DMSP DATA SPECIFICATION

IS-YD-821

OLS 5D-2

15 JANUARY 1977
CHANGE B

PREPARED BY
DEFENSE METEOROLOGICAL SATELLITE PROGRAM
HEADQUARTERS SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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HEADQUARTERS SPACE AND MISSILE SYSTEMS ORGANIZATION
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DMSP DATA SPECIFICATION
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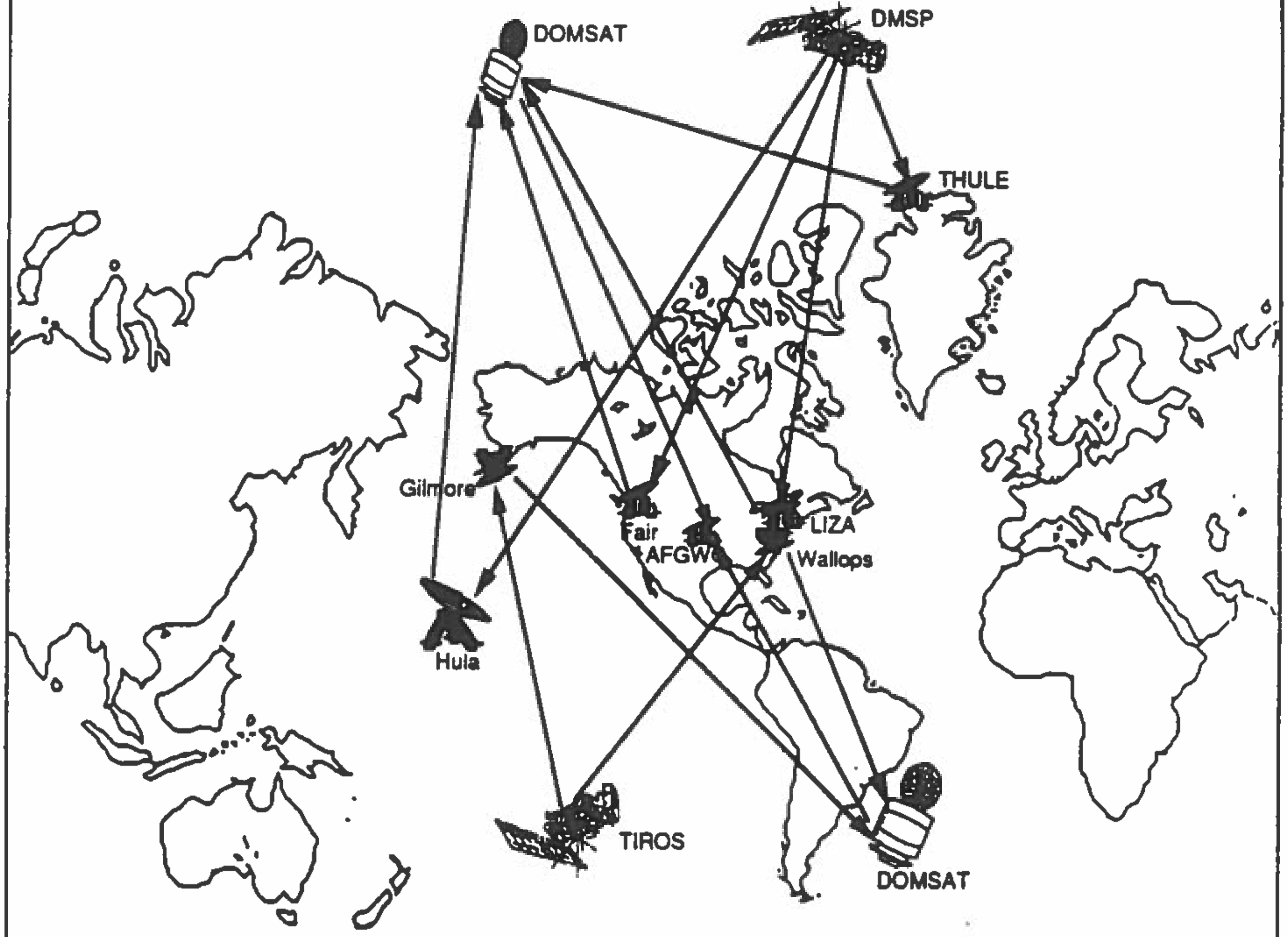

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SPECIFICATION CHANGE NOTICE
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This notice informs recipients that the specification identified by the number (and revision letter) shown in Block 4 has been changed. The page numbers listed below in the summary of changed pages, combined with non-listed pages of the orignial issue of the revision shown in Block 4, constitute the current version of this specification.

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	45	x		

	SUMMARY OF CHANGED PAGES			
001 002 004 005 006	Pages vii and viii dated 15 APR 87 and transmitted herewith contain page numbers and dates of all pages of this specification that have been changed by SCNs and show the paragraphs affected by each SCN. The SCN approval dates are also shown. The date of approval is the earliest date of approval in instances where more than one contract is affected.			

6. TECHNICAL CONCURRENCE

USAF/AFSC

DATE

March 8, 1988

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* "S" indicates supersedes earlier page.
"A" indicates added page.

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DMSP DATA SPECIFICATIONS

1.0 SCOPE

This document specifies the formats of the data that is received at the various interfaces within the system shown in Figure 1.

1.1 SATELLITE SYSTEM DESCRIPTION

The Block 5D sensor is an oscillating scanning radiometer which operates in two spectral intervals; visible and infrared. The sensor system will gather and output in real time or store (multi-orbit) day and night, visual and infrared data from earth scenes and provide such data, together with appropriate calibration, indexing, and other auxiliary signals, to the spacecraft for transmission to ground stations. The data will be collected, stored and transmitted in fine (F data) or smoothed (S data) resolution. Onboard pre-processing of the data by the sensor system provides for the various modes of data output. The sensor provides terminator coverage in both visual (L data) and thermal (T data) modes.

Fine resolution data will be collected continuously, day and night, by the infrared detector (TF data) and continuously, during daytime only, by the silicon diode detector (LF data). Fine resolution data will have a nominal linear resolution of 0.3 nm. Because of the quantity of data collected, it will not be possible to store or to transmit all of the fine resolution information and selective collection will be required. Storage capacity and transmission constraints limit the quantity of fine resolution data (LF or TF) which can be provided in the SDF (Stored Data, Fine) mode.

Data smoothing permits global coverage in both the infrared (TS) and visible (LS) spectrum to be stored on the primary tape recorders in the SDS (Stored Data, Smoothed) mode. Smoothing is accomplished by electrically reducing the sensor resolution to 1.5 nm in the along scan direction, then digitally averaging five such .3 x 1.5 nm samples in the along track direction. A nominal linear resolution of 1.5 nm results. Additionally, a photomultiplier tube will allow collection of visible (LS) data under nighttime conditions at 1.5 nm nominal linear resolution.

For direct transmission to remote readout terminals or transportable terminals (TRANSTERMS) and for fleet operations, the OLS provides real data (RTD) output combinations of TF and LS or LF and TS and Special data. The smooth data in the RTD mode has not been digitally smoothed, so that a smooth sample is 0.3 nm in the along track direction times 1.5 nm in the along scan direction.

The sensor also provides the data management functions to process, record and output data from up to 12 special meterological sensors.

1.2 INTRODUCTION

Figure 1 represents the DMSP Data Distribution. The Command Readout Stations (CRS), Site I and Site II, and the AFSCF's Hawaiian Tracking Station (HTS) are the primary recipients of the stored data streams. Data Stream S for SDS and SDF is as illustrated in this document. The data rate is 1.3312 megabits per second if one type of data (TF or LF) or 2.6624 megabits per second if the data is interleaved bit-by-bit (TF/LF or TS/LS). The DMSP Mux accepts either data rate and formats Equipment Status Telemetry data with the incoming stored data stream. This 3.072 megabits per second data stream is transmitted via a Communications Satellite link to Site III and FNOC for processing. At Site III the multiplexed and interleaved data stream is split into its component parts. EST and LS data are forwarded to Site V for telemetry analysis. All stored data is formatted for processing in AFGWC's computer complex.

Data stream R for RTD data is as illustrated in this document. The data rate is 1.024 megabits per second. RTD data is transmitted to the ground in the same direction as the data is collected. SDS and SDF data is transmitted to the ground reversed in direction from the direction which the data is collected due to storage on the satellite prior to transmission (the recorders do not rewind before playback). Remote Sites (TRANSTERMS) and Shipboard Terminals are capable of receiving the RTD data stream.

Site 4 is the System's Payload Test Facility (PTF) and receives all of the data types (SDS, SDF, and RTD) for evaluation purposes.

Figure 2 shows the Block 5 spacecraft axes relevant to Figure 3 which pictorially represents the direction of scan inherent in the data.

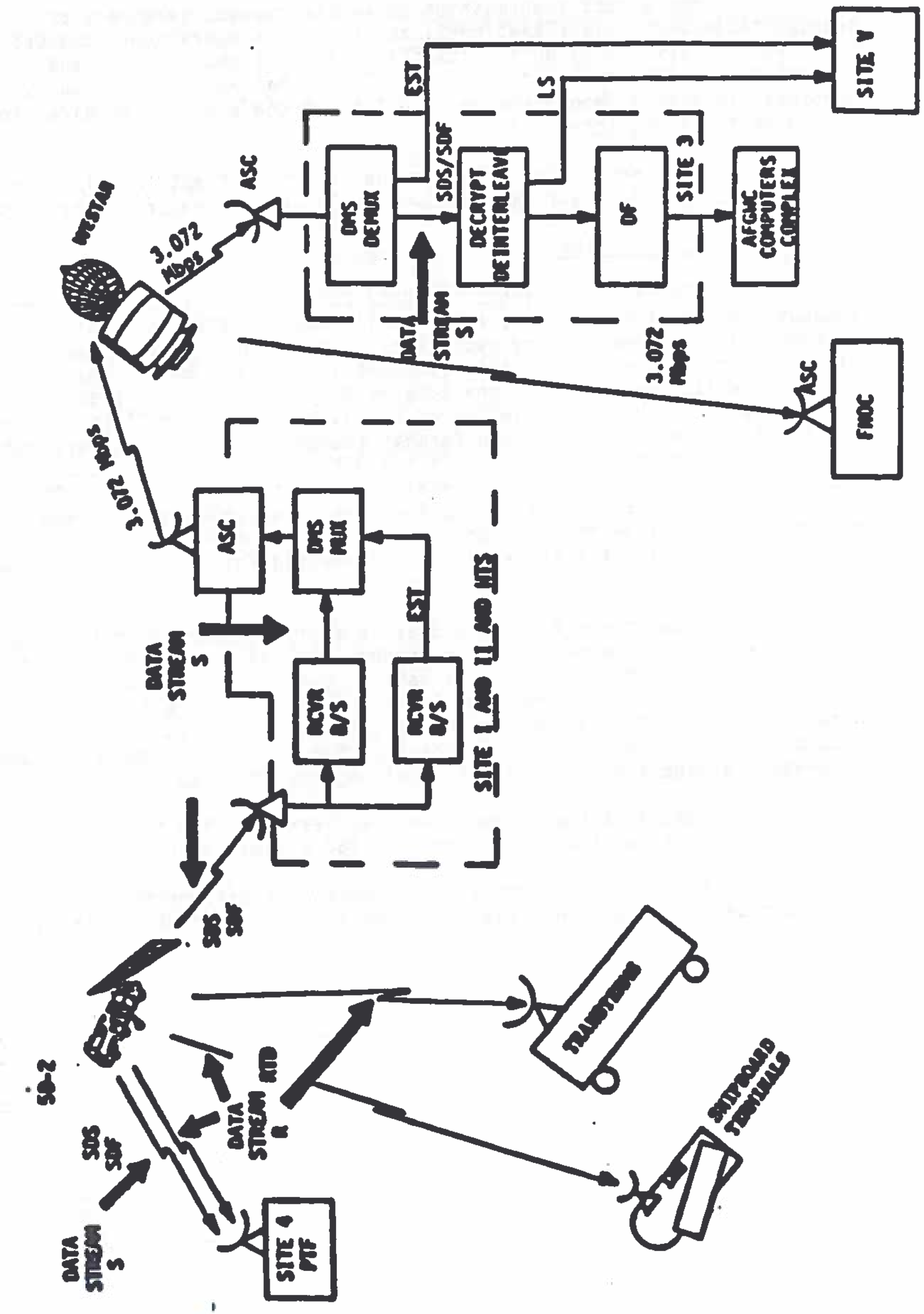
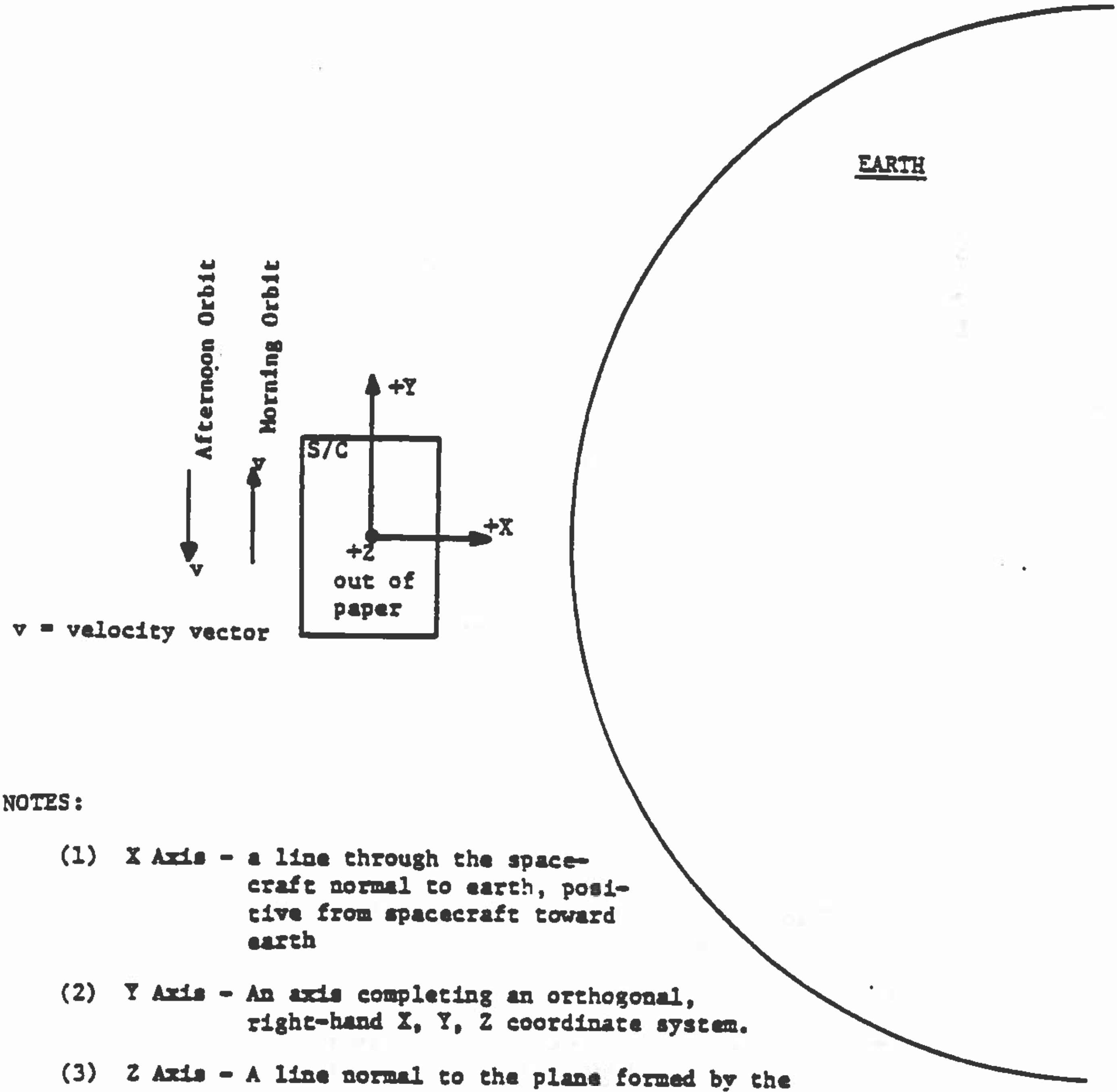


FIGURE 1: DMSP DATA SYSTEM REPRESENTATION



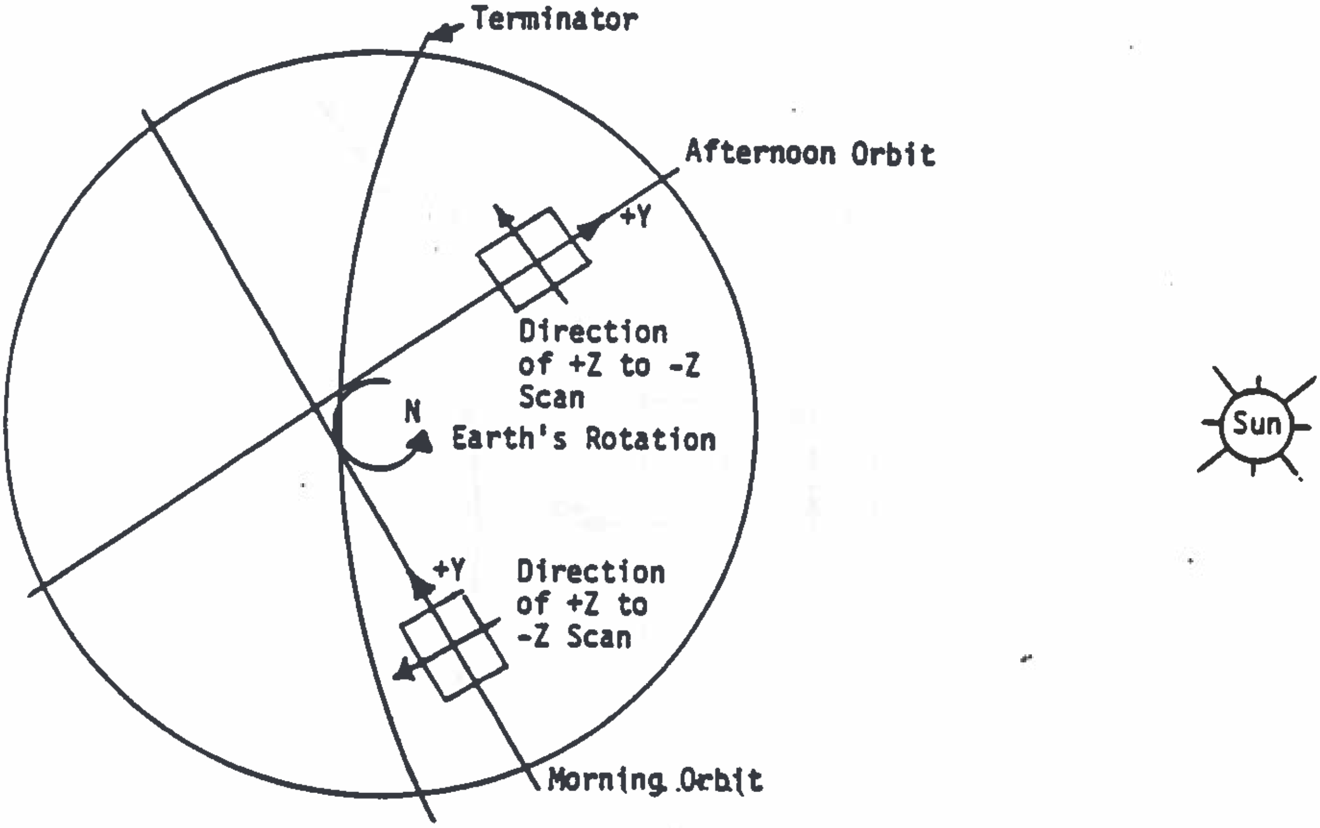
NOTES:

(1) X Axis - a line through the spacecraft normal to earth, positive from spacecraft toward earth

(2) Y Axis - An axis completing an orthogonal, right-hand X, Y, Z coordinate system.

(3) Z Axis - A line normal to the plane formed by the X-Axis and the velocity vector. The vector from the spacecraft to the sun has a positive component along the Z-Axis.

FIGURE 2: BLOCK 5 SPACECRAFT AXES DEFINITION



NOTES:

(1) +Z to -Z scan directions shown for typical orbit ascending nodes.

(2) Scan Directions (as received at data relay):

DOS in Line Sync & Subsync Frame	Video Direction	Video Type
0	+Z to -Z	RTD
1	-Z to +Z	(LF & TS or TF & LS)
0	-Z to +Z	SDF
1	+Z to -Z	(LF, TF or LF & TF)
0	-Z to +Z	SDS
		(LS & TS)

001

FIGURE 3: BLOCK 5 SCAN DIRECTION DEFINITION

2.0 ABBREVIATIONS

ASC	American Satellite Corporation
DMSP	Defense Meteorological Satellite Program
Data Modes:	
RTD	Real Time Data. Block 5D direct transmission data mode consisting of LF and TS or of TF and LS.
SDF	Stored Data Fine. Block 5D very high resolution mode consisting of LF and TF data.
SDS	Stored Data Smooth. Block 5D high resolution mode consisting of LS and TS data.
Data Types:	
LF	Visual Fine Data (L represents Light)
LS	Visual Smooth Data (L represents Light)
TF	Infrared Fine Data (T represents Thermal)
TS	Infrared Smooth Data (T represents Thermal)
DMDM	Direct Mode Data Message
EOAD	End of Active Data
EOSV	End of Smoothed Video
LSB	Least Significant Bit
MSB	Most Significant Bit
OLS	Operational Linescan System (Block 5D Primary Sensor)
OLSD	OLS Demultiplexer

2.0 ABBREVIATIONS (Continued)

PMT	Photomultiplier Tube
SOAD	Start of Active Data
SOSV	Start of Smoothed Video
SSP	Special Sensor (General Term)
TERDATS	Tertiary Data Stream
TM	Telemetry

3.0 COMPLIANCE INFORMATION

This document represents the data formats for the 5D-2 model of the Operational Linescan System.

This document establishes the sensor contractual requirements for the data formats for the 5D-2 model of the Operational Linescan System (OLS).

This document defines agreements reached by the Air Force Program Management Office (PMO) and the sensor contractor as to the actual data formats that the Sensor Contractor shall insure on the 5D-2 model of the OLS as specifically stated in paragraph 3.1. Nothing in this document or its subsequent revisions shall relieve the Sensor Contractor from compliance with any other segment or interface document. If incompatibilities between other documents and this data format specifications document are discovered, the PMO shall be notified and action initiated to determine the impact of, and to minimize, the incompatibility.

3.1 SENSOR CONTRACTOR COMPLIANCE

The Sensor Contractor corporation shall provide and insure each and every data bit location and value within the format lines of RTD (data stream R), SDS (data stream S), and SDF (data stream S) (see Figure 1 for data stream designations) for the 5D-2 model of the OLS. The Sensor Contractor shall insure a minimum transition density of 1 in 36 in that part of the filler code of Figures 13 and 30 that is not special data.

3.2 RESERVED

3.3 SENSOR CONTRACTOR CAUTION

The Sensor Contractor is cautioned on the reversing of the SDS format lines because of OLS on-board recording of data (and playback in the opposite direction).

As explained in the introduction (Para 1.2) this document refers to the formats of received baseband data from the 5D satellite.

3.4 SENSOR CONTRACTOR VERIFICATION

The Sensor Contractor shall verify each and every non video data bit location and value within the format lines of RTD, SDS, and the SDF by test. The Sensor Contractor shall verify each and every video data bit location and level within the format lines of RTD, SDS, and the SDF by test.

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4.0 DATA FORMATS

This section specifies the formats used as referenced to each data type, such that the data can be reconstructed from this information. The data is arranged into a basic, repeating sequence called a frame. Only two types of frame structure are used - the SDF or SDS frame and the RTD frame. Each frame in SDS or SDF is 208 bits long and each RTD frame is 150 bits long. A series of frames, properly referenced, is called a line format. The frames within a line format contain video data, sync codes, and other information as explained in the following sections.

4.1 BLOCK 5D DATA FORMATS

Block 5D video data consists of SDF, SDS, and RTD frames of data. The SDF frame contains either TF or LF video data. The SDS frame contains either TS or LS video data. The RTD frame contains TF and LS or LF and TS video data. The special data is present in selected SDS and RTD frames. The data is obtained from a satellite which employs a bi-directional scanner.

4.1.1 SDF DATA FORMAT

4.1.1.1 FRAME FORMAT

The SDF frame format is shown in Figure 4. The frame is 208 bits long and consists of a Frame Sync Code plus 32 six bit words, all of which contain SDF video.

4.1.1.1.1 FRAME SYNC CODE

The first 13 bits of each frame consist of a frame sync code. This code is 1010110011111 where the leftmost bit is that received first at the interface.

4.1.1.1.2 TAG BITS

The three bits immediately after the last bit of the frame sync code are tag bits (refer to Figure 4 bits A, B, C). These tag bits identify the type of video in the frame. Video type is as follows:

TAG BITS A	B	C	VIDEO MODE
0	0	1	LF
1	0	1	TF

VIDEO:

F1 = MSB = 2.500 Volts **
F2
F3
F4
F5
F6 = $\overline{\text{LSB}}$ = 0.078 Volts

(Note Complemented
Video Bits)

** as formatted by OLS on Satellite

BIT 1

C	E	A	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 2
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 3
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 4
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 5
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 6
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 7
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 8
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 9
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 10
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 11
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 12
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 13
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 14
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 15
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 16
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 17
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 18
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 19
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 20
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 21
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 22
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 23
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 24
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 25
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 26
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 27
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 28
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 29
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 30
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 31
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 32
										$\overline{F6}$	F5	$\overline{F4}$	F3	$\overline{F2}$	F1	word 33

last? →

BIT 208

FIGURE 4: SDF FRAME FORMAT

Tag Bits	Video Type
A B C	
0 0 1	LF
1 0 1	TF

4.1.1.1.3 VIDEO

The frame contains 32 fine video words. Each fine video word is digitized to a 6 bit resolution. The most significant bit (MSB) of each word is that bit received first at the interface (e.g., bit 17,23, ---). The SDF line contains 7322^{+2}_{-0} video samples per line. Nadir nominally exists between the 3661st sample and the 3662nd sample as counted from SOAD. Note that any scanner offset will affect the location of nadir. The first video sample received at the interface after the line sync sequence is the last video sample which was generated in that line. Since there is insufficient space for transition bits within the frame and in order to guarantee a higher average transition density, every other video data bit in a word is complemented. The 2nd, 4th, and 6th bits (see Figure 4) are complemented from the true value. Only actual video words are complemented.

4.1.1.1.4 RELATIONSHIP OF VIDEO TO FRAME

Video samples begin in Frame 3 (refer to Figure 5) and end in Frame 231. Frame 3 has 26^{+2}_{-0} video samples. All other frames have a full 32 video samples.

4.1.1.1:5 LINE DIRECTION

Due to the fact that the SDF video is stored on tape recorders and played back in reverse order, all data is received at the interface reversed in direction from the way the data was formatted in the satellite.

001

4.1.1.1.6 SCAN ANGLE OF VIDEO DATA SAMPLES

The SDF video data is corrected in the OLS so that data samples correspond to fixed scan angles. The SDF data sampling occurs at a varying sampling frequency of nominally 102.4 kHz. These data samples would occur linearly versus time if the scanner motion were nominal. When scanner motion differs from nominal, the correction places the data samples at the same scan angles as a nominal scanner motion would place them.

The scan angle (Ø) for sample number (Si) is defined as follows:

$$\emptyset = (-1)^{D} *\emptyset p* \cos\left(\frac{Si-1}{S_T} *M+B\right) - N*K$$

where:

D = 0 for SDF DOS 0

= 1 for SDF DOS 1

Øp = peak scan angle = 57.85° = 1.009673 radians 001

Si = sample number in order received by the tape recorder (SOAD = 1, EOAD - 7322)

S_T = nominal total sample periods = 7322.179

M = 2.6687426 radians

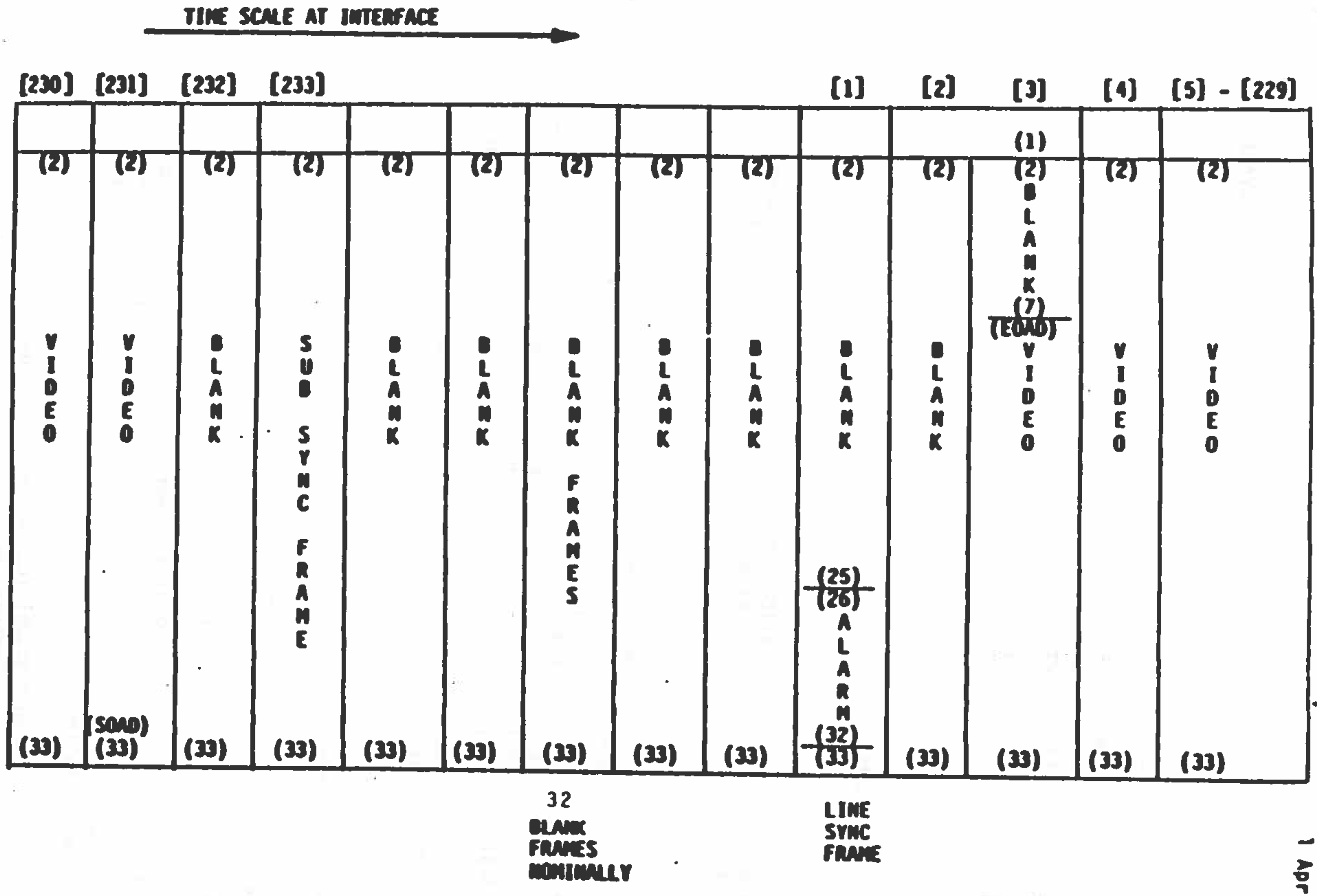
B = 0.2366399 radians

N = signed value of scanner offset from subsync frame of data stream. (see paragraph 4.1.1.6.2)

K = 0.0009855 radians

4.1.1.2 SDF LINE FORMAT

The SDF line format is shown in Figure 5.



NOTES:
1. Frame number in [ ] is referenced to interface timing.
2. Word number within frame is in ( ).
3. In frame 3 EOAD video sample is defined as sample 8 (but samples 6 and 7 can also contain video).

4.1.1.3 LINE SYNC FRAME FORMAT

The Line Sync Frame format is shown in Figure 6. The first 24 video words are Blank Video codes. Following the Blank Video words are 7 Alarm codes as follows:

4.1.1.3.1 ALARM CODES

(1) 111110 (0 = LSB of video word)

This alarm code is formatted in the even-numbered fine video words starting at word 26 (refer to Figure 6 for location of alarm codes).

(2) 000001 (1 = LSB of video word)

This alarm code is formatted in the odd numbered fine video words starting at word 27. (Refer to Figure 6 for location of alarm codes.)

4.1.1.3.2 SCANNER OFFSET WORD

The scanner offset word is a 4 bit number encoded in 2's complement code which identifies the angle between the center of scan and the sensor +X axis. The least significant bit of the scanner offset word is .985 milliradians. Referring to Figure 6, if Q1 is a zero, indicating positive offset, and Q2Q3Q4 is some non zero value then the center of scan is in the +X, -Z quadrant. If Q1 is a one, indicating negative offset, then the center of scan is in the +X, +Z quadrant. 001

In the locked encoder simulator mode the scanner offset may change every other scan line and may be non integer. 001

In the normal encoder mode the scanner offset may change once every 2048 scan lines only when permitted by ground command and must be integer.

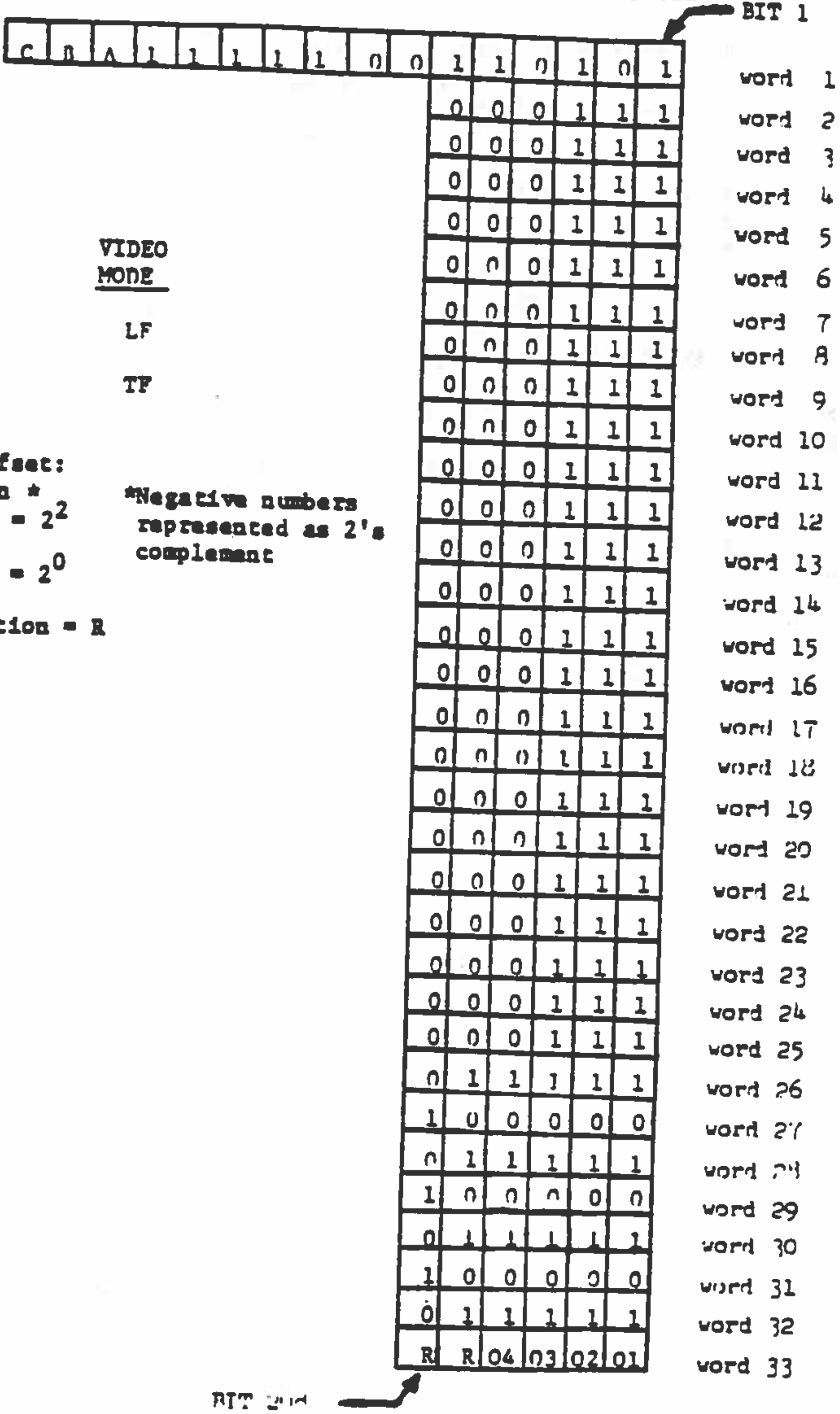
The encoder mode is indicated in the OLS equipment status telemetry.

4.1.1.3.3 SCANNER DIRECTION

The last two bits of word 33 identify the direction of the actual movement of the scanner with respect to the spacecraft Z axis. Note that the data as received at the interface appears in reversed actual scanner direction. Both bits are identical and are encoded as follows:

ZERO = actual scanner rotation from the +Z axis towards the -Z axis.

ONE = actual scanner rotation from the -Z axis towards the +Z axis.



C	B	A	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
										0	0	0	1	1	1	word 2
										0	0	0	1	1	1	word 3
										0	0	0	1	1	1	word 4
										0	0	0	1	1	1	word 5
										0	0	0	1	1	1	word 6
										0	0	0	1	1	1	word 7
										0	0	0	1	1	1	word 8
										0	0	0	1	1	1	word 9
										0	0	0	1	1	1	word 10
										0	0	0	1	1	1	word 11
										0	0	0	1	1	1	word 12
										0	0	0	1	1	1	word 13
										0	0	0	1	1	1	word 14
										0	0	0	1	1	1	word 15
										0	0	0	1	1	1	word 16
										0	0	0	1	1	1	word 17
										0	0	0	1	1	1	word 18
										0	0	0	1	1	1	word 19
										0	0	0	1	1	1	word 20
										0	0	0	1	1	1	word 21
										0	0	0	1	1	1	word 22
										0	0	0	1	1	1	word 23
										0	0	0	1	1	1	word 24
										0	0	0	1	1	1	word 25
										0	1	1	1	1	1	word 26
										1	0	0	0	0	0	word 27
										0	1	1	1	1	1	word 28
										1	0	0	0	0	0	word 29
										0	1	1	1	1	1	word 30
										1	0	0	0	0	0	word 31
										0	1	1	1	1	1	word 32
										R	R	Q4	Q3	Q2	Q1	word 33

TAG BITS A	 B	 C	VIDEO MODE
0	0	1	LF
1	0	1	TF

Scanner Offset:
Q1 = Sign *
Q2 = MSB = 2^2
Q3
Q4 = LSB = 2^0

*Negative numbers represented as 2's complement

Scan Direction = R

FIGURE 6: SDF LINE SYNC FRAME FORMAT

4.1.1.4 BLANK FRAME FORMAT

Blank frames occur during the over scan period of the scanner when video is not being formatted and between the Line Sync frame and the End of Active Data (EOAD). The blank frame format is shown in Figure 7. The nominal number of blank video words between the Line Sync frame and the first video word is 38 (but can be 36, 37 or 38). There is also a constant number of blank video words (32) between the last video word and the Sub-Sync frame.

4.1.1.5 Reserved

4.1.1.6 SUB-SYNC FRAME FORMAT

After the Start of Active Data (SOAD) there is one blank followed by one sub-sync frame. The sub-sync frame format is shown in Figure 9 and contains the following data.

4.1.1.6.1 ALARM CODES

(1) 000001 as received (1 = LSB of video word)

This alarm code is formatted in words 2, 4, 6, and 8. Refer to Figure 9 for the location of alarm code words.

(2) 111110 as received (0 = LSB of video word)

This alarm code is formatted in words 3, 5, and 7. Refer to Figure 9 for the location of alarm code words.

BIT 1

C	B	A	1	1	1	1	1	0	0	1	1	0	1	0	1	word
										0	0	0	1	1	1	word 2
										0	0	0	1	1	1	word
										0	0	0	1	1	1	word 4
										0	0	0	1	1	1	word 5
										0	0	0	1	1	1	word 6
										0	0	0	1	1	1	word 7
										0	0	0	1	1	1	word 8
										0	0	0	1	1	1	word 9
										0	0	0	1	1	1	word 10
										0	0	0	1	1	1	word 11
										0	0	0	1	1	1	word 12
										0	0	0	1	1	1	word 13
										0	0	0	1	1	1	word 14
										0	0	0	1	1	1	word 15
										0	0	0	1	1	1	word 16
										0	0	0	1	1	1	word 17
										0	0	0	1	1	1	word 18
										0	0	0	1	1	1	word 19
										0	0	0	1	1	1	word 20
										0	0	0	1	1	1	word 21
										0	0	0	1	1	1	word 22
										0	0	0	1	1	1	word 23
										0	0	0	1	1	1	word 24
										0	0	0	1	1	1	word 25
										0	0	0	1	1	1	word 26
										0	0	0	1	1	1	word 27
										0	0	0	1	1	1	word 28
										0	0	0	1	1	1	word 29
										0	0	0	1	1	1	word 30
										0	0	0	1	1	1	word 31
										0	0	0	1	1	1	word 32
										0	0	0	1	1	1	word 33

BIT 208

FIGURE 7: SDF BLANK FRAME FORMAT

THIS PAGE

INTENTIONALLY LEFT BLANK

BIT 1

C	B	A	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1	
										1	0	0	0	0	0	word 2	
										0	1	1	1	1	1	word 3	
										1	0	0	0	0	0	word 4	
										0	1	1	1	1	1	word 5	
										1	0	0	0	0	0	word 6	00
										0	1	1	1	1	1	word 7	
										1	0	0	0	0	0	word 8	
										R	R	Q4	Q3	Q2	Q1	word 9	
										E3	E2	E1	0	Q6	Q5	word 10	00
										E9	E8	E7	E6	E5	E4	word 11	
										E15	E14	E13	E12	E11	E10	word 12	
										E21	E20	E19	E18	E17	E16	word 13	
										E27	E26	E25	E24	E23	E22	word 14	
										G6	G5	G4	G3	G2	G1	word 15	
										M3	M2	M1	G9	G8	G7	word 16	
										P4	P3	P2	P1	U	M4	word 17	001
										I2	I1	P8	P7	P6	P5	word 18	
										H2	H1	H0	S	I4	I3	word 19	
										H8	H7	H6	H5	H4	H3	word 20	
										C0	S	Y4	Y3	Y2	Y1	word 21	
										C6	C5	C4	C3	C2	C1	word 22	
										Z4	Z3	Z2	Z1	C8	C7	word 23	
										Z10	Z9	Z8	Z7	Z6	Z5	word 24	
										Z16	Z15	Z14	Z13	Z12	Z11	word 25	
										Z22	Z21	Z20	Z19	Z18	Z17	word 26	
										Z28	Z27	Z26	Z25	Z24	Z23	word 27	
										0	0	Z32	Z31	Z30	Z29	word 28	
										0	0	0	1	1	1	word 29	
										0	0	0	1	1	1	word 30	
										0	0	0	1	1	1	word 31	
										0	0	0	1	1	1	word 32	
										0	0	0	1	1	1	word 33	

BIT 208
Unused Bits: 67,177 to 208

001

Scanner Offset:
Q1 = Sign * *Negative numbers represented
Q2 = MSB = 2^2 as 2's complement
↓
Q6 = LSB = 2^{-2}
R = U = Scan Direction {0 = DOS 0, +Z → -Z; 1 = DOS 1, -Z → +Z}

Time Code:
E1 = MSB = 2^{16} seconds
:
E27 = LSB = 2^{-10} seconds

Gain Code:
G1 = MSB =32 db
:
G9 = LSB = 0.125 db
M1 = Lin/Log (0 = Lin, 1 = Log)
M2-M4 = Sub Mode

Hot T Cal:
H0 = Segment ID (1 = Left, 0 = Right)
H1 = MSB = 2.500 Volts**
:
H8 = LSB = 0.020 Volts**

Cold T Cal:
C0 = Segment ID (1 = Left, 0 = Right)
C1 = MSB = 2.500 Volts**
:
C8 = LSB = 0.020 Volts**

Location Data = Z1-Z32

PMT Cal:
P1 = MSB = 2.500 Volts**
:
P8 = LSB = 0.020 Volts**

Vehicle Identity
I1 = MSB =2^3
:
I4 = LSB = 2^0

T Channel Gain:
Y1 = MSB = 1.28db
:
Y4 = LSB = 0.16 db

** as formatted by OLS on Satellite

S = Spare Bits

FIGURE 9: SDF SUB-SYNC FRAME FORMAT

4.1.1.6.2 SCANNER OFFSET WORD

The scanner offset word is a 6 bit number encoded in 2's complement code which identifies the angle between the center of scan and the sensor +X axis. The least significant bit of the scanner offset word is .246 milliradians. Referring to Figure 9, if Q1 is a zero, indicating positive offset, and Q2Q3Q4Q5Q6 is some non zero value then the center of scan is in the +X, -Z quadrant. If Q1 is one, indicating negative offset, then the center of scan is in the +X, +Z quadrant. 001 001

In the locked encoder simulator mode, the scanner offset may change every other scan line and may be non-integer.

In the normal encoder mode the scanner offset may change once every 2048 scan lines only when permitted by ground command and must be integer. 001

The encoder mode is indicated in the OLS equipment status telemetry.

4.1.1.6.3 SCANNER DIRECTION

The last two bits of word 9 identify the direction of the actual movement of the scanner with respect to the satellite Z axis. Note that the data as received at the interface appears in reversed actual scanner direction. Both bits are identical and are encoded as follows:

ZERO = Actual scanner rotation from the +Z axis toward the -Z axis.

ONE = Actual scanner rotation from the -Z axis towards the +Z axis.

4.1.1.6.4 TIME CODE

Words 10 through 14 define a 27 bit time code. The code is a pure binary number with the least significant bit equal to 1/1024 second. The time code word in the sub-sync frame is the value of the elapsed time counter coincident with the NADIR crossing of the next received video line. The elapsed time counter (which is updated approximately once daily) is a spacecraft clock which provides the reference to spacecraft position and hence gives the ground reference of the data taken at the center of scan of the sensor.

4.1.1.6.5 GAIN CODE

Words 15, 16, and 17 contain a 9 bit gain code plus 4 bits to identify the sub-mode being used. Refer to Figure 9 for the location of the gain code. The gain code gives the necessary information required to determine the gain operating status of the visual processing for each scan. The gain value references the gain value for the last sample received (first sample of active video) if the gain automatically changes during the scan. If the gain mode is PGC then that gain value is the gain for the last video line received. The 4 bits (M1-M4) used to identify the sub-mode are given below:

M1	Mode
0	Gain states in visual processor are linear.
1	Gain states in visual processor are logarithmic.

M2	M3	M4	Mode
0	0	0	UNUSED
0	0	1	ASGC
0	1	0	ATGC
1	0	0	PGC/HRD
1	0	1	PGC/PMT1/9
1	1	0	PGC/PMT - LOW
1	1	1	PGC/PMT - HIGH
0	1	1	SPARE

The three modes for gain control by the processor are: Along Scan Gain Control (ASGC), Along Track Gain Control (ATGC), and Preset Gain Control (PGC). The processor is in only one mode per scan cycle. The mode is commanded from the ground and this mode is set up by the processor during the positive end of scan. 001

CALIBRATION WORDS

The remaining video slots contain various calibration signals. These signals are shown in Figure 9 and are as follows:

(1) Hot T Cal: 8 bits resolution + 1 bit segment I.D.

The Hot T Cal value is updated during each +Z EOS (end of scan) and this value is repeated for the -Z EOS.

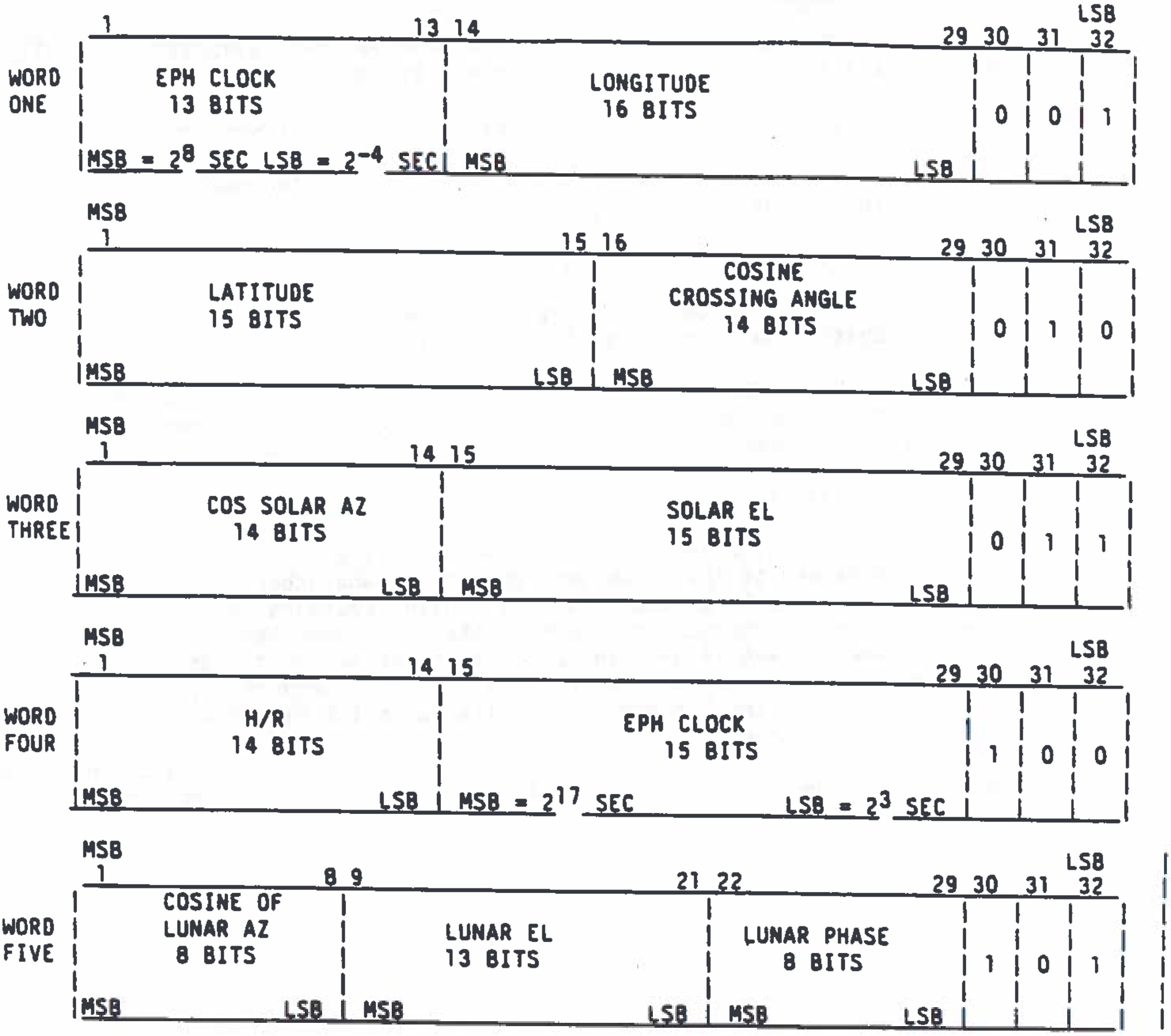
(2) Cold T Cal: 8 bits resolution +1 bit segment I.D.

The Cold T Cal value is updated during each -Z EOS (end of scan) and this value is repeated for the +Z EOS.

The two infrared calibration (T-Cal) words provide the temperatures of the blackbody sources on the sensor. The segment I.D. bit identifies the segment of the T-detector being calibrated.

(3) Location Data:

The information contained in the 32 bits designated Z1-Z32 in Figure 9 refers to the parameters used by ground processing to locate the satellite subpoint (longitude, latitude, cosine crossing angle) and those parameters used by the OLS to determine the Along Scan Gain Control (ASGC) mode. Figures 10 and 11 give the content of the location data. Included with the location data is a time code (EPHCLK) which references the time of calculation of all the information downlinked in the Z1-Z32 bits in SDF. The data is downlinked in the sequence: Word 5 thru Word 1. Because the timing of receipt of the words from the spacecraft is not synchronized to the SDF line, one or more of the location data words may be repeated.



TAG BITS(Z30-Z32)			CODE
30	31	32	
0	0	0	NO DATA
0	0	1	WORD 1
0	1	0	WORD 2
0	1	1	WORD 3
1	0	0	WORD 4
1	0	1	WORD 5
1	1	0	SPARE
1	1	1	SPARE

FIGURE 10. LOCATION DATA WORDS

Paramter	Units	Sign Bit	Bit Range MSB-LSB
EPH CLK	Seconds	N/A	$2^{17} - 2^{-4}$
Longitude	π Radians	S	$2^{-1} - 2^{-15}$
Latitude	π Radians	S	$2^{-1} - 2^{-14}$
Cosine Crossing Angle	None	S	$2^{-1} - 2^{-13}$
Cosine Solar Azimuth	None	S	$2^{-1} - 2^{-13}$
Solar Elevation	Degrees	S	$2^{6} - 2^{-7}$
h/R	Earth Radii (R = 6378.145 Km)	0	$2^{-3} - 2^{-15}$
Cosine Lunar Azimuth	None	S	$2^{-1} - 2^{-7}$
Lunar Elevation	Degrees	S	$2^{6} - 2^{-5}$
Lunar Phase	Degrees	N/A	$2^{7} - 2^{0}$

S = Sign bit with negative numbers represented as 2's complement.

Figure 11. Location Data Words Content

(4) PMT Cal: 8 bits resolution.

The PMT Cal value is updated during each -Z EOS (end of scan) and this value is repeated for the +Z EOS.

The photomultiplier calibration (PMT Cal) word provides the data from the self-calibration of the PMT on the sensor.

(5) Vehicle Identity: 4 bits resolution.

A unique code to identify each spacecraft will be inserted into the four bits for vehicle identity.

(6) T Channel Gain: 4 bits resolution.

The T Channel Gain value is that value set for the T Channel to offset any degradation effects on orbit. This is the gain for the last video sample received (note T Channel gain commands are executed as received by the sensor, they aren't delayed for the beginning of a line).

BIT 1

1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	C	B	A	word 2
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 3
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 4
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 5
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 6
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 7
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 8
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 9
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 10
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 11
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 12
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 13
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 14
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 15
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 16
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 17
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 18
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 19
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 20
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 21
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 22
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 23
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 24
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 25
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 26
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 27
						V7	$\overline{V6}$	V5	$\overline{V4}$	V3	$\overline{V2}$	V1	word 28

BIT 208

TAG BITS A	B	C	VIDEO MODE
0	1	1	LS
1	1	1	TS

TS VIDEO: **

V1 = MSB = 2.500 Volts
V2
V3
V4
V5
V6
V7 = 0.039 Volts
V8=LSB=0.019 volts (V7 of LS Video)

LS VIDEO: **

V1=MSB=2.500 Volts
V2
V3
V4
V5
V6=LSB=0.078 Volts
V7=LSB of TS Video

(Note Complemented Video Bits)

SPECIAL DATA: S1-S10

** as formatted by OLS on Satellite

FIGURE 12: SDS FRAME FORMAT

4.1.2 SDS DATA FORMAT

4.1.2.1 FRAME FORMAT

The SDS frame format is shown in Figure 12. The frame is 208 bits long and consists of a Frame Sync Code, 10 bits of special data, and 26 video words. The SDS frame is different in structure from the SDF frame.

4.1.2.1.1 FRAME SYNC CODE

The first 13 bits of each frame consist of a frame sync code. This code is 1010110011111 where the leftmost bit is that received first at the interface.

4.1.2.1.2 TAG BITS

The three bits immediately following the last bit of the frame sync code are tag bits (refer to Figure 12, bits A, B & C). These tag bits identify the type of video data in the frame. Video type is as follows:

Tag Bits	Video Type
A B C	
0 1 1	LS
1 1 1	TS

Note that LS and TS data line formats contain the same time codes, sub-sync codes and differ only in actual data and tag bits. Therefore, LS and TS data could be interleaved for processing. The 7th bit in the LS video data is the LSB (or 8th bit) of the TS video. Thus, a total of 8 bits comprises a TS video sample and a total of 6 bits comprises a LS video sample.

4.1.2.1.3 SPECIAL DATA

The ten bits immediately subsequent to the tag bits is a special data word. A group of special data words comprises a special data message (See Figure 13). A typical message as received consists of data followed by data format section followed by the time code and sync code. Note that every other SSP bit is complemented starting with the first bit after the format section. Thirty six (36) bit SSP data words may be separated by a filler word.

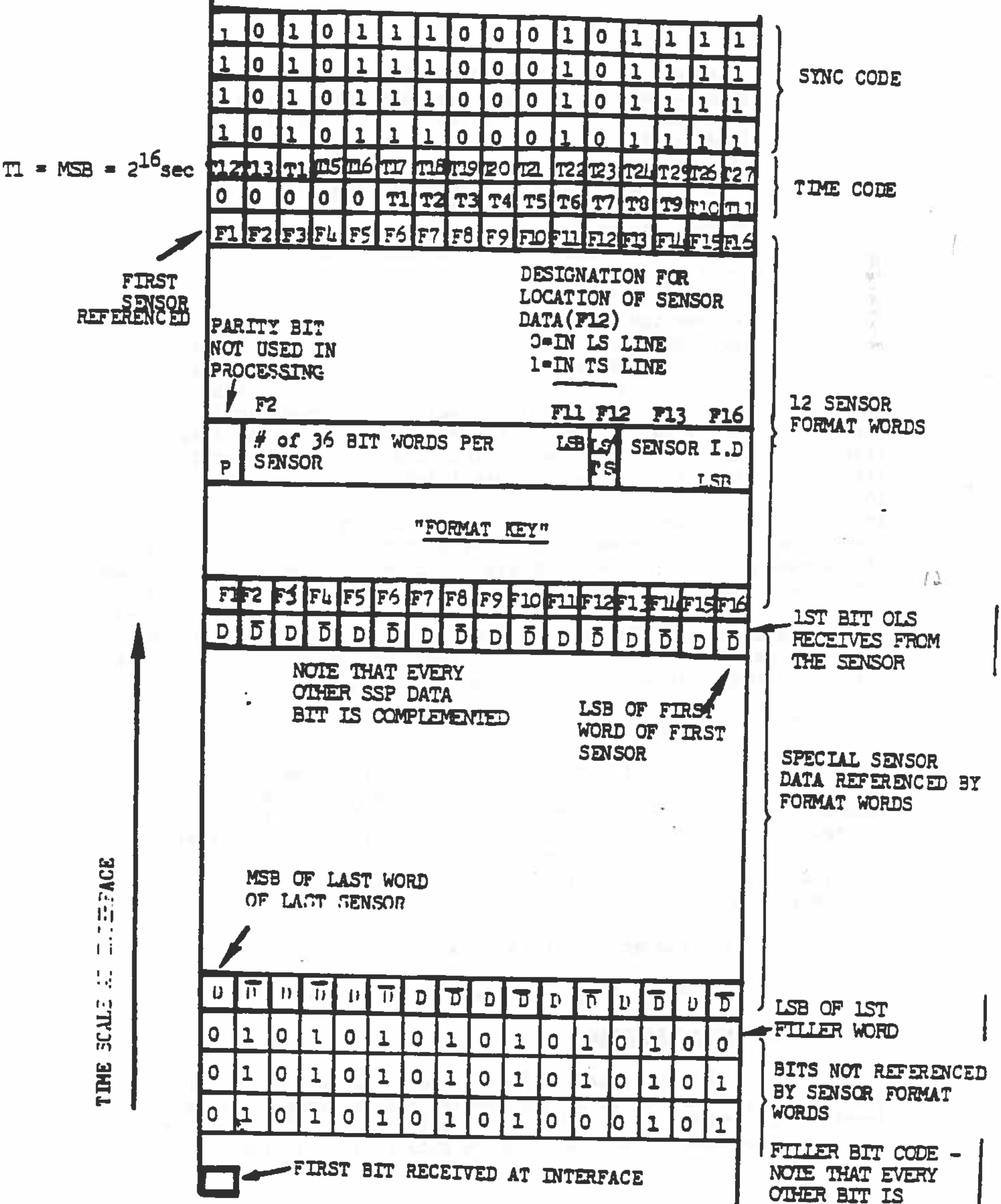


FIGURE 13: SSP MESSAGE FORMAT

The data is formatted in contiguous blocks of sensor data. Each block could contain data from a separate special sensor. Note that different special data will be contained in the LS data line format from that in the TS data line format. The LS data line will contain a special data message of a minimum 2088 bits per second of which 288 bits are used for overhead. The TS data line will contain a special data message of a minimum of 3816 bits per second of which 288 bits are used for overhead. The SSP data message is reconstructed by storing, as received, the S1-S10 bits of each frame (excluding fake frames). SSP data is located in bits 27 thru 208 of frame 2 and 27 thru 145 of frame 3 for both LS and TS mode. SSP data in the TS mode only is located in bits 202 thru 208 of the sub-sync frame, 27 thru 152 of the line sync frame, and bits 27 thru 208 of the four frames between the sub-sync and line sync (see Figure 14). The message is then interrogated in the opposite direction as received for the Sync Code, Time Code, Format Section, and SSP data. The first SSP data bit following the Format Section (the right most bit in Figure 30) is the LSB of the first word of the first sensor specified in the Format Section for the LS data stream. For the TS data stream it's for the first sensor identified with a T bit flag. For both LS and TS data streams, the first and every other SSP data bit is complemented. This bit and every other SSP data bit (all odd bits) require re-complementing before data use. The bits following the SSP data bits of the reconstructed SSP message are filler bits. The Sync Code, Time Code, and Format Section are identical for each interleaved LS and TS data line. The Time Code will change for each new interrogation cycle and the value will differ by 1 ± 0.005 second between adjacent SSP records. The Sync Code will not change. The Format Section can change in both LS and TS by command (however, it will be identical in LS and TS).

4.1.2.1.3.1 TIME CODE

Each special data message includes a time code which references that special data message to the count of the elapsed time counter time coincident with the read clock of the first sensor interrogated for data (see Figure 13). The OLS interrogates the special sensors in the order and way they are defined in the format section, with the first sensor being that which follows the Time Code section. The MSB of the time code is bit T1.

(1) Number of bits of time code = 27

(2) Value of LSB of time code (=T27) = 2^{-10} seconds

4.1.2.1.3.2 FORMAT SECTION

Since there are up to 12 special sensors on the spacecraft, twelve format words in the special data message are used to identify each sensor, the number of 36 bit words in each block of data, and the location of the sensor's data (either in the LS or TS data line).

The Format Section provides the number of 36 bit words per sensor included in the SSP message. The OLS will interrogate each SSP for an integral number of 36 bit words. The actual data bit count of a SSP will not be known from only knowing the Format Section, since the sensor's data may not be divisible by 36. If a SSP has properly indicated to the OLS that it is "off" or has "invalid data", the OLS will insert a unique code replacing the SSP's data. That special code (filler word) is a one in the LSB position and 35 zeros in the other bit positions. The Format Section will not be modified and the correct number of 36 bit words will be included in the SSP message. Note that the special code will be complemented as SSP data is complemented.

The Format Section also includes an identifier bit designating whether the SSP's data is contained within the SSP bits of the LS data line or within the SSP bits of the TS data line. Within the Format Section, the first sensor format word (so identified in Figure 13) precedes the Time Code (as received) and references the last data bits received.

Figure 13 shows the reconstructed SSP message (after received and stored in a buffer bottom to top). Reading from top to bottom, the ground should command the format section so that all LS data line sensors appear first and then all TS data line sensors. Then the LS data line will contain all special sensor data that can be formatted within its timing boundaries starting from top to bottom. Thus, it is possible to have T designated sensors to have their data appear in the LS data stream. The TS data line will contain special sensor data that has a T bit designation.

4.1.2.1.3.3 DATA

Since the special data message is reversed in the satellite due to the recording process, the ground equipment may be required to store the special data message for processing. Note that every other SSP data bit requires complementing before use (see Figure 13).

4.1.2.1.4 VIDEO

The frame contains 26 smooth video words. TS video samples are digitized to 8 bits resolution and LS video samples are digitized to 6 bits resolution. The most significant bit (MSB) of each word is that bit received first at the interface (V1 of Figure 12). The SDS line contains 1465 video samples. Nadir nominally exists at sample number 733 for L data and at sample number 732.5 for T data as counted from SOSV. Note that any scanner offset will affect the location of nadir. Since there is insufficient space for transition bits within the frame and in order to guarantee a higher average transition density, every other video data bit in a word is complemented. The 2nd, 4th and 6th bits of video are the complement of the true value (see Figure 12). Only actual video words are complemented. 001

4.1.2.1.5 RELATIONSHIP OF VIDEO TO FRAME

Video samples begin in Frame 3 (refer to Figure 14) and end in Frame 59. Frame 3 has 9 video samples. All other frames have a full 26 video samples.

4.1.2.1.6 SCANNER DIRECTION

SDS video is stored in the satellite memory and is read into the satellite recorders such that the alternating scan direction is eliminated.

4.1.2.1.7 SCAN ANGLE OF VIDEO DATA SAMPLES

The SDS video is corrected in the OLS so that data samples correspond to fixed scan angles. The data sampling occurs at a varying sampling frequency of nominally 20.48 kHz. These data samples would occur linearly versus time if the scanner motion were nominal. When scanner motion differs from nominal, the correction places the data samples at the same scan angles as a nominal scanner motion would place them.

The T SDS data is shifted one-half sample toward +Z to allow the sample-hold and A/D converter to be shared by both L and T data.

The scan angle (ϕ) for sample number (Si) is defined as follows:

$$\phi = \phi p * \cos\left(\frac{Si-1}{S_T} * M + B\right) - N * K$$

001

where:

ϕp = peak scan angle = 57.85° = 1.009673 radians

Si = sample number in order received by the tape recorder (SOSV = 1, EOAD = 1465)

S_T = nominal total sample periods = 1464.436

M = 2.6687426 radians

B = 0.2368551 radians for L data
= 0.2359074 radians for T data

N = signed value of scanner offset from subsync frame of data stream. (See paragraph 4.1.2.6.2)

K = 0.0009855 radians

4.1.2.2 SDS LINE FORMAT

The SDS line format is shown in Figure 14.

4.1.2.3 LINE SYNC FRAME FORMAT

The line sync frame format is shown in Figure 15.

Words 3 through 19 are telemetry data with word 20 being the telemetry word count in the LS data stream, while words 3 through 20 are SSP data information in the TS data stream. Words 21 through 27 are the 7 alarm code words. Word 28 is the scanner offset word.

4.1.2.3.1 ALARM CODES

(1) 111110 (0 = LSB of video word)

This alarm code is formatted in the odd-numbered video words starting at word 21. (Refer to Figure 15 for location of alarm codes.)

(2) 000001 (1 = LSB of video word)

This alarm code is formatted in the even numbered video words started at word 22. (Refer to Figure 15 for location of alarm codes.)

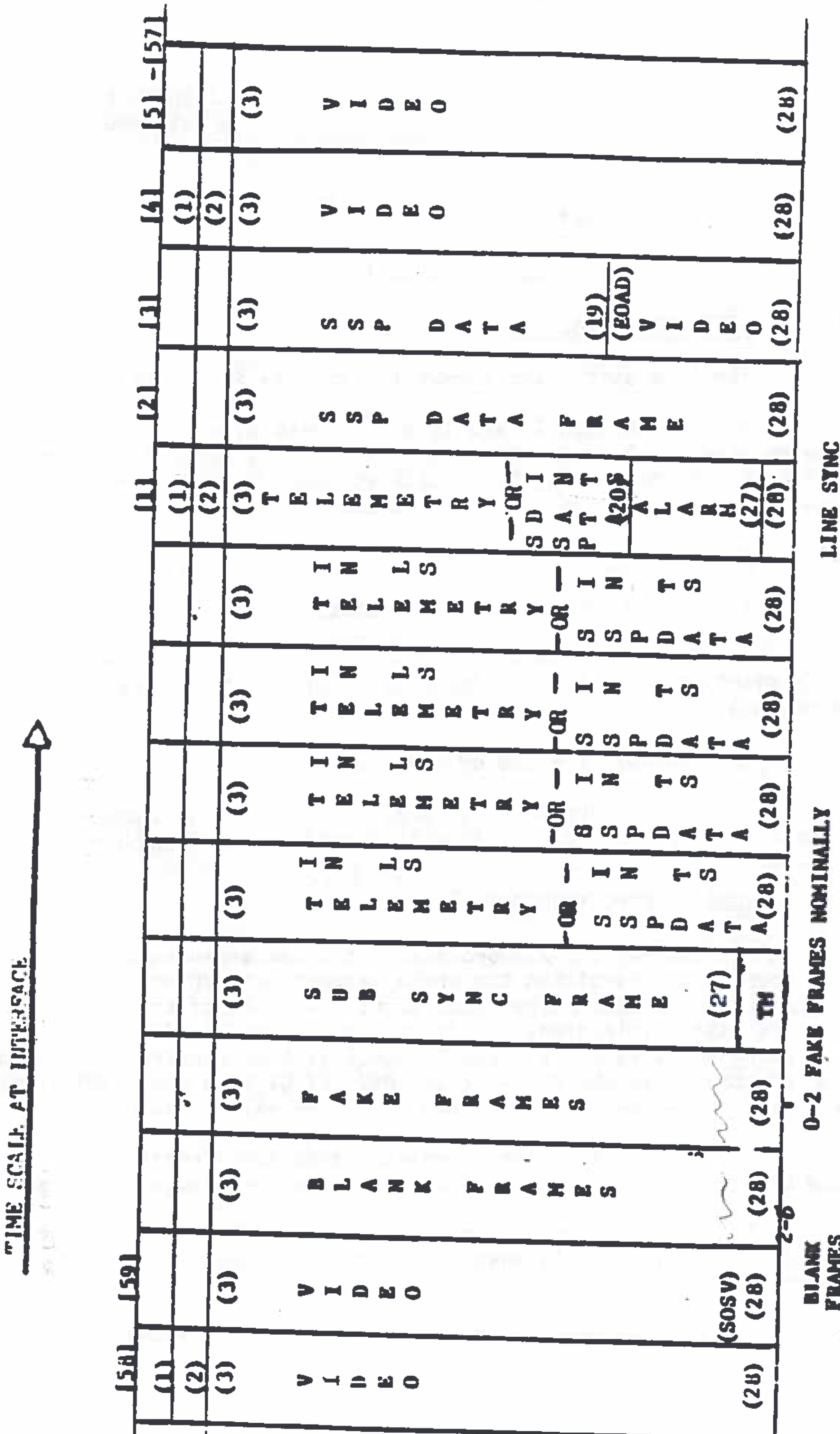
4.1.2.3.2 SCANNER OFFSET WORD

The scanner offset word is a 5 bit number encoded in 2's 001
complement code which identifies the angle between the center of
scan and the sensor +X axis. The least significant bit of the scanner
offset word is .492 milliradians. Referring to Figure 15, if Q1 is a
zero, indicating positive offset, and Q2Q3Q4Q5 is some nonzero value then 001
the center of scan is in the +X, -Z quadrant. If Q1 is a one, indicating
negative offset, then the center of scan is in the +X, +Z quadrant.

In the locked encoder simulator mode the scanner offset may change every other scan line and may be non integer. 001

In the normal encoder mode the scanner offset may change once every 2048 scan lines only when permitted by ground command and must be integer.

The encoder mode is indicated in the OLS equipment status telemetry.



NOTES:
1. Frame number in [ ] is referenced to interface timing.
2. Word number within frame is in ( ).

FIGURE 14: SDS LINE FORMAT

BIT 1

TYPICAL 14-BIT TELEMETRY WORD (words 4–5)

1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	C	B	A	word 2
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 3
						T7	T6	T5	T4	T3	T2	T1	word 4
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 5
						T7	T6	T5	T4	T3	T2	T1	word 6
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 7
						T7	T6	T5	T4	T3	T2	T1	word 8
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 9
						T7	T6	T5	T4	T3	T2	T1	word 10
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 11
						T7	T6	T5	T4	T3	T2	T1	word 12
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 13
						T7	T6	T5	T4	T3	T2	T1	word 14
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 15
						T7	T6	T5	T4	T3	T2	T1	word 16
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 17
						T7	T6	T5	T4	T3	T2	T1	word 18
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 19
						N7	N6	N5	N4	N3	N2	N1	word 20
						0	0	1	1	1	1	1	word 21
						0	1	0	0	0	0	0	word 22
						0	0	1	1	1	1	1	word 23
						0	1	0	0	0	0	0	word 24
						0	0	1	1	1	1	1	word 25
						0	1	0	0	0	0	0	word 26
						0	0	1	1	1	1	1	word 27
						Q5	0	0	Q4	Q3	Q2	Q1	word 28

001

001

BIT 208

TAG BITS A	B	C	VIDEO MODE
0	1	1	LS
1	1	1	TS

Telemetry:
T1 = MSB = Last bit in from Spacecraft
.
.
.
T7 = LSB = First bit in from Spacecraft

Scanner Offset:
Q1 = Sign *
Q2 = MSB = 2^2
Q3
Q4
Q5 = LSB = 2^{-1}

*Negative numbers represented as 2's complement

NOTE: Word 20 has the Telemetry Word Count which refers to the next telemetry record to be received.

$N_1 = \begin{cases} 1, & \text{Loss of data} \\ 0, & \text{No loss of data} \end{cases}$

N_2 = MSB
.
.
.
N_7 = LSB

} Number of 14 bit words of next record to be received

Unused bits: 159, 166, 173, 180, 187, 194, 201

001

NOTE COMPLEMENTED TELEMETRY BITS

NOTE: Words three thru twenty contain telemetry data in the LS mode and SSP data in the TS mode

FIGURE 15: SDS LINE SYNC FRAME FORMAT

4.1.2.3.3 SCANNER DIRECTION

The last two bits of word 28 identify the direction of movement of the scanner with respect to the spacecraft +Z axis. Since the alternating scan direction is removed in the satellite memory, these two bits are always 00. (i.e., scanner rotation is always from +Z axis towards the -Z axis.)

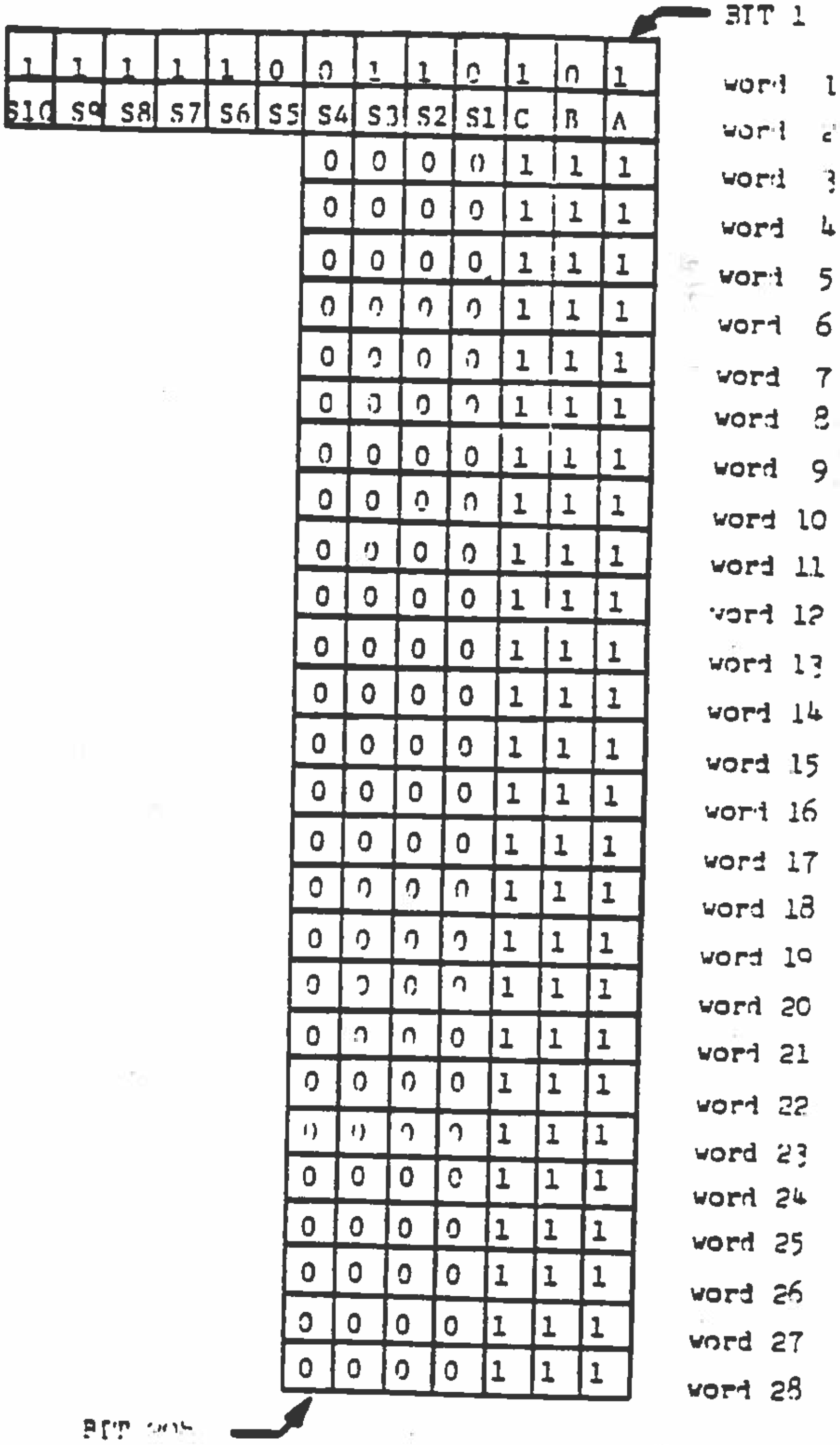
4.1.2.4 BLANK FRAME FORMAT

Blank frames occur during the overscan period of the scanner, when video is not being formatted. There is a variable number of blank frames between the last video frame received and the sub-sync frame. The format for blank frames is shown in Figure 16.

4.1.2.5 Reserved

4.1.2.6 SUB-SYNC FRAME FORMAT

Before the Start of Active Data (SOAD), which is the last video received, there are a variable number of blank frames. Immediately subsequent to these blank frames is a sub-sync frame. This frame is shown in Figure 18 and contains the following data, all of which applies to the video line that has just been received:



1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	C	B	A	word 2
						0	0	0	0	1	1	1	word 3
						0	0	0	0	1	1	1	word 4
						0	0	0	0	1	1	1	word 5
						0	0	0	0	1	1	1	word 6
						0	0	0	0	1	1	1	word 7
						0	0	0	0	1	1	1	word 8
						0	0	0	0	1	1	1	word 9
						0	0	0	0	1	1	1	word 10
						0	0	0	0	1	1	1	word 11
						0	0	0	0	1	1	1	word 12
						0	0	0	0	1	1	1	word 13
						0	0	0	0	1	1	1	word 14
						0	0	0	0	1	1	1	word 15
						0	0	0	0	1	1	1	word 16
						0	0	0	0	1	1	1	word 17
						0	0	0	0	1	1	1	word 18
						0	0	0	0	1	1	1	word 19
						0	0	0	0	1	1	1	word 20
						0	0	0	0	1	1	1	word 21
						0	0	0	0	1	1	1	word 22
						0	0	0	0	1	1	1	word 23
						0	0	0	0	1	1	1	word 24
						0	0	0	0	1	1	1	word 25
						0	0	0	0	1	1	1	word 26
						0	0	0	0	1	1	1	word 27
						0	0	0	0	1	1	1	word 28

FIGURE 16: SDS BLANK FRAME FORMAT

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BIT 1

1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	C	B	A	word 2
						0	1	0	0	0	0	0	word 3
						0	0	1	1	1	1	1	word 4
						0	1	0	0	0	0	0	word 5
						0	0	1	1	1	1	1	word 6
						0	1	0	0	0	0	0	word 7
						0	0	1	1	1	1	1	word 8
						0	1	0	0	0	0	0	word 9
						Q5	0	0	Q4	Q3	Q2	Q1	word 10
						0	E3	E2	E1	0	0	Q6	word 11
						0	E9	E8	E7	E6	E5	E4	word 12
						0	E15	E14	E13	E12	E11	E10	word 13
						0	E21	E20	E19	E18	E17	E16	word 14
						0	E27	E26	E25	E24	E23	E22	word 15
						S	G6	G5	G4	G3	G2	G1	word 16
						S	M3	M2	M1	G9	G8	G7	word 17
						P5	P4	P3	P2	P1	U	M4	word 18
						I4	I3	I2	I1	P8	P7	P6	word 19
						H5	H4	H3	H2	H1	H0	S	word 20
						Y4	Y3	Y2	Y1	H8	H7	H6	word 21
						C5	C4	C3	C2	C1	C0	S	word 22
						Z4	Z3	Z2	Z1	C8	C7	C6	word 23
						Z11	Z10	Z9	Z8	Z7	Z6	Z5	word 24
						Z18	Z17	Z16	Z15	Z14	Z13	Z12	word 25
						Z25	Z24	Z23	Z22	Z21	Z20	Z19	word 26
						Z32	Z31	Z30	Z29	Z28	Z27	Z26	word 27
						S/ T7	S/ T6	S/ T5	S/ T4	S/ T3	S/ T2	S/ T1	word 28

BIT 208

T1 IS THE FIRST
TELEMETRY BIT
RECEIVED

Scanner Offset:
Q1 = Sign* *Negative numbers represented as 2's complement
Q2 = MSB = 2^2
↓
Q6 = LSB = 2^{-2}
Scan Direction = R = 0
U = Predominent Scan direction in video
Time Code:
E1 = MSB = 2^{16} sec.
:
E27 = LSB = 2^{-10} sec.

Gain Code:
G1 = MSB = 32 db
:
G9 = LSB = .125 db
M1 = Lin/Log (0 = lin, 1 = log)
M2-M4 = Sub Mode

Hot T Cal:
H0 = Segment ID (1=LEFT, 0=RIGHT)
H1 = MSB = 2.500 Volts**
:
H8 = LSB = 0.020 Volts **

Cold T Cal:
C0 = Segment ID (1=LEFT, 0=RIGHT)
C1 = MSB = 2.500 Volts**
:
C8 = LSB = 0.020 Volts **

Location Data = Z1-Z32

PMT Cal:
P1 = MSB = 2.500 Volts**
:
P8 = LSB = 0.020 Volts**

Vehicle Identity
I1 = MSB = 2^3
:
I4 = LSB = 2^0

T Channel Gain:
Y1 = MSB = 1.28 db
:
Y4 = LSB = .16 db

S = Spare Bits

**as formatted by
OLS on Satellite

S/T1 - S/T7: TELEMETRY DATA IN LS DATA LINES
SPECIAL DATA IN TS DATA LINES

Unused Bits:
33, 40, 47, 54, 61, 68, 75, 84, 85, 89, 96, 103, 110, 117

FIGURE 18 - SDS SUB-SYNC FRAME FORMAT

4.1.2.6.1 ALARM CODES

(1) 000001 as received (1 = LSB of video word)

This alarm code is formatted in words 2, 4, 6, and 8. Refer to Figure 18 for the location of alarm code words.

(2) 111110 as received (0 = LSB of video word)

This alarm code is formatted in words 3, 5, and 7. Refer to Figure 18 for location of alarm code words.

4.1.2.6.2 SCANNER OFFSET WORD

The scanner offset word is a 6 bit number encoded in 2's complement code which identifies the angle between the center of scan and the sensor +X axis. The least significant bit of the scanner offset word is .246 milliradians. Referring to Figure 18, if Q1 is a zero, indicating positive offset, and Q2Q3Q4Q5Q6 is some nonzero value then the center of scan is in the +X, -Z quadrant. If Q1 is a one, indicating negative offset, then the center of scan is in the +X, +Z quadrant. 001 001

In the locked encoder simulator mode the scanner offset may change every other scan line and may be non integer.

In the normal encoder mode the scanner offset may change once every 2048 scan lines only when permitted by ground command and must be integer. 001

The encoder mode is indicated in the OLS equipment status telemetry.

4.1.2.6.3 SCANNER DIRECTION

The 5th and 6th bits of word 10 identify the direction of movement of the scanner with respect to the spacecraft +Z axis. Since the alternating scan direction is removed in the satellite memory, these two bits are always 00. (i.e., the data is as if the actual scanner rotation were from the +Z axis toward the -Z axis). The 2nd bit of word 18 indicates the predominant direction of scanner rotation for the 5 scan lines during which the video in the SDS line was being sampled. 001

The bit is encoded as follows:

ZERO = Predominent actual scanner rotation from the +Z axis towards the -Z axis.

ONE = Predominent actual scanner rotation from the -Z axis towards the +Z axis.

4.1.2.6.4 TIME CODE

Words 10 through 14 define a 27 bit time code. The code is a pure binary number with the least significant bit equal to 1/1024 second. The time code, as inserted into the sub-sync frame, references the nadir crossing (of the fifth scan of the five scans that are averaged together to produce a single SDS line) to an elapsed time counter. The elapsed time counter (which is updated approximately once daily) is a spacecraft clock which provides the reference to spacecraft position and hence gives the ground reference of the data taken at the center of scan of the sensor. 001

4.1.2.6.5 GAIN CODE

Words 15, 16, and 17 contain a 9 bit gain code plus 4 bits to identify the sub-mode being used. Refer to Figure 18 for the location of the gain code. The gain code gives the necessary information required to determine the gain operating status of the visual processing for each scan. The gain value references the gain value for the first sample of actual video of the fifth scan of the five scans that are averaged together to produce a single SDS line. Therefore the gain value will alternate in subsequent sub-sync frames between the gain value used for the 1st video sample of the 5th line at the +Z end and then the gain value used for the 1st video sample of the 5th line at the -Z end. If the gain mode is PGC, then the gain value is the gain for the fifth scan of the five scans that are averaged to form a SDS line. The 4 bits (M1-M4) used to identify the sub-mode are given below:

M1	Mode
0	Gain states in visual processor are linear.
1	Gain states in visual processor are logarithmic.

M2	M3	M4	Mode
0	0	0	UNUSED
0	0	1	ASGC
0	1	0	ATGC
1	0	0	PGC/HRD
1	0	1	PGC/PMT 1/9
1	1	0	PGC/PMT - LOW
1	1	1	PGC/PMT - HIGH
0	1	1	SPARE

The three modes for gain control by the processor are: Along Scan Gain Control (ASGC), Along Track Gain Control (ATGC), and Present Gain Control (PGC). The processor is in only one mode per scan cycle. The mode is commanded from the ground and this mode is set up by the processor during the positive end of scan. 001

4.1.2.6.6 CALIBRATION WORDS

The remaining words contain various calibration signals. These signals are shown in Figure 18. The values for Hot T Cal, Cold T Cal, and PMT Cal are obtained during the +Z end of scan and the -Z end of scan that occur before and after the fourth scan of the five scans that are averaged together to produce a single SDS line. Location data is that complete correlated set of four words that are available at the center of the fifth scan of the five scans that are averaged. 001

(1) Hot T Cal: 8 bits resolution + 1 bit segment I.D.

The Hot T Cal value is updated during each +Z EOS (end of scan) and this value is repeated for the -Z EOS.

(2) Cold T Cal: 8 bits resolution + 1 bit segment I.D.

The Cold T Cal value is updated during each -Z EOS (end of scan) and this value is repeated for the +Z EOS.

The two infrared calibration (T-Cal) words provide the temperatures of the blackbody sources on the sensor). The segment I.D. bit identifies the segment of the T detector being calibrated.

(3) Location Data:

The information contained in the 32 bits designated Z1-Z32 in Figure 18 refers to the parameters used by ground processing to locate the satellite subpoint (longitude, latitude, cosine crossing angle) and those parameters used by the OLS to determine the Along Scan Gain Control (ASGC) mode. Figures 19 and 20 give the content of the Location Data. Included with the location data is a time code (EPHCLK) which references the time of calculation of all the information of the sequence Word 1 thru Word 5 downlinked in the Z1-Z32 bits in SDS. The data will be downlinked as a correlated group in the sequence Word 5 thru Word 1. Due to the input rate of location data from the S/C to the OLS and the five scan averaging in SDS, not every group of five Location Data words transferred to the OLS will appear in the sub-sync frame.

(4) PMT Cal: 8 bits resolution:

The PMt Cal value is updated during each -Z EOS (end of scan) and this value is repeated for the +Z EOS.

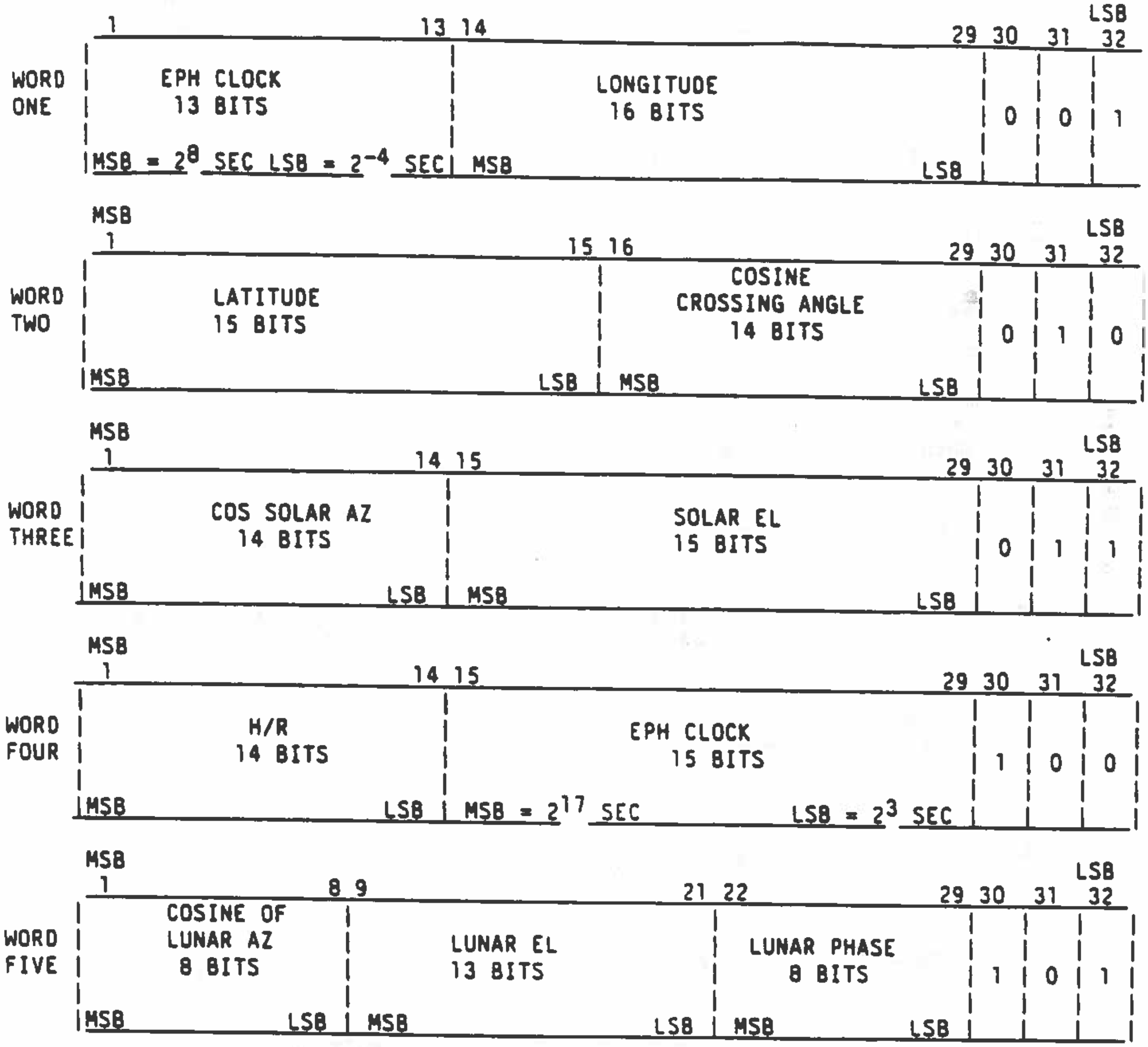
The photomultiplier calibration (PMT Cal) word provides the data from the self-calibration of the PMT on the sensor.

(5) Vehicle Identity: 4 bits resolution.

A unique code to identify each spacecraft will be inserted into the four bits for vehicle identity.

(6) T Channel Gain: 4 bits resolution.

The T Channel gain value is variable to allow compensation for any degradation effects on-orbit since channel adjustment. The Cold T Cal segment I.D. bit identifies the segment of the T channel whose gain is indicated. The T Channel gain for one of the segments is updated at each -Z overscan alternating between the two segments at each update. The indicated segment gain in SDS is the gain in the fifth scan line (SDF data line) of the five scan lines that are averaged to obtain one SDS line.



TAG BITS(Z30-Z32)			CODE
30	31	32	
0	0	0	NO DATA
0	0	1	WORD 1
0	1	0	WORD 2
0	1	1	WORD 3
1	0	0	WORD 4
1	0	1	WORD 5
1	1	0	SPARE
1	1	1	SPARE

FIGURE 19. LOCATION DATA WORDS

Paramter	Units	Sign Bit	Bit Range MSB-LSB
EPH CLK	Seconds	N/A	$2^{17} - 2^{-4}$
Longitude	π Radians	S	$2^{-1} - 2^{-15}$
Latitude	π Radians	S	$2^{-1} - 2^{-14}$
Cosine Crossing Angle	None	S	$2^{-1} - 2^{-13}$
Cosine Solar Azimuth	None	S	$2^{-1} - 2^{-13}$
Solar Elevation	Degrees	S	$2^{6} - 2^{-7}$
h/R	Earth Radii (R = 6378.145 Km)	0	$2^{-3} - 2^{-15}$
Cosine Lunar Azimuth	None	S	$2^{-1} - 2^{-7}$
Lunar Elevation	Degrees	S	$2^{6} - 2^{-5}$
Lunar Phase	Degrees	N/A	$2^{7} - 2^{0}$

S = Sign bit with negative numbers represented as 2's complement.

Figure 20. Location Data Words Content

4.1.2.7 TELEMETRY FRAME FORMAT

The LS line contains slightly over 4 frames of satellite housekeeping telemetry data. Telemetry begins with the last word of the sub-sync frame (as received at the interface) and continues until the Line Sync Frame (see Figure 21). Note that some telemetry bits are complemented for transition density purposes.

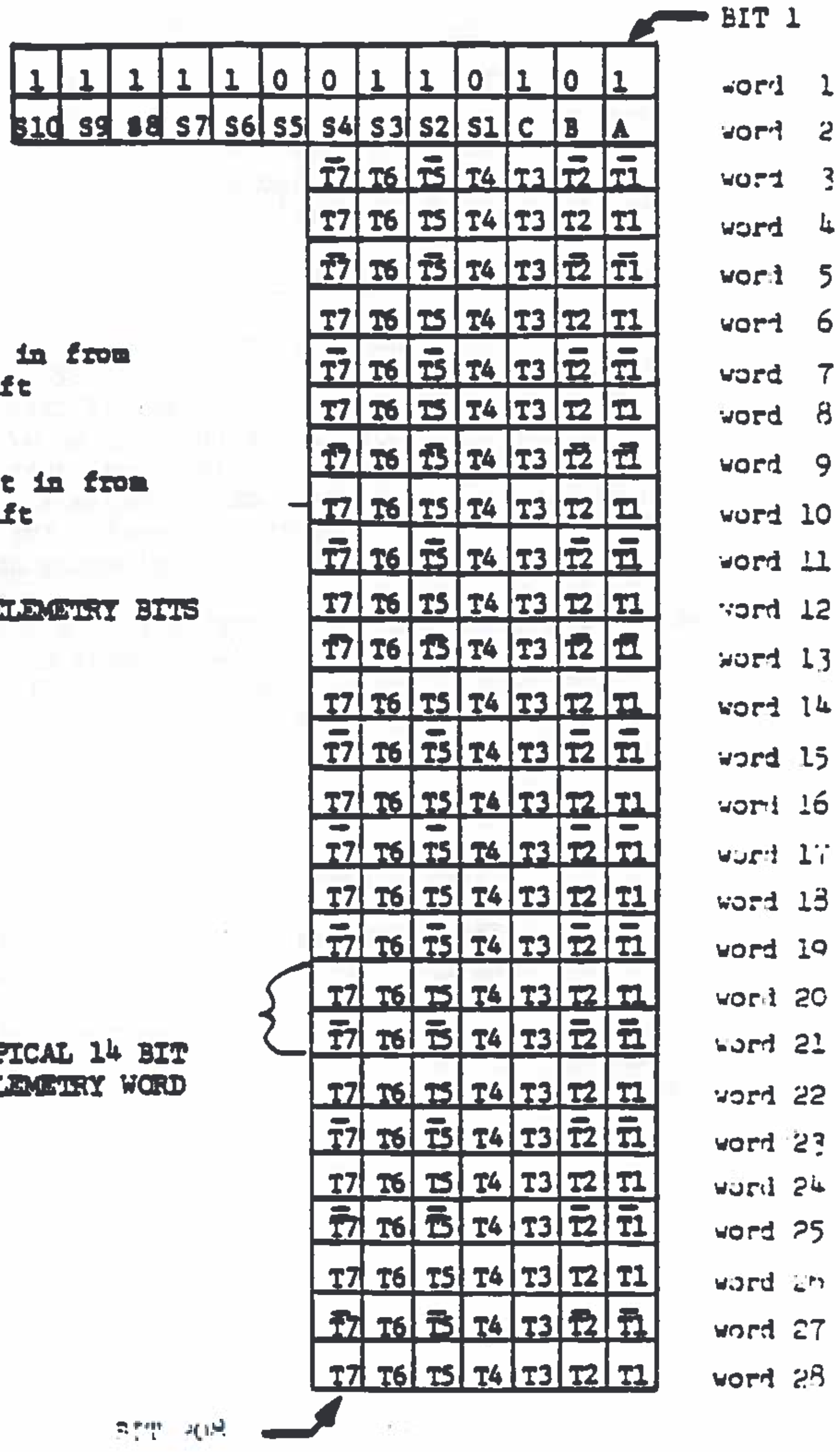
4.1.2.7.1 TELEMETRY RECORD

The telemetry record reconstructed from the telemetry words in the LS line is shown in Figure 22. One spacecraft telemetry word consists of 14 bits. At the end of each received telemetry record is a telemetry word count (bits N1 to N7 of word 20 of the LS Line Sync Frame, Figure 16). The word count refers to the number of valid 14 bit telemetry words contained in the next record. Valid word counts are 0-61 words. N_2 to N_7 contains the word count with the MSB | 001 in N_2. N_1 = 1 indicates that the telemetry data overflowed an OLS buffer and some data has been lost. When an overflow occurs, a new record is started and the N_1 bit is set to logic "1". The word count in N_2-N_7 is not affected. The word count allows ground processing to distinguish new telemetry from old data still in the OLS buffer that has not been overwritten by new telemetry at the time of telemetry transfer into the LS line.

4.1.3 RTD DATA FORMAT

4.1.3.1 FRAME FORMAT

The RTD frame format is shown in Figure 23. The frame is 150 bits long and consists of a 13 bit Frame Sync Code, 1 tag bit, 15 six bit samples of fine data, 3 eight bit samples of smooth data, 6 transition bits, 1 eight bit word for "wow and flutter", and 1 eight bit word for TERDATS data which is implemented for insertion of the DMDM data and SPECIAL data.



1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	C	B	A	word 2
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 3
						T7	T6	T5	T4	T3	T2	T1	word 4
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 5
						T7	T6	T5	T4	T3	T2	T1	word 6
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 7
						T7	T6	T5	T4	T3	T2	T1	word 8
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 9
						T7	T6	T5	T4	T3	T2	T1	word 10
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 11
						T7	T6	T5	T4	T3	T2	T1	word 12
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 13
						T7	T6	T5	T4	T3	T2	T1	word 14
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 15
						T7	T6	T5	T4	T3	T2	T1	word 16
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 17
						T7	T6	T5	T4	T3	T2	T1	word 18
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 19
						T7	T6	T5	T4	T3	T2	T1	word 20
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 21
						T7	T6	T5	T4	T3	T2	T1	word 22
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 23
						T7	T6	T5	T4	T3	T2	T1	word 24
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 25
						T7	T6	T5	T4	T3	T2	T1	word 26
						$\overline{T7}$	T6	$\overline{T5}$	T4	T3	$\overline{T2}$	$\overline{T1}$	word 27
						T7	T6	T5	T4	T3	T2	T1	word 28

Telemetry:

T1 = MSB = Last Bit in from Spacecraft

.

.

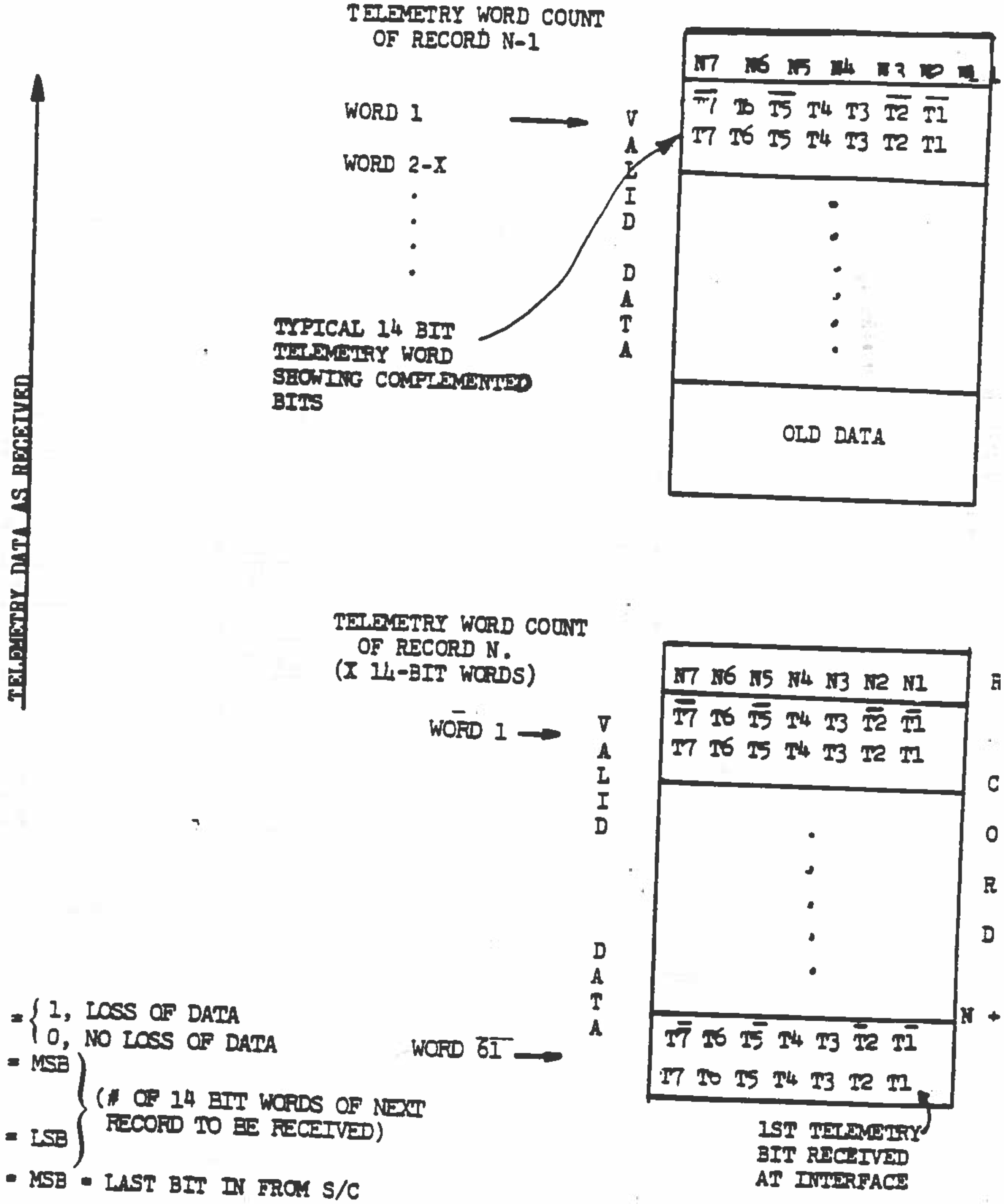
.

T7 = LSB = First Bit in from Spacecraft

NOTE COMPLEMETED TELEMETRY BITS

TYPICAL 14 BIT TELEMETRY WORD

FIGURE 21: SDS TELEMETRY FRAME FORMAT



$N_1 = \begin{cases} 1, \text{ LOSS OF DATA} \\ 0, \text{ NO LOSS OF DATA} \end{cases}$

N_2 = MSB
.
.
N_7 = LSB

(# OF 14 BIT WORDS OF NEXT RECORD TO BE RECEIVED)

T1 = MSB = LAST BIT IN FROM S/C
.
.
T7 = LSB = FIRST BIT IN FROM S/C.

NOTE: ALL TELEMETRY WORDS ARE 14 BITS LONG

FIGURE 22: TELEMETRY RECORD

BIT 1

Z	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
						S2	S1	F6	F5	F4	F3	F2	F1	word 2
						S4	S3	F6	F5	F4	F3	F2	F1	word 3
						S6	S5	F6	F5	F4	F3	F2	F1	word 4
						S8	S7	F6	F5	F4	F3	F2	F1	word 5
						T2	T2	F6	F5	F4	F3	F2	F1	word 6
						S2	S1	F6	F5	F4	F3	F2	F1	word 7
						S4	S3	F6	F5	F4	F3	F2	F1	word 8
						S6	S5	F6	F5	F4	F3	F2	F1	word 9
						S8	S7	F6	F5	F4	F3	F2	F1	word 10
						T2	T2	F6	F5	F4	F3	F2	F1	word 11
						S2	S1	F6	F5	F4	F3	F2	F1	word 12
						S4	S3	F6	F5	F4	F3	F2	F1	word 13
						S6	S5	F6	F5	F4	F3	F2	F1	word 14
						S8	S7	F6	F5	F4	F3	F2	F1	word 15
						T2	T2	F6	F5	F4	F3	F2	F1	word 16
						W8	W7	W6	W5	W4	W3	W2	W1	word 17
						K2	K1	J6	J5	J4	J3	J2	J1	word 18

BIT 150

TAG BIT	VIDEO	
Z	F1-F6	S1 - S8
0	LF	TS
1	TF	LS

TRANSITION BITS:

T2=COMPLEMENT OF PRECEDING F6 BIT

FINE DATA:
F1=MSB = 2.500 volts
.
.
.
F6=LSB = .078 volts

SMOOTH DATA
S1=MSB = 2.500 volts
.
.
.
S8 =LSB = .019 volts

"WOW/FLUTTER":
W1=MSB=2^7
.
.
.
W8=LSB= 2^0

TERDATS DATA TYPE:

K1	K2	DATA
0	0	NO DATA
0	1	DM DM
1	0	SSP DATA
1	1	UNUSED

TERDATS DATA:
J1=MSB
.
.
.
J6=LSB

FIGURE 23: RTD FRAME FORMAT

4.1.3.1.1 FRAME SYNC CODE

The first 13 bits of each frame consist of a frame sync code. This code is 1010110011111 where the leftmost bit is that received first at the interface.

4.1.3.1.2 TAG BIT

The bit immediately after the last bit of the frame sync code is the tag bit (see Figure 23 bit Z). This bit identifies the fine and smooth combination of video in the frame. Video type is as follows:

Tag Bit	Video
0	15 six bit samples of LF 3 eight bit samples of TS
1	15 six bit samples of TF 3 eight bit samples of LS

4.1.3.1.3 VIDEO

The frame contains 15 fine video words, either LF or TF, and 3 smooth video words similar to TS or LS. The fine video samples are of the same resolution as the SDF data. The smooth video samples are derived from the fine video using only analog filtering. Thus the smooth data in the RTD mode is nominally .3 nm along track times 1.5 nm across track (along scan). Each fine sample is digitized to a 6 bit resolution. The most significant bit (MSB) of each fine sample is that bit received first at the interface (e.g., bit 15, 23, 31, . . .). Each smooth sample is digitized to a 8 bit resolution. The most significant bit (MSB) of each smooth sample is that bit received first at the interface (e.g., bit 21, 61, and 101). In order to guarantee a high average transition density, transition bits (T2) are incorporated within the frame structure. The T2 bits (bits 53 and 54; 93 and 94; and 133 and 134) are the complement of the preceding F6 bit. The RTD line contains 1458-1488 samples of smoothed data and 7290-7440 samples of fine data.

Change B
15 Jan 77

4.1.3.1.4 RELATIONSHIP OF VIDEO TO FRAME

In the RTD mode the data is processed and transmitted to the ground as it is generated (i.e., in real time). Note that in the stored modes the same data is buffered and the relationships between the Line Sync Frame and the first video sample are fixed. In the RTD mode, in order to position the video samples accurately, a known reference is provided. In both the Line Sync and Sub-Sync frames a code is inserted to identify the bit in the previous frame at which time coincidence occurred with the start (end) of active video at ± 56.41° on the scanner, relative to nadir. 001

4.1.3.1.5 PHASE RELATIONSHIP OF VIDEO TO FRAME

In order to re-constitute the video signal with the proper phase relationship to the Line Sync pulse, the sampling delays of each fine and smooth sample are given in Figure 24.

4.1.3.1.6 SCANNER DIRECTION

Since RTD data is not stored on a recorder the data is received in the same sequence of alternating directions as the data is produced. Note that the RTD formatter on the satellite arranges the frame bit pattern such that the frame sync code is received exactly as in the stored modes.

001

4.1.3.1.7 SCAN ANGLE OF VIDEO DATA SAMPLES

The RTD video data is not corrected in the OLS so that data samples do not correspond to fixed scan angles. The data sampling occurs at a fixed sampling frequency of 102.4 kHz. Ground correction of video data sample placement to eliminate the effects of scanner motion deviations from nominal is possible using the wow flutter information. (See paragraph 4.1.3.6). The wow flutter clock frequency is deviated from its nominal 6023.53 Hz as a direct function of scanner motion deviation from a nominal sine wave of frequency 5.94 Hz and amplitude 57.85 degrees.

The scan angle ($\O$) for any video data sample is defined as follows:

$$\O = (-1)^{D} * \O p * \cos (W*M+B) - N*K$$

where:

D = 0 for RTD DOS 0
1 for RTD DOS 1 00

$\O p$ = peak scan angle = 57.85° = 1.009673 radians

W = number of wow-flutter periods (including fractional periods) between line sync and the video data sample of interest.

M = 0.00619606 radians

B = 0.22332 radians for fine data
0.22115 radians for smooth data

N = signed value of scanner offset from linesync or subsync frame of data stream. (See paragraph 4.1.3.3.3 and paragraph 4.1.3.5.3).

K = 0.0009855 radians

4.1.3.2 RTD LINE FORMAT

The RTD line format is shown in Figure 25.

4.1.3.3 LINE SYNC FRAME FORMAT

The Line Sync Frame format is shown in Figure 26. When the scanner passes through ± 56.41° towards nadir, the OLS stores the bit number (1-150) of the frame being transmitted. This frame is identified as Frame 1 in Figure 25. When the next frame is formatted words 2-13 contain 12 Alarm codes as follows: 001

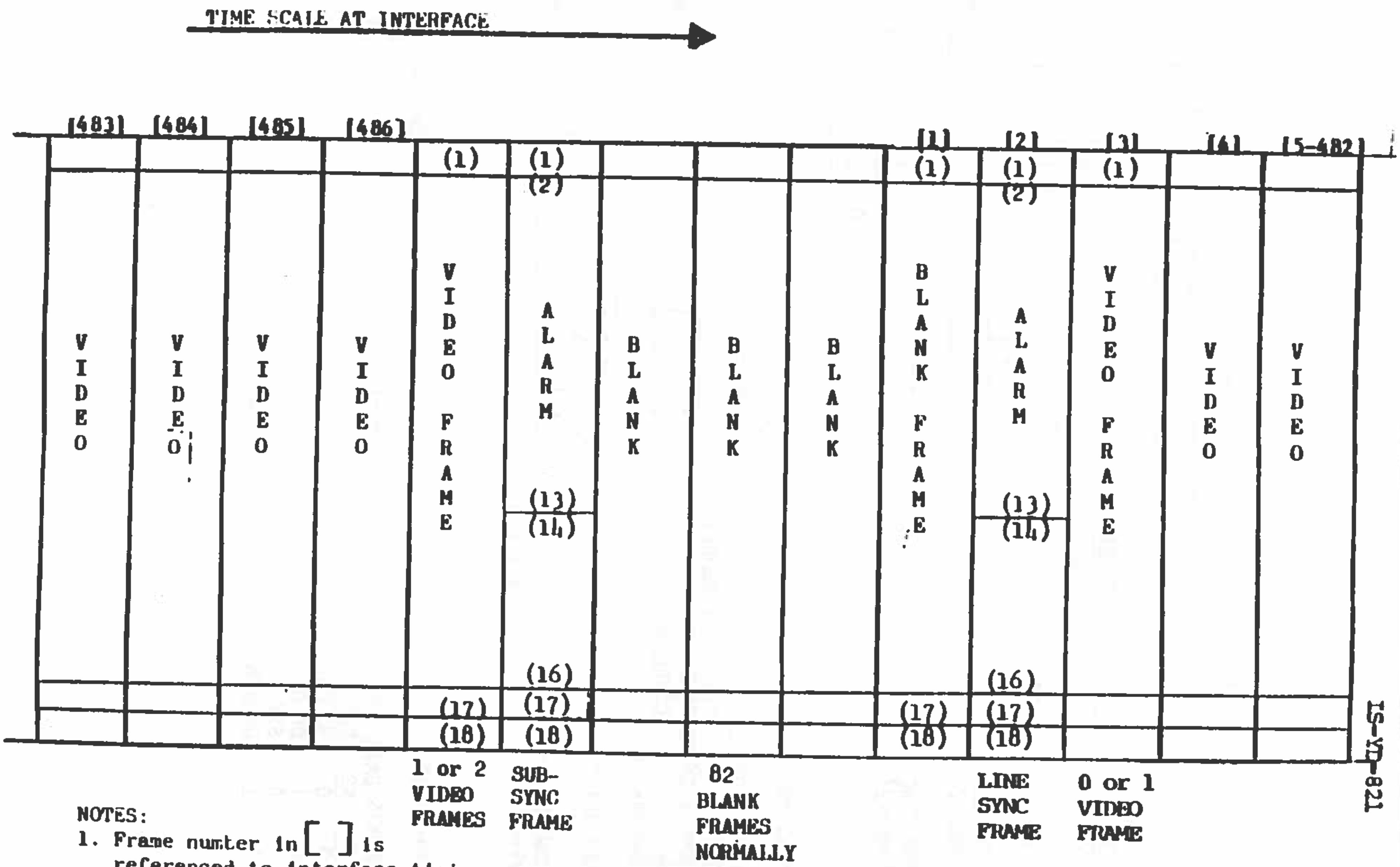
FIGURE 24A: PHASE RELATIONSHIP OF FINE VIDEO TO FRAME

	AVE			OGE
	Start Sample Bit Time Rising Edge	Sample Valid Bit Time Falling Edge		Sample Received Bit Time
Frame N-1	1	3	Frame N	15
	11	13		23
	21	23		31
	31	33		39
	41	43		47
	51	53		55
	61	63		63
	71	73		71
	81	83		79
	91	93		87
	101	103		95
	111	113		103
	121	123		111
	131	133		119
Frame N-1	141	143	Frame N	127
Frame N	1	3	Frame N + 1	15

FIGURE 24B: PHASE RELATIONSHIP OF SMOOTH VIDEO TO FRAME

	AVE			OGE
	Start Sample Bit Time Rising Edge	Sample Valid Bit Time Falling Edge		Sample Received Bit Time
Frame N-1	3	8	Frame N	45
N-1	53	58	N	85
N-1	103	108	N	125
Frame N	3	8	Frame N+1	45

FIGURE 24 : PHASE RELATIONSHIPS OF VIDEO TO FRAME



NOTES:
1. Frame number in [ ] is referenced to interface timing.
2. Word number within frame is in ( ).

BIT 1

Z	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
						1	1	0	1	1	1	1	1	word 2
						1	1	1	0	0	0	0	0	word 3
						1	1	0	1	1	1	1	1	word 4
						1	1	1	0	0	0	0	0	word 5
						1	1	0	1	1	1	1	1	word 6
						1	1	1	0	0	0	0	0	word 7
						1	1	0	1	1	1	1	1	word 8
						1	1	1	0	0	0	0	0	word 9
						1	1	0	1	1	1	1	1	word 10
						1	1	1	0	0	0	0	0	word 11
						1	1	0	1	1	1	1	1	word 12
						1	1	1	0	0	0	0	0	word 13
						0	0	F	E	D	C	B	A	word 14
						0	0	I4	I3	I2	I1	H	G	word 15
						Q6	Q5	R	R	Q4	Q3	Q2	Q1	word 16
						W8	W7	W6	W5	W4	W3	W2	W1	word 17
						K2	K1	J6	J5	J4	J3	J2	J1	word 18

BIT 150

001

TAG BIT	VIDEO	
Z	F1-F6	S1-S8
0	LF	TS
1	TF	LS

ALARM CODE:
WORDS 2-13

LINE SYNC CODE:
A=MSB=2^7
.
.
.
H=LSB=2^0

SCANNER OFFSET:
Q1=SIGN* *NEGATIVE NUMBERS
Q2=MSB=2^2 REPRESENTED AS 2's COMPLEMENT
Q6=LSB=2^{-2}

SCAN DIRECTION=R

"WOW/FLUTTER"
W1=MSB=2^7
.
.
.
W8=LSB=2^0

TERDATS DATA TYPE:

K1	K2	DATA
0	0	NO DATA
0	1	DM DM
1	0	SSP DATA
1	1	UNUSED

TERDATS DATA:
J1=MSB
.
.
.
J6=LSB

Unused Bits:
21, 22, 29, 30, 37, 38, 45, 46, 53, 54, 61, 62, 69, 70, 77, 78, 85, 86, 93, 94, 101, 102, 109, 110, 117, 118, 125, 126

001

FIGURE 26: RTD LINE SYNC FRAME

4.1.3.3.1 ALARM CODES

(1) 111110 (0 = LSB of code)

This alarm code is formatted in the even-numbered words starting at word 2 and ending at word 12 (refer to Figure 26 for location of alarm codes).

(2) 000001 (1 = LSB of code)

This alarm code is formatted in the odd-numbered words starting at word 3 and ending at word 13 (refer to Figure 26 for location of alarm codes).

4.1.3.3.2 LINE SYNC CODE

The Line Sync Code (A-H of words 14 and 15 of Figure 26 is an 8 bit binary number which identifies the bit (1-150) of the previous frame (1) where the line sync pulse occurred. The code is received MSB first (A = MSB = 2^7, H = LSB = 2^0).

4.1.3.3.3 SCANNER OFFSET WORD

The scanner offset word is a 6 bit number encoded in 2's complement code which identifies the angle between the center of scan and the sensor +X axis. The least significant bit of the scanner offset word is .246 milliradians. Referring to Figure 26 if Q1 is a zero, indicating positive offset, and Q2Q3Q4Q5Q6 is some nonzero value then the center of scan is in the +X, -Z quadrant. If Q1 is a one, indicating negative offset, then the center of scan is in the +X, +Z quadrant. 001 001

In the locked encoder simulator mode the scanner offset may change every other scan line and may be non integer. 00

In the normal encoder mode the scanner offset may change once every 2048 scan lines only when permitted by ground command and must be integer.

The encoder mode is indicated in the OLS equipment status telemetry.

4.1.3.3.4 SCANNER DIRECTION

The last two bits of word 16 identify the direction of the actual movement of the scanner with respect to the spacecraft Z axis. Note that the data received at the interface is in the actual scanner direction. Both bits are identical and are encoded as follows:

ZERO = actual scanner rotation from the +Z axis towards the -Z axis

ONE = actual scanner rotation from the -Z axis towards the +Z axis.

4.1.3.4 BLANK FRAME FORMAT

Blank frames occur during the over scan period of the scanner when video is not being formatted between the Line Sync frame and the Sub-Sync frame. The blank frame format is shown in Figure 27.

4.1.3.5 SUB-SYNC FRAME FORMAT

The Sub-Sync frame format is shown in Figure 28. When the scanner passes through +56.41° towards overscan, the OLS stores the bit number (1-150) of the frame being transmitted. The next frame is formatted as the sub-sync frame containing 12 Alarm codes in words 2-13 as follows: 001

4.1.3.5.1 ALARM CODES

(1) 000001 (1= LSB of code)

This alarm code is formatted in the even-numbered words starting at word 2 and ending at word 12 (refer to Figure 28 for location of alarm codes).

(2) 111110 (0 = LSB of code)

This alarm code is formatted in the odd-numbered words starting at word 3 and ending at word 13 (refer to Figure 28 for location of alarm codes).

4.1.3.5.2 SUB-SYNC CODE

The Sub-Sync Code (A-H of words 14 and 15 of Figure 28 is an 8 bit binary number which identifies the bit (1-150) of the previous frame (1) where the sub-sync pulse occurred. The code is received MSB first (A = MSB = 2^7, H = LSB =2^0).

4.1.3.5.3 SCANNER OFFSET WORD

The scanner offset word is a 6 bit number encoded in 2's complement code which identifies the angle between the center of scan and the sensor +X axis. The least significant bit of the scanner offset word is .246 milliradians. Referring to Figure 28, if Q1 is a zero, indicating positive offset, and Q2Q3Q4Q5Q6 is some nonzero value then the center of scan is in the +X, -Z quadrant. If Q1 is a one, indicating negative offset, then the center of scan is in the +X, +Z quadrant. 001 001

In the locked encoder simulator mode the scanner offset may change every other scan line and may be non integer.

In the normal encoder mode the scanner offset may change once every 2048 scan lines, only when permitted by ground command and must be integer. 001

The encoder mode is indicated in the OLS equipment status telemetry.

BIT 1

Z	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
						0	0	0	0	0	0	0	0	word 2
						0	0	0	0	0	0	0	0	word 3
						0	0	0	0	0	0	0	0	word 4
						1	0	0	0	0	0	0	0	word 5
						1	1	0	0	0	0	0	0	word 6
						0	0	0	0	0	0	0	0	word 7
						0	0	0	0	0	0	0	0	word 8
						0	0	0	0	0	0	0	0	word 9
						1	0	0	0	0	0	0	0	word 10
						1	1	0	0	0	0	0	0	word 11
						0	0	0	0	0	0	0	0	word 12
						0	0	0	0	0	0	0	0	word 13
						0	0	0	0	0	0	0	0	word 14
						1	0	0	0	0	0	0	0	word 15
						1	1	0	0	0	0	0	0	word 16
						W8	W7	W6	W5	W4	W3	W2	W1	word 17
						K2	K1	J6	J5	J4	J3	J2	J1	word 18

BIT 150

TAG BIT	VIDEO	
Z	F1-F6	S1-S8
0	LF	TS
1	TF	LS

BLANK CODE:
WORDS 2-16=0's EXCEPT
TRANSITION BITS=1's

"WOW/FLUTTER"
W1=MSB =2^7
.
.
.
W8=LSB=2^0

TERDATS DATA TYPE:

K1	K2	DATA
0	0	NO DATA
0	1	DM DM
1	0	SSP DATA
1	1	UNUSED

TERDATS DATA:
J1=MSB
.
.
.
J6=LSB

FIGURE 27 : RTD BLANK FRAME

BIT 1

Z	1	1	1	1	1	0	0	1	1	0	1	0	1	word 1
						1	1	1	0	0	0	0	0	word 2
						1	1	0	1	1	1	1	1	word 3
						1	1	1	0	0	0	0	0	word 4
						1	1	0	1	1	1	1	1	word 5
						1	1	1	0	0	0	0	0	word 6
						1	1	0	1	1	1	1	1	word 7
						1	1	1	0	0	0	0	0	word 8
						1	1	0	1	1	1	1	1	word 9
						1	1	1	0	0	0	0	0	word 10
						1	1	0	1	1	1	1	1	word 11
						1	1	1	0	0	0	0	0	word 12
						1	1	0	1	1	1	1	1	word 13
						0	0	F	E	D	C	B	A	word 14
						0	0	I4	I3	I2	I1	H	G	word 15
						Q6	Q5	R	R	Q4	Q3	Q2	Q1	word 16
						W8	W7	W6	W5	W4	W3	W2	W1	word 17
						K2	K1	J6	J5	J4	J3	J2	J1	word 18

BIT 150

001

TAG BIT	VIDEO	
Z	F1-F6	S1-S8
0	LF	TS
1	TF	LS

ALARM CODE:
WORDS 2-13

SUB- SYNC CODE:
$A = MSB = 2^7$
.
.
.
$H = LSB = 2^0$

SCANNER OFFSET:
Q1=SIGN* *NEGATIVE NUMBERS REPRESENTED AS 2's COMPLEMENT
$Q2 = MSB = 2^2$
↓
$Q6 = LSB = 2^{-2}$

SCAN DIRECTION=R

"WOW/FLUTTER"
$W1 = MSB = 2^7$
.
.
.
$W8 = LSB = 2^0$

TERDATS DATA TYPE:

K1	K2	DATA
0	0	NO DATA
0	1	DM DM
1	0	SSP DATA
1	1	UNUSED

TERDATS DATA:
J1=MSB
.
.
.
J6=LSB

Unused Bits:
21, 22, 29, 30, 37, 38, 45, 46, 53, 54, 61, 62, 69, 70, 77, 78, 85, 86, 93, 94, 101, 102, 109, 110, 117, 118, 125, 126

001

FIGURE 28: RTD SUB-SYNC FRAME

4.1.3.5.4 SCANNER DIRECTION

The last two bits of word 16 identify the direction of the actual movement of the scanner with respect to the spacecraft Z axis. Note that the data received at the interface is in the actual scanner direction. Both bits are identical and are encoded as follows:

ZERO = actual scanner rotation from the +Z axis towards the -Z axis

ONE = actual scanner rotation from the -Z axis towards the +Z axis

4.1.3.6 WOW/FLUTTER INFORMATION

Word 17 of the RTD frame contains an 8 bit so-called "WOW/FLUTTER" (W/F) code. The W/F code supplies the information required to re-time the occurrence of data samples to conform with actual scanner oscillatory motion. The RTD W/F Frequency is a nominal rate of 6023.53 Hz. When a W/F transition occurs in the OLS, the bit (1-150) of the RTD frame being transmitted is stored. During the next frame a binary number corresponding to that bit is transmitted in the W/F slot of that frame. During any frame where no W/F transition has occurred, the next frame transmitted shall contain the no-transition code of 11110000 (with 1 in the MSB position). The delay from the time when a W/F transition should occur, referenced to the scanner, to when the OLS formats the transition in the frame format is 4-5 microseconds.

4.1.3.7 TERDATS INFORMATION

Word 18 of the RTD frame contains an 8 bit TERDATS (Tertiary Data Stream) word. Bits K1 and K2 identify the type of data contained in J1 - J6 as follows:

K1	K2	Data Type
0	0	No Data
0	1	Direct Mode Data Message (DMDM)
1	0	SSP Data
1	1	Unused

4.1.3.7.1 DIRECT MODE DATA MESSAGE (DMDM)

If there is DMDM information to be transmitted to the ground, that information is inserted only into the J1 - J6 bits of word 18 of the RTD Line Sync Frame as follows:

J	Data
J1 = MSB	1st bit in from the uplinked DMDM
.	.
.	.
.	.
.	.
J6 = LSB	Last bit in from the uplinked DMDM

The DMDM data is encoded as a 6 bit ASCII code shown in Figure 29.

4.1.3.7.2 RTD SPECIAL DATA MESSAGE

A special data message (consisting of data from special meteorological sensors) as transmitted to the ground is inserted into the J1 - J6 bits in the overscan period between the line sync frame and the sub-sync frame including the sub-sync frame and excluding the line sync frame (which has DMDM data).

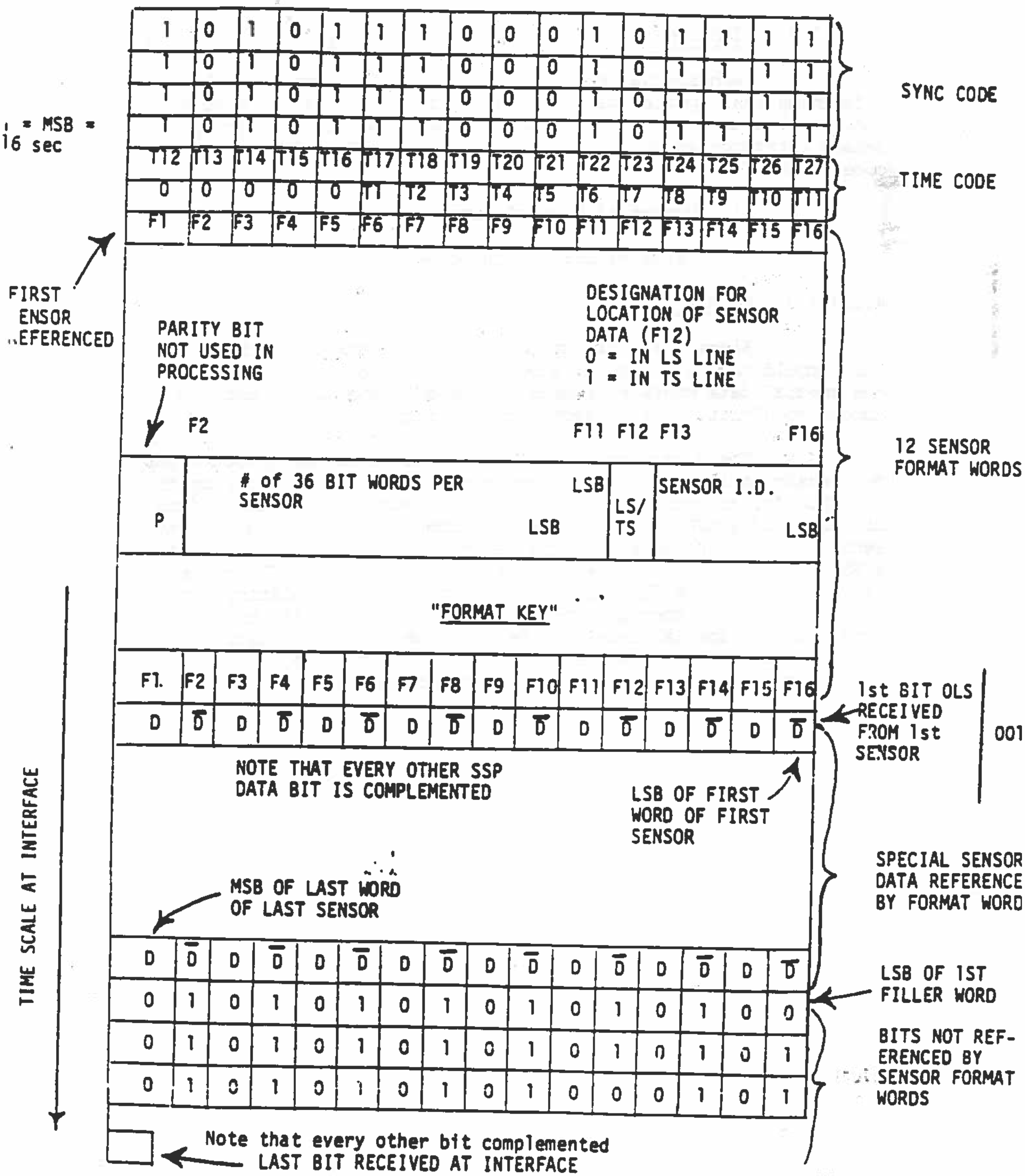
BIT CODE	CHARACTER		
000000	0	@	
000001	1	A	
000010	2	B	
000011	3	C	
000100	4	D	
000101	5	E	
000110	6	F	
000111	7	G	
001000	8	H	
001001	9	I	
001010	10	J	
001011	11	K	
001100	12	L	
001101	13	M	
001110	14	N	
001111	15	O	
010000	16	P	
010001	17	Q	
010010	18	R	
010011	19	S	
010100	20	T	
010101	21	U	
010110	22	V	
010111	23	W	
011000	24	X	
011001	25	Y	
011010	26	Z	
011011	27	[	
011100	28	\	
011101	29	]	
011110	30	↑	
011111	31	←	
100000	32	■	
100001	33	!	
100010	34	"	
100011	35	#	
100100	36	$	
100101	37	%	
100110	38	&	
100111	39	'	(apos.)
101000	40	(	
101001	41	)	
101010	42	*	
101011	43	+	
101100	44	,	(comma)
101101	45	-	
101110	46	.	
101111	47	/	
110000	48	0	
110001	49	1	
110010	50	2	
110011	51	3	
110100	52	4	
110101	53	5	
110110	54	6	
110111	55	7	
111000	56	8	
111001	57	9	
111010	58	:	
111011	59	;	
111100	60	<	
111101	61	=	
111110	62	>	
111111	63	?	

Note: The left most bit in the bit code is the MSB, which is J1 if K1K2 = 01.

FIGURE 29 : SIX UNIT ASCII CODE

4.1.3.7.3 SPECIAL DATA

A group of special data words comprises a special data message (see Figure 30). A typical message as received consists of a sync code followed by the time code followed by the data format section followed by the data. The data is formatted in contiguous blocks of sensor data. Note that the first bit after the format section (the right most bit of Figure 30) is complemented and every second bit will be complemented until the beginning of the next block. Each block could contain data from a separate special sensor. Note that the RTD special data will contain the special data in the OLS LS data line format followed by the special data in the TS data line format to the limits of the RTD overscan frames. The SSP data message is reconstructed by storing as received the J1 to J6 bits of each SSP identified TERDATS word. The message is interrogated in the same direction as received for the Sync Code, Time Code, Format Section, and SSP data. The first SSP data bit following the Format Section is the LSB of the first word of the first sensor identified in the Format Section. The bits following the SSP data bits of the reconstructed SSP message are filler bits. The Time Code will change for each new interrogation cycle and the value will differ by 1 ± 0.005 seconds between adjacent SSP records. The format section will refer to all formatted SSP data (up to 5292 bits per second of which 288 bits are used for overhead).



1	0	1	0	1	1	1	0	0	0	1	0	1	1	1	1
1	0	1	0	1	1	1	0	0	0	1	0	1	1	1	1
1	0	1	0	1	1	1	0	0	0	1	0	1	1	1	1
1	0	1	0	1	1	1	0	0	0	1	0	1	1	1	1
T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27
0	0	0	0	0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16

F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$

D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$	D	$\overline{D}$
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	1

FIGURE 30: SSP MESSAGE FORMAT

4.1.3.7.4 TIME CODE

Each special data message includes a time code which references that special data message to the count of the elapsed time counter time coincident with the read clock of the first sensor interrogated for data (see Figure 30). The MSB of the time code is bit T1.

(1) Number of bits of time code = 27

(2) Value of LSB of time code (T27) = 2^{-10} seconds

4.1.3.7.5 FORMAT SECTION

Since there are up to 12 special sensors, each of which could have a different block length, a special word in the special data message is used to identify the sensor and the number of 36 bit words in each block of data.

The format section provides the number of 36 bit words per sensor included in the SSP message. The OLS will interrogate each SSP for an integral number of 36 bit words. The actual data bit count of a SSP will not be known from only knowing the format section, since the sensor's data may not be divisible by 36. If a SSP has properly indicated to the OLS that it is "off" or has "invalid data", the OLS will insert a unique code replacing the SSP's data. That special code is a one followed by 35 zeros. Note that the special code will be complemented as SSP data is complemented. The format section will not be modified and the correct number of 36 bit words will be included in the SSP message.