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EXTENDED ARRAY EVALUATION PROGRAM

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Alaska Long Period Array *Very Long Period Experiment*

This third quarterly report summarizes progress under the Extended Evaluation of ALPA, NORSAR, and VLPE program, Contract number F33657-72-C-0725. Work to date in the following areas is summarized:

- *Alaska Long Period Array* → ALPA evaluation;
- → NORSAR long period evaluation;
- → NORSAR short period evaluation;
- → VLPE evaluation;
- → Network evaluation

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EXTENDED ARRAY EVALUATION PROGRAM

Quarterly Report No. 3

1 October 1972 to 31 December 1972

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→ Progress is reported in the following areas for the reporting period:

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SECTION I
INTRODUCTION AND SUMMARY

This third quarterly report summarizes progress made during the last quarter, 1 October 1972 to 31 December 1972, on the Extended Evaluation of ALPA, NORSAR and VLPE 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 Long Period 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) network
- 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).

ALPA evaluation included the completion of the processing and analysis of the winter (1 January to 20 March 1972) ensemble and about 130 of the 380 events from the summer (June-August) ensemble. The total number of events successfully analyzed to date under this contract is approximately 308. A re-evaluation of S-wave detection threshold for events from the Kurile Island-Kamchatka region was initiated.

Evaluation of the long-period NORSAR data continued with analysis of the winter event suite being completed and analysis of the summer suite being started. Approximately 161 events were obtained for the winter suite and about 49 events were completed from the summer suite so far. Group velocity measurements have been obtained for a small group of Italian events.

Major revisions in the subarray beamforming program used in the NORSAR short-period evaluation task have been completed. Initial results show a significant decrease in signal attenuation due to subarray beamforming. Event processing has resumed with 78 events from the winter ensemble edited and undergoing analysis.

Evaluation of the VLPE stations continued with 239 events from June and July having been analyzed. Daily noise samples for these months were also analyzed.

Two special reports were generated under the network evaluation task. The first report concerns the amplitude decay of long-period Rayleigh waves as seen on the VLPE seismograms. The second report describes the long-period noise at the VLPE locations. Abstracts of both reports have been submitted for open publication clearance.

SECTION II
ALPA EVALUATION

A. CURRENT STATUS

Through the end of this quarter, 308 out of a total of 686 events from the winter and summer ensembles have been processed and analyzed. The disposition of the other 378 events is shown below.

Total events	686
No data available	48
Bad library tapes	5
Spiked data	45
Interference*	107
Completed events	<u>308</u>
Events in processing	173

Of the 173 events remaining to be processed, 26 are from July and 147 from August. Edits have been obtained for 69 events in August. Re-processing of a number of events from the ISM (2/20/72 - 3/19/72) because of revision of source parameters resulted in an increase by 26 in the number of events successfully processed in that period.

A problem has arisen in the processing of the August data set. The low-rate data library tapes covering the period of about August 1 to about August 19 contain numerous parity errors and timing word errors. These errors tend to produce large spikes in the data thus precluding meaningful analysis. NORSAR data from these tapes have also been found to be faulty. Present indications are that approximately one-third of the August events will be rejected because of this problem.

*(See following page for explanation)

A re-evaluation of the S-wave detection capability of ALPA for events from the Kurile Islands - Kamchatka area was started this quarter. There is evidence that the detection threshold for S-waves from this area may be somewhat lower than $m_b = 5.0$. To date, 58 events have been reprocessed for this purpose.

The investigation of reference waveform matched filtering continued this quarter. This study is intended to elucidate the relative importance of various signal parameters in improving signal-to-noise ratios by this type of matched filter. Events examined so far have all been from the Sinkiang region.

B. FUTURE PLANS

Routine processing of ALPA events will conclude at the completion of the August group. Selection and analysis of noise samples will resume using slightly different procedures so that additional information on propagation direction can be obtained.

* An interfering event is any event which arrives at the array at approximately the same time as the event under analysis, and which would obscure or alter the waveform of the desired event.

An interfering event may be detected by noting:

- the arrival time at ALPA. If this deviates from the estimated arrival time of the event under analysis an interfering event should be suspected.
- the amount of signal degradation caused by the beamforming process. An off-azimuth signal will be highly attenuated.
- the amplitude and duration of the signal. If these seem too great for the given m_b of the signal, an interfering event should be suspected.

When interference is suspected, the information source lists (PDE, SDAC, and NORSAR Seismic Event Summary) are checked to determine the actual epicenter and origin time of the event. From these parameters, an arrival time at ALPA is computed and checked against the plot of the beams. If this computed time agrees with the plot, the event is designated as an interfering event. If no such event can be found, it is necessary to assume that the event in question is in fact the desired event.

SECTION III NORSAR LONG-PERIOD EVALUATION

A. CURRENT STATUS

By the end of this quarter, routine processing of the winter ensemble of events was completed and processing of the summer ensemble started. The number of events successfully processed from the winter ensemble was 161. Processing was almost completed on the June events with approximately 85 usable events obtained. Forty-nine of these events have been analyzed. Editing and beamforming of the July events has been completed with about 83 events out of 113 successfully obtained. Editing of the August events has been started.

The library tape parity error problem discussed in Section II has also affected editing of August NORSAR data. Since edit processing has just been started, we are unable to say how many events will have to be discarded but it is probable that it will be about the same number as for ALPA, or about 50.

Noise analysis was suspended for most of this quarter. This work has resumed and processing of several potential long-duration noise samples covering the period through August has been initiated.

Group velocities of about nine events from Italy have been measured.

B. FUTURE PLANS

Routine processing of NORSAR events will continue. It is estimated that only events through July will be completed by the end of this quarter however. Noise analysis will continue with analysis of both long-duration and short-duration samples covering the period of January to August.

SECTION IV
NORSAR SHORT-PERIOD EVALUATION

A. CURRENT STATUS

This quarter, revisions in the subarray beamforming program NORSPECT were completed and normal processing was resumed. These revisions, which were discussed in the last quarterly report, allow the use of adjusted time delays rather than plane wave model delays in forming subarray beams. Preliminary results from two close events ($< 30^\circ$) indicate an average of 0.5 dB decrease in subarray beamforming signal attenuation may be obtained. For two subarrays, signal attenuation was reduced by more than 3 dB by the elimination of sensors found to have unsuspected polarity reversals.

Seventy-eight events from the winter ensemble have been edited. These events are ones which have been successfully analyzed using both ALPA and NORSAR long-period data. Noise samples for three of these events were edited and subarray beams have been formed for six events.

B. FUTURE PLANS

Twenty-five events remain to be edited from the common ALPA-NORSAR LP analysis list. Sixteen noise samples have been selected but not edited. Processing this quarter will be focused on the analysis of these events and noise samples.

SECTION V
VLPE EVALUATION

A. CURRENT STATUS

One-hour noise samples for each day and 239 events from the June-July 1972 ensemble have been processed and analyzed using the data from the VLPE stations at Australia, Spain, Israel, Norway, Ogdensburg, Hawaii, and New Mexico where available. A total of 900 event signals were examined and 299 were discarded because of bad data or because of interference from other events.

Processing of the August 1972 data is currently in progress.

B. FUTURE PLANS

Routine digital processing will continue for the August 1972 noise samples and ensemble of events. However, the analysis of these data will be temporarily halted on January 15, 1973 for the purpose of analyzing, tabulating, and reporting results.

SECTION VI NETWORK ANALYSIS

A. CURRENT STATUS

Two special reports concerning VLPE network operations are in preparation based upon analysis of seismograms in preceding months. The first special report describes Long-period Rayleigh wave amplitude decay as observed on the VLPE seismograms: an abstract of the report has been submitted for clearance for open publication in the Transactions of the American Geophysical Union. A public presentation of the research results is planned (once clearance is obtained) at the Spring meeting of the American Geophysical Union in Washington, D. C.

The second special report describes long-term long-period (13.5 - 62.5 second) seismic noise at the VLPE locations. An abstract of this report has also been submitted for open publication clearance, and public presentation (upon clearance of text) is planned at the Boulder, Colorado meeting of the Seismological Society of America in May, 1973. Some data for this report are in the process of being analyzed at present.

An extension to the first report is planned to indicate the potential for Rayleigh wave interference times in a network of VLPE stations based upon observed Eurasian seismicity; the second report will be essentially complete with the text submitted for clearance.

B. FUTURE PLANS

Master waveform and chirp filter techniques for improved signal detectability are being initiated.