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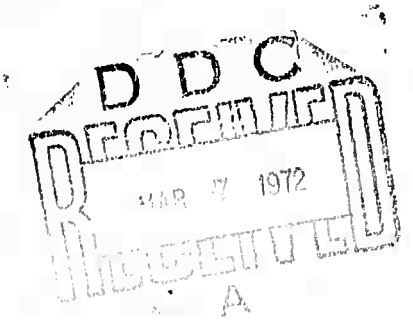
SEISMIC ARRAY ANALYSIS CENTER FINAL REPORT

W. C. DEAN
SEISMIC ARRAY ANALYSIS CENTER

31 JANUARY 1972



Prepared for
AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C.

Under
Project VELA UNIFORM

Sponsored by
ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No.1620

TELEDYNE GEOTECH
ALEXANDRIA LABORATORIES

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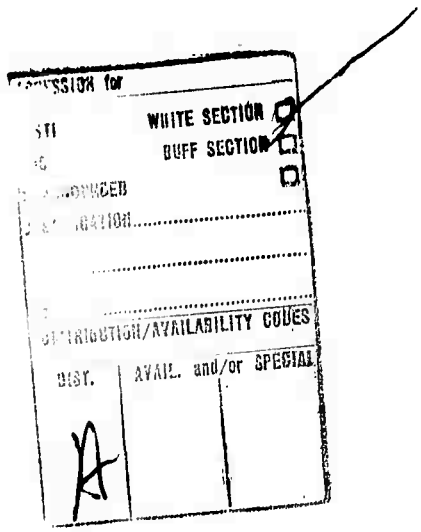

Unclassified

Security Classification

DOCUMENT CONTROL DATA · R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Teledyne Geotech Alexandria, Virginia	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

SEISMIC ARRAY ANALYSIS CENTER FINAL REPORT

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific

5 AUTHOR(S) (Last name, first name, initial)

Dean, W.C.

6 REPORT DATE 31 January 1972	7a TOTAL NO. OF PAGES ~~18~~ 21	7b NO OF REFS 6
8a CONTRACT OR GRANT NO. F33657-71-C-0510 b PROJECT NO. VELA T/1709 c ARPA Order No. 1620 dARPA Program Code No. 1F10	9a ORIGINATOR'S REPORT NUMBER(S) Final Report 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10 AVAILABILITY/LIMITATION NOTICES

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Nuclear Monitoring Research Office Washington, D.C.

13 ABSTRACT

14 KEY WORDS

Unclassified

Security Classification

SEISMIC ARRAY ANALYSIS CENTER

FINAL REPORT

31 January 1972

AFTAC Project Number:	VELA T/1709
Project Title:	Seismic Array Analysis Center
ARPA Order No.:	1620
ARPA Program Code No.:	1F10
Name of Contractor:	TELEDYNE GEOTECH
Contract No.:	F33657-71-C-0510
Effective Date of Contract:	1 December 1970
Amount of Contract:	$ 1,034,946
Contract Expiration Date:	31 December 1971
Project Manager:	William C. Dean (703) 836-7647

P.O. Box 334, Alexandria, Virginia

This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract F33657-71-C-0510.

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I. INTRODUCTION

The purpose of this report is to summarize the Seismic Array Analysis Center (SAAC) activities, results, and evaluation reports published under contract F33657-71-C-0510. The work statement for this contract is given in Appendix I.

SAAC facilities at 811-813 North Royal Street, Alexandria, Virginia were renovated and remodelled in December 1970 and January 1971 so that SAAC equipment, data, and materials, and IBM, Texas Instruments, and Teledyne Geotech personnel associated with SAAC could be moved on schedule during early January 1971.

Teledyne Geotech organized a team in December 1970 and January 1971 for the operation and evaluation of SAAC. Key members of this team were given access during December 1970 to the SAAC facilities at the Van Ness Center, Connecticut Avenue, N.W., Washington, D.C. for familiarization of SAAC equipment configurations and operational procedures.

The move of SAAC equipment data, and material began on schedule with the data shut down at 2100 GMT, December 31, 1970. Computer equipment was re-installed at the Alexandria facility from January 3 to January 10, 1971. System check out and test procedures were completed on schedule by January 15, 1971.

Teledyne Geotech took over operation of the system and started data recording and running the detection processor (DP-ISRSPS) on a 24-hour day,

7-day week basis as of 2300 GMT on January 15, 1971. We started publishing the LASA Daily Summary (earthquake bulletin) internally on February 1, 1971. We started distribution of the LASA Daily Summary to a government approved list of recipients on May 1, 1971.

II. EVALUATION

Our primary objective during 1971 was to evaluate the SAAC automated data acquisition and processing systems as developed by the Federal Systems Division of IBM on contracts F19628-67-C-0198 and F19628-68-C-0400. Only the latest version of IBM-SAAC programs, the Integrated Seismic Research Signal Processing System, (abreviated as ISRSPS) were evaluated.

The ISRSPS programs operated in two parts. The Detection Processor (DP) performs data acquisition and signal detection. The Event Processor (EP) is designed to recognize true signals and false alarms and to extract event parameters, refine locations, and publish an earthquake bulletin. The Event Processor is programmed to work either in an automated mode in which the computer analyzes events and publishes the bulletin without help from a seismic analyst, or to act as an aide to the analyst who can edit the event processing on a display console.

To evaluate the system effectively our philosophy was to operate SAAC as close to full time as possible, to utilize analyst editing on all events accepted by the computer, and to attempt to report all signals greater than our operating (signal-to-noise ratio) threshold, even during the swarms of aftershocks following a major earthquake. By operating full time we get a good measure of system reliability. By employing analyst editing on all events we gain, in addition to quality control of our bulletin output, a statistical comparison

of the automated system output with the bulletin output which the analysts are willing to accept. By attempting to report all events above our operational threshold we obtain a measure of the system detection/analysis threshold. Moreover we can determine whether the volume of signals above the seismic system threshold will saturate the equipment or analyst editing operations.

To evaluate the capability of the network of the three large long period arrays, we have used NORSAR, LASA and ALPA LP data to detect and measure the amplitude of Rayleigh waves associated with P-wave detections reported in the LASA and NORSAR Daily Event Summaries. There are two facets to this work. One is to perform the actual analyses and the other is to develop and implement suitable processing techniques so the data may be analyzed automatically within real-time.

We assumed that the short period detection threshold of LASA is inherently lower than the long period threshold of the three LP arrays. Hence, the LASA Daily Event Summary is used to predict times at which Rayleigh waves, associated with each reported event, would be recorded by the three large arrays. All the LP data from the three arrays are stored in multiplexed form on a common tape. Software has been developed to access this tape directly, edit the individual channels and perform frequency-domain beamforming to detect and measure the power of Rayleigh waves. Time domain beamforming and plotting are available for visual display.

III. EVALUATION RESULTS

Our evaluations of the SAAC system are presented in a series of technical reports. SAAC Report No. 1 (Dean, Ahner, and Chiburis 1971) presents a geophysical evaluation of the short period SAAC/LASA system and statistics on system performance and reliability as it operated from February 1 through May 16, 1971. SAAC Report No. 3 (Dean, 1971) describes the detection threshold of the short period LASA/SAAC system. SAAC Report No. 5 (Dean, in press) up-dates the short period geophysical evaluation given in SAAC Report No. 1 covering the period from February 1 through December 31, 1971. SAAC Report No. 7 (McCoy, in press) presents an equipment evaluation of the SAAC/LASA system for the period from February 1 through December 31, 1971. SAAC Report No. 4 (Mack, 1971) and SAAC Report No. 6 (Mack, in press) present an evaluation of the long period array network of LASA, ALPA, and NORSAR.

SAAC was recording and detecting signals on LASA data (DP) 91.3% of the time from January 15 through December 31, 1971. For the period July 1 through December 31, 1971 SAAC recorded LASA data for 97% of the time. Of the 3% downtime from July 1 through December 31, 1971, outages of the 50 kilobit telephone line accounted for 2% and scheduled preventive maintenance nearly 1% with hardware, software, and other problems accounting for significantly less than 1%.

The LASA Daily Summary (earthquake Bulletin) listed 6,944 events from February 1 through December 31, 1971. The

system performance improved throughout the first half of the year so that an average of 171 events per week were listed from May 1 through December 31, 1971 (Dean et al., SAAC No. 1; SAAC No. 3; SAAC No. 5).

The offline computer (IBM 360/40B) performed event analysis (EP) on all but 62 hours (less than 1%) of data recording hours from March 1 through December 31, 1971. During the last six months the event analysis (EP) time lost was 4.5 hours or 0.1% of the time LASA data was recorded (McCoy, SAAC No. 7, in press).

Time required by an analyst on the EP display console to edit the events accepted by the EP-computer averaged 4 to 5 hours per day. From February 1 through December 31, 1971 there were seven active days requiring 10 to 14 hours of analyst editing on the display console (McCoy, SAAC No. 7, in press).

For long period analysis a fast frequency domain beamforming approach has been developed which operates at approximately 3 to 4 times real-time with continuous data on the SAAC computers. The output is a continuous listing of coherent detections showing velocity, azimuth, signal power, and signal-to-noise ratio. Small signals crossing the LP arrays in the presence of larger ones can be detected by a recently developed wavenumber filtering scheme which strips away the effect of the larger signal (Mack, SAAC No. 4; SAAC No. 6).

IV. SUMMARY OF DATA SERVICES

Data services provided by the SAAC during 1971 fall into two categories, magnetic tape library services and magnetic tape data services. Magnetic tape library services involve the cataloging and storage of magnetic tapes generated by the SAAC system, magnetic tapes saved in archives, and special data and program tapes for SAAC personnel and other contractors. Over 14,000 magnetic tapes comprise the library of which approximately 3,200 are archives, 1000 computer center users' programs and special data tapes, and the remaining 10,000 contain data less than one year old.

Approximately 25 tapes per day enter the library mostly to record raw data and 20 tapes are made available through the process of data retention, the process by which raw data tapes are purged of data older than the retention date.

Magnetic tape data services provide organizations outside the SAAC with data available at the SAAC. In 1971, SAAC filled 393 requests through the Seismic Data Laboratory (SDL):

ALPA Long Period Data	196	requests
LASA High Rate Data	40	"
LASA Low Rate Data	50	"
NORSAR Short Period Data	73	"
NORSAR Long Period Data	34	"

In addition the following 546 requests were filled directly for Lincoln Labs:

ALPA Long Period Data	28	requests
LASA High Rate Data	29	"
LASA Low Rate Data	321	"
NORSAR Short Period Data	23	"
NORSAR Long Period Data	26	"
LASA Event Tapes	91	"
NORSAR Event Tapes	28	"

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Mack, H., 1971, Evaluation of the large array long period network: SAAC Report No. 4, Teledyne Geotech, Alexandria, Virginia.

Mack, H. (in press), 1972, Evaluation of LASA, ALPA, NORSAR long period network: SAAC Report No. 6, Teledyne Geotech, Alexandria, Virginia.

McCoy, E.B. (in press), 1972, SAAC (LASA) equipment and software performance: SAAC Report No. 7, Teledyne Geotech, Alexandria, Virginia.

APPENDIX I

STATEMENT OF WORK TO BE DONE

(AFTAC Project Authorization No. VELA T/1709/S/ASD)

a. The contractor shall provide for approximately 23,000 square feet of floor space at 811-813 North Royal Street, Alexandria, Virginia. The following stipulations shall apply:

(1) A minimum 1-year lease, to start not earlier than 1 December 1970, nor later than 1 January 1971, with a yearly renewable option for a minimum of two additional years.

(2) The lease shall contain provisions authorizing assignment, including any remaining options, to any party which the Government might designate to continue this effort subsequent to Calendar Year 1971.

(3) Provided, however, that nothing herein is neither intended nor shall be construed as obligating the Government to assume or cause any third party to assume the aforementioned lease and provided further that costs incurred by the contractor for any obligation it may assume thereunder for payment of rentals for continuance of the lease beyond the period of performance of this contract or for termination of the said lease in lieu of continuance beyond the said period shall not be considered allowable items of cost under this contract.

b. The contractor shall familiarize key personnel with operations of the Seismic Array Analysis Center (SAAC) at the Van Ness Center, 4301 Connecticut Avenue, N.W., Washington, D.C. Arrangements for entrance to this

facility will be obtained by the Government.

c. The contractor shall provide for the relocation of all GFP, listed in Addendum 1 of this RFQ, from 4301 Connecticut Avenue, N.W., Washington, D.C., to 811-813 North Royal Street, Alexandria, Virginia, and the reinstallation of all GFP at 811-813 North Royal Street. The following subtasks are directed sole source procurements from International Business Machines Corporation/Federal Systems Center.

(1) Provided, under the terms and conditions of the current GSA/IBM contract, customer engineering services, to disassemble, reinstall, and test the IBM standard commerical equipment at SAAC. Provided cartons for magnetic tape reels in the data library.

(2) Disconnect and remove all severable Government property except pedestals for the raised floor, power panels, and cabling from commerical power through power transformers to power panels. Move the Government property to 811-813 North Royal Street, Alexandria, Virginia. Reinstall the special computer room equipment (floor panels, develocorders, special process system experimental operations console) and data tape library. Move all IBM standard commerical equipment. Unit test the special equipment, and then verify system operation by repeating selected system tests. (Reinstallation of air conditioners, electrical equipment and plumbing is not included.)

d. Operate the SAAC on a 24-hour-day, seven-day-week basis, on a full-time basis starting not later than

15 January 1971. Included in this task are the following:

(1) Operate all Government-furnished property and maintain, and keep in serviceable condition all Government-furnished property, except the rental equipment provided under GSA/IBM contract.

(2) Record and store all incoming data from the large research arrays: the Large Aperture Seismic Array (LASA), the Alaskan Long-Period Array (ALPA), and the Norwegian Seismic Array (NORSAR).

(3) Operate on-line short-period detection processor (DP) for LASA data.

(4) Operate on-line long-period processor and display ALPA data.

(5) Operate off-line processor (EP) for detections from the on-line DP (Task d (3)).

(6) Make recommendations for modification to equipment as required and effect such modification as approved.

(7) Maintain and update all operational and maintenance manuals associated with the operations of the SAAC.

(8) Update and maintain digital computer programs developed under ESD Contract F19628-68-C-0400 for on-line processing of seismic data from the LASA, ALPA, and NORSAR data links.

(9) Transmit technical, processed, recorded, and real-time data to users as scheduled or required.

(10) Provided technical support and computer services

for up to 15 personnel of Texas Instruments, Inc., in residence at SAAC performing under Contract F33657-69-C-1063 and follow-on to Project VT/9707. Computer time provided will be not more than 25 percent of available IBM Computer 360/44 time, averaged over a one-month period, and 15 percent of DP on-line IBM 360/40 computer time.

(11) Provided technical support and computer services through 30 June 1971* for up to 23 IBM personnel in residence at SAAC under Contract ESD F19628-68-C-0400 and follow-on contract. Computer time provided will be not more than 40 percent of available IBM Computer 360/44 time averaged over a one-month period.

(12) Provided technical support and computer services to scientific investigators and Government representatives after coordination through the project officer.

(13) Publish and disseminate via teletype (see Data Item A011, DD Form 1423) the LASA daily event summary.

e. Evaluate and modify, after technical liaison with the project officer, the existing SAAC automated data acquisition and processing systems developed under Contract F19628-68-C-0400 and follow-on effort.

f. Investigate short-period network processing techniques using LASA and NORSAR. Included in this task is the evaluation of the NORSAR short-period array as a function of configuration, geographical and geological environment, detection threshold, background noise, etc.

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*Extended through 31 December 1971.

g. Evaluate the network detection and discrimination capability of the three long-period arrays: LASA, ALPA, and NORSAR.

h. Provided up to 25 man-months of research effort directed toward the definition and performance of approved experiments indentified by AFTAC/VELA Seismological Center.