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MONTANA LARGE APERTURE SEISMIC ARRAY

THIRD QUARTERLY TECHNICAL REPORT, PROJECT VT 1708

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by

PHILCO-FORD
COMMUNICATIONS & TECHNICAL SERVICES
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13. ABSTRACT

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This report relates the technical activity associated with the operation, maintenance, and improvement of the Montana Large Aperture Seismic Array (LASA) for the period 1 June - 31 August 1971. Array equipment performance statistics and measurements are indicated. Adoption of a new tolerance for the channel sensitivities of the short and long-period seismographs is discussed. New computer programs prepared for automatic array maintenance and monitoring are identified. A description of the seismograph film recording operation for the Seismic Data Laboratory is given. Statistics relating to the operation and maintenance of the array and data center equipment and land facilities support are provided.

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ACRONYMS

AFTAC	Air Force Technical Applications Center
ESSA	Environmental Science Services Administration
IRSPS	Integrated Seismic Research Signal Processing System
LASA	Large Aperture Seismic Array
LASAPS	LASA Processing Subsystem
LDC	LASA Data Center
LMC	LASA Maintenance Center
LP	Long-Period
MDC	Maintenance Display Console
MOPS	Multiple On-line Processing System
SAAC	Seismic Array Analysis Center
SDL	Seismic Data Laboratory
SEM	Subarray Electronics Module
SP	Short-Period
VLR	Very Low Rate
VSC	VELA Seismological Center
WHV	Well Head Vault

SECTION I

INTRODUCTION

The Large Aperture Seismic Array (LASA) is part of the Vela Uniform Program which is sponsored by the Advanced Research Projects Agency of the Department of Defense. LASA is an experimental system consisting of many seismometers installed near Miles City, Montana, (Figure 1.1) used for the development of appropriate methods for the detection and identification of seismic events. Initially, the detection, location, and identification of seismic data were performed at the LASA Data Center (LDC) located at Billings, Montana. However, with the implementation of the Integrated Seismic Research Signal Processing System (IRSPS) the array data is now transmitted to the Seismic Array Analysis Center (SAAC) in Alexandria, Va., for processing and analysis.

Following a brief history and description of the LASA, a summary of this third quarters activities under Project V/T 1708 is included in Section II. The details of the LASA operation is given in Section III. Array performance is discussed in Section IV. Section V describes the improvements and modifications made during this period. Maintenance activities are presented in Section VI. Assistance provided to other agencies is indicated in Section VII; documentation provided s shown in Section VIII.

1.1 History

The LASA was installed in Eastern Montana during 1964 and 1965 to be used for experiments in advanced seismological detection and discrimination. The initial installation, composed of 21 subarrays at a diameter of 200 kilometers with 525 short-period and 63 long-period seismometers, has evolved into the present array with the original 21 subarrays reduced to 347 short-period seismometers and 51 long-period seismometers; 21 microbarographs and 8 weather stations have also been added.

Philco-Ford's participation in the Montana LASA began in 1964 by providing MIT Lincoln Laboratory with field engineering assistance. In June 1966, Philco-Ford assumed operational and maintenance responsibilities for MIT Lincoln Laboratory. On 1 May 1968, the project direction was transferred to the Electronics Systems Division, AFSC, with prime contracts to Philco-Ford through 30 November 1970.

Beginning 1 December 1970, technical direction of the Montana LASA was assigned to the Air Force Technical Applications Center (AFTAC). Under Project V/T 1708 Philco-Ford continues the work of previous Montana LASA projects. This work basically involves the continued operation and maintenance of the array and data center systems, logistics and administrative support, data provision, and instrument evaluation and installation.

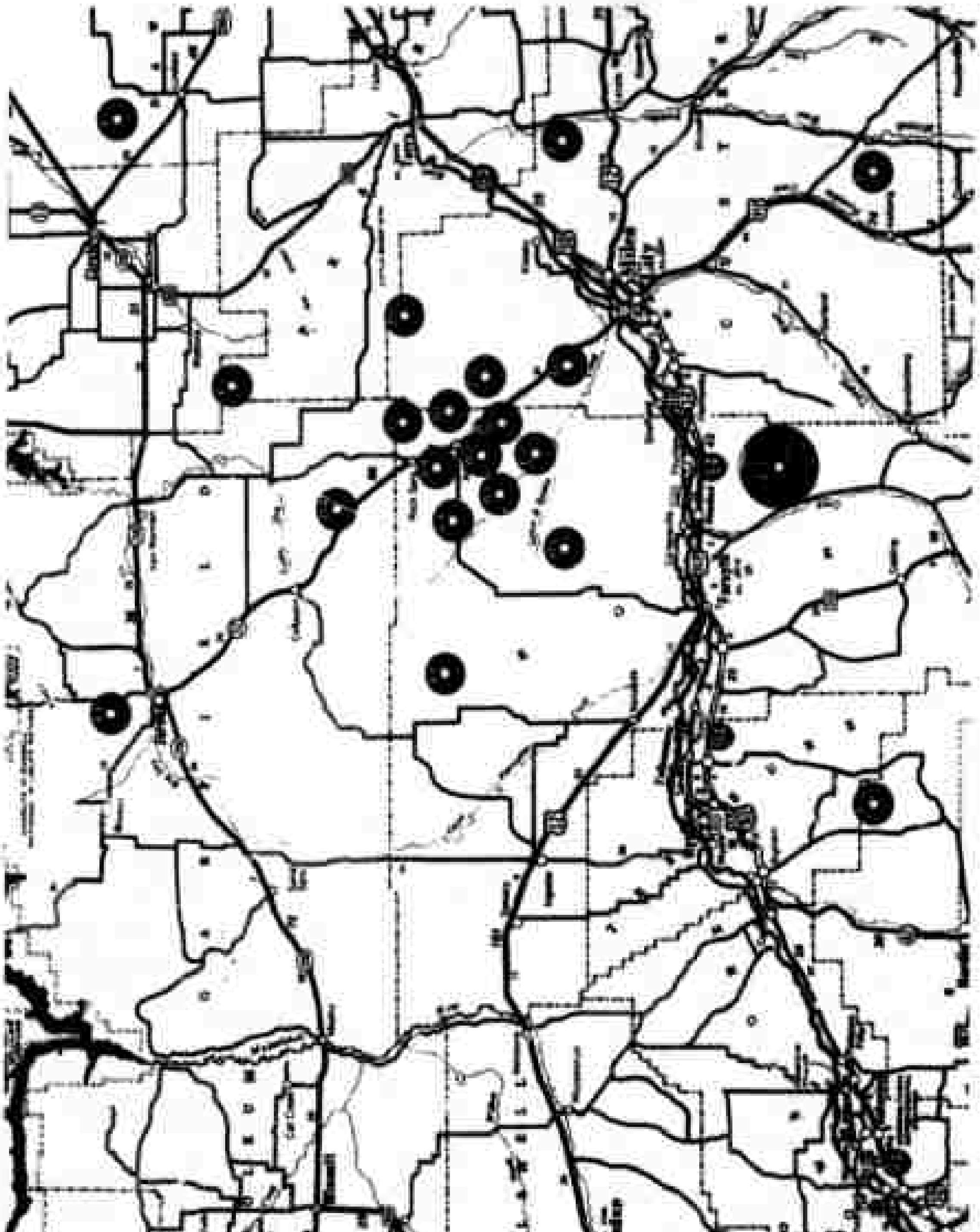


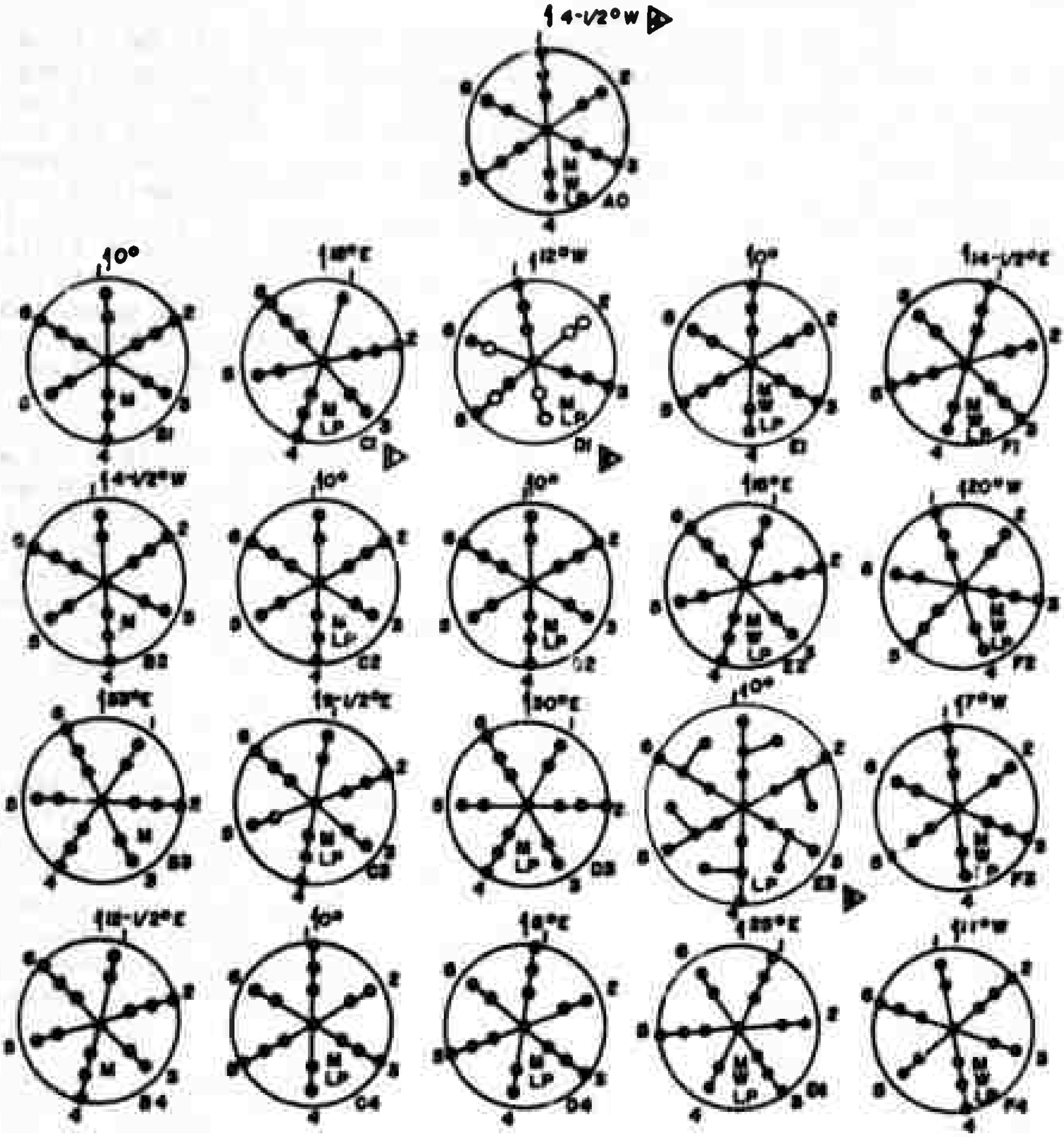
Figure 1.1 Montana LASA

1.2 Description

The LASA array has an overall diameter of 200 kilometers (125 miles) and is composed of 21 subarrays arranged as shown in Figure 1.1. With the exception of subarray E3 which is 19 km in diameter, all subarrays are 7 km in diameter. Subarray E3 is configured for 25 short-period seismometers while all others have 16. The subarrays originally were designed for 25 seismometers each, however, sensor removal has lowered this number to 16 except for E3. The short-period seismometers are located along six radial cables which terminate in a central underground vault containing the Subarray Electronics Module (SEM). The subarrays also contain three-component long-period sensors, microbarograph sensors, and weather sensors. Figure 1.2 shows the present configuration on each subarray.

The LDC is the focal point for complete control of array operation. Twenty times each second (corresponding to a sampling period of 50 milliseconds) a command signal is sent from the LDC to each SEM to cause sampling of the various signals. This command word is suitably delayed within the LDC prior to transmission so that data from all SEM's will arrive at the LDC within predetermined time intervals. The SEM responds to LDC timing system control signals with signal sampling, conversion, and transmission of all data to the LDC. Flexibility exists within the array in that the SEM can accomodate as many as 30 signal inputs; currently, signals from short and long-period seismometers, weather sensing equipment, microbarograph sensors, and other measured parameters are telemetered. Signals from the 21 SEM's are transmitted to microwave junction points they are sent to the LDC by microwave radio facilities. At the LDC the data are recorded and reformatted for transmission over a 50 kilobaud channel to SAAC. The LDC also contains the array timing and maintenance monitoring equipment. By means of telemetry commands, signal sources at the subarray are controlled to provide equipment calibrations and verify equipment performance.

The different LASA seismographs operating parameters and tolerances are identified in Tables I and II. Figure 1.3 shows the five different seismograph responses available.



NOTES

1. Sensors removed from leg I because of access difficulties.
2. O Denotes near surface sensors.
3. Expanded array, 18 Km diameter.
4. All degrees shown are orientations with respect to true north.
5. LP Denotes long period seismometers exist at center of array.
6. M Denotes microbarograph sensors exist at center of array.
7. W Denotes weather sensors exist at center of array.

Figure 1.2 LASA Subarray Configurations

TABLE I

LASA SEISMOGRAPH OPERATING PARAMETERS AND TOLERANCES

CHANNEL IDENT.	OPERATING PARAMETERS AND TOLERANCES				
	T_S	λ_S	(MP_S)	S_{chan}	Full Scale
SPZ	1.0±3%	0.7±0.1		$20^{+7.8}_{-3.8}$ mV/nm@1.0s	700^{+165}_{-195} nm@1.0s
SPIZ	"	"		"	"
SPTZ	1.15	0.7		"	"
SPTN	1.06	"		"	"
SPTE	1.03	"		"	"
SPAZ	1.0±3%	0.7±0.1		636^{+180}_{-140} mV/nm@1.0s	$22.2^{+5.2}_{-6.3}$ μm@1.0s
LPZ	20.0±5%	0.77	0±1.5mm	350^{+80}_{-90} mV/μm@25s	$40^{+14}_{-8.2}$ μm@25s
LPH	"	"	"	"	"
LPAZ	"	"	"	$11^{+2.5}_{-2.8}$ mV/μm@25s	1270^{+425}_{-235} μm@25s
LPAH	"	"	"	"	"
LPWZ	"	"	"	55^{+12}_{-14} mV/μm@25s	225^{+87}_{-46} μm@25s
LPWH	"	"	"	"	"

LEGEND: T_S = Seismometer Free Period (Sec); λ_S = Seismometer Damping

(MP_S) = Seismometer Mass Position from Center

S_{chan} = Channel Sensitivity

TABLE II

LASA SEISMOGRAPH CHANNEL IDENTIFICATION

CHANNEL	MANUFACTURER/MODEL	SEISMIC AMPLIFIER MFGR/MODEL	FILTER MFGR/MODEL/TYPE
SPZ	GeoSpace/HS-10-1A	Texas Inst./RA-5	4 pole ½dB ripple Chebyshev low pass, f_c=5.0 hertz, @10 hertz, -30dB.
SPAZ	GeoSpace/HS-10-1A	Texas Inst./RA-5	
SPIZ	GeoSpace/HS-10-1B	Ithaco/6072-65	"
SPTZ	Teledyne/TD-201D	Texas Inst./RA-5	"
SPTN	Teledyne/TD-201D	Texas Inst./RA-5	"
SPTE	Teledyne/TD-201D	Texas Inst./RA-5	"
LPZ	Geotech/7505A	Texas Inst./Type II	Texas Inst./Type II/Response A. 24 dB/oct high-cut, centered at 65 sec.
LPH	Geotech/8700C	Texas Inst./Type II	
LPAZ	Geotech/7505A	Texas Inst./Type II	"
LPAH	Geotech/8700C	Texas Inst./Type II	"
LPWZ	Geotech/7507A	Texas Inst./Type II	Texas Inst./Type II/Response C. 12 dB/oct high-cut, centered at approx. 100 sec.
LPWH	Geotech/8700C	Texas Inst./Type II	

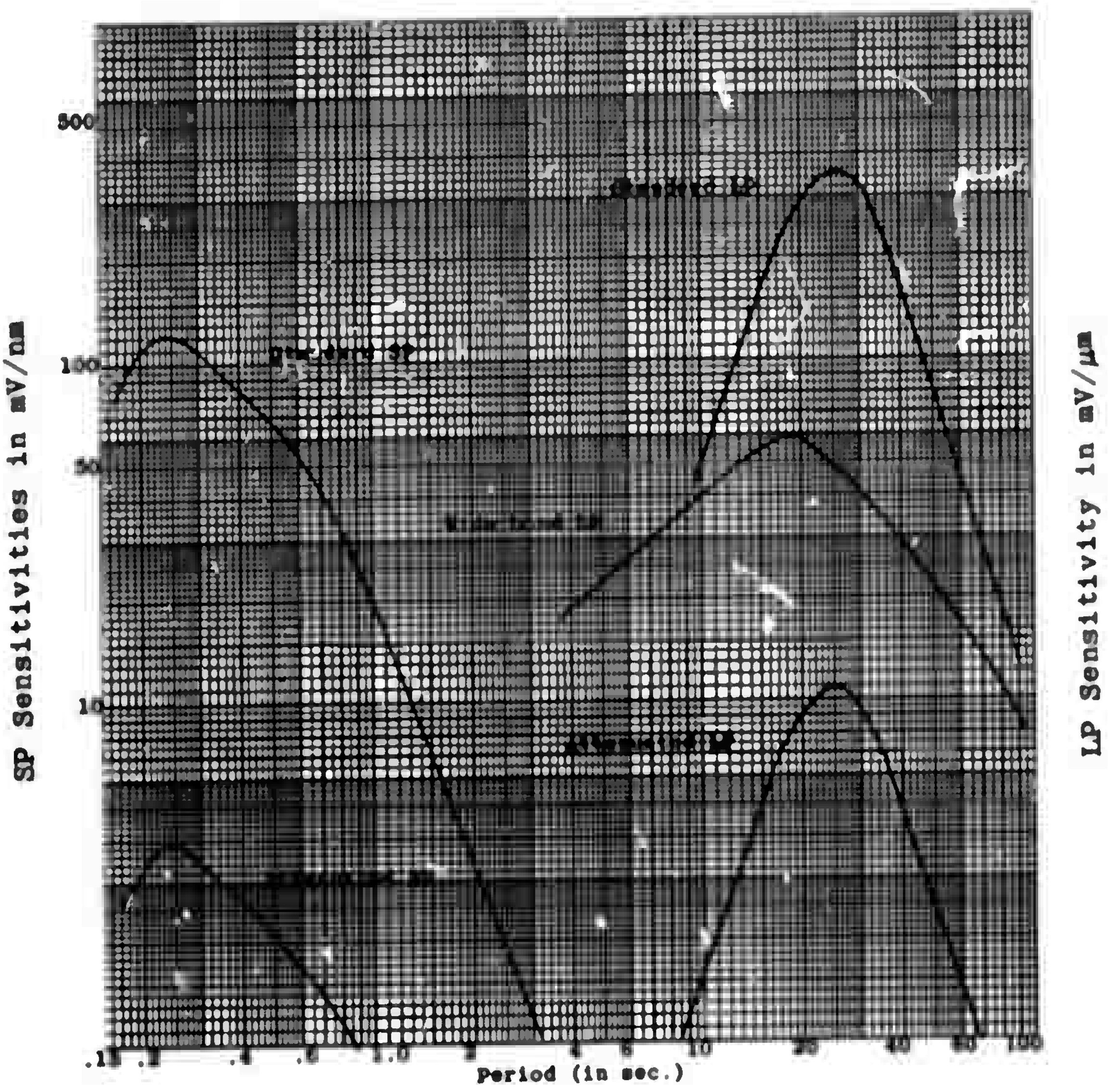


Figure 1.3 LASA Seismographs Response Curves

SECTION II

SUMMARY

The array operation, maintenance and system improvement activities for this period are described. The SP and LP array performance measurements using the remote telemetry controls are reported. New ±15% tolerances for both the SP and LP seismograph sensitivities are presented for adoption in the next reporting period. Descriptions of new PDP-7 computer programs for use in array performance testing and measurement are given. Interim results from the SP seismometer natural frequency measurements program are indicated. Statistics relating to the equipment operation, calibration, failure, and repair are presented. Assistance provided to the Seismic Data Laboratory in develocorder film recording is identified.

SECTION III

OPERATION

3.1 General

Array operation is performed to provide data continuously from the array sensing and data acquisition systems to the LDC, to provide data on-line from the LDC to the SAAC and to provide data recording in the event data transmission to SAAC is interrupted. To accomplish these tasks, operations and quality control activities in each of the following are performed: (1) IBM 360/44 computer operation on-line to SAAC, (2) PDP-7 computer operation to record array data in back-up of the 360 computer and to perform array monitoring, automatic calibrations, and off-line processing of technical information, (3) Maintenance Display Console operation for test and diagnosis of array equipment performance, (4) tape and film library operation for storage, handling, and shipment of array data recordings, (5) develocorder operation for continuous monitoring of selected sensor channels for array quality control testing and analysis and (6) logistics for property control and material acquisition.

3.2 Data Center

3.2.1 SAAC/LDC Systems

Monitoring of the SAAC/LDC operation during the third quarter period produced the operational statistics shown in Table III. Equipment outages resulting in no data being transmitted to SAAC from the Montana array totaled 44.0 hours or 2.1% of the period. This outage time was covered with digital recordings by the PDP-7 computer. Whenever the SAAC computers are not available for LASA data acquisition, no real time data is transmitted from the LDC; 40.2 of 122.5 hours of LDC recording this quarter occurred for this situation. Power failures at the LDC accounted for 2.5 hours downtime and wideband data link outages totaled 15.7 hours.

3.2.2 IBM/360 Model 44 Computer

The IBM/360 computer operated on-line to SAAC 95.2% of this quarter. Details of the 360 computer utilization are shown in Table IV.

3.2.3 DEC PDP-7 Computer

The PDP-7 computer was used in a back-up mode for high-rate recording (Ref. 1) on 33 occasions covering an accumulated time period of 122.5 hours. This operation produced 933 magnetic tapes recorded by the computer on 51 of the 92 days the system was on-line this quarter. The PDP-7 utilization statistics are shown in Table V.

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TABLE III

SAAC/LDC SYSTEM OPERATING TIMES (in hours)

	JUNE	JULY	AUGUST
SAAC & LDC 360 On-Line	683.1	698.4	711.5
SAAC Off-Line, LDC 360 Running			
PDP-7 Recording	15.9	13.8	10.5
360 Idle	0.0	0.0	0.0
SAAC Up, LDC 360 Down, PDP-7 Recording			
Scheduled	3.7	5.1	3.8
Unscheduled	16.2	26.7	1.1
SAAC Up, Other Equipment Down, PDP-7 Recording			
Scheduled	0.0	0.0	0.0
Unscheduled	1.1	0.0	17.1
Totals	720.0	744.0	744.0

TABLE IV

SYSTEM/360 MODEL 44 COMPUTER UTILIZATION

OPERATION	ACCUMULATED TIME, HOURS			
	JUNE	JULY	AUGUST	TOTAL
On-line processing including:				
System initialization	0.1	1.0	0.2	1.3
Fully operational with WAPS	683.1	698.4	711.5	2093.0
Running at LASA only	15.6	12.7	10.3	38.6
Down-time operating including:				
Scheduled maintenance	3.7	5.1	1.9	10.7
Corrective maintenance	4.0	17.5	0.0	21.5
Training	0.0	0.0	1.9	1.[illegible]
Shut down - 360 equipment	12.1	9.3	0.0	21.4
Shut down - other equipment	1.0	0.0	17.1	18.1
Program halt or loop	0.4	0.0	1.1	1.5
Idle time	0.0	0.0	0.0	0.0
TOTAL	720.0	744.0	744.0	2208.0

TABLE V

PDP-7 COMPUTER UTILIZATION

	ACCUMULATED TIME, HOURS			
	JUNE	JULY	AUGUST	TOTAL
On-line program operation including:				
Monitor & Weather Processing only	54.0	227.3	72.5	353.8
VLR Recording only	117.4	0.0	172.7	290.1
High Rate Recording only	8.0	45.9	8.0	61.9
Low Rate Recording only	77.6	342.1	60.0	479.7
VLR & High Rate Recording	27.3	0.0	22.6	49.9
VLR & Low Rate Recording	261.2	0.0	285.3	546.5
VLR, High & Low Rate Recording	0.9	0.0	3.3	4.2
High & Low Rate Recording	3.3	2.6	.6	6.5
Array Calibration	0 0	0.0	0.0	0.0
Off-line program operating including:				
Tape Duplication & Verification	4.6	2.6	6.7	13.9
Data Analysis	1.5	0.0	.4	1.9
Utility Operation	9.4	4.5	7.7	21.6
Program Development	123.2	23.9	78.4	225.5
Diagnostic Programs & Testing	5.2	42.2	12.0	59.4
Training	0.0	0.0	.6	.6
System Initialization	0.4	0.9	0.0	1.3
Down-time operation including:				
Scheduled Maintenance	0.0	1.2	0.0	1.2
Corrective Maintenance	19.9	37.4	5.4	62.7
Shut down PDP-7 Inoperative	0.0	8.0	0.0	8.0
Shut down - Other Equipment	4.0	0.0	2.5	6.5
Program Halts	2.1	3.7	4.3	10.1
Idle	0.0	1.7	1.0	2.7
Totals	720.0	744.0	744.0	2208.0

Very-low-rate (VLR) recording of the microbarograph array data on the incremental recorder were made covering 40.3% of the 2208 hours of this quarter.

Program development accounted for 225.0 hours of the PDP-7 computer use. This time is utilized during periods in which high rate recording is not required. Section 5.1 describes some of the program development work accomplished.

3.2.4 Tape/Film Library

The data center's library is used to store the PDP-7 computer magnetic tape recordings, the IBM 360 computer disc recordings, and the develocorder film recordings for reuse, distribution, or reference. This quarter 933 high-rate tape recordings were retained in the library. Forty-two very-low-rate tape recordings and 70 film recordings were distributed to the Seismic Data Laboratory (SDL).

3.3 Array

3.3.1 Monitoring

The present configuration of the array equipment has been divided into six groupings for the purpose of array control. These groups are: the 347 short-period seismic sensors, the 51 long-period seismic sensors, the 22 microbarograph sensors, the 26 meteorological sensors, the 21 operating subarray electronics and the 21 subarray power systems. The distribution of the sensor equipment groups differs among the 21 subarrays. Short-period seismic sensors are installed at all subarrays, long-period sensors are at all subarrays except in the B-ring, microbarograph sensors are at all subarrays except E3 and meteorological sensors are at eight subarrays only.

Operation and maintenance of the array equipment requires that the data be interrupted at various time periods, during which time normal or reliable data may not be available to the LASA data user. The reasons established for data interruptions are: maintenance, either being performed or initiated, subarray equipment failure in which no maintenance has been initiated, telephone company(s) performing tests on the communication circuits, telephone company(s) communication link not functioning, power outage at the subarray, or special data center testing. In the event any of these situations occur, a notation is made in the data interruption log relating to the data affected and the time period. For the case of short-period and long-period interruptions, SAAC is alerted via the System 360 typewriter. The durations of subarray data interruptions recorded during this contract are listed in Table VI.

Array data availability based on the periods the array systems were on-line has been determined by combining the total subarray data interruption times of Table VI with the total sensor outage times reported on the weekly Defective Signal Channel Status Reports. Disregarding the slight errors caused by outages overlapping into both the subarray and sensor times, the percentage

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES

		TOTAL TIME DURATION OF DATA INTERRUPTIONS (H:MIN)			
SUB-ARRAY	DATA	JUNE	JULY	AUGUST	TOTALS
AO	SP	7:17	3:35	2:14	13:06
	LP	6:47	3:05	1:44	11:36
	μbaro	6:47	3:05	1:44	11:36
	Meter	6:47	3:05	1:44	11:36
	Telco	24:11		35:24	59:35
B1	SP	1:54	6:38	9:40	18:12
	μbaro	1:24	6:08	9:10	16:42
	Telco	5:01		:34	5:35
B2	SP	:30	1:15	:30	2:15
	μbaro		:45		:45
	Telco	5:01	3:28	:34	9:03
B3	SP	:46	:30	9:40	10:56
	μbaro	:16		9:10	9:26
	Telco	5:01		:34	5:35
B4	SP	:30	:59	:30	1:59
	μbaro		:29		:29
	Telco	9:29	5:58	:34	16:01
C1	SP	:30	5:32	8:35	14:37
	LP		5:02	8:05	13:07
	μbaro		5:02	8:05	13:07
	Telco	5:01	:38	:52	6:31
C2	SP	:30	2:44	2:50	6:04
	LP		2:14	2:20	4:34
	μbaro		2:14	2:20	4:34
	Telco	5:01	2:46	1:04	8:51
C3	SP	1:15	11:25	:30	13:10
	LP	50:31	10:55		61:26
	μbaro	:45	10:55		11:40
	Telco	5:01	2:15	4:46	12:02

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES (CONTINUED)

		TOTAL TIME DURATION OF DATA INTERRUPTIONS (H:MIN)			
SUB-ARRAY	DATA	JUNE	JULY	AUGUST	TOTALS
C4	SP	:30	1:45	:30	2:45
	LP		1:15		1:15
	µbaro		1:15		1:15
	Telco	5:01		:34	5:35
D1	SP	3:22	:54	:30	4:46
	LP	2:52	:24		3:16
	µbaro	2:52	:24		3:16
	Telco	11:03	3:53	2:59	18:45
D2	SP	:30	1:34	:51	2:55
	LP		26:26	2:16	28:42
	µbaro		1:04	:21	1:25
	Telco	:09	:10	1:21	1:40
D3	SP	1:51	1:12	:30	3:33
	LP	1:21	:42		2:03
	µbaro	1:21	:42		2:03
	Telco	19:06	24:04	8:35	51:45
D4	SP	1:37	4:55	:30	7:02
	LP	2:07	4:25		6:32
	µbaro	2:07	4:25		6:32
	Telco	5:43	3:06	3:32	9:45
E1	SP	:30	3:26	:30	4:26
	LP		2:56		2:56
	µbaro		2:56		2:56
	Meter		2:56		2:56
	Telco	3:14	4:15	19:05	26:34
E2	SP	:30	:51	1:00	2:21
	LP		:21	:30	:51
	µbaro		:21	:30	:51
	Meter		:21	:30	:51
	Telco	25:07	:10	:34	25:51

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES (CONCLUDED)

		TOTAL TIME DURATION OF DATA INTERRUPTIONS (H:MIN)			
SUB-ARRAY	DATA	JUNE	JULY	AUGUST	TOTALS
E3	SP	:30	:59	:30	1:59
	LP		:29		:29
	Telco	:16	6:47	:39	7:42
E4	SP	:30	:30	4:03	5:03
	LP			3:33	3:33
	μbaro			3:33	3:33
	Meter			3:33	3:33
	Telco	15:58		3:32	19:30
F1	SP	28:31	23:31	:30	52:32
	LP	28:01	23:01		51:02
	μbaro	28:01	23:01		51:02
	Meter	28:01	23:01		51:02
	Telco	1:51	21:51	11:23	35:05
F2	SP	10:44	:30	:30	11:44
	LP	10:14			10:14
	μbaro	10:14			10:14
	Meter	10:14			10:14
	Telco	34:55	:10	1:21	36:26
F3	SP	:30	:30	30:43	31:43
	LP			30:13	30:13
	μbaro			30:13	30:13
	Meter			30:13	30:13
	Telco	17:48		:34	18:22
F4	SP	1:04	2:20	17:16	20:40
	LP	:34	1:50	16:46	19:10
	μbaro	:34	1:50	16:46	19:10
	Meter	:34	1:50	16:46	19:10
	Telco	24:40	5:31	5:45	35:56

data availabilities for this quarter are listed below with those of the preceeding quarterly periods.

	3rd Quarter	2nd Quarter	1st Quarter
SP	97.4	96.7	95.5
LP	98.4	99.3	98.4
μbaro	95.5	97.9	97.9
Met	98.3	99.3	99.5

The percentages include the effects of telco communications outages which for the 3rd quarter reduced the statistics by 0.9%.

3.3.2 Calibrations

The equipment groups connected to the data center via the telemetered communications channels have certain known responses to telemetry commands whereby the condition of the various equipment may be determined. When these responses exceed the tolerances established for a particular channel, an equipment failure is reported. The improper channel responses which can be corrected from the LDC maintenance console are logged on a LP system check sheet. Normal seismic channel responses to sinusoidal calibrations are shown in Table VII.

Table VIII indicates the incidence of defective channels detected by checks performed from the LDC for the four types of array channels and two equipment groupings. Testing of the LP system is more extensive than the other systems. Consequently, the incidence of defective LP channels is considerably greater than the other five categories; however, all except one of the defective LP channels were corrected using the telemetry controls at the MDC. The quantities in parenthesis indicate the out-of-tolerance measurements of seismometer mass position and free-period corrected remotely by telemetry. During the thirteen weeks of this reporting period 159 remote adjustments of 51 long-period seismometers were made; 135 for correcting mass position and 24 for correcting natural frequencies. Mass position is centered to within ±2mm and natural frequency maintained within 20±1 second.

With the addition of array calibration using the PDP-7 computer and the Multiple On-line Processing System (MOPS) on-line monitor feature the precise times in which calibrations occur become more readily available. A report of these times is shown in Table IX along with the equivalent earth motion of the 1-hertz calibration signals as determined from SEM channel 30 measurements during the calibration time. SEM channel 30 monitors the output of the calibration oscillator used to develop the signal applied to the seismometer. Table X shows the LP sensor calibration times and input signal amplitudes for 13 weeks of the contract.

3.4 Communications Meeting

A meeting of representatives from the VELA Seismological Center, the array contractor and the four operating telephone companies providing the array data communications was held on 23 August 1971 at Billings, Montana to review the array communications operation. The more significant subjects of discussion included (1) the procedures for reporting communications equipment troubles and for collecting outage information and (2) the feasibility of changing the array communications data rate from 19.2 to 2.4 kbit/s. Consequently, Mountain Bell's Billings toll will initiate a verification procedure with the LDC's chief operator on all outage times and trouble log information. Further, the installation and construction cost to replace the 19.2 with 2.4 kbit/s equipment is estimated to exceed the initial communication system cost and provide no appreciable decrease in the monthly charges. It was unanimously agreed to convene a meeting with this type representation during the next year.

TABLE VII

LASA SEISMOGRAPH CALIBRATION RESPONSE TOLERANCES

CHANNEL IDENT.	Peak-to-Peak Sinusoidal Amplitudes									
	TC	A_{nom} Volts	A_{max} Volts	A_{min} Volts	A_{nom} Digital	A_{max} Digital	A_{min} Digital	Y_{nom}	Y_{max}	Y_{min}
SPZ	06[1]	7.91	11.0	6.4	9257	12873	7490	395nm	550nm	320nm
SPAZ	06[1]	.25	.348	.202	293	407	236	395nm	550nm	320nm
SPIZ	06[1]	7.91	11.0	6.4	9257	12873	7490	395nm	550nm	320nm
SPTZ	06[1]	7.91	11.0	6.4	9257	12873	7490	395nm	550nm	320nm
SPTN	06[1]	7.91	11.0	6.4	9257	12873	7490	395nm	550nm	320nm
SPTE	06[1]	7.91	11.0	6.4	9257	12873	7490	395nm	550nm	320nm
LPZ	20[2]	7.0	8.6	5.2	8192	10064	6085	20.0μm	24.6μm	14.9μm
LPH	20[2]	7.0	8.6	5.2	8192	10064	6085	20.0μm	24.6μm	14.9μm
LPAZ	20[3]	2.44	3.00	1.81	2855	3511	2118	222μm	273μm	165μm
LPAH	20[3]	2.44	3.00	1.81	2855	3511	2118	222μm	273μm	165μm
LPWZ	20[2]	1.20	1.475	0.895	1404	1719	1047	20.0μm	24.6μm	14.9μm
LPWH	20[2]	1.20	1.475	0.895	1404	1719	1047	20.0μm	24.6μm	14.9μm

Note 1. Amplitude measurements corrected for response to 400nm, 1s calibration signal.
2. Amplitude measurements corrected for response to 20μm, 25s calibration signal.
3. Amplitude measurements corrected for response to 222μm, 25s calibration signal.

TABLE VIII

INCIDENCE OF DEFECTIVE SUBARRAY CHANNELS

SUBARRAY	CHANNELS			
	SP	LP	μBARO	METEOR
A0	1	0 (6)	0	0
B1	9	-	0	-
B2	1	-	0	-
B3	1	-	0	-
B4	2	-	1	-
C1	1	0 (4)	0	-
C2	3	0 (9)	1	-
C3	1	0 (10)	0	-
C4	1	0 (11)	1	-
D1	2	0 (16)	0	-
D2	0	1 (9)	1	-
D3	0	0 (12)	0	-
D4	1	0 (11)	1	-
E1	1	0 (15)	0	0
E2	1	0 (8)	0	0
E3	4	0 (9)	-	-
E4	1	0 (10)	0	0
F1	2	0 (8)	1	0
F2	1	0 (10)	0	0
F3	2	0 (3)	0	0
F4	2	0 (8)	0	1
TOTALS	37	1 (159)	6	1

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS

SUBARRAY	Short-Period Array Sinusoidal Calibration Signal Start Times and Amplitudes										SUBARRAY
	Day 158 7 June 71		Day 165 14 June 71		Day 172 21 June 71		Day 179 28 June 71		Day 187 6 July 71		
	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	
AO	1744:25	381	1753:32	381	1804:18	381	1817:09	381	1737:12	381	AO
B1	1744:55	414	1754:02	414	1804:48	414	1817:39	414	1737:42	414	B1
B2	1745:25	426	1754:32	437	1805:18	437	1818:09	448	1738:12	448	B2
B3	1745:55	381	1755:02	392	1805:48	392	1818:39	381	1738:42	381	B3
B4	1746:25	414	1755:32	414	1806:18	414	1819:09	414	1739:12	414	B4
C1	1746:55	426	1756:02	414	1806:48	414	1819:39	414	1739:42	414	C1
C2	1747:25	403	1756:32	403	1807:18	403	1820:09	403	1740:12	403	C2
C3	1747:55	403	1757:02	403	1807:48	403	1820:39	403	1740:42	403	C3
C4	1748:25	403	1757:32	392	1808:18	403	1821:09	403	1741:12	403	C4
D1	1748:55	403	1758:02	414	1808:48	403	1821:39	414	1741:42	414	D1
D2	1749:25	426	1758:32	426	1809:18	426	1822:09	426	1742:12	426	D2
D3	1749:55	403	1759:02	403	1809:48	403	1822:39	403	1742:42	403	D3
D4	1750:25	381	1759:32	370	1810:18	381	1823:09	392	1743:12	392	D4
E1	1750:55	414	1800:02	414	1810:48	403	1823:39	403	1743:42	403	E1
E2	1751:25	426	1800:32	414	1811:18	426	1824:09	426	1744:12	426	E2
E3	1751:55	403	1801:02	403	1811:48	414	1824:39	414	1744:42	414	E3
E4	1752:25	414	1801:32	414	1812:18	414	1825:09	414	1745:12	414	E4
F1	1752:55	403	1802:02	403	1812:48	403	1825:39	403	1745:42	403	F1
F2	1753:25	414	1802:32	414	1813:18	414	1826:09	414	1746:12	414	F2
F3	1753:55	426	1803:02	414	1813:48	426	1826:39	426	1746:42	426	F3
F4	1754:25	414	1803:32	414	1814:18	426	1827:09	426	1747:12	426	F4

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Day 194, 13 July 71 Start Time (GMT)	Day 194 P-P Ampl. nm	Day 200, 19 July 71 Start Time (GMT)	Day 200 P-P Ampl. nm	Day 208, 27 July 71 Start Time (GMT)	Day 208 P-P Ampl. nm	Day 214, 2 August 71 Start Time (GMT)	Day 214 P-P Ampl. nm	Day 221, 9 August 71 Start Time (GMT)	Day 221 P-P Ampl. nm	SUBARRAY
AO	1540:26	370	1403:57	358	0146:53	358	2041:13	370	2127:40	403	AO
B1	1542:26	403	1404:27	403	0147:23	403	2041:43	403	2128:10	403	B1
B2	1543:44	426	1404:57	448	0147:53	437	2042:13	437	2128:40	448	B2
B3	1545:06	381	1405:27	381	0148:23	381	2042:43	381	2129:10	381	B3
B4	1546:16	414	1405:57	414	0148:53	414	2043:13	414	2129:40	414	B4
C1	1547:37	403	1406:27	403	0149:23	403	2043:43	403	2130:10	403	C1
C2	1549:03	403	1406:57	403	0149:53	403	2044:13	403	2130:40	392	C2
C3	1551:05	414	1407:27	403	0150:23	403	2044:43	403	2131:10	403	C3
C4	1553:04	403	1407:57	403	0150:53	403	2045:13	403	2131:40	403	C4
D1	1554:28	403	1408:27	414	0151:23	426	2045:43	414	2132:10	414	D1
D2	1559:24	426	1408:57	426	0151:53	426	2046:13	426	2132:40	426	D2
D3	1600:47	403	1409:27	403	0152:23	414	2046:43	414	2133:10	414	D3
D4	1602:08	392	1409:57	381	0152:53	381	2047:13	381	2133:40	381	D4
E1	1603:20	403	1410:27	403	0153:23	403	2047:43	403	2134:10	403	E1
E2	1604:41	426	1410:57	426	0153:53	426	2048:13	426	2134:40	426	E2
E3	1606:00	414	1411:27	414	0154:23	414	2048:43	414	2135:10	414	E3
E4	1607:38	414	1411:57	414	0154:53	414	2049:13	414	2135:40	414	E4
F1	1608:57	403	1412:27	403	0155:23	403	2049:43	403	2136:10	403	F1
F2	1610:23	414	1412:57	414	0155:53	414	2050:13	414	2136:40	414	F2
F3	1611:41	414	1413:27	426	0156:23	426	2050:43	426	2137:10	403	F3
F4	1613:05	426	1413:57	426	0156:53	426	2051:13	426	2137:40	426	F4

Short-Period Array Sinusoidal Calibration Siganl Start Times and Amplitudes

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS (CONCLUDED)

SUBARRAY	Short-Period Array Sinusoidal Calibration Signal Start Times and Amplitudes						SUBARRAY
	Day 229 17 August 71		Day 235 23 August 71		Day 242 30 August 71		
	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	
AO	1703:16	426	1603:57	414	1927:13	414	AO
B1	1703:46	403	1604:27	403	1927:43	403	B1
B2	1704:16	448	1604:57	459	1928:13	437	B2
B3	1704:46	381	1605:27	403	1928:43	403	B3
B4	1705:16	426	1605:57	414	1929:13	414	B4
C1	1705:46	414	1606:27	403	1929:43	403	C1
C2	1706:16	403	1606:57	392	1930:13	392	C2
C3	1706:46	414	1607:27	403	1930:43	403	C3
C4	1707:16	414	1607:57	403	1931:13	403	C4
D1	1707:46	414	1608:27	414	1931:43	414	D1
D2	1708:16	437	1608:57	426	1932:13	426	D2
D3	1708:46	370	1609:27	414	1932:43	414	D3
D4	1709:16	381	1609:57	381	1933:13	381	D4
E1	1709:46	414	1610:27	403	1933:43	392	E1
E2	1710:16	426	1610:57	426	1934:13	426	E2
E3	1710:46	426	1611:27	414	1934:43	414	E3
E4	1711:16	414	1611:57	414	1935:13	403	E4
F1	1711:46	403	1612:27	403	1935:43	403	F1
F2	1712:16	414	1612:57	414	1936:13	414	F2
F3	1712:46	414	1613:27	403	1936:43	403	F3
F4	1713:16	437	1613:57	426	1937:13	426	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 158: 7 June 71			Day 165: 14 June 71			Day 172: 21 June 71			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
AO	1623:15	1626:15	20.5	1605:27	1608:27	20.5	1636:13	1639:13	20.5	AO
C1	"	"	20.0	"	"	20.5	"	"	20.5	C1
C2	1631:15	1634:15	272	1613:27	1616:27	265	1644:13	1647:13	265	C2
C3	"	"	20.5	"	"	20.5	"	"	20.5	C3
C4	1639:15	1642:15	21.1	1621:27	1624:28	21.1	1652:13	1655:13	21.1	C4
D1	"	"	21.1	"	"	20.5	"	"	20.5	D1
D2	1647:15	1650:15	21.6	1629:28	1632:28	21.6	1700:13	1703:13	21.1	D2
D3	"	"	21.1	"	"	20.5	"	"	21.1	D3
D4	1655:15	1658:15	21.1	1637:28	1640:28	21.1	1708:13	1711:13	21.1	D4
E1	"	"	20.0	"	"	20.5	"	"	20.5	E1
E2	1703:15	1706:15	20.5	1645:28	1648:28	20.5	1716:13	1719:13	20.0	E2
E3	"	"	21.1	"	"	20.0	"	"	20.5	E3
E4	1711:15	1714:15	20.0	1653:28	1656:28	20.0	1724:14	1727:14	20.5	E4
F1	"	"	20.5	"	"	20.5	"	"	20.5	F1
F2	1719:16	1722:16	21.1	1701:28	1704:28	21.1	1732:14	1735:14	21.1	F2
F3	"	"	20.0	"	"	19.4	"	"	20.0	F3
F4	1727:16	1730:16	20.0	1709:28	1712:28	20.0	1740:14	1743:14	20.0	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 179: 28 June 71			Day 187: 6 July 71			Day 193: 12 July 71			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
AO	1540:05	1543:05	20.4	1536:47	1539:47	20.5	1455:10	1458:10	20.5	AO
C1	"	"	20.1	"	"	20.0	"	"	20.5	C1
C2	1548:05	1551:05	272	1544:47	1547:47	272	1503:10	1506:10	272	C2
C3	"	"	20.3	"	"	20.5	"	"	20.5	C3
C4	1556:06	1559:06	20.4	1552:47	1555:47	21.1	1511:10	1514:10	21.1	C4
D1	"	"	20.7	"	"	20.5	"	"	20.5	D1
D2	1604:06	1607:06	21.1	1600:47	1603:47	21.6	1519:10	1522:10	21.6	D2
D3	"	"	20.9	"	"	21.1	"	"	21.1	D3
D4	1612:06	1615:06	20.9	1608:47	1611:47	21.1	1527:10	1530:10	21.1	D4
E1	"	"	20.2	"	"	20.0	"	"	20.5	E1
E2	1620:06	1623:06	20.1	1616:47	1619:47	20.5	2032:09	2034:29	20.5	E2
E3	"	"	20.9	"	"	20.0	"	"	20.5	E3
E4	1628:06	1631:06	19.7	1624:47	1627:47	20.0	1538:15	1541:47	20.0	E4
F1	"	"	20.3	"	"	20.5	2048:30	2050:36	20.5	F1
F2	1636:06	1639:06	21.1	1649:48	1651:30	20.5	1538:15	1541:47	21.1	F2
F3	"	"	20.0	"	"	20.0	1548:05	1551:31	20.0	F3
F4	1644:06	1647:06	20.2	1659:17	1701:00	20.0	"	"	20.0	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 200: 19 July 71			Day 208: 27 July 71			Day 214: 2 August 71			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
AO	1513:18	1516:18	20.7	1331:52	1334:52	20.5	1847:00	1850:00	20.5	AO
C1	"	"	20.5	"	"	20.5	"	"	21.5	C1
C2	1521:18	1524:18	263	1339:52	1342:52	272	1855:00	1858:00	274	C2
C3	"	"	20.4	"	"	20.5	"	"	20.4	C3
C4	1529:18	1532:18	20.4	1347:52	1350:52	20.5	1903:00	1906:00	21.0	C4
D1	"	"	20.5	"	"	20.5	"	"	20.4	D1
D2	1537:18	1540:18	21.1	1355:52	1358:52	21.6	1911:00	1914:00	21.1	D2
D3	"	"	21.3	"	"	21.1	"	"	21.2	D3
D4	1545:18	1548:18	21.0	1403:52	1406:52	21.1	1919:01	1922:01	21.1	D4
E1	"	"	20.3	"	"	20.5	"	"	20.3	E1
E2	1553:19	1556:19	20.5	1411:53	1414:53	20.0	1927:01	1930:01	20.3	E2
E3	"	"	20.6	"	"	20.5	"	"	20.7	E3
E4	1601:19	1604:19	20.6	1419:53	1422:53	20.5	1935:01	1938:01	20.3	E4
F1	"	"	20.5	"	"	20.5	"	"	20.4	F1
F2	1609:19	1612:19	21.1	1427:53	1430:53	21.1	1943:01	1946:01	21.1	F2
F3	"	"	20.0	"	"	20.0	"	"	19.8	F3
F4	1617:19	1620:19	19.7	1435:53	1438:53	20.0	1951:01	1954:01	19.5	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude						SUBARRAY
	Day 221: 9 August 71			Day 228: 16 August 71			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
AO	1646:14	1649:14	20.0	-	-	-	AO
C1	"	"	21.6	1848:30	1851:31	20.5	C1
C2	1654:14	1657:14	265	1856:31	1859:31	265	C2
C3	"	"	20.5	"	"	20.5	C3
C4	1702:14	1705:14	21.1	1904:31	1907:31	21.1	C4
D1	"	"	20.5	"	"	20.5	D1
D2	1710:14	1713:14	21.6	1912:31	1915:31	21.6	D2
D3	"	"	20.5	"	"	20.0	D3
D4	1718:14	1721:14	21.1	1920:31	1923:31	21.1	D4
E1	"	"	20.0	"	"	20.5	E1
E2	1726:14	1729:14	20.0	1928:31	1931:31	20.0	E2
E3	"	"	20.5	"	"	20.0	E3
E4	1734:15	1737:15	20.5	1936:31	1939:31	20.0	E4
F1	"	"	20.5	"	"	20.5	F1
F2	1742:15	1745:15	21.1	1944:31	1947:32	21.1	F2
F3	"	"	19.4	"	"	20.0	F3
F4	1750:15	1753:15	20.0	1952:32	1955:32	19.4	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONCLUDED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude						SUBARRAY
	Day 235: 23 August 71			Day 242: 30 August 71			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
AO	1649:39	1652:39	20.5	1646:18	1649:18	20.6	AO
C1	"	"	20.5	"	"	21.8	C1
C2	1657:39	1700:39	258	1654:18	1657:18	263	C2
C3	"	"	20.5	"	"	20.4	C3
C4	1705:39	1708:39	20.5	1702:18	1705:18	20.9	C4
D1	"	"	20.5	"	"	20.4	D1
D2	1713:39	1716:39	21.6	1710:18	1713:18	20.0	D2
D3	"	"	20.5	"	"	21.2	D3
D4	1721:39	1724:40	21.1	1718:18	1721:18	21.1	D4
E1	"	"	20.5	"	"	20.3	E1
E2	1802:59	1804:57	20.5	1726:18	1729:19	20.1	E2
E3	"	"	20.5	"	"	20.5	E3
E4	1731:59	1733:20	20.0	1734:19	1737:19	20.1	E4
F1	"	"	20.5	"	"	20.4	F1
F2	1740:38	1743:28	21.1	1742:19	1[illegible]45:19	21.0	F2
F3	"	"	20.5	"	"	20.0	F3
F4	1749:36	1752:37	20.0	1750:19	1753:19	20.0	F4

SECTION IV

ARRAY PERFORMANCE

4.1 Systems

Integral parts of the LASA system philosophy are the remote-controlled troubleshooting, routine calibrations and performance tests made on the array equipment from the LDC. Analysis of the data collected from this effort, together with the test data collected on site, provide information not only to assist the array maintenance teams in the repair of equipment malfunctions but to determine how well the actual equipment performance conforms to the intended operation.

4.1.1 Short-Period Seismograph

The performance monitoring of the 347 short-period sensors during this three-month period has indicated an average channel sensitivity of 19.9 mV/nm at 1 s with a standard deviation of 1.50. This compares with 20.3 mV/nm and 1.80 for the two parameters over the nine months of the contract to date. A summary of the test results obtained each week is shown in Table XI. The mean and standard deviation of the channel calibration output and the sensitivities as determined from the 1.0 hertz sinusoidal equivalent earth motion input are shown, together with the minimum and maximum channel sensitivities of the indicated total number of sensors, for each week. When a channel output is very low during a calibration test, it is not used in the calculation of the mean; hence the total number of sensors is less than 347. Averages for the quarter are indicated and compared with those of the previous quarter.

Measurement of the SP channel frequency response by subarray continued with the collection of response data for 63 sensors at seven subarrays this quarter. Shown in Figure 4.1 are the plots of the mean, the minimum, and the maximum of 278 sensors from 17 subarrays measured over the period March 1970 through August 1971. In addition to displaying the frequency response of each seismograph channel, plots of the individual channel responses and used with the 1.0 hertz sinusoidal responses and seismometer natural frequency measurements to determine channel malfunctions.

4.1.2 SP Seismograph Sensitivity Tolerance

The present LASA SP seismograph sensitivity tolerance (refer to Table I) is from 16.2 to 27.8 mV/nm at a period of 1 s. This tolerance established by Lincoln Laboratory has been in effect since the initial operation of the array. Specifically the tolerance is for the amplitude response to sinusoidal calibration which is measured remotely at the data center and used to determine the mid-range sensitivity of the seismograph. The nominal value

TABLE XI

SP ARRAY PERFORMANCE TESTING SENSITIVITY STATISTICS

DATE	NO. SENSORS	SENS. MEAN mV/nm	SENS. σ mV/nm	SENS. MAX. mV/nm	SENS. MIN. mV/nm	SENS. DEV. mV/nm
6/7	345	20.71	1.377	24.8	16.3	8.5
6/14	345	20.19	1.496	24.0	13.4	10.6
6/21	347	19.94	1.558	26.2	12.7	13.5
6/28	345	20.42	1.401	24.8	16.3	8.5
7/6	345	19.76	1.493	24.8	12.0	12.8
7/13	344	20.14	1.489	24.8	15.6	9.2
7/19	344	20.12	1.432	24.8	15.6	9.2
7/27	344	19.56	1.616	25.5	8.5	17.0
8/2	339	19.31	1.559	24.0	14.9	9.1
8/9	342	18.91	1.609	24.0	13.4	10.6
8/17	344	19.54	1.506	24.8	14.9	9.9
8/23	343	19.66	1.496	25.5	15.6	9.9
8/30	341	19.99	1.438	25.5	14.2	11.3
AVERAGE	343.6	19.86	1.498	24.9	14.1	10.8
PREV. AVERAGE	345.2	20.71	1.823	26.9	9.9	17.0
CONTRACT AVERAGE	344.5	20.32	1.804	27.3	11.6	15.6

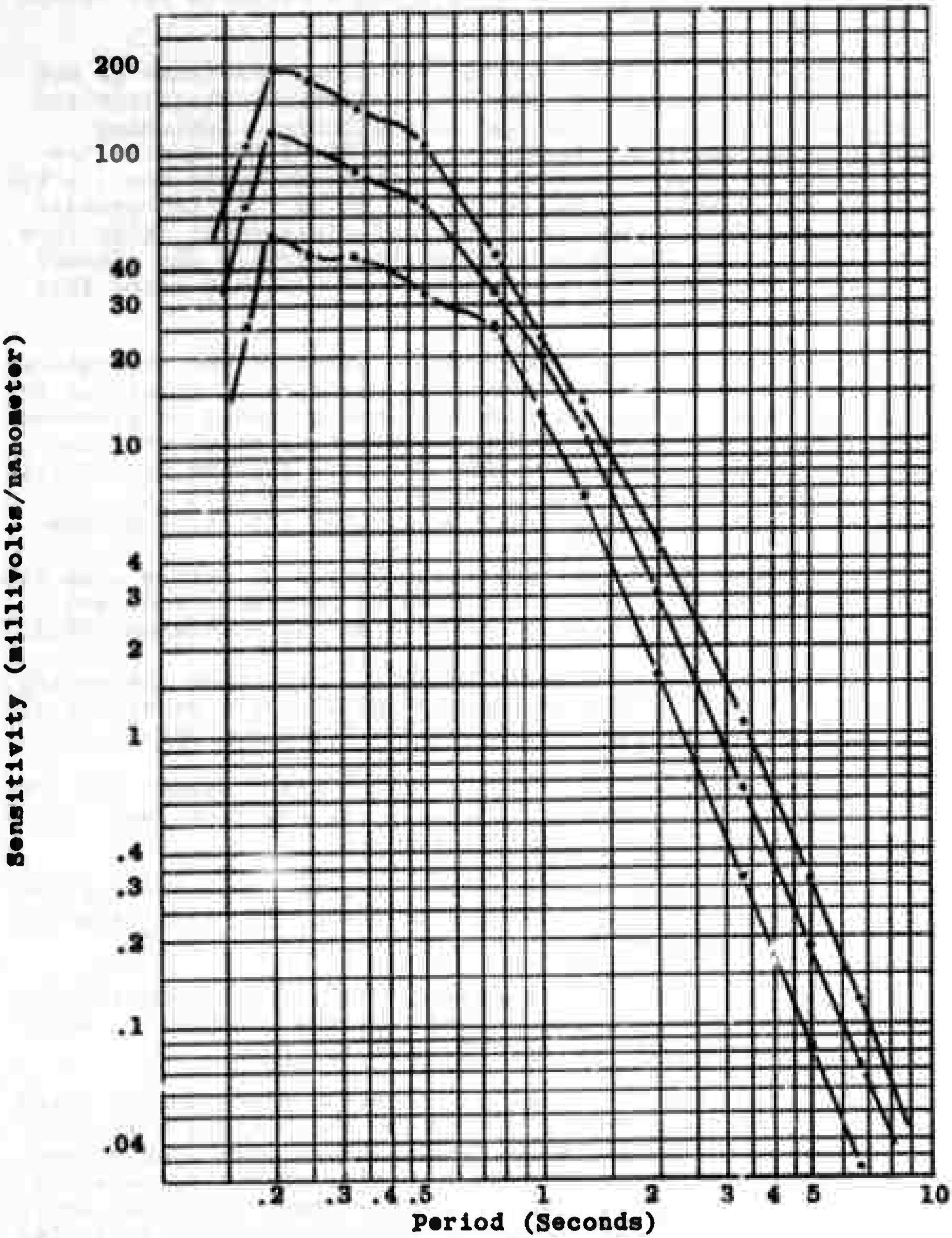


Figure 4.1 Short-Period Sensor Period vs Sensitivity Response

established for SP seismograph sensitivity is 20 mV/nm at 1.0 s. To verify this value the channel output amplitude at 1.0 s should be 7.92 Vp-p with a 400 nm p-p signal input (see reference 2). The present allowable range of variation in output amplitude among the SP seismographs is 6.4 to 11.0 Vp-p which reflects the sensitivity tolerance shown above.

Improvement in the amplitude response tolerance is now possible due to the success of the RA-5 amplifier rehabilitation work being performed at the LMC and in the array. Beginning 6 September a new amplitude tolerance of ±15% of the nominal response is being adopted. This will permit a mid-scale sensitivity tolerance at one second periods of 20 ± 3 mV/nm. An improvement of about 40% is made in the allowable full-scale value range from 51.5% to 31.2% of the 700 nm nominal value (assuming the channel is linear) specified for the Montana LASA SP channels using this new tolerance.

Prior to adopting this change a study of the statistics obtained from the weekly SP calibrations was made to determine the amount of improvement obtained from the improved RA-5 maintenance practices. Plotted in Figure 4.2 are statistics which show the percentage of SP array sensors within the 20 ± 3 mV/nm sensitivity tolerance throughout the 17 month period 30 March 1970 and 23 August 1971. The statistics may be divided into five groups:

1. Summer 1970 (May-August). Period of stable high temperatures. Subarray maintenance program in progress; four subarrays completed. Mean number of sensors within tolerance, 88.3.

2. Fall 1970 (September-October). Variable decreasing temperatures. Subarray maintenance continued; three subarrays completed. Mean percentage of sensors within tolerance, 85.3.

3. Winter 1970-71 (November-February). Stable low temperatures. Subarray maintenance performed at two subarrays. Mean percentage of sensors within tolerance, 88.4.

4. Spring 1971 (March-April). Variable increasing temperatures. Subarray maintenance started again; two subarrays complete. Mean percentage of sensors within tolerance, 86.5.

5. Summer 1971 (May-August). Stable high temperatures. Subarray maintenance in progress; nine subarrays complete. Mean percentage of sensors within tolerance, 94.7.

Using these statistics the poorest performance is noted in the fall and spring during periods when the Montana weather is undergoing more pronounced temperature changes. Improved sensor stability performance appears to occur during stable temperature periods. Realizing the full impact of this phase of the SP array sensor maintenance program has not become completely evident, improvement can be seen between the two summer periods of 1970 and 1971. As the program is continued these statistics will provide a basis of reference.

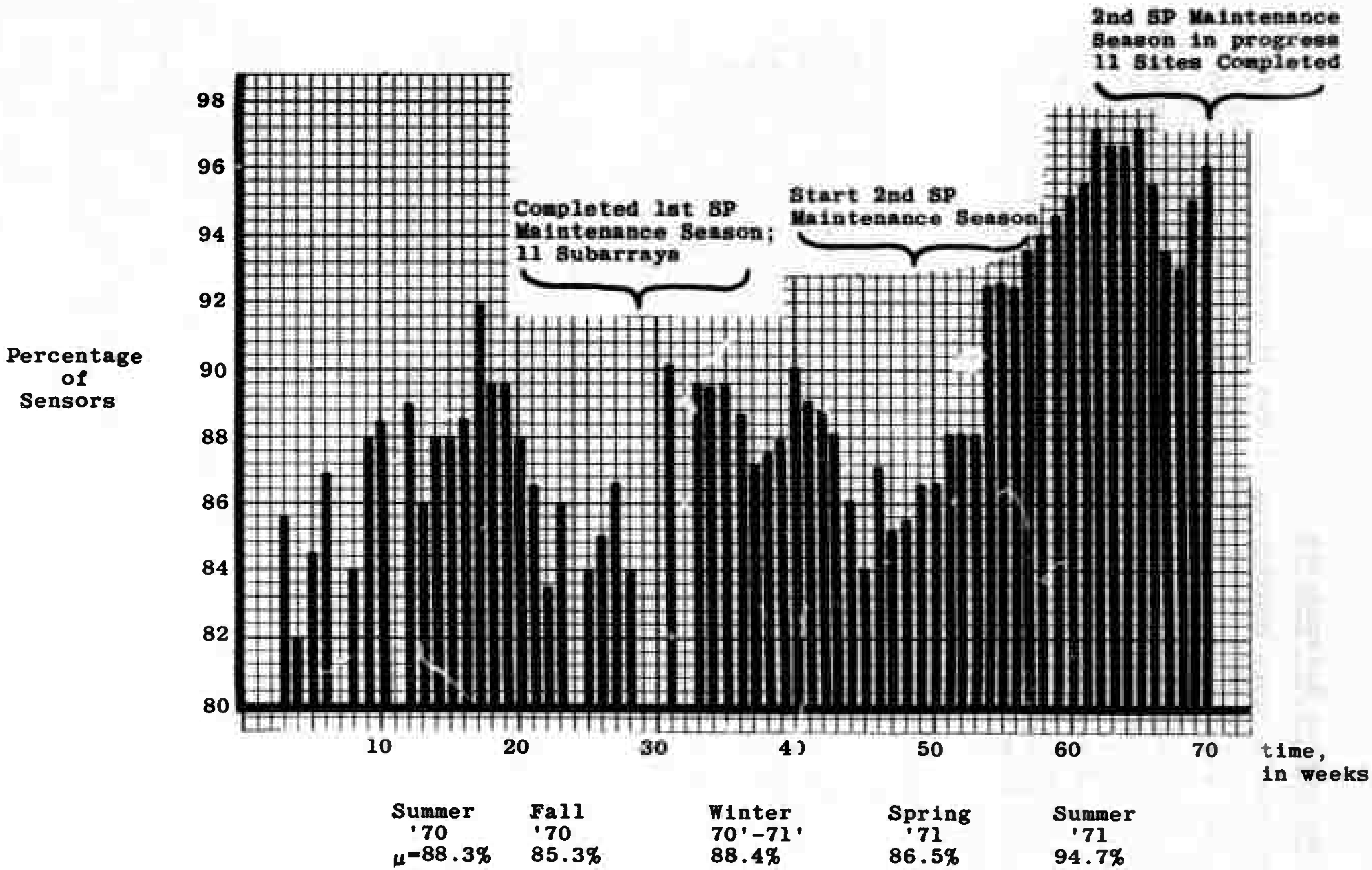


Figure 4.2 Percentage Distribution of SP Sensors in ± 15% Sensitivity Tolerance

4.1.3 Long-Period Seismograph

The performance monitoring of the 45 standard LASA long-period sensors during this three-month period had indicated an average channel sensitivity of 365 mV/μm at 25 s with a standard deviation of 17.3. A summary of the test results obtained each week is shown in Table XII. This table shows the mean and standard deviations of the channel sensitivities calculated from the 25 s, 20 μm p-p sinusoidal equivalent earth motion inputs. The range of the sensitivity deviations over the 45 standard LP seismographs in the array is shown as well as the maximum and minimum values. For comparison the averages for the quarter are shown with average for each parameter from the preceeding period and the total contract period to date.

4.1.4 LP Seismograph Sensitivity Tolerance

The LASA LP seismograph sensitivity tolerance as shown in Table I is from 260 to 430 mV/μm at a period of 25 s. This tolerance has been used in the maintenance of the LP seismograph systems since February 1967 when Philco-Ford completed a series of initial visits to each subarray following the LP seismograph system installation. Channel sensitivity is determined from measurements made at the data center of the amplitude responses of each seismograph to known sinusoidal inputs. The nominal value of the mid-range sensitivity calculated from these measurements is 350 mV/nm at 25 s. Table VII shows the measurement values necessary to verify a seismograph within the sensitivity tolerance.

Improvements in the maintenance performed on the LP seismograph channel components, particularly the Texas Instruments Type II seismic amplifier, have increased the stability performance of the sensitivity measurements to the point where a new tolerance is suggested. Starting with the weekly testing of the coming quarterly period, a new sensitivity tolerance of 350 ± 50 mV/μm at 25 s will be in effect for the LASA LP seismograph channels.

4.2 Equipment

4.2.1 SP Seismometer, HS-10-1/A

The program of natural frequency measurements being made at the LP sensor locations in conjunction with the array preventive maintenance continued throughout the quarter at seven subarrays. The natural frequency data collected is tabulated in Table XIII where the measured value may be compared with the previous frequency measurement made following the seismometer installation. These measurements have been combined with others collected from this program to produce the frequency distribution shown in Figure 4.3.

TABLE XII

LP ARRAY PERFORMANCE TESTING SENSITIVITY STATISTICS

DATE	NO. SENSORS	SENS. MEAN mV/μm	SENS. σ mV/μm	SENS. MAX. mV/μm	SENS. MIN. mV/μm	SENS. DEV. mV/μm
6/7	45	353.0	15.9	390	332	68
6/14	45	342.6	20.1	407	310	97
6/21	45	349.2	16.3	385	321	64
6/28	45	347.5	16.4	388	317	71
7/6	45	347.8	18.2	394	321	73
7/13	45	345.6	19.7	394	309	75
7/19	45	340.2	18.1	390	312	78
7/27	45	339.3	17.2	383	309	74
8/2	45	337.8	18.1	378	293	85
8/9	45	332.8	24.9	392	272	120
8/16	42	331.5	21.2	377	279	98
8/23	45	330.6	18.8	380	283	97
8/30	42	333.0	15.7	368	310	58
AVERAGE	44.5	341.6	18.5	387	304	81
PREV. AVERAGE	44.9	364.3	17.3	408	325	82
CONTRACT AVERAGE	44.8	357.8	19.1	404	312	91

TABLE XIII

SP SEISMOMETER NATURAL FREQUENCY MEASUREMENTS

JUNE - AUGUST 1971

SUBARRAY SENSOR	CURRENT f_n HERTZ	1965 f_n HERTZ	Δf_n HERTZ
AO			
10	0.89	1.45	-0.56
41	0.95	1.03	-0.08
54	1.12	1.23	-0.11
65	1.11	1.04	+0.07
76	1.03	1.03	0.00
B1			
10	1.11	1.50	-0.39
42	1.07	1.40	-0.33
46	0.96	1.40	-0.44
51	1.06	1.07	-0.01
53	1.22	1.22	0.00
66	1.12	1.03	+0.09
82	1.15	0.98	+0.17
86	1.13	0.94	+0.19
B3			
10	1.00	1.28	-0.28
42	1.17	1.09	+0.08
44	0.97	0.94	+0.03
46	0.95	0.93	+0.02
75	1.09	1.03	+0.06

TABLE XIII

SP SEISMOMETER NATURAL FREQUENCY MEASUREMENTS (CONTINUED)

JUNE - AUGUST 1971

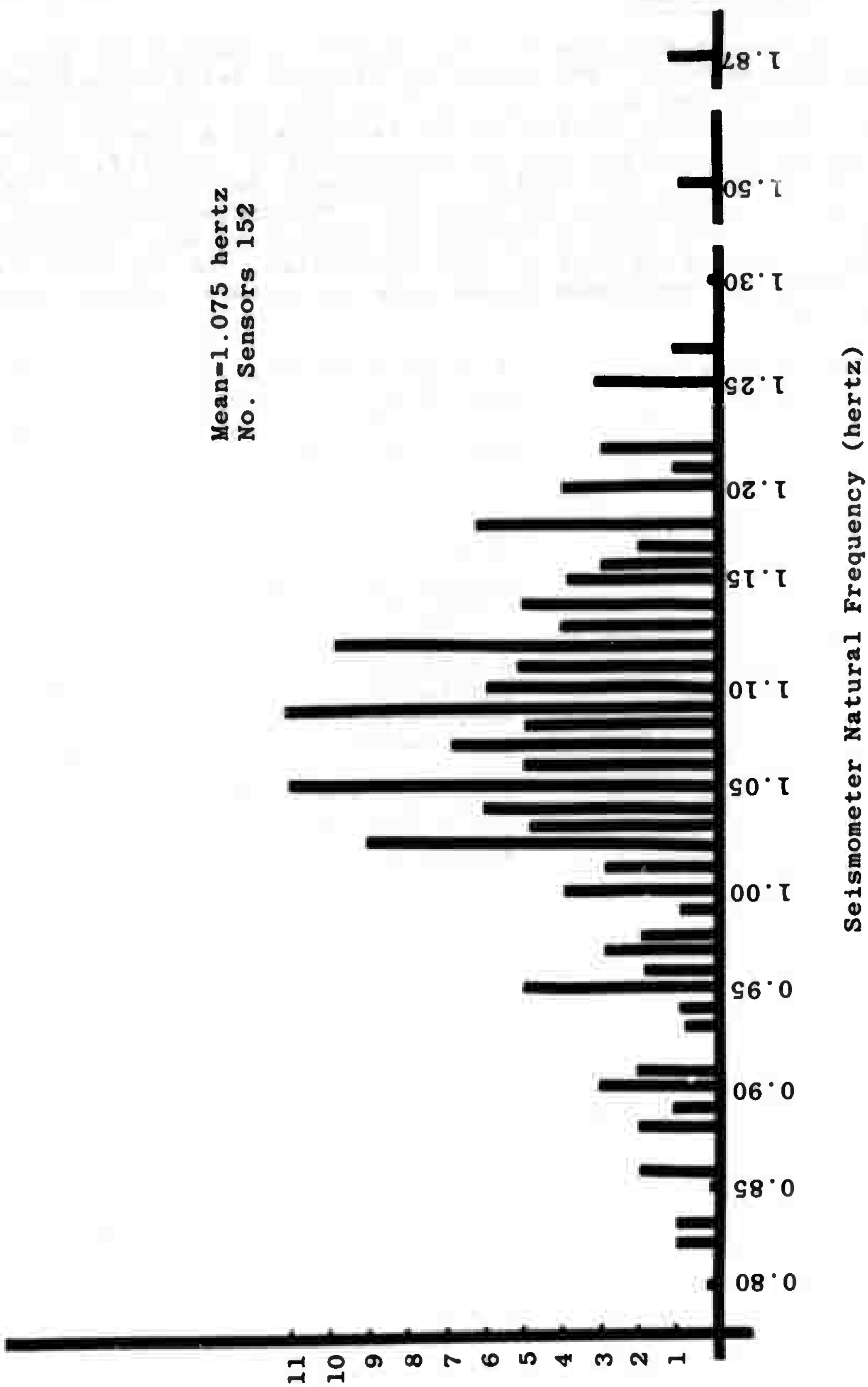
SUBARRAY SENSOR	CURRENT f_n HERTZ	1965 f_n HERTZ	Δf_n HERTZ
C1			
10	1.02	1.23	-0.21
42	1.11	1.04	+0.07
44	1.05	0.97	+0.08
53	1.18	0.98	+0.20
62	1.14	1.07	+0.07
C3			
51	1.08	1.00	+0.08
66	1.20	1.10	+0.10
71	1.01	1.03	-0.02
82	0.95	0.92	+0.03
86	1.10	1.08	+0.02
F1			
43	0.86	0.96	-0.10
45	0.83	0.90	-0.07
54	1.05	1.14	-0.09
74	0.98	1.20	-0.22
76	0.91	1.06	-0.15
85	0.93	1.01	-0.08

TABLE XIII

SP SEISMOMETER NATURAL FREQUENCY MEASUREMENTS (CONCLUDED)

JUNE - AUGUST 1971

SUBARRAY SENSOR	CURRENT f_n HERTZ	1965 f_n HERTZ	Δf_n HERTZ
F2			
10	1.05	1.44	-0.39
43	0.90	0.99	-0.09
45	1.05	1.09	-0.04
54	1.16	1.13	+0.03
56	0.88	0.96	-0.08
74	0.86	0.94	-0.08
83	1.87	1.13	+0.74


Mean=1.075 hertz
No. Sensors 152
Seismometer Natural Frequency (hertz)
0.80
0.85
0.90
0.95
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.50
1.87
1
2
3
4
5
6
7
8
9
10
11

4.3 Failure Report

Equipment failures for this reporting period are discussed in this section. The number of failures detected and corrected in each of the twelve equipment systems is indicated in Table XIV. Eighty-two percent of the failures this quarter were in four of the 12 systems, viz. SP sensor, PDP-7 computer, SEM and LDC test and support. The number of equipment failures corrected in each system is indicated in Table XV. The different systems are divided into the major equipment assemblies to show in greater detail where the system failures are occurring. The failures are further classified according to the type of failure. These classifications are:

(1) System failure - A failure resulting in zero or no system output which prevents the system or equipment assembly from performing its primary function and identified as a Type 1 failure.

(2) Mode failure - A failure resulting in a zero or no system output only during one of several different modes of operation; a Type 2 failure.

(3) Limited failure - A failure resulting in a system output which is outside the allowable tolerance limits but permits degraded performance; a Type 3 failure.

(4) Latent failure - A failure which changes a system output either by an amount less than the allowable tolerance or from the nominal output when no tolerance limits have been established; a Type 4 failure.

(5) Temporary failure - A failure produced by an operating or environmental stress which results in no permanent physical damage; a Type 5 failure.

The WHV panel RA-5 caused 65 failures in the short-period system. Of these 6 failed completely, 8 were out of tolerance, 46 were not nominal and were repaired under the SP rehabilitation program, and 5 were either self-correcting or were replaced due to intermittent operation. The main SEM problems were 39 corrections for channel dc offsets. This task is performed periodically to maintain the array within specified tolerances.

Further discussion of the failures is found in conjunction with the maintenance actions reported in Section VI.

TABLE XIV

LASA SYSTEM FAILURE DETECTIONS AND CORRECTIONS

	SP SENSOR	LP SENSOR	LTV-6 μBaro	[redacted] μBaro	METEOR	SEM	POWER SYSTEM	360 COMPUTER	PDP-7 COMPL 'ER	LDC DIGITAL	LDC ANALOG	LDC TEST & SUPPORT	TOTALS
Starting Backlog	15	2	1	0	0	0	0	0	3	0	2	0	23
Detected	59	2	2	4	1	52	2	5	32	5	16	21	201
Corrected	69	4	3	4	1	52	2	5	31	5	17	17	210
Ending Backlog	5	0	0	0	0	0	0	0	4	0	1	4	14

TABLE XV

EQUIPMENT FAILURES (CONTINUED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
360 System						
CPU 2044	3	0	1	0	0	4
Disc Drive 2315	0	0	0	0	0	0
Typewriter 1052	0	0	1	0	0	1
Card Reader 2501	0	0	0	0	0	0
Data Control 1826	0	0	0	0	0	0
Data Adapter 1827	0	0	0	0	0	0
Data Adapter 2701	0	0	0	0	0	0
Total	3	0	2	0	0	5
PDP-7 System						
Computer	1	0	1	1	2	5
Teletypewriter KSR-35	0	0	2	0	0	2
Card Reader	1	0	1	0	0	2
SOU	1	0	0	0	0	1
Interface	0	0	0	0	0	0
Tape Unit #19	3	0	1	0	1	5
Tape Unit #32	2	0	3	0	1	6
Tape Unit #33	2	0	4	0	0	6
Incremental Recorder	3	0	1	0	0	4
Total	13	0	13	1	4	31
Digital System						
Timing System #1	1	0	2	0	0	3
Timing System #2	0	0	1	0	0	1
Digital Data Simulator	0	0	0	0	0	0
Power System	0	0	0	0	0	0
PLINS	0	1	0	0	0	1
MINS	0	0	0	0	0	0
Total	1	1	3	0	0	5

TABLE XV

EQUIPMENT FAILURES (CONTINUED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
Meteorological System						
Aerovane, Wind Direction	0	0	0	0	0	0
Aerovane, Wind Speed	0	0	0	0	0	0
Pole Assembly	0	0	0	0	0	0
Pole Junction Box/Cabling	0	0	0	0	0	0
Temperature Probe	0	0	0	0	1	1
Electrobarometer/Baffle	0	0	0	0	0	0
Rain Gauge	0	0	0	0	0	0
Rain Gauge Electronics Panel	0	0	0	0	0	0
Total	0	0	0	0	[illegible]	1
Subarray Electronics Modules						
Input Drawer #1	0	0	15	0	0	15
Input Drawer #2	1	0	18	0	0	19
Multiplexer/ADC	1	0	3	0	1	5
Output Drawer	0	0	3	0	1	4
PDC Drawer	0	0	9	0	0	9
ACC Cabinet	0	0	0	0	0	0
SEM Cabinet/Cabling	0	0	0	0	0	0
Alarms	0	0	0	0	0	0
Total	2	0	48	0	2	52
Power System						
Control Drawer	0	0	0	0	0	0
Inverter	1	0	0	0	0	1
Charger	0	0	0	0	0	0
Battery	0	0	0	0	0	0
SOLA Transformer	0	0	0	0	0	0
Rack/Cabling	0	0	0	0	0	0
Isolation Transformer	0	0	0	0	0	0
Breaker Panel	0	0	0	0	0	0
Vault/Wiring/Breakers/Outlets	1	0	0	0	0	1
Total	2	0	0	0	0	2

TABLE XV

EQUIPMENT FAILURES

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
Short-Period System						
Seismometer	0	0	1	0	0	1
WHV Panel W/RA-5	6	0	8	46	5	65
RA-5 Power Supply	0	0	0	0	0	0
WHV Junction Box	0	0	0	0	0	0
WHV/Cables	1	0	0	0	0	1
CTH Junction Box (SP)	0	0	2	0	0	2
Total	7	0	11	46	5	69
Long-Period System						
Vertical Seismometer/Tank	0	0	0	0	0	0
Horizontal Seismometer/Tank	0	0	0	0	0	0
LP Vault/Cabling	0	0	0	0	0	0
LP Junction Assembly	0	0	0	0	2	2
Motor Assembly	0	0	0	0	0	0
Seismic Amplifier, Type 2	0	0	1	0	0	1
Amplifier Power Supply	0	0	1	0	0	1
CTH Junction Box (LP)	0	0	0	0	0	0
Total	0	0	2	0	2	4
LTV-6 Microbarograph						
Microbarograph	1	0	1	0	0	2
Power Supply	0	0	0	0	0	0
Cabinet Cabling	0	0	0	0	0	0
Pipe Array	0	0	1	0	0	1
Total	1	0	2	0	0	3
[redacted] Microbarograph						
Acoustical Can/Cabling	1	0	0	0	0	1
Capsule	0	0	0	0	0	0
Oscillator	0	0	0	0	0	0
Discriminator/Power Supply/Cables	0	0	3	0	0	3
Pipe Array	0	0	0	0	0	0
Total	1	0	3	0	0	4

TABLE XV

EQUIPMENT FAILUR (CONCLUDED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
Analog System						
D/A Patch Panel Cabinet	0	0	0	0	0	0
D/A Converter #1	1	0	2	0	0	3
D/A Converter #2	0	0	0	0	0	0
D/A Converter #3	0	0	0	0	0	0
D/A Converter #4	0	0	1	0	0	1
FM System	0	0	1	0	0	1
16 Channel Chart Recorder	0	0	0	0	0	0
WWV Receiver	1	0	0	1	0	2
Analog Calibration System	0	0	0	0	0	0
Analog Timing System	0	0	2	0	0	2
SP Develocorder	2	1	0	2	1	6
LP Develocorder	0	0	1	1	0	2
Total	4	1	7	4	1	17
LDC Test and Support System						
MDC-1	0	0	9	0	0	9
MDC-2	0	0	8	0	0	8
Clocks	0	0	0	0	0	0
Film Viewer	0	0	0	0	0	0
Film Duplicator	0	0	0	0	0	0
Copier	0	0	0	0	0	0
Emergency Lights	0	0	0	0	0	0
Compressor, Blower	0	0	0	0	0	0
Digital Clocks	0	0	0	0	0	0
Air Conditioners	0	0	0	0	0	0
Humidifier	0	0	0	0	0	0
Tape Cleaner	0	0	0	0	0	0
Electrostatic Filters	0	0	0	0	0	0
Total	0	0	17	0	0	17

SECTION V

IMPROVEMENTS AND MODIFICATIONS

5.1 PDP-7 Programming

PDP-7 programming efforts this quarter included the preparation of new or improved programs for the family of automatic array maintenance and monitoring programs. These patch-type programs are used on-line with the PDP-7 Multiple On-line Processing System (MOPS) and overlay a portion of the computer memory not used for the basic system functions (see reference 3). The program development is briefly described in this section; complete description of all programs prepared under VT 1708 are planned for the contract final report.

5.1.1 TELP

Program TELP used to provide a computer measurement of the long-period seismograph response to sinusoidal calibration (see reference 4) has been further developed to calculate seismograph channel parameters from the measurement data. The parameters calculated by the program include: the sensitivity of each channel, the gain of each Type II and SEM amplifier, the sensitivity mean and standard deviation of the LP array, and the equivalent earth motion of each subarray's calibration signal.

5.1.2 TESP

Program TESP which permits PDP-7 computer assistance in performing short-period seismograph sinusoidal calibrations (see reference 4) now provides additional information for measuring array performance. In addition to the average positive half-cycle to the negative half-cycle of the response waveform is determined to detect signal distortions. Included in the TESP printouts are: (1) the calculated channel sensitivity at 1.0 second periods, (2) the number of data samples received during the 25 cycles of the measured sinusoid, (3) the mean and standard deviation of the sensor channel sensitivities between the limits of 13 and 27 mV/nm, and (4) the most recent array hourly weather report.

5.1.3 DCOFF

The DCOFF program provides a precision measurement of voltage and polarity of the DC offset on each of the instrumentation channels in the LASA SP data acquisition equipment. The program provides PDP-7 computer control of telemetry for input of zero volts into the SEM SP input and multiplexer assemblies, commands 5 and 3 respectively. Site selection of a particular subarray, or any group of subarrays is made by the operator at the teleprinter. This overlay program is loaded by paper tape during PDP-7 operation under MOPS system program control and executed from the teletypewriter.

5.1.4 FREECK

Program FREECK provides a measurement of the free-period of the long-period seismometers. Under PDP-7 control, telemetry command TC-19 is sent sequentially in groups of two to all seventeen subarrays with LP seismographs. For each instrument the computer determines the free-period from the elapsed time between zero crossings of five cycles of response to the telemetry control of the seismometer. Output is available in two forms; averages of the five cycles are printed to the nearest tenth of a second and a display from the serial output unit to a chart recorder is produced by selection of appropriate digital-to-analog word select switches. The precise calibration times are also available from this overlay type program which is run in conjunction with the MOPS system program.

5.1.5 MASPOS

Program MASPOS provides automatic control by the PDP-7 computer of the telemetry used for measurement and control of the long-period seismometers' mass position. The mass positions of each of the 51 seismometers are measured to the nearest 0.03 mm. If desired adjustment of the seismometers mass positions by computer controlled telemetry is initiated by the computer operator typing "CORRECTMP." following the 51 measurements. Seismometer mass positions are maintained to within ±2 mm of center. This program, another of the overlay type used with the operating system program, requires only 1.5 minutes to complete the 51 measurements. Time for repositioning the seismometers mass positions to approximately 0.5 mm from center varies with the number of sensors requiring correction and the amount of correction required by particular sensors; time periods ranging up to 15 minutes have been required.

SECTION VI

MAINTENANCE

6.1 General

Maintenance activity on the twelve LASA systems includes correction of failures, preventive maintenance, modifications, and special tests required for evaluations or quality control activities. The number and location of system failures corrected are indicated in Section IV.

Table XVI summarizes the number of all equipment (LASA) and facility (utility) work orders for this quarter. The 534 completed work orders represented 625 separate maintenance actions by technical personnel. During this quarter 88% of the scheduled preventive maintenance routines were completed.

6.2 Data Center

Three failures occurred in the CPU 2044 resulting in 360 system downtime. The SCR diodes failed in the temperature controller for one of the memory core stacks which prevented the system from powering up. Another, a failure of a 6 volt power supply resulted from a factory defective component; a mechanical open in one of two high wattage resistors used in providing a current path through parallel transistor regulators. Overheating in the one resistor carrying the full load current caused the failure. Finally, a power outage caused by an electrical storm kicked off a circuit breaker that had to be reset before re-cycling the system.

Program malfunctions resulted in an increased amount of PDP-7 computer corrective maintenance. Maintenance performed included retiming of the main and extended arithmetic element timing chains, retuning of the memory, relocation of several sense amplifier logic cards, replacement of the logic card used to generate the "slow cycle" timing required for all multiply and divide operations, and replacement of the memory buffer logic cards for bits 0-5. Several problems occurred with the incremental recorder. One was based on an improper hardware connection of the input-output transfer (I/OT) instructions to coincide with the program instructions used with the MOPS program. To improve a high parity error rate, three logic cards were replaced and the recording head alignment corrected by shimming the head mount.

The 8-channel chart recorders in MDC-1 and 2 required bias battery replacement on 17 occasions. These units are on 24 hours a day and this consumption is expected.

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TABLE XVI

WORK ORDER SUMMARY

WORK ORDER TYPE	BACK LOG START OF QTR	INITIATED	COMPLETED	BACK LOG END OF QTR
System - A	55	307	312	50
Subassembly - B	17	45	32	30
Component - C	3	14	7	10
Total	75	366	351	90
Utility:				
Cable trench & trail inspection	9	2	11	0
Cable trench backfill	1	8	4	5
WHV sites landscaped	0	87	87	0
Marker posts &/or WHV covers replaced	0	14	11	3
CTH maintenance	0	22	21	1
Vehicle maintenance and inspection	3	15	14	4
Fence inspections	14	28	30	12
Trail repairs	1	8	5	4
Total	28	184	183	29
WORK ORDER TOTALS	103	550	534	119

The PDP-7 tape units continue to require attention to the vacuum systems. This is attributed to their age and high useage rates. Trouble has been experienced with rubber pressure hoses cracking with resulting leaks. A different type reinforced hose is now being used to correct the problem.

6.3 Maintenance Center

Weather and road conditions were good during this quarter and did not interfere with the work schedule. There were 128 field trips covering 20,803 miles and three trips to the PMEL at Great Falls to pick-up and deliver test equipment for repair and calibration.

Phase 1, the WHV amplifier rehabilitation, of the SP array sensor maintenance program was completed at subarrays AO, B1, B3, C1, C3, F1, F2, and F3. Subarrays B3, C2, D1, and D2 are scheduled for the next quarter after which all subarrays will have been rehabilitated at least once.

The cables on leg 6 of subarray E1 were cut by a county road crew. A new section of cable was spliced in and retrenched. The cable to the [redacted] microbarograph at subarray C2 was damaged by a rodent and had to be spliced.

Modification P-81, relocation of the [redacted] microbarograph discriminator/power supply (see reference 3) is complete at all applicable subarrays.

The DCOFF program, see paragraph 5.1.3, was used to check dc offset on all channels in the array. All out-of-tolerance channels were adjusted or repaired. This will become a periodic check under the quality control program.

6.4 Facilities Support

A total of 47 landowners were contacted regarding LASA operations and site agreements.

Oil exploration drilling occurred at one location five miles from WHV 72 of subarray E4. This well has been plugged and abandoned.

The cable trenches at all subarrays have been inspected and necessary repair work scheduled.

SECTION VII

ASSISTANCE PROVIDED TO OTHER AGENCIES

7.1 Seismic Data Laboratory

Develocorder film recording of the data from a selected number of SP sensors for the Seismic Data Laboratory (SDL) began this quarter. Weekly shipments totaling 70 films were sent to SDL together with the operating logs and calibration data. Each film covers a period approximately twenty-four hours; film change is made at about 2200 GMT. The format of the film recordings are as follows:

Develocorder Channel	Signal Input
1	Vela time code
2	Site F4 sensor 10
3	Site F1 sensor 10
4	Site F3 sensor 10
5	Site F2 sensor 10
6	Site AO sensor 10
7	Site E3 sensor 10
8	Site E3 sensor 82
9	Site E3 sensor 84
10	Site E3 sensor 86
11	WWV time code

The block diagram of the system employed is shown in Figure 7.1. The data center analog system converts the digital signals from the array to analog for recording on the develocorder. Calibration of the complete seismograph channel from the seismometer through to the develocorder is performed using the PDP-7 computer program DEVCAL (see reference 3) once for each film usually at the start of the film.

Assistance to SDL is also provided by the recording and shipment of microbarograph array and related digital data recorded by the PDP-7 computer's incremental recorder. This recording system and the record format are described in detail in reference 5.

7.2 [redacted] Weather Bureau

Hourly weather information obtained from sampling the outputs of the array's twenty-six temperature, wind direction and speed, barometric pressure and rainfall sensors are transmitted via TWX from the data center's PDP-7 computer to the Billings weather bureau office. The details of the weather sensors and instrumentation (Ref. 6) and the TWX format (Ref. 7) have previously been reported.

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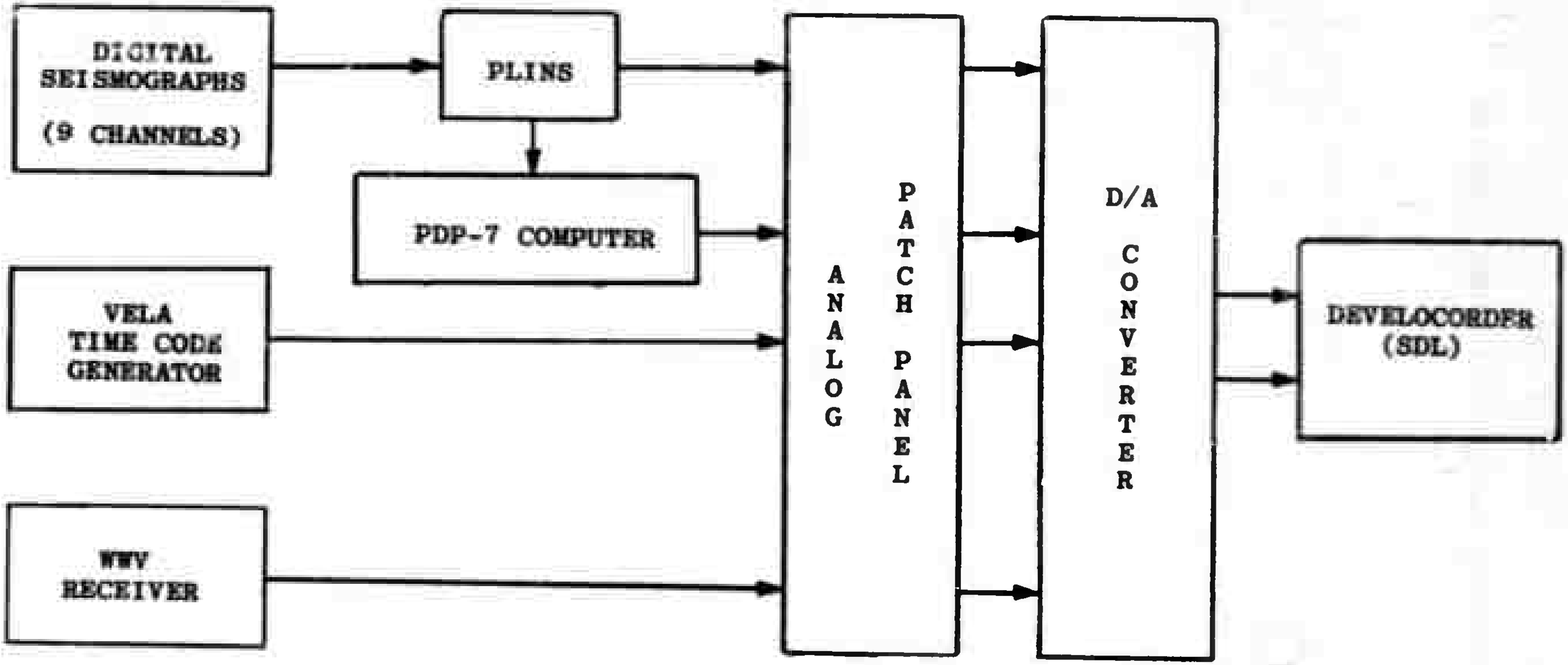

Figure 7.1 LDC Film Recording System for SDL Support

7.3 MIT Lincoln Laboratory

Changes were made to the channel assignments of the ten channel FM link between the data center and MIT. The new channel assignments are:

FM Channel	Signal Input
1	Subarray F1 short-period analog sum, word 29
2	Subarray F2 short-period analog sum, word 29
3	Subarray F3 short-period analog sum, word 29
4	Subarray F4 short-period analog sum, word 29
5	Subarray F1 long-period vertical, word 26
6	Subarray E1 short-period analog sum, word 29
7	Subarray E2 short-period analog sum, word 29
8	Subarray E3 short-period analog sum, word 29
9	Subarray E4 short-period analog sum, word 29
10	(Subcarrier oscillator removed for repair)

The system provides continuous on-line data transmission to MIT for array analysis.

7.4 Visitors

Visitors to the Montana LASA during this quarter were:

(a) Capt. John H. Fergus, Montana LASA Project Officer from Vela Seismological Center made inspection tours of the LDC and array 20-24 August.

(b) Raymond Cherry, Purchasing Specialist, Philco-Ford C&TS Division, June 25-30.

(c) Jerome Richter, EG&G, Goleta, Calif., June 15.

(d) Keith Westhusing, NASA MSC, Houston, Texas, June 23.

SECTION VIII

DOCUMENTATION PROVIDED UNDER VT 1708

8.1 Technical Reports

The following reports were distributed as required by Project VT 1708:

a. "Operation and Maintenance of LASA, Monthly Progress Report", Report No. 2039-71-08, June 1971.

b. "Operation and Maintenance of LASA, Monthly Progress Report", Report No. 2039-71-09, July 1971.

8.2 Letters

The following letters were submitted to the Project Officer:

a. "Modification of Develocorder Usage", 21 June 1971.

b. "DCAS" Safety Survey", 19 July 1971.

c. "Estimate of Cost - LASA Subarray Removal", 27 July 1971.

d. "SP Sensor Maintenance Visits", 27 July 1971.

e. "LASA Low Rate Data Communications", 6 August 1971.

8.3 Operations Data

Thirteen weekly issues of the Defective Signal Channel Status and Data Interruption Log Reports were distributed to the approved using agencies. New issues of the array modification status (MS-51) were distributed.

8.4 Alternate Management Summary Reports

Three Alternate Management Summary Reports (AMSR) were distributed; one for each of the months June, July and August.

REFERENCES

1. Philco-Ford Corporation, Montana LASA Second Quarterly Technical Report, AD846155, Nov. 1968, Appendix A.

2. Philco-Ford Corporation, Montana LASA Final Report, AD874665, July 1970, page 19.

3. Philco-Ford Corporation, Montana LASA Second Quarterly Technical Report, Project VT 1708, AD885649, 15 June 1971, Section V.

4. Philco-Ford Corporation, Montana LASA First Quarterly Technical Report, Project VT 1708, AD882818, 12 March 1971, Section V.

5. Philco-Ford Corporation, Montana LASA First Quarterly Technical Report, AD876826, Sept. 1970, Section II.

6. Philco-Ford Corporation, Montana LASA Third Quarterly Technical Report, AD850373, Feb. 1969, Section II.

7. Philco-Ford Corporation, Montana LASA Final Report, AD874665, July 1970, Appendix E.