

ADA 086802

LEVEL II

12

SDAC-TR-78-7

SEISMIC DATA ANALYSIS CENTER FINAL REPORT

Robert R. Blanford
Seismic Data Analysis Center
Teledyne Geotech, 314 Montgomery Street, Alexandria Virginia 22314

17 July 1978

DTIC
ELECTE
JUL 17 1980
S D C

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Sponsored by
The Defense Advanced Research Projects Agency (DARPA)
DARPA Order No. 2551

Monitored By
AFTAC/VSC
312 Montgomery Street, Alexandria, Virginia 22314

DOC FILE COPY.

80 7 16 028

Disclaimer: Neither the Defense Advanced Research Projects Agency nor the Air Force Technical Applications Center will be responsible for information contained herein which has been supplied by other organizations or contractors, and this document is subject to later revision as may be necessary. The views and conclusions presented are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency, the Air Force Technical Applications Center, or the US Government.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SDAC-TR-78-7 /	2. GOVT ACCESSION NO. AD-A086802	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) Seismic Data Analysis Center Final Report	5. TYPE OF REPORT & PERIOD COVERED (9) Final Technical Rept.	6. PERFORMING ORG. REPORT NUMBER 1 Oct 76-30 Sep 77
7. AUTHOR(s) (10) Robert R. Blandford	8. CONTRACT OR GRANT NUMBER(s) (15) F08606-77-C-0014 DARPA Order-2551	9. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS VT/7709
9. PERFORMING ORGANIZATION NAME AND ADDRESS Teledyne Geotech 314 Montgomery Street, Alexandria, Va. 22314	10. REPORT DATE (11) 17 Jul 1978	11. NUMBER OF PAGES 39
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Advanced Research Projects Agency Nuclear Monitoring Research Office 1400 Wilson Blvd., Arlington, Va. 22209	12. SECURITY CLASS. (of this report) Unclassified	13. DECLASSIFICATION/DOWNGRADING SCHEDULE
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) VELA Seismological Center 312 Montgomery Street Alexandria, Va. 22314 (12) 43	16. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Author's Report Date 04/15/78		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Alexandria Laboratories Division of Teledyne Geotech operated the Seismic Data Analysis Center (SDAC) during the twelve month period beginning 01 October 1976 and ending 30 September 1977. The objectives of the work were to: (1) operate, program, and maintain real time and batch processors; (2) provide services to other government agencies and VELA participants; (3) conduct research in seismology; and (4) develop systems to control and process seismic information generated by remote stations in the Expanded VELA Seismic Network.		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

408258 LM

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

During the contract, SDAC personnel assumed operational control of the Communications and Control Processor (CCP) from the BB&N corporation.

Three IBM Computers were available 24 hours per day throughout the contract for real time and batch processing. However, a considerable amount of downtime was experienced in the real time system because of extensive development work. The production of the routine seismic bulletin started early in the contract and continued during the period. In June the Alaskan Network of seismic stations was added to the Network and was integrated into the event bulletin. Late in the contract procurement procedures were completed for a system to allow researchers to access the Mass Store.

SDAC personnel provided data to thirty-nine different foreign and domestic companies, agencies, and institutions, and maintained comprehensive seismicity files from the U. S., Sweden, Norway, and France on magnetic tapes.

Staff researchers completed or submitted to Technical Publications numerous technical reports. Nine of the reports were the result of the research conducted during this contract period. In addition, SDAC scientists produced 17 technical memoranda on a variety of subjects for both external and in-house distribution. Three papers were cleared for presentation or publication and two special reports were prepared on key events. The technical reports focused on the problem of seismic discrimination.

➤ Network development tasks included refining and developing the Detection Processing System (DPS) and completing efforts to make the Network Event Processor fully operational.

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SEISMIC DATA ANALYSIS CENTER FINAL REPORT

SEISMIC DATA ANALYSIS CENTER REPORT NO.: SDAC-TR-78-7

AFTAC Project Authorization No.: VELA T/7709/B/ETR
Project Title: Seismic Data Analysis Center
ARPA Order No.: 2551

Name of Contractor: TELEDYNE GEOTECH

Contract No.: F08606-77-C-0014
Date of Contract: 01 October 1976
Amount of Contract: \$3,005,183
Contract Expiration Date: 31 April 1978
Project Manager: Robert R. Blandford
(703) 836-3882

P. O. Box 334, Alexandria, Virginia 22313

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Accession For	
NTIS	GRA&I
DDC TAB	
Unannounced	
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or special
A	

ABSTRACT

The Alexandria Laboratories Division of Teledyne Geotech operated the Seismic Data Analysis Center (SDAC) during the twelve month period beginning 01 October 1976 and ending 30 September 1977. The objectives of the work were to: (1) operate, program, and maintain real time and batch processors; (2) provide services to other government agencies and VELA participants; (3) conduct research in seismology; and (4) develop systems to control and process seismic information generated by remote stations in the Expanded VELA Seismic Network.

During the contract, SDAC personnel assumed operational control of the Communications and Control Processor (CCP) from the BB&N corporation.

Three IBM Computers were available 24 hours per day throughout the contract for real time and batch processing. However, a considerable amount of downtime was experienced in the real time system because of extensive development work. The production of the routine seismic bulletin started early in the contract and continued during the period. In June the Alaskan Network of seismic stations was added to the network and was integrated into the event bulletin. Late in the contract procurement procedures were completed for a system to allow researchers to access the Mass Store.

SDAC personnel provided data to thirty-nine different foreign and domestic companies, agencies, and institutions, and maintained comprehensive seismicity files from the U. S., Sweden, Norway, and France on magnetic tapes.

Staff researchers completed or submitted to Technical Publications numerous technical reports. Nine of the reports were the result of the research conducted during this contract period. In addition, SDAC scientists produced 17 technical memoranda on a variety of subjects for both external and in-house distribution. Three papers were cleared for presentation or publication and two special reports were prepared on key events. The technical reports focused on the problem of seismic discrimination.

Network development tasks included refining and developing the Detection Processing System (DPS) and completing efforts to make the Network Event Processor fully operational.

TABLE OF CONTENTS

	Page
ABSTRACT	2
LIST OF TABLES	4
I. INTRODUCTION	5
II. OPERATIONS	7
Real Time Operations	7
III. PROGRAMMING	15
CCP	15
360/40A	15
360/40B	16
IBM 360/44	17
PDP-15/50	20
Datacomputer	21
Documentation	21
IV. MAINTENANCE	22
Mass Store Data Retrieval System	22
Analog Laboratory	22
NEP Graphics System	22
CCP System	23
Terminals	23
Plotters	23
Maintenance Plan	23
Contract Maintenance	23
Air Conditioners	23
PDP-15	23
IBM Equipment	24
Disk Systems	24
Miscellaneous	24
V. DATA SERVICES	25
VI. SEISMOLOGICAL RESEARCH	27
VII. VELANET DEVELOPMENT	34
Detection Processing System	34
Network Event Processor	34
ARPCOM	35
Processing Task	35
Analyst Task	36
Graphics Task	36
Alphanumeric Terminal	38

LIST OF TABLES

	Page
I Real Time Performance in Hours	8
II Distribution of 360/44 Block Time (In Hours)	9
III Utilization of the 360/44 Operating Under DOS After GRASP Discontinuance (In Hours)	10
IV Utilization of TS44 System October 1976 through September 1977 (In Runs)	11
V Monthly Use of TS44 System	12
VI Summary of 360/40B Use	13
VII Utilization of PDP-15/50 (In Hours)	14

I. INTRODUCTION

This final report summarizes work performed at the Seismic Data Analysis Center (SDAC) in Alexandria, Virginia during the period 1 October 1976 through 30 September 1977. The contract was ammended to procure additional hardware which extend the completion date to 31 April 1978. The work at SDAC was performed under contract number F-08606-77-C-0014; this report fulfills data item A00N of the contract's Data Requirements List.

Sections II through V of this report focus on the operations, programming, and maintenance of SDAC equipment, as well as data services provided. Section VI summarizes research projects completed during the contract and Section VII details accomplishments in VELANET development.

Routine computer operations continued on the SDAC systems during the contract period. The most significant statistic was the amount of downtime experienced by the real time systems due to development tasks. The production of the routine seismic bulletin started early in the contract and continued throughout the period. In June the Alaskan Network of seismic stations was added to the VELA Network and this new data contributed to the seismic bulletin.

Programming effort consisted primarily of modifications to operational programs to either increase their efficiency or to account for changes in the data sources. The operating systems of the various computers were also maintained by SDAC personnel.

Several problem areas, relating to system maintenance, developed during the contract period. The most crucial remained the trouble with the air-conditioning systems. They continued to be unreliable and their failure resulted in computer downtime during the summer months. Also, the continual failure of the Bucode tape units on the PDP-15 caused considerable downtime and DEC stated its intention to end contract maintenance of the PDP-15 at the end of their current contract. A late amendment to the contract was the procurement of a major system for the researchers to access the Mass Store. The system consisted of a DEC PDP-11/70 and the peripherals required to support remote users. The hardware for this system was successfully installed by the end of the contract and some work was started on the software.

Data services continued to supply data to numerous agencies connected with the VELA program. Facilities were provided for the Project Office, Texas Instruments and visiting scientists. Considerable effort was required to routinely maintain the libraries of digital and analog tape and the files of film and seismic bulletins used for reference to conduct the research activities.

Numerous technical reports, technical memoranda, papers, and presentations relating to Seismological Research were developed and given during this period. The primary topics addressed were concerned with magnitude vs. yields, discrimination techniques, and evaluations of seismic systems.

The VELA Network development was characterized by continued system enhancements. The two major accomplishments during the period were adding the capability of waveform analysis to NEP and adding data from the Alaskan Network to the system. Specific capabilities and accomplishments are given in Chapter VII.

II. OPERATIONS

This section of the report concerns the operation of government-furnished equipment including: 1) processors used in a real time mode to receive and process data from remote seismic stations; 2) processors operating in the near real time mode to analyze and to store data from the real time system; 3) processors used in the "batch" mode to support researchers and data specialists.

Real Time Operations

A new version of the CCP was installed to accommodate the new Alaskan data. Considerable operational support, including testing and software corrections, were made on this updated system. Attempts were made to install the Buffered Serial Line Interface (BSLI) cards in the CCP, but this was not completed during the contract period.

Seismic bulletins continued to be created five days a week and the results sent to the mass store and other government agencies, as directed by the Project Office.

Effort was also devoted to reduce the time for the transfer of ILPA data to the mass store facility by using both the IBM 40B and the 44. However, this work was not completed during the contract period.

Air conditioning problems continued for all of the systems, but especially with those cooling the 360/44. The failures resulted in some loss of processing time.

The following tables provided data on system usage and reliability. Table I gives the performance for the real time system operations during the contract. The table shows that the overall reliability for this system was 75%. Between 1 October and the end of May performance was slightly over 88%. System development (discussed in section III) of the Detection Processor System (DPS) between June and the end of the contract sharply reduced real time operations. Table II shows that the IBM 360/44 was most heavily used by the time sharing system TS44 and the operations was the second most intensive user. Table III gives data relating to use of the 360/44 for DOS programs, after we terminated rental of the GRASP system. The actual breakdown of 360/44 computer time usage is detailed in Table IV. Note that the SDAC research department, Data Services, and Texas Instruments accounted for over 70% of the available computer time. Table V is a monthly summary of 44 user statistics. A summary of the use of the IBM 360/40B appears in Table VI. Note that the Network Event Processor (NEP) utilized 72% of available computer time. Table VII details utilization of the PDP-15/50.

Table I Real Time System Performance In Hours

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Total Possible Recording Hours	720	744	720	744	744	720	744	720	744	744	672	720
CCP Downtimes												
BB&N CCP Testing	.0	.0	146.0	.0	90.8	101.1	62.7	97.4	99.6	43.1	8.0	43.2
SDAC System Testing	39.1	18.0	80.7	33.8	26.4	116.2	.0	.0	1.6	1.2	2.9	11.5
CCP Malfunction	.3	.5	5.0	12.6	28.6	55.7	5.1	1.7	1.7	2.7	.9	4.8
CCP Self Restarts	.3	1.2	2.3	1.7	6.1	3.1	.1	.0	1.4	1.3	1.1	.7
CCP Data Flush	2.1	3.9	4.6	3.4	15.2	9.6	12.6	.4	5.6	18.4	1.2	34.1
DP Downtime	34.1	24.9	112.7	137.7	244.8	237.4	15.4	5.4	8.3	26.2	12.6	13.6
Total Hours Recording Experience	644	695	369	555	332	197	648	615	626	651	645	612
Total Percentage Recording Experience	89	93	51	75	45	27	88	85	84	87	96	85
LASA Statistics												
Data Loss Due to:												
LASA Data Center	4.3	1.1	35.1	29.9	109.0	1.4	4.5	96.3	2.2	102.7	88.4	26.1
Telephone Company	1.3	.3	2.8	1.9	.8	.0	.9	.7	.6	.7	1.2	1.6
CCP	.6	.3	.5	2.1	10.4	1.5	.6	.5	.2	.9	1.5	1.5
Miscounts*	6.2	1.7	38.4	33.9	120.2	2.9	6.0	97.5	3.0	104.3	91.1	29.2
NORSAR Statistics												
Total NORSAR Miscounts	198.2	94.7	187.7	337.8	133	41.4	74.0	10.8	91.6	137.9	124.9	79.2
Loss due to NORSAR	34.1	17.5	N/A	N/A	N/A	N/A	43.1	4.9	74.9	74.9	47.2	47.6
Alaska												
Alaska Miscounts			21.4	33.4	16.9	34.2	-	-	-	-	-	-

*Missing Message

Table II
Distribution of 360/44 Block Time (In Hours)

	Classified	System	Ops	TS44	Down
October	-	20:00	279:40	404:00	40:20
November	-	4:00	224:00	424:00	68:00
December		:30	167:30	567:00	69:30
January	Accounting program modified				
February	6:00	6:00	127:30	526:00	6:30
March	3:30	23:00	75:00	630:30	12:00
April	9:00	13:00	117:00	441:00	140:00
May	7:00	4:00	94:00	553:00	86:00
June	10:30	8:30	105:30	554:30	41:00
July	6:00	6:00	39:00	664:00	29:00
August	9:30	11:30	70:00	602:00	51:00
September	18:30	-	39:00	628:30	34:00

TABLE III

Utilization of the 360/44 Operating Under DOS
After GRASP Discontinuance (In Hours)

(This Table Shows Number of Jobs/Total Time)

	Oct	Nov	Dec	*Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Data Services	61 31:55	83 53:73	28 9:00	N/A	38 13:30	28 9:47	39 39	32 7	18 17	13 16	40 18	55 26:30
Operations	3 :22	9 1:09	11 14	N/A	72 85:25	59 58:48	- 15:00	- 10	- 8	- 2	- 1	- -
ILPA	-	-	-	N/A	-	-	46	72	75 :30	19	50	11
DP	-	-	-	N/A	01 :05	-	-	01 :30	-	-	01 01:00	-
TI	183 106:40	308 121:25	149 73:50	N/A	60 28:30	15 06:25	27 17:00	11 3:30	14 05:00	06 2:00	-	-
Research	22 7:27	12 3:34	-	N/A	-	-	-	-	-	-	-	-
Batch	-	-	01 :10	N/A	-	-	-	04:1:00 1:00	-	-	-	01 :30
NEP	-	02 :16	-	N/A	-	-	-	-	-	-	-	-
Idle	119 :04	-	-	N/A	-	-	-	-	-	-	-	-

*Statistics during January were not maintained during the transition of operating systems. Testing and debugging made such records questionable and difficult to obtain.

Table IV
Utilization of TS44 System
October 1976 Through September 1977 (In Runs)

	Oct	Nov	Dec	*Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	% of Total Runs
ENSCO	-	-	-	N/A	-	-	-	-	-	-	130	-	
Programming for 360/44	856	686	68	N/A	-	61	47	79	36	47	60	28	3%
Programming for PDP-15	3	-	-	N/A	-	-	-	-	-	-	-	-	-
DP	-	-	-	N/A	-	2	-	-	-	-	-	-	-
Documentation and Program Lic.	-	-	-	N/A	-	-	-	-	-	-	-	-	-
Systems													
Development	587	582	618	N/A	989	1078	1011	1112	1522	1413	1271	833	16
SDCS	158	-	-	N/A	-	-	-	-	-	-	-	-	-
NEP	144	144	-	N/A	148	150	113	54	56	91	66	29	1
Texas Instruments	1067	1263	1359	N/A	1960	2125	1650	1610	1757	1888	2037	2076	28
Data Services	582	1144	1227	N/A	1194	1548	1484	1825	1955	1619	1825	1767	24
Research	1154	1024	1436	N/A	1092	1596	1304	1325	1257	1171	1377	1163	20
Operations	-	110	-	N/A	-	-	-	-	-	-	-	-	-
VSC	-	-	-	N/A	-	-	-	-	-	-	137	165	-
Maintenance	-	9	2	N/A	45	25	3	5	10	1	6	62	-
VSC Priority	-	-	-	N/A	-	-	-	-	-	-	-	62	-
Batch	-	-	547	N/A	526	418	305	248	369	466	467	318	5
	4551	4962	5257	N/A	6009	6803	5917	6258	6962	6697	7246	6621	97

*Statistics during January were not maintained during the transition of operating systems. Testing and debugging made such records questionable and difficult to obtain.

Table V
Monthly Use of the TS44 System

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Hours	N/A	N/A	575	N/A	516	652	476	575	680	667	797	582
Runs	4551	4962	5257	N/A	6009	6803	5917	6258	6962	6697	7240	6621
												*5520
												67283

*The accounting system was not fully implemented until February 1977.

Table VI
Summary of 360/40B Use

Description	Hours	Percentage
DP	348	5%
Data Services	473	7%
Programming for 360	476	7%
T. I.	155	1%
NEP	4559	72%
VSC	1	-
Research	3	-
Batch	93	1%
Operations	176	2%
Classified	4	-
SCDS	2	-
ILPA Transfer Project	315	4%
	6290	98%

Table VII
Utilization of the PDP-15/50 (In Hours)

	Hours	Percentage of Total
Systems Development	662	7%
Research & Data Services	801	9%
A/D Conversion	199	2%
Hardware Failure	244	3%
Preventive Maintenance	237*	3%
Texas Instruments	936	10%
Idle	5681	66%
	8760	100%

*82 hours represents work on Bucode units in September; it hindered but did not completely stop system development.

III. PROGRAMMING

The programming staff at the SDAC developed, modified, and corrected programs for the Communication and Control Processor (CCP), two IBM 360/40 computers, an IBM 360/44, and a DEC-15/50 interactive processor. These systems routinely record and process seismic data and support the research efforts of VSC, Texas Instruments, and Geotech. They also serve to satisfy the requirements for the data service activities. This chapter reviews the programming support.

CCP

SDAC programming staff continued to improve the operation of the Communication Control Processor (CCP) throughout the contract year. During the first months of the contract, modifications to the interface of the 360/44 were made and the "activity bits" that route data from the CCP were respecified so that LASA, NORSAR and ALK data could be transmitted over the VELA link.

Other modifications and corrections were as follows:

- o Incorrect message lengths for forwarded data were corrected.
- o Default parameters for the data output to the display were modified.
- o The module that forwards NORSAR DP results to the 40A was corrected.
- o An ARPANET IMP-to-Host message deblocking routine was rewritten.
- o Routines to count and acknowledge Type 8 status messages and acknowledge any host messages were written.
- o The HOST-IMP communication code was replaced by several modules to reduce execution time and provide a flexible environment for new protocol implementations.
- o A change was made to the CCP operational program to count the NORSAR DP detections.
- o The parameter value that controls the LP data offset within an ALK record was corrected.
- o The "activity bits" that route data from the CCP were respecified so that LASA, NORSAR, and ALK data could be transmitted over the VELA link.
- o Verification was made that a data block sent from the 360/44 was received by the CCP and enqueued onto the VELA output queue.
- o The data spikes that occurred in data sent to the SIP and the 40A were eliminated.

- o The TBM acknowledgement message routine and the SIP operator message module were corrected; bad buffers were the cause of the problems.
- o The hourly crash problem in the CCP was eliminated.

The contract period ended with version #116 of the CCP.

360/40A

The IBM 360/40A continued to run the real time Detection Processing System (DPS) throughout the contract period. This operation is continuous and requires seismic data to be recorded and processed 24 hours per day, seven days per week. The processing consists mainly of detecting seismic signals occurring as the data flow through the system and recording these detections for subsequent evaluation by the seismic analyst.

Several capabilities were added and modifications were made to this system. These changes included:

- o Making the DPS accommodate tests of simulated Site II data from the CCP.
- o Adding ALK data recording and detecting.
- o Programming to reduce the amount of DP tape used during tape recovery.
- o Altering the NORSAR beam set.
- o Installation of the corrected ENQDV macro and updates to the standard system assignments.
- o Changing the DPS/CCP protocol to communicate directly with the CCP without using the ARPANET.

360/40B

The 360/40B was dedicated to the Network Event Processor (NEP) task during the term of the contract. NEP receives data from DPS and creates seismic events through automatic association and manual analysis.

Programming additions and modifications to the operational version of this system during the contract period were:

FGXFER - was modified to write record images of the PDP-11/35's disk onto tape. This enhancement of FGXFER, which spools printer output from the PDP-11/35 to the 360, provides the ability to create back-ups of the 11/35's disk for the NEP Graphics programming group. FGXFER was further enhanced with the addition of a new graphic display on the 2260 terminal. This display shows the type of character representation used and the format attributes of the data transferred between the PDP-11/35 and the 360/40.

PAQQC - was created to extract information in PAQ format from the NEP preliminary tapes and reformat it into SEISFILE input parameter cards.

CVDBUL - was created to reformat Daily Bulletin cards to SEISFILE input parameter cards.

Other programming and system support efforts were as follows:

- o The File Transfer Program (FTP) was modified to write data onto tape received from the ARPANET; this change was necessary to support retrieval of time series from the Datacomputer. The FTP was later further modified to enable the operator to cleanly terminate data transfer.
- o CVBULL was modified to block its output tape to 3200 bytes, or 40 card image records per block.
- o PRTSAQ was modified to correct intermittent bugs.
- o A new DOS supervisor was generated to allow creation of private core-image libraries for NEP.
- o A program was written to test the ability to read from and to write to a terminal from the 360/40 using the 2701 TWX adapter.
- o The master tape for Flinn-Engdahl region codes, used to create a disk file for NEP, was updated to reflect changes to the file.
- o A modification was made to the Network Control Program (NCP) to insure that the minimum number of bits transferred is not less than the BYTESIZE parameter of the FTP.

IBM 360/44

The IBM 360/44 performs most of the batch processing done at the SDAC. Two Calcomp disk drives were added to the 360/44 to support increasing demands for disk space while running this system. These changes required creation of several new versions of the TS44 system supervisor. Other system modifications included a new subsystem Read Data Computer (RDC) which was developed to allow interactive communication with the Datacomputer. During the course of the contract RDC was modified to include visible editing and other features.

SDAC staff provided considerable programming support to the 360/44 during the contract period. Among the more important program additions and modifications was the introduction of a new version of DPBEAM. This program was modified to automatically detect the reconfiguration of the NORSAR seismic array as it is recorded on tape, thus making the effects of the reconfiguration transparent to users. In March and April, DPBEAM was further modified to interpret NORSAR status, assign channel gain constants for the high gain stations, and to process data retrieved from the Datacomputer.

Improved file security procedures were implemented for users of the 360/44. The procedures divided users into groups and denied access to users outside of each group.

Other routines developed or modified to run under TS44 in the order they were produced were as follows:

BSUBMIT	was modified to allow job streams to contain \$COPY and \$INCLUDE statements. When BSUBMIT recognizes these control cards, it expands the statements to include information contained in other disk data sets. The program facilitates NEP program development by making the program decks compatible with the 360/40B.
SROIN	was modified to correct ambiguities in the user specified start times.
OLDCPY	was created to copy selected time windows of LASA data from ISRSPS low and high rate tapes. It has the capability of processing multiple input tapes and producing multiple-file output tapes.
SDCS	was created to read SDCS field tapes and to produce SDAC output tapes in subset format. The program also allows scaling of the data.
NEWPLT	was created as a special version of PLTTPS, a program to plot subset tapes. This new version allows the user to specify special scaling parameters to produce several seismograms calibrated to a known reference.
ILPACPY	was created to copy up to four ILPA field tapes onto a single 1600 EPI tape.
MASSPLOT	was created to plot data retrieved from the mass store.
TALLY	was created to plot cumulative event detections.
SUBSETQC	was created to perform quality control checks and editing of SUBSET tapes. This program was enhanced to validate all known characteristics of the tapes.
MAGNIT	was modified to correct its least square algorithm; the program computes M_s/m_b relationships.
SEISFILE	was modified to incorporate the new USGS data format and converted to run on TS44.

FTP	the File Transfer Program for TS44 was modified to prevent programs from running out of estimated run time while retrieving files from remote ARPANET computers.
HYP0	was modified to allow more than 50 pages of printout.
M7AF	was reorganized to run in an overlay structure.
QSTATUS	was created as a new command to produce a display of jobs awaiting execution in the batch queues; only jobs eligible for execution are displayed, thus reducing output to the terminals and quickly providing concise information to users.
SENDT019	a batch version of the FTP was changed to skip a tape file marker, transfer a tape data file, close the connection to the remote computer, and continue the process until the tape ends.
DATACV	was created to make up to five copies of a single input tape.
EVENT	was modified to read NORSAR event tapes.
PLTTPS	was modified to provide more detailed label information on the plots, the program plots seismograms from SDAC subset tapes.
NEWQC	was modified to allow user selection of time windows, thus expanding its quality control function on DP tapes, to deblock the print request for NORSAR EP results records on the DPS tape and to deblock and decode the print request for DPS results records.
DARCOS	which computed arc cosines, was modified in the DOS version of SEISFILE.
SCORER	was created to validate time codes on new DPS tapes and integrated into DPBEAM.
TRANSL	was created to translate from ASCII to EBCDIC or vice versa.

Other programs that were either written, altered or corrected provided the following capabilities:

- o ILPA and PESF transfers to the mass store using both the 360/44 and 360/40B.
- o ARPANET communication between the 360/44 and the CCP.

- o SP and LP data formats compatible to the HDT for transmission using the 360/44-CCP connection.

PDP-15/50

The PDP-15/50 is an interactive processor used by the research staff for A/D conversions, to evaluate data recorded by the Special Data Collection System (SDCS), and to study data from the Seismic Research Observatories (SRO).

Program additions and modifications to this system were as follows:

- o PDP7CV was modified to zero-fill bad input records and to allow the user to decimate Long Period data from 10 samples per second to one sample per second.
- o PDP7ED was created to convert LASA edit tapes to SDAC subset format. It was later modified to allow zero-fill of bad input records.
- o EXBP was written to stop the execution of the executive at various steps.
- o RSX was modified to allow interpartition data transfer and a debugging facility was completed.
- o DEBUG facility was modified to incorporate a new command LOCATE that finds a given value in core.
- o SDCS5 was coded. It is a program combining the capabilities of scrolling through data, taking amplitude measurements, and creating subset tapes of significant events.
- o SDCS6 was enhanced; it is a program system allowing interactive analysis of SDCS field tapes. With the modifications, user input is done using the VT15 graphics terminal, eliminating the need to alternate between the operator console and the VT15. The program options were made available as a menu in the VT15's offset display area.

In addition, modifications were made to the new RSX version of the A/D process to print I/O error messages. A utility program that copies long period experiment tapes was modified to accept card input for start-stop times and to run the USR2 partition, thus allowing developmental programming to be carried on in the TDV partition while this utility is being used. Also, a switch was provided to reconfigure the VT15 graphics controller to its original state to be compatible with DEC software. Finally, a series of lectures was begun on software and user techniques for the PDP-15.

Datacomputer

The Datacomputer is a data base management system developed by the Computer Corporation of America (CCA). It is designed for shared remote access to large on-line data sets. It makes use of tertiary memory, which is large capacity slower access memory beyond primary core and secondary disk memory. The Datacomputer is the only operational general purpose system capable of efficient handling data sets of over a trillion bits.

SDAC has been routinely transferring data to the Datacomputer since November 1976. The computer is located in Cambridge, Massachusetts. It is linked to the ARPANET and provides long term storage of data for storage and access by the seismic community.

The programming efforts focused on preparing the data for transfer to the mass store and testing the sending and retrieval systems. The programming efforts were as follows:

- o The PSWF file and port descriptions were recompiled in preparation for test data transfer. The data was successfully transferred and then retrieved. Command procedures were created for the transfer.
- o Testing of ILPA data transfer in APPEND mode instead of update mode began. Investigations into problems of ILPA data transfer were ongoing.
- o Temporary files for LP data were created; a transfer for a single LP file was completed.
- o The contents of the "C" seismicity file, containing epicentral data from January 1962 through February 1975, was transferred to the Datacomputer. Procedures to facilitate access to the file were developed on the Information Science's Institute (ISI) TENEX system.
- o File management procedures and controls were implemented on the VELANET files at the Datacomputer.

Documentation

The following programs and system enhancements were documented and distributed during the contract period:

DPBEAM - a beamforming program
PDP7CV - a program to process PDP7 LASA backup tapes
SDAC Programmers Guide

IV. MAINTENANCE

During the contract period, Geotech maintained the analog laboratory equipment, terminals, incremental plotters, timing systems, communications modems, ARPANET interfaces, the NEP graphics system and its interface, and the Communications Control Processor (CCP). The remainder of the SDAC equipment was maintained under subcontracts with local field service organizations.

Mass Store Data Retrieval System

Amendment eight to the contract was for procuring a major system for researchers to retrieve data from the Mass Store Facility at CCA. The components for this system, called the Mass Store Data Retrieval System (MSDRS) were purchased from several equipment suppliers and integrated by our staff.

By the end of the contract period the hardware was received and assembled. We also sent a member of our staff to Lincoln Laboratories for a month to become familiar with the UNIX operating system and other software development by Lincoln Laboratories.

Analog Laboratory

The analog laboratory digitized a total of 1,064 seismograms, and numerous direct-writes of events requested by researchers.

The analog TR-48 computer was returned to the Project Office for use at another government facility.

Through the year only routine maintenance of the analog lab equipment was required and no new equipment was added and no major malfunctions recurred.

NEP Graphics System

The NEP graphics system consists of the Evans and Sutherland Picture System, a Digital Equipment Model PDP-11/35 computer, an Ann Arbor alphanumeric terminal, a computer labs dual cartridge disk, a dual digital cassette unit, and a model 1140 interface to the IBM 360/40B computer.

The interface between the IMLAC hardcopy unit and the E&S Graphics System posed some difficulties. The source of the problem was the speed difference between the two CRT's. To correct the problem a modification to the yoke of the IMLAC cable was made. Modifications made to this system included the installation of a picture processor speed-up card on the E&S and the memory management and stack limit cards on the PDP-11/35.

Routine weekly maintenance was also performed on this system during the contract period.

CCP System

The SDAC staff assumed much of the hardware maintenance for this system. CCP hardware problems corrected by our staff with some assistance from BBN were: defective memory, parity problems between BCI and BCM cards, the Codex 4800 AV modems, failure of the reliability code diagnostic test, and difficulties in playing back LASA data for system performance evaluation.

Other significant maintenance tasks on the CCP were: 1) engineering changes made to the BCM card necessary to support new reliability code, 2) modifications of VELA serial-line interface cards to make them compatible with Alaska data, 3) constructing a serial line interface to provide five outputs to simulate data inputs, and 4) modification to allow parity checking in the CCP.

Terminals

SDAC maintained five terminals in addition to those dedicated to the NEP graphics and CCP systems. The remaining terminals were maintained by either the manufacturer or the lessor.

Plotters

The aging plotters required considerable repairs. The takeup and drum motors were replaced on the 12 inch plotter. The 30 inch plotter in the PDP-15 room also failed, the drum motor was replaced.

Maintenance

A maintenance plan was published in final form in January 1977 and then updated in June of that year. The document specifies maintenance programs, lists subcontractors, and lists equipment located in the SDAC facility, as well as maintenance and parts logging procedures.

The update outlined modifications in the plan during the contract year.

CONTRACT MAINTENANCE

Air Conditioners

The cooling systems continued to cause significant problems during the contract period. Major repairs were required for units one, three, five, and six. Temperature problems caused some computer downtime during the summer months.

The present contractor responded well to calls for assistance.

PDP-15

The major problem during the contract year was the almost continual failure of the auto-load feature on the Bucode tape units. Several field service experts were called in to resolve the problem, generally without success. After several replacements of the major components, SDAC met with DEC field service personnel to discuss the maintenance problems. DEC promised to provide diagnostics by the end of the contract showing that the components met specifications; DEC also stated that the company considered the Bucodes worn out and that contract maintenance would end in one year. The diagnostics

were provided as scheduled, but tape drive failures prevented and extended diagnostic test.

Other important maintenance on this system included:

- o a new video amplifier and an ARC suppression network was installed on the VT-15 and an upgrading kit was received and installed for the VT-15.
- o cooling fans on the power supply were replaced with another type in order to increase the air flow.

IBM Equipment

The IBM central processors and peripheral equipment continued to be generally reliable and IBM maintenance personnel provided responsible and effective on call and routine maintenance.

Disk Systems

No major equipment failures occurred during the contract on either the Memorex 3660 or the Calcomp CD-14 disk systems.

Miscellaneous

Other major accomplishments completed during the contract include completion and implementation of the spare parts inventory system.

The following tabulation shows the major equipment changes made during the contract:

Quantity	Description	Date
1	Ann Arbor Terminal	Nov 1976
2	12K Monolithic memory boards	Oct 1976
1	PDP-11/05 CPU (rented)	Sept 1976 thru March 1977

V. DATA SERVICES

The SDAC is the repository of a large seismic data base. The libraries are comprised of 16 and 35 millimeter film, analog tape, and digital recordings of segmented and continuous data. All of the data from the LRSM program are recorded on film and analog tape, many digital tapes have also been made from this data source. The digital libraries are comprised of both continuous and segmented data from LASA, NORSAR, KSRS, ILPA, ALPA, and the SDCS and SRO stations.

It is the functions of data services to extract data from these libraries in response to requests from an array of international agencies, universities, and contractors participating in the VELA project and conducting seismic research. The following institutions were supplies data during this contract period:

AFTAC/TGS
Atomic Weapons Research Establishment, Blacknest
Australilian National University
California Institute of Technology
Carnegie Institution of Washington
CIRES, University of Colorado
Cornell University
ENSCO
Hagfors Observatory
Institute of Geological Sciences, Edinburgh
Institute of the Physics of Earth, Paris
Lamont-Doherty Geological Observatory
Massachusetts Institute of Technology
MIT Lincoln Laboratory
NOAA
NORSAR
Patrick Air Force Base
Pennsylvania State University
Rice University, Houston
Saint Louis University
Southeastern Massachusetts University
Southern Methodist University
Systems, Science & Software, Inc.
Teknekron Energy Resource Analysis Corporation
Texas Instruments
U.S. Geological Survey, Branch of Seismicity and Earth Structure
U.S. Geological Survey, Denver
University of California, Berkeley
University of California, Los Angeles
University of California, San Diego
University of Nevada
Universite Scientifique et Medicale de Grenoble
University of Southern California
University of Texas, Dallas
University of Texas, Galveston
Weston Geophysical Research
Woodward-Clyde Consultants
VELA Seismological Center

Dr. V. I. Marza of Bucharest, Romania also received assistance; his institutional affiliation was unknown.

To carry out the data services tasks for both our own use and outside users, the SDAC staff:

- o maintained and updated lists of data tapes;
- o verified data requests and Analog/Digital conversions;
- o filed data plots;
- o maintained the Long Range Seismic Measurement (LRSM) tape and film libraries;
- o received data from outside sources and maintained shipping records;
- o maintained and updated lists of instrument response curves, array configurations, and station locations; and
- o kept a library of seismicity data from several sources, including France, Sweden, and Scotland.

Data services changed procedures for several tasks, which resulted in increases in efficiency and cost savings. A program was written to consolidate digital tapes and procedures adopted to recycle older tapes for field use. Still further reductions in tape usages followed a decision to add the A/D conversion for SDCS to an existing tape containing the same class of data until the tape is full. This change reduces tape usage by a factor of fifty to one hundred, depending upon the number of points digitized.

In May 1977, the procedure for updating the seismicity data files was altered. Prior to this time, the frequent changes in the NEIS computer system created difficulties in maintaining the files. Implemented changes will allow more current updating than ever before. Additional time savings was achieved when, in August 1976, Lincoln Labs, and other users agreed to accept SRO tapes, rather than the SRO-HGLP tapes.

SRO and ASRO data continued to be received during the contract period. At the beginning of October 1976 data were received from ANMO, MAIO, NWAQ, and ZOBO. Six more sites were added by the end of September 1977, they were CHTO, TATO, SNZO, CTAO, KAAO, and MAJO.

Processing SRO/ASRO data consisted of extracting times beginning at 00 hours GMT and continuing to 0200 GMT on the following day from the sites, then combining these to form a day tape from all available stations. This was accomplished for all days in the contract period.

An original and backup of the day tapes are retaining in the SDAC library. It is usually possible to respond to a request for those data within 24 hours.

VI. SEISMOLOGICAL RESEARCH

During the contract period, nine technical reports concerning the research effort were prepared. In addition, 18 technical memoranda were completed, 3 papers were cleared for publication in the open literature and 2 special earthquake reports were distributed. The technical reports were distributed to those on the government approved list and a copy sent to the National Technical Information Service for cataloging and distributing to other users. The memoranda were distributed to members of the research staff at SDAC and at the VELA Seismological Center. In addition, two Special Data Collection Station (SDCS) reports were distributed at the client's request.

Summaries of the distributed reports, titles of the memoranda, titles of papers cleared for printed or oral presentation, titles of the SDCS reports, and titles and abstracts of research reports are included in this chapter.

The following seven Technical Reports were prepared under VT/6709 and are included herein for completeness:

EXPERIMENTS IN REFINING M_S ESTIMATES FOR SEISMIC EVENTS (SDAC-TR-75-17)

Two experiments were conducted to investigate the possibility of reducing the observed scatter in M_S estimates for seismological events. The first experiment was intended to remove dispersion effects on calculated M_S by empirically estimating a $\log ([dU/dT]^2)$ term at each station for an event. The second experiment involved tracing surface-wave rays over the globe using laws of geometrical optics, and a grid of phase velocity values for 20-second Rayleigh waves. Results of the first experiment showed that subtracting the log term from the M_S values did not improve the scatter, a result showing that other terms predominate in producing scatter. In the second experiment the ray-tracing indicated large zones of intense focusing and defocusing, refracted paths, and multipath propagation to stations.

FINAL REPORT ON THE ANALYSIS OF RECORDINGS FROM THE VERY LONG-PERIOD EXPERIMENTAL STATIONS (U) (SDAC-TR-76-1)

This report is classified SECRET.

EXPERIMENTAL DETERMINATION OF SCALING LAWS FOR CONTAINED CRATERING EXPLOSIONS (SDAC-TR-76-3)

Application of cube-root scaling to the observed Rainier reduced displacement potential for tuff satisfactorily explains spectral ratio's over the yield range 0.7 to 1200 kilotons for NTS Pahute Mesa shots detonated below the water table and observed at KNUT and MNNV. The same theory extended to the time domain, assuming the attenuation parameter of $t^*=0.1$, explains amplitude

observations at KNUT and MNNV. However, it cannot explain the observed tele-seismic $m_b:M_s$ slope of unity, which seems to result from the fact that the waves emergent vertically downward are significantly different from those emergent vertically upward or nearly horizontally.

Using Bridgeman's dimensional analysis, no clear empirical scaling conclusions could be derived from the limited data for cratering events.

EVALUATION OF THE KOREAN SHORT-PERIOD ARRAY (SDAC-TR-76-5)

The Korean Seismic Research Station (KSRS) short-period array was evaluated using data covering eight-hour time periods daily between May and June 1973. Most of the data is of poor quality because of instrument problems. The average noise reduction obtained by beaming was about 2db better than $\sqrt{N}$ due to the almost continuous presence of propagating coherent noise at the station. The 50% detection bodywave magnitude threshold was found to be $4.35 \pm .45$ (95% confidence interval) at the epicentral distance of 60° . The 90% detection threshold was found to be $4.52 \pm .45$ magnitude units.

OF THE EXISTENCE, MAGNITUDE AND OF BROAD REGIONAL VARIATIONS IN BODY-WAVE AMPLITUDES (SDAC-TR-76-8)

This report is a review of evidence for anomalous attenuation of short-period seismic body-waves in the upper mantle under the Western United States. The attenuation reduces the amplitudes of these waves by a factor of about two relative to those observed in stable, continental shield type areas. The magnitude of this amplitude anomaly is consistent with spectral differences of body-waves observed in the same region, assuming a simple exponential attenuation law with a constant quality factor Q . The most likely cause of the attenuation is partial melting in the upper mantle under the Western United States. This hypothesis is supported by measurements of travel-time delays, upper mantle conductivity and heat flow. The report also includes a considerable number of new results obtained recently at the Seismic Data Analysis Center.

STUDY OF SELECTED EVENTS IN THE TIEN SHAN REGION IN A SEISMIC DISCRIMINATION CONTEXT (SDAC-TR-76-9)

Eleven earthquakes with low reported M_s for their m_b from the area near Lop Nor in the eastern Tien Shan were examined in a seismic discrimination context. Seismograms from ALPA, LASA, NORSAR, the HGLP and the WWSSN stations were studied for source mechanisms, M_s-m_b , corner frequency, long-period body-wave excitation, pP, complexity, spectral ratio, and S/P excitation. All events can be identified as earthquakes, except the 20 October 1975 event which exhibited explosion characteristics.

EMPIRICAL $m_b:M_s$ RELATIONS AT THE NEVADA
TEST SITE WITH APPLICATIONS TO THE m_b -YIELD RELATIONS
(SDAC-TR-76-14)

Measurements were made of first motion amplitude and of the period and amplitude of the second peak-to-trough excursion (termed the c phase) for the short-period vertical P-wave signals from approximately 60 Nevada Test Site (NTS) explosions. The signals were recorded at HNME and RKON. In general, the data supported the conclusion that the m_b :yield curve begins to bend significantly at approximately 200 kt. This curvature may not have been previously observed at the NTS because of the effects of scatter.

The following reports were prepared for the tasks in this contract:

STUDY OF SELECTED KAMCHATKA EARTHQUAKES
IN A SEISMIC DISCRIMINATION CONTEXT
(SDAC-TR-76-10)

Seismic discrimination in the Kamchatka source region is studied using data from earthquakes, inferences from measurements of teleseismic explosions, and results from the Amchitka tests. A small suite of 9 earthquakes, most having low M_s for their m_b , was selected in the range $5 < m_b < 6$ and with depth of focus < 50 km. These earthquakes lay near the top of the downgoing Pacific plate and had predominantly a thrust mechanism. Major source and transmission path effects on signals recorded at LASA, NORSAR, HGLP, and WWSSN stations are identified and related to discrimination parameters. On the basis of several parameters taken together, such as M_s-m_b , spectral ratio, corner frequency, pP , complexity, long-period body-wave excitation, and shear-wave excitation, discrimination of events of this type in the Kamchatka region poses no special problems so long as discrimination against shot arrays is not at issue. If shot arrays are considered, then the problem is more difficult, but still tractable.

OBSERVED VARIATION IN THE SPECTRAL RATIO
DISCRIMINANT FROM SHORT-PERIOD WAVES
(SDAC-TR-76-12)

Short-period P-wave first arrivals recorded at LASA were filtered in the bands of 0.4-3.0, 0.4-0.8, 1.4-1.8, and 1.8-4.0 Hz, and the estimates of signal amplitude in each band were used to form spectral ratios similar to amplitudes already proposed for the discrimination process. Ratio values were scattered over about two orders of magnitude, and they did not depend upon earthquake magnitude or epicentral distance. The average logs of spectral ratios for 166 geographic regions ranged over one order of magnitude and showed some correlation with known patterns of lateral Q homogeneity in the earth. The study concluded that variation in stress drop, and other physical processes connected with earthquakes, caused at least as many spectral discriminant variations as do variations in attenuation.

THE EFFECT OF CRUSTAL STRUCTURE ON STATION
MAGNITUDE ANOMALIES (MAGNITUDE BIAS)
(SDAC-TR-77-1)

The amplification of P-wave amplitudes by the receiver crustal structure was modelled for 34 LRSM stations using crustal structures derived from data in the open literature. Crustal amplification was found linearly related to the acoustical impedance of near-surface materials at each site. If two subsets of stations in the Western and the Eastern United States are used, a linear trend between the computed crustal amplification and the magnitude residuals can be observed within each set, but a separation of about .3 magnitude units exists between the groups. Anelastic attenuation under the mantle in the Western United States most likely accounts for the separation.

SUMMARY OF SHORT-PERIOD EXPLOSION AND
EARTHQUAKE CODA SHAPES WITH IMPLICATIONS FOR
REGIONAL DISCRIMINATION
(SDAC-TR-77-2)

This report presents a collection of small and large earthquake short-period coda shapes as a function of distance. It is summarized from previous studies by Cohen, Sweetser, and others. New results include coda shapes for $\Delta < 20^\circ$. The report is intended to serve as a reference for workers who investigate problems related to hiding an explosion in an earthquake. A detailed examination of earthquake and explosion coda also shows for $\Delta < 20^\circ$ that the amplitude ratio P_g/L_g serves as a discriminant in the Southwestern United States.

STUDY OF SELECTED EVENTS IN THE PAMIRS
IN A SEISMIC DISCRIMINATION CONTEXT
(SDAC-TR-77-3)

Eleven earthquakes from the North Pamirs with low reported M_s for their m_b were examined in a seismic discrimination context. Seismograms from ALPA, LASA, NORSAR, HGLP and the WWSSN stations were studied for source mechanisms, M_s-m_b , corner frequency, pP , complexity, and spectral ratio. The Pamir events were identified as earthquakes when compared to characteristics of Kazakh explosions. However, the discriminants found effective would not work against shot arrays configured to simulate Pamir earthquakes of $m_b \sim 4.5$.

INTERSITE MAGNITUDE-YIELD BIAS EXEMPLIFIED BY
UNDERGROUND NUCLEAR EXPLOSIONS MILROW AND BOXCAR
(SDAC-TR-77-4)

Estimates of surface-wave and body-wave magnitude were made from available teleseismic WWSSN recording of nuclear shot BOXCAR, exploded at the Nevada Test Site (NTS), and MILROW, exploded at the Amchitka Test Site. Study of the magnitudes indicated that tectonic strain release was not a significant factor in the amplitudes of either set of waves from these shots. When averaged over common networks, and corrected for a slight yield difference, the BOXCAR m_b is approximately 0.3 less than the MILROW m_b , and the M_s of BOXCAR was approximately 0.5 larger than the M_s of MILROW.

A COMPARISON OF TELESEISMIC P-WAVE
AMPLITUDES AND SELECTED BASIN AND RANGE SITES WITH
AMPLITUDES AND SPECTRA OBSERVED IN EASTERN NORTH
AMERICA. PHASE I, FINAL REPORT
(SDAC-TR-77-7)

Three Seismic Data Collection System (SDCS) stations were deployed at the Nevada Nuclear Test Site (NTS) and two in the Eastern United States (EUS) to measure magnitude residuals and spectral differences. This deployment was intended to determine the degree of anelastic attenuation under the NTS. At the NTS sites, the higher frequency content of P waves is significantly less than in the EUS. Measurements at several other Western US sites yielded similar figures. These results confirm that body waves suffer considerable anelastic losses traversing the mantle under the Western US, including the NTS sites.

TELESEISMIC P-WAVE AMPLITUDES AND
SPECTRA AT NTS AND THE SHOAL SITE AS COMPARED
TO THOSE IN EASTERN NORTH AMERICA, PRELIMINARY REPORT
(SDAC-TR-77-9)

Three Seismic Data Collection System stations were deployed at the Nevada Test Site (NTS) to measure magnitude residuals and spectral differences relative to two Eastern United States (EUS) stations to determine the degree of anelastic attenuation under the NTS. At all NTS sites the high frequency content of P-waves is less than at RKON; the difference is statistically significant for two of three NTS stations and marginally significant for the third station. Measurements at the SHOAL site yield similar figures, showing lower high frequency content and lower magnitudes of P-waves relative to the EUS. These results are indicative of anelastic losses of body-waves traversing the mantle under both test sites.

A THREE-COMPONENT, SINGLE-STATION, MAXIMUM-LIKELIHOOD
SURFACE WAVE PROCESSOR
(SDAC-TR-77-14)

An entirely analytic single-station surface-wave processor is developed that analyzes long-period seismic records two orders of magnitude faster than real time on an IBM 360/44 computer. In processing four days of continuous synthetic data the algorithm detected 85% of the 170 signals of $S/N = 1/2$, with a false alarm rate of one per day. A novel detection theory is introduced that exploits the consistency of the azimuthal estimates associated with a sequence of detections.

TECHNICAL MEMORANDA

During the contract period, the following memoranda were completed and distributed:

- "Weekly Digital Tape Q.C.," dated 2 November 1976
- "NORSAR SPVF Fields Used in Plot Program", dated 19 November 1976
- "Spectra of Selected Nuclear Explosions", dated 30 November 1976
- "NORSAR DP Scaling and Conversion Factors", dated 3 May 1977
- "Thoughts on FSWF", dated 16 May 1977
- "Error in IBM Version of NETWORTH for the Long-Period Source, Station, and Source Station Magnitude Correction Table Input", dated 26 May 1977
- "Effects of Spall on m_b and M_s ", dated July 1977
- "Review of Evasion Research with Suggestions for Further Work", dated 15 July 1977
- "Monthly NEP Bulletin Evaluation", dated 15 July 1977
- "Cube-root Scaling of Decoupling Ratios", dated 19 July 1977
- "Noise Levels at Various SDCS Stations", dated 29 August 1977
- "Frequency Content of Signals at the Pahute Mesa Sites", dated 29 August 1977
- "Final Horatatory", dated 6 September 1977
- "Difference in M_s - m_b Populations", dated 12 September 1977
- " M_s correction in the case of a Near-Surface Strike-Slip Strain Release by an Explosion", dated 21 September 1977
- "Simulation of AFTAC Calibration Scheme for North American Net", dated 23 September 1977
- "A/D of Earthquake Santiago del Estero Province, Argentina", dated 26 September 1977

PAPERS CLEARED FOR PUBLICATION IN THE OPEN LITERATURE

- "The relationship between anelastic attenuation and regional amplitude anomalies of short-period teleseismic P waves in North America", Clearance received 1 April 1977

Presentations

"Automatic Analysts Tasks in Producing a Global Seismic Bulletin" --
Abstract Cleared 24 May 1977

"Analysis and Reduction of False Alarms at LASA", Clearance dated
24 May 1977

SPECIAL DATA COLLECTION SYSTEMS EVENT REPORTS

The purpose of the Special Data Collection Systems (SDCS) program is to routinely collect seismic data at five sites and to process the data as the client requests. The program also provides for special seismic data projects that the government directs.

SDCS-ER-105	Eastern Kazakh	09 June 1976
SDCS-ER-106	Kodiak Island Region	17 June 1976

VII. VELANET DEVELOPMENT

The objective of the work in this section is to create an automatic digital system capable of receiving, processing, and storing seismic data from remote recording sites. The system elements are the revised LASA Processing System (LASAPS), the Detection Processing System (DPS), and the Network Event Processor (NEP). This section summarizes the effort in task 4.6 in the Statement of Work.

Detection Processing System (DPS)

Development and refinement of the DP System continued. Work during the first months of the contract were confined to specifying the VELANET protocol and NORSAR transmission revisions and preliminary design of the implied software revisions. The goal was to develop a phased integration with the CCP; integration of the revised protocol in the DPS with the CCP was accomplished for most capabilities in May 1977. By June the integration of the protocol with BB&N was completed. The last phase of the contract work focused on achieving real time processing of Alaskan data; the DPS version that performs the detections was put on-line during September. The following itemize the results of the acceptance testing:

Capability	Date	Purpose
Individual Channel Scaling	06 Sept 77	to verify the algorithm for scaling in the routine XAEDIT
Filter Response	06 Sept 77	to illustrate the capa- bility of the bandpass filter and to verify the algorithm and its parameters.
Rectify, Integrate, and Threshold (RIT) Algorithm	06 Sept 77	To verify the process- ing parameters for the RIT algorithm.
The Detection Algorithm	06 Sept 77	to demonstrate the effectiveness of routine XAEP3R.

Network Event Processor (NEP)

NEP became fully operational early in the contract period and the Daily Earthquake Bulletin was produced routinely. Beginning in February the Bulletin reflected the addition of waveform analysis. Hardware modifications during the year including installation and acceptance of the E&S hardcopy device.

System development and testing continued during the contract period. The major software accomplishments were as follows:

- o the capability to transfer to the E&S screen waveforms associated with an event was established.

- o the capability to predict event arrivals was established.
- o revisions of the VELANET Protocol were made.
- o Commands for the alphanumeric terminal were completed.
- o The last Acceptance Test for the Minimum System was completed.
- o the implementation of the TRIX command to produce preliminary locations using three stations.
- o a large PAQ/EFW file area was developed together with changes to reduce the access speed and to improve the file integrity in the event of system failure.
- o an operational program library was built completely separately from the development library.
- o routines called by the table maintenance commands of the PAQ/EFW display were modified to speed up command execution.

In addition, documentation for the NEP project was completed and the draft of the Analyst's Guide was approved by VSC.

The following sections summarize accomplishments within the major tasks of the NEP project during the contract.

ARPCOM

System development continued through February, when it was halted and deleted from the contract following a design review meeting during that month.

Processing Task

Programming development continued during the contract. Additions and modifications are as follows:

- o programs to provide the analyst with information concerning epicentral and depth agreement were completed and integrated into the system.
- o the PDP-11 MACRO assembler language was enhanced with the addition of IF-THEN-ELSE, DO WHILE, and other structured statements. These changes resulted in reducing programming time and greater code readability for assembly routines and in core savings for some routines written in FORTRAN.
- o a unified scheme for storing data on either disk or extended memory was designed and implemented.
- o program specifications for modifications needed to incorporate the NORSAR EPX and NEIS detection lists into the PAQ were developed.
- o the overall design of the Automatic Association software was completed and distributed.

- o routines to reformat, sort, and incorporate the NEIS arrival data into the PAQ were completed and tested.
- o the PRINTSAQ program was modified to accommodate the new SAQ record format.
- o programs to prepare the PSWF file were specified, coded, and tested.
- o the command skeleton file COMMAND.NEP was completed.
- o a BATCH file generating program was written to aid in generating the NEP Graphics System.

During the development a PDP-11/05 was leased and used to reduce programmer contention for the 11/35.

The Analyst Task

During the contract, work continued on integrating the Analyst Task into the NEP system. Programming additions and modifications were as follows:

- o a debug print option scheme was implemented and installed that eliminated the need for two versions of several programs, thus simplifying the testing procedures.
- o the ability to predefine a set of commands and to invoke the set was implemented, tested, and provided to the analyst.
- o enhancements to the FIND initial command and the PREDICT INITIAL commands were developed.

Graphics Task

Development and enhancements of the NEP Graphics System continued during the contract year.

Programming changes and additions were as follows:

- o capabilities were checked out to the point of interaction with the 360 to: transfer waveforms, change PAQ and EWF records, delete PAQ and EWF records, and associate arrivals with events.
- o completed and tested for the fundamental capabilities of displaying menus, prompts, traces, trace alphanumeric data, and for processing tablet interaction for menu and trace selection.
- o other command capabilities were added to: Cancel, Exit, Move, Select Arrival, Delete Arrival, Vertical Gain Change, Remove Trace.
- o the ability to display up to eight traces on the ECD was added to the graphics task.
- o a utility program was introduced that shortened the process of recovering information from a disk failure.

- o a command to enter event location information used in a HYPO or FI was implemented.
- o the routine SCAN, which parses the data portion of the analyst's commands to make it more flexible for adding new command formats.
- o several Table Maintenance Commands were introduced to enable the analyst to build tables of information. The commands are: AT (Add to the tables); BT (build a table); CT (clear a table); and RT (remove the table); CW (clear waveforms).
- o the Focal Sphere Display was implemented and installed into the graphics task.
- o the time required to initialize the waveform file on the PDP-11 was reduced about 50%.

Alphanumeric Terminal

The commands to change, manipulate, and delete PAQ and EWF records were implemented. The commands to manipulate the event records were also completed.

Demonstrations were given throughout the contract in an effort to validate the software and to provide the government with insight visibility of the system's performance and capability. The following list summarizes these demonstrations:

DEMONSTRATION	DATE	PURPOSE
PDP-11 Macro Capability	9 May 77	To demonstrate that commands, DEF, ELIM, and END, which provide the macro capability, function as described in the NEP Design Plan.
Display of Eight traces on the ECD	19 May 77	To demonstrate the capability of displaying and manipulating eight traces simultaneously on the event calculator display (ECD).
ENTER EVENT INFORMATION FOR	10 May 77	To demonstrate the functioning of commands Enter Location (EL) and HYPO, utilizing the analyst entered location to start the HYPO process.
TRIX Command	6 Jun 77	To demonstrate the ability to determine starting event locations utilizing the TRIx algorithm.
Focal Sphere Display	5 Jul 77	To display the outline or background of the Focal Sphere Display.
ACCESS Data Volume	6 Jul 77	To demonstrate the increase data volume available with ACCESS.
FI Command Enhancements	8 Jul 77	To demonstrate the ability to do Find Initial arrivals utilizing the starting event location from TRIx, HYPO, ANALYST INPUT, and an existing event.

PI Command	10 Aug 77	To demonstrate the ability to predict initial arrival times for a set of stations and for a set of phases for each station, given an event.
Display Waveforms by Event	10 Aug 77	To demonstrate the capability to transfer and to add waveforms by event and page the waveforms on the E&S.
Complete Focal Sphere Display	26 Aug 77	To demonstrate the focal sphere projection, the magnitude/residual symbols, and all display control commands.
Automatic Association	30 Sept 77	To demonstrate the current status of the Automatic Association program.

The following documentation was delivered and accepted by the Project Office:

<u>DOCUMENT</u>	<u>CDRL</u>	<u>DATE</u>
a) Design Plan	A001	30 Jan 1977
b) Analyst Task Procedure	A002	4 Apr 1977
c) Operations Manual Revisions (Draft)	A004	15 Aug 1977
d) DP Systems Reference	A005	30 Sep 1977
e) Design Plan	A009	30 Jan 1977
f) NEP Users Guide (Revisions)	A00A	1 Jul 1977
g) Acceptance Test Results Manual	A00B	1 Mar 1977
h) System Description (NEP)	A00C	11 Jul 1977
i) System Specifications (NEP) Revisions	A00D	30 Sep 1977
j) Program Description (NEP)	A00E	30 Sep 1977
k) Analyst Task Procedures Manual	A00F	29 Aug 1977
l) Mass Store Data Retrieval Guide	A00G	2 May 1977
m) Operations Manual (Revisions)	A00H	14 Jul 1977
n) Maintenance Plan (Revisions)	A00J	14 Jun 1977
o) Computer Program Documentation	A00K	14 Nov 1977