

UNCLASSIFIED

AD NUMBER

AD863984

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

**Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; 14 JAN 1970.
Other requests shall be referred to Defense Advanced Research Projects Agency, Arlington, VA 22203.**

AUTHORITY

USAF ltr 3 Mar 1972

THIS PAGE IS UNCLASSIFIED

AD 863984

SEISMIC DATA LABORATORY
QUARTERLY TECHNICAL SUMMARY REPORT

OCTOBER - DECEMBER 1969

14 JANUARY 1970

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

By
SEISMIC DATA LABORATORY

Under
Project VELA UNIFORM

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 624



This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC

Handwritten signature: Miranda, V. B. B.

**BEST
AVAILABLE COPY**

SEISMIC DATA LABORATORY
QUARTERLY TECHNICAL SUMMARY REPORT
October - December 1969

AFTAC Project No.:	VELA T/9706
Project Title:	Seismic Data Laboratory
ARPA Order No.:	624
ARPA Program Code No.:	9F10
Name of Contractor:	TELEDYNE INDUSTRIES, INC.
Contract No.:	F33657-69-C-0913-PZ01
Date of Contract:	2 March 1969
Amount of Contract:	\$ 2,000,000
Contract Expiration Date:	1 March 1970
Project Manager:	Royal A. Hartenberger (703) 836-7647

P. O. Box 334, Alexandria, Virginia 22313

AVAILABILITY

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC.

This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM and accomplished under technical direction of the Air Force Technical Applications Center under Contract F33657-69-C-0913-PZ01.

Neither the Advanced Research Projects Agency nor the Air Force Technical Applications Center will be responsible for information contained herein which may have been supplied by other organizations or contractors, and this document is subject to later revision as may be necessary.

TABLE OF CONTENTS

<u>SECTION</u>		<u>PAGE NO.</u>
	ABSTRACT	
I	INTRODUCTION	1
II	WORK COMPLETED	1
	A. The Long Shot Experiment	1
	B. Rayleigh Mode Synthesis and Analysis at a Typical Vertical Array Site	2
	C. Intrinsic Redundancy of Seismic Data	2
III	SUPPORT AND SERVICE TASKS	4
	A. Data Cataloging, Classifying, and Retrieval	4
	B. Equipment Modifications	5
	C. Maintain and Operate Equipment	5
	D. Digital Programming	5
	E. VELA and PRIME ARGUS Data Copies	8
	F. Analog Tape Compression	9
	G. LASA Data Service	9

ABSTRACT

This report summarizes the work done by the SDL during the period October through December 1969, and is primarily concerned with seismic research activities related to the detection and identification of nuclear explosions and earthquake phenomena. Also discussed are the support tasks and data services performed for other government contractors and participants in the VELA-Uniform and PRIME ARGUS projects.

I. INTRODUCTION

This quarterly report summarizes the technical work, support effort, and service tasks completed during the period October through December 1969. Current and past work are mentioned only if related to the present discussions.

Reviews of technical reports completed during the reporting period are contained in Section II under descriptive headings. Section III is a summary of the support and service tasks performed for other government contractors, and for VELA-Uniform and PRIME ARGUS participants.

II. WORK COMPLETED

A. The Long Shot Experiment

The purpose of this study is to document in a single comprehensive report the important results relating to the location and identification of underground nuclear explosions obtained from the LONG SHOT experiment. This synthesis has involved not only the collection of basic observations from LONG SHOT and critical review of previous work based on LONG SHOT data, but also considerable additional data analysis to aid in the overall interpretation of LONG SHOT results.

The report is contained in two volumes. Volume I presents the basic observational data obtained for all the available stations which recorded the LONG SHOT event. To illustrate the quality of seismic recordings from LONG SHOT obtained throughout the world, reproductions of a large number of seismograms are included. In addition, Volume I contains a complete bibliography of publications which deal with LONG SHOT.

Volume II presents a comprehensive analysis of the LONG SHOT explosion including both near-source and far-field observations. It is written and illustrated such that frequent reference to Volume I is not required. Included are discussions of the physical setting of LONG SHOT, near-source behavior, and location and magnitude estimates. We have also applied the principal identification criteria to LONG SHOT in an effort to assess the effectiveness of each diagnostic for this source region. In addition we compare LONG SHOT directly with equivalent magnitude earthquakes from the same source region to elucidate their differences and similarities.

It is hoped that this comprehensive report will serve as a point of departure for future work both on LONG SHOT and the Aleutian Arc source region and that it will aid in evaluating any future experiments in other localities.

B. Rayleigh Mode Synthesis and Analysis at a Typical Vertical Array Site

The purpose of this study was to provide a reference for identifying Rayleigh modes recorded in vertical arrays. A Canadian Shield model consisting of plane-parallel homogeneous layers was used to synthesize the Rayleigh wave normal modes. Our procedures included the computation of frequency-wavenumber and impulse seismogram patterns. Also included in the report are eighty-four figures illustrating 3-dimensional plots of depth-frequency-amplitude variation of the Rayleigh modes, power spectra, and spectral ratios.

C. Intrinsic Redundancy of Seismic Data

The object of this investigation was to determine the intrinsic redundancy of seismic data. Redundancy in a time series is defined as the existence of data points which may be derived, within a given precision, from neighboring data points by some simple interpolation procedure. If redundancy is of sufficient magnitude, economic and operational benefits can be obtained. Our approach was to select a redundancy reduction algorithm, apply this algorithm to various types of seismic data recorded at the Tonto Forest Seismological Observatory, reconstruct the data by interpolation and observe the effects of the process on the time function and its frequency spectrum.

The report describes the historical background and philosophy of redundancy reduction of data, as well as the advantages that may accrue from this type of processing before data transmission or storage. Under ALGORITHMS AND DEFINITIONS are given possible algorithms and definitions; the algorithm chosen for use in this study is discussed in detail. The results are given under RESULTS and conclusions are set out as follows:

Based upon a representative set of five seismograms, each 1000 points long, and a wide range of sampling errors for each time series. The redundance factors are sufficiently large

over most of the examples to warrant further work, and that whenever seismic data is to be transmitted over communication lines or to be recorded, redundancy techniques should be considered.

It has been observed that the redundancy factor R is a function of the noise level and frequency, therefore, when systems are designed to obtain the benefits of redundancy reduction, each system will be optimized on an individual basis.

The net redundancy reduction factor for Tonto Forest is considered to be approximately 3 after all allowances are made for time and channel labelling. Gross redundancy exceeded 5.

III. SUPPORT AND SERVICE TASKS

In addition to the research described above, the SDL performed certain service tasks as follows:

A. Data Cataloging, Classifying, and Retrieval

The library contains digitized seismograms, digital and analog magnetic tapes, as well as 16- and 35-mm film data. Station logs corresponding to each data set are arranged chronologically by stations either in looseleaf binders or in file cabinets.

At the end of the fourth quarter the library contained approximately:

- 13,459 digitized seismograms;
- 4,760 digital magnetic tapes;
- 29,769 analog magnetic tapes;

as well as 16-mm film data recorded at seismic observatories during the period September 1960 to the present, and 35-mm film data recorded at LRSM stations during the interval September 1961 to the present. The increase in digital tapes reflects a transfer of the LASA Data file.

Although the proportion of digital tapes assigned to a specific function changes constantly, the library consisted of the following groups at the end of the reporting period:

- 258 UBO multiplexed
- 37 UBO demultiplexed
- 1,897 LASA multiplexed
- 405 LASA demultiplexed
- 780 TFO-37 multiplexed
- 72 TFO-37 demultiplexed
- 70 TFO permanent save field tapes
- 40 Systems
- 1,201 Scratch, save, and A/D.

A complete updating of the entire seismogram index file is in progress, and an inventory of all in-house production programs is complete.

The analog magnetic tape library consisted of the following groups:

- 8,526 compressed
- 3,380 uncompressed (6 months intentional backlog)
- 482 composites
- 17,381 save.

B. Equipment Modifications

During the quarter we modified the analog playout system to eliminate excessive set-up time and to yield precisely calibrated outputs.

C. Maintain and Operate Equipment

Equipment maintenance engineers were on duty two full shifts each day and were on standby for the remaining shift. During the reporting period their tasks included preventive and corrective maintenance.

Preventive maintenance was performed daily on all equipment in accordance with equipment maintenance manuals. The digital system received three additional performance checks on a monthly basis.

Prolonged corrective maintenance was performed on the main frame of the 1604-B computer and the disk file. We have ordered several bearings, disks, and heads for the disk file to replace worn out units.

D. Digital Programming

The following programs were written during the fourth quarter of 1969.

SEPARATE - This program computes the difference of two F-K spectra and plots a contour map of the difference.

FKBLAND - This program is a modification of FKNORM. The modifications allow the user to set the range of FKX and FKY to arbitrary values.

LONGCOPY - Copies a tape which has 6000 word data records and 4 word header records. (- such as the T.I. calibration tapes).

RAYPATH - This program was written originally in FORTRAN II for operation under SCOPE monitor on a CDC 3100 computer system, and is now converted to FORTRAN 63 for use on 1604. This program was designed to trace rays in geologic structures which can be described by sets of arbitrarily oriented planes separating regions of constant velocity.

LISTSEIS - This program is designed to read any SDL tape and list each seismogram label by determining if the tape is in current SDL Unpacked or Packed Data Formats and to select the correct format for each label printed.

BEAMSAN - This program is a revision of LASAN which reads fast mode Lasa data and detrends, demagnifies, computes RMS on a specified noise interval, obtains maximum peak-to-peak amplitude, computes ratio of signal-to-noise, forms an unphased and phased sum of individual channels of each subarray, obtains the $(P-P)^2$, RMS, and S/N ratios of each sum and has three filtering options.

EFUNCS - Computes values of 3 exponential f^{ns} .

ARRAYCAL - Computes counts/micron from the instrument calibrations of any array data in SDL format.

PSPZPLOT - Plots two channels of seismic data using the same scale factor.

CONVOLVE - Records on a subset tape and plots two channels of seismic data and a third channel formed from one of the input channels convolved with impulse response data.

MAGFIND - Computes distance correction factors according to the various formulas.

COMPMAG - Computes two versions of unified magnitude using the formulas: (1) $M_1 = \log_{10} (A/T) + B$ and $M_2 = \log_{10} (A/T) + BB$. This is done for a number of cases and the sum, mean magnitude, and standard deviation are computed for each formula.

PRNTMIS - Reads in a series of tape numbers from cards and prints out the missing numbers.

PRNTKARD - Reads a binary tape consisting of blocked BCD card images and prints these card images out.

The following programs were modified during the reporting period.

TESTUNK - This program was modified to plot only a select portion of an input trace.

CONVOLVE - This program was modified to compute and plot the difference between the input trace and the convolved trace normalized by the ratio of the rms (root mean square) of both traces.

MERGSEIS - This program was modified to accept input from two different tapes.

TODOIT - This routine was modified to handle data from special SDL library tapes written with 50 channel headers by program MERGSEIS. It was further modified to create plot data for the Calcomp 763 and 565 plotters.

The following subroutines were written during the reporting period.

RECT - This subroutine uses the Calcomp Plotter to draw rectangles.

CIRCLE - This subroutine draws a circle, arc, or spiral starting at a given point with either a solid or a dashed line.

CURVEX - This subroutine plots a function of X over a given range.

CURVEY - This subroutine plots a function of Y over a given range.

CLIPS - This is a Calcomp Plotter subroutine used to draw an ellipse or elliptical arc.

FIT - This is a Calcomp Plotter subroutine used to fit three points to a semihyperbolic curve.

SCALE - This subroutine scales array of values for Calcomp Plotter.

POLY - This subroutine draws equilateral polygens or n-pointed stars on Calcomp Plotter.

LGLINE - This is a Calcomp Plotter subroutine used to plot data in either log-log or semi-log mode.

LGAXIS - This is a Calcomp Plotter subroutine used to draw a log logarithmic axis with annotation in powers of ten and annotation of intermediate values of cycle is greater than two inches.

GRID - This subroutine uses Calcomp Plotter to draw grids.

DASHPT - This subroutine uses Calcomp Plotter to draw dashed lines between 2 points.

AXIS - This subroutine uses Calcomp Plotter to draw axes.

RESUBPK - This is a package of subroutines to solve a system of differential equations.

E. VELA and PRIME ARGUS Data Copies

During the period 01 March 1969 through December 1969, the SDL supplied data services to the following:

Air Force Office of Scientific Research
Lawrence Radiation Laboratory
Pennsylvania State University
University of California
MIT, Lincoln Laboratory
Geotech, Garland
U.S. Coast & Geodetic Survey
U.S. Geological Survey
National Aeronautics and Space Administration (NASA)
University of Michigan
Stanford Research Institute
Brown University
Princeton University
Environmental Science Services Administration (ESSA)
St. Louis University
University of Texas at Dallas
Lamont-Doherty Observatory
Southern Methodist University
University of Western Ontario
University of Alaska

F. Analog Tape Compression

During the fourth quarter of 1969, we compressed 2223 field tapes and returned 2499 degaussed tapes to the field.

G. LASA Data Service

LASA weekly event summaries as well as film and tape copies were made and distributed. During the interval 01 March 1969 through December 1969, the SDL supplied LASA and LAMA data copies to the following:

U.S. Geological Survey
Isotopes
MIT, Lincoln Laboratory
Stanford University
University of Wisconsin
University of Michigan
Air Force Office of Scientific Research
St. Louis University
Southern Methodist University
New Mexico Tech
University of Bergen, Norway
University of Western Ontario
Seismic Array Analysis Center (SAAC)
Air Force Technical Applications Center (AFTAC).

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 INDUSTRIES, INC.
ALEXANDRIA, VIRGINIA

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

SEISMIC DATA LABORATORY
QUARTERLY TECHNICAL SUMMARY REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific

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

Hartenberger, R.A.

6. REPORT DATE

14 January 1970

7a. TOTAL NO. OF PAGES

13

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

F33657-69-C-0913-PZ01

8. PROJECT NO.

VELA T/9706

c. ARPA Order No. 624

d. ARPA Program Code No. 9F10

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

ADVANCED RESEARCH PROJECTS AGENCY
NUCLEAR MONITORING RESEARCH OFFICE
WASHINGTON, D. C.

13. ABSTRACT

the
This report summarizes the work done by the SDL during the period October through December 1969, and is primarily concerned with seismic research activities related to the detection and identification of nuclear explosions and earthquake phenomena. Also discussed are the support tasks and data services performed for other government contractors and participants in the VELA-Uniform and PRIME ARGUS projects. ()
↑

14. KEY WORDS

Seismic Data Laboratory - Quarterly
Technical Summary
VELA-UNIFORM Project

Unclassified

Security Classification