AD NUMBER

AD482046

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited. Document partially illegible.

FROM:

**Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; MAR 1965. Other requests shall be referred to Air Force Tactical Air Command, Washington, DC 20025. Document partially illegible.**

AUTHORITY

usaf ltr, 25 jan 1972

TEXAS INSTRUMENTS
INCORPORATED
100 EXCHANGE PARK NORTH • DALLAS, TEXAS
SCIENCE SERVICES DIVISION

(11) 10 March 1965,

(12) 12 p.

Headquarters
United States Air Force
AFTAC/VSC
Washington, D. C. 20025

Subject: (9) Monthly Report, No. 15, 25 Jan-25 Feb 1965,

Identification: (16) AFTAC VT/4053
(6) Array Research,
ARPA Order No.: 104-60
ARPA Project Code No.: 8100
Name of Contractor: Texas Instruments Incorporated
Date of Contract: 13 November 1963
Amount of Contract: $1,023,805
Contract Number: (15) AF 33(657)-12747, ARPA Order 104-60
Contract Expiration Date: 31 December 1965
Program Director: (10) Milo Backus,
Fleetwood 7-4311, Ext. 319
Dallas, Texas

GENERAL

Project VT/4053 is directed toward the continued development of array processing technology for nuclear surveillance and the exploitation of the superior data available from arrays for the analysis of distant P waves.

WORK PROGRESS

(1) UBO Vertical Array Data Analysis

In the previous month two complete sets of correlation functions (one for signals and the other for noise) for a six seismometer vertical array was built up from numerous UBO recordings where only two depths were recorded at a time. Plots of these correlation functions are

very interpretable. The signal autocorrelations for the deeper seismometers have symmetrical side peaks corresponding to the correlation between the up and down traveling signals. The crosscorrelations between two depths often split up into four peaks corresponding to the correlation between the signal and its reflection at one seismometer and the signal and its reflection at the other. The noise correlations tend to show similar features.

The signal and noise correlations were input into the MCF time domain program. However, the program gave a negative mean-square-error for a very short filter indicating that the correlation matrix was not positive definite, i.e., was not in fact a possible correlation matrix. This result is due to building the matrix up from piecemeal recordings and not from simultaneous 6 seismometer recordings. Since the frequency domain MCF synthesis program is less sensitive to poor data, Fourier transforms of the correlations are being made and the auto and cross-power spectra will be used to attempt to design multichannel filters.

(2) Array Research Horizontal and Vertical Arrays for Teleseismic Signal Enhancement: UBO Model Theoretical Results Special Report No. 6.

This report was shipped out during this reporting period. The main result of this report is that theoretically a horizontal array is better than a vertical array in extracting vertically traveling signals from normal mode noise.

(3) Grapevine Recording of Vertical Array

The plans are to record data from the Geotech Grapevine vertical array during the period of 3 March to 13 March 1965.

(4) Signal and Noise Analysis at TFO

Frequency and wave number spectra of an equalized teleseism from Honshu, Japan, have been obtained where the teleseism was whitened before computing the correlation and cross-power functions. The frequency biasing problem, mentioned in monthly letter report no. 10, was eliminated, the f and $\vec{k}$ plots closely resemble a time shifted version of the straight sum power response of the array.

In monthly report no. 13, a long noise sample from TFO made up of 10 consecutive 2 minute samples to form a 20 minute noise sample was discussed. This combination has been made and all possible correlation functions ($\pm$ 61 lags) from 26 channels (cross array plus ring sums)

TFO have been computed. These 351 correlations are being transferred from TIAC to the IBM 7040 through an IBM tape unit on TIAC. A plot of all these correlations was made on a Calcomp plotter before a transfer program error was discovered. However, the correlations look good and will be used in the time domain MCF program to design additional filter systems with this statistically accurate data. F and $\vec{k}$ plots from this data will be made in the near future.

(5) Confirmation of WMO Calibration

In the Array Research Semiannual Technical Report No. 2, 15 November 1964, p. III-2 in which a uniform worldwide level of mantle P-wave noise was postulated, the measurement from WMO (straight summation power spectrum which would suppress non-mantle p wave noise) was too high (about 6 db) to fit the postulated theory nicely. Attached to this monthly letter is the results of a new calibration of the WMO noise which still agree with those reported before. Thus, the WMO noise, although not refuting the worldwide postulate, does not lend it much support.

(6) Direct Correlation Matrix Generator for Theoretical Models

The correlation matrices generated by this program have been successfully run in the multichannel time domain program for disk and annular f and $\vec{k}$ models.

ACTION REQUIRED BY AFTAC

None.

Yours truly

Milo Backus
Program Director

MB/JB:hn

ABSOLUTE SCALES FOR WMO NOISE

I. INTRODUCTION, SUMMARY, AND CONCLUSIONS

It has been postulated that there is a worldwide level of mantle P-wave noise which has an absolute power spectrum slightly less than the power spectrum output of the average of the 31-seismometers at TFO. This is based on noise studies at CPO and TFO. However, a calibrated output derived from the average of the ten JM seismometers at WMO has been found to have a power level higher than that postulated for the worldwide level of mantle P-wave noise, as mentioned in reference number one.

A further independent investigation into the absolute power level of the WMO noise has been conducted, and the results confirm those obtained previously as reported in reference number one.

In order to eliminate certain possibilities of error, analysis was performed on a single recording which contained both a seismometer calibration and the noise sample. The calibration was analyzed to obtain a transfer function relating mμ ground motion to recording units, and then the power density spectrum of the noise was computed in $(\text{units})^2/\text{cps}$.

It has been concluded that the results previously obtained for WMO are substantially correct, provided field recording logs are correct, and are being properly interpreted. It should be noted in passing

---

[1] Array Research Semiannual Technical Report No. 2, 15 November 1964, p. III-2.

that these recordings were some of the first made by TI using the modified Digital Field System.

II. PRESENTATION OF EXPERIMENTAL RESULTS

Figure II-1 shows the power density spectrum of WMO noise sample number 7, seismometer Z10. This sample was recorded on 27 April 1962, during the recording of a set of calibrations. The start time of the recording was 15 59 50 GCT. The noise sample itself began 290.88 seconds later and was 138 seconds in length.

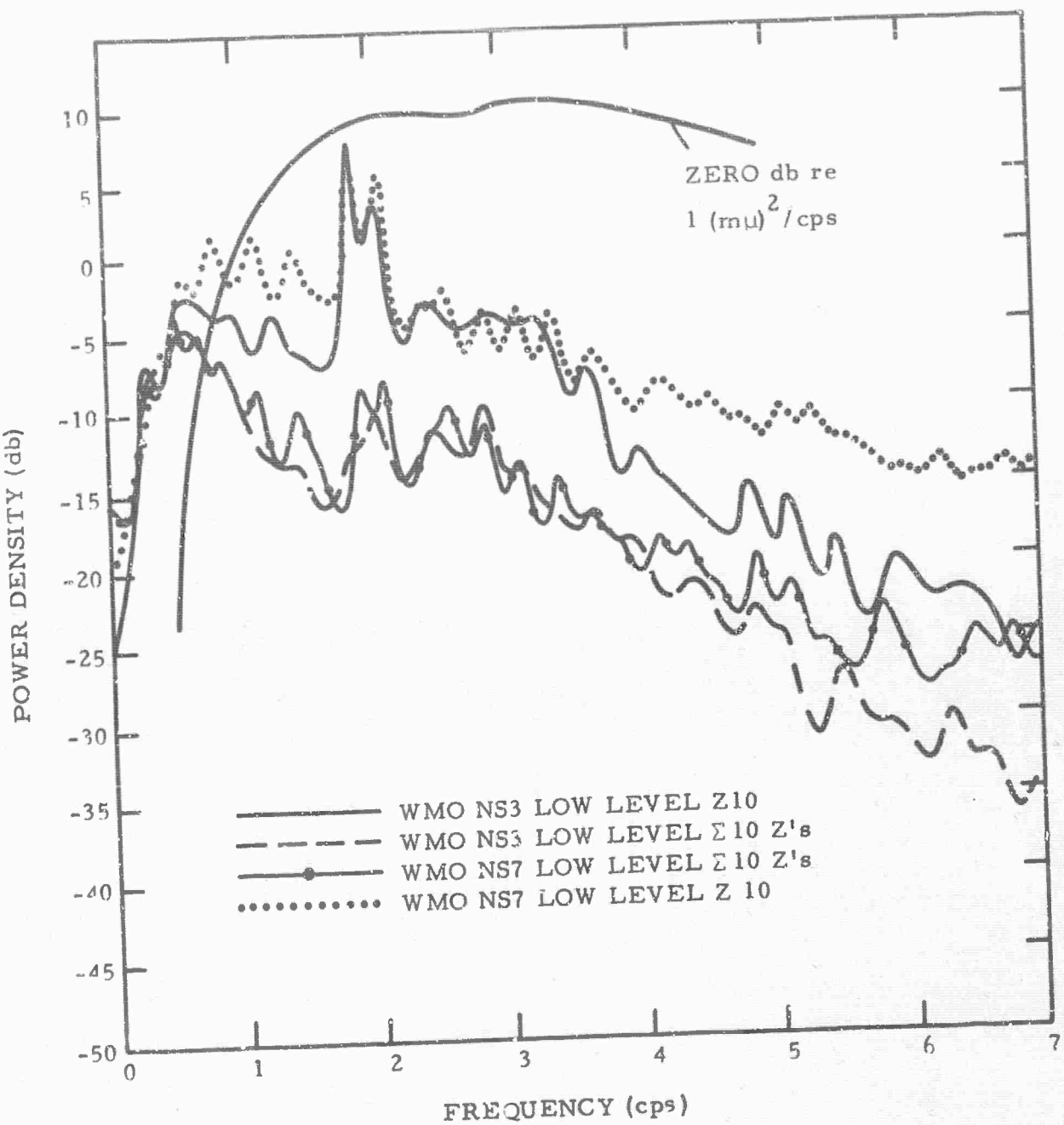
Calibration analysis results for this data have been published previously[2], and were the results used to assign the absolute scales to both noise sample 3 and noise sample 7. The difference between the two processes was that NS7 was recorded during the calibration procedure, whereas NS3 was recorded at a later time.

Figure II-1 also shows the power density spectrum of a simple seismometer average process on NS7.

The power density spectra obtained previously (1, p. II-2) for NS3 are shown for comparison. Good agreement is seen for the single seismometer spectra in the region between 1.8 and 3.5 cps. Also, there is good agreement between the summation outputs in the entire frequency range below 4.5 cps.

---

[2] Array Research Multichannel Filter Systems for Tonto Forest Observatory, Special Report No. 2, Appendix A, p. A-3.


POWER DENSITY (db)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
1
2
3
4
5
6
7
FREQUENCY (cps)
ZERO db re
1 (mμ)^2/cps
WMO NS3 LOW LEVEL Z10
WMO NS3 LOW LEVEL Σ10 Z's
WMO NS7 LOW LEVEL Σ10 Z's
WMO NS7 LOW LEVEL Z 10

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No. 104-60
2. Project: Array Research VT/4053
3. Component
4. Name and Location of Preparing Activity:
   Texas Instruments Incorporated
   Science Services Division
   P. O. Box 5621
   Dallas, Texas 75222
5. Contract Number: AF 33(547)-12747
6. Report for Month Ending: 25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
1	In Core Large Time Domain Filter Design Program Operational	1 May 1964	6 June 1964	6 June 1964	
1	S/N Improvement Analysis Program Operational	15 June 1964	Revised approach		
1	Direct Correlation Matrix Generator for Theoretical Models	1 August 1964	15 Feb. 1965	15 Feb 1965	Necessary complete correlation edit for time domain program in more precise manner.
2	Detection Processor Design Computer Program Feasibility Established	15 Mar. 1965	15 Apr. 1965		
2	Topical Report: Detection Theory	31 July 1964	1 Dec. 1964	3 Dec. 1964	Obtaining processing examples to illustrate theory
2	Inverse Matrix Program	Jan. 1965	30 Apr. 1965		
2	Detection Processor; Matrix Multiplication Technique	Feb. 1965	15 May 1965		
2	Time Series Generator and Theoretical Evaluation Program	Mar. 1965	30 May 1965		

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No. 104-60
2. Project: Array Research VT/4053
3. Component:
4. Name and Location of Preparing Activity:
   Texas Instruments Incorporated
   Science Services Division
   P. O. Box 5621
   Dallas, Texas 75222
5. Contract Number: AF 33(547)-12747
6. Report for Month Ending: 25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
2	Preliminary Report on Applying Matrix-Multiply Detection Processing to Recorded Array Data	May, 1965	30 June 1965		
2	Eigenvalues and Eigenvectors Program (Conditional)	July 1965			
2	Detection Processor; Filtering and Squaring (Conditional)	Aug. 1965			
2	Final Report on Detection Processing Evaluation (Conditional)	Dec. 1965			
3	Topical Report: 3 Dimensional Spectral Analysis Teleseismic Signal & Noise TFO	3 Aug. 1964	15 Nov. 1964 (Noise) 15 Dec. 1964 (Signal & Summary)	15 Dec. 1964	TFO MCF and wind noise study preceding this task. Work extended to obtain estimates from deconvolved data.
3	Report on the Design of Velocity Filters for CPO, TFO and WMO	Feb. 1965	15 May 1965		
3	Production Multichannel Filtering Program	Feb. 1965	15 May 1965		
3	Initial Simple Velocity Filtering Results for CPO	Feb. 1965	30 May 1965		

SD FORM 350 (1 Jan. 59) COPY - COPY - COPY - COPY - COPY - COPY - COPY - COPY

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No. 104-60

2. Project
Array Research VT/4053

3. Component

4. Name and Location of Preparing Activity
Texas Instruments Incorporated
Science Services Division
P. O. Box 5621
Dallas, Texas 75222

5. Contract Number
AF 33(547)-12747

6. Report for Month Ending
25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
3	Report on Velocity Filtering Analysis of CPO	Oct. 1965			
3	Report on Velocity Filtering Analysis of TFO	June 1965			
3	Report on Velocity Filtering Analysis of WMO	Sept. 1965			
3	Combined TFO, CPO and WMO Analysis Report	Dec. 1965			
3	Report on the Two-Dimensional Spectra of Ambient Seismic Noise from Correlation Analysis of a Long Time Sample from the Cross-Array at TFO	April 1965	30 May 1965		
4	Concurrent Noise for Filter Design & Potential Improvements in Transient Response of MCF for CPO Evaluated	1 May 1964	6 June 1964	6 June 1964	
4	Evaluation of Partial & Full Arrays TFO for Teleseisms	1 Dec 1964	1 Jan 1965		
4	Evaluation of Wiener Directional Processing for TFO Using Pre-Whitened (by deconvolution) Local Noise, Large Array, and Long Filters	Mar. 1965	30 July 1965		

SD FROM 350 (1 Jan. 59) COPY - COPY - COPY - COPY - COPY - COPY - COPY - COPY

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No. 104-60
2. Project: Array Research VT/4053
3. Component
4. Name and Location of Preparing Activity:
   Texas Instruments Incorporated
   Science Services Division
   P. O. Box 5621
   Dallas, Texas 75222
5. Contract Number: AF 33(547)-12747
6. Report for Month Ending: 25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
4	Empirical Evaluation Summary on the Effectiveness of Wiener Signal Extraction as a Function of Number of Seismometer Used at TFO, WMO, CPO.	Mar. 1965	Sept. 1965		
4	Evaluation of Local MCF Using Measured Noise and Measured Signal	Mar. 1965	Oct. 1965		
4	Evaluation of Multichannel Filtering Including Isotropic, Directional, and Including Use of a Single 3-Component Seismometer, for "Phase" Extraction on Near Zone Events	Dec. 1965			
5	Topical Report: Vertical arrays, theoretical results and results of analysis of 7 signal set from Grapevine vertical array	31 Aug 1964		22 Aug 1964	
5	Noise Analysis from Special Vertical Array Experiment	1 Nov 1964	10 Apr 1964	non-positive definiteness of correlations forces a change in analysis methods	Combined for UBO data. This will not complete analysis of UBO data but definitive results are the goal sought.
5	Vertical Array MCF Evaluated using Grapevine Data	1 Feb 1965	10 Apr 1964	delay in recording of new Grapevine data.	

SD FORM 350 (1 Jan. 59) COPY - COPY - COPY - COPY - COPY - COPY - COPY - COPY

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No. 104-60
2. Project: Array Research
3. Component
4. Name and Location of Preparing Activity:
   Texas Instruments Incorporated
   Science Services Division
   P. O. Box 5621
   Dallas, Texas 75222
5. Contract Number: AF 33(547)-12747
6. Report for Month Ending: 25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
6	Station Calibration Evaluation for CPO	1 May 1964	15 July 1964	16 July 1964	
6	Calibration Evaluation of Seismometer Coupling & Local Interaction Signal Compensation CPO	1 July 1964			
6	Effectiveness of Signal Response Correction in MCF for CPO	1 Nov. 1964	Part II, 15 Nov. 1964	Part I, 16 July 1964	
6	Preliminary Report: Intra-array Equalization Problem Large TFO Array	1 July 1964	15 July 1964	16 July 1964	
6	Topical Report Summary Code 6 Work	30 Nov. 1964	15 Nov. 1964	15 Dec. 1964	
7	Deconvolution, Autocorrelation, Depth of Focus for Kurile Islands Ensemble	1 July 1964	15 Nov. 1964	15 Dec. 1964	Priority this task replaced by W. Texas Vertical Array Data Acquisition follow by UBO. Extended to include source function deconvolution.
7	Deconvolution, Autocorrelation, Depth of Focus for 2nd & 3rd Ensembles	1 Dec 1964	15 May 1965		Delayed by UBO data analysis and 1965 Grapevine data collection

SD FORM 350 (1 Jan. 59) COPY - COPY - COPY - COPY - COPY - COPY - COPY - COPY

UNCLASSIFIED

REPORT OF PROGRESS AGAINST SELECTED MILESTONES

1. ARPA Order No.
104-60

2. Project
Array Research

3. Component

4. Name and Location of Preparing Activity
Texas Instruments Incorporated
Science Services Division
P. O. Box 5621
Dallas, Texas 75222

5. Contract Number
AF 33(547)-12747

6. Report for Month Ending
25 September 1964

Code a.	Milestone b.	Scheduled Completion Date c.	Estimated Completion Date d.	Date Completed e.	Remarks f.
7	Derivation of Crustal Characteristics from Ensemble Data	Aug 1965			
7	Interpretation of Teleseismic Power Spectra in Terms of Source and Propagation Path Characteristics	Aug. 1965			
7	Topical Report Summary Code 7 Work	1 Jan 1965	30 May 1965		
	Describe Milestones for 1965 Work	1 Oct. 1964		1 Oct. 1964	
	Semi-Annual Report	15 May 1964	6 June 1964	6 June 1964	
	Semi-Annual Report	15 Nov. 1964	15 Nov. 1964	15 Dec. 1964	
	Semi-Annual Report	15 May 1965			
	Final Report	28 Feb. 1965			

Typed Name and Title	Signature	Telephone	Date Signed
Milo Backus Program Director	Milo Backus	Area Code 214 FL 7-5411 Ext. 319	2

SD FORM 350 (1 Jan. 59) COPY - COPY - COPY - COPY - COPY - COPY - COPY - COPY