MSC-00119
Rev. 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL TECHNICAL NOTE

DATA PROCESSING PLAN FOR ALSEP AND EASEP

This paper replaces previously
published Plan dated June 26, 1969

PREPARED BY

REQUIREMENTS AND ANALYSIS SECTION
OF THE

DATA PROCESSING BRANCH

COMPUTATION AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
10 OCT 69

INTERNAL NOTE MSC-00119

DATA PROCESSING PLAN FOR EASEP - ALSEP

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1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of this Data Processing Plan is to serve as a reference for the Lunar Surface Project Office (TD4) and as a guide for the Computation and Analysis Division in processing ALSEP data.

This document covers the processing of telemetry data, preparing tapes compatible with Principal Investigators computers, ephemeris data, calibration tape copies and the digital-to-analog tapes for passive seismic experiment. Any modifications and/or additions to the Data Processing Plan, resulting from changes in processing requirements, will be published as addenda, when required. Should the user have any questions regarding the processing of his data, contact the Requirements and Analysis Section, Data Processing Branch, telephone HU3-5457.

1.2 Organizational Relationships

The Lunar Surface Operations and Planning Office (TD4) has the responsibility to contact the various Principal Investigators concerning their data requirements. TD4 and ED53 work together in finalizing the overall requirements. ED53 will ship data directly to the Principal Investigators with a copy of the transmittal going to TD4.

Manned Space Flight Network (MSFN) tapes will be shipped directly to the Computation and Analysis Division's Central Metric Data File, ED5, NASA, MSC, Houston, Texas, 77058.

1.3 Project Discussion

The Apollo Lunar Surface Experiments Package (ALSEP) will be used to obtain long-term scientific measurements of various physical and environmental properities of the Moon consistent with the scientific objectives of the Apollo Program. ALSEP will be transported to the lunar surface aboard the Lunar Module (LM). The astronauts will deploy the different scientific packages. The ALSEP will remain on the lunar surface after the astronauts return and will transmit scientific and engineering data to the MSFN. Each ALSEP

package is designed to transmit for "1 year" but has the capability to transmit for "2 years." The ALSEP, on the lunar surface, is controlled by ground command from the MSFN. Commands from Earth and automatically generated commands will direct ALSEP operation. Automatic systems shutdown is provided after the elapse of two years.

Early Apollo Scientific Experiments Payload (EASEP) data will be processed by the same procedures as ALSEP. EASEP will include the Passive Seismic and the Laser Ranging Retro-Reflector experiments. ED will support only the Passive Seismic data reduction portion of this package. EASEP is scheduled to be deployed on Apollo 11.

ALSEP FLIGHT ASSIGNMENTS

	EASEP	ALSEP A	ALSEP B	ALSEP C
Passive Seismic	X	X	X	X
Lunar Surface Magnetometer		X		
Solar Wind Spectrometer		X		
Active Seismic				X
Heat Flow			X	
Suprathermal Ion Detector/ Cold Cathode Gage		X		X
Charged Particle			X	X
Housekeeping and Engineering	X	X	X	X
Cold Cathode Gage			X	

2.0 DATA RECORDING

The data subsystem transmitter generates an S-Band carrier frequency between 2275 and 2280 MHZ which is phase modulated by the split-phase serial bit stream from the data processor. Transmitter frequencies will vary between individual ALSEP systems. The radio frequency bit stream is recorded at 3 3/4 IPS on one channel of the 14-track tape and another channel is used to record time-of-day (GMT). Current plans are for the tape to be rewound and two more tracks used until the tape is filled. The procedure allows up to 56 hours of data to be packed on one tape. Full tapes will be shipped to NASA, MSC, Houston.

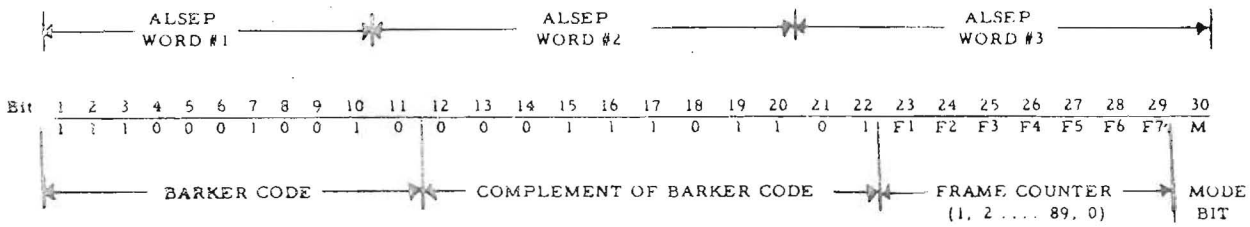
2.1 ALSEP Downlink Data

PCM telemetry is downlinked at either a normal or slow (MSFN selectable) data rate (except for Active Seismic) as shown below:

Normal Data Rate	Slow Data Rate
1060 BPS	530 BPS
10 Bits/Word	10 Bits/Word
64 Words/Frame	64 Words/Frame
640 Bits/Frame	640 Bits/Frame
0.943 MS/Bit	1.887 MS/Bit
603.773 MS/Frame	1.21 Sec/Frame

Transmitted MSB First (Bit 1)

CONTROL WORD FORMAT



The Active Seismic Experiment data rate will be 10.600 KBPS, 32 twenty-bit words (each word consists of 4 five-bit subwords). (Sync word 0000111011.)

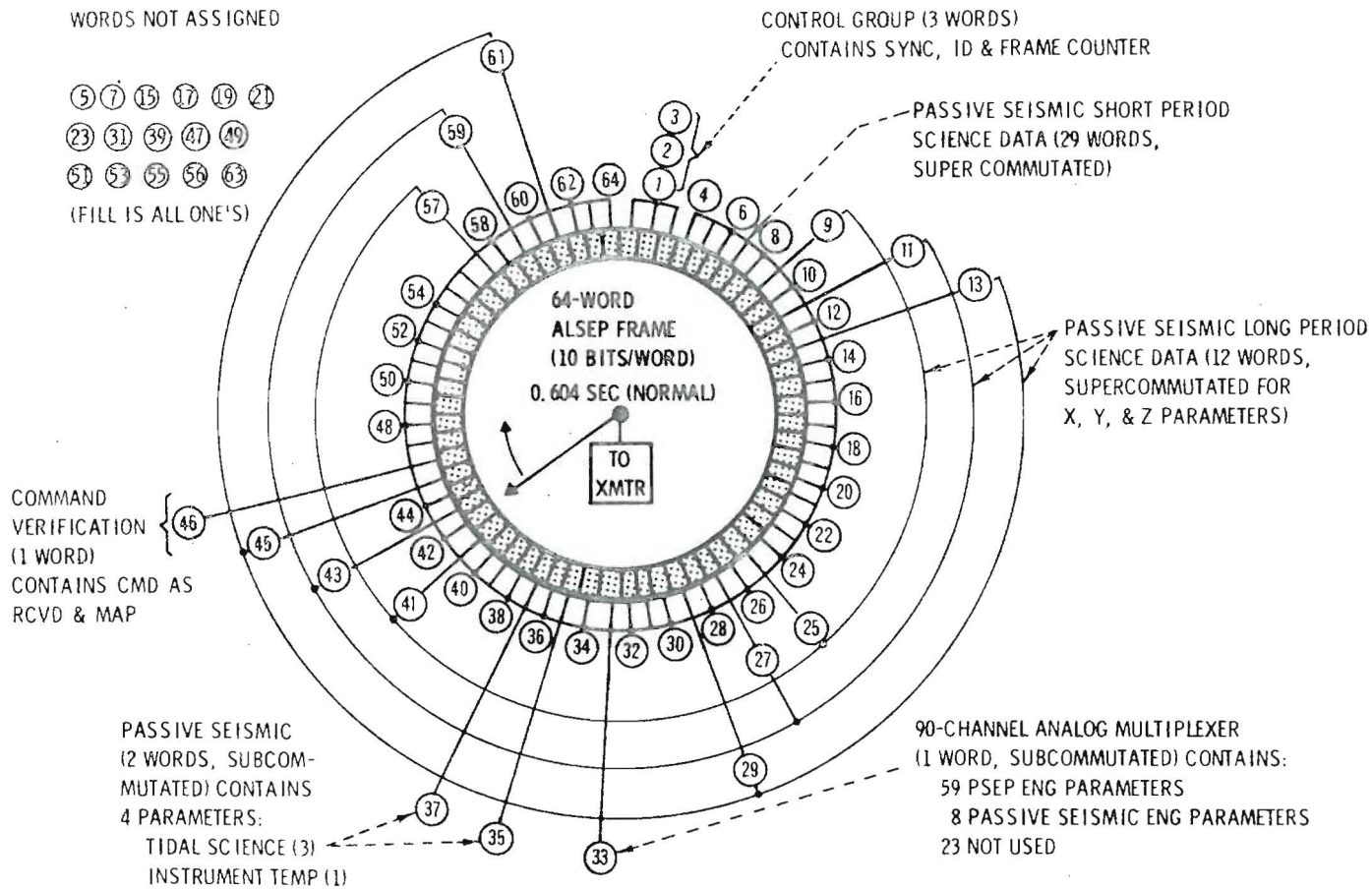

WORDS NOT ASSIGNED
5 7 15 17 19 21
23 31 39 47 49
51 53 55 56 63
(FILL IS ALL ONE'S)
CONTROL GROUP (3 WORDS)
CONTAINS SYNC, ID & FRAME COUNTER
PASSIVE SEISMIC SHORT PERIOD
SCIENCE DATA (29 WORDS,
SUPER COMMUTATED)
64-WORD
ALSEP FRAME
(10 BITS/WORD)
0.604 SEC (NORMAL)
TO
XMTR
PASSIVE SEISMIC LONG PERIOD
SCIENCE DATA (12 WORDS,
SUPERCOMMUTATED FOR
X, Y, & Z PARAMETERS)
COMMAND
VERIFICATION
(1 WORD)
CONTAINS CMD AS
RCVD & MAP
PASSIVE SEISMIC
(2 WORDS, SUBCOM-
MUTATED) CONTAINS
4 PARAMETERS:
TIDAL SCIENCE (3)
INSTRUMENT TEMP (1)
90-CHANNEL ANALOG MULTIPLEXER
(1 WORD, SUBCOMMUTATED) CONTAINS:
59 PSEP ENG PARAMETERS
8 PASSIVE SEISMIC ENG PARAMETERS
23 NOT USED

Table I

3.0 DATA PROCESSING

Data tapes will be processed on the CDC 3200 computer telemetry processing system at 16 times real time to produce a computer compatible tape. This computer compatible tape will be further processed on the UNIVAC 1108 computer to produce tapes compatible with each Principal Investigator's computers.

In addition to the digital processing, there will be two 1/2" analog tapes, FM recorded to support the Passive Seismic experiment for Lamont-Doherty Geological Observatory.

There will also be an Active Seismic digital tape (computer compatible) made for Stanford University.

Ephemeris data will be processed for a two year period and computer compatible tapes will be shipped to the requesting Principal Investigators.

Detailed procedures, tape formats and explanations are included in this section of the data plan by experiment.

1	2	3	4	5	6	7	8
x	x	x	X	0	X	s	X
9	10	11	12	13	14	15	16
-	X	-	X	-	X	I	X
17	18	19	20	21	22	23	24
0	X	0	X	0	X	s	X
25	26	27	28	29	30	31	32
-	X	-	X	-	X	I	X
33	34	35	36	37	38	39	40
H	X	o	X	o	X	s	X
41	42	43	44	45	46	47	48
-	X	-	X	-	CV	I	X
49	50	51	52	53	54	55	56
0	X	0	X	0	X	s	I
57	58	59	60	61	62	63	64
-	X	-	X	-	X	I	X

FLIGHT SYSTEM A ALSEP

1	2	3	4	5	6	7	8
x	x	x	X	CV	X	CP	X
9	10	11	12	13	14	15	16
-	X	-	X	-	X	CG	X
17	18	19	20	21	22	23	24
CP	X	CP	X	HF	X	CP	X
25	26	27	28	29	30	31	32
-	X	-	X	-	X	CG	X
33	34	35	36	37	38	39	40
H	X	o	X	o	X	CP	X
41	42	43	44	45	46	47	48
-	X	-	X	-	X	CG	X
49	50	51	52	53	54	55	56
NA	X	NA	X	NA	X	CP	CG
57	58	59	60	61	62	63	64
-	X	-	X	-	X	CG	X

FLIGHT SYSTEM B ALSEP

1	2	3	4	5	6	7	8
x	x	x	X	CV	X	CP	X
9	10	11	12	13	14	15	16
-	X	-	X	-	X	I	X
17	18	19	20	21	22	23	24
CP	X	CP	X	NA	X	CP	X
25	26	27	28	29	30	31	32
-	X	-	X	-	X	I	X
33	34	35	36	37	38	39	40
H	X	o	X	o	X	CP	X
41	42	43	44	45	46	47	48
-	X	-	X	-	X	I	X
49	50	51	52	53	54	55	56
NA	X	NA	X	NA	X	CP	I
57	58	59	60	61	62	63	64
-	X	-	X	-	X	I	X

FLIGHT SYSTEM C ALSEP

ALSEP - DATA FORMAT MATRIX

Table II

1 x	2 x	3 x	4 X	5 NA	6 X	7 NA	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 NA	16 X
17 NA	18 X	19 NA	20 X	21 NA	22 X	23 NA	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 NA	32 X
33 H	34 X	35 o	36 X	37 o	38 X	39 NA	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 NA	48 X
49 NA	50 X	51 NA	52 X	53 NA	54 X	55 NA	56 NA
57 -	58 X	59 -	60 X	61 -	62 X	63 NA	64 X

FLIGHT SYSTEM EASEP

NOTE: Each box contains one 10 bit word.

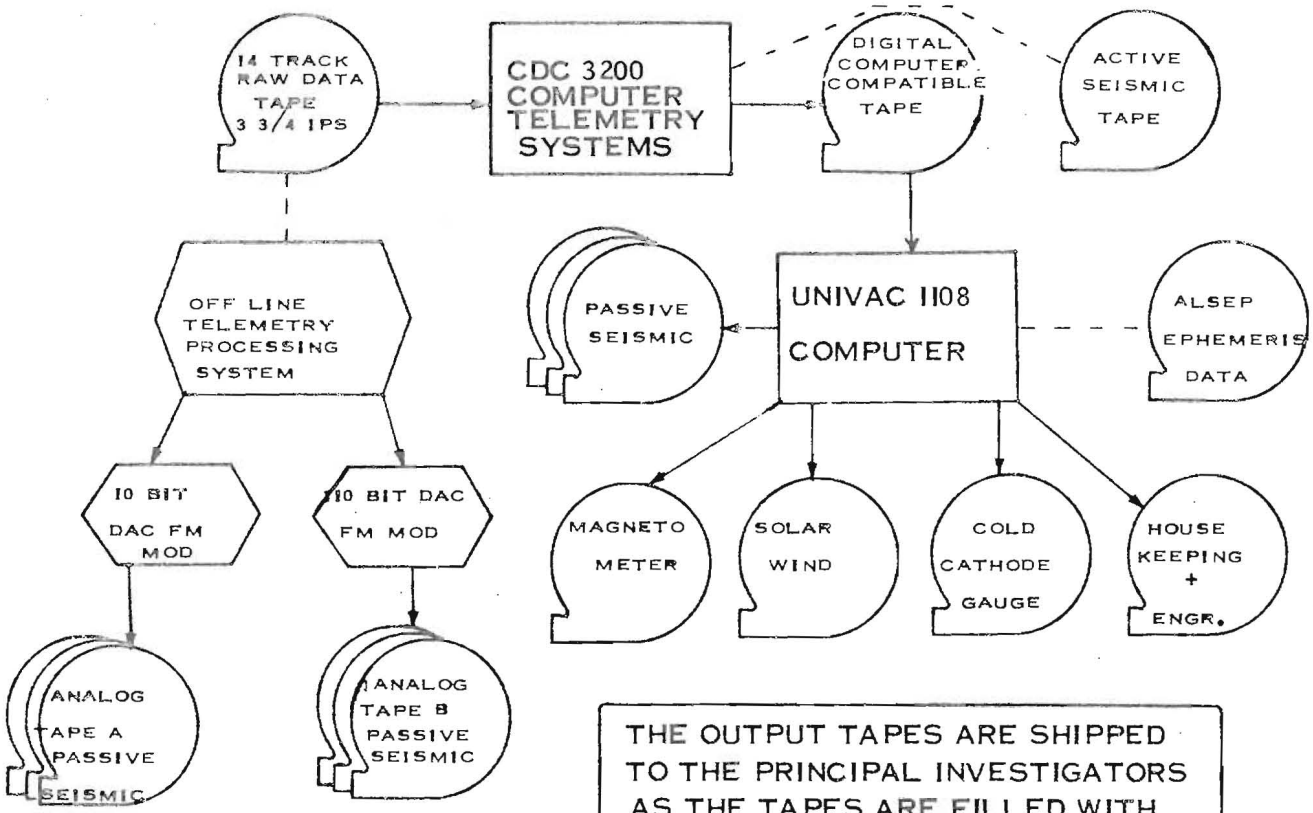
Total bits per frame, 10 x 64 = 640 bits

Legend -
- x - control
- X - passive seismic, short period
- - - passive seismic, long period seismic
- o - passive seismic, long period tidal and one temperature
- 0 - magnetometer
- s - solar wind
- I - suprathermal ion detector
- hf - heat flow
- cp - charged particle
- cv - command verification(upon command;otherwise,all zero)
- h - housekeeping
- na - not assigned(all zeros will be transmitted)
- CG - cold cathode gage experiment (MSC)

ALSEP - DATA FORMAT MATRIX - continued

ALSEP A DATA PROCESSING FLOW THROUGH THE

COMPUTATION AND ANALYSIS DIVISION



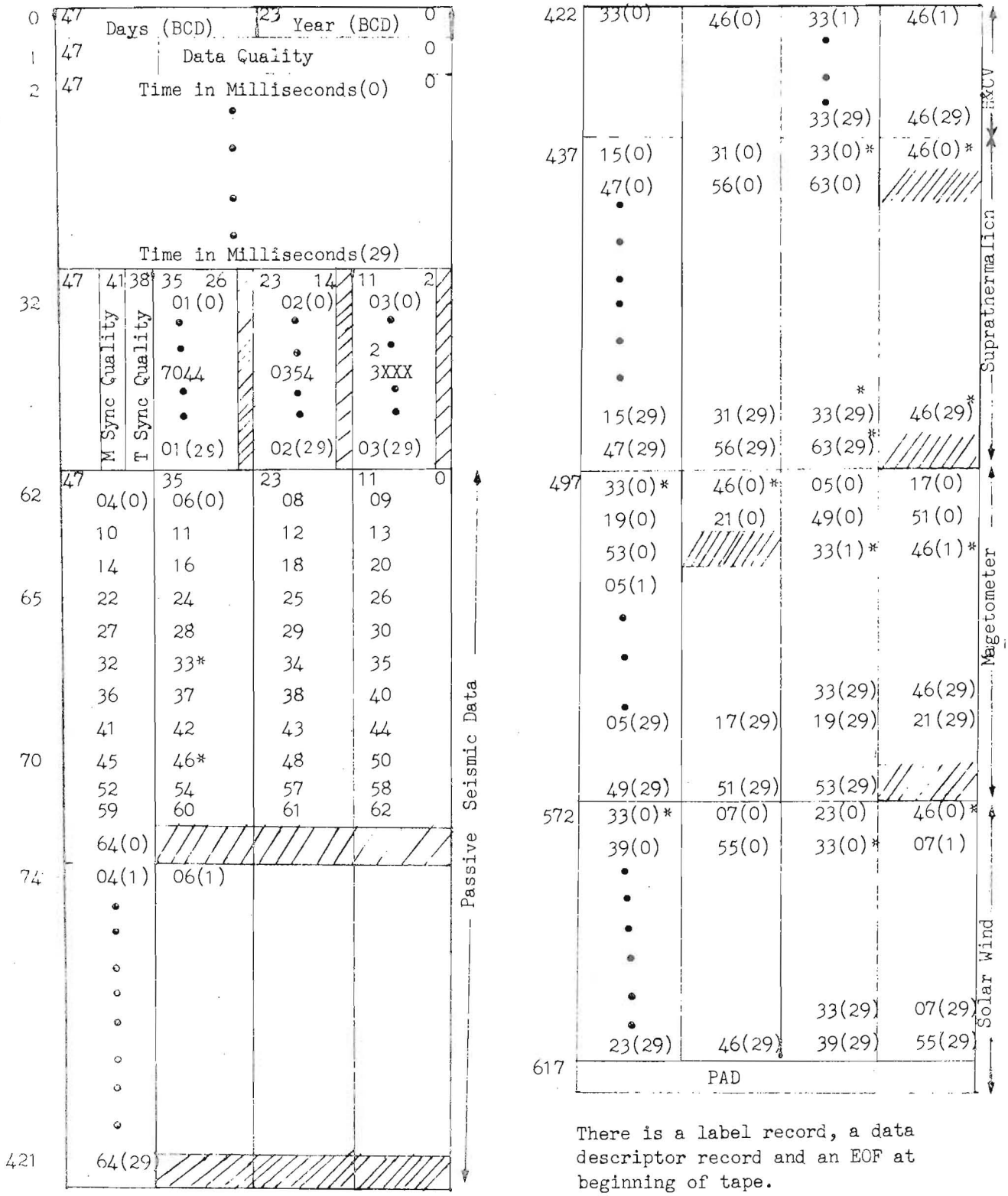
3.1 Processing Range Telemetry Tapes

The range analog PCM tapes will be processed on the CDC 3200 computer telemetry system. In this processing the tapes are played back on the DRC VR 2600 tape recorder through the Dynatronics bit synchronizer, the Beckman PCM control unit, time through the Astro Data timing translator with both time and data being buffered and formatted by the CDC 3200 Computer to a parallel recorded tape. The computer compatible tape (parallel) will then be again processed through CDC 3200 computer to do a quality check and correct most time errors before further processing. (See next pages for the tape format.)

ALSEP ARRAY A (PRIMARY)

30 ALSEP FRAMES/RECORD

ALL DATA IS 10 BITS LEFT JUSTIFIED IN A 12 BIT BYTE



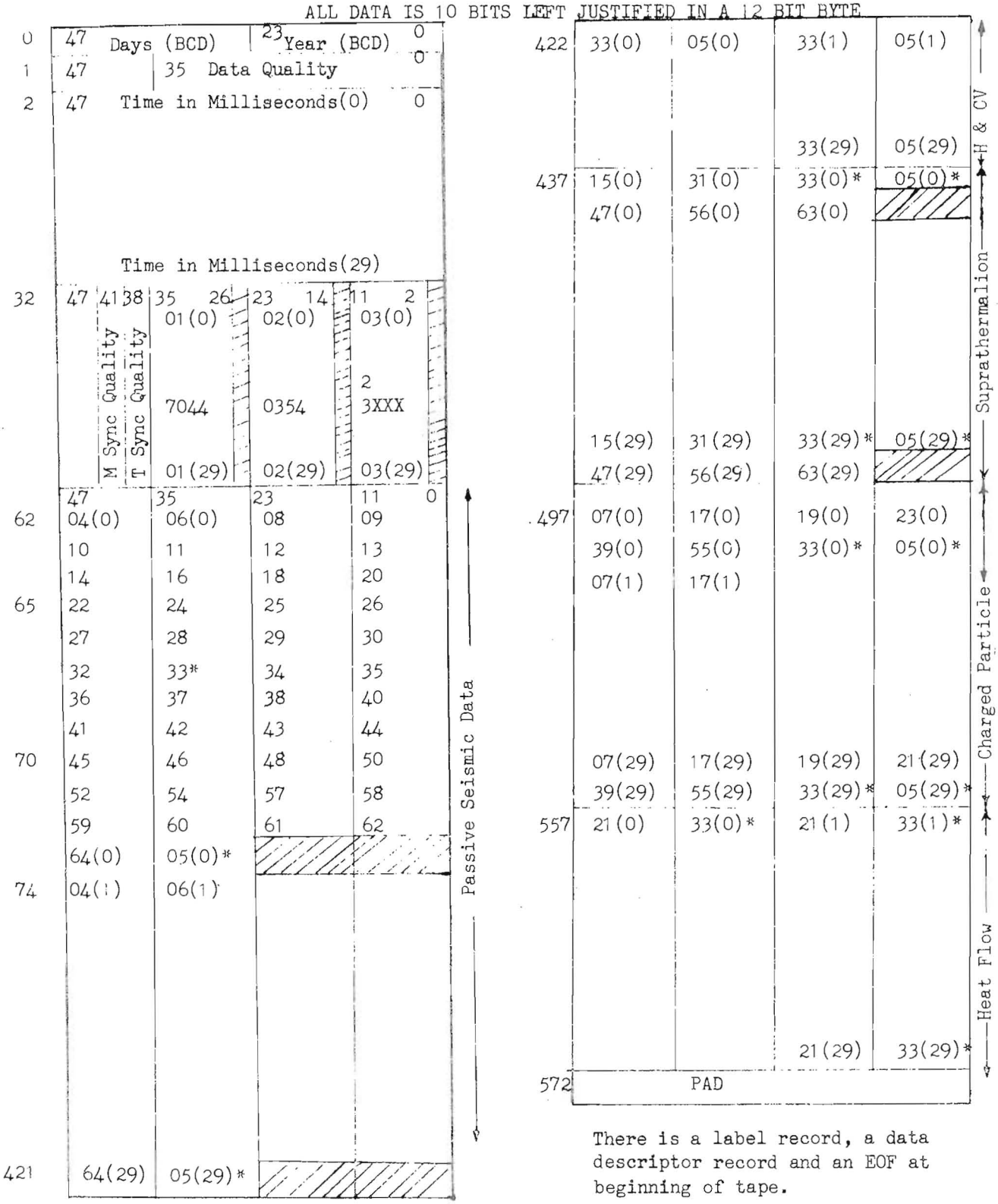
There is a label record, a data descriptor record and an EOF at beginning of tape.

Table IV

ALSEP ARRAY B PRIMARY

30 ALSEP FRAMES/RECORD

ALL DATA IS 10 BITS LEFT JUSTIFIED IN A 12 BIT BYTE



There is a label record, a data descriptor record and an EOF at beginning of tape.

Table IV Continued

3.2 Producing Principal Investigator (P.I.) Computer Tape

The time edited good computer compatible tape will be processed on the UNIVAC 1108 computer to produce as many tapes as there are experiments P.I. requiring data. (See list of tables in section 5.0 for tape formats.) This processing sorts data and outputs only data required by each P.I. on tape compatible with his computer.

3.2.1 Passive Seismic Experiment.- The Passive Seismic Experiment will determine the seismic activity of the moon and, by analysis of the form and characteristics of the seismic waves, will provide data on the physical properties of the lunar interior. Seismic energy is expected to be produced on the moon by quakes, meteoroid impacts, and tectonic disturbances. Subsurface materials will differ in density, compressibility, rigidity, pressure, and temperature. These differences will impart variations to seismic wave velocities and character from which the materials may be inferred.

The experiment will consist of triaxial orthogonal and short-period vertical seismometers, servosystem, calibration system, thermal control system, command decoder subsystem, and electronics subsystem. The triaxial seismometer is used to monitor long-period, low-frequency energy. The short-period vertical seismometer, which has a high sensitivity, is used to monitor high-frequency energy.

The data for this experiment occupy 43 words in each ALSEP frame for flight systems A and EASEP, and 44 words for flight systems B and C. The Passive Seismic data words are formated as follows:

Long-period data	Words
X (N-S)	9, 25, 41, 57
Y (E-W)	11, 27, 43, 59
Z	13, 29, 45, 61
Long-period total	
X (N-S)	35 on even frames
Y (E-W)	37 on even frames
Z	35 on odd frames

Sensor unit temperature	37 on odd frames
Short-period seismic: Z	Every even word, except 2, 46, 56

The IBM compatible tapes will be supplied to the P.I. with the experimental data formated as shown in table V. Three separate copies of this tape are required. In addition to the requirements for decommutated digital data, the Passive Seismic Experiment imposes a requirement for analog data. These data will be converted, digital-to-analog, and recorded by frequency modulation (FM) on 1/2-inch, 7-track analog tapes. Three separate copies of this tape are required. See section 3.4 for digital to analog processing details.

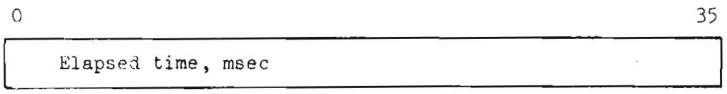
3.2.1 Passive Seismic Experiment Tape Format[a].-

I. Label record (appears twice on tape)

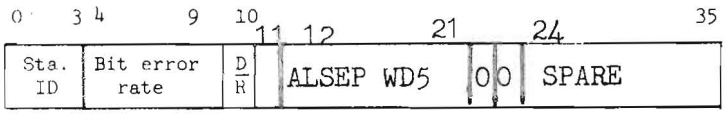
Word	Parameter	Mode
1	Experiment identification (PS EXP)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 18 words/logical record

Word 1



Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)



Word 3 ALSEP words 1, 2, 3

Word 4 ALSEP words 4, 6, 8

Word 5 ALSEP words 9, 10, 11

Word 6 ALSEP words 12, 13, 14

Word 7 ALSEP words 16, 18, 20

Word 8 ALSEP words 22, 24, 25

Word 9 ALSEP words 26, 27, 28

Word 10 ALSEP words 29, 30, 32

Word 11 ALSEP words 33, 34, 35

Word 12 ALSEP words 36, 37, 38

Word 13 ALSEP words 40, 41, 42

Word 14 ALSEP words 43, 44, 45

Word 15 ALSEP words 46, 48, 50

Word 16 ALSEP words 52, 54, 57

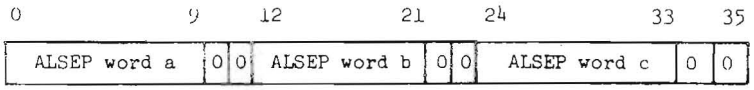
Table V

3.2.1 - PASSIVE SEISMIC EXPERIMENT TAPE FORMAT[a] - Concluded

Word 17 ALSEP words 58, 59, 60

Word 18 ALSEP words 61, 62, 64

Packed IBM word format for ALSEP data words



90 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI, 7 track, standard IBM EOF.

[a]Principal Investigator, Dr. Gary Latham, Lamont Doherty Geological Observatory, Columbia University, Palisades, New York 10946

3.2.2 Magnetometer Experiment.- The Lunar Surface Magnetometer will examine the topology of the interplanetary field which diffuses through the moon; determine a set of bounds upon the electromagnetic diffusivity of the lunar body; and examine electromagnetic propagation. The experiment will give some indication of radial and azimuthal inhomogeneities in the lunar interior. The experiment will consist of a triaxial magnetometer with three sensors, sensor electronics, calibration electronics, flipping motors, gimbal system, structure, and thermal control.

This experiment contains seven 10-bit words in each ALSEP frame comprised of six words of scientific data and one word of engineering (housekeeping) data. Word 1 (word 5 in each ALSEP frame) is used for engineering data and is recycled every 16 frames. Words 2 through 7 are for scientific data. Words 2 and 3 (words 17 and 49 in each ALSEP frame) are used for the X-axis measurement. Words 4 and 5 (words 19 and 51 in each ALSEP frame) are used for the Y-axis measurement. Words 6 and 7 (words 21 and 53 in each ALSEP frame) are for the Z-axis measurement. For words 17, 19, 21, 49, and 51, the most significant bit of each data word will indicate polarity, and the other nine bits will consist of data. The ALSEP word 5 will be comprised of 10 bits, the first bit (most significant) being a subframe mark bit. A logic 1 in this location indicates the beginning of a 16-point engineering subcommutation. Bits 2 through 8 comprise the actual data, and bits 9 and 10 are status indication bits. An IBM-compatible tape will be supplied to the PI formated as shown in table VI.

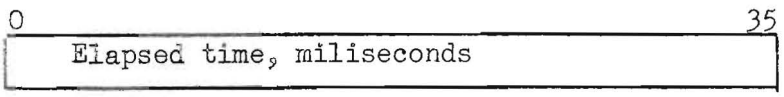
3.2.2 - MAGNETOMETER TAPE FORMAT[a]

I Label record (appears twice on tape)

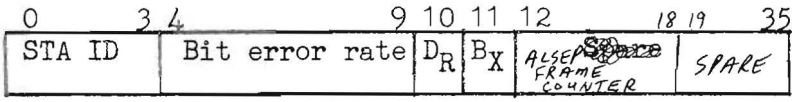
Word	Parameter	Mode
1	Experiment identification(MAGEXP)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification(A/Sxxx)	BCD
4	Spare	BCD

II Data record format, 4 words/logical record

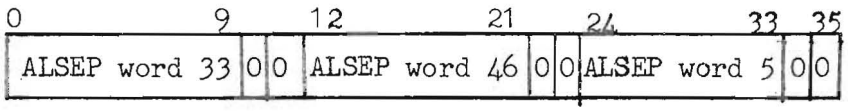
Word 1



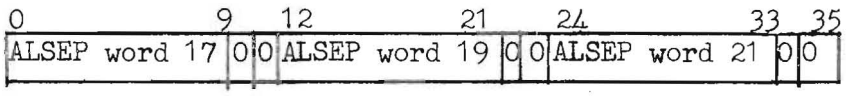
Word 2



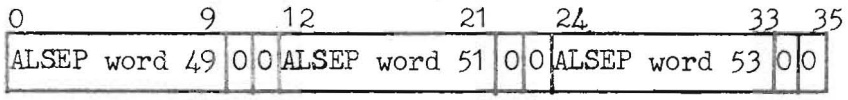
Word 3



Word 4



Word 5



90 logical records/physical record.

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI; 7 track, standard IBM EOF.

[a]Principal Investigator: Dr. Charles P. Sonett, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California

[b]Frame marker 1 for first ALSEP Frame Counter 1, 0 for all other.

TABLE VI

3.2.3 Solar Wind Spectrometer Experiment. The Solar Wind Spectrometer Experiment will measure properties of the solar wind on the lunar surface. The areas of scientific interest to be measured are: existence of solar wind plasma on the moon, properties of lunar surface and interior, general solar wind properties, and magnetospheric tail of the earth.

The experiment will consist of a basic sensor, seven Faraday cups, grids, collector, programer, modulator, signal chain, and power supply. The seven Faraday cups are oriented such that one cup faces the vertical and the remaining six surround the vertical cup with an angle of approximately 1 radian between the normals of any two adjacent cups. Each cup has a circular opening, five grids, and a circular collector.

The data for this experiment consist of four 10-bit words in each ALSEP frame (words 7, 23, 39, and 55). This output sequence has a cyclic repetition of 186 words (46.5 ALSEP frames) requiring 28.1 seconds of transmission time at normal ALSEP telemetry rates. The 186-word block is subcommutated over 16 cycles such that 2976 words (744 ALSEP frames) represent a full nonrepetitive data cycle. Each 186-word sequence will be divided into 8-words of data as follows: the first 14 blocks (112 words will consist of proton measurements, the next 2 blocks (16 words) will consist of calibration data, the next 7 blocks (56 words) will consist of electron measurements, and the remaining two words will define the end of the 186-word cycle and include a sequence count to identify the subcommutation.

The 10-bit solar-wind words are broken down into 8-bits of data and 2-bits of code identifying the type of measurement information. The first 2-bits of each word identify the data: measurement of raw data will be identified as zero-zero (00), calibration as zero-one (01), and sequence count as one-zero (10). An IBM-compatible tape will be supplied to the PI formated as shown in table VII.

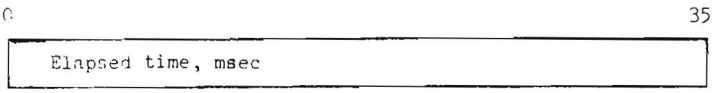
3.2.3 - SOLAR WIND SPECTROMETER TAPE FORMAT[a]

I. Label record (appears twice on tape)

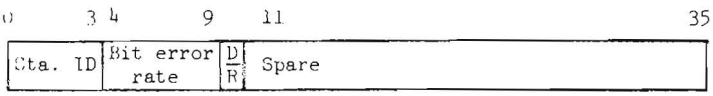
Word	Parameter	Mode
1	Experiment identification (SOLWDS)	BCD
2	LSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 5 words/logical record

Word 1



Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)

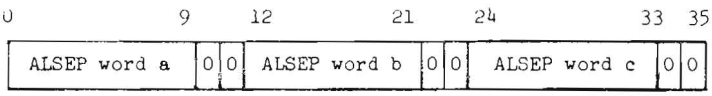


Word 3 Words 1, 2, 3 of each ALSEP frame

Word 4 Words 33, 7, 23 of each ALSEP frame

Word 5 Words 46, 39, 55 of each ALSEP frame

Packed IBM word format for ALSEP data words



88 logical records/physical record 440 words/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI; 7 track, Standard IBM EOF.

[a]Principal Investigator: Dr. Conway Snyder, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, California 91103.

Table VII

3.2.4 Active Seismic Processing - This experiment interrupts all the other experiments, changes the data rate to 10,600 bps and the sync word changes to 0000111011 followed by geophone 2(DS-2) and geophone (DS-3) and repeats DS-2 and DS-3 to the end of the frame and starts over. ED will process this data with a different CDC 3200 computer-telemetry system program upon request from TD4.

The Active Seismic Experiment will measure the characteristics of the lunar surface material. The objectives of the experiments are to determine structure, thickness, physical properties, and elastic constants of the surface and shallow-depth materials on the moon. Seismic energy will be artifically produced by explosive devices, transmitted through the lunar rocks, and detected by a geophone array. The velocity of propagation to compressional waves, the frequency spectra, and the attenuation of seismic energy are functions of the physical constants on the near-surface rocks, and permit the rock type and character to be inferred. In addition, data on the bearing strength of the surface materials and surface will be provided by the experiment.

The experiment consists of three geophones and cables, thumper, grenade package, and central electronics. The geophones will be linearly arranged along a straight line at distances from 10 to 310 feet from the ALSEP. Two seismic energy sources will be employed: a thumper device operated by the astronaut, and a mortar device operated by earth commands after deployment.

The experiment operates twice during the mission when taking advantage of artifically produced seismic energy: once at the beginning of the mission, and once at the end of the mission (approximately 1 year later). Each period of operation is less than 2 hours, and during this time, the normal ALSEP mode (1060 bps) is preempted. All the data in the high-rate mode are transmitted in the data format of this experiment, including some ALSEP housekeeping data. Additional requirements for the Active Seismic Experiment include a 1-hour operation approximately once a week in a listening mode, that is, seismic energy is not artifically produced.

The telemetry data frame for the high-rate mode is composed of thirty-two 20-bit words, each composed of four 5-bit subwords. The first 10 bits of word 1 (subwords 1 and 2) contain frame synchronization. Readouts from geophones 2 and 3 are contained in subwords 2 and 4, respectively, of all active seismic words. The readout from geophone 1 is contained in active seismic words 3 to 28 contain ALSEP housekeeping information; the first 4 bits of subword 1 in two consecutive active seismic words comprise one 8-bit housekeeping measurements. For example, radiosotopic thermal generator (RTG) temperature number 1

is formated as follows: active seismic word 3, bits 1 to 4 are temperature number 1 bits 1 to 4; active seismic word 4, bits 1 - 4 are temperature number 1 bits 5 to 8. Subword 1 of active seismic words 29 - 32 contains count and identification data.

It is necessary to strip out the ALSEP engineering (housekeeping) data included in the high bit rate mode, as previously described, so that the data can be used for systems analysis work by the PI and the equipment contractor. An IBM-compatible tape will be supplied to the PI, including scientific and engineering data formated as shown in table VIII.

ALSEP ACTIVE SEISMIC TYPE A
5 Frames of Data/Record
168-48 Bit Words or 224-36 Bit Words/Record
Time is Read for each Frame of Data

SYNC PATTERN - 11 Bits = 7044_8

EARLY DESIGN

0	47 FORTRAN 36	HEADER 12		0	
1	47 DAYS (BCD) 24		YEAR	0	
2	47 (BCD) 35			0	
3	47 BINARY MILLISECONDS(0) 12		BINARY	0	
4	47 MILLISECONDS(1) 24		BINARY MILLISEC-	0	
5	47 ONDS(2) 36	BINARY MILLISECONDS(3)		0	
6	47 BINARY MILLISECONDS(4) 12			0	
7	47 24		CONTROL WORD(0) 3	0	
8	47 DATA WORD(2) 27	24	DATA WORD(3) 3	0	FRAME NO. 1
9	DATA WORD(4)				
	•				
	•				
	•				
39	DATA WORD(64)		CONTROL WORD(1)		
40	DATA WORD(2)		DATA WORD(3)		FRAME NO. 2
	DATA WORD(4)				
	•				
	•				
	•				
71	DATA WORD(64)		CONTROL WORD(2)		
72	DATA WORD(2)		DATA WORD(3)		FRAME NO. 3
	DATA WORD(4)				
	•				
	•				
	•				
103	DATA WORD(64)		CONTROL WORD(3)		
104	DATA WORD(2)		DATA WORD(3)		FRAME NO. 4
	DATA WORD(4)				
	•				
	•				
	•				
135	DATA WORD(64)		CONTROL WORD(4)		
136	DATA WORD(2)		DATA WORD(3)		FRAME NO. 5
	DATA WORD(4)				
	•				
	•				
	•				
167	DATA WORD(64)				

Table VIII

ALSEP ACTIVE SEISMIC TYPE B
10 Frames of Data/Record
170-48 Bit Words or 228-36 Bit Words/Record
Time is Read for each Frame of Data

0	FORTRAN HEADER			
1	DAYS (BCD)		YEAR	
2	(BCD)			
3	BINARY MILLISECONDS(0)		BINARY	
4	MILLISECONDS(1)		BINARY MILLISEC-	
5	ONDS(2)	BINARY MILLISECONDS(3)		
6	BINARY MILLISECONDS(4)		BINARY	
7	MILLISECONDS(5)		BINARY MILLISEC-	
8	ONDS(6)	BINARY MILLISECONDS(7)		
9	BINARY MILLISECONDS(8)		BINARY	
10	MILLISECONDS(9)		CONTROL WORD(0)	
11	DATA WORD(2)		DATA WORD(3)	
12	DATA WORD(4)			
	•			
	•			
26	DATA WORD(32)		CONTROL WORD(1)	
27	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
42	DATA WORD(32)		CONTROL WORD(2)	
43	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
58	DATA WORD(32)		CONTROL WORD(3)	
59	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
74	DATA WORD(32)		CONTROL WORD(4)	
75	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
90	DATA WORD(32)		CONTROL WORD(5)	
91	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
106	DATA WORD(32)		CONTROL WORD(6)	
107	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
122	DATA WORD(32)		CONTROL WORD(7)	
123	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
138	DATA WORD(32)		CONTROL WORD(8)	
139	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
154	DATA WORD(32)		CONTROL WORD(9)	
155	DATA WORD(2)		DATA WORD(3)	
	DATA WORD(4)			
	•			
	•			
170	DATA WORD(32)			

SYNC PATTERN - 10 Bits = 0254_8

Table VIII - Continued

3.2.5 Charged Particle Lunar Environment.- The Charged Particle Lunar Environment Experiment, will measure the particles in the interplanetary space. These particles coming from the sun will be measured by number and by energy spectrum. Studies have shown that an interface, known as the magnetopause, exists between the interplanetary magnetic field and the magnetic field of the earth. Whether such a shock front and interface exist around the moon is not known. This experiment will measure protons and electrons over the energy ranges to define the particle environment.

The experiment will consist of two individual instruments, each having six Channeltron detectors, instrument electronics, thermal control heaters, and sensors. The particles pass through an entrance slit to a pair of deflection plates where a voltage is impressed. The particles are deflected by the electric field into one of the six Channeltron detectors.

This experiment contains six 10-bit words in each ALSEP frame. Thirty-two ALSEP frames, or one hundred-ninety-two 10-bit ALSEP words, represent one Charged Particle Lunar Environment Experiment (CPLEE) cycle.

The CPLEE data consist of data from the six detector channels of two analyzers (A and B) stepped through voltage levels in the following sequence: +3500, +350, +35, 0, -3500, -350, -35, 0. The CPLEE sampling may initialize at any step voltage, but always starts with analyzer A, detector 1 on an even ALSEP frame. One CPLEE data sequence (16 sequence per cycle) is formated as follows:

Measurement	Bits/sample	Frame	Words
Channel no. 1 (count)	19	Even	7, 17
Channel no. 2 (count)	19	Even	19, 23
Channel no. 3 (count)	19	Even	39, 55
Channel no. 4 (count)	19	Odd	7, 17
Channel no. 5 (count)	20	Odd	19, 23
Channel no. 6 (count)	20	Odd	39, 55
Analyzer	1	Even	7 (bit 1)
Polarity	1	Even	19 (bit 1)
Voltage step	2	Even	39 (bit 1)
		Odd	7 (bit 1)

Six channels of engineering measurements from this experiment are included in the ALSEP housekeeping data. An IBM compatible tape will be supplied to the P. I., including scientific and engineering data formated as shown in table IX.

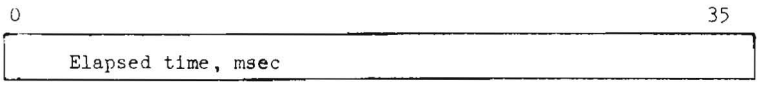
3.2.5 .- CHARGED PARTICLE LUNAR SPECTROMETER TAPE FORMAT[a]

I. Label record (appears twice on tape)

Word	Parameter	Mode
1	Experiment identification (CPLSPE)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 6 words/record

Word 1



Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)

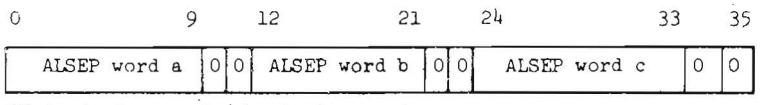
Word 3 ALSEP words 1, 2, 3

Word 4 ALSEP words 7, 17, 19

Word 5 ALSEP words 23, 39, 55

Word 6 ALSEP words 33, 5

Packed IBM word format for ALSEP data words



90 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 556 BPI; 7 track, standard IBM EOF.

[a]Principal Engineer, Dr. David Reasoner, Department of Space Science, Rice University, Houston, Texas 77001

Table IX

3.2.6 Heat Flow Experiment.- The Heat Flow Experiment will determine lunar heat flow by measuring the temperature of the moon as a function of depth, and by determining the steady-state vertical temperature gradient.

The experiment will consist of probes, probe electronic packages, and a common electronic package. The probes are to be placed by the astronaut in vertical holes 3.0 meters deep in the lunar surface. This experiment contains one 10-bit word in each ALSEP frame (ALSEP word 21). One measurement of heat flow will consist of eight 10-bit ALSEP words, formated as shown in table IV. The ALSEP 90-frame counter will determine the beginning of a heat-flow sequence. Two measurements of heat flow (sixteen 10-bit words) will follow the ALSEP 90-frame mark, thus requiring ALSEP frames 0-15. Word 21 will then contain fill data for the remainder of the frames until the sequence is again initiated with the next ALSEP 90-frame mark.

Seven separate heat-flow sequences, initiated by ground command, may be transmitted. These are:

Sequence	Length of sequences, ALSEP frames
Full	720
Probe I	360
Probe II	360
High-sensitivity temperature gradient	180
Low-sensitivity temperature gradient	180
Ambient temperature	180
Cable temperature and reference junction	180

Seven channels of engineering data for the experiment will be included in the ALSEP housekeeping data. An IBM compatible tape will be supplied to the P.I., including scientific and engineering data formated as shown in table X.

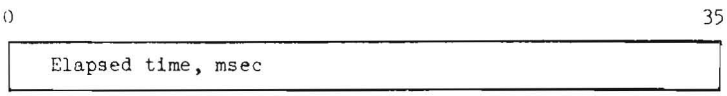
3.2.6 - HEAT FLOW EXPERIMENT TAPE FORMAT[a]

I. Label record (appears twice on tape)

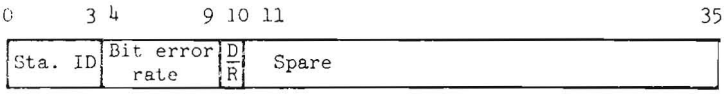
Word	Parameter	Mode
1	Experiment identification (HEATFL)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 3 words/record

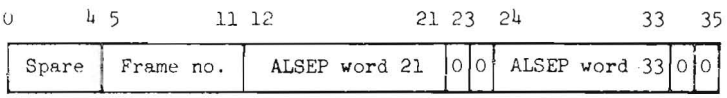
Word 1



Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)



Word 3 ALSEP frame number, ALSEP words 21, 33



180 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI; 7 track, standard IBM EOF.

NOTE: Word 21 valid on frames 0-15 (word 33 invalid).
Word 33 valid on frames 29, 45, 55, 57, 74, and 75 (word 21 invalid).
All other frames are omitted.

[a]Principal Investigator: Dr. Marcus Langseth, Lamont Geological Observatory, Columbia University, Palisades, New York 10964.

Table X

3.2.7 Suprathermal Ion Detector Experiment.- The Suprathermal Ion Detector Experiment (SIDE) will detect and measure ion density, temperature, and a rough composition of the cold lunar ionosphere; detect the raw and thermalized solar wind at the lunar surface; and detect non-Maxwellian components of the energy spectrum as an indicator of local electric fields.

The experiment will consist of two detectors (low and high energy), detector amplifiers, data accumulator, calibration clock, stepping voltage supplies, command decoder, analog-to-digital converter, commutator, readout register, master timing generator, and low-voltage power converter.

This experiment contains five 10-bit words in each ALSEP frame and uses a 10-word sequence which cycles 128 times before repeating. The words are used as follows:

Measurement	Bits/sample	ALSEP word	Frame	SIDE word
SIDE frame number (0 to 127)	7	15	Even	1
Cold Cathode Gage Experiment and housekeeping data	8	31	Even	2
High-energy charged particle analyzer (CPA) voltage	8	47	Even	3
High-energy data	10	56	Even	4
High-energy data	10	63	Even	5
Status subcommutation	7	15	Odd	6
Velocity filter voltage	8	31	Odd	7
Low-energy CPA voltage	8	47	Odd	8
Low-energy data	10	56	Odd	9
Low-energy data	10	63	Odd	10

Additional SIDE data (detector count data) are contained in ALSEP housekeeping word 33. An IBM compatible tape will be supplied to the P.I., including scientific data and engineering data as shown in table XI.

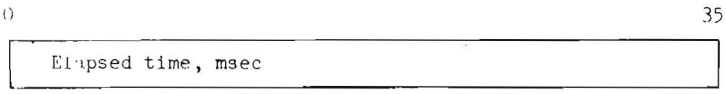
3.2.7 - SUPRATHERMAL ION DETECTOR EXPERIMENT TAPE FORMAT[a]

I. Label record (appears twice on tape)

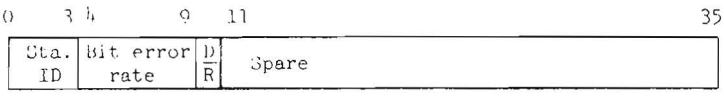
Word	Parameter	Mode
1	Experiment identification (SIDE)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 6 words/logical record

Word 1



Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)



Word 3 Words 1, 2, 3 of each ALSEP frame

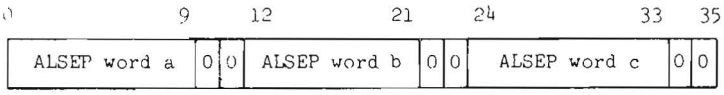
Word 4 Words 15, 31, 33 of each ALSEP frame

Word 5 Words 46, 47, 56 of each ALSEP frame

Word 6 Word 63 of each ALSEP frame

NOTE: Word 46 will be replaced in this format by Word 5 for Flight C only.

Packed IBM word format for ALSEP data words



90 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 556 BPI; 7 track, standard IBM EOF.

[a]Principal Investigator: Dr. John Freeman, Department of Space Sciences, Rice University, Houston, Texas 77001.

Table XI

3.2.8 Cold Cathode Gage Experiment. - The Cold Cathode Gage Experiment (CCGE) will determine the density of any lunar ambient atmosphere, including any temporal variations either of a random character or associated with lunar local time or solar activity. Additionally, the CCGE will determine the rate of loss of contaminants left in the landing area by the astronauts and the lunar module.

The CCGE is intimately associated with SIDE and is flown as part of the SIDE experiment on flight systems A and C. On these flights, the CCGE data will be extracted from the SIDE data format for separate data analysis. For flight system B, the CCGE will be flown by MSC as a single experiment (without SIDE) and will telemeter a different data format through the central station. The CCGE data will replace the SIDE data for flight system B, and will occupy ALSEP words 15, 31, 47, 56 and 63.

The first CCGE word (ALSEP word 15) contains six experiments state conditions. CCGE word 2 (ALSEP word 31) is the cold cathode gage output data. The CCGE word 3 (ALSEP word 47) contains gage temperature. The CCGE word 4 (ALSEP word 56) consists of CCGE electronics temperature, and CCGE word 5 (ALSEP word 63) is housekeeping data subcommutated over four ALSEP main frames. (See table XII for the P.I. tape formats.)

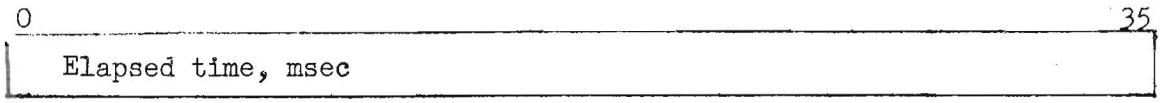
3.2.8 Cold Cathode Gage Experiment (MSC)

I Label Record (appears twice on tape)

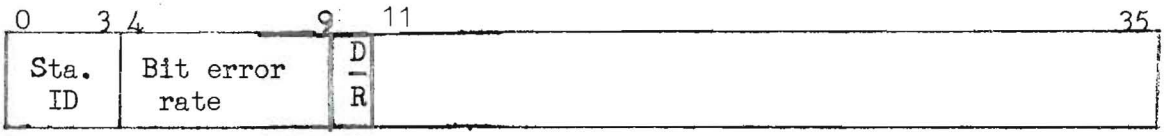
Word	Parameter	Mode
1	Experiment identification (SIDE)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	

II Data record format, 6 words/logical record

Word 1



Word 2 Station ID, bit error rate, data rate (1=1060 bps; 0=530 bps)



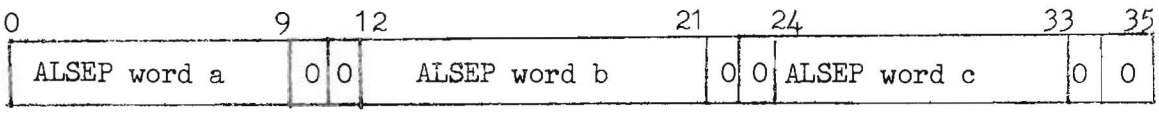
Word 3 Words 1,2,3 of each ALSEP frame

Word 4 Words 15,31,33 of each ALSEP frame

Word 5 Words 5,47,56 of each ALSEP frame

Word 6 Word 63 of each ALSEP frame

Packed IBM word fromat for ALSEP data words



90 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI; 7 track, standard IBM EOF.

[a]Principal Investigator: Dr. Francis Johnson, Graduate Research Center of Southwest, Dallas, Texas 10946

Table XII (CCGMSC)

COLD CATHODE GAUGE EXPERIMENT TAPE FORMAT

Non-FORTRAN Binary Tape (36 Bits per word)

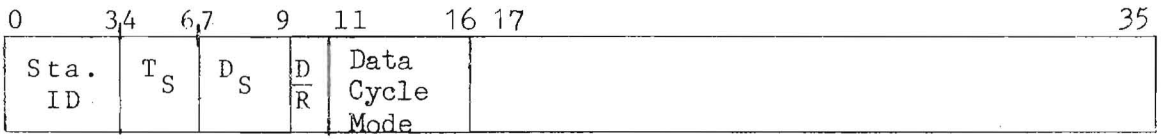
RECORD NO. 1 Master Header Record (4 Words)
(this record appears twice on tape)

Word	Contents		Mode
1	Experiment Name	(CCGEbb)	BCD
2	ALSEP Number	(ALSEPX)	BCD
3	Spacecraft ID	(A/SXXX)	BCD
4	Date Tape was Generated	(YRMODY)	BCD

RECORD NO. 2 Data Record

Word 1

Word 2



a. Bits 0 - 3: Station ID
b. Bits 4 - 6: Time sync quality code (7 = best, 0 = worst)
c. Bits 7 - 9: Data sync quality code (7 = best, 0 = worst)
d. Bit 10: Data rate (1 = 1060 bps, 0 = 530 bps)
e. Bits 11 - 16: Data cycle mode
f. Bits 17 - 35: Spare (will be zeros)

Word 3

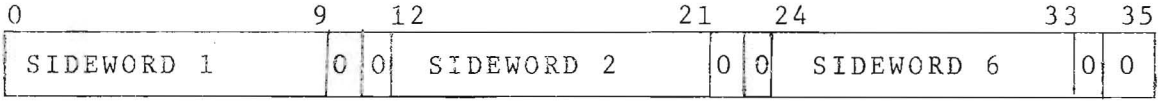


Table XII (CCGE)

a. Bits 0 - 11: SIDEWORD 1 as follows:

(1) Bit 0: Parity bit for the previous frame
(2) Bits 1 - 2: Two "zero" bits for even frame sync (frame sync bits)
(3) Bits 3 - 9: Contents of SIDE frame counter
(4) Bits 10 - 11: Will always be zeros

b. Bits 12 - 23: SIDEWORD 2 as follows:

(1) Bits 12 - 13: Will always be zeros
(2) Bits 14 - 21: CCGE data
(3) Bits 22 - 23: Will always be zeros

c. Bits 24 - 35: SIDEWORD 6 as follows:

(1) Bit 24: Parity bit for the previous frame
(2) Bits 25 - 26: Two "one" bits for odd frame sync (frame sync bits)
(3) Bit 27: Will always be zero
(4) Bits 28 - 33: CCGE data
(5) Bits 34 - 35: Will always be zeros

Words 1 - 3 will repeat 90 times within a record to produce a 270 word record. Incomplete records will have the remaining portion filled with zeros. Last record on tape will contain all "ones" (001 bit configuration) followed by an end of file mark.

800 BPI, 7 track, standard IBM EOF

Principal Investigator: Dr. Francis Johnson, Graduate Research Center of Southwest, Dallas, Texas 10946.

There are 4 modes of operation. Values from 1-15 excluding 2,3,5 and 6 are normal mode, mode 2 = 2, mode 3 = 3, mode 5 = 5 or 6.

Required SIDE frames for normal mode (code either 1,4,7-15)

1	34	72	120
2	39	73	121
3	40	74	122
5	41	88	123
7	42	89	124
8	56	98	125
9	57	103	126
10	66	104	127
24	67	105	
25	71	106	

Required SIDE frames for mode 2 (code 2 only)

1	3	7	9
2	5	8	10

Required SIDE frames for mode 3 (code 3 only)

1	5	9	25
2	7	10	34
3	8	24	39

Required SIDE frames for mode 5 (code 5 or 6 only)

1	9	40	67
2	10	41	71
3	24	42	72
5	25	56	73
7	34	57	74
8	39	66	

NOTE: There are four modes of operation (Data Cycle Mode) and data is included from above listed frames by mode code.

3.2.9 Engineering and Housekeeping Flight "B"

The engineering data will consist of housekeeping measurements from the ALSEP system. These data appear once each ALSEP frame. The engineering word recycles every 90 frames. An IBM-compatible tape will be supplied to the equipment contractor, including the engineering data, timing, and general header information, formated as shown in Table XIII

- THE ALSEP SYSTEM DATA TAPE FORMAT[a]

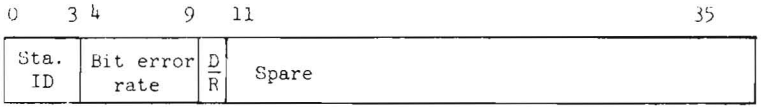
I. Label record (appears twice on tape)

Word	Parameter	Mode
1	Experiment identification (ENGRNG)	BCD
2	ALSEP number (ALSEPX)	BCD
3	Mission identification (A/Sxxx)	BCD
4	Spare	BCD

II. Data record format, 4 words/logical record

Word 1

Word 2 Station ID, bit error rate, data rate (1 = 1060 bps; 0 = 530 bps)

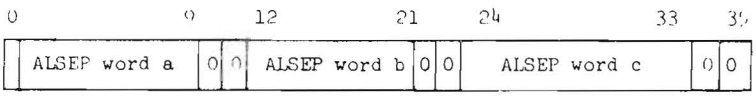


Word 3 Words 1, 2, 3 of each ALSEP frame

Word 4 Words 33 and 5 of each ALSEP frame

NOTE: Word 5 will be replaced by 46 on Flight "A"

Packed IBM word format for ALSEP data words



180 logical records/physical record

Finish filling last record of data with zeros; last record filled with all ones followed by EOF. Binary tape, 800 BPI; 7 track, standard IBM EOF.

[a]Principal Investigator: Bendix Aerospace Systems Division, Ann Arbor, Michigan.

Table XIII

3.3 Digital to Analog Tapes for Passive Seismic Experiment

This procedure describes the method of processing PSE analog data tapes. These tapes contain PCM and time code information of which certain data parameters will be reduced as dictated by the Lamont Geological Observatory of Columbia University.

GENERAL

The data to be reduced is provided in magnetic tape form on a 1" X 10½" reel. It is recorded at 3-3/4 ips in direct and FM modes. The FM carrier frequency has a center carrier of 6.75 KHZ and a deviation of ±40%.

Decommutation of the PCM bit stream is required in providing the output tape copy. The following is the specification of the format to be reduced.

PCM DATA	SPLIT Ø
BIT RATE	1.06 KBITS
WORD LENGTH	10 BITS
FRAME SAMPLE RATE	1.67 SAMPLES/SEC
MAJOR FRAME	90 FRAMES

APPLICABLE DOCUMENTS

- ALSEP Data Plan
- Off-Line Telemetry Alignment Procedures

EQUIPMENT REQUIRED

- FR 1400/600 (2)
- Brush Recorder - Mark 200
- PCM Decommutator - Vector
- FM Calibration Test Unit - Ampex TC-10
- Astrodata Galvo Amplifiers (10) Model

PROCEDURE

4.1 Inspect data tape and reel for physical damage.

4.2 Configure playback system accordingly.

o Head	1" standard
o Electronics	Direct reproduce with 60 ips equalizers. FM demodulators with 108 KHZ plug-in filters.

- o Tape Speed — 60 ips

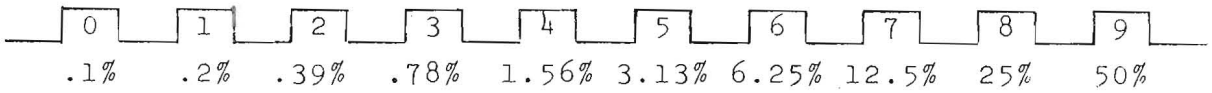
Configure recording system accordingly.

- o Head — 1/2" standard
- o Electronics — FM modulators selected for center frequency of 27 KHZ and having a ± 40% deviation. One track selected for direct recording. (Track to be specified on request.)
- o — FM Demodulators with plug-in filters for 27 KHZ center carrier adjusted for ± deviation. One track selected for direct reproduceing. (Track to be specified on request.)
- o Tape Speed — 15 ips

Configure the PCM decommutation system accordingly.

- o Programming — Format board patched to recognize PSE format. Program loaded via tape reader to program selected parameters from Decom to DAC's. DAC's outputs are patched to Galvo Amps to provide ± voltage to record on FR 1400.
- o DACS — The digital to analog converters are programmed to select 10 bits and convert the digital data into analog form.

LSB



- o DAC Calibrator — CAL or OPERATE position as required

GALVO AMPLIFIERS — Receive + 10 V from DAC and Offset this to ± 2V for recording on FR 1400.

Configure the Brush recorder accordingly.

- o Analog Pens — Adjusted for 0, 50, 100% deviation. This is accomplished by recording a signal from the PCM DACS on the recording system and using the output of the demodulators to drive the pens.
- o Event Pens — Adjust to display slo-code time.

Playback the data tape at 60 ips and observe data signals on oscilloscope. Data is compressed at a real time ratio of 16:1.

- Route the time code signal to time code translator. The TCT should have the applicable type plug-in module. The IRIG B time code output from the TCT is routed to the requested track of recorder configured as the recording system.

- Route PCM signal to input of PCM decommutation system. Set the PCM mode selector switch to the CAL position. At the time main comm sync is obtained the DAC outputs will provide calibration steps of 0, 50 and 100%.

- Route DAC outputs to recording system. Record the calibration signals on the tracks requested, for data recording. Run at least five cycles of 0, 50 and 100% calibration to provide PRE-CAL on recording. Record a 50 KHZ signal on the track selected for direct recording. Record the sync status on track 6.

- Route the demodulator outputs of recording system to data pen of Brush oscillograph recorder. Assure that calibration signals deflect the proper precentages. (Do not strip out 50 KHZ signal.)

- Route the time code output of recording system to a time code translator. The slo-code output from this translator, is routed to the event marker on the Brush recorder to allow displaying Astrodata slo-code time in relation to the data.

- Stop all machines after calibration signals are obtained.

- Place the PCM mode selector switch to DATA position. Rewind data tape only. Restart all systems. A permanent analog tape copy of the data is being produced.

- Repeat the process of recording 0, 50 and 100% calibrations after the data has been recorded, (POST CALS). Assure that the calibration signals recorded are from the output of the DACS.

Permanent analog copy is at a real time ratio of 32:1 when reproduced at a 30 ips tape speed. The FM carrier frequency at that speed is 54 KHZ with a deviation of $\pm$ 40%.

DATA TAPE	Tape Speed 3-3/4 ips FM carrier frequency 6.75 KHZ Data Real Time Ratio 1:1
REPRODUCE DATA TAPE	Tape Speed 60 ips FM carrier frequency 108 KHZ Data Real Time Ratio 16:1
VECTOR PCM DECOMM	Decommutated at 16:1 Real Time Data Ratio
RECORDED ANALOG COPY	Tape Speed 15 ips FM carrier frequency 27 KHZ Data Real Time Ratio 16:1

Special ALSEP Array A Analog Tape Formats for Passive Seismic

This special run is to convert certain PCM measurements from PCM wave train, to analog signals that will be recorded directly onto an analog tape.

Input Information

TRK Assignments

1. Speed Lock
2. Open
3. Array A PCM Downlink
4. Open
5. Uplink PCM
6. Open
7. IRIG B Time Code

PCM Set Up

1. Bit Rate = 1.06 Kb Split Phase B-O-L
2. Sync Word
   Barker Code 111 000 100 100 001 110 110 1
3. Word Length = 10 Bits
4. 64 words/frame
5. Frame counter is in word 3, bits 3→9, goes 1→89, 0

Output Tape A Standard or Intermediate Recorded

Recorded Track 1 - LPZ Seismic O/P 4 samples/frame on Pins 13,29,45 & 61
" " 2 - LPX Seismic O/P 4 samples/frame on Pins 9,25,41,57
" " 3 - LPY Seismic O/P 4 samples/frame on Pins 11,27,43,59
" " 4 - 25 KHz ref
Recorded Track 5 - SPZ Seismic O/P 29 samples/frame Every even word except 2,46, & 56
" " 6 - Sync
" " 7 - IRIG B Time Code from original tape

Tape must have DC→25 HZ frequency response. Time may be biased by request only.

Output Tape B Standard or Intermediate Recorded

Recorded Track 1 - Z - FB 0.5 Samples/frame odd Pin 35
" " 2 - X - FB 0.5 Samples/frame even Pin 35
" " 3 - Y - FB 0.5 Samples/frame even Pin 37
" " 4 - 25 KHz ref
Recorded Track 5 - Temperature 0.5 Sample/Frame odd Frames Pin 37
" " 6 - Sync
" " 7 - IRIG B Time Code from original tape

Output tape must have DC → 25 HZ Frequency response. Time may be biased but by request only.

3.4 Ephemeris Data

Ephemeris data for the ALSEP are required in tabular printout form and on a data tape. The data format for the computer tape data will be as shown in table XIV. Ephemeris data will be listed in three different ALSEP-centered coordinate systems by ED32.

System 1. - The first coordinate system has as its primary plane, the ALSEP meridian plane. The Cartesian X-axis points radially outward from the ALSEP (toward the zenith), the Z-axis lies in the ALSEP meridian plane in a northerly direction, and the Y-axis lies in the equatorial plane completing the right-handed system.

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = \begin{bmatrix} \cos\Phi\cos\lambda & \cos\Phi\sin\lambda & \sin\Phi \\ -\sin\lambda & \cos\lambda & 0 \\ -\sin\Phi\cos\lambda & -\sin\Phi\cos\lambda & \cos\Phi \end{bmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

where X', Y', Z' denotes the ALSEP-centered axes

X, Y, Z, denotes the selenographic axes

λ = selenographic longitude of the ALSEP

Φ = selenographic latitude of the ALSEP

The spherical coordinate system has as its primary plane the Cartesian X'-Z' plane, with the principal axis being the X' axis. The in-plane angle θ is measured from X' toward Z' in the range $-\pi$ to π. The out-of-plane angle ψ is measured from the primary plane toward the positive Y' axis, in the range $-\frac{\pi}{2}$ to $\frac{\pi}{2}$.

System 2. - The Cartesian X-axis of system 2 is the ALSEP-earth line, positive toward the earth. The Y-axis lies parallel to the earth-moon plane in the direction opposite the moon's velocity vector. The Z-axis completes the right-handed system.

The primary plane of the spherical system is the X-Y plane of coordinate system 2 and 3. The principal axis of the spherical system is the Cartesian X-axis.

System 3. - The X-axis of system 3 is the unit vector directed from ALSEP toward the sun. The Z-axis is very nearly normal to the ecliptic plane, positive northward. (The X-axis is not truly in the ecliptic plane.) The Y-axis completes the right-handed system.

EPHEMERIS DATA FORMAT

I. Units: All putput angles are in radians.

Distance units are earth radii, equal to

20 925 696.3 U.S. feet

20 925 738.19 international feet

6 378.165 kilometers

II. Output tape format:

A. Header record - Four integers giving ALSEP number, month, day, and year

B. Data records - Twenty-four hour blocks of ephemeris data will be contained in 468 words per record where

Word	Designation
1	Calendar year
2	Greenwich mean time (GMT) elapsed days from January 0
3	00 which corresponds to 0000 GMT
Words 4 to 15 will all be relative to system 1	
4	X-coordinate from ALSEP to center of earth
5	Y-coordinate from ALSEP to center of earth
6	Z-coordinate from ALSEP to center of earth
7 to 9	Spherical coordinates ρ, θ, ψ of words 4,5,6
10 to 12	Cartesian coordinates X,Y,Z, respectively, measured from ALSEP to center of sun at 0000 GMT
13 to 15	Spherical coordinates ρ, θ, ψ, respectively, of words 10,11, 12
Words 16 to 27 will all be relative to system 2	
16 to 18	Cartesian coordinates X,Y,X of earth center at 0000 GMT
19 to 21	Spherical coordinates ρ, θ, ψ, of words 16,17,18

Table XIV

Word	Designation
22 to 24	Cartesian coordinates X, Y, Z of sun center at 0000 GMT
25 to 27	Spherical coordinates ρ, θ, ψ, of words 22, 23, 24
Words 28 to 39 will be information using system 3	
28 to 30	Cartesian coordinates X, Y, Z of earth center at 0000 GMT
31 to 33	Spherical coordinates ρ, θ, ψ, of words 28, 29, 30
34 to 36	Cartesian coordinates X, Y, Z of sun center at 0000 GMT
37 to 39	Spherical coordinates ρ, θ, ψ, of words 34, 35, 36
40	Calendar year
41	GMT elapsed days from January 0
42	02 hours of GMT for word 41
43 to 78	Repeat of words 4 to 39 except for a new time (word 42)
79	Calendar year
80	GMT elapsed days from January 0
81	04 hours of GMT for word 80
82 to 117	Repeat of words 4 to 39 except for a new time (word 81)

This scheme will repeat nine additional times to complete the day.

Words 1, 40, 79, 118, 157, 196, 235, 274, 313, 352, 391, and 430 will all be calendar year. For a given record, each of these words will contain the same constant value.

Words 2, 41, 80, 119, 158, 197, 236, 275, 314, 353, 392, and 431 will all contain the number of days elapsed from January 0. For a given record, each of these words will contain the same constant value.

Words 3, 42, 81, 120, 159, 198, 276, 315, 354, 392, and 432 will be the hour designator, starting at 00 hours and incrementing by 2 each word.

Example: The ephemeris information for GMT noon, October 20, 1966, would be the 12 words following word 237 of the 293 day of 1966.

Within each system:

First three words	Earth Cartesian X, Y, Z
Second three words	Earth Spherical ρ, θ, ψ
Third three words	Sun Cartesian X, Y, Z
Fourth three words	Sun Spherical ρ, θ, ψ

III. Output: One complete ephemeris 36-bit magnetic tape will be sent to each PI (six tapes). Books from 4020 microfilm will be available as demand requires.

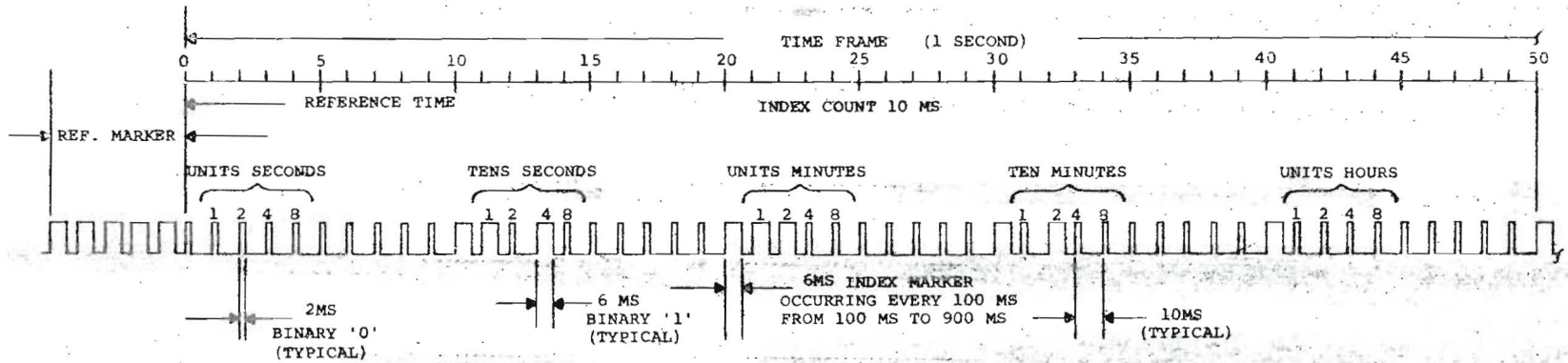
IV. Source of format: ALSEP Ephemeris Description by Geroge Roush, CAAD, Project no. 8042

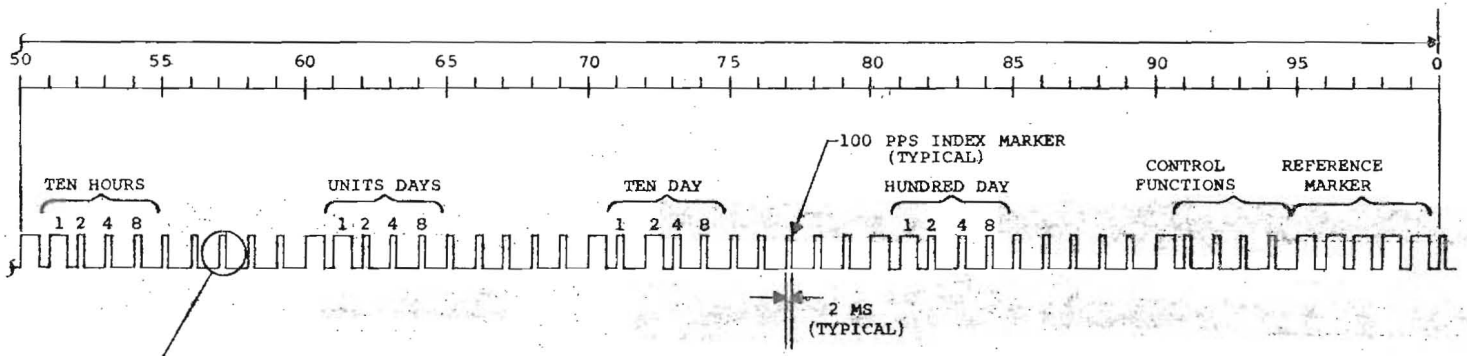
3.5 Calibration Tapes

Calibration tapes are not used by the Computation and Analysis Division in processing ALSEP data. This Division does convert 7-track Apollo-Saturn format calibration tapes to 9-track tapes for the Flight Support Division (FS5).

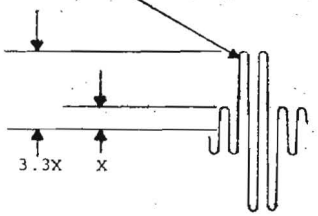
3.6 Timing Codes

The following time codes are used and output during ALSEP processing within ED.



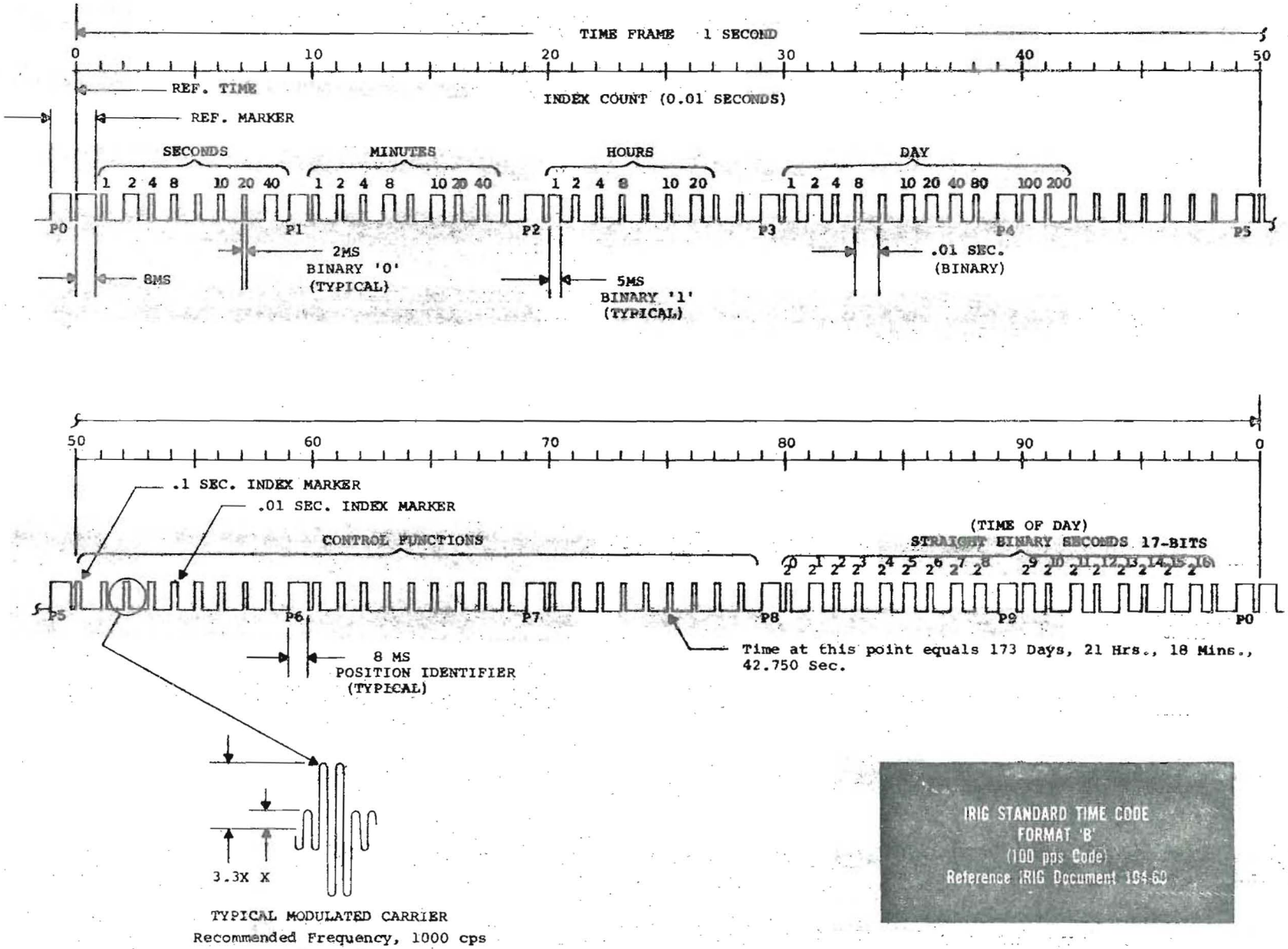


Time at Reference Marker is: 121 Days, 10 Hrs., 23 Mins., 41 Sec.



TYPICAL MODULATED CARRIER
Recommended Frequency 1000 cps

NASA 36-BIT TIME CODE
Reference IRIG Document 104-59


TIME FRAME 1 SECOND
0 10 20 30 40 50
REF. TIME
INDEX COUNT (0.01 SECONDS)
REF. MARKER
SECONDS
MINUTES
HOURS
DAY
1 2 4 8 10 20 40
1 2 4 8 10 20 40
1 2 4 8 10 20
1 2 4 8 10 20 40 80 100 200
P0
P1
P2
P3
P4
P5
8MS
2MS
BINARY '0'
(TYPICAL)
5MS
BINARY '1'
(TYPICAL)
.01 SEC.
(BINARY)
50 60 70 80 90 0
.1 SEC. INDEX MARKER
.01 SEC. INDEX MARKER
CONTROL FUNCTIONS
(TIME OF DAY)
STRAIGHT BINARY SECONDS 17-BITS
P5
P6
P7
P8
P9
P0
8 MS
POSITION IDENTIFIER
(TYPICAL)
Time at this point equals 173 Days, 21 Hrs., 18 Mins., 42.750 Sec.
3.3X X
TYPICAL MODULATED CARRIER
Recommended Frequency, 1000 cps
IRIG STANDARD TIME CODE
FORMAT 'B'
(100 pps Code)
Reference IRIG Document 104-60

4.0 Data Handling

MSFN tapes will be shipped directly to The Computation and Analysis Division's Central Metric Data File, ED5, Bldg. 12, Room 133, NASA MSC Houston, Texas 77058

4.1 Receipt and Storage of ALSEP Data

Range Analog Tapes When received by the Central Metric Data File, tapes will be assigned accession numbers and catalogued. Each ALSEP package will have a number as:

90 - XXXX - EASEP

91 - XXXX - ALSEP A

. . .

. . .

99 - XXXX - ALSEP I

The tapes will be checked in and out of this file when processing is requested by the Experiments Program Office.

Calibration Data There will be very few calibration tapes to be stored for ALSEP. There will be an equal number of rolls of film and calibration books.

Intermediate Data ED will hold the computer compatible tapes (output from ground station) until all Principal Investigators are assured of good experiment tapes. TD4 is expected to keep ED informed, so that the tapes can be released as soon as possible.

4.2 Shipment of ALSEP Data Principal Investigators

The Central Metric Data File will ship ALSEP output tapes to the Principal Investigators via Air Freight. Principal Investigators address and experiments for mailing purposes:

Suprathermal Ion Detector	Dr. John Freeman Attn: Dr. Kent Hills Dept. of Space Science Rice University Houston, Texas 77001
Charged Particle	Dr. David Reasoner Dept. of Space Science Rice University Houston, Texas 77001

Solar Wind	Dr. Conway Snyder Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, California 911037
Passive Seismic	Dr. Gary V. Latham Lamont Doherty Geological Observatory Columbia University Palisades, New York 10946
Heat Flow	Dr. Marcus Langseth Attn: Kevin McDermott Lamont Geological Observatory Columbia University Palisades, New York 10946
Cold Cathode Gage	Dr. Francis Johnson Graduate Research Center of Southwest Dallas, Texas 75230
Active Seismic	Dr. Robert Kovach Dept. of Geophysics Standford University Palo Alto, California 94305
Magnetometer	Dr. Charles P. Sonett Attn: Dr. Palmer Dyal National Aeronautics and Space Administration AMES Research Center Moffett Field, California 94035

4.3 COMPUTER COMPATIBLE TAPES FOR ALSEP

ALSEP A

Experiment	Words/ Frame	Capacity of One Reel	Nominal	Tapes Required Per Year			
Passive Seismic	48	33 hrs	24 hrs	365	one copy	1095	three copies
Magnetometer	7	100 hrs	72 hrs	122			
Cold Cathode Gauge	1/2	40 days	30 days	13			
Solar Wind	9	100 hrs	72 hrs	122			
Housekeeping and Engineering	5	135 hrs	96 hrs	92			
Suprathermal Ion Detector	10	87 hrs	72 hrs	122			

ALSEP B

Passive Seismic	48	33 hrs	24 hrs	365	one copy	1095	three copies
Heat Flow	3	448 hrs	336 hrs	26			
Charged Particle	11	87 hrs	72 hrs	122			
Cold Cathode Gauge MSC	1/2	87 hrs	72 days	122			
Housekeeping and Engineering	5	135 hrs	96 hrs	92			

ALSEP C

Passive Seismic	48	33 hrs	24 hrs	365	one copy	1095	three copies
Suprathermal Ion Detector	10	87 hrs	72 hrs	122			
Charged Particle	11	87 hrs	72 hrs	122			
Cold Cathode Gauge	1/2	40 days	30 days	13			
Housekeeping and Engineering	5	135 hrs	96 hrs	92			

EASEP

Passive Seismic	48	33 hrs	24 hrs	365	one copy	1095	three copies
Housekeeping and Engineering	5	135 hrs	96 hrs	92			

Analog Tapes for Passive Seismic - $\frac{1}{2}$" tapes, 10$\frac{1}{2}$" reels (A&B), two tapes, three times a day, 3 copies of each --- 18 tapes per day per ALSEP

Estimates based on 800 BPI density.

5.0 List of Tables

6.0 Abbreviation List

ALSEP	Apollo Lunar Surface Experiment Package
BPS	Bits Per Second
CAAD	Computation and Analysis Division
CCGE	Cold Cathode Gage Experiment
CMDF	Central Metric Data File
CPLEE	Charged Particle Lunar Environment Experiment
DACS	Digital-to-Analog Converters
ED	Office Code for Computations and Analysis Division
ED53	Office Code for Requirements and Analysis Section
EASEP	Early Apollo Scientific Experiments Package
EMR1	Part of CAAD Ground Station (Electro Magnetic Research)
FM	Frequency Modulated
FS5	Flight Support - Flight Hardware Branch
GMT	Greenwich Mean Time
IRIG	Inter-Range Instrument Group (Telemetry Standards)
KHZ	1000 Cycles
K BPS	1000 Bits Per Second
LSB	Least Significant Bit
LM	Lunar Module
MHZ	Millions Cycles
MSFN	Manned Spaceflight Network
MSB	Most Significant Bit
MS	Millisecond
SIDE	Suprathermal Ion Detector Experiment
PCM	Pulse Code Modulation
P.I.	Principal Investigator
TD4	Lunar Surface Operations and Checkout Office
TCT	Timing Code Translator