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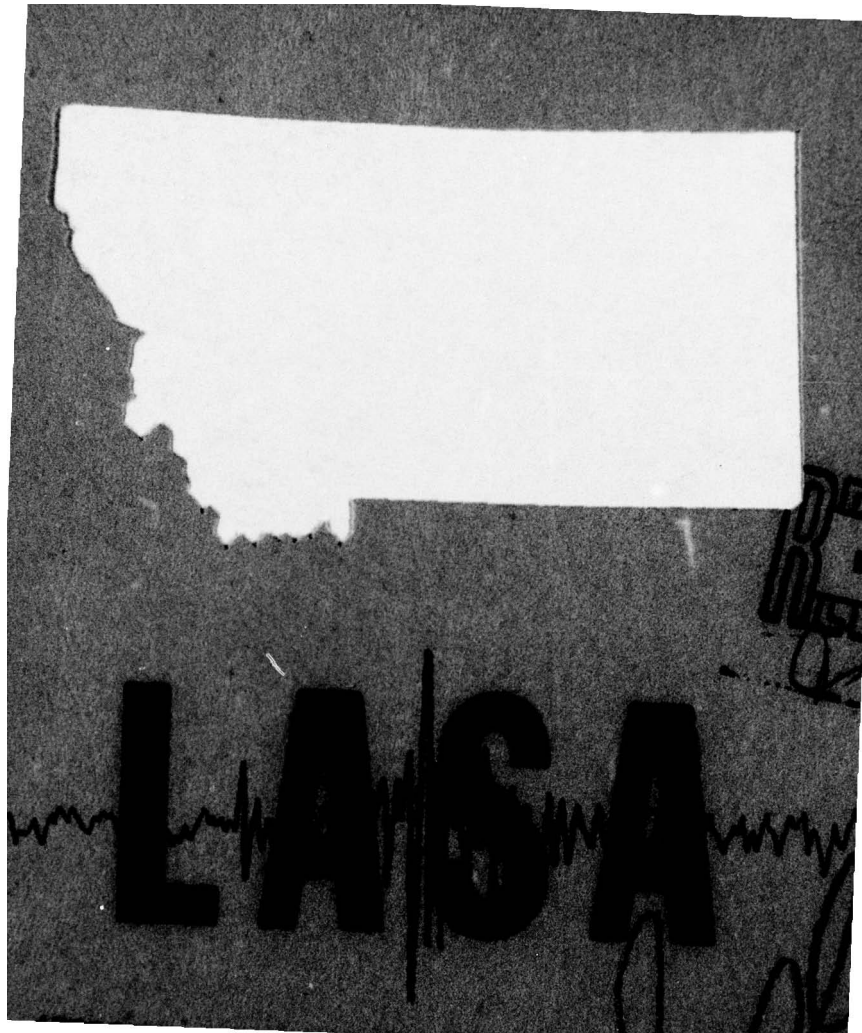
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Technical Report 2145-79-118

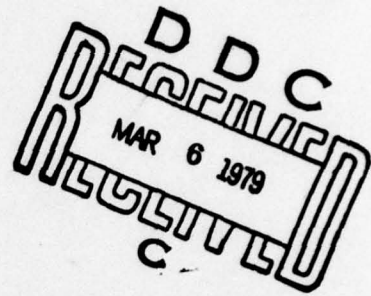
MONTANA LARGE APERTURE SEISMIC ARRAY

FINAL TECHNICAL REPORT

PROJECT VT/8708

CONTRACT F08606-78-C-0003

1 APRIL - 31 DECEMBER 1978



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FORD AEROSPACE AND COMMUNICATIONS CORPORATION  
ENGINEERING SERVICES DIVISION  
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Billings, Montana

79 03 02 003

**MONTANA LARGE APERTURE SEISMIC ARRAY  
FINAL TECHNICAL REPORT**

**Report No. 2145-79-118**

**IDENTIFICATION**

**AFTAC Project Authorization No.:** VELA T/8708  
**Title of Work:** Montana Large Aperture Seismic Array  
**Name of Contractor:** Ford Aerospace and Communications Corporation  
**Contract No.:** F08606-78-C-0003  
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**ABSTRACT**

The continued operation and maintenance activities at the Montana LASA during the period April 1 and June 30, 1978, and the seismic array roll-up activities between July 1 and December 31, 1978, are described. Array operations including the preparation of daily teleseismic event reports are detailed. Maintenance activities at both the data and maintenance centers are discussed. The array roll-up effort is described by task and the equipment disposition status reported.

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**ACKNOWLEDGEMENT**

**Ford Aerospace and Communications Corporation wishes to recognize the excellent technical direction provided to the Montana LASA project during this contract period by Capt. Robert J. Woodward at the VELA Seismological Center.**

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## INTRODUCTION

This is the final technical report of the activity by Ford Aerospace and Communications Corporation on the Montana Large Aperture Seismic Array (LASA), Project VELA T/8708 under contract F08606-78-C-0003.

The work described here began 1 April 1978 and continued through 31 December 1978. During this reporting period the work performed was divided into two separate functions. The first was the period of 1 April through 30 June in which the primary goal of this project was to operate and maintain the LASA in a manner which produced unique high quality seismic data for use by other government sponsored research projects. The second period from 1 July through 31 December covered the task of the roll-up of the LASA.

The sections following in this report describe the operation of the various systems installed at the LASA, the performance measurements of the equipment, the teleseismic and near-regional event reporting, the PDP-7 computer programming, the maintenance performed on the systems, and the LASA roll-up activities.

SECTION I  
SUMMARY OF EVENTS

This last technical summary report, describes the activities at the Montana LASA during April 1978 through December 1978. These activities include the operation and maintenance of the systems installed both in the array and at the data center (LDC) until June 30. The LASA roll-up has been in progress since July 1. Property and material disposition instruction delays have prevented our completion of this task.

The LASA Processing System (LASAPS) operated continuously, with the Seismic Data Analysis Center (SDAC), 99.4% of the three months that the LASA was in an operational mode.

Digital recording of the array data by the PDP-7 computer operated on a full time basis with the exception of an average 36 minute per day interruption for off-line program processing and system maintenance. All recordings have been forwarded to SDAC.

Teleseismic event processing using film recordings and on-line computer playouts were routinely performed, for the first three months of this reporting period, with the average daily result of 18.5 events or phases reported to VSC. Also, periodic near-regional and strip-mine blast listings added an average of 8.8 events/day.

Equipment and facilities maintenance allowed the continued operation of the array in a manner similar to previous periods for the first three months of this reporting period.

The LASA roll-up is complete except for the disposition of the government property remaining at the Miles City Maintenance Center and awaiting plant clearance actions.

SECTION II

OPERATION OF ALL LASA SYSTEMS

A. LASAPS OPERATIONS

The LDC computer provided LASA data to the SDAC trans-continental data link 99.4% of the three-month period from April 1977 thru June 1978. The one-year percentage equaled 96.4%. Interruptions in the computer's on-line operation with SDAC which have occurred are listed in Table I.

TABLE I

LASAPS DATA INTERRUPTIONS

Cause	<u>April 78 - June 78</u>		<u>VT/8708</u>	
	Hours	%	Hours	%
Corrective Maint.				
Active Maint.	0.0	0.00	74.1	1.13
Awaiting Pers.	0.0	0.00	106.0	1.62
Awaiting Parts	0.0	0.00	12.1	0.18
Preventive Maint.	2.0	0.09	11.6	0.18
Program Halts/Power Loss	9.6	0.44	18.8	0.29
Admin. Use (Training)	0.6	0.03	5.7	0.09
Other LDC Systems Inop.	0.8	0.04	0.9	0.01

TOTALS

B. PDP-7 COMPUTER OPERATIONS

1. Data Recording

The LASA Inner Array Recording System (LIARS) operated on the almost full-time basis to record LASA data. Recordings covering an average of 23.4 hr/day for the 91 day period were made. This system previously described by Potter (1975) provides four modes of array data recording either 10 or 20 samples/sec (s/s) from either a 10 or 16 SP sensor configuration of all 13 subarrays. LIARS tape recordings totaling 5377 were produced

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Potter, George (1975) "LASA Inner Array Recording System" LASA Program Description. Ford Aerospace & Communications. Billings, MT 26 MAR 75.

using the slow-mode (10 s/s) and fast-mode (20 s/s), short (10 sensor) format and covering 97.6% of the total time. All recordings have been sent to SDAC.

Interruptions in the data recording were necessary to support other LDC operations and logistics functions of 36.9 hr (1.7%) and for computer downtime 9.0 hr. (0.4%).

## 2. Event Detection

Automatic event detection continued using the same event detection processor routine as used and reported by Needham (1969). The event detection lists speed the manual analog film reading process from which we prepare our daily teleseismic reports. Event detections also provided a means of verifying the SP array sensing performance.

## 3. Event Processing

Event processing at the LDC was performed to assist in our teleseismic event reporting to VSC. Event data with amplitudes too small to pick from the analog film recordings are processed digitally through a filter, a beam former, and a cross-correlation routine. The time picks from either these strip charts or film recordings were further processed to obtain location and other event parameter information. (See Section III.A).

# C. ARRAY OPERATIONS

## 1. Monitoring

The array and data center systems were monitored on a continuous basis to provide an up-to-date site/sensor status information input to the LASAPS processor and to alert maintenance to trouble sources. Interruptions of the array data are shown in the monthly operations summary reports. SP data was interrupted 236.6 hr during this period; LP, 218.6 hr. Each subarray averaged 18.0 hr/month outage; LP, 23.9 hr/month. Table II indicates the data interruptions by the purpose of the outage and Table III shows a summary by subarray of the outages.

## 2. Communications Monitoring

Monitoring of the array communications circuits between each of the thirteen subarrays and the data center indicated about the same level of performance as previously observed. The long term circuit availability (since DEC 1970) of array circuits decreased slightly from 0.99669 to 0.99658. Circuit outages—those which normally exceed 2 or 3 minutes—of each subarray are

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Needham, R. and A. Steele. (1969) Montana LASA Data Analysis Techniques. S-110-33 Billings, MT MAY 1969.

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TABLE II

DATA INTERRUPTIONS BY PURPOSE OF OUTAGE

APRIL 1978 - JUNE 1978

SP ARRAY, 13 SITES	TOTAL HOURS OUT	AVERAGE PER SITE
LDC TESTING	2.14	0.16
SITE FAILURES	47.57	*
LDC MAINTENANCE	2.44	0.19
TELCO TEST/OUTAGE	184.41	14.16
POWER	0.00	0.00
LDC FAILURES	0.00	0.00
TOTAL SP ARRAY	236.56	14.51

NOTE - SITE A0 FAILURE WAS ONLY FAILURE

LP ARRAY, 9 SITES

LDC TESTING	4.56	0.51
SITE FAILURES	47.57	*
LDC MAINTENANCE	1.40	0.16
TELCO TESTING/OUTAGE	184.41	14.16
POWER	0.00	0.00
LDC FAILURES	0.00	0.00
TOTAL LP ARRAY	220.94	19.81

TABLE III

SUMMARY OF SUBARRAY DATA INTERRUPTION OUTAGES

APRIL 1978 - JUNE 1978

SITE	SP DATA	LP DATA	TELCO
A0	47.57	48.30	52.19
B1	0.42	.	1.75
B2	.00	.	4.32
B3	.37	.	4.23
B4	.00	.	13.26
C1	.00	.00	8.62
C2	.00	.00	17.04
C3	.12	.00	74.52
C4	1.40	1.40	5.67
D1	.00	.00	41.43
D2	.00	.00	7.40
D3	.00	.00	5.34
D4	.13	.00	3.67

shown together with the short-and long-term circuit availabilities in Table IV.

The extended outages exceeding a two-hour duration are listed in Table V.

### 3. Array Calibrations

Sinusoidal calibrations were performed daily using Program TESP for the SP seismographs to determine the condition of the array equipment. LP seismographs were routinely tested each week using Program TELP for sinusoidal calibrations, Program FREEK for free period measurement, and Program MASPOS for measuring and positioning the LP seismometer masses. Other computer controlled tests were periodically performed.

### D. ANALOG SYSTEM

The LASA SP Develocorder operated on-line with the array. The recording format consisted of center holes from the C-and D-ring and AO subarrays plus the attenuated signals from AO and D4. Develocorder film recordings dating from 24 DEC 73 are stored in the library.

Analog signals from two subarrays (D1 and C2) were transmitted to the National Earthquake Information Service facility in Golden, Colorado, as a part of their on-line seismic recording system.

**TABLE IV**

**ARRAY COMMUNICATIONS OUTAGE STATISTICS**

SITE CIRCUIT	OUTAGE 04/78-06/78	SHORT TERM 04/78-06/78	LONG TERM 12/70-06/78
A0 4GD2704	4.62	99.788	99.462
B1 4GD2701	1.75	99.920	99.798
B2 4GD2710	4.32	99.802	99.726
B3 4GD2705	4.23	99.806	99.804
B4 4GD2707	9.03	99.587	99.741
C1 4GI2708	8.62	99.605	99.836
C2 4GD2739	17.00	99.222	99.540
C3 4GI2711	72.73	99.703	99.317
C4 4GI2706	4.23	99.907	99.761
D1 4GI2714	41.45	99.100	99.501
D2 4GI2715	7.40	99.661	99.642
D3 4GI2712	5.34	99.700	99.515
D4 4GI2713	3.67	99.030	99.702

**TABLE V**

**EXTENDED ARRAY DATA COMMUNICATIONS OUTAGES**

APRIL 1978 - JUNE 1978

DATE	DURATION	SITE	REASON
04/12/78	2 05	C3	BROKEN DATA
04/18/78	9 18	C3	BROKEN DATA
04/18/78	2 16	D3	BROKEN DATA
05/09/78	2 10	B2	TESTING
05/09/78	2 10	C2	TESTING
05/10/78	2 47	B3	TESTING
05/10/78	2 47	C4	TESTING
05/11/78	2 52	A0	BROKEN DATA
6/8-9/78	8 02	B4	DEAD
6/8-9/78	7 37	C1	DEAD
6/14/78	10 01	B3	DEAD-STOPPED ROADS
6/15-10/78	40 05	D1	DEAD-STOPPED ROADS
6/15/78	18 55	C3	DEAD-STOPPED ROADS
6/24/78	9 07	C1	LOST DATA
6/26-27/78	22 25	C3	LOST DATA

SECTION III  
ARRAY PERFORMANCE

The Performance of the array as determined locally is based on the results of our seismic event processing, SP and LP seismometer testing and reliability studies. Results from each of these activities are summarized in the following paragraphs.

A. SEISMIC EVENT PROCESSING

1. Teleseismic Processing Summary

We reported to VSC 1,511 events and 152 phases between April 1, 1978 and June 29, 1978. These events are classified in Table VI and show an average of 18.48 detections per day. Approximate locations were indicated for 34% of the detected events.

Magnitudes were determined for the 541 located events. The smallest magnitude reported was 3.1; the largest 7.1. Figure 3.1 shows the distribution of these magnitudes.

2. Near-Regional Detections

The LASA near-regional detection reports continued with 6 issues between April 1 and June 29, 1978. A total of 37 near-regional or regional arrivals were reported.

Periodic supplements report the blasting activity at the known strip-mines located near the LASA. Table VII shows the number of blasts detected from each of the several strip-mines in the region. The blasting activity during this three month period increased by about 1% to an average of 8.4 blasts/day from 8.3 reported for the previous period.

B. SEISMIC EVENT PROCESSING ANALYSIS

Because of the shut-down of the LASA, the analysis of our seismic reporting which includes confirmation, location capability, magnitude accuracy, and the detection threshold of the LDC teleseismic reports will be included in our final report of the seismic activities of the LASA.

TABLE VI

CLASSIFICATION OF DETECTED TELESEISMIC EVENTS

APRIL 1, 1978 - JUNE 29, 1978

	<u>Number of Events</u>	<u>Daily Average</u>
Located Teleseisms (excluding PKP's)	541	6.01
PKP (Located)	19	0.21
PKP (Unlocated)	106	1.18
Poor or Weak Teleseisms (Not located)	160	1.78
pP Phases	102	1.13
Other Phases	50	0.56
Unprocessed Detections	685	7.61
<b>TOTAL</b>	<b>1663</b>	<b>18.48</b>

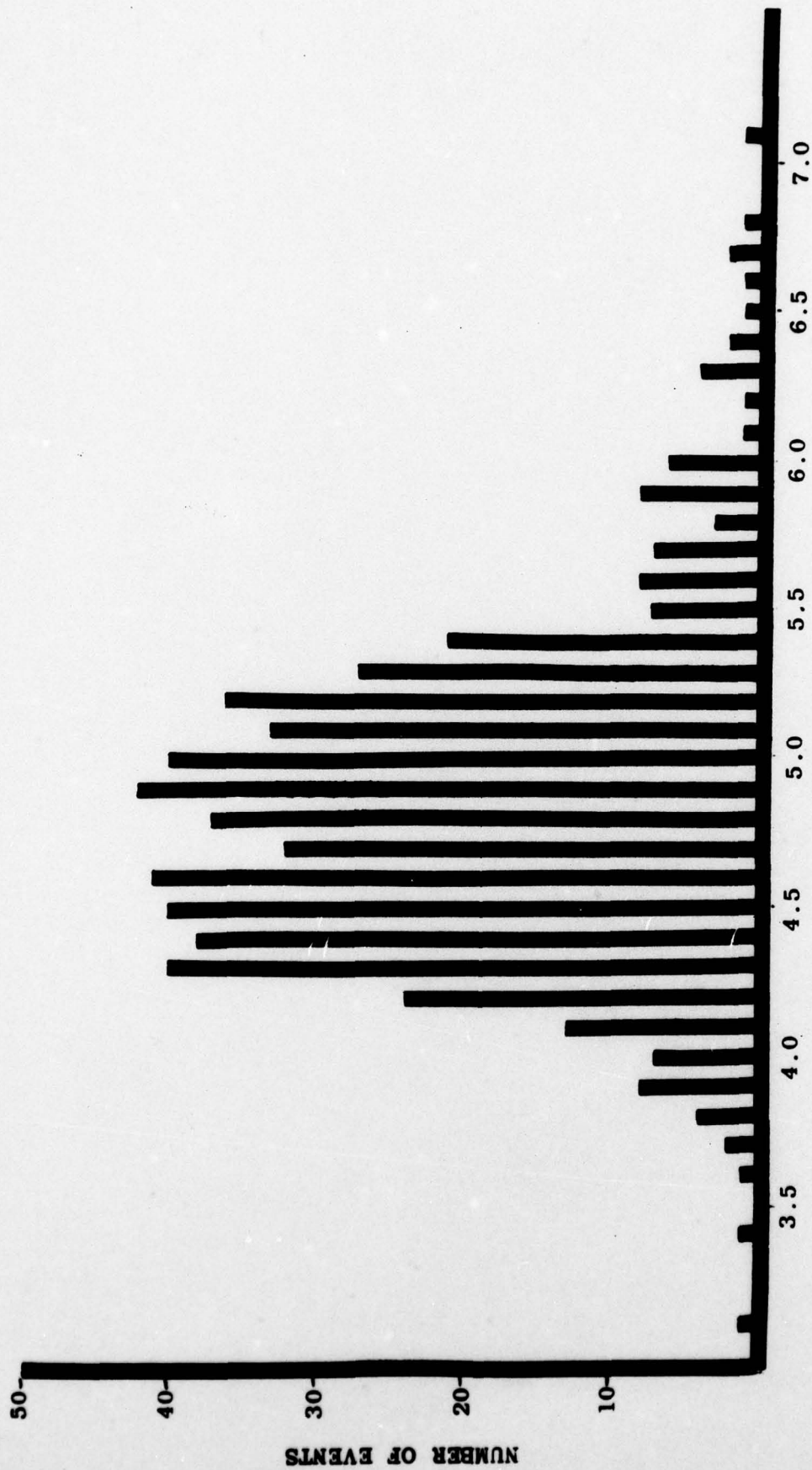


Figure 3.1 Magnitude Distribution of Located Events, April 1, 1978-June 29, 1978

TABLE VII

SUMMARY OF STRIP-MINE BLASTING ACTIVITIES REPORTED BY LDC

APRIL 1, 1978 - JUNE 29, 1978

	Number Blasts Reported	
Colstrip, MT (WE)	344	( 45.4%)
Decker, MT	210	( 27.7%)
Wyoming	59	( 07.8%)
Sarpy Creek, MT (W)	54	( 07.1%)
Colstrip, MT (P)	40	( 05.3%)
Unknown NE	23	( 03.0%)
British Columbia, Canada	15	( 02.0%)
South Dakota	6	( 00.8%)
Unknown	6	( 00.8%)
Roundup, MT	1	( 00.1%)
TOTALS	758	(100.0%)

SECTION IV  
IMPROVEMENTS AND MODIFICATIONS

A. PDP-7 PROGRAMMING

The development and maintenance of programs for the PDP-7 computer continue to provide an important part of the overall task of operating and improving the Montana Array as a seismological observatory.

The programming activity during the six-months period supported LDC operations by (1) updating our Auto-Edit patch program to include data for noise, and the capabilities of on-line tape duplication and (2) updating RPG I and RPG II for an expanded frequency response. The programs completed during the period are listed in Table VIII.

TABLE VIII

PDP-7 PROGRAMMING ACTIVITY

October 77 - June 78

PROGRAM	VERSION	BY	APPROVED
Auto-Edit	VL5	Potter	11/77
RPG I	VL4	Lidderdale	11/77
RPG II	V6	Lidderdale	11/77
DGAV	V1	Lidderdale	01/78
LIST EP 77	VL1	Lidderdale	03/78
CAL LP	VL1	Potter	03/78
Noise Data Analysis	VL1	Potter	03/78
FM-Edit	VL1	Potter	05/78
Auto-Edit	VL6	Potter	05/78
APPLE	VL5	Lidderdale	05/78

## SECTION V

### MAINTENANCE

LASA maintenance activity was divided into three different categories: Data Center (LDC), Maintenance Center (LMC) and Facilities Support. The LDC in Billings operates and maintains the following five systems: The IBM 360/44 computer, the DEC PDP-7 computer, LDC Digital, LDC Analog and the LDC Test and Support. The LMC located in Miles City maintains all array equipment systems which are comprised of SP Sensor, LP Sensor, Meteorological, SEM, and Power. Facilities Support provides maintenance of buildings, vehicles, land leases, and array facilities such as cable trenches, access trails, fences, WHV site, and CTH sites.

#### A. SUMMARY

The maintenance activities during this six-month period included preventive maintenance at both LMC and LDC, clean-up of vaults in arrays, repair of defective sensor channels, and installation of a modified LP develocorder. Maintenance, property, and material inspections were completed by DCASMA at both LDC and LMC. All maintenance activity ceased when equipment operation was terminated on 1 July 1978. Since that date all maintenance personnel have been involved in equipment removal. All statistics in this section on maintenance activities reflect the three months of operational status.

A summary of the total maintenance activity is given in Table IX where the number of work orders actions in the LMC, LDC and utility areas are shown. The completed work orders represent 609 separate and traceable actions by the maintenance activities and since several repair actions may result from the clearing of one particular trouble, the number of maintenance actions can exceed the number of work orders. The work orders do not indicate the man-hours involved but are indicative of the work load. The system work orders completed consisted of 98 preventive maintenance routines, 57 corrective maintenance, 1 modification and 47 utility actions. A total of 13 items of equipment were repaired in the LMC and LDC shops. The 47 utility work orders consisted of 20 actions on land, 12 repairs of facilities, and 2 vehicle inspections. The remainder (13) were closed after 1 July without any action taken. There were 33 work orders at LMC and 43 at LDC that were closed without any action taken due to system shut-down.

#### B. DATA CENTER

A total of 125 work orders were completed for 122 maintenance actions plus 2 repairs in the shop. Table X provides a breakdown of the LDC maintenance actions by system and month.

**TABLE IX**

## SUMMARY - WORK ORDERS

APRIL - SEPTEMBER 1978

WORK ORDER TYPE	TYPE	BACKLOG START OF PERIOD	INITIATED	COMPLETED	BACKLOG END OF PERIOD
LDC					
SYSTEM	-A	12	77	89	0
SUBASSEMBLY	-E	15	10	25	0
COMPONENT	-C	3	6	9	0
TOTALS		30	93	123	0
LTC					
SYSTEM	-A	9	97	106	0
SUBASSEMBLY	-E	1	0	1	0
COMPONENT	-C	16	2	18	0
TOTALS		26	99	125	0
TOTALS		56	192	248	0
CONDENSED TOTALS		71	274	293	0

**TABLE X**

## DATA CENTER MAINTENANCE ACTIONS

APRIL - SEPTEMBER 1978

	APR	MAY	JUN	JUL	AUG	TOTALS
360						
CORRECTIVE	0	0	0	0	0	0
PREVENTIVE	0	3	0	0	0	3
PDP-7						
CORRECTIVE	4	5	4	0	0	13
PREVENTIVE	21	22	12	0	0	55
DIGITAL						
CORRECTIVE	0	0	1	0	0	1
PREVENTIVE	4	4	3	0	0	11
ANALOG						
CORRECTIVE	2	5	5	0	0	12
PREVENTIVE	0	1	0	0	0	1
TEST AND SUPPORT						
CORRECTIVE	6	6	4	0	0	16
PREVENTIVE	0	0	0	0	0	0
TOTALS	37	54	29	0	0	120

### 1. System 360

The maintenance responsibility for the IBM 360/44 is handled locally with assistance from IBM as needed. During this period there were no repairs on the system and 3 preventive maintenance actions. This was an improvement over the 16 repairs during the last reporting period.

### 2. PDP-7 System

Maintenance of the LDC's PDP-7 computer system which includes the peripheral equipment as well as the basic CPU included 3 repairs and 55 preventive maintenance actions. The repair distribution follows: tape units, 7; teletypewriters, 2; line printer, 1; CPU, 1; and SOU, 2. The tape unit failures were routine in nature and the teletype problems were solved with the completion of a complete overhaul on the KSR-35 teletypewriter.

### 3. Other LDC Systems

The other systems maintained at the LDC are the Digital, Analog, and Test and Support systems. There was one repair and 11 preventive maintenance actions performed on the Digital System. The one failure of telemetry signals to subarray C3 was fixed by reseating a loose card (SD1) in the SDU unit.

Twelve troubles and one PM were required for the Analog System. The troubles were mostly minor problems with the Develocorders. The WWV antenna installation was considered completed and the work order closed. Four troubles were discovered and cleared in the D/A drawers in checking out the system for the LP Develocorder.

The Test and Support System encompasses not only the two Maintenance Display Consoles (MDC) but all other equipment for the support of the data center's operation such as the environmental equipment (air conditioners, electrostatic air filters) and the film viewers and copiers. Of 24 maintenance actions on this system, 16 were corrective and 8 were for preventive maintenance.

Fourteen of the corrective actions were on the maintenance display console and are routine. The rooftop air conditioner had to be repaired due to a leaky overpressure valve on the compressor.

## C. MAINTENANCE CENTER

The LMC supported the LASA operation with both array activities and shop testing and repairs.

LMC personnel completed 123 work orders representing 106 separate maintenance actions plus 11 items repaired in the

shop. The array work orders included 17 corrective maintenance, and 60 preventive maintenance.

#### 1. Array Activities

Table XI shows the array maintenance actions by system and month. To accomplish this maintenance, 43 visits to CTH's and 9 visits to WHV's were made. This required 29 trips to the field plus 3 trips to the Malmstrom AFB, PMEL and covered 5,146 miles. The array corrective actions included 10 on SP channels, 3 LP circuits, 3 power system repairs, and 1 on a SEM unit.

Travel in the array was limited until June because of continuous rainy weather. The road and trails were very muddy and many WHV's in grain field were inaccessible. Two gallons of water were cleaned up at D1 in May and a small amount at B2 in June with no damage at either subarray. For the amount of moisture this year the vaults stayed remarkably dry. None of the failures were unusual and were repaired without problems.

#### 2. Shop Activities

The extent of the shop work is summarized in Table XII. The minimal activity in shop repairs was due to emphasis on field activities at LMC and LP Develocorder modification at LDC.

### D. FACILITIES SUPPORT

LASA operations were supported by the facilities and vehicles available.

#### 1. Land Provision

Provision of the land for the array requires 50 leases. In the interest of good relations with the landowners, contacts were made to deliver lease checks, discuss subarray access trails, and other matters concerning the land use.

#### 2. Land and Facilities Maintenance

The amount and type of utility work engaged in at the LMC is shown in Table XIII. The 47 completed work orders show 20 land repairs/inspections, 12 facility repair/inspections, and 2 vehicle inspections. Road conditions in the array were very muddy through May. This limited activity to essential repairs and inspections.

#### 3. Vehicles

Over 40,000 miles were driven in support of the LASA operation and roll-up during this final period; no accidents occurred.

**TABLE XI**

## ARRAY MAINTENANCE ACTIONS

APRIL - SEPTEMBER 1978

	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
SP							
CORRECTIVE	4	0	6	0	0	0	10
PREVENTIVE	22	16	8	0	0	0	46
LP							
CORRECTIVE	2	0	1	0	0	0	3
PREVENTIVE	0	0	0	0	0	0	0
SEM							
CORRECTIVE	1	0	0	0	0	0	1
PREVENTIVE	7	3	4	0	0	0	14
POWER							
CORRECTIVE	0	1	2	0	0	0	3
PREVENTIVE	7	3	4	0	0	0	14
WEATHER STATION							
CORRECTIVE	0	0	0	0	0	0	0
PREVENTIVE	0	0	0	0	0	0	0
TOTALS	45	20	20	0	0	0	51

**TABLE XII**

## EQUIPMENT SHOP REPAIR SUMMARY

APRIL - SEPTEMBER 1978

	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
SEM ASSEMBLIES	1	0	0	0	0	0	1
SP ASSEMBLIES	2	1	1	0	0	0	4
LP ASSEMBLIES	0	0	0	0	0	0	0
POWER ASSEMBLIES	0	0	0	0	0	0	0
OTHER ASSEMBLIES	1	0	0	0	0	0	1
CARD REPAIRS	4	1	2	0	0	0	7
TOTALS	8	2	3	0	0	0	13

**TABLE XIII**

**SUMMARY - UTILITY WORK ORDERS**

**APRIL - SEPTEMBER 1978**

WORK ORDER TYPE	BACKLOG START OF PERIOD	INITIATED	COMPLETED	BACKLOG END OF PERIOD
CABLE TRENCH AND TRAIL INSPECTION	13	0	13	0
CABLE TRENCH BACKFILL	0	0	0	0
WHV SITES LANDSCAPED	0	12	12	0
MARKER POST OR WHV COVERS REPLACED	2	3	5	0
CTA MAINTENANCE	0	11	11	0
VEHICLE MAINTENANCE INSPECTION	0	2	2	0
FENCE INSPECTION	0	2	2	0
TRAIL REPAIRS	0	0	0	0
LINE EROSION CONTROL	0	0	0	0
TOTALS	15	38	45	0

## SECTION VI

### LASA ROLL-UP

The LASA roll-up commenced on 1 July 1978. Activities performed in completing this task included:

- ( 1) prepare especially formatted property and material inventories and furnish copies to the technical project officer.
- ( 2) remove all remote site instrumentation and electronics.
- ( 3) contact all remote site landowners to determine their requirements for site rehabilitation.
- ( 4) perform site rehabilitation as required.
- ( 5) obtain written releases from the landowners for the rehabilitation and/or real property remaining on the site.
- ( 6) obtain leases for the LASA site land locations through 30 September 1979.
- ( 7) terminate the LASA Data Center (LDC) lease on 31 December 1978 and retain the LASA Maintenance Center (LMC) as a warehouse for the remaining government property until all property and material dispositions are complete.
- ( 8) discontinue telephone and power service to all subarrays.
- ( 9) inventory and store all field equipment in the LMC until it and all LMC equipment is transferred.
- (10) secure and ready all LDC equipment and materials for shipment to locations provided by the technical project officer.
- (11) complete all other roll-up actions associated with the termination of the LASA operation.

#### A. INVENTORY LISTS

The first step in the roll-up process identified the LASA property and material installed at the subarray sites and at the data and maintenance centers. Nine separate inventory listed 1867 property items, 9 real property line items, and

1394 material line items. The categories included:

- 1) automatic data processing equipment, 90 items;
- 2) remote site electronics, 1054 items;
- 3) other plant equipment over \$1000, 15 items;
- 4) other plant equipment under \$1000, 573 items;
- 5) industrial plant equipment (DIPEC), 21 items;
- 6) special test equipment, 114 items;
- 7) real property, 9 line items;
- 8) material at data center (Billings), 861 line items;  
and
- 9) material at maintenance center (Miles City), 533  
line items.

Also, summary inventory lists grouped all identical items and showed the quantity, model number and manufacturer code to aid in the equipment disposition.

B. SUBARRAY EQUIPMENT REMOVAL

The actual removal of the seismic instrumentation systems from the field sites began on 10 July 78 after a brief planning and preparation period and continued to 14 November 78, 18½ weeks. Rainy weather in September prevented travel into the array for seven work days.

The array equipment removed from each subarrays' central terminal housings (CTH), long period vaults (LPV), and well head vaults (WHV) consisted of:

- CTH - Subarray Electronics Module (SEM)  
Standby Power System with battery bank  
Auxiliary Control and Conditioning Box  
LP Seismic Amplifier with heavy case  
Junction Box
- LPV - LP Seismometer, vertical and horizontals  
Remote Positioning Devices  
Junction Assemblies
- WHV - SP Seismometer  
SP Amplifier Panel with RA-5 Amplifier  
Junction Box

Removing the equipment from the CTH required a winch to lift the heavy items from the underground vault area. Disassembly of some of the large equipment was needed to remove it from the vaults. These equipment were reassembled at the Miles City maintenance center. The LP instrumentation was prepared in the LPV for transporting and also required a winch for removal from this underground vault.

Removing the SP seismometers at the WHV locations required four technicians and used equipment built especially to

assist in the laborious task for downhole seismometer removal. Technicians from the Billings office were temporarily assigned on a weekly basis to assist the two Miles City technicians with this task. At 26 SP sensor locations the HS-10-1/A seismometers were either stuck at the bottom of the hole or became lodged in the casing during removal and were abandoned.

At subarray D3 some seismic instrumentation was left within the 150 ft by 150 ft fenced-in central area vaults for use by USGS National Earthquake Information Service. Contract technicians escorted USGS personnel and briefed them on the transferred LASA equipment operation and other subarray information.

In preparation for the site rehabilitation work, we contacted the landowners to determine their requirements for site restoration. The owners were given the option to have the CTHs, LPVs, and WHVs on their property either removed, permanently sealed, or allowed to remain for use by the farmer/rancher.

Direct contact was made with the owners living in the area and together we visited the sites to inspect the facilities. In all cases except D2 the owners decided to retain the LPV and CTH vaults for their use. At D2 a recent land ownership change and snow cover over the area have prevented a final inspection and acceptance of the D2 vaults at the time of this writing. The LASA land administrator is being retained on the contract in Miles City until late spring to handle this and other land administration matters. A list of the CTH area landowners is shown below.

#### Central Terminal Area Landowners

Subarray	Landowner
A0	John Lockie Ranch - South of Miles City, MT
B1	Mathers Brothers - Miles City, MT
B2	Hunt, Sherman & Stuart (Hook Ranch) Dallas, TX
B3	Hunt, Sherman & Stuart (Hook Ranch) Dallas, TX
B4	First Continental Corp. - Great Falls, MT
C1	James Taylor - Spearfish, SD
C2	State of Montana - Helena, MT
C3	State of Montana - Helena, MT
C4	William Killen - Miles City, MT
D1	T Diamond Ranch - Miles City, MT
D2	Brewer, Kevin - West of Forsyth, MT
D3	Bureau of Land Management - Billings, MT
D4	Burlington Northern - Miles City, MT

WHV site rehabilitation was performed at 63 of the over 320 WHV site locations. In addition to removing and restoring the land at those locations requested by the landowners, we included the WHVs of those landowners who live away from the immediate area and who could not feasibly inspect the site. The majority

of the WHVs removed at the request of the landowners were located in grain fields. The site rehabilitation consisted of:

- 1) removing the WHV barrel from the well casing,
- 2) plugging the well hole casing with a special plug,
- 3) filling the barrel hole with dirt,
- 4) tamping the dirt to ensure a satisfactory fill,
- 5) landscaping and reseeding (if requested), and
- 6) removing the site marker post.

Written releases were requested from all landowners. Two types of releases were used. One for those landowners who asked that the vaults remain and the other for those who wanted the vaults removed and the land restored.

D. LAND LEASES

The land used for the thirteen LASA subarrays has been leased to provide access for possible future use as requested by the government through 30 September 1979. The 50 leases covering these land sites and site access expire between 30 September and 16 December 1979. If the individual landowners are not contacted prior to 30 August 1979 or 30 days before the lease expiration date with a request to exercise the lease option for another year, then the leases will automatically terminate. A separate report, entitled LASA Lands, FY79, is being prepared for use by VSC; this report describes the LASA leases and lands covered by them.

E. FACILITIES CLOSE DOWN

The LASA Data Center at 214 N. 30th St., Billings, Montana, was vacated on December 29, 1978. All services were disconnected.

The LASA Maintenance Center at the SW Corner of 5th and Pacific in Miles City, Montana, is being retained to warehouse and process the excess government property and material through the government's plant clearance procedures.

F. PROPERTY DISPOSITION

Following the disconnection and removal of all LASA systems and equipment, redistribution of the LASA inventory began. The entire LASA inventory was covered by the nine inventory lists and categories identified in paragraph 6.1. VSC reviewed these nine inventories with all known government and non-government organizations who conduct seismic surveillance operations. In addition to the VSC eight such organizations demonstrated a valid requirement for and expressed interest in obtaining selected items of LASA equipment and materials.

The names of the organizations to whom items of LASA property and material were transferred to included:

- |   |                          |
|---|--------------------------|
| 1. 1155 Technical Operations Squadron<br>McClellan AFB, California<br>Maj. Ryder                              | December 21-22           |
| 2. U.S. Geological Survey<br>National Earthquake Information Service<br>Golden, Colorado<br>M. R. Carlson     | November 08              |
| 3. U.S. Geological Survey<br>Albuquerque Seismological Lab<br>Kirtland AFB, New Mexico<br>O. J. Britton       | December 18              |
| 4. Weston Observatory<br>Boston College<br>Weston, Mass<br>Dr. E. Chiburis                                    | (Planned for January 79) |
| 5. Seismological Laboratory<br>Mackay School of Mines<br>University of Nevada<br>Reno, Nevada<br>Dr. R. Ryall | (Planned for January 79) |
| 6. Department of Geosciences<br>Penn State University<br>University Park, Pennsylvania<br>Dr. S. Alexander    | (Planned for January 79) |
| 7. Geophysical and Polar Research Center<br>University of Wisconsin<br>Madison, Wisconsin<br>B. Unger         | December 15              |
| 8. Seismic Data Analysis Center<br>Alexandria, Virginia<br>Dr. R. Blandford                                   | December 22              |

The remainder of the equipment has been stored at the LMC in Miles City awaiting plant clearance actions.

The array facilities abandoned to the landowners included nine different items of real property. The release of these items was as follows:

- (1) vault, CTH w/stairwell, 12'x9'x10"x6'6", w/150'x150' wire fence w/12' aluminum gate 11 each
- (2) vault, LP, 12'x10'x6'6" 1 each

At all subarrays except B1 and D3.

- (3) Vault, CTH, 12'x9'10"x6'6" w/6'x8' blockhouse cover w/150'x150' wire fence, w/12' aluminum gate 1 each
- (4) Enclosure, SP, approximately 81'x36' wire fence 1 each  
Vault, LP, 12'x10'x6'6" 1 each

These are at subarray B1.

- (5) Cable, data 19 gauge, 6 pr, PE-23 (buried) 297.0 miles

This cable is buried and abandoned at 12 of the 13 LASA subarrays (all except B1). At each subarray the cable is buried along a line connecting the LASA sensor locations. For example, at subarray A0 the leg<sup>1</sup> cable run extends from the CTH to location 21, to 41, to 61, and then terminates at 81.

- (6) Cable, data, 22 gauge, 6 pr., PE-23 (buried) 12.2 miles

This cable is buried and abandoned at subarray B1 as described under item 5.

- (7) Casing, well, 5½" ODx200' steel. 290 each

These well casings are in holes and abandoned to the land-owners at the 290 well locations indicated below:

Subarray:	<u>A0</u>	<u>B1</u>	<u>B2</u>	<u>B3</u>	<u>B4</u>	<u>C1</u>	<u>C2</u>	<u>C3</u>	<u>C4</u>	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>
Well:	21	21	21	21	21	21	21	21	21		21	21	21
	41	31	31	31	31	31	31	31	41		31	31	41
	61	51	51	51	51	51	51	51	61	61	51	51	61
	81	71	71	71	71	71	71	71	81		71	71	81
	22	22	22	22	22	22	22	22	22		22	22	22
	32	42	42	42	42	42	42	42	32		42	42	32
	52	62	62	62	62	62	62	62	52		62	62	52
	72	82	82	82	82	82	82	82	72		82	82	72
	23	23	23	23	23	23	23	23	23		23	23	23
	43	33	33	33	33	33	33	33	43		33	33	43
	63	53	53	53	53	53	53	53	63		53	53	63
	83	73	73	73	73	73	73	73	83		73	73	83
	24	24	24	24	24	24	24	24	24		24	24	24
	34	44	44	44	44	44	44	44	34		44	44	34
	54	64	64	64	64	64	64	64	54		64	64	54
	74	84	84	84	84	84	84	84	74		84	84	74
	25	25	25	25	25	25	25	25	25		25	25	25
	45	35	35	35	35	35	35	35	45		35	35	45
	65	55	55	55	55	55	55	55	65		55	55	65
	85	75	75	75	75	75	75	75	85	85	75	75	85
	26	26	26	26	26	26	26	26	26		26	26	26
	36	46	46	46	46	46	46	46	36		46	46	36
	56	66	66	66	66	66	66	66	56		66	66	56
	76	86	86	86	86	86	86	86	76		86	86	76

(8) Casing, well, 7"ODx500' steel 13 each

These well casings are in holes and abandoned to the land-owners at the 13 well locations at the center hole 10 of each subarray except subarray B2 which has two 500' well holes and D3 center hole 10 which is excluded from the real property release.

(9) Casing, well, 5½"OD, plastic 3 each

These well casings are in holes and abandoned to the land-owners at these three locations:

Subarray	Well Location
D1	22
D1	83
AO	27 (approx. 10' from location 25)

## SECTION VII

### ASSISTANCE PROVIDED TO OTHER AGENCIES

A. SEISMIC DATA ANALYSIS CENTER (SDAC)

The LASAPS processor was operated at the LDC 24 hrs/day and 7 days/week to provide real time array data on line to SDAC. The weekly near-regional reports with events and blasts within 20° of the array center were also distributed to SDAC.

B. NATIONAL EARTHQUAKE INFORMATION SERVICE (NEIS)

The LDC provided NEIS with the weekly reports of near-regional events and blasts, responded to their telephone requests for selected event information, and operated an FM telemetry link for transmitting data from three selected SP seismometer channels.

C. MIT LINCOLN LABORATORY

The periodic near-regional reports with the strip-mine blast supplements were distributed to Lincoln Laboratory. LASA digital data tapes were mailed upon request.

D. MONTANA DEPARTMENT OF STATE LANDS

The strip-mine blast supplement to the near-regional reports was mailed to the Dept. of State Lands in Helena, Montana.

SECTION VIII  
DOCUMENTATION DEVELOPED

A.        Technical Reports

The following reports were prepared during the final nine months of this project:

1. "Montana LASA Semi-Annual Technical Report 1 OCT 77-31 MAR 78"  
T/R 2145-78-107 25 April 78
2. "Montana LASA Operation Report for April 1978" T/R 2145-78-108  
5 May 78
3. "Montana LASA Operation Report for May 1978" T/R 2145-78-109  
7 June 78
4. "Montana LASA Operation Report for June 1978" T/R 2145-78-110  
11 July 78
5. "Montana LASA Operation Report for July 1978" T/R 2145-78-111  
1 August 78
6. "Montana LASA Operation Report for August 1978" T/R 2145-78-112  
6 September 78.
7. "Montana LASA Operation Report for September 1978" T/R 2145-78-  
113 2 October 78
8. "Montana LASA Operation Report for October 1978" T/R 2145-78-114  
2 November 78
9. "Montana LASA Operation Report for November 1978" T/R 2145-78-  
115 4 December 78
10. "Montana LASA Operation Report for December 1978" T/R 2145-78-  
116 2 January 79
11. "Montana LASA Final Seismic Analysis Report" T/R 2145-78-117
12. "Montana LASA Final Technical Report" T/R 2145-78-118
13. "Montana LASA Lands, FY79" T/R 2145-79-119

## CONCLUSIONS

Operation and maintenance performed at the Montana LASA allows us to conclude:

- 1) That the LASAPS operation as observed from the array end of the transcontinental data link succeeded in meeting the 95% data availability goal with no outside assistance to our operations and maintenance team.
- 2) That the LASA Inner Array Recording System using only a 16K memory computer system provided a very efficient and effective method of array monitoring, calibration, event detection, and processing without interfering with the data recording.
- 3) That the Montana array systems at the subarray sites and at the data center continued to meet their expected performance levels until shutdown for the array roll-up.
- 4) That the teleseismic and near-regional event processing incorporated into the data center's daily operational activities could be handled using the minimum of operations personnel (2 per/shift) and was important in our assuring the array was operating as an effective seismic observatory.

## REFERENCES

1. Potter, G. A. (1975) "LASA Inner Array Recording System (LIARS)" LASA Program Description. Ford Aerospace and Communications, Billings, MT.
2. Needham, R. and A. Steele. (1969) "Montana LASA Data Analysis Techniques" S-110-33. Ford Aerospace and Communications. Billings, MT.
3. Gress, D. P. (1978) Montana Final Seismic Analysis Report T/R 2145-78-117 Ford Aerospace. Billings, MT.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <b>The continued operation and maintenance activities at the Montana LASA during the period April 1 and June 30, 1978, and the seismic array roll-up activities between July 1 and December 31, 1978, are described. Array operations including the preparation of daily teleseismic event reports are detailed. Maintenance activities at both the data and maintenance centers are discussed. The array roll-up effort is described by task and the equipment disposition status reported.</b>			

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