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630-204

**MAGELLAN
MISSION OPERATIONS SYSTEM-RADAR SYSTEM
INTERFACE REQUIREMENTS
DOCUMENT**

MAY 1987

**NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION**

JPL

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CALIFORNIA INSTITUTE OF TECHNOLOGY
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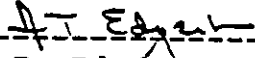
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ACRONYM LIST

ALT	Altimeter
bps	Bits Per Second
CDDS	Command, Data and Data Storage
CDS	Command and Data Subsystem
CMD	Command
DED	Delayed Engineering Data
DN	Data Number
DSB	Data System Bus
DSN	Deep Space Network
EDR	Experiment Data Record
ENGR	Engineering
EU	Engineering Units
HGA	High Gain Antenna
ICD	Interface Control Document
IPP	Interpulse Period
IRD	Interface Requirements Document
JPL	Jet Propulsion Laboratory
Kbps	Kilobits per second
LSB	Least Significant Bit
MGN	Magellan
MOS	Mission Operations System
MSB	Most Significant Bit
PRF	Pulse Repetition Frequency
RAM	Random Access Memory
RCD	Radar Composite Data
RCPF	Radar Control Parameter File
RDPT	Radar Data Processing Team
RG	Range Gate
RET	Radar Engineering Team
RS	Radar System
RTI	Real Time Interrupt
SAB	SAR/Altimeter Burst
SAR	Synthetic Aperture Radar
SCLK	Spacecraft Clock
SCS	Spacecraft System
SCT	Spacecraft Team
SFS	Spacecraft Flight System
SIS	Software Interface Specification
TBD	To Be Determined
TLM	Telemetry

1 INTRODUCTION

1.1 Purpose -

The purpose of this document is to place technical requirements on the interface between the Radar System (RS) and the Mission Operations System (MOS) for the Magellan (MGN) project. This interface includes definitions of the Radar Sensor uplink command and downlink telemetry structure. It is the intent of this document to describe the format of these interfaces and to defer to other sources for the detailed content of the command and telemetry streams. This MOS-RS IRD also includes a list of Radar System related information necessary for MGN Mission Operations.

1.2 Scope -

This document describes the characteristics of the required interfaces between the Radar System and the MOS, and minimizes the discussion of processing and use of the data within the specific systems to that necessary to the interface description. For the purposes of this document, the Radar System is defined as comprising the flight Radar Sensor only; Radar Engineering Team (RET) and Radar Data Processing Team (RDPT) elements and activities which support the Radar System lie on the MOS side of the interface. Information specific to the Spacecraft Flight System (SFS) and not to the Radar System is not included in this document, but may be found in the Spacecraft Flight System - Mission Operations System Interface Requirements Document (PD630-105).

1.3 Approval And Maintenance -

This IRD is an approval code "A" document submitted to JPL for approval. Following approval, changes to the document shall be by change pages unless the extent of the revision necessitates re-publication of the entire document.

2 APPLICABLE DOCUMENTS

The latest MGN project approved issue of the following documents constitute reference material for this IRD. In event of conflict between documents referenced herein and the content of this IRD, the detailed requirements herein shall be considered superceding for this application.

2.1 NASA/JPL Documents -

PD630-52	VRM Information System Plan
PD630-100	VRM Spacecraft System Requirements
PD630-104	Spacecraft System - Radar System IRD
PD630-200	VRM Radar System Requirements
PD630-300	MGN Mission Operations System Design Book
2-100	Uplink Process
2-200	Downlink Process
4-130	Radar Engineering Team
4-170	Radar Data Processing Team
4-230	Radar Engineering Subsystem
4-251	Telemetry Processing Subsystem
4-270	Radar Data Processing Subsystem
SIS-RES-102	Radar Control Parameter File (RCPF) SIS

2.2 Martin Marietta Documents -

VRM-SE-004-014	Spacecraft Flight System - MOS IRD (PD630-105)
VRM-SE-003-010	Spacecraft System - Radar System ICD
VRM-SE-001-002	Spacecraft System and Subsystem Design Book
2-270	Data System Bus
2-280	Telemetry Measurements and Data Format
2-290	Command Structures and Assignments

2.3 Hughes Documents -

956572	JPL Magellan Radar System Full Scale Development Contract
DS32466-101	VRM Radar System Sensor Subsystem Development Specification (CDRL CM002)
DS32466-111	Venus Radar Mapper PRF/Timing Unit Development Specification (CDRL CM002)
DS32466-121	Venus Radar Mapper Data Formatter Unit Development Specification (CDRL CM002)
DS32466-141	Venus Radar Mapper Telemetry and Command Unit Development Specification (CDRL CM002)
HS513-088	VRM Radar System Design Description (CDRL SE014)

3 COMMAND INTERFACE REQUIREMENTS

Ground commanded values representing the radar control parameters shall be supplied by the RET to the Spacecraft Team (SCT) for each upload in the form of a Radar Control Parameter File (RCPF). (The detailed software interface specification for the RCPF is SIS-RES-102.) The radar commands shall be imbedded into the spacecraft command sequence by the SCT, uplinked to the spacecraft and stored in the on-board Command and Data Subsystem (CDS).

3.1 Command Types And Rates -

The spacecraft CDS shall be capable of transferring several types of commands across the Data System Bus (DSB) to the Telemetry and Command unit of the radar sensor for use by other radar units and for possible later inclusion into the radar burst header (see section 4.1.2). In addition, spacecraft timing information and requests for telemetry shall also be passed to the telemetry and command unit across the DSB. The command message types and their descriptions and rates are as follows:

3.1.1 PRF Change Command Message -

The Pulse Repetition Frequency (PRF) change command is used to select radar control parameters so as to maximize good data return. It shall be issued by the CDS in any Real Time Interrupt (RTI), with a maximum rate of issue of one message per five RTIs. A maximum of 950 PRF change messages shall be used to cover a North-South swath combination or a single non-alternating swath. (The CDS zero pads two LSBs onto the 13-bit Burst Period parameter; the resultant 15-bit information, together with the remaining RCPF provided PRF parameter data is transferred from the CDS to the Telemetry and Command unit).

3.1.2 Range Gate Change Command Message -

The Range Gate (RG) change command shall be issued with each PRF change command. In addition, Range Gate change command messages may be issued between PRF change command messages in any RTI, with a maximum of one RG change command message every two RTIs. (The CDS generates RG change commands based upon the RG Flag, Change Magnitude, Value and Update parameter data, provided originally in the RCPF, and passes them to the Telemetry and Command unit.)

3.1.3 Redundancy And State Command Message -

The Redundancy and State commands shall be issued during RTIs 2, 4 or 6, at a maximum rate of one every spacecraft minor frame (10 RTIs). These commands are used to configure the radar sensor into mapping and standby modes as well as to select radar sensor units. A set of five commands is planned for each nominal (i.e. no anomalies) mapping orbit.

3.1.4 Spacecraft Time Message -

The Spacecraft Time shall be passed from the CDS to the radar sensor once every spacecraft minor frame during RTI 8. This information is transferred in addition to the regular radar commands. Spacecraft Time is used by the radar sensor to time tag the radar sensor engineering and science data.

3.1.5 Telemetry Request Message -

The Telemetry Request Message shall be passed from the spacecraft to the radar sensor over the supervisory bus to enable the collection of radar engineering telemetry once every spacecraft minor frame. The radar telemetry shall be collected in RTI 1. The telemetry data shall be sent over the reply bus in response to the Telemetry Request Message.

3.2 Command Message Formats

The following figures detail the command messages at the spacecraft - radar interface. Command messages shall be executed with an accuracy of ± 67 milliseconds with respect to the expected time of periapsis passage in the orbit where the command is issued. (The command message spacecraft - radar interface is specified in the Spacecraft System - Radar System IRD, PD630-104.) The first seven words of each command message and the Spacecraft Time message are CDS control parameters. (The bit resolution of the value fields for each command type is found in Appendix A - Definition of Burst Parameters; conversion expressions relating burst parameter bit values to command parameter "engineering" units are provided in Appendix B - Burst Parameter Conversions.) The first ten words of the Telemetry Request message are the CDS telemetry header information.

Figure 3-1 illustrates the format for the PRF Change command message. The message consists of seventeen (17) ten-bit CDS words at the interface. The individual PRF command information fields are combined into a single message by the CDS. The tenth bit of every word is a parity bit and is not used by the radar sensor. The range of the 7-bit PRFs is 0-127.

Figure 3-2 shows the format for the Range Gate Change command message. The message consists of eight ten-bit CDS words at the interface. The Range Gate messages shall be determined by an on-board CDS algorithm. The tenth bit of every word is a parity bit and is not used by the radar sensor. The range of the 8-bit RGs is 0-255.

Figure 3-3 illustrates the format for the Redundancy and State command message. The message consists of twelve (12) ten-bit CDS words at the interface. The tenth bit of every word is a parity bit and is not used by the radar sensor.

Figure 3-4 shows the format for the Spacecraft Time message. The message consists of thirteen (13) ten-bit CDS words at the interface. The tenth bit of every word is a parity bit and is not used by the radar sensor.

Figure 3-5 illustrates the Radar telemetry reply burst; however the first ten words of the data are provided by the CDS in the Telemetry Request Message.

3.3 CDS Memory Storage Requirements

The CDS shall be capable of storing a minimum of 950 PRF Change command messages for a North-South swath mapping set or one non-alternating mapping swath. These same PRF Change commands shall be issued on every orbit in the sequence load. The PRF Change commands shall be transmitted from Earth as a set (1-950) of eleven (11) byte messages plus a set (1-35) of two-byte messages describing other slowly varying parameters in the PRF message. The CDS shall have the capability to combine the information and to transfer the resultant seventeen (17) byte command across the interface.

The CDS shall store a set of RTI offsets, up to a maximum of 32, to enable the same set of PRF Change commands to be used each orbit in the sequence. This requirement permits the entire sequence load of radar control parameters to be shifted dependent upon the movement of periapsis passage from orbit to orbit, instead of modifying individual PRF Change commands for each mapping pass.

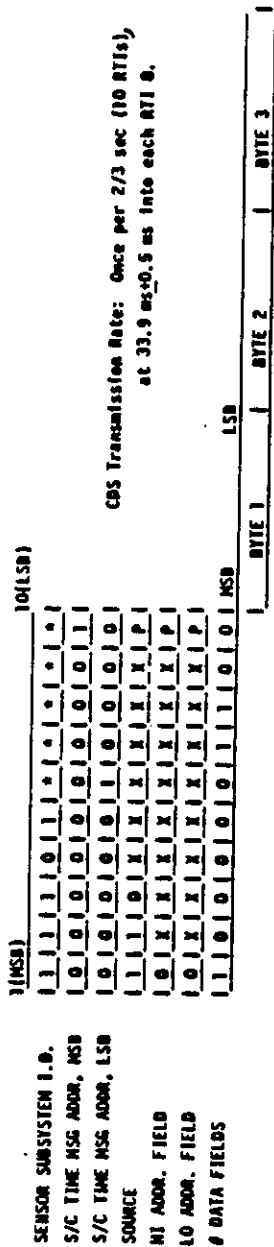
The CDS on-board algorithm responsible for the generation of the large number of Range Gate Change messages shall calculate, format and issue the RG messages from the PRF information at the proper intervals, up to a maximum of one RG Change every 2 RTIs.

3.4 88-Bit Serial Radar Burst Command String

An 88-bit command string format shall exist for communicating changes in radar burst parameters from the Telemetry and Command unit to the PRF/Timing unit.

Figure 3-4 Spacecraft Time Message Format

Spacecraft Time Message Definition
(Bus Format)



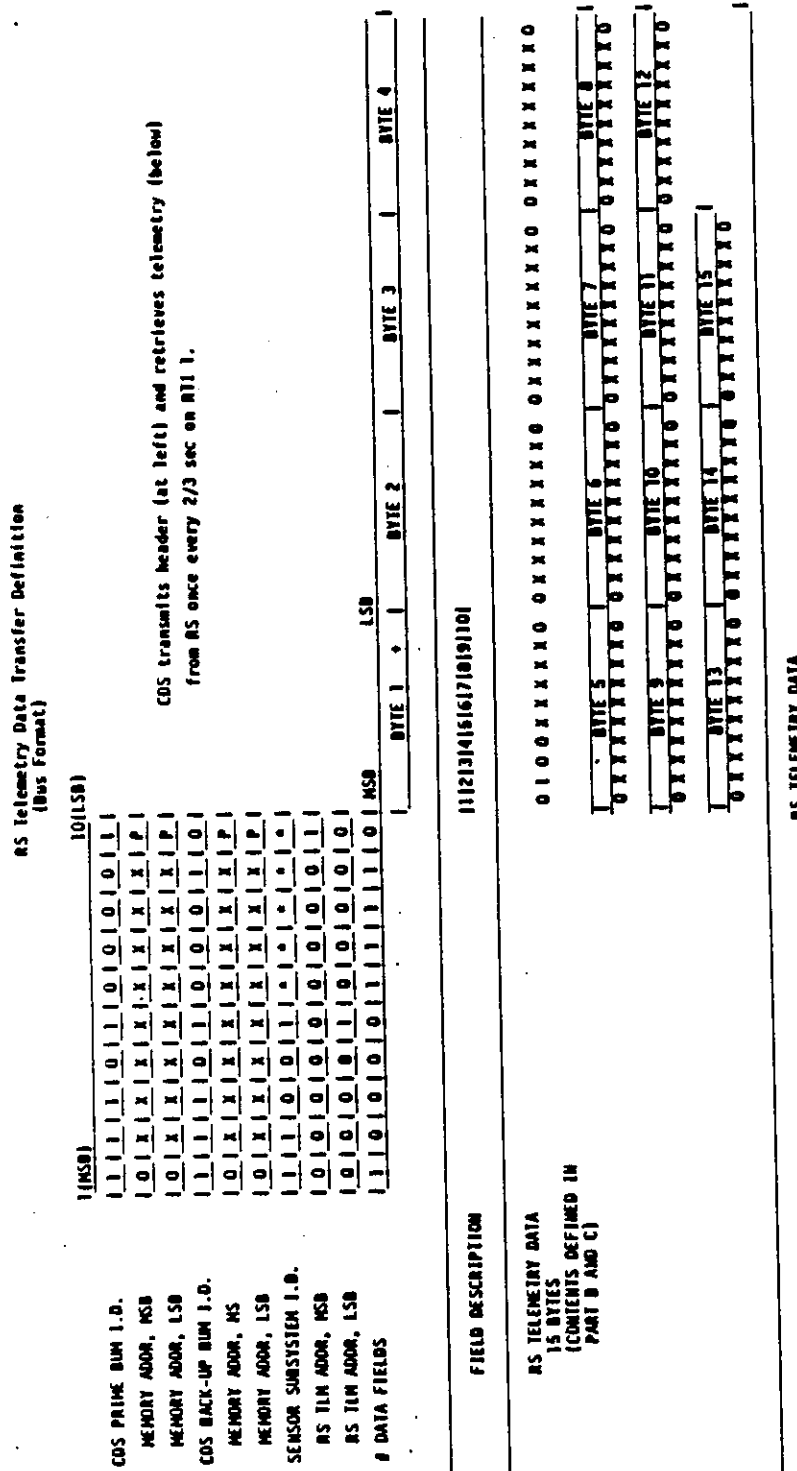
FIELD DESCRIPTION	BYTE 1	BYTE 2	BYTE 3
SPACECRAFT TIME MESSAGE CLOCK ID BYTE (HEX C6) REAL-TIME IMAGE COUNT (RIM)	0110001101	0XXXXXXXXXP	0XXXXXXXXXP
RIM, cont M0001 M0010	0XXXXXXXP	0XXXXXXXXXP	0XXXXXXXXXP

SPACECRAFT TIME MESSAGE

0110 - COMMAND SENT TO SENSOR SUBSYSTEM TELEMETRY AND COMMAND UNIT A
 1001 - COMMAND SENT TO SENSOR SUBSYSTEM TELEMETRY AND COMMAND UNIT B
 P - PARITY, SUPPLIED BY CBS

NOTE: THE SPACECRAFT TIME MESSAGE IS TRANSMITTED MSB FIRST
 EACH FIELD WITHIN THE MESSAGE IS TRANSMITTED MSB FIRST

Figure 3-5 Spacecraft Telemetry Transfer Format



*01110 - COMMAND SENT TO SENSOR SUBSYSTEM TELEMETRY AND COMMAND UNIT A
 *10011 - COMMAND SENT TO SENSOR SUBSYSTEM TELEMETRY AND COMMAND UNIT B
 *P - PARITY, SUPPLIED BY CDS
 *BYTE 1, BITS 5-9 CONTAIN MINOR FRAME I.D., NUMBERED 0 THROUGH 23

• NOTE: THE TELEMETRY DATA MESSAGE IS TRANSMITTED MSB FIRST
 EACH FIELD WITHIN THE MESSAGE IS TRANSMITTED MSB FIRST

The information represented in the 88-bit command string originates in the RCPF and becomes imbedded into the spacecraft command sequence; after uplink to the spacecraft and storage in the CDS, the radar burst parameter information awaits transfer to the radar sensor at the time specified in the RCPF. The CDS shall issue PRF and RG change messages containing the radar burst parameters which are combined by the Telemetry and Command unit into the 88-bit serial command format for transmission to the PRF/Timing unit. A summary of the 88-bit format is presented in table 3-1. (A detailed description of the serial command data is included as Appendix A - Definition of Burst Parameters.) The 88-bit radar burst command string format is separate and different from the uplinked 11-byte PRF Change command information (section 3.3).

3.5 Command Transmission

The Spacecraft and DSN systems shall provide a coded command data stream from the ground to the spacecraft. The decoded command stream as delivered to the radar sensor shall have a command error rate which is less than 0.00001. (Details of the interface from the ground to the spacecraft are contained in the SFS - MOS IRD, PD630-105.) The spacecraft shall be capable of receiving the command sequences for a full North-South, two swath combination, during the nominal non-mapping portion of a single orbit.

Table 3-1 88-Bit Serial Command Data (Burst Parameters)

ITEM	BITS	NAME	DESCRIPTION
1	8	SAR fine resolution	Determines location of SAR range gate within a SAR IPP
2	7	PRF code	Determines desired PRF
3	8	SAR coarse resolution	Determines number of SAR IPPs before reception of first echo
4	8	Range Gate length	Determines length of data collection window within an IPP
5	11	SAR transmit pulses	Determines number of pulses transmitted in a SAR burst
6	9	ALT coarse resolution	Determines number of altimeter clock counts between end of altimeter burst and enabling of altimeter data window
7	15	Burst period	Determines length of burst cycle from cycle start, to the following cycle start (Note: 2 LSBs zero-filled by CDS)
8	6	zero fill	Not used in serial command (These bits are sent in order to maintain command length)
9	5	ESG position	Determines ESG position within a SAR IPP
10	3	Receiver gain- ALT	Sets attenuation of receiver gain for altimeter burst (from 0 to 28 dB in 4 dB steps)
11	3	Receiver gain- SAR	Sets attenuation of receiver gain for SAR burst (from 0 to 28 dB in 4 dB steps)
12	3	Receiver gain - Radiometer	Sets attenuation of receiver gain during radiometer function (from 0 to 28 dB in 4 dB steps)
13	2	Altimeter skip factor	Determines presence of altimeter burst in a burst cycle (range: from every burst to every fourth burst)
88		total bits	

4 TELEMETRY INTERFACE REQUIREMENTS

4.1 Telemetry Types And Rates -

Telemetry from the radar sensor is comprised of both Radar science data and engineering data; the engineering telemetry reports on the health and status of the radar sensor hardware units. The spacecraft CDS shall collect and format the radar and spacecraft telemetry together into composite data frames, complete with time tags. Transmission of these frames to the ground by the spacecraft is described in the Spacecraft Flight System - MOS IRD (PD630-105).

The following sections detail the radar sensor telemetry types, formats and rates to the extent that this composite data stream information is necessary to characterize the interface.

4.1.1 Engineering Telemetry -

The engineering telemetry data consists of analog and bilevel data to provide all information required to determine the state of mode control, power and redundancy switches, as well as to report the actual critical parameter measurements.

The radar sensor engineering telemetry shall be transferred to the spacecraft CDS across the user reply bus lines of the DSB. The format for the radar engineering data messages to the CDS shall be as shown in figure 3-5. The first ten words, which are required by the CDS, shall be sent to the radar sensor over the supervisory bus by the CDS in a Telemetry Request message (see sections 3.1.5 and 3.2).

The radar sensor engineering data shall be arranged into eight bits of information per word. A block of fifteen (15) of these words (i.e. one radar sensor minor frame) shall be transferred to the CDS every tenth RTI, beginning with the first word sync after reception of the first ten data words in the Radar Engineering Telemetry Data message (figure 3-5). This radar sensor engineering data amounts to 120 bits of information every spacecraft minor frame, at a rate of 180 bits per second (bps). The engineering telemetry data are transferred beginning with the sync word of a minor frame; but since the radar sensor engineering data and the spacecraft data are collected asynchronously, the transfer of radar sensor engineering data may not necessarily begin at minor frame one.

Twenty-four (24) minor frames make up one major frame. The position of each radar sensor telemetry point within the major frame is illustrated in figure 4-1. The contents of the "Minor Frame Id" field are defined in the VRM Telemetry and Command Unit Development Specification (DS32466-141); the eight-bit field is of the binary format "100nnnnn" where "nnnnn" counts from "00000" to "10111" (0-23 decimal), corresponding to the 24 minor frames. The radar telemetry

Figure 4-1 Radar Engineering Major Frame Format

WORD NUMBER

EACH ENTRY = 8 bits

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0 MINOR FRAME ID	B1-8	B9-16	B17-24	B25-32	B33-40	P17	P18	T2	V20	P11	P15	P13	I10	T6	
1 MINOR FRAME ID	B41-46 (3 SPARE)	B46-50 (3 SPARE)	B51-56 (2 SPARE)	P19	P20	P18	P18	T3	V21	P12	V2	P17	I11	T7	
2 MINOR FRAME ID	I1	I2	I4	I6	I26	I28	I30	I32	V4	P11	P16	V3	I12	T8	
3 MINOR FRAME ID	I1	I3	I5	I7	I27	I29	I31	I33	V5	P12	V14	V15	I13	T9	
4 MINOR FRAME ID	I8	P1	P3	P5	P7	P9	I34	T4	V20	P11	P15	P14	I14	T10	
5 MINOR FRAME ID	I9	P2	P4	P6	P8	P10	I34	T5	V21	P12	V2	P18	I15	T11	
6 MINOR FRAME ID	B1-8	B9-16	B17-24	B25-32	B33-40	P13	P14	T20	V6	P11	P16	V3	I16	T12	
7 MINOR FRAME ID	B41-46 (3 SPARE)	B46-50 (3 SPARE)	B51-56 (2 SPARE)	P19	P20	P17	P15	T21	V7	P12	V16	V17	I17	V1	
8 MINOR FRAME ID	I1	I2	I4	I6	I26	I28	I30	I32	V20	P11	P15	P13	I18	T1	
9 MINOR FRAME ID	I1	I3	I5	I7	I27	I29	I31	I33	V21	P12	V2	P17	I19	T13	
10 MINOR FRAME ID	I8	P1	P3	P5	P7	P9	P13	T22	V8	P11	P16	V3	I20	T14	
11 MINOR FRAME ID	I9	P2	P4	P6	P8	P10	P14	T23	V9	P12	V14	V15	I21	T15	
12 MINOR FRAME ID	B1-8	B9-16	B17-24	B25-32	B33-40	V22	I34	T2	V20	P11	P15	P14	I22	T16	
13 MINOR FRAME ID	B41-46 (3 SPARE)	B46-50 (3 SPARE)	B51-56 (2 SPARE)	P19	P20	T30	I34	T3	V21	P12	V2	P18	I23	T17	
14 MINOR FRAME ID	I1	I2	I4	I6	I26	I28	I30	I32	V10	P11	P16	V3	I24	T18	
15 MINOR FRAME ID	I1	I3	I5	I7	I27	I29	I31	I33	V11	P12	V16	V17	I25	T19	
16 MINOR FRAME ID	I8	P1	P3	P5	P7	P9	I34	T24	V20	P11	P15	P13	V12	V13	
17 MINOR FRAME ID	I9	P2	P4	P6	P8	P10	I34	T25	V21	P12	V2	P17	V18	V19	
18 MINOR FRAME ID	B1-8	B9-16	B17-24	B25-32	B33-40	P18	P17	T26	V12	P11	P16	V3	V1	V22	
19 MINOR FRAME ID	B41-46 (3 SPARE)	B46-50 (3 SPARE)	B51-56 (2 SPARE)	P19	P20	P13	P14	T27	V13	P12	V14	V15	T1	T30	
20 MINOR FRAME ID	I1	I2	I4	I6	I26	I28	I30	I32	V20	P11	P16	P14	T2	T3	
21 MINOR FRAME ID	I1	I3	I5	I7	I27	I29	I31	I33	V21	P12	V2	P18	V6	V7	
22 MINOR FRAME ID	I8	P1	P3	P5	P7	P9	I34	T28	V18	P11	P16	V3	V8	V9	
23 MINOR FRAME ID	I8	P2	P4	P6	P8	P10	I34	T29	V19	P12	V16	V17	V10	V11	

EACH ENTRY = 8 bits

MAJOR TELEMETRY FRAME FORMAT

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list is presented in table 4-1. The radar sensor engineering telemetry data message shall be inserted by the CDS into the spacecraft engineering frame (800 bits, format as described in SFS - MOS IRD, PD630-105). The radar sensor engineering data shall exist in the downlink telemetry in the following modes:

- 1) Spacecraft real time engineering downlink
- 2) Embedded in the Radar Composite Data (RCD) frame (played back from the spacecraft tape recorder)
- 3) As part of the Delayed Engineering Data (DED) buffer

The maximum transmission link bit error rate shall be less than 0.001, where the link is defined as from the spacecraft through the DSN telemetry stream.

The radar sensor engineering telemetry data shall be extracted from the spacecraft real time telemetry stream and DED buffer on the ground by MOS elements and be provided to the Radar Engineering Team so as to enable real time status evaluation of the radar sensor.

4.1.2 Radar Science Data -

The radar science data consists of Synthetic Aperture Radar (SAR), altimeter and radiometer data. The complete radar data stream as shown in figures 4-2a, 4-2b and 4-2c shall be transferred to the spacecraft by means of the CDS high rate data interface. Figure 4-2a illustrates the format of the radar data stream.

Figure 4-2b shows the format of the radar burst header. The threshold data found in the burst header shall consist of 24 eight-bit words as defined in section 3.2.1.1.1.3 of the VRM Data Formatter Unit Development Specification (DS32466-121). The radiometer data in the burst header shall occupy a twelve-bit field as defined in section 3.2.1.1.1.4 of the VRM Data Formatter Unit Development Specification (DS32466-121). The radiometer mode monitors received power during an interval when no echo is present. The receiver output is square-law detected and integrated over a major fraction of a burst cycle (section 6.2.6 of VRM Radar System Design Description, HS513-088).

The spacecraft time shall be contained in a 52-bit field of the burst header as defined in sections 3.1.2.3.2.5 and 3.2.1.1.1.5 of the VRM Data Formatter Unit Development Specification (DS32466-121). Table 4-2 lists the SAR status bits contained in the radar burst header. (A detailed description of the SAR status bits which correspond directly to the serial command data is found in Appendix A - Definition of Burst Parameters.) The buffer memory checkout flag field of the burst header shall occupy 16-bits, all ones for memory checkout mode and zeros for normal mode, as defined in section 3.2.1.1.1.8 of the VRM Data Formatter Unit Development Specification (DS32466-121).

Table 4-1 Radar Telemetry List

CHAN MEASURE NUMBER ID	TELEMETRY MEASURE NAME	T B Y I P T E S	FRAME LOCATION (minor frame #, word #)
T & C UNIT MEASUREMENTS			
R-0150 V1	VOLTAGE (+5V) Active T&C	A 8	(7,15), (18,14)
R-1150 V22	VOLTAGE (+5V) Inactive T&C	A 8	(12,7), (18,15)
R-0160 I1	PRE-REG CURRENT Active T&C	A 8	(2,2), (3,2), (8,2), (9,2), (14,2), (15,2), (20,2), (21,2)
R-1160 I34	PRE-REG CURRENT Inactive T&C	A 8	(4,8), (5,8), (12,8), (13,8), (16,8), (17,8), (22,8), (23,8)
R-0170 T1	TEMPERATURE Active T&C	A 8	(8,15), (19,14)
R-1170 T30	TEMPERATURE Inactive T&C	A 8	(13,7), (19,15)
COMMAND WORD STATUS (24 bits, 2 spare, 14 unused)			
R-2101 B1	STALO B	B 1	(0,2), (6,2), (12,2), (18,2)
R-2102 B2	STALO A	B 1	(0,2), (6,2), (12,2), (18,2)
R-2103 B3	BPU B	B 1	(0,2), (6,2), (12,2), (18,2)
R-2104 B4	BPU A	B 1	(0,2), (6,2), (12,2), (18,2)
R-2105 B5	RXU B	B 1	(0,2), (6,2), (12,2), (18,2)
R-2106 B6	RXU A	B 1	(0,2), (6,2), (12,2), (18,2)
R-2107 B7	ONU B	B 1	(0,2), (6,2), (12,2), (18,2)
R-2108 B8	ONU A	B 1	(0,2), (6,2), (12,2), (18,2)
R-2109 B9	XMTR B	B 1	(0,3), (6,3), (12,3), (18,3)
R-2110 B10	XMTR A	B 1	(0,3), (6,3), (12,3), (18,3)
R-2111 B11	ROU B	B 1	(0,3), (6,3), (12,3), (18,3)
R-2112 B12	ROU A	B 1	(0,3), (6,3), (12,3), (18,3)
R-2113 B13	PRF/TU B	B 1	(0,3), (6,3), (12,3), (18,3)
R-2114 B14	PRF/TU A	B 1	(0,3), (6,3), (12,3), (18,3)
R-2115 B15	DFU B	B 1	(0,3), (6,3), (12,3), (18,3)
R-2116 B16	DFU A	B 1	(0,3), (6,3), (12,3), (18,3)
R-2117 B17	RECEIVER TRANSFER SWITCH	B 1	(0,4), (6,4), (12,4), (18,4)
R-2118 B18	DC RESTORE A	B 1	(0,4), (6,4), (12,4), (18,4)
R-2119 B19	DC RESTORE B	B 1	(0,4), (6,4), (12,4), (18,4)
R-2120 B20	OUTPUT INHIBIT A	B 1	(0,4), (6,4), (12,4), (18,4)
R-2121 B21	OUTPUT INHIBIT B	B 1	(0,4), (6,4), (12,4), (18,4)
R-2122 B22	EMERGENCY OFF	B 1	(0,4), (6,4), (12,4), (18,4)
R-2123 B23	SAR REDUNDANCY SWITCH	B 1	(0,4), (6,4), (12,4), (18,4)
R-2124 B24	ALT REDUNDANCY SWITCH	B 1	(0,4), (6,4), (12,4), (18,4)
825-826	LEVEL CMD SPARE 1 & 2	B 2	(0,5), (6,5), (12,5), (18,5)
927	TCU A	B 2	(0,5), (6,5), (12,5), (18,5)
928	TCU B	B 2	(0,5), (6,5), (12,5), (18,5)
829-840	UNUSABLE BILEVEL BITS	B 14	
PRF/TIMING UNIT MEAS.			
R-0251 V2	STALO VOLTAGE (+15V) A	A 8	(1,12), (5,12), (9,12), (13,12), (17,12), (21,12)
R-1251 V3	STALO VOLTAGE (+15V) B	A 8	(2,13), (6,13), (10,13), (14,13), (18,13), (22,13)
R-0250 V4	VOLTAGE (+5V) A	A 8	(2,10)

Table 4-1 Radar Telemetry List (Continued)

CHAN NUMBER	MEASURE ID	TELEMETRY MEASURE NAME	T B Y I P T E S	FRAME LOCATION (minor frame #, word #)
R-1250	V5	VOLTAGE (+5V) B	A 8	(3,10)
R-0260	I4	PRE-REG CURRENT A	A 8	(2,4), (8,4), (14,4), (20,4)
R-1260	I5	PRE-REG CURRENT B	A 8	(3,4), (9,4), (15,4), (21,4)
R-0270	T2	STALO TEMPERATURE A	A 8	(0,9), (12,9), (20,14)
R-1270	T3	STALO TEMPERATURE B	A 8	(1,9), (13,9), (20,15)
R-0261	I2	STALO CURRENT A	A 8	(2,3), (8,3), (14,3), (20,3)
R-1261	I3	STALO CURRENT B	A 8	(3,3), (9,3), (15,3), (21,3)
R-0231	B41	ECHO SAMPLE GATE POS MSB 1 A	B 1	(1,2), (7,2), (13,2), (19,2)
R-0232	B42	ECHO SAMPLE GATE POS BIT 2 A	B 1	(1,2), (7,2), (13,2), (19,2)
R-0233	B43	ECHO SAMPLE GATE POS BIT 3 A	B 1	(1,2), (7,2), (13,2), (19,2)
R-0234	B44	ECHO SAMPLE GATE POS BIT 4 A	B 1	(1,2), (7,2), (13,2), (19,2)
R-0235	B45	ECHO SAMPLE GATE POS LSB 5 A	B 1	(1,2), (7,2), (13,2), (19,2)
R-1231	B46	ECHO SAMPLE GATE POS MSB 1 B	B 1	(1,3), (7,3), (13,3), (19,3)
R-1232	B47	ECHO SAMPLE GATE POS BIT 2 B	B 1	(1,3), (7,3), (13,3), (19,3)
R-1233	B48	ECHO SAMPLE GATE POS BIT 3 B	B 1	(1,3), (7,3), (13,3), (19,3)
R-1234	B49	ECHO SAMPLE GATE POS BIT 4 B	B 1	(1,3), (7,3), (13,3), (19,3)
R-1235	B50	ECHO SAMPLE GATE POS LSB 5 B	B 1	(1,3), (7,3), (13,3), (19,3)
RDU MEASUREMENTS				
R-0350	V6	VOLTAGE (+5V) A	A 8	(6,10), (21,14)
R-1350	V7	VOLTAGE (+5V) B	A 8	(7,10), (21,15)
R-0360	I6	PRE-REG CURRENT A	A 8	(2,5), (8,5), (14,5), (20,5)
R-1360	I7	PRE-REG CURRENT B	A 8	(3,5), (9,5), (15,5), (21,5)
R-0370	T4	TEMPERATURE A	A 8	(4,9)
R-1370	T5	TEMPERATURE B	A 8	(5,9)
R-0380	P1	RF POWER A	A 8	(4,3), (10,3), (16,3), (22,3)
R-1380	P2	RF POWER B	A 8	(5,3), (11,3), (17,3), (23,3)
R-0381	P3	LO POWER A	A 8	(4,4), (10,4), (16,4), (22,4)
R-1381	P4	LO POWER B	A 8	(5,4), (11,4), (17,4), (23,4)
TRANSMITTER MEASUREMENTS				
R-0450	V8	VOLTAGE (+32V) A	A 8	(10,10), (22,14)
R-1450	V9	VOLTAGE (+32V) B	A 8	(11,10), (22,15)
R-0451	V10	VOLTAGE (+28V) A	A 8	(14,10), (23,14)
R-1451	V11	VOLTAGE (+28V) B	A 8	(15,10), (23,15)
R-0460	I8	PRE-REG CURRENT A	A 8	(4,2), (10,2), (16,2), (22,2)
R-1460	I9	PRE-REG CURRENT B	A 8	(5,2), (11,2), (17,2), (23,2)
R-0461	I10	CURRENT DRIVER STAGE 1 A	A 8	(0,14)
R-1461	I18	CURRENT DRIVER STAGE 1 B	A 8	(8,14)
R-0462	I11	CURRENT DRIVER STAGE 2 A	A 8	(1,14)
R-1462	I19	CURRENT DRIVER STAGE 2 B	A 8	(9,14)
R-0463	I12	CURRENT DRIVER STAGE 3 A	A 8	(2,14)
R-1463	I20	CURRENT DRIVER STAGE 3 B	A 8	(10,14)
R-0464	I13	CURRENT DRIVER STAGE 4 A	A 8	(3,14)
R-1464	I21	CURRENT DRIVER STAGE 4 B	A 8	(11,14)
R-0465	I14	CURRENT DRIVER STAGE 5 A	A 8	(4,14)

Table 4-1 Radar Telemetry List (Continued)

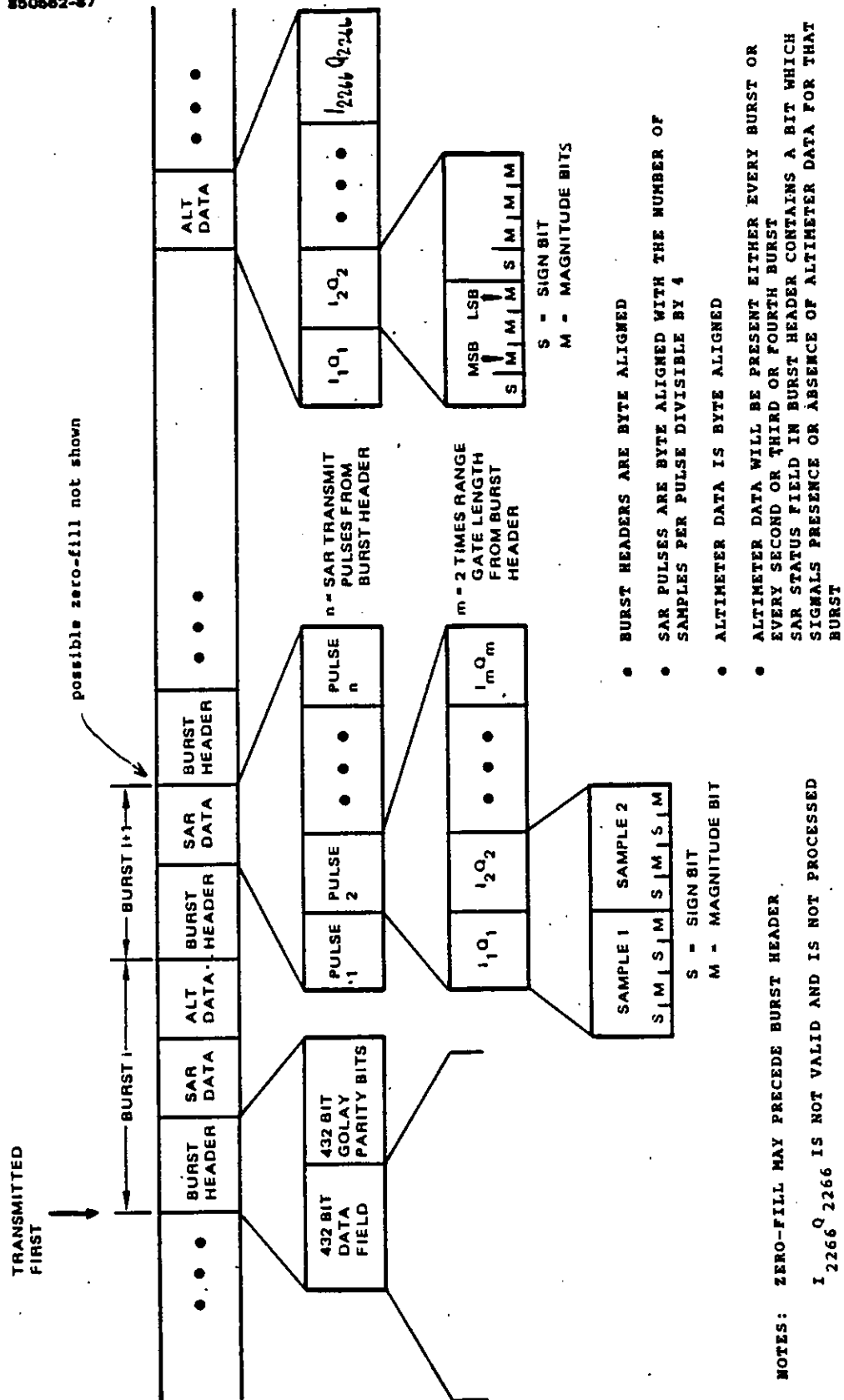
CHAN NUMBER	MEASURE ID	TELEMETRY MEASURE NAME	T 8 Y I P T E S	FRAME LOCATION (minor frame #, word #)
R-1465	I22	CURRENT DRIVER STAGE 5 B	A 8	(12,14)
R-0466	I17	CURRENT OUTPUT DRIVER A	A 8	(7,14)
R-1466	I25	CURRENT OUTPUT DRIVER B	A 8	(15,14)
R-0467	I15	CURRENT OUTPUT BANK 1 A	A 8	(5,14)
R-1467	I23	CURRENT OUTPUT BANK 1 B	A 8	(13,14)
R-0468	I16	CURRENT OUTPUT BANK 2 A	A 8	(6,14)
R-1468	I24	CURRENT OUTPUT BANK 2 B	A 8	(14,14)
R-0472	T8	TEMPERATURE DRIVER 1 A	A 8	(2,15)
R-1472	T15	TEMPERATURE DRIVER 1 B	A 8	(11,15)
R-0473	T9	TEMPERATURE DRIVER 2 A	A 8	(3,15)
R-1473	T16	TEMPERATURE DRIVER 2 B	A 8	(12,15)
R-0474	T12	TEMP OUTPUT DRIVER A	A 8	(6,15)
R-1474	T19	TEMP OUTPUT DRIVER B	A 8	(15,15)
R-0475	T10	TEMP OUTPUT BANK 1 A	A 8	(4,15)
R-1475	T17	TEMP OUTPUT BANK 1 B	A 8	(13,15)
R-0476	T11	TEMP OUTPUT BANK 2 A	A 8	(5,15)
R-1476	T18	TEMP OUTPUT BANK 2 B	A 8	(14,15)
R-0470	T6	TEMPERATURE PREREG A	A 8	(9,15)
R-1470	T13	TEMPERATURE PREREG B	A 8	(9,15)
R-0471	T7	TEMP +32V POSTREG A	A 8	(1,15)
R-1471	T14	TEMP +32V POSTREG B	A 8	(10,15)
R-0480	P5	SAR OUTPUT POWER A	A 8	(4,5), (10,5), (16,5), (22,5)
R-1480	P6	SAR OUTPUT POWER B	A 8	(5,5), (11,5), (17,5), (23,5)
R-0481	P7	ALT OUTPUT POWER A	A 8	(4,6), (10,6), (16,6), (22,6)
R-1481	P8	ALT OUTPUT POWER B	A 8	(5,6), (11,6), (17,6), (23,6)
R-0482	P9	DRIVER ELEMENT POWER A	A 8	(4,7), (10,7), (16,7), (22,7)
R-1482	P10	DRIVER ELEMENT POWER B	A 8	(5,7), (11,7), (17,7), (23,7)
CNU MEASUREMENTS				
R-0560	I26	PRE-REG CURRENT A	A 8	(2,6), (8,6), (14,6), (20,6)
R-0560	I27	PRE-REG CURRENT B	A 8	(3,6), (9,6), (15,6), (21,6)
R-0570	T20	TEMPERATURE SAR POWER MONITOR A	A 8	(5,9)
R-0570	T21	TEMPERATURE SAR POWER MONITOR B	A 8	(7,9)
R-0571	T22	TEMPERATURE ALT POWER MONITOR A	A 8	(10,9)
R-0571	T23	TEMPERATURE ALT POWER MONITOR B	A 8	(11,9)
R-0580	P11	SAR FORWARD POWER A	A 8	(0,11), (2,11), (4,11), (6,11), (8,11), (10,11), (12,11), (14,11), (16,11), (18,11), (20,11), (22,11)
R-0580	P12	SAR FORWARD POWER B	A 8	(1,11), (3,11), (5,11), (7,11), (9,11), (11,11), (13,11), (15,11), (17,11), (19,11), (21,11), (23,11)
R-0581	P13	SAR REVERSE POWER A	A 8	(0,13), (6,7), (8,13), (10,8), (16,13), (19,7)
R-0581	P14	SAR REVERSE POWER B	A 8	(4,13), (5,8), (11,8), (12,13), (19,8), (20,13)
R-0582	P15	ALT FORWARD POWER A	A 8	(0,12), (1,8), (4,12), (7,8), (8,12), (12,12), (16,12), (20,12)

Table 4-1 Radar Telemetry List (Continued)

CHAN NUMBER	MEASURE ID	TELEMETRY MEASURE NAME	T B	
			Y I	FRAME LOCATION (minor frame #, word #)
R-1592	P16	ALT FORWARD POWER B	A 8	(0,8), (2,12), (6,12), (10,12), (14,12), (18,12), (22,12)
R-0583	P17	ALT REVERSE POWER A	A 8	(0,7), (1,13), (7,7), (9,13), (17,13), (18,8)
R-1583	P18	ALT REVERSE POWER B	A 8	(1,7), (5,13), (13,13), (18,7), (21,13)
R-0540	851	SAR REDUNDANCY SWITCH BAR A	B 1	(1,4), (7,4), (13,4), (19,4)
R-1540	854	SAR REDUNDANCY SWITCH BAR B	B 1	(1,4), (7,4), (13,4), (19,4)
R-0541	852	ALT REDUNDANCY SWITCH BAR A	B 1	(1,4), (7,4), (13,4), (19,4)
R-1541	855	ALT REDUNDANCY SWITCH BAR B	B 1	(1,4), (7,4), (13,4), (19,4)
R-0542	853	RECEIVER SELECT SWITCH SAR A	B 1	(1,4), (7,4), (13,4), (19,4)
R-1542	856	RECEIVER SELECT SWITCH BAR B	B 1	(1,4), (7,4), (13,4), (19,4)
RXU MEASUREMENTS				
R-0660	I28	PRE-REG CURRENT A	A 8	(2,7), (8,7), (14,7), (20,7)
R-1560	I29	PRE-REG CURRENT B	A 8	(3,7), (9,7), (15,7), (21,7)
R-0670	T24	TEMPERATURE PRE-AMPLIFIER A	A 8	(16,9)
R-1570	T25	TEMPERATURE PRE-AMPLIFIER B	A 8	(17,9)
R-0680	P19	ECHO SAMPLE GATE POWER A	A 8	(1,5), (7,5), (13,5), (19,5)
R-1680	P20	ECHO SAMPLE GATE POWER B	A 8	(1,6), (7,6), (13,6), (19,6)
BPU MEASUREMENTS				
R-0750	V12	VOLTAGE (+5V) A	A 8	(16,14), (18,10)
R-1750	V13	VOLTAGE (+5V) B	A 8	(16,15), (19,10)
R-0751	V14	DC RESTORE (I) A	A 8	(3,12), (11,12), (19,12)
R-1751	V16	DC RESTORE (I) B	A 8	(7,12), (15,12), (23,12)
R-0752	V15	DC RESTORE (Q) A	A 8	(3,13), (11,13), (19,13)
R-1752	V17	DC RESTORE (Q) B	A 8	(7,13), (15,13), (23,13)
R-0760	I30	PRE-REG CURRENT A	A 8	(2,8), (8,8), (14,8), (20,8)
R-1760	I31	PRE-REG CURRENT B	A 8	(3,8), (9,8), (15,8), (21,8)
R-0770	T26	TEMPERATURE A	A 8	(18,9)
R-1770	T27	TEMPERATURE B	A 8	(19,9)
DFU MEASUREMENTS				
R-0850	V18	VOLTAGE (+5V) A	A 8	(17,14), (22,10)
R-1850	V19	VOLTAGE (+5V) B	A 8	(17,15), (23,10)
R-0860	I32	PRE-REG CURRENT A	A 8	(2,9), (8,9), (14,9), (20,9)
R-1860	I33	PRE-REG CURRENT B	A 8	(3,9), (9,9), (15,9), (21,9)
R-0870	T28	TEMPERATURE A	A 8	(22,9)
R-1870	T29	TEMPERATURE B	A 8	(23,9)
POU MEASUREMENTS				
R-0950	V20	S/C BUS VOLTAGE BUS A	A 8	(0,10), (4,10), (8,10), (12,10), (16,10), (20,10)
R-1950	V21	S/C BUS VOLTAGE BUS B	A 8	(1,10), (5,10), (9,10), (13,10), (17,10), (21,10)

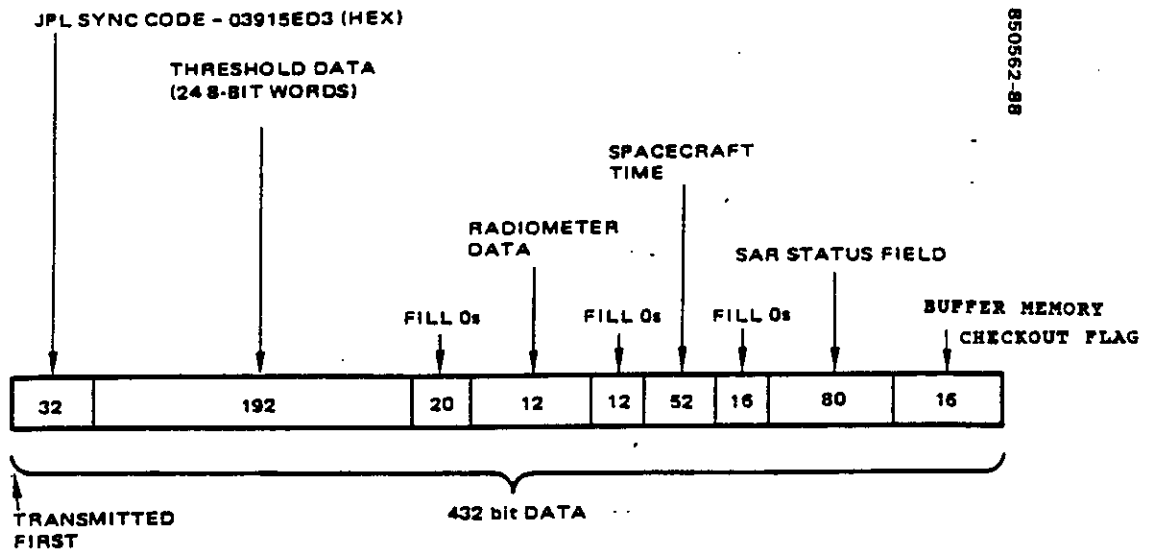
Figure 4-2a Radar Science Data Stream Format

850862-87



a) RADAR DATA STREAM FORMAT

Figure 4-2b Radar Data Stream Burst Header Format



850562-88

- EACH DATA FIELD IS RIGHT JUSTIFIED AND ZERO FILLED TO A 32 BIT BOUNDARY
- EACH DATA FIELD IS TRANSMITTED MSB FIRST

b) BURST HEADER DATA FIELD FORMAT

Table 4-2 Radar Burst Header Status Bits

ITEM	BITS	NAME	DESCRIPTION
1	1		Zero fill bit
2	8	SAR fine resolution	Determines location of SAR range gate within a SAR IPP
3	7	PRF code	Determines desired PRF
4	8	SAR coarse resolution	Determines number of SAR IPPs before reception of first echo
5	8	Range Gate length	Determines length of data collection window within an IPP
6	11	SAR transmit pulses	Determines number of pulses transmitted in a SAR burst
7	9	ALT coarse resolution	Determines number of altimeter clock counts between end of altimeter burst and enabling of altimeter data window
8	15	Burst period	Determines length of burst cycle from cycle start, to the following cycle start
9	3	Receiver gain- ALT	Sets attenuation of receiver gain for altimeter burst (from 0 to 28 dB in 4 dB steps)
10	3	Receiver gain- SAR	Sets attenuation of receiver gain for SAR burst (from 0 to 28 dB in 4 dB steps)
11	3	Receiver gain - Radiometer	Sets attenuation of receiver gain during radiometer function (from 0 to 28 dB in 4 dB steps)
12	2	Altimeter skip factor	Determines presence of altimeter burst in a burst cycle (range: every burst to every 4th)
13	1	Radiometer source	Determines whether the receiver is protected (for calibration) or switched to antenna for rad mode
14	1	Altimeter data set flag	Flag set high if an alt burst will be present in cur burst cycle
	80	total bits	

The burst buffer memory checkout shall consist of six burst cycles where a "0101..." (i.e. "55..." hexadecimal) checkerboard pattern is loaded into memory immediately following burst header numbers 1, 3 and 5, and a "1010..." (i.e. "AA..." hexadecimal) checkerboard pattern is loaded immediately following burst header numbers 2, 4 and 6, as defined in section 3.2.1.2 of the VRM Data Formatter Unit Development Specification (DS32466-121). The first two memory checkout bursts will not have valid/complete burst headers; the CDS may capture a subset of the final four memory checkout burst cycles (i.e. burst header numbers 3 through 6).

The SAR bursts are variable in length and nominally fill from 15 to 100 spacecraft composite frames dependent upon radar control parameter values. (Detailed timing diagrams and relationships may be found in section 3.5 of the VRM PRF/Timing Unit Development Specification, DS32466-111 and section 3.1.2.3.2.5 of the VRM Data Formatter Unit Development Specification, DS32466-121.)

Figure 4-2c presents the separation of the radar data onto the MSB and LSB data lines. The separation is solely for transmission from the radar sensor to the spacecraft; the CDS recombines the MSB and LSB data back into bytes. The CDS high rate radar data interface consists of four signals; all signals are supplied by the radar sensor. The four signals are:

- a) High Rate Data 4 MSBs
- b) High Rate Data 4 LSBs
- c) High Rate Data Bit Sync
- d) High Rate Data Word Sync

The radar data stream shall be transferred to the CDS in frames of 823 bytes between sub-RTI transitions. The bit sync and word sync pulses need not be synchronous with other CDS signals, but high rate data shall not be transferred at RTI and sub-RTI transition times. In addition, no data shall be transferred for one word length of the DSB serial data stream after an RTI or sub-RTI, and no data shall be transferred for three word lengths of the DSB serial data stream before an RTI or sub-RTI.

A straightforward algorithm is now outlined which presents a procedure for locating successive SAR/Altimeter Burst (SAB) headers within the radar data stream. However, under error recovery situations, it may be desirable to perform a byte by byte search for the sync word to locate a SAB header data field start. (Note that SAB headers, as well as SAR and ALT data fields are always byte aligned.) To locate SAB headers within the radar data stream:

1. Look for the sync word signaling a SAB header data field at the start of each 823 byte data frame.
2. After locating the SAB header data and performing any required processing on it, the next SAB header data field can be found by looking immediately after the corresponding burst data or at a successive data frame start.

- a. First calculate the length "L" of the current burst data, where "L" is given by:

$$L = (\text{SAB Hdr Length}) + (\# \text{ SAR Pulses}) * (\text{RG Length}) + (2266) * (\text{ALT Data Set Flag})$$

where: SAB Hdr Length = 108
 # SAR Pulses = 2's complement of item 6 in SAR Status Field
 RG Length = 2's complement of item 5 in SAR Status Field
 ALT Data Set Flag = item 14 in SAR Status Field

- b. Look at "L" bytes past the start of the current SAB header data for the sync word signaling the start of a SAB header data field. If the sync word is found, the next burst in the radar data stream follows directly after the current burst and processing can continue at the beginning of step 2; if the sync word is not found, continue searching successive frame boundaries for the next SAB header by going back to step 1, as the remainder of the current data frame will be zero-filled and the next SAB header will be frame aligned.

An algorithm designed to detect missing SAB headers within the radar data stream is included as Appendix C - Algorithm for Missing Burst Detection.

The spacecraft high rate composite data stream shall be processed by MOS elements into engineering telemetry files, SAB header files and science Engineering Data Records (EDRs), and be provided to the Radar Data Processing and Radar Engineering Teams so as to enable further data product generation as well as radar sensor and data processing evaluation.

4.2 CDS Memory Storage Interface Requirements

A special DED buffer shall be established within the CDS Random Access Memory (RAM) to hold 4000 to 5000 bytes of selected engineering telemetry measurements. This buffer shall be utilized to store engineering telemetry when the High Gain Antenna (HGA) is not oriented towards the Earth. This engineering data area shall contain at least 360 bytes (i.e. one major frame) of radar sensor engineering parameters; each radar sensor engineering value shall be time tagged with a spacecraft Spacecraft Clock (SCLK) time word. The specific radar sensor engineering measurements to be stored within the buffer shall be modifiable by ground command from MOS elements if required during flight operations. The DED buffer shall be played into the real time engineering telemetry stream at least once per orbit.

4.3 CDDS Tape Recorder Interface Requirements

The spacecraft Command, Data and Data Storage (CDDS) tape recorder shall have a recording capability of at least 1.8 gigabits per orbit allocated to the radar science data stream and the necessary spacecraft header, engineering data, and required tape recorder data overlap in a format compatible with the mission design.

Radar science data shall be stored on the tape recorder at 806.4 Kbps as composite data including the 790.08 Kbps radar data, the recorded (spacecraft and radar sensor) engineering data, and the 11.52 Kbps composite headers.

No radar data shall be lost due to tape recorder start-up or turnaround time. Playback to Earth shall be accomplished such that the radar data stream is returned in the same time sequence in which the data was recorded. Playback to Earth of one mapping swath shall be accomplished prior to the next mapping swath.

4.4 Downlink Telemetry

The high rate telemetry channel from the spacecraft shall be the only mode of radar system science data transmission during the mission. The data rate for playback to Earth of the radar data stream shall be nominally 268.8 Kbps; this data stream includes radar data, headers, and other CDS-added information. If insufficient communications link margins exist, or in special circumstances (e.g. In-orbit Checkout), the downlink playback rate shall be changed to 115.2 Kbps.

5 FLIGHT OPERATIONS INTERFACE REQUIREMENTS

Monitoring and control of the health and performance of the radar sensor shall be the responsibility of the RET. During design, development and test of the radar flight equipment, a quantity of information shall be generated to be used during flight operations by the RET to perform this responsibility. This information may be in the form of documents, computer data files, log books or computer programs. In the broadest sense, this data is a part of the MOS-RS interface. The data shall be collected and cataloged prior to flight operations to enable it to be readily accessible. The following sections describe the radar sensor information and documents which are needed to support the RET control and monitoring responsibilities of the MOS; the planned contents of each item is described.

5.1 Reference Documents -

The following list of key documents shall be developed by the radar system contractor and shall be available to the RET during mission operations. Additional documents prepared by the radar system contractor, spacecraft contractor and JPL MOS shall be available to the Radar Engineering Team upon request as flight operations necessitate.

- a. Engineering Documentation and Data List (CM002) - Shall contain the document reference file for the description of the radar sensor. It shall contain installation control drawings, interface control drawings, circuit data sheets and other information that may be necessary during flight operations to understand the radar sensor.
- b. (Sensor) End Item Data Packages (QA002) - Shall contain a comprehensive data package that is a history of and a current record for the radar sensor delivered end items, including the results of all tests performed on the items.
- c. Problem/Failure Reports (RA001) - Shall contain documentation of problems and failures encountered by radar components during development and test.
- d. Hazard Analysis Data Log (SA003) - Shall contain a hazard analysis of the radar sensor.
- e. Mass Properties Status Report (SE003), Final Version - The final version of this quarterly report shall contain structural dynamics data (e.g. mass, center-of-mass, moments).
- f. Power Status Report (SE004), Final Version - The final version of this quarterly report shall contain information on allocated power consumption, actual power consumption and power transients for the units

of the radar sensor.

- g. Telemetry Measurements Calibration Report (SE005) - Shall contain the tables, coefficients and plots for conversion of each telemetry measurement Data Number (DN) to Engineering Units.
- h. Telemetry List (SE007) - Shall contain a description of telemetry formats, measurement sample rates, accuracy, range, alarm limits by mode, and sample time vs. time tag information for RET telemetry analysis.
- i. Command List (SE008) - Shall contain a listing of all radar commands, names, numerical designation, structures, usage constraints, and expected radar hardware response and telemetry changes.
- j. Constraints and Idiosyncracies (SE009) - Shall contain the set of all sensor hardware operational limits and constraints derived from design or implementation. It shall contain descriptions of any unusual or anomalous performance characteristics.
- k. Radar System Analysis Methods and Performance Estimates Report (SE011) - Shall include a description of analysis methods and performance estimates necessary to demonstrate the achievement of Radar System requirements.
- l. Radar Systems Description (SE014) - Shall contain a summary description of the design of each of the units/subsystems.
- m. Software Documentation (SW002) - Shall contain user's guides, annotated program listings, detailed design documents and information necessary to understand and operate the radar system ground mission operations software.

Several spacecraft contractor and JPL produced documents shall have significant input from the radar system contractor. Those needed for reference and having significant radar interfaces are:

- a. Spacecraft System/Radar System IRD (PD630-104)
- b. Spacecraft System/Radar System ICD (VRM-SE-003-010)
- c. VRM Information Systems Plan (PD630-52)
- d. VRM MOS Requirements Document (PD630-300)
- e. MGN Space Flight Operations Plan (PD630-500)

5.2 Reference Data Bases -

In addition to documents, some radar specific data will be contained in machine readable data bases. These are also required to support mission operations. Some data bases are produced and maintained by the RET; others are produced by the Spacecraft Team or other MOS entities.

The following is a list of key data bases for which preparation support is planned by the radar system contractor. Additional data bases shall be created by the Radar Engineering Team during mission operations when necessary.

- a. Command Data Base
- b. Telemetry Calibration Data Base
- c. Test Data Files

6 INTERFACE REQUIREMENTS VERIFICATION

Prior to flight operations, all Radar System related interfaces with the MOS described in this document shall be verified. For most of the interface requirements, verification shall be achieved through MOS participation in various radar and spacecraft system level tests and interface compatibility tests.

Radar data shall be available on tape from the radar subsystem and spacecraft system tests. This data can be formatted and played through the JPL simulation system to test the ground MOS elements.

Details of the MOS participation in certain tests, as well as the resultant data links, may be found in the appropriate test plans. These tests include the Spacecraft System (SCS) - RS Integration tests, the SFS-MOS Compatibility tests and the Thermal-Vacuum tests.

Appendix A - Definition of Burst Parameters

Item No.	No. Of Bits	Name	Description
1	8	SAR Fine Resolution (FR)	Determines the location of the rising edge (RE) of the SAR range gate or sample envelope within an interpulse period (IPP). The LSB of the FR corresponds to two periods of the RES CLK. FR is to be given in 2's complement: that is, 11111111 causes the RE of the SAR sample envelope to occur 2 RES CLK periods after the falling edge (FE) of a SAR PRF CLK pulse, and 00000000 causes the RE of the SAR sample envelope to occur 512 RES CLK periods after the FE of a SAR PRF CLK pulse. See also SCR, PC, and RGL.
2	7	PRF Code (PC)	Determines the SAR pulse repetition frequency. The LSB of the PC corresponds to 1 period of the RES CLK. PC = 0000000 corresponds to a pulse repetition period of 512 RES CLK periods, and PC = 1111111 corresponds to a pulse repetition period of 385 RES CLK periods. See also FR, SCR, RGL, NP, and EGP.
3	8	SAR Coarse Resolution (SCR)	Determines the number of complete SAR IPPs between the transmission of a SAR pulse and its associated sample envelope. SCR is to be given in 2's complement: that is, 11111111 means that the radar energy transmitted after SAR PRF CLK pulse number N is expected to be received after SAR PRF CLK pulse number N + 1, etc., whereas 00000000 means that the energy from SAR pulse N is expected to be received after SAR PRF CLK number N + 256. Since the first SAR pulse is transmitted after SAR PRF CLK pulse number 1, the earliest a SAR sample envelope can be produced is after SAR PRF CLK number 2, the second SAR PRF CLK following cycle start FE. See also FR, PC, RGL, NP, and EGP.

(Continued)

Item No.	No. Of Bits	Name	Description
4	8	Range Gate Length (RGL)	Determines the length of time the SAR range gate, or sample envelope, is in a logic 1 (high) state. The LSB corresponds to 2 RES CLK periods. RGL is to be given in 2's complement: that is, 11111111 corresponds to a sample envelope whose FE occurs 2 RES CLK periods after its RE, and 00000000 corresponds to a sample envelope whose FE occurs 512 RES CLK periods after its RE. See also FR, PC, and SCR.
5	11	SAR Transmit Pulse (NP)	Determines the number of pulses to be transmitted in a SAR burst. NP is to be given in 2's complement: that is, 1110000000 means that 256 SAR pulses are to be transmitted in a burst, and 0001111111 means that 1793 SAR pulses are to be transmitted. See also PC and SCR.
6	9	Altimeter Coarse Resolution (ACR)	Determines the number of ALT CLK periods between the last ALT transmission and the RE of the ALT sample envelope. The LSB corresponds to 151 RES CLK periods. ACR is to be given in 2's complement: that is, 11111111 means that if the last ALT pulse transmission (the 17th in an ALT burst) follows the Kth ALT CLK pulse, the ALT sample envelope RE will occur on the FE of the (K+1)st ALT CLK pulse, whereas 00000000 means that it will occur on the FE of the (K+512)th ALT CLK pulse.
7	15	Burst Period (BP)	Determines the length of the burst period. The LSB corresponds to 151 RES CLK periods. NOTE: The spacecraft CDS always zero-fills the two LSBs of BP so that the effective resolution is 604 RES CLK periods. BP is to be given in 2's complement: that is, 111000000000000 corresponds to a burst period of (151) (4096) RES CLK

(Continued)

Item No.	No. Of Bits	Name	Description
			periods, and 000111111111100 corresponds to a burst period of (151)(28676) RES CLK periods.
8	6	Zero Fill	Not used.
9	5	ESC Position (EGP)	Determines the location of the ESC RE within an IPP. The LSB corresponds to 16 RES CLK periods. EGP is to be given in 2's complement: that is, 11111 causes the RE of the ESG to occur 16 RES CLK periods after the FE of a SAR PRF CLK pulse, and 00000 causes it to occur (32)(16) = 512 RES CLK periods after the FE of a SAR PRF CLK pulse. See also PC and SCR.
10	3	Receiver Gain-Altimeter (GA)	Determines the attenuation of the receiver gain for the ALT burst. The LSB corresponds to 4 dB of attenuation. It is not a timing parameter, and is not in 2's complement. If GA = 000, the receiver attenuation during an ALT burst is 0 dB; if GA = 111, the receiver attenuation during an ALT burst is 28 dB.
11	3	Receiver Gain-SAR (GS)	Determines the attenuation of the receiver gain for the SAR burst. The LSB corresponds to 4 dB of attenuation. It is not a timing parameter and is not in 2's complement. If GS = 000, the receiver attenuation during a SAR burst is 0 dB; if GS = 111, the receiver attenuation during a SAR burst is 28 dB.
12	3	Receiver Gain-Radiometer (GR)	Determines the attenuation of the receiver gain for the RAD burst. The LSB corresponds to 4 dB of attenuation. It is not a timing parameter, and is not in 2's complement. If GR = 000, the receiver attenuation during a RAD burst is 0 dB; if GR = 111, the receiver attenuation during a RAD burst is 28 dB.

(Continued)

Item No.	No. Of Bits	Name	Description
13	2	Altimeter Skip Factor (ASF)	<p>Determines how often an altimeter burst is included in a burst cycle. The LSB corresponds to one burst period. ASF is to be given in 2's complement: 00 means that an ALT burst is included in one burst out of every four, 11 means that an ALT burst is included in every burst. ASF is only to be updated in the altimeter skip factor counter on burst cycles which include an ALT burst. The ALT burst shall be included on the last burst of a series of skip cycles. The sequence, in other words, shall be as follows:</p> <p>Choose any cycle which contains an ALT burst and call it cycle 0, for reference. If, during cycle 0, the active burst parameter set contains an ASF of 00, then there shall be no ALT burst during cycles 1, 2 and 3, no matter what ASF the active parameter set contains during those cycles. Cycle 4 shall contain an ALT burst, and the altimeter skip counter shall be loaded with the ASF that is in the active parameter set during cycle 4. Thus, if an ASF of 11 is loaded into the active parameter set during cycle 2 and left unchanged, it will become effective on cycle 4 and the net effect shall be: cycles 1, 2 and 3: no ALT burst, cycle 4: ALT burst, all cycles after 4 until ASF changed again: ALT burst.</p>

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TABLE COMMAND PARAMETER DEFINITION
Timing Parameters (1-7,9)

Signal₁ rising/falling edge occurs on nth rising edge of RES CLK after rising/falling edge of Signal₂

Signal ₁	rising/ falling	n	Signal ₂	Comments
Cycle Start (CS)	R	151(32768-BP)	Previous CSRE	Test access point. Serial command from spacecraft will always have 2 LSB of BP equal to zero
	F	(3)(151)	CSRE	
Ath SAR PRF CLK	R	(512-PC)A-1	CSFE	Test access point only SAR pulses transmitted only for 1SAS(2048-NP)
	F	1	SAR PRF CLK RE	
PRE/POST PRF for Ath SAR pulse	R	(512-PC)A	CSFE	RE simultaneous with Ath SAR PRF CLK FE 1SAS(2048-NP)
	F	1	RE of "PULSE COMPLETE"	
Bth SAR sample env.	R	(512-PC)(8+256-SCR)*2(256-FR)	CSFE	Bth sample envelope starts (256-SCR) SAR PRF clocks plus 2(256-FR) RES CLKs after Bth SAR PRF CLK FE 1SBS(2048-NP)
	F	2(256-RGL)	Sample env. RE	
Cth ALT PRF CLK	R	(151C)-1	CSRE	Test access point only fCS(32768-BP) ALT pulses transmitted only for N _{AO} +16SCSN _{AO} +32 (see below)
	F	1	ALT PRF CLK RE	

Table (continued) Timing Parameters (1-7,9)
 Signal₁ rising/falling edge occurs on nth rising edge of RES CLK after rising/falling edge of Signal₂

Signal ₁	rising/ falling	n	Signal ₂	Comments
SAR/ALT DATA FLAG	R	$(512-PC) \lfloor 2048-NP+256-SCR+1 \rfloor$	CSFE	Test Access Point RE simultaneous with FE of first SAR PRF CLK after last SAR sample envelope
	F	$(15)(151)$	ALT Samp. Env. RE	
PRE/POST PRF for Dith ALT pulse	R	$151(D+N_{Ao}+15)$	CSFE	RE simultaneous with FE of $D+N_{Ao}+14$ th ALT PRF CLK pulse $N_{Ao} = INT \left[\frac{(512-PC) \lfloor 2048-NP+256-SCR+1 \rfloor - 1}{151} \right] + 1$ 1SDS17
	F	1	RE of "PULSE COMPLETE" from ROU	
ALT Samp. Env.	R	$151(N_{Ao}+32+512-ACR)$	CSFE	
	F	$(15)(151)$	ALT Samp. Env. RE	
Radiometer Integrate	R	$151(N_{Ao}+62+512-ACR)$	CSFE	
	F	$(750)(151)$	Rad. Int. RE	
DC Restore/ Radiometer Digitize	R	$151(N_{Ao}+813+512-ACR)$	CSFE	
	F	$(17)(151)$	DC Restore RE	

Table (continued)
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Timing Parameters (1-7,9)
Signal₁ rising/falling edge occurs on nth rising edge of RES CLK after rising/falling edge of Signal₂

Signal ₁	rising/ falling	n	Signal ₂	Comments
Eth Echo Sample Gate	R	$(512-PC)(E+256-SCR)+16(32-EGP)$	CSFE	1 ≤ E ≤ 64
	F	60	ESG RE	

Gain Parameters (10-12) Receiver Attenuation (dB) (0 ≤ GA, GS, GR ≤ 7)	
ALT	4GA
SAR	4GS
RAD	4GR

ALT Skip Factor (13) Let F be the number of Cycle Starts since last ASF update: (E = 1, 2, 3, 4)	
F MOD (4-ASF) = 0	ALT burst present; update ASF
F MOD (4-ASF) ≠ 0	No ALT burst present Do not update ASF

Appendix B - Burst Parameter Conversions

<u>Item Numbers</u> ¹					
<u>Range</u>	<u>PRF</u>		<u>Item</u>	<u>Output</u> ²	<u>Item to Output</u> ³
<u>Gate</u>	<u>Cmd</u>	<u>Description</u>	<u>Mnemonic</u>	<u>Units</u>	<u>Unit Conversion</u>
8		Sar Fine Resolution	FR	Samples	2(256-FR)
	8	PRF code	PC	Samples	512-PC
				Hz	STALO ----- 32(512-PC)
	9	Sar coarse resolution	SCR	Pulses	256-SCR
	10	Range gate length	RGL	Samples	2(256 - RGL)
	11	Number of SAR pulses	NP	Pulses	2048-NP
	12	Alt coarse resolution	ACR	Pulses	512-ACR
	13	Burst period	BP	Alt Ticks	32768-BP
				Seconds	(32768-BP) 151 x 3! ----- STALO
	15	ESG position	EGP	Counts	32 - EGP
				Samples	16(32 - EGP)
	16	Receiver gain - Alt	GA	Counts	GA
				dB	4GA
	17	Receiver gain - SAR	GS	Counts	GS
				dB	4GS
	18	Receiver gain - Rad	GR	Counts	GR
				dB	4GR
	19	Alt skip factor	ASF	Bursts	3-ASF

1 - The item numbers correspond to the item numbers in Table 4-1 of VRM-SE-002-007 (Spacecraft System-Radar System Interface Requirements Document). The item mnemonics correspond to Table 3.1.2-2 of DS 32466-111 (PRF/Timing Unit Development Specification) which provides more definition of each of the fields.

2 - Units of 'samples' indicates radar resolution elements
Units of 'Alt ticks' indicates counts at the altimeter PRF rate.

3 - STALO represents the sensor subsystem STALO frequency
(nominally 72.27 Mhz)

Appendix C - Algorithm for Missing Burst Detection

INTERDEPARTMENTAL CORRESPONDENCE

HUGHES

To: A. Edgerton
Org:

CC: System Engineering

Date: Jan 19, 1987
Ref: HS513-3236

Subject: Preliminary Algorithm Definition
for Missing Burst Detection

From: PA Hascall
Org: 49-12-20

Bldg: S40 MS: T311
Loc: SC Ph: 88312

Reference: JPL Letter (MGN-R-SCO-1205) Dated Dec 11, 1986

This IDC is in response to the above JPL letter, and the included memorandum, which requested information about an algorithm to detect missing SAB headers in the RDS. After conversations with Betsy Wilson (the originator of the memorandum), it was determined that the necessary information could best be transferred as part of an ongoing process. This IDC is the initiation of that process, and as such provides characteristics of the RDS which can be used to detect missing SAB headers and an algorithm to use those characteristics. Refinements of the algorithm and/or further pertinent sensor subsystem characteristics will be provided as requested.

Some definitions will be provided first to preclude problems caused by differences in nomenclature. The sensor subsystem operates on a cyclical basis. For each of these cycles (called burst cycles), radar data is collected and buffered for transmission to the spacecraft. This data is called the Radar Data Stream (RDS), and for each burst cycle, it contains a burst header, SAR data and at commandable intervals, altimeter data. This IDC will refer to burst cycles as the internal timing events inside the sensor subsystem, and will refer to Sar/Altimeter Bursts (SABs) as the portion of the RDS containing data from a burst cycle. The second set of definitions relate to time tags. There is a spacecraft time tag and a burst time tag. The burst time tag includes the spacecraft time tag with an additional time update counter which is appended by the sensor subsystem.

The characteristic of the sensor subsystem most easily used to detect missing SAB headers are the burst time tags. The cycle start of each burst is tagged using the spacecraft clock as a basis. This time tag is placed in the SAB header. The time between burst cycle starts is counted using the sensor subsystem clock (the STALO). The burst period can be computed using information contained in the SAB header. If all burst headers have been located, then the difference between any two successive burst time tags should match the burst period associated with the

earlier time tag. The remainder of this IDC describes the time tags, how to compute the burst period from information in the SAB header, and some error considerations.

The spacecraft provides a time tag to the sensor subsystem every 2/3 of a second. However, since the burst periods can be short relative to the 2/3 second interval, the sensor subsystem must append some information to delineate the time of cycle start relative to the arrival of the spacecraft time tag. This information is a time update counter which is derived from the spacecraft bus sync (and thus is directly relatable to the spacecraft clock). Figure 1 shows the timing relationship between the spacecraft bus signals (specifically the RTI), the arrival of the spacecraft time tag, and a sequence of burst cycle starts. The update counters for each burst are also shown. The time tags arrive from the spacecraft during RTI 8 of each minor frame, and are used after the start of RTI 9. The update counter counts from RTI 9 to the burst cycle start. Attachment 1 is a copy of the definition of the time tag as contained in the Spacecraft to Sensor Subsystem Interface Requirements Document. Attachment 2 contains the format of the RDS showing the location of the burst header. Attachment 3 contains the format of the combined time tag as it appears in the RDS burst header.

The convenient units to use for the determination of the difference between two time tags are the same units as the time update counter. Some conversion factors to help in the subtraction are:

1 minor frame = 10 RTI = 2100 time update counts
1 RIM = 91 minor frames

$806400/256 =$ update counter rate (3150 per second)
 $806400/(256*210) =$ RTI rate (15 per second)
 $806400/(256*2100) =$ minor frame rate (3/2 per second)

Note that 806400 is the nominal spacecraft bus rate derived directly from the spacecraft clock. Given the time tag definition and the relationships above, computing the difference between two time tags requires carries from the higher fields and compensation for the fact that the time update counter starts at RTI 9 in one minor frame and runs until RTI 9 in the next minor frame.

The sensor subsystem burst period can be computed using the burst cycle length field in the SAR status field of the RDS burst header. Attachment 3 shows the location of the SAR status field in the header and attachment 4 shows the format of this field. The burst period can be computed (in seconds) as follows:

$$p = (32768 - \text{code}) \frac{151 \times 32}{\text{STALO}}$$

where code is the 15 bit value contained in item 8 of the SAR status field.

STALO is the STALO frequency (72.27 Mhz nominal).

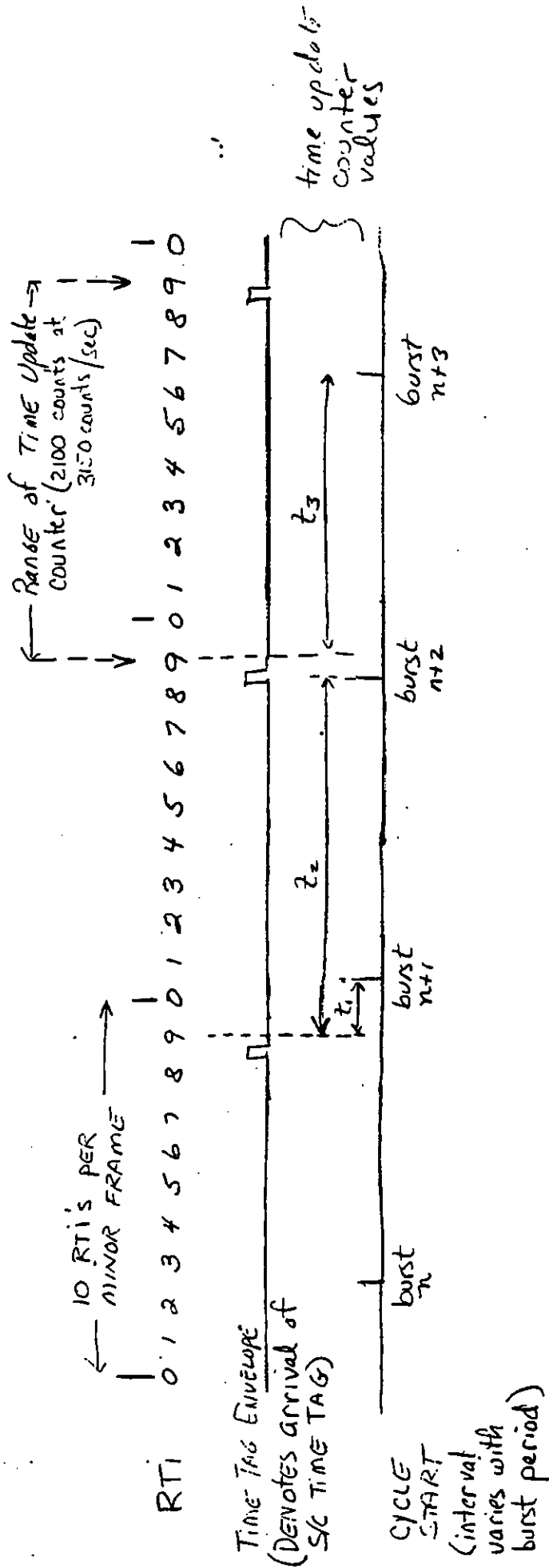
What remains then is the comparison of the burst period (computed in seconds) to the difference between two time tags (computed in counts at 3150 counts per second). This is not an exact comparison due to the quantization error on the time tags and errors in knowledge of the clock frequencies. Since each time tag has a quantization error of minus 0 to plus 1, the difference between two time tags has a quantization error of plus or minus 1. This is illustrated graphically in Figure 2.

Both clock frequencies are expected to be known to an accuracy sufficient for this algorithm. The STALO frequency will be known to 1 part per million. It is assumed that the spacecraft clock frequency is (or will be) known reasonably well. Knowledge to within about one part in 4000 would provide accuracy commensurate with the quantization error on the time tags.

To put the error discussion in perspective, we are talking about plus or minus 1 or 2 counts of the update counter for both quantization and frequency knowledge errors. The minimum usable burst period is around .1 seconds, which is equivalent to 310 counts of the update counter. The actual minimum burst period is expected to be around .2 seconds. Thus this method for detecting missing bursts should be fairly robust.

P.A. Hascall

P.A. Hascall

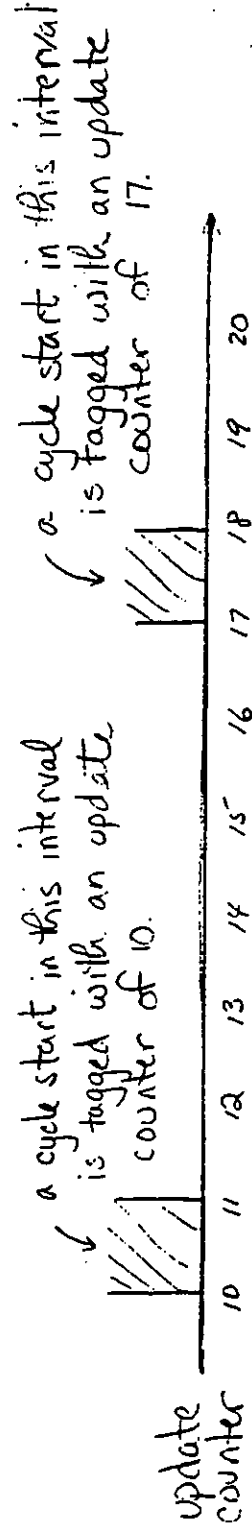


t_i is the time interval measured by the time update counter contained in the SAB header.

- t_1 is contained in SAB header $n+1$
- t_2 " " " " $n+2$
- t_3 " " " " $n+3$

note that successive SAB headers can have the same S/C time tag.

Figure 1: S/DARECRAFT TIME TAG ARRIVAL vs P... and Cycle Start



← min burst period = 6
 ← max burst period = 8

Two burst cycle starts occurring as shown above would have a difference of

$$17 - 10 = 7.$$

Figure 2. Quantization Effects on the Difference Between Two Time Tags.

ATTACHMENT 1 -

SPACECRAFT TIME TAG FORMAT

VRM-SE-002-007

4-9

4.1.1.1.2 Sensor Subsystem Redundancy and State Commands

The CDS shall transfer, over the DSB, commands to select the redundant elements and power states of the sensor subsystem. For the redundancy and state commands defined in Table 4-3, the first seven words are required in the CDS format and have eight information bits each. The sensor control words in the table shall be arranged into eight-bit words as specified by the IWG and documented in the Interface Control Document, VRM-SE-003-010.

Table 4-3. Sensor Subsystem Redundancy and State Messages

<u>Item Number</u>	<u>Number of Bits Required</u>	<u>Description</u>
1	8	Sensor Subsystem ID code word.
2	8	Redundancy and state address MSB.
3	8	Redundancy and state address LSB.
4 through 7	8 each	CDS-required words.
8 through 12	8 each	State and Redundancy command.

4.1.1.1.3 Spacecraft Time Information

Spacecraft time shall be provided to the sensor subsystem on the DSB every 10 RTI cycles. The spacecraft time supplied to the sensor subsystem shall be capable of being correlated to Greenwich Mean Time (GMT) within 5.0 milliseconds, 3 sigma. The time is correlated and synchronous with every 9th RTI pulse (RTIs are numbered 0-9). The format of the five words used to denote spacecraft time on the DSB shall be as follows:

- a. Real-Time Image Count (RIM): The RIM is a 24-bit binary integer (in three words) which increments once every major telemetry frame. The rate is one increment each 60-2/3 s.

ATTACHMENT 1 -

SPACECRAFT TIME TAG FORMAT (Continued)

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- b. Modulo 91 Count (MOD91): The MOD91 is an 8-bit binary counter which begins at zero at the beginning of each telemetry major frame and increments once each $2/3$ s, reaching a maximum value of 90. This is the equivalent of one increment for each telemetry minor frame (low-rate science frame) which in turn is one per 10 RTIs.
- c. Modulo 10 Count (MOD10): The MOD10 is an 8-bit binary counter which begins at zero at the beginning of each telemetry minor frame and increments once each $66-2/3$ ms, reaching a maximum value of 9. This represents an increment once per RTI.

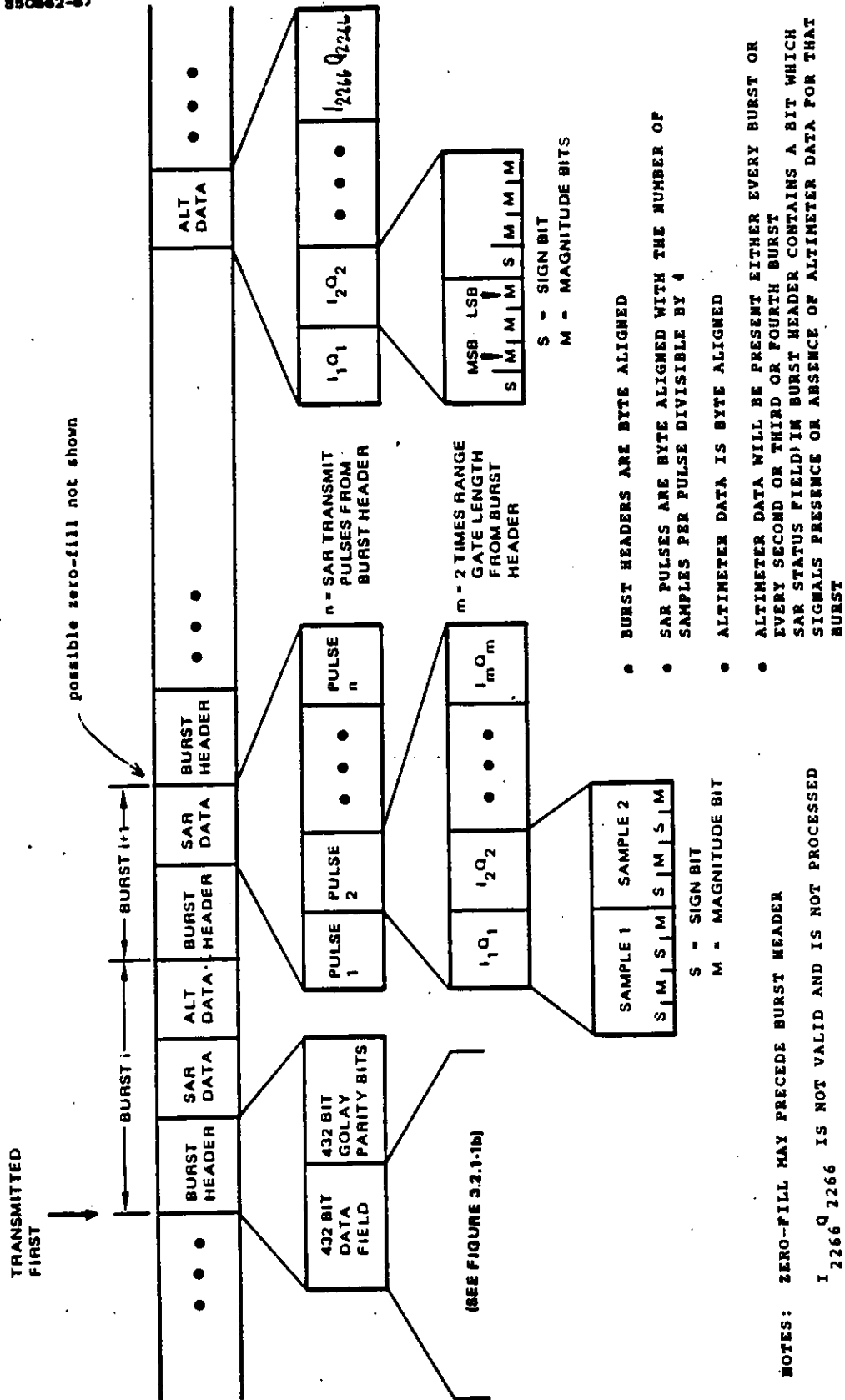
The spacecraft time message shall be as shown in Table 4-4, in which the first seven words are required in the CDS format and have eight information bits each. The eighth item is required by the CDS but ignored by the sensor subsystem. The time words have eight information bits each. If the spacecraft time message is also being sent to other spacecraft subsystems, the first three items of Table 4.4 will be preceded and/or followed by the ID code words and addresses of the other recipients.

Table 4-4. Spacecraft Time Message

<u>Item Number</u>	<u>Number of Bits Required</u>	<u>Description</u>
1	8	Sensor Subsystem ID code word.
2	8	S/C time message address MSB.
3	8	S/C time message address LSB.
4 through 7	8 each	CDS-required words.
8	8	Clock ID byte (HEX C6).
9	8	First RIM byte.
10	8	Second RIM byte.
11	8	Third RIM byte.
12	8	MOD91 byte.
13	8	MOD10 byte.

ATTACHMENT 2 - RDS STRUCTURE

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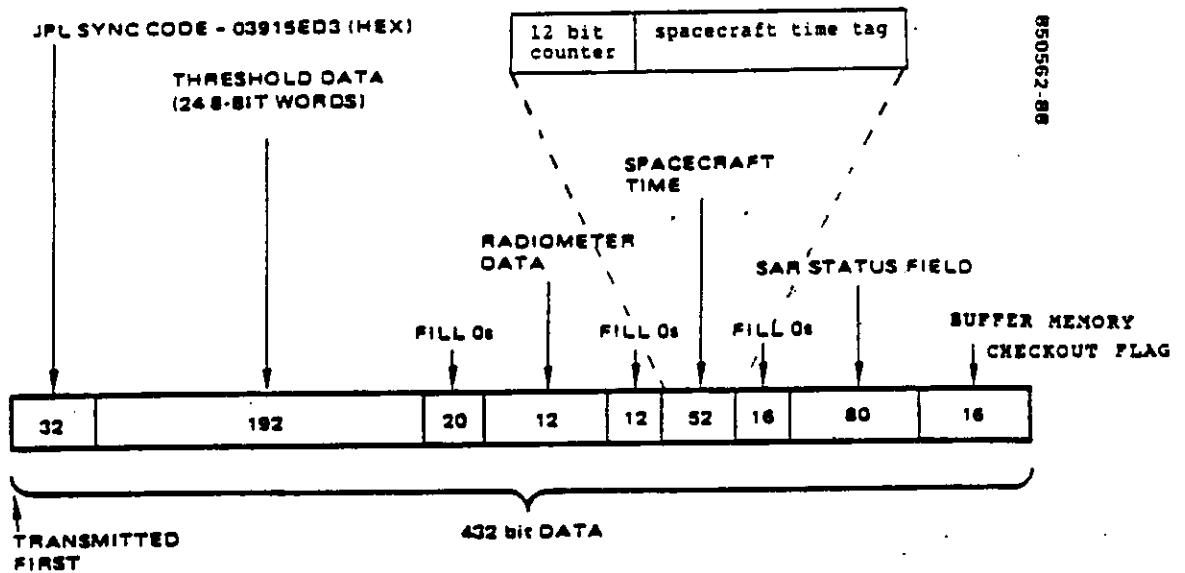
ATTACHMENT 3 -

TIME TAG FORMAT & SAR STATUS FIELD LOCATION

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- EACH DATA FIELD IS RIGHT JUSTIFIED AND ZERO FILLED TO A 32 BIT BOUNDARY
- EACH DATA FIELD IS TRANSMITTED MSB FIRST
- REQUIREMENTS FOR EACH DATA FIELD CAN BE FOUND IN PARAGRAPH 3.2.1.1.1

ATTACHMENT 3 - Continued

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The 24, 8-bit threshold words shall then be stored in memory until the next burst cycle. The 7 LSBs of the threshold words 1-burst cycle old shall then select which of the SAR data bits to downlink while all 8 bits of the threshold words shall get downlinked in the burst header. The threshold data in the header shall consist of 24, 8-bit words for a total data field of 192 bits as shown in Figure 3.2.1-1b. The first threshold word shall be used to select the downlinked data bits for the first 16 samples of the first SAR pulse. The SAR data magnitude bits shall be bit selected for downlink as follows:

If data \leq threshold choose "0"
 If data $>$ threshold choose "1"

The SAR data sign bits shall be unaffected by the block adaptive quantizer and are always downlinked. The second threshold word shall be used to select the downlinked data bits for the second 16 samples of the first SAR pulse. This shall continue until all the samples of the pulse have been compressed. The process of bit selection shall then continue on the remaining SAR pulses of that burst in the same manner as described above.

3.2.1.1.1.4 Radiometer Data Field. Each burst cycle, an analog radiometer data value (Section 3.1.2.3.2.10) is digitized in the receiver using the Radiometer Clock (Section 3.2.1.4.1.1). The 12-bit value is sent from the receiver to the data formatter unit and shall be packed in the burst header as shown in Figure 3.2.1-1b. The data shall be downlinked MSB first. The data shall actually be composed of radiometer information taken in the previous burst cycle.

3.2.1.1.1.5 Spacecraft Time Data Field. The burst header spacecraft time data shall consist of the 40 bits of spacecraft time that are sent to the telemetry and command unit via the CDS DSB, as well as an additional 12 bit time update value. The data shall be downlinked in the burst header as shown in Figure 3.2.1-1b with the time update value downlinked first (MSB first), followed by the 40 bits of data (RIM 1, RIM 2, RIM 3, MOD 91, MOD 10) which were sent from the spacecraft via the T&C unit.

ATTACHMENT 3 - Continued

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The spacecraft time shall be updated from the ^{rising edge of the} ninth RTI pulse (numbered 0 through 9) as received via the CDS DSB, until the rising edge of the following cycle reset. The update value shall be capable of counting up to 1.3 seconds in increments of $317.5 \pm 3.2 \mu\text{s}$ (3.15 KHz). The time update counter clock shall be synchronized to RTI number 9 upon power up of the unit.

↑
bus sync
250

3.2.1.1.6 SAR Status Field. The SAR status field shall be downlinked MSB first. The SAR status field shall be packed in the burst header as shown in Figure 3.2.1-1b.

3.2.1.1.7 Radar Data Stream Zero Fill. Data shall be transferred across the high rate data interface in 823 byte transfer blocks as specified in Table 3.2.1-1. Word sync (Section 3.2.1.4.1.2) shall be disabled between transfer blocks. Word sync shall be enabled during transfer blocks. If the data for a given burst cycle is completely read out in the middle of a transfer block, and there are less than 512 bytes of data from the following burst cycle available for downlink, the remainder of the transfer block shall be zero filled. If at least 512 bytes of data are still not available for downlink at the next transfer block, that whole transfer block shall be zero filled. If a transfer block is zero filled, the next available burst header shall start on a transfer block boundary (byte 1). If the data from burst n is completely read out in the middle of the transfer block, and more than 512 bytes of data from burst n+1 are available, the burst header for burst n + 1 shall be read out immediately. Thus, data flow within a transfer block remains uninterrupted and a burst header may appear in the middle of a transfer block.

3.2.1.1.8 Buffer Memory Checkout Flag. This shall consist of 16 bits in the burst header which shall all be "1" if in the memory checkout mode (Section 3.2.1.2) or all "0" if in the normal mode. See Figure 3.2.1-1b for the position of the bits in the header.

3.2.1.1.2 SAR Data Output. SAR data shall be output to the spacecraft CDS via the high rate data interface (Section 3.2.1.4.1.2) in the format defined in Figures 3.2.1-1a and 1c. A sign and magnitude bit shall be downlinked for each I or Q 8 bit sample. The number of samples per pulse (sample envelope) will be divisible by 4, leading to an even number of 8-bit SAR data bytes.

ATTACHMENT 4 -

SAR STATUS FIELD FORMAT

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TABLE 3.2.1-3. SAR STATUS FIELD

ITEM	BITS	NAME	DESCRIPTION
1	1		Zero fill bit
2	8	SAR fine resolution	Determines location of SAR range gate within a SAR IPP
3	7	PRF code	Determines desired PRF
4	8	SAR coarse resolution	Determines number of SAR IPPs before reception of first echo
5	8	Range Gate length	Determines length of data collection window within an IPP
6	11	SAR transmit pulses	Determines number of pulses transmitted in a SAR burst
7	9	ALT coarse resolution	Determines number of altimeter clock counts between end of altimeter burst and enabling of altimeter data window
8	15	Burst period	Determines length of burst cycle from cycle start, to the following cycle start
9	3	Receiver gain- ALT	Sets attenuation of receiver gain for altimeter burst (from 0 to 28 dB in 4 dB steps)
10	3	Receiver gain- SAR	Sets attenuation of receiver gain for SAR burst (from 0 to 28 dB in 4 dB steps)
11	3	Receiver gain - Radiometer	Sets attenuation of receiver gain during radiometer function (from 0 to 28 dB in 4 dB steps)
12	2	Altimeter skip factor	Determines presence of altimeter burst in a burst cycle (range: every burst to every 4th)
13	1	Radiometer source	Determines whether the receiver is protected (for calibration) or switched to antenna for rad mode
14	1	Altimeter data set flag	Flag set high if an alt burst will be present in cur burst cycle
	80	total bits	

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