DMSP DATA SPECIFICATIONS

IS-YD-821

REVISION C

28 APRIL 1993

Prepared for

DEFENSE METEOROLOGICAL SATELLITE PROGRAM
HEADQUARTERS SPACE AND MISSILE SYSTEMS CENTER
DEPARTMENT OF THE AIR FORCE
Los Angeles, California 90245

Prepared by

WESTINGHOUSE ELECTRIC CORPORATION
Electronic Systems Group
Space Division
Baltimore, Maryland 21203

AUTHENTICATED BY ____________ (CONTRACTING AGENCY)

DATE 19 NOV 93

APPROVED BY ____________ (CONTRACTOR)

DATE Nov 11 1993

TABLE OF CONTENTS

Add 4.1.4 CFD Data format

GRP21.rco

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (cont'd)

SCN NO.	SCN DATE	PARAGRAPHS AFFECTED	DATE APPROVED

GRP21.rco

EFFECTIVE PAGES

PAGE	DATE	PAGE	DATE	PAGE	DATE
All	28 April 93				

3RP21.rco

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 and/or transmitted real time to remote mobile readout terminals in the RDS (Realtime 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 0.3 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 night-time 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 meteorological sensors.

1.2 INTRODUCTION

Primary mission data recovery sites are POGO, HULA, BOSS, and Site I. 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.

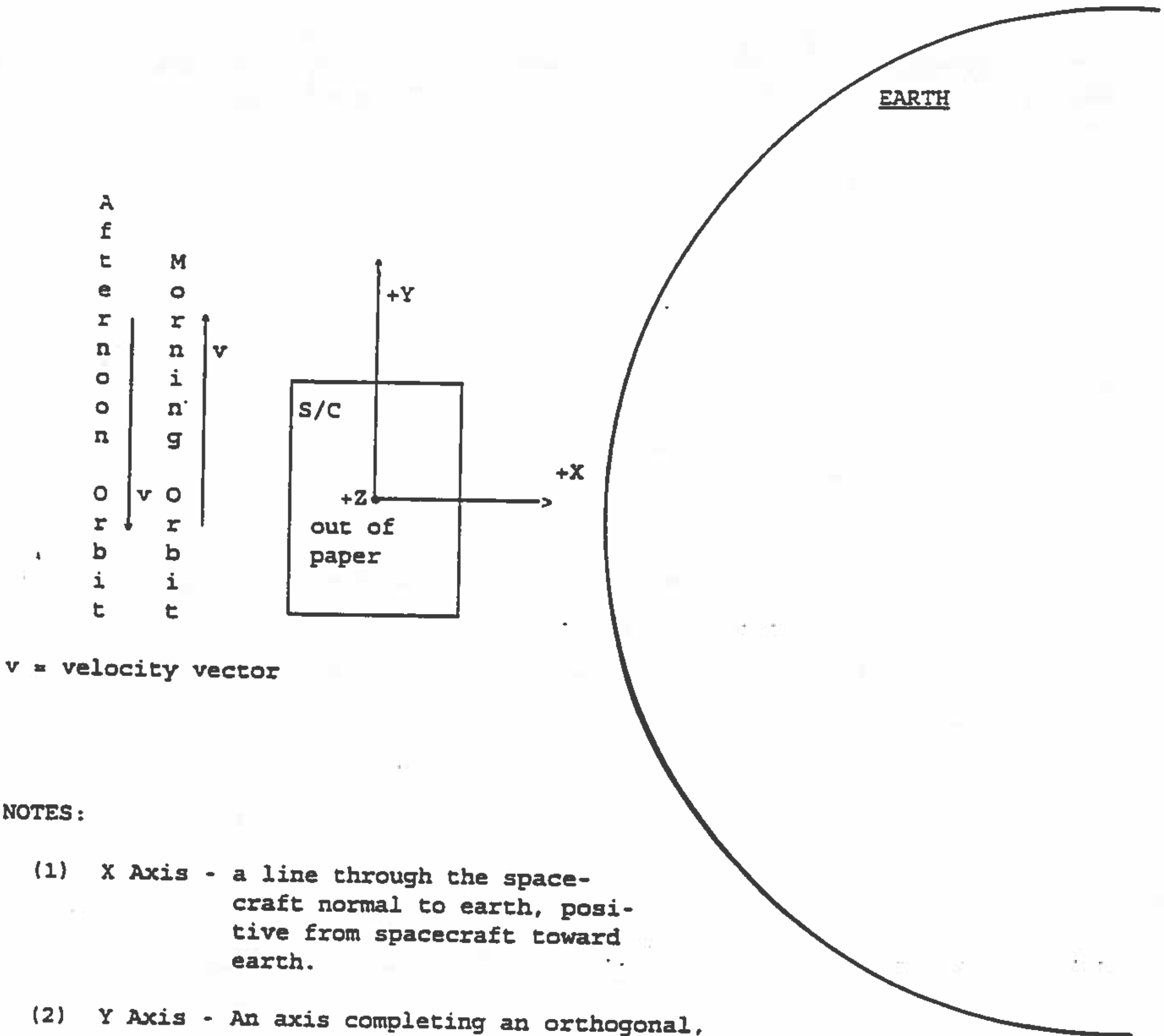
Data stream R for RTD data is as illustrated in this document. The data rate is 1.024 megabits per second. RTD data is transmitted to the ground in the same direction as the data is collected. SDS and SDF data is transmitted to the ground reversed in direction from the direction which the data is collected 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.

Data stream RDS is as illustrated in this document. The data rate is 133.1 kilobits per second (for OLS serial number 12 to 16) or 177.5 kilobits per second (for OLS serial number 17 and up). RDS data is identical in format to SDS data. RDS data is transmitted to the ground in real time (i.e. in the same direction as the data is collected) whereas SDS data is transmitted to the ground reversed in direction from the direction which the data is collected due to storage on satellite tape recorders prior to transmission (the recorders do not rewind prior to playback). The primary recipients of the RDS data stream are mobile remote sites. The RDS data stream consists of bit-by-bit interleaved LS and TS data, mission sensor data, telemetry data, synchronization data, Direct Mode Data Message(DMDM) and calibration data. The RDS data stream (except on OLS 7) shall be encoded with a Rate 1/2 convolutional encoder of constraint length 7, with G0=1111001 and G1=1011011.

Site 4 is the System's Payload Test Facility (PTF) and receives all of the data types (SDS, SDF, RTD and RDS) 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: RESERVED



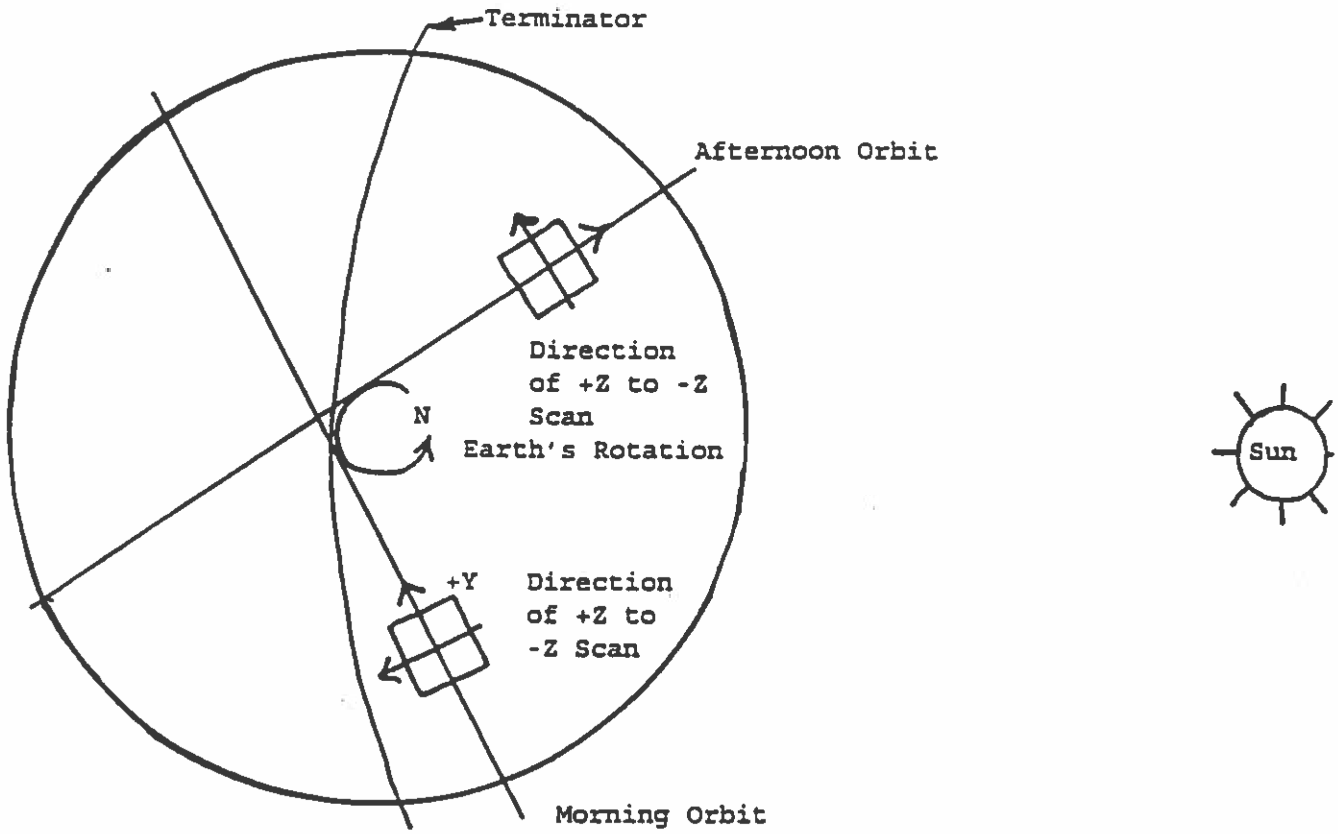
NOTES:

(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)
0	+Z to -Z	RDS (LS & TS)

FIGURE 3: BLOCK 5 SCAN DIRECTION DEFINITION

GRP21.rzo

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.
- RDS — Realtime Data Smoothed. Block 5D direct transmission of interleaved LS and TS data. Same format as SDS.

Data Types:

- LF — Visual Fine Data (L represents Light)
- LS — Visual Smooth Data (L represents Light)
- TF — Infrared Fine Data (T represents Thermal)
- TS — Infared 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	Mission Sensor (formerly Special Sensor Package)
TERDATS	Tertiary Data Stream
TM	Telemetry

3.0 COMPLIANCE INFORMATION

This document represents the data formats for the 5D-2 and 5D-3 models of the Operational Linescan System.

This document establishes the sensor contractual requirements for the data formats for the 5D-2 and 5D-3 models of the Operational Linescan System (OLS).

This document defines agreements reached by the Air Force Program Office (PMO) and the sensor contractor as to the actual data formats that the Sensor Contractor shall insure on the 5D-2 and 5D-3 models 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, SDS, RDS and SDF for the 5D-2 and 5D-3 models 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, RDS, 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, RDS and the SDF by test.

THIS PAGE INTENTIONALLY LEFT BLANK

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, SDS or RDS frame and the RTD frame. Each frame in SDS, RDS 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, RDS, and RTD frames of data. The SDF frame contains either TF or LF video data. The SDS/RDS frame contains either TS or LS video data. The RTD frame contains TF and LS or LF and TS video data. The mission sensor data is present in selected SDS, RDS 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:

BIT 1

C	B	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

BIT 208

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 = LSB = 0.078 Volts

(Note Complemented Video Bits)

**as formatted by OLS on Satellite

FIGURE 4: SDF FRAME FORMAT

GRP21.rco

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_{-0}^{+2} 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_{-0}^{+2} video samples. All other frames have a full 32 video samples.

4.1.1.1.5 LINE DIRECTION

Due to the fact that 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.

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 ($\varnothing$) for sample number (S_i) is defined as follows:

$$\varnothing = (-1)^D * \varnothing_p * \cos([\frac{S_i - 1}{S_T} * M] + B) - N * K$$

where:

D = 0 for SDF DOS 0

= 1 for SDF DOS 1

$\varnothing_p$ = peak scan angle = 57.85° = 1.00967 radians

S_i = sample number in order received by the tape recorder

(SOAD = 1, EOAD = 7322)

S_T = nominal total sample periods = 7322.179

M = 2.66874 radians

B = 0.23665 radians

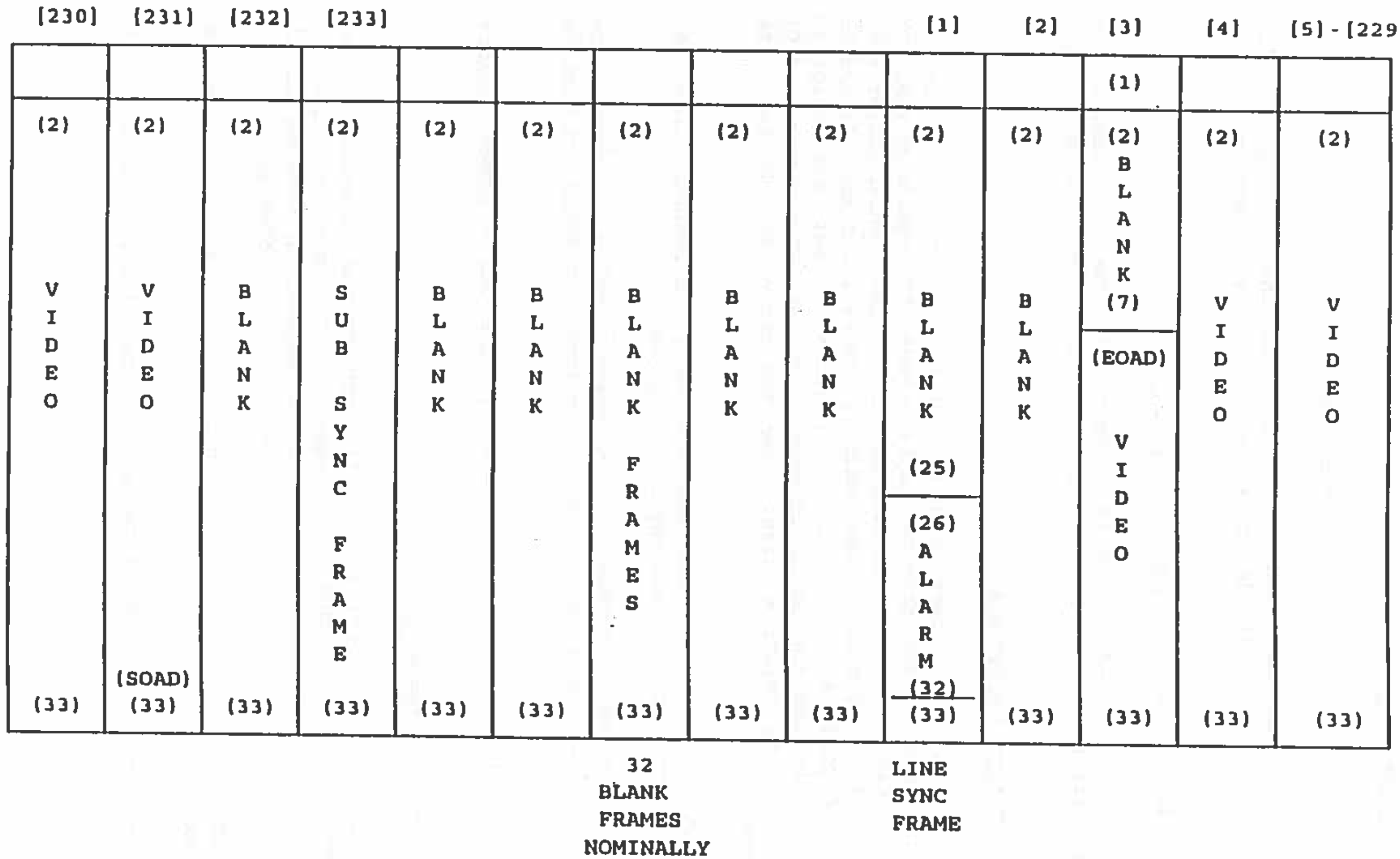
N = signed value of scanner offset in units of value K, from subsync frame of data stream. (see paragraph 4.1.1.6.2)

K = 0.00099 radians

4.1.1.2 SDF LINE FORMAT

The SDF line format is shown in Figure 5.

-------TIME SCALE AT INTERFACE ---->



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).

FIGURE 5: SDF LINE FORMAT

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 2^0 units of value .99 milliradians which is .99 milliradians. Referring to Figure 6, if Q1 is a zero, indicating positive offset, and Q2Q3Q4 is some nonzero value then the center of scan is 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.

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.

BIT 1

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

BIT 208

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 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	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

BIT 1

| C | B | A | 1 | 1 | 1 | 1 | 1 | 0 | 0 | (word 1, continued below) |

Scanner Offset:
Q1 = Sign*
Q2 = MSB = 2^2
:
Q6 = LSB = 2^{-2}

*Negative numbers represented as 2's complement

R = U = Scan Direction 0 = DOS 0, +Z to -Z
1 = DOS 1, -Z to +Z

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

** As formatted by OLS on Satellite

T Channel Gain OLS 8-10:
C0 = Segment ID (1 = Left, 0 = Right)
Y1 = MSB = 1.28 db
:
Y4 = LSB = 0.16 db

T Channel Gain OLS 7,11-16:
C0 = Segment ID (1 = Left, 0 = Right)
Y1 = MSB = 1.85 db
:
Y4 = LSB = 0.23 db

S = Spare Bits

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
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
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
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

FIGURE 9: SDF SUB-SYNC FRAME FORMAT (OLS 7-16)

GRP21.tco

Inner Offset:
- Q1 = Sign*
- Q2 = MSB = 2^{2}
- :
- Q6 = LSB = 2^{-2}

*Negative numbers represented as 2's complement

R = U = Scan Direction
- 0 = DOS 0, +Z to -Z
- 1 = DOS 1, -Z to +Z

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}

** As formatted by OLS on Satellite

T Channel Gain:
- C0 = Segment ID (1 = Left, 0 = Right)
- Y1 = MSB = 2.352 db
- :
- Y5 = LSB = 0.147 db

S = Spare Bits

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
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
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
I2	I1	P8	P7	P6	P5	word 18
H3	H2	H1	H0	I4	I3	word 19
Y1	H8	H7	H6	H5	H4	word 20
C0	S	Y5	Y4	Y3	Y2	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

FIGURE 9a: SDF SUB-SYNC FRAME FORMAT (OLS 17 and up)

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 2^{-2} units of value .99 milliradians, which is .25 milliradians. Referring to Figure 9, 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.

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.

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 towards 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.

4.1.1.6.6 <u>CALIBRATION WORDS</u>

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.

WORD ONE

Bits 1–13 (MSB 1)	Bits 14–29	30	31	32 (LSB)
EPH CLOCK 13 BITS MSB $=2^{8}$ SEC LSB $=2^{-4}$ SEC	LONGITUDE 16 BITS MSB ... LSB	0	0	1

WORD TWO

Bits 1–15 (MSB 1)	Bits 16–29	30	31	32 (LSB)
LATITUDE 15 BITS MSB ... LSB	COSINE CROSSING ANGLE 14 BITS MSB ... LSB	0	1	0

WORD THREE

Bits 1–14 (MSB 1)	Bits 15–29	30	31	32 (LSB)
COS SOLAR AZ 14 BITS MSB ... LSB	SOLAR EL 15 BITS MSB ... LSB	0	1	1

WORD FOUR

Bits 1–14 (MSB 1)	Bits 15–29	30	31	32 (LSB)
H/R 14 BITS MSB ... LSB	EPH CLOCK 15 BITS MSB $= 2^{17}$ SEC LSB $= 2^{3}$ SEC	1	0	0

WORD FIVE

Bits 1–8 (MSB 1)	Bits 9–21	Bits 22–29	30	31	32 (LSB)
COSINE OF LUNAR AZ 8 BITS MSB ... LSB	LUNAR EL 13 BITS MSB ... LSB	LUNAR PHASE 8 BITS MSB ... LSB	1	0	1

TAG BITS (Z30-Z32) 30	31	32	CODE
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

Parameter	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 OLS 7-16;
5 bits resolution OLS 17 and up.

The T Channel Gain value is variable to allow compensation for any degradation effects since channel adjustment. The Cold T Cal segment I.D. bit identifies the segment of the T Channel whose gain is indicated. 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 applies to all video in the four SDF data lines consisting of the DOS 0/DOS 1 line pair whose subsync frames contain the same segment I.D. and the immediately preceding received line pair.

4.1.2 SDS AND RDS DATA FORMAT

4.1.2.1 FRAME FORMAT

The SDS and RDS frame format is shown in Figure 12. The frame is 208 bits long and consists of a Frame Sync Code, 10 bits of mission sensor data, and 26 video words. The SDS and RDS frame is different in structure from the SDF frame. With reference to Figures 12, 15, 16, 18 and 21 Bit 1 is the first bit received at the interface in SDS. In RDS Bit 1 is the last bit received at the interface and Bit 208 is the first bit received at the interface.

4.1.2.1.1 FRAME SYNC CODE

The first 13 bits of each frame consists 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 MISSION SENSOR DATA

Each mission sensor (SSP) outputs data to the OLS. Approximately once per second the mission sensor data are formatted into mission sensor data messages, one for each of the LS and TS line formats. Since the transmission of mission sensor data messages is not synchronized with the line formats, the start of a mission sensor data message can occur anywhere within a TS or LS line format. Each message consists of a 288-bit (8-word) header containing the Sync Code, Time Code and Format Section followed by the mission sensor data.

For OLS 7-16 the message is inserted into the line formats as follows (see Figure 14):

LS: S1-S10 bits of each frame
Bits 27-208 of frame 2
Bits 27-145 of frame 3

TS: S1-S10 bits of each frame
Bits 27-208 of frame 2
Bits 27-145 of frame 3
Bits 202-208 of the sub-sync frame
Bits 27-152 of the line sync frame
Bits 27-208 of the four frames between the sub-sync and line sync frames

For OLS 17-21 the mission sensor data rate is increased by inserting 22 additional SSP frames into the OLS line format and using two of the existing blank frames for mission sensor data (see Figure 14a). Therefore, in addition to the locations specified above, SSP data is also located in bits 27-208 of frames 60-83 in both the LS and TS line formats.

The minimum and maximum message lengths are given in the following table. Proper programming of the Format will use no more than the minimum length to assure valid data.

OLS	LS				TS			
	MIN		MAX		MIN		MAX	
	BITS	WORDS	BITS	WORDS	BITS	WORDS	BITS	WORDS
7-16	2,160	60	2,484	69	3,888	108	5,040	140
17-21	11,412	317	16,092	447	13,140	365	18,684	519

Note that these message lengths include the 288 bits of header. Note also that a mission sensor data message may be of a length which is not an integral number of 36-bit words. The individual mission sensor data formats are defined in ICDs for each sensor.

The mission sensor data message is reconstructed by storing, as received, all the mission sensor data bits contained in the SDS/RDS line format seperately for LS mission sensor data and seperately for TS mission sensor data. As shown in Figure 13, a typical message in SDS, as received, consists of data, followed by a data format section, followed by the time code and sync code. After the mission sensor data bits in SDS have been reconstructed into the message format of Figure 13, the message is interrogated in the direction opposite to that received to obtain the sequence: Sync Code, Time Code, Format Section, and mission sensor data. In RDS, the data is received in the Sync Code first sequence and does not require reversal.

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)

MISSION SENSOR DATA: S1-S10

** as formatted by OLS on Satellite

FIGURE 12: SDS AND RDS FRAME FORMAT

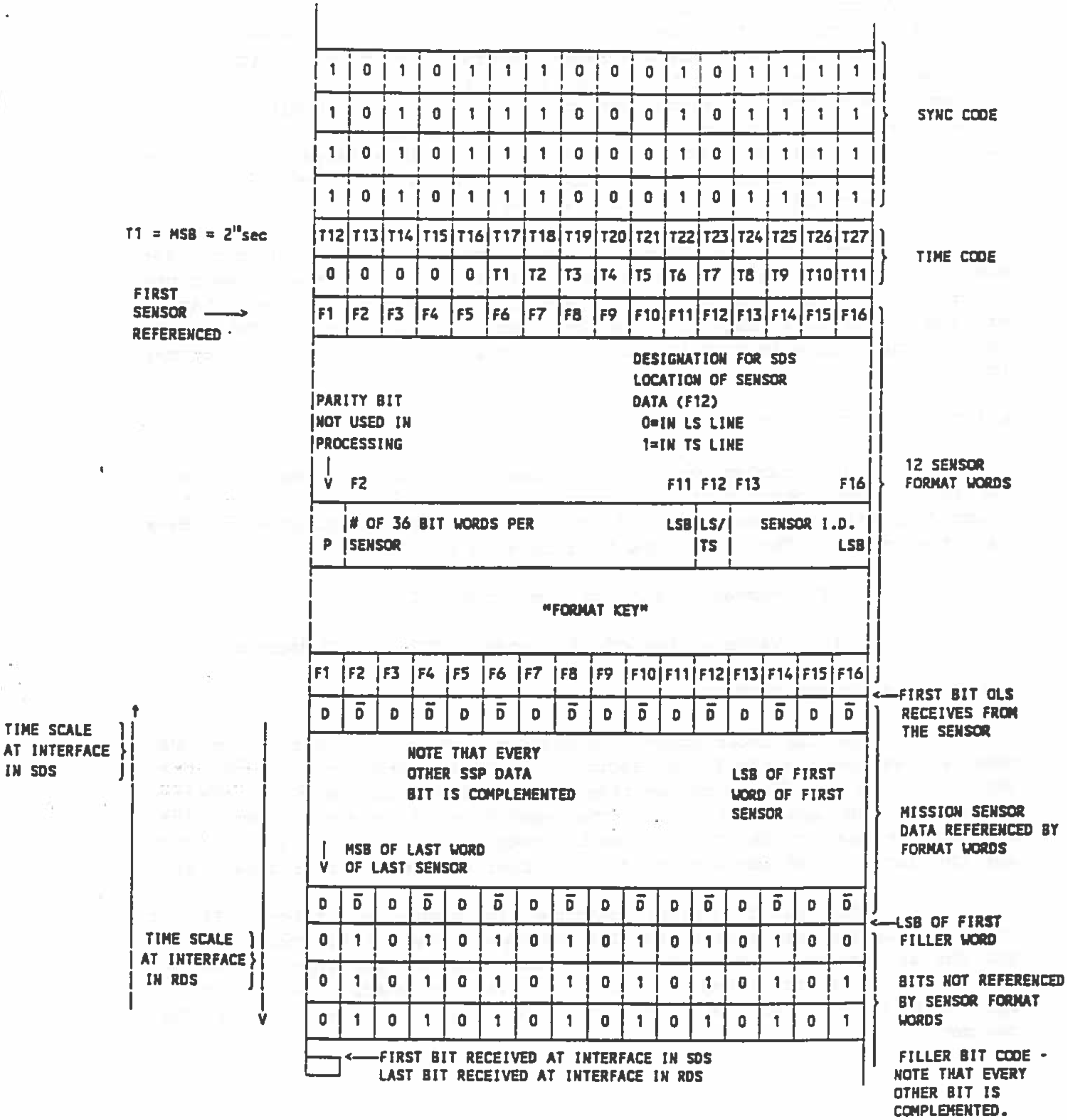


FIGURE 13: SSP MESSAGE FORMAT

The first mission sensor data bit following the Format Section (the right most bit in Figure 13) is the LSB of the first word of the first sensor specified in the Format Section for that data stream (LS or TS). For both LS and TS data streams, every other mission data bit is complemented starting with the first bit after the format section. This bit and every other mission sensor data bit (all odd bits) require recomplementing before data use. The words following the mission sensor data words of the reconstructed mission sensor data message are filler made up of a unique code (filler word) for the TS data stream and of TS mission sensor data for the LS data stream.

The Sync Code, Time Code, and Format Section are identical for each interleaved LS and TS data line. The Time Code changes for each new interrogation cycle; the value differs by 1 ± 0.005 seconds between adjacent mission sensor data messages. The Sync Code does not change. The Format Section can change in both LS and TS by command (however, it is identical in LS and TS).

4.1.2.1.3.1 <u>TIME CODE</u>

Each mission sensor data message includes a time code which references that 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 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 <u>FORMAT SECTION</u>

The OLS interrogates the mission 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. Since there are up to 12 mission sensors on the spacecraft, 12 format words in the mission sensor data message are used to identify for each sensor, the number of 36 bit words, and the location of the sensors data (either in the LS or TS data line).

The Format Section provides the number of integral 36 bit words per sensor included in the SSP message. The OLS interrogates each SSP for an integral number of 36 bit words. If an SSP provides the OLS with data in a non-integral number of 36 bit words, the effect is described as part of the data format definition in the ICD for that sensor.

If an SSP properly indicates to the OLS that it is "off" or has "invalid data", the OLS inserts a unique code replacing the SSP's data. That unique code (filler word) is a one in the LSB position and 35 zeros. The Format Section is not modified and the indicated number of 36 bit words is included in the SSP message. Note that the unique code is 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 at the interface in SDS mode) and references the last data bits received at the interface in SDS mode. Within the Format Section, the first sensor format word (so identified in Figure 13) follows the Time Code (as received at the interface in RDS mode) and references the first data bits received at the interface in RDS mode.

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.

4.1.2.1.3.3 DATA

Since the mission sensor data message is reversed in the satellite due to the recording process (SDS only), the ground equipment may be required to store the mission sensor 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 smoothed 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 and RDS line contains 1465 video samples. Nadir nominally exists at sample number 733 for L data and at sample number 733.5 for T data as counted from SOSV on OLS 7-16. On OLS 17- 21 nadir nominally exists at sample number 733 for L and 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.

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. RDS video is temporarily stored in the satellite memory such that the alternating scan direction is eliminated.

4.1.2.1.7 SCAN ANGLE OF VIDEO DATA SAMPLES

The SDS and RDS video data 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 and RDS data on OLS 7-16 is shifted approximately one-half sample toward +Z to allow the sample-hold and A/D converter to be shared by both L and T data. The T SDS data on OLS 17-21 is coincident with the L SDS data.

The scan angle (ø) for sample number (S_i) is defined as follows:

$$ø = ø_p * \cos([\frac{S_i - 1}{S_T} * M] + B) - N*K$$

where:

$ø_p$ = peak scan angle = 57.85° = 1.00967 radians

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

S_T = nominal total sample periods = 1464.436

M = 2.66874 radians

B = 0.23686 radians for L data on OLS 7-16
= 0.23591 radians for T data on OLS 7-16
B = 0.23686 radians for L and T data on OLS 17-21

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

K = 0.00099 radians

4.1.2.2 SDS AND RDS LINE FORMAT

The SDS and RDS line format is shown in Figure 14 and 14a.

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 starting 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 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 2^{-1} units of value .99 milliradians which is .49 milliradians. Referring to Figure 15, if Q1 is a zero, indicating positive offset, and Q2Q3Q4Q5 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.

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.

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

<------TIME SCALE AT INTERFACE IN RDS------------

-------TIME SCALE AT INTERFACE IN SDS------------>

[58]	[59]							[1]	[2]	[3]	[4]	[5-57]
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
(3) VIDEO	(3) VIDEO SOSV	(3) BLANK	(3) SUB SYNC (27)	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TEL IN LS or SSP DATA IN TS (20)	(3) SSP DATA	(3) SSP DATA (19)	(3) VIDEO	(3) VIDEO
								ALARM (27)		(EOAD) VIDEO		
(28)	(28)	(28)	TM/SSP	(28)	(28)	(28)	(28)	(28)	(28)	(28)	(28)	(28)
		2-5 BLANK FRAMES						LINE SYNC FRAME				

^ TIME SCALE AT INTERFACE IN RDS

TIME SCALE AT INTERFACE IN SDS V

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

FIGURE 14: SDS AND RDS LINE FORMAT OLS 7-16

<------TIME SCALE AT INTERFACE IN RDS------------

-------TIME SCALE AT INTERFACE IN SDS------------>

[58]	[59]	[60-83]							[1]	[2]	[3]	[4]	[5-57]
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
(3) VIDEO	(3) VIDEO SOSV	(3) SSP DATA	(3) BLANK	(3) ALARM (9)	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TELEMETRY IN LS or SSP DATA IN TS	(3) TEL IN LS or SSP DATA IN TS (20)	(3) SSP DATA	(3) SSP DATA (19)	(3) VIDEO	(3) VIDEO
				ANCILLARY (27)					ALARM (27)		(EOAD) VIDEO		
(28)	(28)	(28)	(28)	TM/SSP	(28)	(28)	(28)	(28)	(28)	(28)	(28)	(28)	(28)
			0-4 BLANK FRAMES	SUB SYNC FRAME					LINE SYNC FRAME				

^ TIME SCALE AT INTERFACE IN RDS

TIME SCALE AT INTERFACE IN SDS V

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

FIGURE 14a: SDS AND RDS LINE FORMAT OLS 17-21

GRP21.rco

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

TYPICAL 14 BIT TELEMETRY WORD

$\overline{T7}$	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

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 *   *Negative numbers represented as 2's complement
Q2 = MSB = 2^2
Q3
Q4
Q5 = LSB = 2^{-1}

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   Number of 14 bit words of next record to be received
.
.
.
N_7 = LSB

NOTE COMPLEMENTED TELEMETRY BITS

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

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

FIGURE 15: SDS AND RDS LINE SYNC FRAME FORMAT

4.1.2.3.3 SCANNER DIRECTION

Bits 5 and 6 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 0. (i.e., the data is as if the actual scanner rotation were 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

After the Start of Smoothed Video (SOSV), which is the last video received at the interface in SDS and the first video received at the interface in RDS, 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:

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	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

BIT 208

FIGURE 16: SDS AND RDS BLANK FRAME FORMAT

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	D6	D5	D4	D3	D2	D1	word 16
						D12	D11	D10	M1	D9	D8	D7	word 17
						P5	P4	P3	P2	P1	U	S	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

Scanner Offset:
- Q1 = Sign*
- Q2 = MSB = 2^2
- ↓
- Q6 = LSB = 2^{-2}

*Negative numbers represented as 2's complement

Scan Direction = R = 0

U = Predominent Scan direction in video

Time code:
- E1 = MSB = 2^{16} sec.
- :
- E27 = LSB = 2^{-10} sec.

Direct Mode Data Message:
- D1 = MSB of character i
- D6 = LSB of character i
- D7 = MSB of character i+1
- D12 = LSB of character i+1

M1 = Lin/Log Gain Mode (0 = Lin, 1 = Log)

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

**as formatted by OLS on Satellite

T Channel Gain:
- C0 = Segment ID (1 = Left, 0 = Right)

S = Spare Bits

<u>OLS 8-10:</u>	<u>OLS 7,11-16:</u>
Y1 = MSB = 1.28 db	Y1 = MSB = 1.85 db
:	:
Y4 = LSB = .16 db	Y4 = LSB = .23 db

S/T1 - S/T7: Telemetry Data in LS Data Lines
Mission Sensor Data in TS Data Lines

T1 IS THE FIRST TELEMETRY BIT RECEIVED

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

FIGURE 18: SDS AND RDS SUB-SYNC FRAME FORMAT (OLS 7-16)

Scanner Offset:
- Q1 = Sign*
- Q2 = MSB = 2^2
- :
- Q6 = LSB = 2^{-2}

*Negative numbers represented as 2's complement

Scan Direction = R = 0

U = Predominant Scan direction in video

Time code:
- E1 = MSB = 2^{16} sec.
- :
- E27 = LSB = 2^{-10} sec.

Direct Mode Data Message:
- D1 = MSB of character i
- D6 = LSB of character i
- D7 = MSB of character i+1
- D12 = LSB of character i+1

M1 = Lin/Log Gain Mode (0 = Lin, 1 = Log)

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

**as formatted by OLS on Satellite

T Channel Gain:
- C0 = Segment ID (1 = Left, 0 = Right)
- Y1 = MSB = 2.352 db
- :
- Y5 = LSB = 0.147 db

S = Spare Bits

BIT 1 (upper right of frame); BIT 208 (lower left of frame)

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	D6	D5	D4	D3	D2	D1	word 16
						D12	D11	D10	M1	D9	D8	D7	word 17
						P5	P4	P3	P2	P1	U	S	word 18
						I4	I3	I2	I1	P8	P7	P6	word 19
						H6	H5	H4	H3	H2	H1	H0	word 20
						Y5	Y4	Y3	Y2	Y1	H8	H7	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

S/T1 - S/T7: Telemetry Data in LS Data Lines
Mission Sensor Data in TS Data Lines

T1 IS THE FIRST TELEMETRY BIT RECEIVED

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

FIGURE 18a: SDS AND RDS SUB-SYNC FRAME FORMAT (OLS 17 and up)

GRP21-2.rco

4.1.2.6.1 ALARM CODES

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

This alarm code is formatted in words 3, 5, 7, and 9. 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 word 4, 6, and 8. 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 2^{-2} units of value .99 milliradians, which is .25 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.

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.

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.

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 11 through 15 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/RDS 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.

4.1.2.6.5 GAIN MODE

Word 17 contains a single bit (M1) which identifies the gain amplification mode of the visual processor for each scan. M1 references the gain amplification mode for the first sample of actual video of the fifth scan line of the five scans that are averaged together to produce a single SDS/RDS line. Therefore the gain amplification mode will alternate in subsequent sub-sync frames between the gain amplification mode used for the 1st video sample of the 5th line at the +Z end and then the gain amplification mode used for the 1st video sample of the 5th line at the -Z end.

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

4.1.2.6.6 Direct Mode Data Message (DMDM)

Words 16 and 17 contain 12 bits which define two ASCII characters of the DMDM. Refer to Figures 18 and 18a for the location of the DMDM bits. The DMDM information is inserted into the D1-D12 bits of words 16 and 17 as follows:

D	Data
D1 = MSB	1st bit of character (i) in from the uplinked DMDM
.	
.	
D6 = LSB	Last bit of character (i) in from the uplinked DMDM
D7 = MSB	1st bit of character (i+1) in from the uplinked DMDM
.	
.	
D12 = LSB	Last bit of character (i+1) in from the uplinked DMDM

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

4.1.2.6.7 CALIBRATION WORDS

The remaining words contain various calibration signals. These signals are shown in Figures 18 and 18a. 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/RDS 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.

(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/RDS. 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/RDS, 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 OLS 7-16
5 bits resolution OLS 17 and up.

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 or RDS is the gain in the fifth scan line (SDF data line) of the five scan lines that are averaged to obtain one SDS/RDS line.

	Bits 1–13 (MSB 1)	Bits 14–29	30	31	32 (LSB)
WORD ONE	EPH CLOCK 13 BITS (MSB $=2^8$ SEC, LSB $=2^{-4}$ SEC)	LONGITUDE 16 BITS (MSB … LSB)	0	0	1

	Bits 1–15 (MSB 1)	Bits 16–29	30	31	32 (LSB)
WORD TWO	LATITUDE 15 BITS (MSB … LSB)	COSINE CROSSING ANGLE 14 BITS (MSB … LSB)	0	1	0

	Bits 1–14 (MSB 1)	Bits 15–29	30	31	32 (LSB)
WORD THREE	COS SOLAR AZ 14 BITS (MSB … LSB)	SOLAR EL 15 BITS (MSB … LSB)	0	1	1

	Bits 1–14 (MSB 1)	Bits 15–29	30	31	32 (LSB)
WORD FOUR	H/R 14 BITS (MSB … LSB)	EPH CLOCK 15 BITS (MSB $= 2^{17}$ SEC, LSB $= 2^3$ SEC)	1	0	0

	Bits 1–8 (MSB 1)	Bits 9–21	Bits 22–29	30	31	32 (LSB)
WORD FIVE	COSINE OF LUNAR AZ 8 BITS (MSB … LSB)	LUNAR EL 13 BITS (MSB … LSB)	LUNAR PHASE 8 BITS (MSB … LSB)	1	0	1

TAG BITS (Z30-Z32)

30	31	32	CODE
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

Parameter	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 in SDS) 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 15). 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 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 smoothed 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.

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
						$\overline{T7}$	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

BIT 208

Telemetry:

T1 = MSB = Last bit in from Spacecraft

.

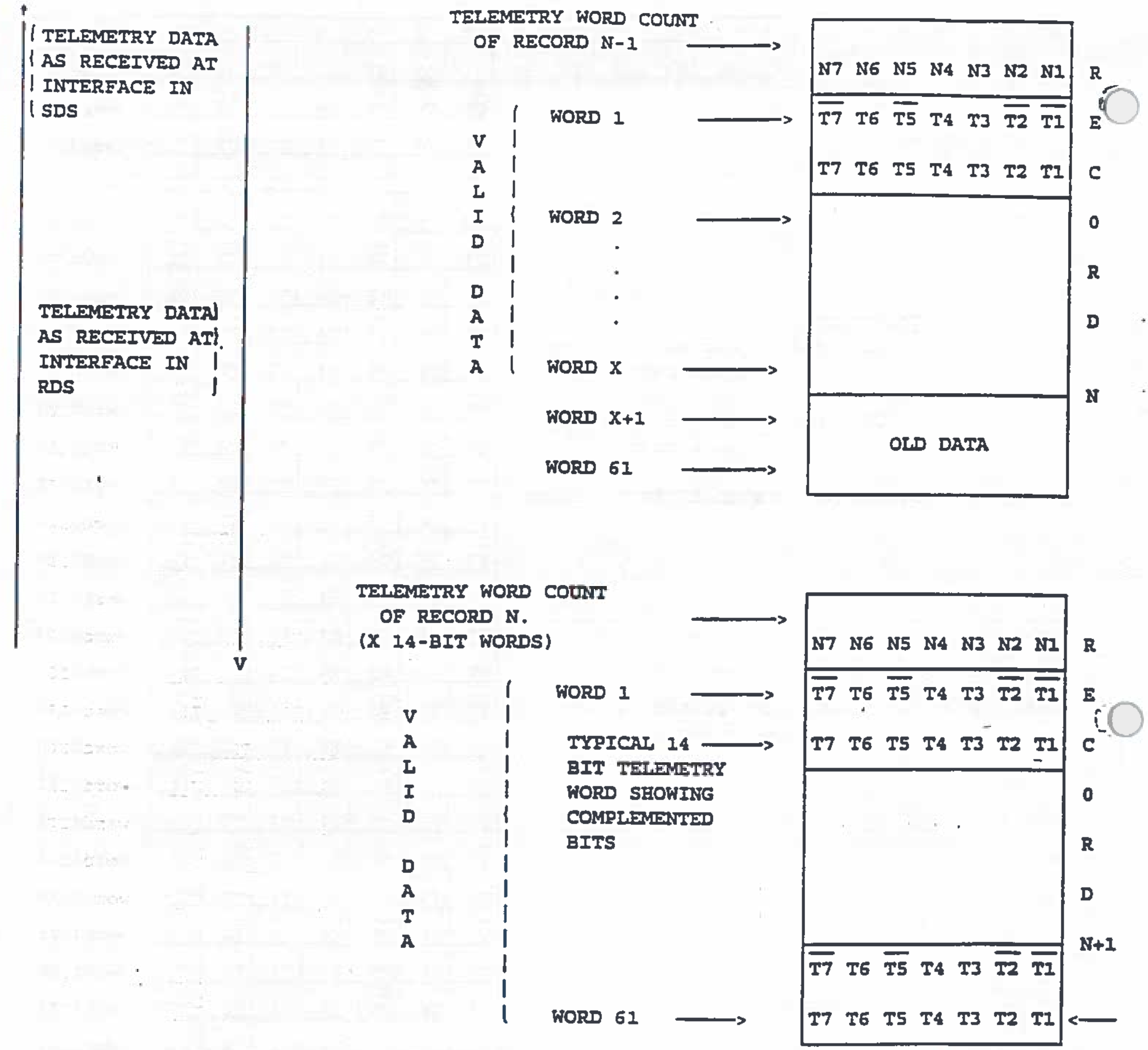
.

T7 = LSB = First bit in from Spacecraft

NOTE COMPLEMENTED TELEMETRY BITS

* TYPICAL 14 BIT TELEMETRY WORD

FIGURE 21: SDS AND RDS TELEMETRY FRAME FORMAT



N_1 = { 1, LOSS OF DATA; 0, NO LOSS OF DATA }

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

SMOOTHED 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	DMDM
1	0	SSP DATA
1	1	UNUSED

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

FIGURE 23: RTD FRAME FORMAT

GRP21-2.rco

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 smoothed 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 smoothed video words similar to TS or LS. The fine video samples are of the same resolution as the SDF data. The smoothed video samples are derived from the fine video using only analog filtering. Thus the smoothed data resolution in the RTD mode is nominally .3 nm along track and 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 smoothed sample is digitized to an 8 bit resolution. The most significant bit (MSB) of each smoothed 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 1452-1500 samples of smoothed data and 7260-7500 samples of fine data.

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 $\pm 56.41°$ on the scanner, relative to nadir.

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 smoothed 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.

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 varying sampling frequency of nominally 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 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 ($\varnothing$) for sample number (S_i) is defined as follows:

$$\varnothing = (-1)^D * \varnothing_p * \cos([W*M]+B) - N*K$$

where:

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

$\varnothing_p$ = peak scan angle = 57.85° = 1.00967 radians

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

M = 0.0061961 radians

B = 0.22310 radians for fine data
= 0.22104 radians for smoothed data

N = signed value of scanner offset, in units of value K, from subsync frame of data stream. (See paragraph 4.1.3.3.3 and paragraph 4.1.3.5.3).

K = 0.00099 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:

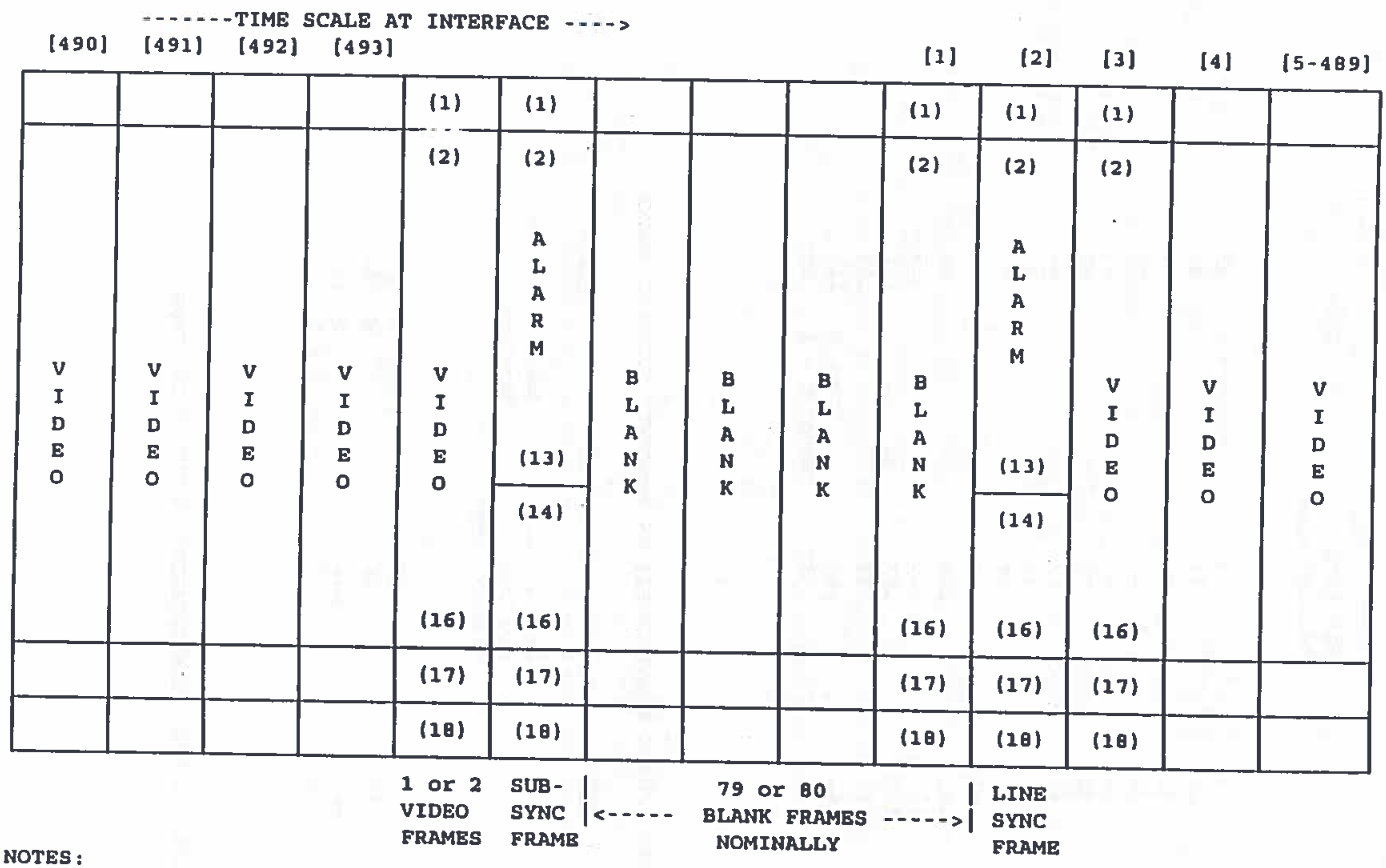
FIGURE 24A: PHASE RELATIONSHIP OF FINE VIDEO TO FRAME

	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 SMOOTHED 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
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 ().
3. This figure represents the nominal line format. Due to 1% frequency deviation (from 5.94 Hz) and maximum amplitude deviation (from 57.85°) of the scanner motion, the total number of blank frames can range from 77 to 84. The total number of video frames can range from 484 to 500. The total number of frames can range from 568 to 581.

FIGURE 5: RTD LINE FORMAT

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
						O	O	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

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 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

VEHICLE IDENTITY
I1=MSB=2^3
.
.
I4=LSB=2^0

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

TERDATS DATA TYPE

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

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

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 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 2^{-2} units of value .99 milliradians, which is .25 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.

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.

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

4.1.3.3.4 SCANNER DIRECTION

Bits 5 and 6 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 toward 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 overscan 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:

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 2^{-2} units of value .99 milliradians, which is .25 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.

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.

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 and Bits
46, 86, & 126 = 1's

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

TERDATS DATA TYPE:

K1	K2	DATA
0	0	NO DATA
0	1	DMDM
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
						O	O	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

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

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

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

VEHICLE IDENTITY:
I1=MSB=2^3
.
.
I4=LSB=2^0

TERDATS DATA TYPE:

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

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

FIGURE 28: RTD SUB-SYNC FRAME

4.1.3.5.4 SCANNER DIRECTION

Bits 5 and 6 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 MISSION SENSOR DATA

Each mission sensor (SSP) outputs data to the OLS. Approximately once per second, the mission sensor data are formatted into a mission sensor data message record and transmitted in the RTD line format. Since the transmission of mission sensor data messages is not synchronized with the line format, the start of a mission sensor data message can occur anywhere within the RTD line format. Each message consists of a 288-bit (8-word) header containing the Sync Code, Time Code and Format Section followed by the mission sensor data.

On OLS 7-16 mission sensor data 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). The OLS mission sensor data buffer capacity (8K) exceeds the maximum available mission sensor bit space per record in the RTD line format over the one second record interval.

On OLS 17-21 the mission sensor data message is inserted into the J1-J6 bits of all required frames except the line sync frame (which has DMDM data). The minimum available mission sensor bit space per record in the RTD line format over the one second record interval exceeds the OLS mission sensor data buffer capacity (32K). The mission sensor data buffer capacity exceeds the mission sensor data message capacity (24.2K) which is constrained by the

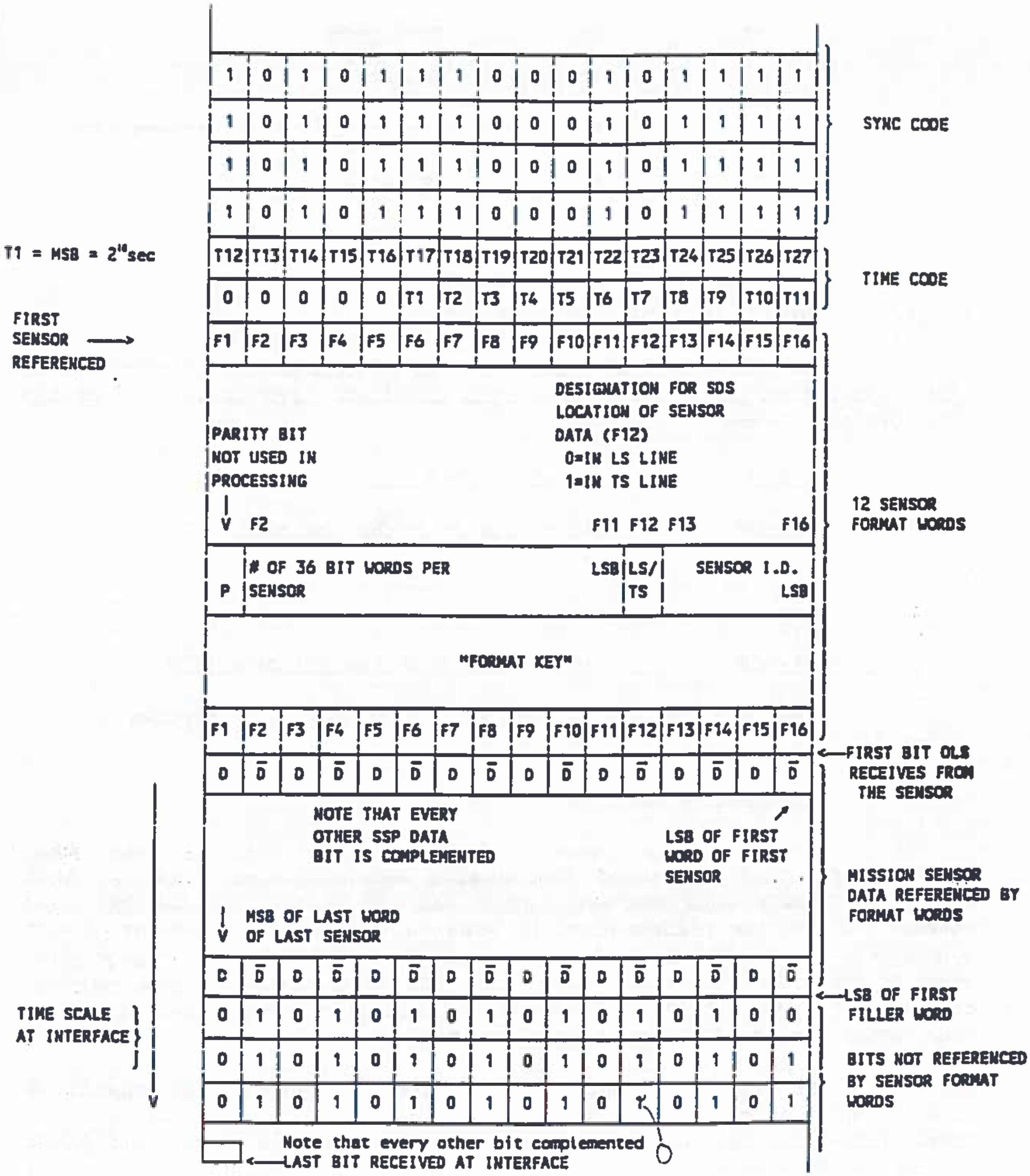


FIGURE 30: SSP MESSAGE FORMAT

4.1.3.7.2.1 TIME CODE

Each mission sensor data message includes a time code which references that 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

4.1.3.7.2.2 FORMAT SECTION

The OLS interrogates the mission sensors in the order they are defined in the Format Section with the first sensor being that which follows the Time Code section. Since there are up to 12 mission sensors, 12 format words in the mission sensor data message are used to identify for each sensor the number of 36 bit words.

The format section provides the number of integral 36 bit words per sensor included in the SSP message. The OLS interrogates each SSP for an integral number of 36 bit words. If an SSP provides the OLS with data in a non-integral number of 36-bit words, the effect is described as part of the data format definition in the ICD for that sensor.

If an SSP properly indicates to the OLS that it is "off" or has "invalid data", the OLS inserts a unique code replacing the SSP's data. That unique code is a one followed by 35 zeros. Note that the unique code is complemented as SSP data is complemented. The format section is not modified and the indicated number of 36 bit words is included in the SSP message.

5.0 RESERVED

6.0 NOTES

Symbols are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.