EXTENDED ARRAY EVALUATION PROGRAM

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Texas Instruments, Incorporated

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EXTENDED ARRAY EVALUATION PROGRAM

Quarterly Report No. 1

1 April 1972 to 30 June 1972

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13. ABSTRACT

This first quarterly report summarizes progress under the Extended Evaluation of ALPA, NORSAR, and LPE program, Contract number F33657-72-C-0725. Work through 30 June 1972 in the following areas is summarized.

- ALPA evaluation
- NORSAR long period evaluation
- NORSAR short period evaluation
- LPE evaluation
- Network analysis

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SECTION 1
INTRODUCTION AND SUMMARY

This first quarterly report summarizes progress made during the past quarter, 1 April 1972 to 30 June 1972, on the Extended Evaluation of ALPA, NORSAR, and LPE Data program being conducted by Texas Instruments Incorporated at the Seismic Array Analysis Center in Alexandria, Virginia. The program consists of the following five tasks:

- Continued evaluation of the Alaskan Seismic Array (ALPA)
- Continued evaluation of the long-period Norwegian Seismic Array (NORSAR)
- Continued evaluation of the short-period Norwegian Seismic Array
- Continued evaluation of the stations of the Very Long Period Experiment (VLPE)
- Investigation of network processing and analysis techniques

The software required to perform the evaluation was developed under a previous contract (Contract F33657-69-C-1063).

A master list of events has been prepared for the months of January, February, and March. Events to be processed under each task are selected from this list to ensure common coverage of events by each array and the stations of the VLPE. Events to be processed later in the year will be selected from a similar list covering several summer months.

About 100 January and February events have been processed at ALPA, and an additional 50 are in various stages of completion. These events have been selected to fill in gaps in our event population so as to enable more effective study of regional detectability and discriminant performance.

Fifty-four January events have been processed for the NORSAR long-period array. Sixty-eight February events have been selected and are

currently in process. Routine noise analysis has continued with special emphasis given to several winter time samples which showed high microseismic levels. It appears that the noise on such days is correlatable with storms in the vicinity of Norway.

Under the NORSAR short-period task fifty-six events from late 1971 are near the completion of processing. Processing of 1972 events, particularly those processed under the NORSAR long-period task, will begin during the second quarter. A problem of concern is the excessive beamforming signal degradation observed for events from Greece and Turkey. Neither the use of our estimated delay anomalies for these areas nor of a set provided by IBM personnel in Norway has been successful in resolving this problem. It is currently under study.

Approximately 300 VLPE events have been edited, reformatted, and rotated. These events occurred during the months of January, February, and March, and were recorded at Thailand, Alaska, Spain, Norway, and Ogdensburg. Daily noise samples covering this period have also been edited. Chirp filtering of VLPE events will begin during the second quarter.

Under the network evaluation task analysis of VLPE paper records for all known Eurasian earthquakes has been completed for available data recorded since 1 January 1972. The purpose of this analysis is to provide observational data for empirical evaluation of the detection, unmixing, and identification capabilities of the existing array - VLPE station network.

SECTION II
ALPA EVALUATION

A. CURRENT STATUS

During the past quarter approximately 100 events recorded at ALPA have been processed. Fifty more events are in various stages of completion. These 150 events occurred during the period January through March, 1972 and in many cases were taken from the International Seismic Month list. The same events are being processed using NORSAR and VLPE data whenever possible.

There has been some suggestion that the surface wave detectability at ALPA is not materially better for events within 45 degrees than it is for more distant events. The majority of the nearer events occur in the Kuriles- Kamchatka area. Our entire suite of these events is being examined in an effort to better understand this apparently anomalous behavior.

Noise analysis in 1972 is confined to selecting samples at ten-day intervals, beamsteering for the area of interest, and measuring the output RMS levels.

A procedure for estimating the ALPA detection threshold indirectly has been reported previously (Harley, 1971). Unfortunately when applied to our 1971 data this procedure suggests a significantly lower detection threshold than is observed directly. The procedure involves estimating the surface-wave detectability from observed noise levels, and using a fixed M_s-m_b relationship to express this in terms of m_b. This overlooks the fact that at any value of m_b, the observed values of M_s are distributed about the value given by the fixed relationship. If one utilizes this fact in converting to m_b the detection threshold S curves are flattened out, thereby raising the 90% detectability estimate. Data supporting this contention will be presented in a special report during the second quarter.

B. FUTURE PLANS

The fifty events which are partially completed as well as several other events from the January - March period will be completed. A new list of events similar to the January - March list, but covering the summer months will be prepared, and processing of these events will commence during the second quarter.

SECTION III
NORSAR LONG-PERIOD EVALUATION

A. CURRENT STATUS

During the past quarter, the evaluation effort on the NORSAR long-period array concentrated on obtaining a new ensemble of events and noise samples for analysis. In addition, some program modification and housekeeping on last year's data was done.

The passband of 0.025 - 0.059 Hz has been chosen for routine use on all NORSAR long-period data. This passband was selected after considerable effort was expended last year to determine the bandwidth behavior of detection probability, matched filter gains, and array gains. It was found that, under the specified detection criteria, all passbands gave essentially identical detection behavior. However, using subjective judgement, more detections were obtained with the passbands having higher cutoff frequencies. The array processing results showed better performance when both the lower and upper passbands were raised. The passbands of best matched filter improvements were regionally dependent.

Eighty January events were selected for editing with 54 actual event edits obtained suitable for use. The 26 events were not useable or obtainable for the following reasons:

No data available	9
Time gaps or timing errors	2
Strongly interfering event	8
Overdriven array data	1
Spike in surface waves	1
Incorrect edit parameters	5

Sixty-eight events in February 1972 have been selected for editing. The editing is not yet complete but approximately 24 events have been obtained so far. All edited events have been checked for site quality, the data rotated and beamformed. Detection processing and M_s measurements are in progress on a group of 43 events.

Seven additional long noise samples have been obtained from days 18, 28, 49, 58, 71, 79, and 99 in 1972. The noise levels on days 18 and 71 are greatly increased in a manner similar to day 348 of 1971. Vertical component RMS levels were 44 and 21 $m\mu$ respectively in the 20-40 second band. The data were also examined from days 347, 348, and 349 of 1971 to check in closer detai the unusually high noise levels on those days. Close correlation was found between noise level and wave height and wind direction. Weather maps have been ordered from the U.S. Weather Service for the periods of the seven new noise samples to see if similar correlations can be obtained for days 18 and 71.

The N-S and E-W components of site 01C (9) were observed to be interchanged from as early as 1 January 1972 to as late as 6 June 1972. A message was sent to NDPC (Norsar Data Processing Center) on about 14 or 15 June informing them of this. Their reply indicated that the interchange would be corrected by 18 June. No amplitude or phase response calibrations have been obtained from NDPC yet.

B. FUTURE PLANS

The remaining events from the common event list will be edited. Of a total of approximately 310 events, it is estimated that about 240 will be available for analysis. This event ensemble contains several small swarms of events from the same epicenters, e.g., Iran and Italy, which will be analyzed as separate groups.

Long-duration noise samples will be edited through at least day 120 so as to complete one full year of data. Whenever possible multichannel filter behavior will be examined on these noise samples. Short-term noise levels will be obtained from the event data.

SECTION IV
NORSAR SHORT-PERIOD EVALUATION

A. CURRENT STATUS

While awaiting the arrival of 1972 data tapes, the first quarter was devoted to processing late 1971 data. Fifty-six events have been processed through plane-wave beamforming, and the adjusted delay beams will be formed in the near future. Five noise samples have been processed. Noise samples for evaluation this year will be selected at approximately seven-day intervals.

Our estimated adjusted delay anomalies have been compared with a set provided by IBM personnel in Norway. In general there is good agreement between the two sets, but in the case of events from Greece and Turkey there are differences. Our adjusted delays introduce excessive signal degradation for these near events, but the degradation appears to be even more severe when the IBM delays are used. This problem is currently under study.

B. FUTURE PLANS

Routine processing of events will continue, focusing on small events and on those events processed under the NORSAR long-period task. Efforts will be made to understand the beamforming signal degradation problem for near events.

SECTION V
VLPE EVALUATION

A. CURRENT STATUS

During the past quarter routine processing of the 1972 VLPE data was initiated. As part of the routine processing, each field tape received was checked for errors and/or incorrect tape formatting. The results of these checks are being filed so that a detailed summary of tape problems and tape errors will be available at the end of the current contract. Also, results of these tape checks are used to determine which data for each station is available for the merge program.

During the past quarter the program which generates the tapes to be used in producing the 16 mm film playbacks was modified to remove the means from each individual component and to scale each component (all traces will now have the same number of millimicrons of ground motion per millimeter of trace deflection at a specified period). Data for January, February, and March for Thailand, Alaska, Spain, Norway, and Ogdensburg were merged during the quarter and have been processed through the new film tape generation program. Sixteen millimeter films for this data are currently being generated at the Dallas playback center. It should be noted that data for all 5 stations was not available for the entire 3 month period.

Routine signal and noise analysis was initiated for the January - March data. For noise studies, one sample per day was edited for each station present from January 1 to March 20. For each sample, single channel power spectra and RMS calculations were performed. For the same period, all signals of interest from the Sino-Soviet area were edited, reformatted, and rotated. The number of events processed by month for each station is shown below.

VLPE January - March 20 Events

Number of Events	Month	*Stations Processed
82	January	2, 3, 4, 6, 7
133	February	3, 4, 6, 7
97	March 1-20	3, 4, 6, 7

*Station Designations:

2 - Thailand

3 - Alaska

4 - Spain

6 - Norway

7 - Ogdensburg

B. FUTURE PLANS

During the coming quarter routine processing of the above signals will be completed. This will include generation of single station power spectra, and Calcomp plotting of raw and band pass filtered time domain data. From this data, detection studies and M_s calculations will be performed. Also, for a subset of events, chirp filter studies will be initiated. Also, noise and signals for the spring months will be edited and analyzed.

SECTION VI
NETWORK EVALUATION

A. CURRENT STATUS

Analysis of VLPE paper records for all known Eurasian earthquakes has been completed for available data recorded since 1 January 1972. The purpose of this analysis is to provide observational data for empirical evaluation of the detection, unmixing, and identification capabilities of the existing array - VLPE station network. Many seismograms from these stations are not yet available, but these data will be necessary to provide a "true" picture of the network aspects of capability. Film reproductions are expected to be available soon from the digital recordings to aid in expanding and extending the data bases currently available for analytical use.

The seismicity data are also being used to identify seismic events of special interest to the network, such as mixed events from the same source region, the length of time interference from earthquake occurrence hampers detection at existing stations, and occurrence of events in previously aseismic regions. The visual analysis of paper recordings is also being used to cull the seismicity for particularly interesting events for detailed analysis and to test signal processing procedures.

B. FUTURE PLANS

Analysis of paper records (and film, when available) will be continued during the next reporting period to build detection, mixing (time overlapping signal), and signal persistence statistics. Special emphasis will be placed on the "International Seismological Month" recording (20 February through 19 March) to provide a strong basis for comparison with other studies. Initial tests of beamforming for P and S, and filter-beamform effects will also be applied to data selected from the visual analysis effort.

SECTION VII
REFERENCES

Harley, T. W., 1971, Long Period Array Processing Development; Final Report AFTAC Project No. VT/9707, Contract F33657-69-C-1063, Texas Instruments, Incorporated, Dallas, Texas, May.