPS, it enters a sequence 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:

$$bw = b0 + (bd - b0)\frac{(tw - t0)}{(td - t0)} \qquad (3.6\text{-}12)$$

Using *bw* and *ibrate*, the bias term *bn* for the nth IR pixel of a scan is computed from the following:

$$bn = bw + (n - 1)\; ibrate \cdot dir \qquad (3.6\text{-}13)$$

where *dir* is +1 for a W-E scan and –1 for an E-W scan. The calibration coefficients provided in the Imager Scan Documentation Block 0 include *bw, m, q*, and *ibrate · 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 Section 3.3.7.7. Similarly, statistics are computed on detector BB-Cal data and transmitted with the raw BB data in GVAR BB-Cal Block 11s (see Section 3.3.7.8). Telemetry Statistics Block 11s are generated following each reported spacelook event (see Section 3.3.7.5).

3.6.2.2 Modifications to Correct for East-West Variation in Scan Mirror Reflectance

The standard IR calibration equations are modified due to errors caused by the E-W variation in the reflection 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 BB event, a table of emissivity ϵ verses instrument address θ is generated for each detector from the polynomial as follows:

$$\epsilon(\theta) = a + b\theta + c\theta^2 \tag{3.6-14}$$

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 as follows:

$$\theta = (\,increments + 3\,)/4 \quad (Imager) \tag{3.6-15}$$

and

$$\theta = (\,increments + 7\,)/8 \quad (Sounder) \tag{3.6-16}$$

The basic calibration equation 3.6-1 is modified to become the following:

$$R = \frac{\{qC^2 + mC + b - (\epsilon[\theta] - \epsilon[sp])\,R_M\}}{(1 - \epsilon[\theta])} \tag{3.6-17}$$

where *R* is radiance, *b* is the intercept (bias factor), *m* is the slope (gain factor), *q* is the quadratic (second-order) term, and *C* is the measured counts, as in equation 3.6-1. The variable $\epsilon(\theta)$ is the emissivity at the address of the target; $\epsilon(sp)$ 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 3.6-4.

Corresponding changes are made in the scaling equations 3.6-2 and 3.6-3. However, the user still derives radiances from GVAR counts exactly as before, by subtracting the scaling bias and dividing by the scaling gain.

Equation 3.6-7, the computation of gain, is replaced with the following:

$$m = \frac{[r_{bb} - q(c_{bb}^2 - c_{sp}^2)]}{(c_{bb} - c_{sp})} \tag{3.6-18}$$

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

$$r_{bb} = (1 - \epsilon[bb])\,R(T) + (\epsilon[bb] - \epsilon[sp])\,R_{M,bb} \tag{3.6-19}$$

where *R(T)* is the radiance of the BB and is computed from its temperature as described in Section 3.6.2.1. The quantity $R_{M,bb}$ is the radiance of the scan mirror computed with equation 3.6-4 from a window-average temperature at the time of the BB event. The window-average temperature of the scan mirror is computed in the same exact way as that of the BB's, as described in Section 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 $\epsilon[bb]$ and $\epsilon[sp]$ are the scan mirror's emissivity at the BB and spacelook addresses, respectively.

Equation 3.6-8 remains unchanged, although it is understood that *m* is now computed as in the preceding paragraph.

With *m* and *b* computed as described above, the calibration is applied to the counts at each address according to equation 3.6-17. In this equation, R_M is computed by equation 3.6-4 from the most recent 2-minute average temperature of the scan mirror. As before, the Imager drift correction time interpolates *b* between the spacelooks preceding and following the address. The value of *b*, for the Sounder, 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 for the Imager are reported in the Calibration and Limits Block 11s in Table 3-28, words 417–419. The Sounder's active calibration algorithms are listed in Table 3-29, words 2097-2099. These words denote the currently active calibration mode for the three calibration terms *b*, *m*, and *q*. Each of these words is set to one in the standard algorithms defined in the preceding section. The following sections provide a description of each extended calibration mode.

3.6.2.3.1 Bias Versus Optics Temperatures (BMODE = 2)

BMODE equals two is available only for Sounder data. The algorithm uses a rotating history of times, biases, and an 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, primary mirror, 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 following form:

$$b = kT + h \qquad (3.6\text{-}20)$$

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 a fraction of the file or the entire 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 BB-Cal event. The k coefficients determined by the regression are used between spacelooks to estimate a new bias (for each detector-channel) from the following:

$$b = b_0 + k(T - T_0) \qquad (3.6\text{-}21)$$

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, and the SEE are determined by the most recent linear regression. 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 BB-Cal. 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 First-Order Gain Versus Patch Temperature (MMODE = 2)

MMODE 2, available for both the Imager and Sounder, adjusts the IR first-order gain terms between BB 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 spacecraft panel. The patch provides a controlled thermal environment for the detectors, radiates excess heat to space and warms the detectors 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, reports statistics, and averages values every 2 minutes.

The standard calibration algorithm computes each IR detector's instantaneous first-order gain at each BB 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 BB events to compute the relation between instantaneous first-order gain and patch temperature. The computation determines the slope of the line defined by the two gain-temperature points provided by the BB events.

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

$$m' = m0 + A\,(t' - t0) \qquad (3.6\text{-}22)$$

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

3.6.2.3.3 First-Order Gain – Diurnal Filtering (MMODE = 3)

TBP

3.6.2.3.4 First-Order Gain – Temperature Regression (MMODE = 4)

TBP

3.6.2.3.5 First-Order Gain – Combined Modes 3 and 4 (MMODE = 5)

TBP

3.6.2.3.6 First-Order Gain – Linear Fit of History (MMODE = 6)

TBP

3.6.2.3.7 First-Order Gain – Curved Fit of History (MMODE = 7)

TBP

3.6.2.3.8 Second-Order Gain Versus Patch Temperature (QMODE = 2)

QMODE 2 is available for both the Imager and Sounder and computes the IR second-order gain terms at 2-minute intervals as a function of patch temperature. The second-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 second-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 second-order gain using the new, nearest tabled values. The option selected by the SPS is denoted by the patch temperature control level reported in Table 3-28, word 416, or Table 3-29, word 2096, of the Calibration and Limits Block 11s.

3.6.2.3.9 Second-Order Gain Versus Baseplate Temp (QMODE = 3)

QMODE 3, available for both the Imager and Sounder, uses the baseplate temperature to compute the IR second-order gain terms at 2-minute intervals. A LUT containing values of *q* at different baseplate temperatures is defined for each IR detector. A separate table is provided for three distinct patch temperatures. The table values are derived from factory measurements and provided in the Imager and Sounder documentation blocks. An effective baseplate temperature is calculated at 2-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. The current smoothed patch temperature determines which of the three available LUTs is used for this interpolation. If the current patch temperature lies outside 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 second-order gains. A critical alarm is generated, and reported in the Block 11, if the effective baseplate temperature is out of the LUTs range. If the baseplate temperature is out of range, 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 BB-Cal sequence on the Imager and 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 (see Section 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 or step minimums, and high or low filters are reported in the Calibration Coefficients and Limits Block 11s.

It is important to note that filter delays in the Imager data result in invalid samples being downlinked to the SPS preceding the valid ECAL data. These invalid samples are discarded. The number of samples 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 eight visible star sense detectors are increased from 108 – 432 (nominal). The scanning mirror settles at this location and waits 2 seconds for the start of the star sense data sequence.

The star passes through the detector's FOV by normal in-orbit rotation of the satellite (0.25° per minute). The star senses last from 1 – 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 µrads 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 it occupied prior to the initiation of the star sense and continues the previously active operation. The detector amplifier gains are restored to a value of 108, and the nominal space clamp value 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 the following 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 degrees per minute = 72.722 µrad per second
w = detector width = 28 µrad
d = star blur spot diameter = 10 µrad (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 as follows:

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

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 as follows:

$$t_1 = t_3 = d/r = 0.1375 \text{ seconds}$$

The resulting plateau time is the following:

$$t_2 = 0.5225 – 0.1375 – 0.1375 = 0.2475 \text{ seconds}$$

The Sounder generates pixels at a rate of 40 pixels per second (10 frames per second x 4 pixels per frame) for the 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 – 64 seconds in duration, the number of pixels included in the analysis of each detector can range from 160 – 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. 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-msec increments to the initial CDA time stamp. The remainder of this section presents an algorithm from the viewpoint of a single detector.

The star sense pixel array, P_i, is formed by the 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*, 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 window 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 first-order filtering of noise effects that may be present in the pixel data. The *WTL* 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 *WTL* before a star crossing has 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 window mean value, *WMV*, of the pixels contained within the window is computed. Next, an *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.

Table 3-36. Sounder Star Crossing Analysis Terms (1 of 2)

Analysis Terms	Equation
input sample array (160 ≤ *N* ≤ 2560) expanded input time array	$S_i \Big\vert_1^N$ $T_i \Big\vert_1^N$
star sense pixel value (W is integer: {1,2,3,...})	$P_i = \frac{1}{W} \sum_{g}^{g+W-1} S_g \Big\vert_{g=1}^{g=N-W+1}$
DMV (interval mean value or detector)	$DMV = \frac{1}{N-W+1} \sum_{1}^{N-W+1} P_i$
DWT (window threshold tolerance/detector), separate value each detector	$DWT = \text{constant}_d$
WTL (Window Threshold Level/Detector)	$WTL = DMV + DWT$
Window Threshold count (used with WTL to locate window start (h) and end (k) indices)	$WTC = \text{constant}_1$
WMV (Window Mean Value)	$WMV = \frac{1}{k-h+1} \sum_{h}^{k} P_i$
ETL (event thresholding level)	$ETL = WTL + \frac{WMV - WTL}{2}$
ETC (event thresholding count), used with ETL to locate event start (m) and end (n) indices	$ETC = \text{constant}_2$

Table 3-36. Sounder Star Crossing Analysis Terms (2 of 2)

Analysis Terms	Equation
EMV (event mean value)	$EMV = \frac{1}{n-m+1}\sum_{m}^{n} P_i$
TEV (Time of Event)	$TEV = T_m + \frac{T_n - T_m}{2}$

The value of *ETC* specifies the number of sequential pixels with values exceeding *ETL* that defines the edge of a star crossing event. The following two passes are made through each set of windowed pixels:

1. In the forward direction to locate the rising edge of the event
2. 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 *TEV* is computed at 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 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 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 msec.

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 – 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–µrad 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 $1/4M$ in the averaging algorithm to compensate for the effects of the summing operation performed by the SDI.

Table 3-37. Imager Star Crossing Analysis Terms

Analysis Terms	Equation
input sample array (100 ≤ *N* ≤ 6400) input time array	$S_i \Big\rvert_1^N$ $T_i \Big\rvert_1^N$
star sense pixel value (W is integer: {1,2,3,...}) (2 ≤ *M* ≤ 1024)	$P_i = \frac{1}{4MW} \sum_{g}^{g+W-1} S_g \Big\rvert_{g=1}^{g=N-W+1}$
DMV (interval mean value or detector)	$DMV = \frac{1}{N-W+1} \sum_{1}^{N-W+1} P_i$
DWT (window threshold tolerance/detector), separate value each detector	$DWT = \text{constant}_d$
WTL (Window Threshold Level/Detector)	$WTL = DMV + DWT$
WTC (Window Thresholding Count) used with WTL to locate the window start (h) and end (k) indexes	$WTC = \text{constant}_3$
WMV (Window Mean Value)	$WMV = \frac{1}{k-h+1} \sum_{h}^{k} P_i$
ETL (event thresholding level)	$ETL = WTL + \frac{WMV - WTL}{2}$
ETC (event thresholding count) used with ETL to locate event start (m) and end (n) indices	$ETC = \text{constant}_4$
EMV (event mean value)	$EMV = \frac{1}{n-m+1} \sum_{m}^{n} P_i$
TEV (time of event)	$TEV = T_m + \frac{T_n - T_m}{2}$