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SPACECRAFT 4431/URSALA IV

COMMAND CAPABILITIES & LIMITATIONS DOCUMENT ~~(S)~~

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Prepared by

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FOREWORD

This document has been prepared in accordance with the requirements of sequence no. A018 of DD1423 (exhibit A to contract [redacted] 25X1

REVISION RECORD

Revision	Document: Spacecraft 4431/URSALA IV Command Capabilities and Limitations Document	Date
--	Basic Issue	74 Feb 8
A	This revision updates the phase1/phase 2 assignments, deletes a maximum command rate restriction, restricts LVCO enable/disable timings, and makes other minor changes	74 May 1
A Change pages	These change pages incorporate the preferred power system mode to be used at launch and provide a general updating of the document.	74 Sep 30 LW
A Change pages	These change pages incorporate the addition of more restrictions to TRG selection and minor corrections.	75 Mar 20 LPW
Change pages	These change pages incorporate changes in orbit altitudes and SE-1 time, add data on tape recorder rollback, and add information on payload commanding.	75 Oct 21 LPW
A Change pages	Added a restriction of no bypass mode operation during ACS maneuvers and updated spacecraft power available information	76 May 20 LPW
A Change pages	Pages have been changed to add tape recorder rollback information and to correct wideband transmitter requirements.	76 Dec 22 LPW
B	Incorporated various payload and spacecraft modifications including addition of COMSEC.	78 Dec 6

Note: Changes incorporated into the current revision are indicated by change bars affixed to the right margin of affected pages.

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Section 1

INTRODUCTION

This document describes the operational capabilities of Spacecraft 4431 and the URSALA IV reconnaissance receiving system and establishes guidelines for the collection and recovery of spacecraft and payload data. Special features, constraints, and limitations of the spacecraft and payload systems are provided to establish on-orbit operational criteria for the spacecraft.

Section 2

GENERAL SYSTEM DESCRIPTION

The URSALA IV intercept system is a 2- to 12-GHz monopulse, direction-finding, electronic order of battle (EOB), reconnaissance receiving system which is mounted on a spin-stabilized spacecraft orbiting in a 340-nm circular orbit at a spin rate of approximately 55 rpm. (See figure 2-1.) The system uses two parabolic pencil-beam antennas plus five omni/inhibit antennas to provide omnidirectional coverage. The parabolic antennas are mounted such that each antenna views the earth during one-half of each spacecraft spin. Switching between antennas and switching of RF bands maximizes the coverage time and, thus, the probability of intercept.

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The spacecraft contains an attitude control system, a spin-rate control system, and an attitude sensing system that consists of four solar aspect sensors, two shift registers (one spare), and two horizon sensors (one spare).

A simplified block diagram of the spacecraft/payload system is shown in figure 2-2. Three tape recorders are available, with each one having a read-in/readout ratio of 4:1 or 1:1. These recorder outputs are connected to three Digital Interface Units (DIU's) in such a manner that each recorder track 2 output is directed to one DIU and each recorder track 1 output is directed to another DIU.

The logic is configured so that one transmitter will transmit either track of the dual-track tape recorder. This is accomplished by selecting one of two DIU's to handle the recorder readout.

The dejittered DIU data output and the resultant clock are used to drive a KGX-28B encryptor in the baseband 1 channel. This scheme provides encrypted readout or transponds on URSALA IV.

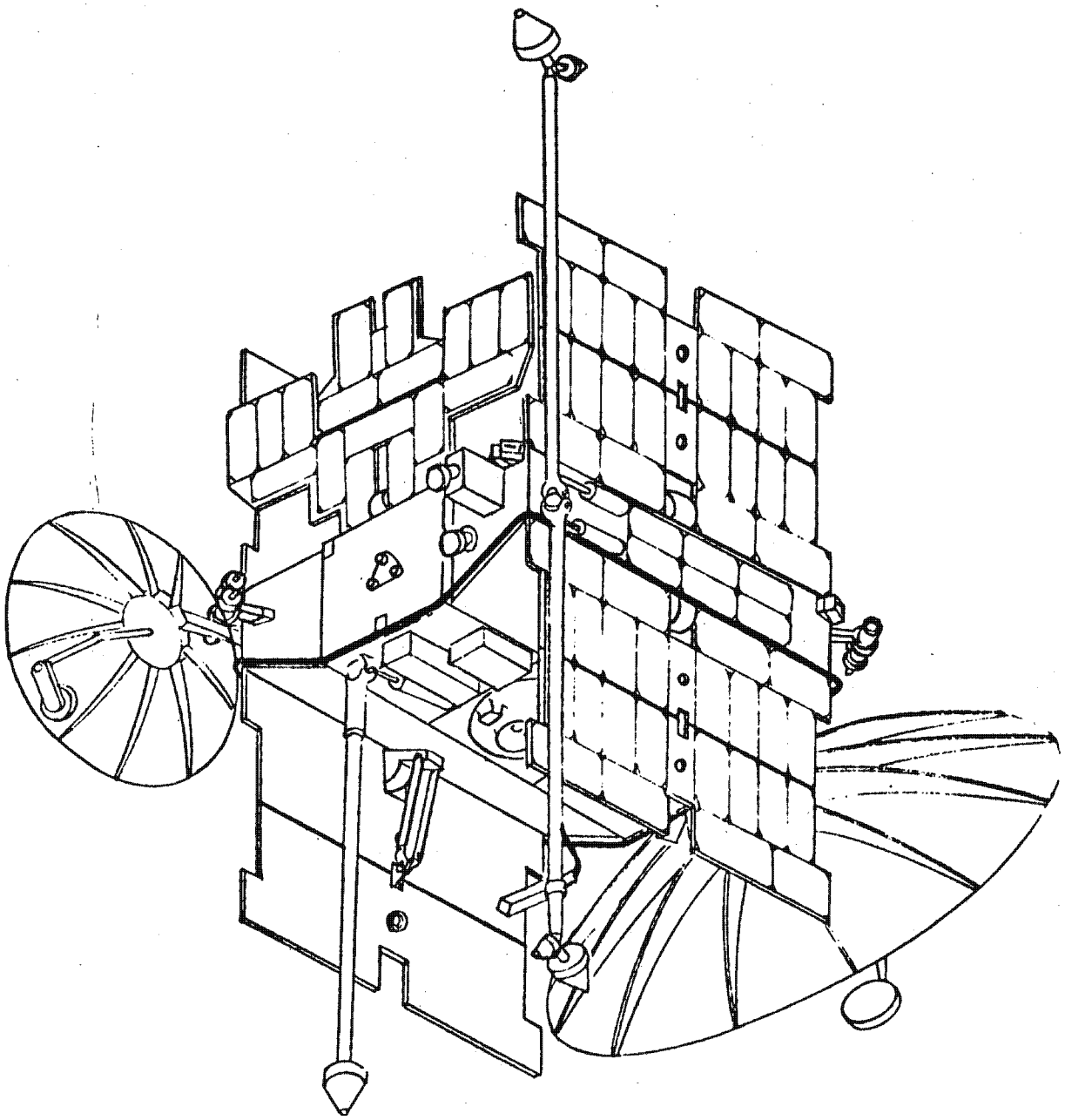

Figure 2-1 Spacecraft 4431/URSALA IV On-Orbit Configuration

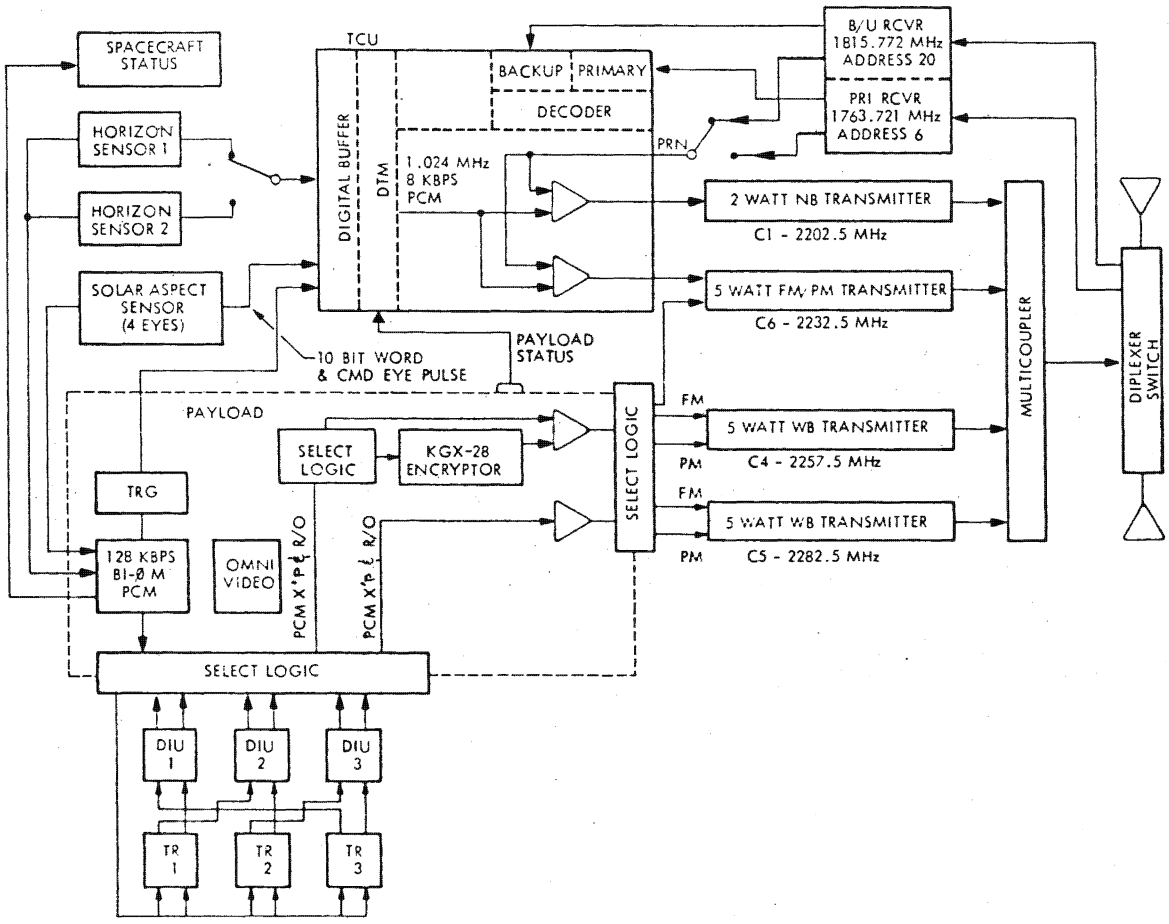

Figure 2-2 Spacecraft 4431/URSALA IV Simplified Block Diagram

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Section 3

REAL TIME CONTROL AND DATA RECOVERY

3.1 INTRODUCTION

This section describes the commands and functions associated with data recovery. Spacecraft 4431/URSALA IV Systems Requirements Document, BIF003W/2-078566-78, Rev D, provides a detailed description of all spacecraft commands, and Spacecraft 4431/URSALA IV Intercept System Technical Description, BIF003W/2-079154-78, Rev A delineates payload mode selection commanding.

3.2 TRANSMITTER OPERATION

3.2.1 Transmitter Selection Logic

Spacecraft 4431 contains the four transmitters that perform the following functions:

a. Carrier 1 Transmitter. Normally transmits spacecraft status data

b. Carrier 4 Transmitter. Normally transmits payload channel 1 data*

c. Carrier 5 Transmitter. Normally transmits payload channel 2 data*

d. Carrier 6 Transmitter. Backup transmitter for carriers 1, 4, or 5* transmitters.

Carriers 2 and 3 are reserved for standard SGLS downlink data, and are not used. Power output of the carrier 1 transmitter is two watts, minimum, and power output of the other transmitters is five watts, minimum. The selection of a given transmitter to be used for a given function is accomplished via primary command 0.06XX or backup command 0.31XX. The possible transmitter/function configurations available are shown in table 3-1.

*NOTE: The system is redundant to the extent that only one transmitter is needed for status (i.e. either Carrier 1 or 6) and only one tape recorder (of 3) and one transmitter (i.e. either Carrier 4 or 5 or 6) is needed for payload information.

Table 3-1

TRANSMITTER/FUNCTION CONFIGURATIONS

(See pages 8-2 and 8-3 for details of this table.)

NORMAL COMMAND (0.06XX)	ALTERNATE COMMAND (0.31XX)	CONFIGURATION SELECTED
1F	1T	Select carrier 4 for P/L channel 1 data (command 8 to payload)
1T	1F	Select carrier 6 for P/L channel 1 data (command 9 to payload). Also selects BBU 1 to real time data mode.
2F	2T	Select carrier 5 for P/L channel 2 data (command 10 to payload)
2T	2F	Select carrier 6 for P/L channel 2 data (command 11 to payload). Also selects BBU 2 to the real time data mode.
3F	3T	P/L channel 1 & 2 transfer reset (command 12 to payload)
3T	3F	P/L channel 1 & 2 transfer (command 13 to payload)
4F	4T	Status baseband no. 1 and no. 2 transfer reset (normal mode)
4T	4F	Status baseband no. 1 and no. 2 transfer
5F	5T	Select carrier 1 for spacecraft status (carrier 6 to FM mode)
5T	5F	Select carrier 6 for spacecraft status (carrier 6 to PM mode)

Once the desired transmitter configuration has been selected, it need not be repeated for every acquisition, since it will remain the same until deliberately changed. If selection of either payload baseband unit is made to the real time data mode, then either carrier 4 or 5 must be reselected in place of carrier 6.

3.2.2 Transmitter Turn On

The transmitters are turned on via normal command 0.01XX or alternate command 0.36XX as shown in Table 3-2a. A "channel" rather than a "carrier"* is turned on by bits 1, 2, or 3. The channel 1 encryption equipment is turned on after a 2-4 second delay to the carrier which is selected to do the transmitting. The delay is needed

*I.e., the channel is a selectable carrier

to insure that the encryption equipment is turned on in the presence of clock and data signals from the payload. LVCO Reset/Override will occur with each 0.01, i.e., override if below the LVCO voltage region; reset if above. Bits 2 and 3 true select the channel desired for wideband transmission, turn on the encryption equipment and the payload baseband units. Also the real time data mode select is reset for both channels. If bit 4 is false, SE-1 will start and will clock out at 808 +4, -0 seconds. The function of SE-1 is to turn off the transmitters and terminate the acquisition should, for some reason, the tracking station be unable to transmit real time termination commands. Bit 5 is used for antenna selection, and bit 6 is used for selection of primary or backup receiver PRN.

Other associated functions have been incorporated into normal command 0.00XX and alternate command 0.37XX as shown in Table 3-2b.

Table 3-2a

TELEMETRY-ON COMMANDS

NORMAL COMMAND (0.01XX)	ALTERNATE COMMAND (0.36XX)	TELEMETRY-ON CONFIGURATION LVCO RESET/OVERRIDE
1F	1T	Spare
1T	1F	Status channel ON Carrier 1 or 6 ON, as selected Bus and T/R current monitors ON, Status monitors ON Command 1 to payload (50 ma) DTM, HS and SAS ON
2F	2T	Spare
2T	2F	Channel 1 ON, Carrier 4 or 6 ON as selected* Payload Command (SC-2) readout mode ON. Encryption equipment ON after 2-4 second delay if cypher text enabled and baseband channels NORMAL. Reset real time data mode selects.
3F	3T	Spare
3T	3F	Channel 2 ON, Carrier 5 or 6 ON as selected* Payload Command (SC-2) readout mode ON. Encryption equipment ON after 2-4 second delay if cypher text enabled and baseband channels CROSSFD. Reset real time data mode selects.
4F	4T	Start SE-1
4T	4F	Spare

* To conserve power, a channel should be turned on only if it is to be used to transmit desired data.

Table 3-2a (Cont.)

TELEMETRY-ON COMMANDS

NORMAL COMMAND (0.01XX)	ALTERNATE COMMAND (0.36XX)	TELEMETRY-ON CONFIGURATION LVCO RESET/OVERRIDE
5F	5T	Select -Y antenna (uplink and downlink)
5T	5F	Select +Y antenna (uplink and downlink)
6F	6T	Select receiver 1 PRN, disable receiver 2 PRN
6T	6F	Select receiver 2 PRN, disable receiver 1 PRN

Table 3-2b

ADDITIONAL TRANSMITTER/TAPE RECORDER-DIU

DOWNLINK FUNCTIONS

NORMAL COMMAND (0.00XX)	ALTERNATE COMMAND 0.37XX	MISCELLANEOUS DOWNLINK FUNCTIONS
1F	1T	Select Switched Bus bypass
1T	1F	Select Switched Bus normal
2F	2T	Spare
2T	2F	Enable pyro power; turn on SA motor power bus; enable 1st deploy logic relays (backup)
3F	3T	Enable the encryption equipment (SC-38)
3T	3F	Disable the encryption equipment (SC-39)
4F	4T	Select FM mode for carriers 4 and 5
4T	4F	Select PM mode for carriers 4 and 5
5F	5T	Select "Exclusive" read-in or transpond modes
5T	5F	Select "Mixed" read-in and transpond modes
6F	6T	Transpond with SGLS filters
6T	6F	Transpond without SGLS filters

Bit 1 is used to select the Switched Bus to NORMAL or BYPASS.

Bit 2 is used to recycle deployment sequence. It enables pyro power, turns on the Solar Array motor power bus and re-enables the 1st deploy logic relays.

Bit 3 is used to enable/disable the KG-28B encryption equipment.

Bit 4 selects the FM/PM modes of carrier's 4 and 5. The PM mode is used to close the narrowband 128 KBPS data link to a remote van in the field or at TTS.

Bit 5 is used to either select the "Exclusive" read-in or transpond modes of operation or the "Mixed" read-in and transpond mode. The "Exclusive" mode of operation refers to the original spacecraft design where either four payload/tape recorder read-in segments could be programmed or four payload transpond segments with or without tape recorder read-in could be programmed. In the "Mixed" mode one transpond segment and 2 read-in segments are possible with PE 2 used for a remote TC downlink antenna switch during the transpond segment.

Bit 6 is used to enable/disable the payload SGLS filters. The filter keeps the SGLS transmitter from interfering with the payload received data.

3.2.3 Transmitter Turn Off. Normal command 0.02XX or alternate command 0.35XX (or SE-1*) are used to turn off the payload read-in transponds, the encryption equipment and the transmitters at the end of a pass. Bits are assigned to transmitters rather than to channels. If a payload read-in mode started by a PE or a real time command and an SE-2, before the TLM OFF command then the payload will reamin on after TLM OFF. Bit 6 will stop any tape recorder in readout.

The TLM OFF command selects the downlink via the -Y antenna and the uplink via both the -Y and +Y antennas. Table 3-3 shows the various TLM OFF command functions.

*SE = Single event

Table 3-3

TELEMETRY-OFF COMMANDS

NORMAL COMMAND (0.02XX)	ALTERNATE COMMAND (0.35XX)	TLM OFF CONFIGURATION
1F	1T	Payload and Tape recorder in read-in transpond mode OFF.
1T	1F	Spare
2F	2T	Carrier 1 transmitter OFF
		If FM mode is selected for carrier 6 → DTM, H/S & SAS OFF; Bus & T/R current monitors OFF; Payload cmnd (SC-7a) status TLM OFF; Reset cmnd/TLM antenna
2T	2F	Spare
3F	3T	Carrier 4 transmitter OFF
3T	3F	Spare
4F	4T	Carrier 5 transmitter OFF
4T	4F	Spare
5F	5T	Carrier 6 transmitter OFF
		If FM mode is selected for carrier 6 → DTM, H/S and SAS OFF; Bus & T/R current monitors OFF; Payload cmnd (SC-7a)status TLM OFF; Reset cmnd/TLM antenna
6F	6T	Stop TRs in readout and turn all DIUs OFF. P/L cmnd, (SC-7) readout mode OFF, BBUs OFF encryption equipment OFF.
6T	6F	Spare

3.3 UPLINK AND DOWNLINK ANTENNAS

As stated previously, one bit of the TLM ON command is used to select the uplink and downlink via the -Y or +Y antenna. Real time switching of the antennas once per pass is necessary to maintain the required signal strengths at the tracking station throughout the pass. A data loss in the order of 10 msec (maximum) can be expected during antenna switching. The TLM OFF command resets the uplink to both the -Y and +Y antennas and the downlink to the -Y antenna. Normal command 0.13XX or alternate command 0.24XX are used to set up the logic required to select which downlink antenna shall be used with a remote transpond operation. PE 2 will switch the downlink antenna in the "Mixed Mode" and PE 3 and PE 4 will do the same in the "Exclusive Mode" of operation.

3.4 TAPE RECORDER OPERATION

The three tape recorders have a read-in/readout ratio of 4:1, read-in time capacity is 1280 seconds minimum with no roll-back.* A read-in/readout ratio of 1:1, 320 seconds minimum, is available for NB transmissions to POGO RTS if necessary. Normally, only one recorder at a time should be read in (i.e., in series but not in parallel) except for the "overlap" at the end of one tape recorder and start of a second tape recorder. Two recorders may be read out at the same time. If so commanded, up to three tape recorders can be readin simultaneously. PCM data from the URSALA IV payload is simultaneously recorded on both tracks of the tape recorder being readin.

*Derivation of the minimum read-in time interval is as follows: 330 seconds nominal at 100 ips with no rollback at either end of tape yields 1320 seconds at 25 ips. 1320 seconds ±2 percent speed variation ±0.5% speed ratio tolerance equals 1280 seconds.

3.4.1 Tape Recorder Readout Via DIUs. The tape recorder readout through Digital Interface Units is initiated by normal command 0.03XX or alternate command 0.34XX as shown in table 3-4. The commands shown in table 3-4 will change the payload mode from "before-and-after tape recorder readout" to "tape recorder readout." Note that the false states of bits 1, 2, and 3 are tape recorder readout stop commands. Therefore, care must be exercised in selecting the proper bit state. For example, if tape recorder 1 is started first, followed by the start of tape recorder 2 before tape recorder 1 has reached end-of-tape, bit state selection would be 0.03-1T, -2T, -3T for start of tape recorder 1 and 0.03-1T, -2T, -3F (not 0.03-1F, -2T, -3F) for start of tape recorder 2. Tape recorded data is readout through a Digital Interface Unit (DIU) to remove flutter components and reconstruct the data. DIU operation is explained further in paragraph 3.4.3.

Bit 5 of command 3 is used to select either tape recorder track 1 data to be readout via the alternate DIU or tape recorder track 2 data through the associated DIU.

Bit 6 of command 3 selects which data rate the payload phase lock loop is to be used for readout. 4:1 is normal, 1:1 is for special readouts to narrow-band remote tracking stations with a 14 foot antenna.

Table 3-4

TAPE RECORDER READOUT COMMANDS

NORMAL COMMAND (0.03XX)	ALTERNATE COMMAND (0.34XX)	TAPE RECORDER READOUT CONTROL
1F	1T	DIU-1 off, TR 1 or TR 3 stop
1T	1F	DIU-1 on, TR 1 or TR 3 readout P/L command (SC-3) DIU-1 R/O (stored data mode)
2F	2T	DIU-2 off, TR 1 or TR 2 stop
2T	2F	DIU-2 on, TR 1 or TR 2 readout P/L command (SC-4) DIU-2 R/O (stored data mode)
3F	3T	DIU-3 off, TR 2 or TR 3 stop
3T	3F	DIU-3 on, TR 2 or TR 3 readout P/L command (SC-5) DIU-3 R/O (stored data mode)
4F	4T	TLM monitors to Phase 2
4T	4F	TLM monitors to Phase 1
5F	5T	Select TR track 1 data for readout thru alternate DIU (see command 10, 11, 12) and switch TR logic to alternate DIU commands.
5T	5F	Select TR track 2 data to its associated DIU for readout. Reset TR logic to be consistent with its normal DIU.
6F	6T	BBU-1 phase lock loop to 4:1 (512 kbps)
6T	6F	BBU-1 phase lock loop to 1:1 (128 kbps)

The selection of which one of the two transmitter links a tape recorder/DIU combination will read out on is accomplished automatically by spacecraft payload logic as shown in table 3-5.

Table 3-5

TAPE RECORDER/DATA LINK CONFIGURATION

T/R SELECTED	READOUT CHANNEL	
T/R 1	Channel 1 only (CT)	Channel 1 and 2 (PT)
T/R 2	Channel 1 only (CT)	Channel 1 and 2 (PT)
T/R 3	Channel 1 only (CT)	Channel 1 and 2 (PT)
T/R 1 & T/R 3	Channel 1 and 2, respectively	Chan. 1 (PT or CT) Chan. 2 (PT)
T/R 1 & T/R 2	Channel 1 and 2, respectively	Chan. 1 (PT or CT) Chan. 2 (PT)
T/R 2 & T/R 3	Channel 1 and 2, respectively	Chan. 1 (PT or CT) Chan. 2 (PT)

PT = Plain Text CT = Cypher Text

NOTE: Normal tape recorder readout is serial via the encypted channel (BBU 1). Dual readouts are possible with second recorder readout on channel 2 in plain text.

3.4.2 Tape Recorder Read-In. A read-in is initiated by SE-2, which is started by primary events (PE's) 1, 2, 3A, or 4A. When the PE occurs, it turns on the horizon sensor and the solar aspect sensor, starts its associated companion event (CE) counting, and starts SE-2 counting. SE-2 clocks out in 32 seconds and applies read-in power to the payload, increments the payload burst counter, and starts the selected tape recorder reading in. Also, SE-2 selects subsequent PE commands to increment the burst counter commensurate with any other tape recorder read-in initiation. A CE resets this function back to SE-2. The capability to disable SE-2 does not exist. (If SE-2 fails, the backup timer should be selected.) The purpose of the SE-2 32-second delay is to allow the horizon sensor signal to stabilize after initial turn-on by the PE.

The choice of which tape recorder a selected PE will cause to be readin is controlled by real time command. A complete listing of the commands that control this function is shown in table 3-6.

Table 3-6

TAPE RECORDER READ-IN/PE COMMANDS

NORMAL COMMAND	ALTERNATE COMMAND	FUNCTION
0.10XX	0.27XX	T/R 1 R/I Control
1T	1T	Select T/R 1 for R/I via PE-1
2T	2T	Select T/R 1 for R/I via PE-2
3T	3T	Select T/R 1 for R/I via PE-3A
4T	4T	Select T/R 1 for R/I via PE-4A
5F	5T	Enable DIU-1
5T	5F	Disable DIU-1 and enable track 1 selection for DIU-2
6F	6T	Select DIU-1 to 128 kbps data rate T/R-1 to 1:1 read-in speed (100 ips)*
6T	6F	Select DIU-1 to 512 kbps data rate T/R-1 to 4:1 read-in speed (25 ips)*
0.11XX	0.26XX	T/R 2 R/I Control
1T	1T	Select T/R 2 for R/I via PE-1
2T	2T	Select T/R 2 for R/I via PE-2
3T	3T	Select T/R 2 for R/I via PE-3A
4T	4T	Select T/R 2 for R/I via PE-4A
5F	5T	Enable DIU-2
5T	5F	Disable DIU-2 and enable track 1 selection for DIU-3
6F	6T	Select DIU-2 to 128 kbps data rate T/R-1 to 1:1 read-in speed (100 ips)*
6T	6F	Select DIU-2 to 512 kbps data rate T/R-1 to 4:1 read-in speed (25 ips)*

* Tape recorder readout speed is always 100 ips.

Table 3-6 (Cont.)

TAPE RECORDER READ-IN/PE COMMANDS

NORMAL COMMAND	ALTERNATE COMMAND	FUNCTION
0.12XX	0.25XX	T/R 3 R/I Control
1T	1T	Select T/R 3 for R/I via PE-1
2T	2T	Select T/R 3 for R/I via PE-2
3T	3T	Select T/R 3 for R/I via PE-3A
4T	4T	Select T/R 3 for R/I via PE-4A
5F	5T	Enable DIU-3
5T	5F	Disable DIU-3 to and enable Track 1 selection for DIU-1
6F	6T	Select DIU-3 to 128 kbps data rate T/R-1 to 1:1 read-in speed (100 ips)*
6T	6F	Select DIU-3 to 512 kbps data rate T/R-1 to 4:1 read-in speed (25 ips)*

* Tape recorder readout speed is always 100 ips.

Bit 1-4 of commands 0.10, 0.11, and 0.12 select read-in PE 1 - 4 for tape recorder 1, 2 and 3 respectively.
Bit 5 of commands 0.10, 0.11 and 0.12 is used for the enable/disable function of DIU's 1, 2 and 3.
Bit 6 is used for 1:1 and 4:1 read-in speed selection for tape recorders 1, 2 and 3 and consistant data rates for the associated DIU's.

3.4.3 Digital Interface Unit (DIU) Operation. The DIU is a device which is installed between a tape recorder output and the payload tape recorder data select logic. Its purpose is to remove flutter and reshape the data played back from a tape recorder. On URSALA IV the clock generated internally in the DIU buffer and timing circuit is routed to the payload code conversion circuit along with the re-clocked data from either track 1 or track 2 of the

tape recorder. These data and clock signals are code converted from BiØM to NRZ-L, then encyphered, code converted back to BiØM and transmitted over channel one baseband unit to the ground.

DIU cross wiring has been incorporated in the design so that Track 1 data from a tape recorder is played back through an alternate DIU. Track 2 data from a tape recorder is played back through the normally associated DIU.

3.5 PROGRAMMED COMMANDS

The system timer has four independent Programmed Events (PE's) and four associated Companion Events (CE's). The PE commands are used to start payload and tape recorder read-ins and the CE's are used to stop payload and tape recorder read-ins. When a PE command clocks out of the timer, it starts its associated CE (e.g. PE-1/CE-1, PE-2, CE-2, etc.). See paragraph 4.2 and 4.3 for PE and CE accuracies. The PE commands may be used to identify the various targets being tasked, as the payload burst counter will update with the PE command once the payload is on in a read-in mode. Any of the three tape recorders are assigned to read-in the collection data in either 4:1 or 1:1 mode. Simultaneous readouts of two recorders plus the serial readout of the third recorder results in readout of all data within 12 minutes.

3.6 READ-IN CONTROL LIMITATIONS

Programmed commands PE-3/CE-3 and PE-4/CE-4 control both read-in selection and operation of the attitude control system (ACS) via common relays. Therefore, these commands may not be used for read-in on/off control while the ACS is in operation.

3.7 TRANSPOND (BYPASS) MODE

In the transpond mode, the payload is in the read-in mode, but the data are routed directly to the transmitters; thus, "real time" operation of the payload results. In a limited transpond, no tape recorder read-in occurs; in a normal transpond/read-in, both real time payload data and the recording of that data are available. Both payload baseband units will be turned on during transpond (the same as a normal TLM ON). Encrypted transponds, either local

or remote, can only be transmitted via baseband unit 1. The input to baseband unit 2 is switched to ground. Only the wideband transmitter that is connected to baseband channel 1 is to be used for remote encrypted transponds. All other transmitters are to be OFF.

The transpond mode is controlled via normal command 0.13XX or alternate command 0.24XX as shown in table 3-7. Turn on or off of the spacecraft in the transpond mode is via real time commands 0.23XX and 0.02-1F or by the usual PE/CE method of read-in control.

Table 3-7

TRANSPOND (BYPASS) MODE SELECTION

Normal Command (0.13XX)	Alternate Command (0.24XX)	Tape Recorder Bypass
1F	1T	Reset transpond mode P/L command (SC-14), Disable SGLS Filters (SC-41)*
1T	1F	Enable transpond mode P/L command (SC-15), Enable SGLS filters if activated (SC-40)
2F	2T	Disable downlink channel 1 during transpond
2T	2F	Enable downlink channel 1 during transpond
3F	3T	Disable downlink channel 2 during transpond
3T	3F	Enable downlink channel 2 during transpond *
4F	4T	Disable status channel during transpond
4T	4F	Enable status channel during transpond (Payload command (SC-1) at start of transpond) *
5F	5T	Select -Y antenna during transpond (downlink only)
5T	5F	Select +Y antenna during transpond (downlink only)
6F	6T	Disable tape recorder read-in during transpond mode if 0.13-1T *
6T	6F	Enable tape recorder read-in during transpond mode if 0.13-1T

* The bit postions associated with these functions should not be selected during remote transponds.

NOTE: During "Exclusive Mode" operations all the various options provided by command 0.13 bits 2 through 6 can be selected to suit the operation. However, bit 1 must be in the false state during normal read-ins. During "Mixed Mode" operations PE(1) will enable the Transpond Mode automatically and PE-3A and 4A will disable the Transpond Mode automatically. PE-2 will switch the downlink antenna to the opposite axis, as selected by command 0.13 bit 5, when it is programmed.

Section 4

PAYLOAD OPERATIONAL CONTROL

Details of the payload features are presented in Spacecraft 4431/URSALA IV Intercept System Technical Description, BIF003W/2-077876-73. This section deals only with a delineation of the actual operational control of the payload.

4.1 READ-IN OPTIONS AVAILABLE

The payload read-in mode can be programmed during a real time acquisition only. Any one of the four PE/CE combinations can be programmed to initiate a partial or full read-in on any of the three recorders. During any acquaisition, as many as four read-ins can be programmed with delays up to six orbits. Any sequence or combination of tape recorders can be selected for this programming. The payload readin mode can be initiated by real time command 0.23XX also.

4.2 PAYLOAD READ-IN ON

The start of SE-2 and, thus, payload read-in is controlled by the PE's. SE-2 time tolerances are +4, and -0 seconds of their programmed times (plus 0.03 percent, minus 0.01 percent). Thus, SE-2 will occur between 32 and 36 seconds. The PE accuracy is +0, -1 second +0.03, -0.01 percent of the programmed delays. PE delays can be programmed in 16-second increments to occur from a minimum of 16 seconds to a maximum of 32,754 seconds. The time delays must be reprogrammed for each read-in. Magnitude commands MC -1, -2, -3 and -4 load primary events PE-1, -2, -3, and -4, respectively. This is accomplished following an 0.05-5T or 0.32-5F command. Following an 0.05-5F or 0.32-5T command, the MC's load the CE delay. PE-3 and -4 are used for payload-on (via SE-2) only after commands 0.07-3F and -4F or 0.30-3T and -4T. Commands 0.07-3T or 0.30-3F enable ACS no. 1, and commands 0.07-4T or 0.30-4F enable ACS no. 2. Thus, if the ACS is to be used, PE-3 and -4 cannot be used for payload tasking. Any payload read-ins, commanded in realtime, that are to remain on after an RTS fade should only be initiated after the spacecraft dual timer has been loaded with PE and CE commands and these events have been started.

4.3 PAYLOAD READ-IN OFF

Each PE in the timer has an associated companion event (CE) that is initiated with the occurrence of its respective PE. CE-1, -2, -3, and -4 can be programmed in 8 second increments from 8 to 2040 seconds. The CE will occur within +0.03, -0.01 percent of the programmed time.

The CE memory logic is non-volatile; therefore, the delay is required to be reprogrammed only when there is a change in the time delay. Magnitude commands MC-1, -2, -3, and -4 load the CE delays following 0.05-5F or 0.32-5T, as described in section 4.2. CE-3 and -4 are switched between readin off and ACS functions as described for PE's in section 4.2. Payload read-in off can be controlled by real time command 0.14XX. Tape recorder read-in off is also via command 0.14XX.

4.4 PAYLOAD MODE PROGRAMMING

Magnitude commands MC-5 and MC-6 together with bits 9 through 19 are used to select program steps and read-in modes. See BIF003W/2-079154-78 for a detailed listing of these assignments.

Various basic commands are used to select different configurations for the different payload operations (TLM ON, BEFORE AND AFTER R/O, R/O,TRANSPOND) and equipment options, i.e., normal or alternative. Table 4-1 shows these assignments.

Magnitude command MC-7 (together with bits 9-19)is available for current payload read-in counter count and target identification information.

4.5 PAYLOAD TURN-ON TIME

The payload data stream may require up to 10 seconds after TLM or R/I turn-on for full updating and synchronization of PCM subframes, etc.

Table 4-1

PAYLOAD SUBCOMMAND ASSIGNMENTS

P/L S/C	NORMAL Command	ALTERNATE Command	Function
-1	0.01-1T	0.36-1F	Energize status monitor power supplies both (PCM and analog).
-2	0.01-2T 0.01-3T	0.36-2F 0.36-3F	Energize the before T/R readout mode or the T/R readout mode (see commands 0.01-2T and 0.01-3T)Reset real time data mode selects.
-3	0.03-1T	0.34-1F	T/R 1 readout voltage on
-4	0.03-2T	0.34-2F	T/R 2 readout voltage on
-5	0.03-3T	0.034-3F	T/R 3 readout voltage on
-6	0.03-1F, 2F, 3F	0.034-1T 2T, 3T	Enable after T/R readout mode and disable T/R readout mode via readout voltage off (i.e., no command pulse enters the payload)
-7	0.02-6F	0.35-6T	Disable TR readout mode, before-and-after TR readout mode. De-energize both BBUs and the status monitor (PCM and analog) power supplies.
-7a	0.02-2F	0.35-2T	De-energize the status monitor (PCM and analog) power supplies.
-8	0.06-1F	0.31-1T	Connect baseband unit 1 to carrier 4*
-9	0.06-1T	0.31-1F	Connect baseband unit 1 to carrier 6 and select real time data via BBU #1 **
-10	0.06-2F	0.31-2T	Connect baseband unit 2 to carrier 5
-11	0.06-2T	0.31-2F	Connect baseband unit 2 to carrier 6 and select real time data via BBU # 2**
-12	0.06-3F	0.31-3T	Transfer reset baseband units 1 and 2
-13	0.06-3T	0.31-3F	Transfer baseband units 1 and 2
-14	0.13-1F	0.24-1T	Disable transpond mode (A CE or RTC deenergizes the P/L and T/R read-in mode) SGLS filters off.

*See page 8-3 for more detail on these TLM configurations.

**When either baseband unit real time data mode has been selected either carrier 4 or 5 must be re-selected in order to restore the normal data transmission path.

Table 4-1

PAYLOAD SUBCOMMAND ASSIGNMENTS (Cont)

P/L S/C	NORMAL COMMAND	ALTERNATE COMMAND	Function
-15	0.13-1T	0.24-1F	Enable transpond mode (A PE or RTC energizes the transpond mode). Both baseband units on or as selected with SC-9 or SC-11. SGLS filters on if activated.
-16	0.16-1F	0.21-1T	Select primary power supply no. 1
-17	0.16-1T	0.21-1F	Select secondary power supply no. 1
-18	0.16-2F	0.21-2T	Select primary power supply no. 2
-19	0.16-2T	0.21-2F	Select secondary power supply no. 2
-20	0.16-3F	0.21-3T	Select primary memory
-21	0.16-3T	0.21-3F	Select secondary memory
-22	0.16-4F	0.21-4T	Select primary TRG
-23	0.16-4T	0.21-4F	Select secondary TRG
-24	0.16-5F	0.21-5T	Select primary band 2 LO
-25	0.16-5T	0.21-5F	Select secondary band 2 LO
-26	0.16-6F	0.21-6T	Select primary band 3 LO
-27	0.16-6T	0.21-6F	Select secondary band 3 LO
-28	0.15-2F	0.22-2T	Select primary band 4 LO
-29	0.15-2T	0.22-2F	Select secondary band 4 LO
-30	0.15-3F	0.22-3T	Select primary band 5 LO
-31	0.15-3T	0.22-3F	Select secondary band 5 LO
-32	0.15-4F	0.22-4T	Select primary sum channel path
-33	0.15-4T	0.22-4F	Select backup sum channel path (see paragraph 6.1a Item 4).

Table 4-1

PAYLOAD SUBCOMMAND ASSIGMENTS (Cont.)

P/L S/C	NORMAL COMMAND	ALTERNATE COMMAND	FUNCTION
-34	0.15-5F	0.22-5T	Enable CW receiver
-35	0.15-5T	0.22-5F	Disable CW receiver
-36	0.16-6F	0.22-6T	Band 2 from antenna B, band 3 from antenna A
-37	0.16-6T	0.22-6F	Band 3 from antenna B, band 2 from antenna A
-38	0.00.3F	0.37-3T	Enable Encryption Equipment
-39	0.00-3T	0.37-3F	Bypass Encryption Equipment
-40	0.00-6F	0.37-6T	Enable SGLS filters for transpond (SC-15 actually activates the SGLS filter function)
-41	0.00-6T	0.37-6F	Disable SGLS filters for transpond (SC-14 actually de-activates the SGLS filters)
-42	0.03-6T	0.34-6F	Select BBU-1 for 1:1 readout (128 kbps)
-43	0.03-6F	0.34-6T	Select BBU-1 for 4:1 readout (512 kbps)

Section 5

SPACECRAFT OPERATIONAL ASPECTS

5.1 ATTITUDE CONTROL SYSTEM

5.1.1 Purpose of Attitude Control System

An attitude control system (ACS) will be used to permit orbit injection at an attitude such that the boost motors will change the orbit inclination up to two degrees while lifting the altitude to 340 nm. This provides more favorable orbit plane spacing between successive spacecraft and enhances the solar illumination history. After deployments, the spin axis will be reoriented approximately parallel to the earth's axis to accomplish the mission.

5.1.2 Initial Spin Axis Attitude Adjustment

Upon initial insertion into orbit, the spacecraft spin axis orientation will depend on the host vehicle attitude and the point of spacecraft separation. The first three days of operation will be used to establish spacecraft attitude. An additional one to six days will be required to reorient the spin axis from the injection attitude to the mission attitude. For the URSALA payload, the mission attitude will be approximately parallel to the earth's spin axis. At the mission attitude, drift will be small.
It is anticipated that small, infrequent ACS operations will be adequate to maintain the spacecraft at the mission attitude.

5.1.3 In-Plane Restrictions

In-plane commanding must be time limited to certain desirable orbit geometries. For cross-plane corrections, the turn-on times are noncritical. Thus, orbits not over targets can be used for cross-plane corrections.

5.1.4 Operations During Large-Angle Maneuvers

DF operations during large-angle maneuvers will probably be less accurate due to the uncertainty of the spin axis position at any given time. During such maneuvers, the dual ACS will be using about 432 watt-hours per day, and the single ACS will be using about 216 watt-hours per day. Therefore, if operations were to be conducted during large-angle maneuvers, the power limitations would impose a reduction of approximately 125 minutes of read-in operations per day for dual ACS or 63 minutes for single ACS.

5.1.5 ACS Enable-Disable

Normally, both ACS no. 1 and no. 2 would be used during an attitude change maneuver. In case of a failure of only one of these two units, the failed unit should be switched out by a "disable" command. Operations can be continued at reduced gain with only the other unit enabled. The "disable" commands must be sent at the end of the sequence turn-off following a maneuver so that the PE/CE relay matrix can be returned from the ACS mode to the T/R R/I mode.

5.1.6 ACS Following LVCO

The LVCO pulse is wired to turn off the ACS by pulsing the disable relays in each of the two units. If the ACS is not being used when the LVCO occurs (as indicated by the LVCO flag monitor), then no action is required. The mode and power relays may or may not be reset.

The enable/disable relays remove power from the ACS coils and disable the circuitry that provides the grounds needed to operate the on/off relays. Thus, because of this relay "race," power to the electronics boxes and to the on/off monitors may not be switched off, even though current has been removed from the relay coils by the enable/disable relays. Consequently, when the LVCO flag monitor indicates an LVCO condition during an ACS maneuver, perform the following operations:

a. Check that the enable/disable monitors indicate a disable condition for both ACS no. 1 and no. 2.

b. Check the on/off monitors. If both monitors indicate "off," notify the technical advisor. (A new maneuver may be required later).

c. If one or both monitors indicate an "on" condition, send the following commands:

0.07-3T or 0.30-3F (enable ACS no. 1) and/or
0.07-4T or 0.30-4F (enable ACS no. 2) and
0.07-1F & -2F or 0.30-1T & -2T (ACS off and reset)
0.07-3F or 0.30-3T (disable ACS no. 1) and/or
0.07-4F or 0.30-4T (disable ACS no. 2)

Notify the technical advisor. A new maneuver may be necessary.

5.1.7 ACS Monitor Peculiarities

5.1.7.1 On-Off/Enable-Disable Monitors. As noted in section 5.1.6, an LVCO may cause the power to be removed from the ACS coil via a disable pulse and leave the rest of the electronics powered in the on condition. The enable/disable monitor will read enable and the on/off monitor may read on (or off).

5.1.7.2 Full-Half Monitor. This monitor also requires a ground circuit only when the ACS is enabled. Thus, if in the half and disabled modes, the monitor will incorrectly read full mode until the ACS is enabled.

5.2 SPIN RATE CONTROL SYSTEM

Because of deflections in the antenna booms, the exact position of all payload antennas will vary with the spacecraft spin rate. This, in turn, will cause a variation in dynamic balance. Thus, the elevation angles of antennas A and B are doubly affected by the spin rate.*

A spin rate control system (SRCS) will prevent deflection changes in the antenna-mounting boom from creating spacecraft imbalance and will maintain the spin rate at an optimum 55 rpm, plus or minus 0.5 rpm.

*Antenna A is the 3-ft-diameter antenna, and antenna B is the 6-ft-diameter antenna.

The SRCS consists of an electronics box, a sense coil that provides a control signal when it is rotated in the earth's magnetic field, and a torquer coil that acts as a dipole that is influenced by the magnetic field. The SRCS is turned on via commands 0.07-5T or 0.30-5F and turned off via commands 0.07-5F or 0.30-5T. A spin up (positive) is selected via commands 0.07-6F or 0.30-6T, and a spin down (negative) is selected via commands 0.07-6T or 0.30-6F. System gain is such that approximately one day of operation (12 hours minimum to 36 hours maximum) equals the spin decay of one week, i.e., about one-half rpm. Since the power required for this system is only 6 watt-hours/day, power consumption can be ignored in power studies.

5.3 ATTITUDE SENSING SYSTEM

The attitude sensing system consists of two horizon sensor subsystems (one on-line and one backup) and a solar aspect sensor subsystem consisting of two shift registers (one on-line and one backup) and four SAS eyes.

5.3.1 Horizon Sensor Subsystem

Two horizon sensors are installed on the spacecraft. Only one sensor is on-line and operational at a time; the other sensor is a spare. Following the evaluation phase, horizon sensor no. 1 will be used for operation, unless otherwise directed by the CSE.

The horizon sensor provides to the payload a positive rectangular digital pulse that switches from 0 VDC (+0.25, -0.0 VDC) to +5 VDC ($\pm$0.5 VDC) during sky-to-earth crossings and returns from the positive level to 0 VDC during earth-to-sky crossings.

This pulse, along with timing information in 100-usec increments, is processed and formatted via the telemetry/command unit into PCM main frame words 26 and 27 as a 16-bit horizon sensor time word. The first bit of the time word is an identification bit that indicates which edge of the earth sensor pulse the timing data represents. The leading edge of the pulse is represented by a binary one and the trailing edge is represented by a binary zero. The second through 15th bits of this word constitute a binary representation of the time

interval between the trailing edge of the 1-pps timing signal and the leading or trailing edge of the horizon sensor data pulse. The time interval is divided into 100-usec increments, and the most significant bit is first. The 16th bit is an error alarm and is a binary one except when the leading or trailing edge of the horizon sensor pulse occurs during the formatting (read-out) of the time word into the PCM bit stream; then, the error alarm bit is a binary zero.

When the horizon sensor scans across the sun, the sensor signals are inhibited for 10 to 30 seconds. During ACS operations, the switching of ACS modes in many cases will cause the horizon sensor signal to cut off for up to 30 seconds. No detrimental effects to the spacecraft and/or mission will result from these horizon sensor cutouts. Also, the first 30 seconds of data after turn on may not be valid and is inhibited from R/I data processing via SE-2.*

5.3.2 Solar Aspect Sensor Subsystem

Signals from the four SAS eyes are combined in the on-line shift register. The output from the shift register to the command data processor contains the sun word signal and the command eye pulse. Output pulse characteristics are as follows:

a. 10-Bit Serial Digital Word

Type	Return to bias (50% duty cycle)
Zero Level	0 ±0.25 volts
Bias Level	+2.5 ±0.25 volts
One Level	+4.75 ±0.25 volts
Bit Rate	10 ±1.5 kbps
Rise and Fall Times	10 usec, maximum
Source Impedance	1000 ohms maximum

*However, there is no inhibit at TLM on.

b. Command Eye Pulse

True Level	+5.0 ±1.0 volts
False Level	0.0 ±0.25 volts
Pulsewidth	170 ±40 usec
Rise and Fall Times	10 usec, maximum
Repetition Rate	4.5 pps, maximum

The readout of the digital word from the solar aspect sensor subsystem is initiated not less than 150 usec after the leading edge of the command eye pulse.

The solar aspect sensor data, together with 100-usec time increments, are processed and formatted into PCM main frame words 17, 18, and 19 as a 24-bit solar aspect sensor data word structured as follows:

a. The first 14 bits of the solar aspect sensor data word constitute a binary representation (most significant bit first) of the time, in 100 usec increments, between the trailing edge of the 1-pps time signal and the leading edge of the solar aspect sensor command eye pulse.

b. The 15th through 24th bits of the solar aspect sensor data word represent the same data bit sequence as the solar aspect sensor 10-bit serial digital word.

Receipt of new solar aspect sensor data during the formatting of previous solar aspect sensor data into the PCM mainframe causes all subsequent bits of the previous solar aspect sensor data to be formatted as zero. The new solar aspect sensor data are then formatted into the next PCM main frame.

5.4 DEPLOYMENTS

Details of the deployment sequence are presented in Spacecraft 4431/URSALA IV Spacecraft Systems Requirements Document, BIF003W/2-078566-78. The state of one or two of the six basic command bits is shown for each step in the deployment sequence. The remaining bits should be false. Following the deployment sequence, command 0.05-6F (SELECT TIMER 1, DISABLE TIMER 2) should be sent to prevent possible noise on the PE lines during their later use for read-in selection.

5.5 POWER SYSTEM

5.5.1 Depth of Discharge Limits

The power usage shall be limited to three ampere-hours per single rev read-in/readout cycle. The maximum daily excursion in depth of discharge shall be limited to six ampere-hours.

5.5.2 Control Modes

The primary charge-control mode uses third-electrode signal outputs to switch from full to trickle charge. This is effective during high temperatures. Each battery has its own separate control. There are two third-electrodes per battery. One of the four levels at which the signal causes a switch of charging mode must be selected via the following basic commands:

Basic Command	Charge Level
0.04-3F and 0.04-4T	Battery 1, level 1
0.04-3T and 0.04-4T	Battery 1, level 2
0.04-3F and 0.04-4F	Battery 1, level 3
0.04-3T and 0.04-4F	Battery 1, level 4
0.17-3F and 0.17-4T	Battery 2, level 1
0.17-3T and 0.17-4T	Battery 2, level 2
0.17-3F and 0.17-4F	Battery 2, level 3
0.17-3T and 0.17-4F	Battery 2, level 4

The primary charge control mode also uses voltage/temperature switching circuits which are effective at normal and low temperature conditions. This V-T curve is similar to the level 4 (highest) curve of the backup mode.

The backup charge control mode uses pure voltage-temperature switching controls. One of four levels, or V-T curves, is command selectable using the same commands indicated earlier.

Command 0.04-1F selects the primary mode and command 0.04-1T selects the backup mode for battery 1 circuits. Command 0.17-1F selects the primary mode and 0.17-1T selects the backup mode for the battery 2 circuits.

If both electrodes of a battery should fail open, one would normally switch to the backup mode and select a voltage/temperature level to operate on. If one or both third electrodes of a battery fail short, the backup mode and a voltage temperature level should be selected.

5.5.3 LVCO Enable/Disable Command Restriction

To provide circuit discharge time, a "LVCO enable" command should not be sent until at least ten seconds after a "LVCO disable" command. (Also a "LVCO disable" shall not be sent until 10 seconds after a "LVCO enable".) These commands would normally be used only in case of a failure in the power system.

5.5.4 Preferred Launch Configuration

To reduce the open-circuit battery losses, the preferred mate/launch configuration is in the backup charge control mode with control electrode no. 2 selected on both batteries.

Section 6

OPERATIONAL CONSTRAINTS AND LIMITATIONS

Operation of the spacecraft is subject to the limitations and special requirements detailed in the following sections:

6.1 PAYLOAD

a. An alternate (redundant) unit as a rule should not be selected unless normal unit has failed.

1. Switching is performed by mechanical relays. The fewer the operations, the greater the probability they will work when needed.

2. Interchanging LO's will offset the RF frequencies. Thus, a different calibration table must be provided to the computer whenever such a change occurs.

3. Interchanging the TRG's will cause the TRG time drift compared to ground time to change. A new calibration period will be needed to establish this rate. Also, the TRG will start from zero each time an interchange occurs.

4. Use of the backup sum channel involves the loss of the difference channel and of all monopulse information. This means payload subcommand (SC-33) must never be used unless it is required by a failure in the sum channel.

5. Transfers between primary and backup power supplies occur only at turn-ons (SC-1, SC-2, or PE for B box, PE only for A box). Therefore, if a transfer is required, the procedure should be as follows:

A. If only the A box is to be transferred, select the A box backup during a status on, B & A R/O period. The next PE will complete the transfer.

B. If the B box power supply must be transferred, the select command will have to be sent during a power-off period. Follow the select command with an SC-1 and an SC-2 to confirm B box transfer and satisfactory operation of the backup supply. The A box power supply can be selected at the same time if desired, but the actual transfer will still wait for a PE.

C. If an input short occurs in the A box supply, the transfer can be forced by a backup select followed by a PE/CE pair.

6. Transfers between the primary and backup memories:

A. Should not be accomplished during the read-in or bypass modes because a different content would probably exist in the other memory

B. Should be accomplished in the status TLM mode, only

C. Should be followed by fully reloading the newly selected memory

D. May result in nonvalid data on payload PCM or payload status TLM on spacecraft status TLM for up to three seconds.

b. C-band antenna assignments (SC-36 and -37) should be changed only when required.

c. **Disabling the CW receiver (SC-35) also disables the TSG. This mode is designed to conserve power. When adequate power is available, but CW data are not desired, CW reject can be selected (Magnitude Command 6, word 3, bits -16 and -17) instead to allow TSG operation.**

d. MC-5 is used to define the operating modes for eight program steps. The odd-numbered steps are intended for use with the A antenna (3-foot dish). As long as the program sequence is controlled by the horizon sensor, the A antenna will scan the ground during these steps. The B antenna should not be used for these (the odd steps) since it will normally be pointing at the sky during these periods. Likewise, the even steps are intended for the B antenna (6-foot dish) and should not be used by the A antenna. (Antenna selection is implied by band selection, since each band is available from only one antenna during a given pass.)

e. The two-second backup for the horizon sensor (to control the program sequence) should not be used as long as the horizon sensor is functioning satisfactorily. This mode is intended for use only if the horizon sensor signal should become very noisy, so that it no longer controlled the program sequence properly. Therefore, MC-6, word 0, bit 19 should normally be a 1.

f. The SGLS-reject filter must be selected whenever the TRANSPOND mode is selected if band 1 is to be used. Otherwise, the downlink transmitters will saturate the receivers in band 1.

g. Charging up the input filter circuit of a TRG may cause the TCU current limiter to shut down the command expander output. Therefore, the back-up (or primary) TRG should not be selected at the same time another back-up element is being selected.

h. Pulse frequency and sidelobe inhibit overrides are provided for use prior to launch. These should never be used unless the inhibit circuitry fails. Therefore, MC-6, word 0, bit 13 and MC-6, word 1, bit 15 should normally be a 1.

i. Use of K_o to bias the sidelobe inhibit test reduces system sensitivity by 5 dB. This is not normally acceptable. Therefore, MC-5, words 0 through 7, bit 16 should normally be a 1.

j. Use of G_o to bias the Σ/Δ test narrows the effective antenna beamwidth. It also reduces system sensitivity. Therefore, MC-5, words 0 through 7, bit 15 should normally be a 1.

k. Overrides should be kept set for A, B, C, and D < T inhibits. This will maximize the amount of DF data provided. Therefore, MC-6, word 1, bits 16, 17, 18, and 19 should normally be a 0.

l. The continuous CAL mode preempts the system, so that only CAL data are processed. This is intended to be a troubleshooting mode, only. Therefore, MC-6, word 0, bits 16 and 17 should normally not both be at 1.

m. Fine pulse frequency measurement should be enabled. This option is included for use should power be inadequate to support required tasking. Therefore, MC-6, word 0, bit 14 should normally be a 0.

6.2 ACS/SRCS/HS/SAS

a. The ACS shall be used only at the direction of the CSE.

b. The command to change the polarity of the SRCS (spin up or spin down) should not be sent while power is applied to the SRCS. Selection of a change in polarity should be made prior to turn-on of the SRCS. If selection of polarity is made while power is applied to the SRCS, damage could result to the system.

c. The first 30 seconds of horizon sensor data after turn-on may not be valid. SE-2 allows for this delay prior to tape recorder read-in and transpond operations.

d. Use of the alternate horizon sensor shall be at the direction of the technical advisor.

e. In-plane commanding must be time-limited to certain orbit geometries. Turn-on time of day is, therefore, restricted for in-plane maneuvers.

f. Operations during maneuvers are restricted in accordance with section 5.1.4.

g. The alternate solar aspect sensor shift register should be selected only in the case of a failure of the normal unit.

h. To avoid the occurrence of one additional CE-4 event after turn-off of the ACS system, the 0700 command (reset PE/CE-3 and PE/CE-4 from ACS to tasking mode) should be executed after the time that the additional CE-4 is scheduled to occur following PE/CE-3 (ACS OFF). There should not be a 0714 command executed (ENABLE ACS 1 and 2) as part of the ACS-off and reset sequence.

i. One additional CE-4B event will occur after the ASC system is turned off. To avoid having the last CE-4B turn off the payload, the 0.07-3F and 4F commands (reset PE/CE 3 and PE/CE 4 from ASC to P/C read-in) must be executed after the last CE-4B.

j. The ACS system must be enabled by 0.07-3T and 0.07-4T in order for the following commands to perform <u>all</u> of their functions:

1.	0.07-1F	Stop CE-4 recycle and ACS off and reset
2.	0.07-2F	
3.	PE-3B	
4.	CE-3B	
5.	0.07-1T	Negative polarity
6.	0.07-2T	In-plane

k. SRCS commands are not to be sent when ACS commands are in effect.

6.3 DATA STORAGE - TAPE RECORDERS

a. To simplify data management, avoid splitting the data read-outs. Acquisitions selected for tape recorder readout should allow sufficient time at acceptable signal strengths to reach readout end-of-tape on the recorder.

b. Do not command readout unless wideband carriers 4, 5 or 6 are on.

c. Do not read out three tape recorders at one time (unless data are to be dumped).

d. The execution of tape recorder readout commands should be avoided when the tape recorder is already at readout end-of-tape.

e. Do not read out a tape recorder which is being read in during a transpond exercise with tape recorder read-in; other tape recorders, though, are candidates for readout.

f. Real time initiation of payload and tape recorder read ins designed to extend past an RTS fade should only be instigated after the PE and CE commands are loaded and started to ensure proper read-in control. Also, any tape recorders in read out should be at least 30 seconds from EOT if they are to be read in via a real time read-in command. The reason for this requirement is obvious, plus the payload-on in read in terminates the readout mode by turning off the baseband units.

g. Readout of any tape recorder via both its alternate and associated digital interface unit simultaneously shall not be allowed with the encryptor enabled, as this will result in cypher text and plain text data from from the same source being transmitted.

h. During mixed tape recorder readout and transpond operations the following commanding precautions should be taken:

1. Do not terminate an encrypted readout on baseband unit 1 during a real time transpond operation on baseband unit 2 as this will result in a simultaneous encrypted transpond on baseband 1. Back-to-back readouts of two tape recorders can be accommodated on baseband unit 1 during a transpond if one TR DIU is switched off as the second TR DIU is switched on.

2. Do not terminate an encrypted transpond exercise on baseband unit 1 during tape recorder readout on baseband unit 2 as this will cause encrypted B&A mode to be transmitted via baseband unit 1. A subsequent tape recorder readout-off command will result in B&A mode via baseband unit 2, unencrypted.

3. The readout mode on command 0.01-2T or 3T (SC-2 to the payload) will be required to be sent again if a tape recorder readout on baseband unit 1 is to follow a transpond exercise on baseband unit 1 where there had been a tape recorder readout via baseband unit 2 during the transpond. I.e., anytime a baseband unit has been selected to the real time data mode via command .06-1T or 2T, it can be reset to accept the stored data (readout mode) with command 0.01-2T or 3T; however no tape recorder should be reading out when this is done.

   NOTE: Simultaneous B&A mode or transponds that could occur on both downlinks can be avoided by disabling channel 2 downlink at the completion of mixed transpond/readouts.

4. During mixed readout transpond exercise where channel 1 data are to be encrypted, the tape recorder readout should be initiated prior to the turn-on of the transpond to avoid the simultaneous red clock/black data on the two downlink channels. Transponds which must preceed TR readouts can be accommodated by initiating the readout after the transpond is complete on the cypher text channel.

i. Tape recorder readouts which are terminated for ground antenna slewing at midpass revert to the B&A mode. B&A is plain text in this situation even though the encryption equipment was being used during the readout. Resumption of the tape recorder readout on channel 1 is encrypted.

6.4 POWER/TASKING

a. Spacecraft status should be checked a minimum of once every six hours.

b. To conserve power, the payload-on duration, as controlled by the CE's, should not be larger than the remaining read-in capacity of the tape recorders; e.g., if only 300 seconds of tape remains before read-in end-of-tape, do not select the CE for longer than 300 seconds.

c. The average power usage shall be three ampere hours per charge/discharge cycle (1.5 ampere-hour per battery). The maximum power usage shall be 6 ampere hours per charge/discharge cycle.

d. Backup charge controls, trickle charge use, and disabling LVCO should be restricted.

e. Control levels should be selected and commanded only with the approval of the technical advisor.

f. LVCO enable and LVCO disable commands must be separated by at least ten seconds (see para. 5.5.3).

g. To reduce the open-circuit battery losses, the preferred mate/launch configuration should be in the backup charge-control mode with control electrode no. 2 selected on both batteries.

h. Conduct power management in accordance with the requirements of Power Management of P-989 Spacecraft, BIF003W/2-112264-76 Spacecraft-peculiar constants are:

$$P(\gamma) = a_0\gamma + a_1\gamma + a_2\gamma + a_3\gamma + a_4\gamma + a_5\gamma \quad \text{(AMPERES)}$$

Where:
$a_0 = -6.274009868 \times 10^{-1}$
$a_1 = +4.022112596 \times 10^{-2}$
$a_2 = +5.509869348 \times 10^{-5}$
$a_3 = -1.681704876 \times 10^{-6}$
$a_4 = 0.0$
$a_5 = 0.0$

For a determination of power consumed by the various combinations of components and subsystems, refer to Spacecraft 4431/URSALA IV Spacecraft Systems Requirements Document, BIF003W/2-078566-78.

6.5 COMMAND AND TELEMETRY

a. Telemetry should not be transmitted when the payload is reading in while in the band 1 configuration (2 to 4 GHz) unless the SGLS filters are activated. Also, (transpond) should not be commanded with the payload in the band 1 configuration unless the SGLS filters have been activated.

b. A 0.01-2T or -3T (or 0.36-2F or -3F) readout mode on command should not be sent while the tape recorder is reading out, since to do so would result in the payload logic reverting to its before-and-after tape recorder readout configuration, thus causing loss of the recorded data.

c. The antenna select is reset to -Y for telemetry and to -Y and +Y for commanding by 0.02-2F if carrier 1 has been selected for status or by 0.02-5F if carrier 6 has been selected for status.

d. Don't turn on carrier 4 or 5 (payload channels 1 and 2) unless status carrier 1 is on.

e. The backup timer should be selected only if the primary timer has failed.

f. Carrier 6 should not be selected and left selected unless there is a failure of one of the other carriers.

g. BBU select to realtime data (Select Carrier 6) should be followed by either main carrier select command to restore the data path to the transmitter.

h. BBU transfer should occur only in the case of a failure.

i. Two basic command pulses are needed to turn on TLM. (See para. 9.7).

j. Status data cannot be transmitted via carriers 1 and 6 simultaneously.

k. When carrier 6 is being used in the PM mode as a status carrier it shall not be selected as an alternate wideband carrier in the FM mode or vice versa.

The following general rules should apply to commanding:

a. Spacecraft termination commands should not be sent without proper authorization. (They should be prohibited.) However, basic command 0.14xx is used to terminate real time read-in and is permitted.

b. There should be no use of redundant equipment without CSE approval.

c. Unnatural and/or illogical operational modes should be avoided.

d. Commands resulting in loss of data or which result in unexpected changes that would affect data processing should be avoided.

e. If any equipment should fail and its alternate unit selected, then selection commands to return to the failed unit should not be sent without direction from the technical advisor. Ganged commands will be excluded once approval is issued by CSE.

f. Mutually exclusive modes (tabulated in section 7) should not be commanded at the same time. In general, this is only possible for basic commands 0.06-1T (Channel 1 to Carrier 6) and 0.06-2T (Channel 2 to Carrier 6), since in all other basic commands that select mutually exclusive modes, assignment pairs are on the T and F state of the same bit or on another basic command.

The following restrictions apply to the various specific basic commands:

Command	Limitations and Restrictions
1	a. Do not turn on carrier 4 or 5 (payload channels 1 and 2, respectively) without status carrier 1 also being turned on.
	b. Restrict the use of receiver no. 2 PRN.
	c. Two basic command pulses are needed for TLM On.
2	a. Do not turn off carrier 1 without carriers 4 or 5 also being turned off.
	b. Do not turn off carriers 4 or 5 if the tape recorder is reading out.
	c. Do not send payload command 7 to the payload prior to tape recorder stop.
3	a. Do not read out three tape recorders at one time.
	b. Do not send command 0.03-5T (Pyro Bus On) after the deployment sequence has been completed.
	c. Do not read out tape recorders unless carriers 4 or 5 (or backup carrier 6) are on.
4	a. Restrict the use of backup charge control B1.
	b. Restrict the use of command trickle charge B1.
	c. Restrict the use of disable LVCO no. 1.
	d. LVCO enable and LVCO disable commands must be separated by at least 10 seconds. See para. 5.5.3.
5	Restrict selection of timer no. 2.

Command	Limitations and Restrictions
6	a. Do not select horizon sensor no. 2 unless directed by the CSE. b. Do not select carrier 6 as an alternate for both carriers 1 and 4 or 1 and 5 simultaneously. c. Restrict the use of status baseband 1 and 2 transfer. d. Restrict the use of channels 1 and 2 transfer.
7	a. Do not use ACS without the direction of the CSE. b. Commanding of SRCS NEGATIVE (bit 6T) and SRCS ON (bit 5T) at the same time may damage the SRCS. This grouping should be restricted. To assure that there have been no unknown EMI-induced effects which could cause this damage, the normal SRCS turn-on should be via a 2-command block. The first command, 0.07-5F and 0.07-6F, will assure that the logic is positive and off; the second command. 0.07-5T and 0.07-6F, will assure the desired positive turn-on.
10	DIU 1 must be disabled to select TR 1 track 1 to DIU 2. Do not re-enable DIU 1 after track 1 selection.
11	DIU 2 must be disabled to select TR 2 track 1 to DIU 3. Do not re-enable DIU 2 after track 1 selection.
12	DIU 3 must be disabled to select TR 3 track 1 to DIU 1. Do not re-enable DIU 3 after track 1 selection. Note: Do not disable DIUs while data are being read out thru them. Do not change tape recorder speeds while a recorder is being read in. If two or more DIUs have to be disabled for any reason, the data from affected tape recorders will have to be read out plain text as the DIU clock is required to operate the encryptor.
13	a. Do not disable carrier 1 status during transpond* b. Do not transmit status data via carriers 1 or 6 during a remote transpond to an RTIP van in the field unless van is in the ZI. c. If 0.13-1T (Transpond ENABLE) is in effect, SE-1 can turn off the payload.

*Except for special cases, such as a power problem, etc.

Command	Limitations and Restrictions
14	Transpond mode operation during an ACS manuever is possible if done with real time commanding. The use of ENABLE TERMINATION commands 0.14-1T, -2F, and -3T, and the use of TERMINATION COMMAND 0.14-1T, -2F, and 3F shall be prohibited. Note: The reset termination command is not restricted nor prohibited. Basic command 0.14xx (Real Time Read-In Off) is not restricted.
15	Spacecraft: Restrict selection of SAS no. 2 Payload: a. Use of a backup LO will require use of a different calibration table; therefore, commands 0.15-2T and 0.15-3T should be restricted. b. Use of the backup sum channel will cause loss of delta channel and all of monopulse information; therefore, command 0.15-4T should be restricted. c. The DISABLE CW mode causes some loss of data and is to be used in case of power limitation failure only; therefore, command 0.15-5T should be restricted. d. The C-band antenna assignments on bit 6 should be changed only when required.
16 (Two phases deploy and postdeploy)	Spacecraft: No restrictions during either phase. Payload: (Both phases) a. The use of the backup TRG will cause a TRG time drift as well as the need for a new calibration period (also, the backup TRG starts at zero); therefore, command 0.16-4T should be restricted. (See item e., below.) b. The use of the backup LO will require a different calibration table; therefore, commands 0.16-5T should be restricted. c. Memory contents will be scrambled by a transfer to the backup memory; therefore, command 0.16-3T should be restricted.

Command	Limitations and Restrictions
16	d. Power supplies should be switched to their backups only at payload power turn on at a PE. This is taken care of automatically, but it is advisable to restrict commands 0.16-1T and 0.16-2T (see section 6.1, item a-5).
	e. Charging up the input filter circuit of a TRG may cause the TCU current limiter to cut off the command expander output. Therefore, the back-up (or primary) TRG should not be selected at the same time that another back-up element is being selected, i.e., send 0.16-4T only when 0.16-1, -2, -3, and/or -5 are F.
17	a. Restrict use of backup charge control B2
	b. Restrict use of command trickle charge B2
	c. Restrict use of disable LVCO no. 2.
0	a. Enabling the encryption equipment allows it to be powered with the next downlink-on command.
	b. Disabling the encryption equipment while the encryptor is on only switches the data path to bypass around the encryptor. It does not turn the encryption equipment off.
	c. Disabling the encryption equipment prevents it from being powered on via the next downlink-on command.
	d. Selection of the PM mode for carriers 4 and 5 is only compatible with 1:1 tape recorder readouts. 4:1 readouts shall be accomplished only with the transmitters in the FM mode. This is to prevent loss of data.
	e. The downlink antennae will switch in the exclusive read-in or transpond mode for every PE-3/CE-3 and PE-4/CE-4.
	f. The downlink antennae will only switch with PE-2/CE-2 in the mixed read-in transpond mode. The PE-1 command can only be used for transpond exercises, and PEs 3 and 4 can only be used for read-ins.
	g. Transpond with SGLS filters shall only be necessary when band 1 is to be tasked during the transpond. Transpond without SGLS filters shall be used for all transponds that exclude band 1 tasking.

Command	Limitations and Restrictions
23	This command is the basic command used to turn on payload/ tape recorder read-in or transpond exercises. It will perform the same operations that are prescribed for PE-1. There are no restrictions connected with this command other than if it is to be used to start a read-in prior to a tracking station fade, the programmed PE and CE commands must have been loaded and started. Payload and tape recorder read-ins can be turned off with basic command 14, and payload transponds with tape recorder read-in can be terminated with the downlink-off command 0.02-1F. SE-1 (ALL OFF) also terminates payload transponds with tape recorder read-in. SE-1 will not terminate payload read-ins which have been started by command 23.

6.6 TIMER

a. The backup timer should be selected only if the primary timer has failed.

b. If a PE is sent when its associated CE is counting, the CE will stop its count. If the PE is started again and allowed to clock out, a CE of unknown value will start counting.

c. Sending a new CE when a CE is counting will probably load a CE of unknown quantity and the new CE will immediately begin counting down. A new CE may be loaded when a PE is counting.

d. To conserve power, the payload-on duration, should be limited to the duration of the required read-in.*

e. Sending a PE when a PE is clocking out will stop the clock-out and load the new PE.

f. A PE start command has no adverse affects if sent after the PE or CE is counting down.

g. A PE start command should not be sent when a PE has not been loaded. If a start command is sent under these circumstances than a PE of 28658 seconds will start counting.

h. PE delay command logic is destroyed when the PE clocks out; therefore, PE delays must be reloaded whenever it is desired to read-in again.

i. CE delay logic is not destroyed when it clocks out, and needs only to be changed when a different clockout time is desired.

j. Additional CE-4B command (See Section 6.2 (i).

k. Commands 0.07-3F and -4F limit PE-3/CE-3 and PE-4/CE-4 to payload on/off. Commands 0.07-3T or -4T limit PE-3/CE-3 and PE-4/CE-4 to ASC control.

l. Do not program a CE to occur between a PE and an SE-2 clockout; otherwise, the following conditions could result:

   1. A read-in could occur without horizon sensor or solar aspect sensor data.

   2. The payload could be left on until another CE was programmed to occur.

m. A CE should never be programmed to occur coincident with a PE or SE-2.

n. SE-1 will not turn off a read-in that has been started by a real time command.

*See paragraph 6.4, b. for details.

o. A PE/CE combination can only be assigned to one tape recorder at a time.

p. Real time commands to turn equipment on should not be sent when a CE command to turn equipment off is to be clocked out of the dual timer.

q. PE and CE commands are no longer required to initiate and terminate real time transpond operations. Real time commands for this purpose have been incorporated in URSALA IV.

Section 7

MUTUALLY EXCLUSIVE MODES

Certain spacecraft operational modes are mutually exclusive, i.e., if one particular mode is in effect, the other mode is disabled. The design for these circuits is either/or logic. Table 7-1 lists the commands that control mutually exclusive modes. In addition, many payload modes, as controlled by the magnitude command internal logic within the payload, fall in this same category. (BIF003W/2-077876-73 delineates these modes.) Because true-false logic is used, only one of the two commands can be chosen, (i.e., either F or T) at the same time for any bit. In Table 7-1, backup commands are not shown, and the commands shown are those following the launch sequence logic reset, unless otherwise specified.

Table 7-1

MUTUALLY EXCLUSIVE MODES

Either	Or
0.01-1T Status TLM on	0.02-2F or -5F or SE-1 or CE Status TLM off
0.01-2T Channel 1 TLM on	0.02-3F, or -5F or SE-1 or CE Channel 1 TLM off
0.01-3T Channel 2 TLM on	0.02-4F or -5F or SE-1 or CE Channel 2 TLM off
0.01-5F -Y antenna	0.01-5T +Y antenna
0.01-6F Receiver 1 PRN	0.01-6T Receiver 2 PRN
0.03-1T T/R 1 R/O	0.03-1F or 0.01-6F or SE-1 or CE T/R 1 stop
0.03-2T T/R 2 R/O	0.03-2F or 0.01-6F or SE-1 or CE T/R 2 stop
0.03-3T T/R 3 R/O	0.03-3F or 0.01-6F or SE-1 or CE T/R 3 stop
0.03-4T Phase 1	0.3-4F Phase 2

Table 7-1
MUTUALLY EXCLUSIVE MODES
(Continued)

Either	Or
0.04-1F B1 primary charge control	0.04-1T B1 backup charge control
0.04-2F B1 normal charge	0.04-2T B1 trickle charge
0.04-3F &-4T B1 level 1	0.04-3T &-4T B1 level 2
0.04-3F &-4T B1 level 1	0.04-3F & -4F B1 level 3 } etc.
0.04-3F & -4T B1 level 1	0.04-3T & -4F B1 level 4
0.04-5F B1 3rd electrode 1	0.04-5T B1 3rd electrode 2
0.04-6F Select LVCO 1	0.04-6T Disable LVCO 1
0.17-1F B2 primary charge control	0.17-1T B2 backup charge control
0.17-2F B2 normal charge	0.17-2T B2 trickle charge
0.17-3F & -4T B2 level 1	0.17-3T & -4T B2 level 2
0.17-3F & -4T B2 level 1	0.17-3F & -4F B2 level 3
0.17-3F & -4T B2 level 1	0.17-3T & -4F B2 level 4
0.17-5F B2 3rd electrode 1	0.17-5T B2 3rd electrode 2
0.17-6F Select LVCO 1	0.17-6T Disable LVCO 1
0.05-5F Enable CE load	0.05-5T Enable PE load
0.05-6F Select timer 1	0.05-6T Select timer 2
0.06-1F Carrier 4 for channel 1	0.06-1T Carrier 6 for channel 1 Baseband Unit #1 to real time data*
0.06-2F Carrier 5 for channel 2	0.06-2T Carrier 6 for channel 2 Baseband Unit #2 to real time data*

*Real time data selection on either BBU must be followed by the command to reselect either carrier 4 or 5 unless carrier 6 is desired. Command .01-2T or 3T will reset either baseband unit so that stored data from tape recorder can be readout.

Table 7-1

MUTUALLY EXCLUSIVE MODES
(Continued)

Either	Or
0.06-3F P/L BBU transfer reset	0.06-3T P/L BBU transfer
0.06-4F Status BBU transfer reset	0.06-4T Status BBU transfer
0.06-5F Carrier 1 for status	0.06-5T Carrier 6 for status
0.06-6F Select H/S 1	0.06-6T Select H/S 2
0.07-1F & -2F, CE-3B, CE-4B ACS off	PE-3B or PE-4B ACS on
0.07-1T ACS negative polarity	0.07-1F & -2F or CE-3B or -4B ACS positive polarity
0.07-2T ACS in-plane	0.07-1F & -2F or CE-3B or -4B ACS cross-plane
0.07-3F Disable ACS no. 1	0.07-3T Enable ACS no. 1
0.07-4F Disable ACS no. 2	0.07-4T Enable ACS no. 2
0.07-3F or -4F PE/CE matrix to R/I	0.07-3T & -4T PE/CE matrix to ACS
0.07-5F SRCS off	0.07-5T SRCS on
0.07-6F SRCS spin up	0.07-6T SRCS spin down
0.10-1T T/R 1 for PE-1	0.11-2T or 0.12-3T T/R 2 or T/R 3 for PE-1
0.10-2T T/R 1 for PE-2	0.11-2T or 0.12-3T T/R 2 or T/R 3 for PE-2
0.10-3T T/R 1 for PE-3	0.11-3T or 0.12-3T T/R 2 or T/R 3 for PE-3
0.10-4T T/R 1 for PE-4	0.11-4T or 0.12-4T T/R 2 or T/R 3 for PE-4
0.13-1F Reset Transpond mode	0.13-1T Transpond mode

Table 7-1

MUTUALLY EXCLUSIVE MODES
(Continued)

Either	Or
0.13-2F Disable channel 1 for transpond	0.13-2T Enable channel 1 for transpond
0.13-3F Disable channel 2 for transpond	0.13-3T Enable channel 2 for transpond
0.13-4F Disable status channel for transpond	0.13-4T Enable status channel for transpond
0.13-5F -Y antenna for bypass (TLM only)	0.13-5T +Y antenna for bypass (TLM only)
0.13-6F Disable tape recorder readin during transpond	0.13-6T Enable tape recorder readin during transpond
0.14-1T & -2F & -3T Enable termination	0.14-1F or -2T Reset termination enable
0.14-1T & -2F & -3F Termination (if enabled)	0.14-1F or 2T or 3T termination
0.15-1F SAS no. 1	0.15-1T SAS no. 2
0.15-2F Primary band 4 LO	0.15-2T Backup band 4 LO
0.15-3F Primary band 5 LO	0.15-3T Backup band 5 LO
0.15-4F Primary sum channel	0.15-4T Backup sum channel
0.15-5F Enable CW	0.15-5T Disable CW
0.15-6F Antenna B to band 2, antenna A to band 3	0.15-6T Antenna A to band 2, antenna B to band 3
0.16-1F Primary power supply 1	0.16-1T Backup power supply 1
0.16-1T, -2T Pyro power off, Monitors to phase 2, S/A motor bus off, Disable deploy logic (deploy phase only)	0.03-5T Pyro power on, etc. S/A motor bus on Enable deploy logic
0.16-2F Primary power supply 2	0.16-2T Backup power supply 2

Table 7-1

MUTUALLY EXCLUSIVE MODES
(Continued)

Either	Or
0.16-3F Primary memory	0.16-3T Backup memory
0.16-4F Primary TRG	0.16-4T Backup TRG
0.16-5F Primary band 2 LO	0.16-5T Backup band 2 LO
0.16-6F Primary band 3 LO	0.16-6T Backup band 3 LO
0.00-2T Disable LVCO bypass	0.00-1T LVCO bypass
PE's (A mode) H/S, SAS on (etc.) P/L and T/R on after SE-2	CE's (A mode), 0.02 H/S, SAS off (etc.) Reset SE-2 function
SE-2 P/L, T/R on, select PE's to perform these functions	CE's (A mode), 0.02 P/L, T/R off (etc.) Reset SE-2 functions
LVCO 0.02 and 0.07F functions	0.01, 0.03, 0.07T functions and SE-2 & PE's (A)

Section 8

SPACECRAFT TELEMETRY

8.1 CARRIER 1

Carrier 1 is used to carry the spacecraft status information via an 8-kbps, NRZ-L, PCM bit stream. It also contains a 500-kHz PRN ranging signal. The transmitter is phase-modulated at 3 radians. The output power is two watts, minimum, and frequency is 2202.5 MHz, ±0.003 percent.

The PCM main frame is 800 bits (100 8-bit words), the first 24 bits are for synchronization. Main frame words 96 and 97 are subcommutated into two 10-channel, 8-bit analog words with a sample speed of 1 sps. Main frame word 48 is subcommutated into 30 8-bit words. Three parameters may be supercommutated at 100 sps. Time code data, subframe identification, SAS data word, and horizon sensor time word data are presented. For details see Spacecraft 4431/URSALA IV Instrumentation Schedule, BIF003W/2-079479-78, Rev. B.

The PRN ranging signal waveform is noise contaminated, 1-megabit NRZ-L with a bandwidth of 750 Hz to 850 kHz,

8.2 CARRIERS 4 AND 5

Carriers 4 or 5 transmit 512 kbps biphase-mark PCM data during T/R readout in the 4:1 mode or 128 kbps biphase-mark PCM data during TR readout in the 1:1 mode. Output power is 5 watts, minimum, and the output frequencies are 2257.5 MHz for carrier 4 and 2282.5 MHz for carrier 5. The frequency tolerance for the type 25 transmitters is ±0.05 percent. Details on the data for these carriers are provided in Spacecraft 4431/URSALA IV Payload Technical Description, BIF003W/2-079154-78.

8.3 CARRIER 6

Carrier 6 may be selected to back up carrier 1 or carrier 4 or 5. The output power is 5 watts, minimum, and the output frequency is 2232.5 MHz. The frequency tolerance of the type 25 transmitter is ±0.05 percent in the FM mode and ±0.0065 percent in the PM mode.

8.4 STATUS BBU AND PRN ASSIGNMENTS

The matrix of commands shown in table 8-1 will help in commanding the assignment of which status baseband unit, receiver PRN signal, and status transmitter are selected.

Table 8-1

STATUS BBU, PRN, STATUS TRANSMITTER SELECTION COMMANDS

Selectable Equipment			Commands		
BBU	Carrier	PRN	0.06-4	0.06-5	0.01-6
1	1	1	F	F	F
1	1	2	F	F	T
2	1	1	T	F	F
2	1	2	T	F	T
1	6	1	T	T	F
1	6	2	T	T	T
2	6	1	F	T	F
2	6	2	F	T	T

8.5 PAYLOAD CARRIER-TO-CHANNEL ASSIGNMENTS

Carrier-to-channel assignments as configured by bits 1, 2, and 3 of command 0.06XX are shown in table 8-2. The same assignments are obtained with the complementary state of these bits for command 0.31XX.

Table 8-2

PAYLOAD CARRIER-TO-CHANNEL ASSIGNMENTS

Command 0.06-X				Channel	Channel
1	2	3		1	2
T	T	T	Carrier	6	5
T	T	F	Carrier	5	6
T	F	F	Carrier	6	5
T	F	T	Carrier	5	6
F	T	T	Carrier	6	4
F	T	F	Carrier	4	6
F	F	T	Carrier	5	4
F	F	F	Carrier *	4	5

*NORMAL OPERATION is carrier 4 for channel 1 and carrier 5 for channel 2

NOTE: Selection of carrier 6 to either channel 1 or 2 also selects the real time data mode to that channel. The real time data mode selects are reset by command 0.01-2T or 3T.

Section 9

COMMAND SYSTEM

9.1 FREQUENCY ASSIGNMENTS

The uplink frequency assignments are as follows:

a. Channel 1 [redacted] for receiver no. 1 25X1

b. Channel 14 [redacted] for receiver no. 2 (which is an active redundant backup)

9.2 DECODER ADDRESSES

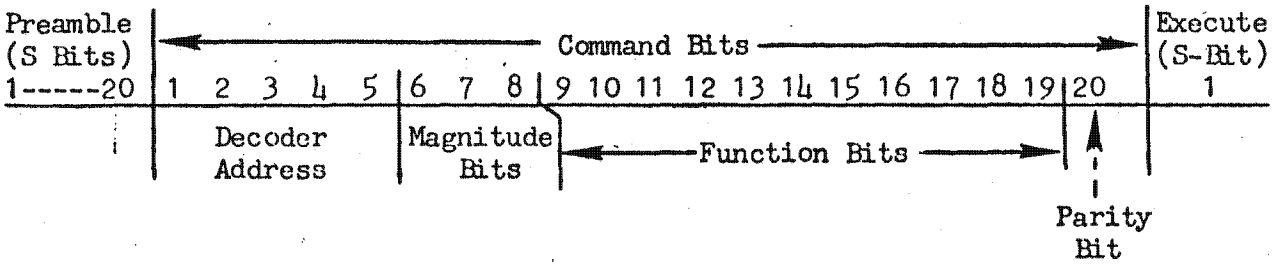
The decoder addresses are as follows:

a. Octal 6 for decoder no. 1

b. Octal 20 for decoder no. 2 (which is an active redundant backup)

9.3 UPLINK SIGNALS

The uplink command message structure is as follows:



This message structure is the same as that used on previous spacecraft except that the most significant bit is now first. Message bits 14 through 19 are used for command expansion bit drivers. Message bit 19 is assigned to bit driver 1 and message bit 14 is assigned to bit driver 6. Each command message word that sends a basic command (i.e., magnitude command zero) results in six

commands at the Telemetry Command Unit (TCU). The six commands result from the use of true/false logic (on previous spacecraft, only true logic was used).

Continuous S bits should be transmitted between messages at a rate of one kbps ±0.01 percent. There should be five S bits preceding a message and five S bits following, with the exception of the first message which should be preceeded by a minimum of 20 S bits.

The three PM subcarriers applied to the receivers are: an S bit at 65 kHz, a binary one at 95 kHz, and a binary zero at 76 kHz. A symmetrical triangular signal amplitude modulates the command subcarrier 50 percent to generate a read or shift command. The uplink modulation also contains a PM PRN ranging signal.

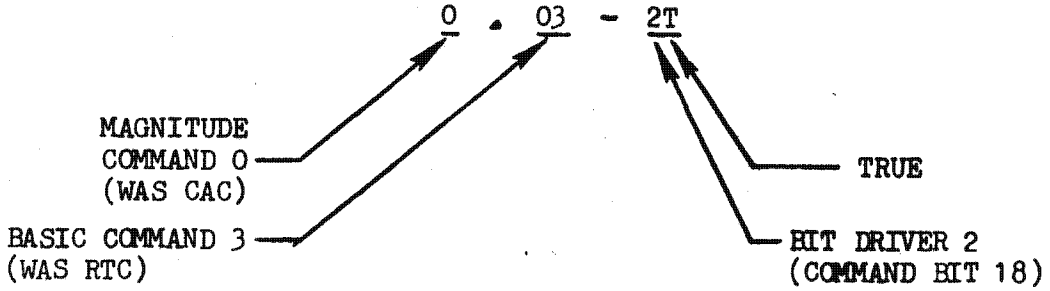
Three validity checks are used to verify message correctness: correct address, correct message length (20 bits), correct parity (odd number of ones in the entire message). Spacecraft 4430 does not use a scramble plug.

9.4 COMMAND NOMENCLATURE

The following standard nomenclature will be used with "cast iron" SGLS-equipped spacecraft:

Is	Was
Basic Command (BC)	Real Time Command (RTC)
Magnitude Command (MC)	Command Address Command (CAC)

The new command callouts shown below are also used in the spacecraft systems requirements document and the command data processor documents:



a. In the octal system, numbers range from 0 through 7. For this reason, no commands contain 8 or 9.

b. Function bits to drive the bit drivers (command bits 14 through 19) will be designated as 1 through 6 followed by a "T" or "F" to signify whether it is true or false. Command bit 19 is designated as bit driver 1 and command bit 14 is designated as bit driver 6.

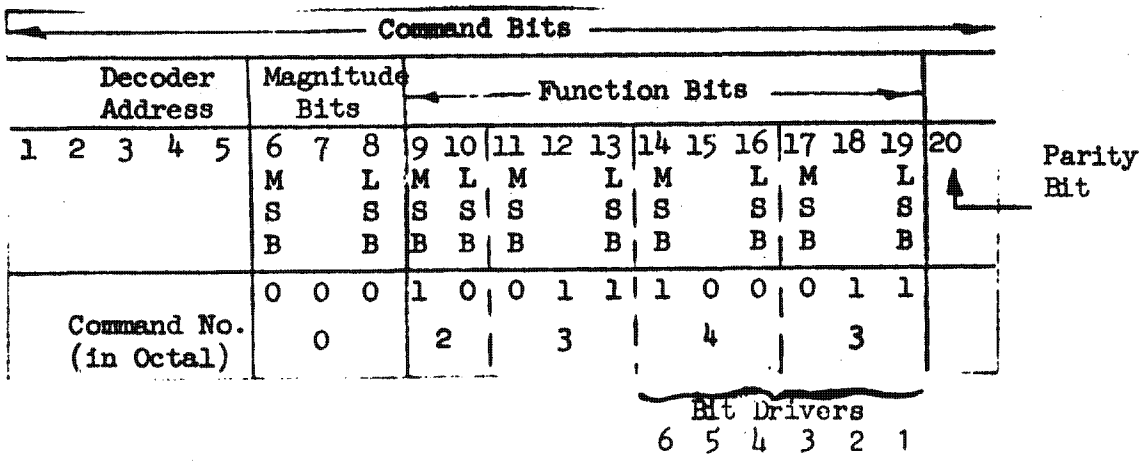
9.4.1 Basic Command

A basic command is a command that performs spacecraft functions in real time and is routed through the TCU command expander and control logic.

When command bits 6, 7, and 8 are all "0's", command bits 9 through 13 will determine which one of the 32 basic command circuits will have an output. The last six command bits (bits 14 through 19) of the command word are used to activate individual bit driver circuitry which provides up to 12 additional command functions (true "1"; false "0").

Example Basic Command

If command bits 6, 7, and 8 are all zeros, this indicates a basic command.



This example represents basic command 23 with bit drivers 6, 2, and 1 true, and bit drivers 5, 4, and 3 false.

9.4.2 Magnitude Command

A magnitude command is a command which controls the orbit programmable modules of the spacecraft timers or which is to be gated to the payload to perform unique functions peculiar to each spacecraft.

When command bits 6, 7, and 8 are other than all "0's" they determine which magnitude command will have an output (octal 1 through 7). The last 11 bits (bits 9 through 19) will either be gated to the orbital timer and used to determine start times (PE) or stop times (CE) or will go to the payload to perform unique functions.

Example of Magnitude Commands

Command Bits																			
Decoder Address					Magnitude Bits			Function Bits											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					MSB		LSB	MSB	LSB	MSB		LSB	MSB		LSB	MSB		LSB	PARITY
					0	0	1	0	0	0	0	0	1	0	0	1	1	0	
Command No. (in Octal)					1*			0		0			4			6			

* Magnitude Command No. 1

The delay time for magnitude commands is found by converting command bits 9 through 19 from binary to decimal, with command bit 19 as the LSB and having a weight of 1. Then, use the following equations.

a. Time Delay for PE (Seconds)

$16(N+1)$ Where N is the decimal equivalent of bits 9 through 19.

b. Time Delay for CE (Seconds)

$8(N+1)$ Where N is the decimal equivalent of bits 9 through 19.

The use of magnitude commands to control the payload is detailed in BIF003W/2-077876-73. The command bits are stored in a nonvolatile memory. Bits 9, 10 and 11 steer bits 12 through 19 to one of eight registers assigned to each magnitude command. Magnitude command 5, words 1 through 8, define program step configurations (RF band, inhibits, DF threshold). Magnitude command 6, words 1 through 4, define read-in modes and words 5 through 8 are spares.

9.5 COMMAND NUMBERS

Command number assignments will be in accordance with the following algorithm:

The command number for single commands consists of five octal digits. If we are looking at the command bits according to the new format described above, then:

a. The first digit (MSB) is the octal number in bits 6, 7, and 8
b. The second digit is the octal number in bits 9 and 10
c. The third digit is the octal number in bits 11, 12, and 13
d. The fourth digit is the octal number in bits 14, 15, and 16
e. The fifth digit (LSB) is the octal number in bits 17, 18, and 19.

With the implementation of MADCOM "T" at the SCF, the command number as applied to the spacecraft will correspond to the order of command bits transmitted by the RTS.

The same command numbering system will also be used with pre-SGLS systems.

However, to provide some degree of correlation between presently used command numbers and new command numbers, MADCOM T will have the capability of recognizing the decoder address assigned to pre-SGLS systems. In which case, the order of transmission of function bits will automatically be rearranged as required.

9.6 COMMANDING RECOMMENDATIONS

9.6.1 Basic Commands

If the system configuration is known from preceding acquisitions, and if there is an ability to confirm system configuration via status TLM in a relatively short time, it is recommended that only those commands needed to achieve the required system configuration relative to configuration at acquisition be sent.

9.6.2 Magnitude Commands

a. MC's 1 Through 4

PE's are reloaded as required due to their destructive readout. CE's have nondestructive readout but should be reloaded as required as there is no direct confirmation of the register contents.

b. MC's 5 and 6

If the system configuration is known from preceding acquisitions, if there is the ability to confirm system configurations via status telemetry in a relatively short time, and if the same tasking configuration is required, confirm the configuration via status telemetry and send only those commands needed to make a correction if the status has changed.

If a different configuration is required from the preceding state, send all commands needed to achieve the required payload configuration.

c. MC 7

Send all the command bits for every new tasking configuration.

9.7 TCU CURRENT LIMITER EFFECT ON TLM ON

The TCU current limiter will clamp the first basic TLM on command pulse so that it may not perform its normal function. A second pulse will perform its normal function. If the "repetitive" mode is used, this should be no problem.

NOTE: A similar current-limit clamp will occur when the back-up (or primary) TRG is being selected. (See item e., page 6-7.)

Section 10

SPACECRAFT TERMINATION MODE

A means has been provided to terminate the spacecraft's operational capability when it is no longer desired to task with normal operations. The termination sequence shall be implemented at the direction of the technical advisor and is as follows:

Command	Function
0.14-1T & -2F & -3T	Enable termination
0.04-2T	Enable termination (trickle charge B1)
0.17-2T	Enable termination (trickle charge B2)
0.14-1T & -2F & -3F	Termination (if enabled) Disconnect solar array from PSCA

The continuous current load of the spacecraft (approximately 300 ma) will discharge the battery. To reset the spacecraft out of the termination mode, send the following sequence:

Command	Function
0.04-2F	Enable reset (normal charge B1)
0.17-2F	Enable reset (normal charge B2)
0.14-1F & -2T & -3T	Reset termination Connect solar array to PSCA Disable terminate command

NOTE: Payload real time readin OFF's command 14XX all bits false, so the spacecraft termination is not enabled or executed during its use.

Section 11

EMERGENCY PROCEDURES

a. Battery Temperature Out of Limits

1. If the battery temperature is below 20°F, continue tasking and notify the technical advisor.
2. If the battery temperature is above 100°F, continue tasking and notify the technical advisor.

b. Battery in Trickle-Charge Mode

If the battery has been inadvertently commanded to the trickle charge mode, send 0.04-2F or 0.17-2F as soon as possible to return the power system to a normal-charge condition.

c. Battery Voltages Below +24.0 VDC at Acquisition

1. If heavy tasking indicates that the power system is being over-extended, continue the pass as planned and notify the technical advisor.
2. If there is no apparent reason for the low-voltage condition, discontinue tasking and notify the technical advisor.

d. Spacecraft in LVCO-Bypass Condition

If the battery has inadvertently been placed in LVCO bypass, send basic command 0.00-2T as soon as possible to return the power system to the normal charge condition.

e. Negative Acquisition of Spacecraft Links

1. Do not conduct the pass without spacecraft status information. Notify the technical advisor.
2. If the links do not respond to basic command 0.01, insure that the proper antenna has been selected. The -Y S-band antenna should be selected (TLM off or basic command 0.01-5F) for the start of descending passes and the +Y S-band antenna should be selected (basic command 0.01-5T) for the start of ascending passes.

3. If the links fail to respond to basic command 0.01, execute basic command 0.02 followed by basic command 0.36.

4. Terminate the above efforts with a combination of basic commands 0.04, 0.17, and 0.02.

f. Low-Voltage Cutoff (LVCO)

If the spacecraft unexpectedly terminates telemetry, the power system may be in a low-voltage condition. Using data from prior to termination, determine that the battery voltages are normal and that the power system is in a normal condition. Discontinue tasking and notify the technical advisor.

g. Spacecraft Unexpectedly in Terminate Mode

1. Reset the spacecraft but of the termination mode; send basic commands 0.04-2F, 0.17-2F, 0.14-1F & -2T & -3T sequence.

2. Notify the technical advisor.

h. ACS Is Unexpectedly Turned On

Send basic command 0.07-1F & -2F and notify the technical advisor.

i. Battery Third Electrode Failure

Send basic command 0.04-1T (for battery 1) or 0.17-1T (for battery 2) to select the backup charge mode and notify the technical advisor.

j. Failure of any Primary Equipment for Which There is a Backup

Notify the CSE who may direct use of the backup unit.