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TECHNICAL REPORT NO. 67-73

OPERATION OF THE UINTA BASIN SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 6

1 August through 31 October 1967

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GEOTECH

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TECHNICAL REPORT NO. 67-73

OPERATION OF THE UINTA BASIN SEISMOLOGICAL OBSERVATORY,
QUARTERLY REPORT NO. 6
1 August through 31 October 1967

Sponsored by

Advanced Research Projects Agency
Nuclear Test Detection Office
ARPA Order No. 624

TELEDYNE INDUSTRIES
GEOTECH DIVISION
3401 Shiloh Road
Garland, Texas

15 November 1967

IDENTIFICATION

| | |
|---------------------------|---|
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| Project Title: | Operation of UBSO |
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| Contract Expiration Date: | 31 October 1967 |
| Program Manager: | B. B. Leichter, BR1-2561 Garland, Texas |

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ABSTRACT

This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 August through 31 October 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operations of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory.

OPERATION OF UBSO - QUARTERLY REPORT NO. 6
1 AUGUST 1967 THROUGH 31 OCTOBER 1967

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC), under Contract AF 33(657)-16563. The statement of work for this contract is shown in the appendix.

1.2 HISTORY

The Uinta Basin Seismological Observatory (UBSO) was constructed under Contract AF 33(657)-7185. Site selection and noise surveys were accomplished by Geotech; the final decision on the observatory location was made by AFTAC. Texas Instruments Incorporated (TI) was responsible for the construction of all physical facilities.

2. OPERATION OF UBSO

2.1 GENERAL

Data are recorded at UBSO on a 24-hour basis. The observatory is normally manned 8 to 10 hours a day, 5 days a week. On weekends and holidays, a skeleton crew mans the observatory 8 hours a day; however, additional personnel are on call in case of emergency.

The UBSO array configuration is shown in figure 1.

The Project Officer and the Geotech Program Manager visited UBSO on 28 and 29 September to discuss plans for the long-period array.

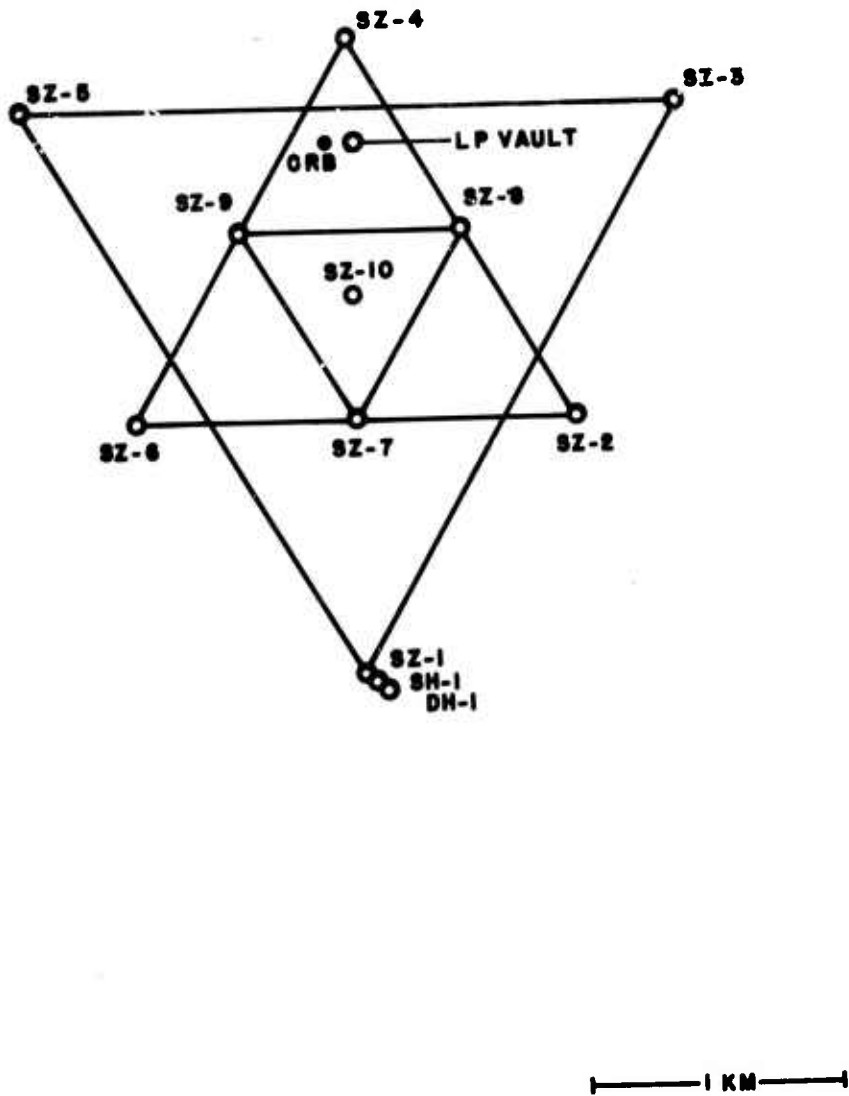


Figure 1. Orientation and configuration of UBSO arrays

2.2 SEISMOGRAPH OPERATING PARAMETERS

2.2.1 Standard Seismographs

The operating parameters and the tolerances for the standard observatory seismographs are shown in table 1. These parameters are reset if the frequency response of a seismograph is found to be out of tolerance. The frequency response norms and their respective tolerances are shown in table 2. The frequency responses of the UBSO seismographs, as normally operated, are shown in figure 2.

2.2.2 Filters for Multichannel Array Processors (MAP)

All MAP channels utilize a band-pass filter with the following settings: a high-cut corner frequency of 3 cps at 6 dB per octave cutoff rate, and a low-cut corner frequency of 1 cps at 12 dB per octave cutoff rate.

2.2.3 Filters for Shallow-Buried Array Summations

The summation of the ten-element shallow-buried array is filtered by a band-pass filter with the following settings: a high-cut corner frequency of 3 cps and a low-cut corner frequency of 0.8 cps, both at a cutoff rate of 18 dB per octave.

2.2.4 Filters for Vertical Array Summations

The vertical array was inoperative during this quarter because of a faulty cable. A new cable is scheduled to be sent to UBSO when it is available as Government furnished equipment. Prior to 1 July, the summation output of the vertical array was filtered as follows: a high-cut corner frequency of 3 cps at a cutoff rate of 24 dB per octave and a low-cut corner frequency of 0.75 cps at a cutoff rate of 36 dB per octave.

2.3 DATA CHANNEL ASSIGNMENTS

The current data-channel assignments and normal operating magnifications for all UBSO data groups are shown in table 3. The key to the designators used in the data-channel assignments is given in table 4.

2.4 COMMERCIAL POWER FAILURES AND DATA OUTAGES

Failures of commercial power occurred on 6, 11, 12, and 13 August; 11 and 12 September; and 6 October. No loss of data resulted from the August failures or from the failure on 11 September. The failure on 12 September lasted for 2 hours and 22 minutes. The emergency systems functioned

Table 1. Operating parameters and tolerances of seismographs at UBSO

| Seismograph | | Operating parameters and tolerances | | | | | Filter settings | | | | |
|-------------|---------|-------------------------------------|-------|--|----------|-------------|-----------------|-------------|------------|-------------------------------|------------------|
| System | Comp | Seismometer | | | T_s | λ_s | T_g | λ_g | σ_z | Cut off rate | |
| | | Type | Model | | | | | | | Bandpass at 3 dB cutoff (sec) | SP side (dB/oct) |
| SP | Z and H | Johnson Matheson | 7515 | | 1.25 ±2% | 0.51 ±5% | 0.33 ±5% | 0.65 ±5% | 0.03 | 0.1-100 | 12 |
| SP | SZ | Geotech | 6480 | | 1.25 ±2% | 0.51 ±5% | 0.33 ±5% | 0.65 ±5% | 0.053 | 0.1-100 | 12 |
| SP | Z | UA Benioff | 18300 | | 1.0 ±5% | 1.0 | 0.083 ±5% | ~1.4 | 1.0 | - | - |
| IB | Z | Melton | 1001C | | 2.5 ±5% | 0.65 ±5% | 0.64 ±5% | 1.2 ±5% | 0.018 | 0.05-100 | 12 |
| IB | H | Geotech | 8700B | | 2.5 ±5% | 0.65 ±5% | 0.64 ±5% | 1.2 ±5% | 0.001 | 0.05-100 | 12 |
| BB | Z | Geotech | 7505 | | 12.5 ±5% | 0.485 ±5% | 0.64 ±5% | 9.0 ±5% | 0.0007 | 0.05-100 | 12 |
| BB | H | Geotech | 8700A | | 12.5 ±5% | 0.485 | 0.64 ±5% | 9.0 ±5% | 0.0007 | 0.05-100 | 12 |
| LP | Z | Geotech | 7505A | | 20.0 ±5% | 0.74 ±5% | 110 ±10% | C.85 ±10% | 0.63 | 25-1000 | 12 |
| LP | H | Geotech | 8700A | | 20.0 ±5% | 0.74 ±5% | 110 ±10% | 0.85 ±10% | 0.63 | 25-1000 | 12 |

| | | | |
|----|--|-------------|--------------------------------|
| | | KEY | |
| SP | Short period | T_s | Seismometer free period (sec) |
| IB | Intermediate band (currently inactive) | T_g | Galvanometer free period (sec) |
| BB | Broad band | λ_s | Seismometer damping constant |
| LP | Long period | λ_g | Galvanometer damping constant |
| UA | Unamplified (i.e., earth powered) | σ_z | Coupling coefficient |

Table 2. Calibration norms and operating tolerances for frequency responses of the standard seismographs at UBSO

| SP Vertical 18300 and SP Johnson-Matheson Vertical and Horizontal | | | | LP Vertical and Horizontal ^c | | | |
|---|------------|--------|---------------|---|------------|-------|---------------|
| f (cps) | T (sec) | R. M. | A. T. (±%) | f (cps) | T (sec) | R. M. | A. T. (±%) |
| 0.2 | 5.0 | 0.0113 | 10 | 0.01 | 100 | 0.246 | 20 |
| 0.4 | 2.5 | 0.0950 | 7.5 | 0.0125 | 80 | 0.377 | 20 |
| 0.8 | 1.25 | 0.685 | 5 | 0.0167 | 60 | 0.589 | 15 |
| 1.0 | 1.0 | 1.0 | - | 0.02 | 50 | 0.745 | 15 |
| 1.5 | 0.67 | 1.52 | 5 | 0.025 | 40 | 0.899 | 10 |
| 2.0 | 0.5 | 1.90 | 5 | 0.033 | 30 | 1.06 | 5 |
| 3.0 | 0.33 | 2.12 | 7.5 | 0.04 | 25 | 1.0 | - |
| 4.0 | 0.25 | 1.87 | 12 | 0.05 | 20 | 0.822 | 5 |
| 6.0 | 0.167 | 1.15 | 20 | 0.0667 | 15 | 0.506 | 10 |
| 8.0 | 0.125 | | | 0.10 | 10 | 0.173 | 20 |
| 10.0 | 0.100 | | | 0.143 | 7 | b | a |

| IB Vertical and Horizontal | | | | BB Vertical and Horizontal | | | |
|----------------------------|------------|--------|---------------|----------------------------|------------|-------|---------------|
| f (cps) | T (sec) | R. M. | A. T. (±%) | f (cps) | T (sec) | R. M. | A. T. (±%) |
| 0.1 | 10.0 | 0.0090 | 25 | 0.04 | 25.0 | 0.104 | 20 |
| 0.2 | 5.0 | 0.068 | 20 | 0.06 | 16.7 | 0.350 | 20 |
| 0.3 | 3.3 | 0.25 | 15 | 0.08 | 12.5 | 0.775 | 15 |
| 0.4 | 2.5 | 0.46 | 10 | 0.1 | 10.0 | 0.950 | 10 |
| 0.5 | 2.0 | 0.64 | 5 | 0.2 | 5.0 | 1.0 | 5 |
| 0.7 | 1.43 | 0.86 | 5 | 0.4 | 2.5 | 1.0 | 5 |
| 1.0 | 1.0 | 1.0 | - | 0.8 | 1.25 | 1.0 | - |
| 1.5 | 0.67 | 1.04 | 5 | 1.6 | 0.625 | 1.0 | 5 |
| 2.0 | 0.5 | 1.0 | 10 | 3.2 | 0.312 | 1.0 | 10 |
| 3.0 | 0.33 | 0.89 | 15 | 6.4 | 0.156 | 0.980 | 15 |
| 5.0 | 0.2 | 0.66 | 20 | | | | |

KEY

- R. M. Relative magnification
- A. T. Amplitude tolerance
- a Tolerance not established in the period
- b Measurements not reliable due to interference from microseismic background noise
- c These norms and tolerances apply to the broad-response, long-period system (LP1).

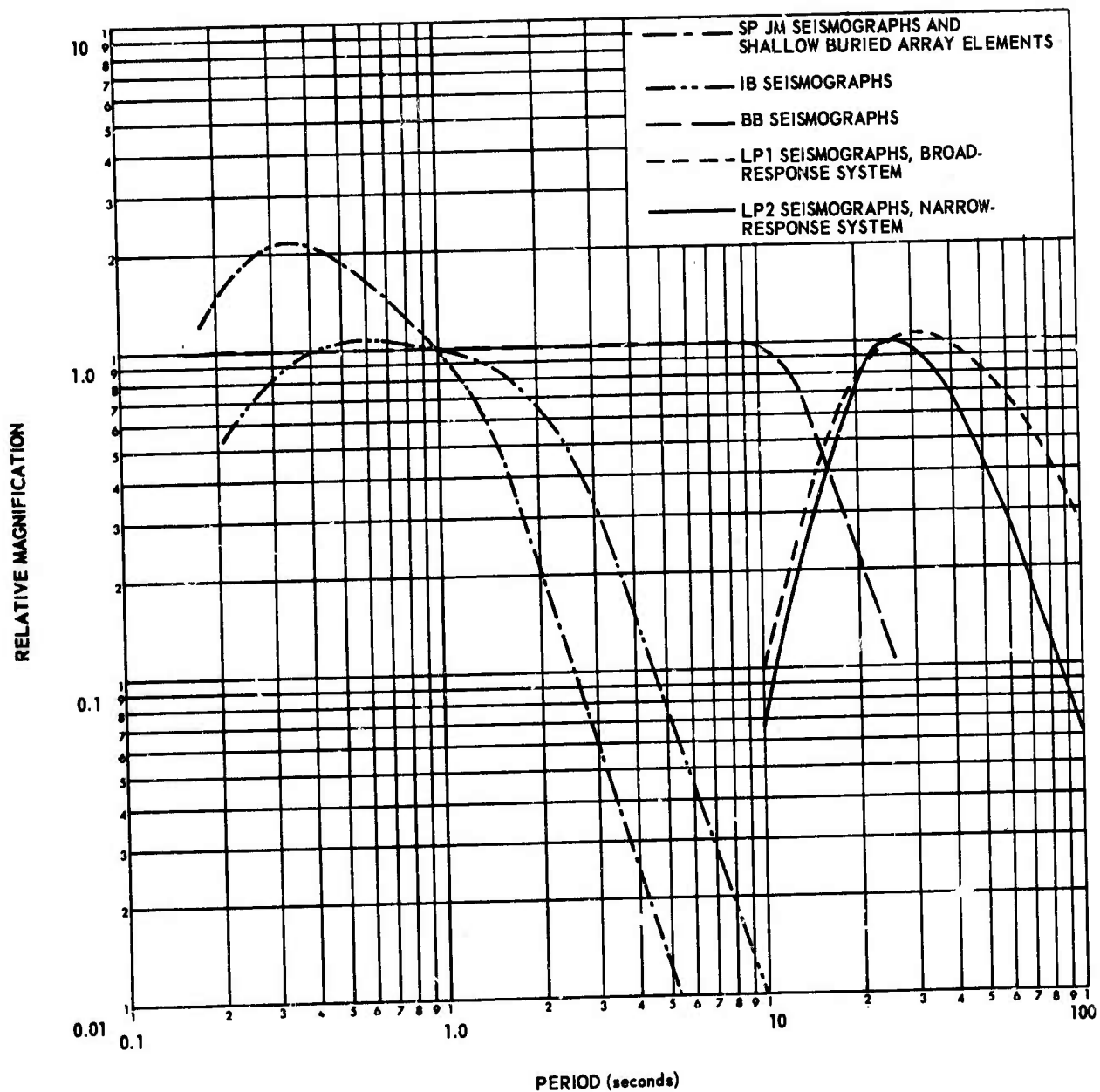


Figure 2. Normalized response characteristics of the standard seismographs at UBSO

Table 3. Data channel assignments and normal operating magnifications at UBSO

DEVELOCORDERS

SLOW SPEED 3mm/min.

FAST SPEED 30mm/min.

| DATA GROUP 5044 | | DATA GROUP 5076 | | DATA GROUP 5072 | | DATA GROUP 5074 | |
|-----------------|--------------------|-----------------|--------------------|-----------------|----------------------|-----------------|------------------------------|
| Channel | Trace Mag. | Channel | Trace Mag. | Channel | Trace Mag. | Channel | Trace Mag. |
| 1 | V 20K | 1 | SZ10L 60K | 1 | Test --- | 1 | W1 $\frac{3}{5}=0/8$ mm(E=6) |
| 2 | SZ1 600K | 2 | NSPL 60K | 2 | MCF11 Testing | 2 | SZ2 300K |
| 3 | SZ3 600K | 3 | ESPL 60K | 3 | MCF12 Testing | 3 | ZLP1 25K |
| 4 | SZ5 600K | 4 | Z10LL 5K | 4 | MCF13 Testing | 4 | NLP1 25K |
| 5 | DH6 1000K | 5 | NSPLL 5K | 5 | MCF14 Testing | 5 | ELP1 25K |
| 6 | DH5 1000K | 6 | ESPLL 5K | 6 | MCF15 Testin. | 6 | ZLP2 100K |
| 7 | SZ4 600K | 7 | SZ1 600K | 7 | MCF16 Testing | 7 | NLP2 100K |
| 8 | SZ7 600K | 8 | SZ3 600K | 8 | MCF17 Testing | 8 | ELP2 100K |
| 9 | SZ8 600K | 9 | SZ5 600K | 9 | BSSV1 T-ting | 9 | ML1 3μ b/mm |
| 10 | SZ9 600K | 10 | Σ SSF 6000K | 10 | BSSV2 Testing | 10 | ML2 3μ b/mm |
| 11 | Σ SSF 6000K | 11 | Σ SS 1500K | 11 | BSSV3 Testing | 11 | USO - LP - |
| 12 | Σ SS 1500K | 12 | Z10 600K | 12 | BSSV4 Testing | 12 | ZBB 1.0K |
| 13 | SZ10 600K | 13 | NSP 600K | 13 | BSSV5 Testing | 13 | NBB 1.0K |
| 14 | NSP 600K | 14 | ESP 600K | 14 | BSSV6 Testing | 14 | EBB 1.0K |
| 15 | ESP 600K | 15 | TC.DMG (Tape #1) | 15 | Σ DVS Testing | 15 | WVW |
| 16 | WVW --- | 16 | WVW --- | 16 | WVW ---- | 16 | ---- |

MAGNETIC TAPE RECORDERS

| DATA GROUP 5029 | | DATA GROUP 5023 | | DATA GROUP 5025 | | DATA GROUP 5035 | |
|-----------------|--------------|-----------------|---------|-----------------|-------------|-----------------|--------------|
| Channel | Trace | Channel | Trace | Channel | Trace | Channel | Trace |
| 1 | TC.DMG | 1 | TC.DMG | 1 | TC.DMG | 1 | TC.DMG |
| 2 | DH1 | 2 | ZBB | 2 | SZ1 | 2 | USOZSP |
| 3 | DH2 | 3 | NBR | 3 | SZ2 | 3 | USOZLP |
| 4 | DH3 | 4 | EBJ | 4 | SZ3 | 4 | USO Time |
| 5 | DH4 | 5 | NSP | 5 | SZ4 | 5 | Σ SSF |
| 6 | DH5 | 6 | ESP | 6 | SZ5 | 6 | MCF11 |
| 7 | Comp. | 7 | Comp. | 7 | Comp. | 7 | Comp. |
| 8 | DH6 | 8 | ZLP1 | 8 | SZ6 | 8 | MCF12 |
| 9 | Σ DH | 9 | NLP1 | 9 | SZ7 | 9 | MCF13 |
| 10 | Σ DHF | 10 | ELP1 | 10 | SZ8 | 10 | |
| 11 | Z10LL | 11 | ZLP2 | 11 | SZ9 | 11 | |
| 12 | NSPLL | 12 | NLP2 | 12 | SZ10 | 12 | |
| 13 | ESPLL | 13 | ELP2 | 13 | Σ SS | 13 | |
| 14 | WVW | 14 | WVW | 14 | WVW | 14 | WVW |
| | & Voice | | & Voice | | & Voice | | & Voice |

Table 4. Key to the designations used in the data format assignments at UBSO

| | | | |
|------|--|--------------|---|
| Z | Amplified vertical short-period seismograph from a surface site identified by a suffix number | EBB | East-west broad-band seismograph |
| | | ΣS | Summation of Z1 through Z10 |
| SZ | Amplified vertical short-period seismograph from a shallow-buried site identified by a suffix number | ΣSF | ΣS filtered |
| | | ΣSS | Summation of SZ1 through SZ10 |
| | | ΣSSF | ΣSS filtered |
| NSP | Amplified north-south short-period seismograph | DH1 | Vertical-array element at 8895 feet |
| ESP | Amplified east-west short-period seismograph | DH2 | Vertical-array element at 7903 feet |
| V | Unamplified vertical short-period seismograph | DH3 | Vertical-array element at 6910 feet |
| ZLP1 | Vertical long-period seismograph, broad response | DH4 | Vertical-array element at 5894 feet |
| NLP1 | North-south long-period seismograph, broad response | DH5 | Vertical-array element at 4901 feet |
| ELP1 | East-west long-period seismograph, broad response | DH6 | Vertical-array element at 3907 feet |
| ZLP2 | Vertical long-period seismograph, narrow response | ΣDH | Summation of DH1 through DH6 |
| | | ΣDHF | ΣDH filtered |
| NLP2 | North-south long-period seismograph, narrow response | ML1 | Long-period microbarograph (inside LP vault) |
| ELP2 | East-west long-period seismograph, narrow response | ML2 | Long-period microbarograph (outside LP vault) |
| ZBB | Vertical broad-band seismograph | MS1 | Short-period microbarograph (inside LP vault) |

Table 4. Continued

| | | | |
|--------|---|-------|---|
| NBB | North-south broad-band seismograph | MS2 | Short-period microbarograph (outside LP vault) |
| WWV | Radio time (WWV, STS, and voice on tape) | WI | Anemometer-wind speed and direction |
| Test | Test instrumentation | BSS3 | Beam-steered summation: 8.1 km/sec signal from azimuth of 120°, using Z1 - Z10 |
| Comp | Compensation | | |
| Mag | Magnification (see note) | BSS4 | Beam-steered summation: 8.1 km/sec signal from azimuth of 180°, using Z1 - Z10 |
| TCDMG | Time code data management group | | |
| USO-SP | Unmanned seismological observatory short-period seismograph | BSS5 | Beam-steered summation: 8.1 km/sec signal from azimuth of 240°, using Z1 - Z10 |
| USO-LP | Unmanned seismological observatory long-period seismograph | BSS6 | Beam-steered summation: 8.1 km/sec signal from azimuth of 300°, using Z1 - Z10 |
| MCF1 | Multichannel filter: velocity signal and measured noise correlations (not including road noise) using Z1 - Z10 | MCF11 | Multichannel filter: velocity signal and measured noise correlations (not including road noise), using SZ1 - SZ10 |
| MCF3 | Multichannel filter: 8.1 km/sec velocity signal and measured noise correlations (not including road noise) using Z1 - Z10 | MCF12 | Multichannel filter: velocity signal and theoretical noise model, using SZ1 - SZ10 and DH1-DH6 |
| MCF4 | Multichannel filter: velocity signal and measured noise correlations (including road noise), using Z1 - Z10 | MCF13 | Multichannel filter: velocity signal and theoretical noise model, using DH1 - DH6 |
| ΣSBS | Summation of Z1 - Z10, with MAP band-pass filter | MCF14 | Deghost filter: up-going velocity P-wave signal and theoretical noise model, using DH1, DH3, and DH5 |

Table 4. Continued

| | | | |
|-------|--|-------|---|
| BSS1 | Beam-steered summation: 8.1 km/sec signal from azimuth of 0°, using Z1 - Z10 | MCF15 | Deghost filter: down-going velocity P-wave signal and theoretical noise model, using DH1, DH3, and DH5 |
| BSS2 | Beam-steered summation: 8.1 km/sec signal from azimuth of 60°, using Z1 - Z10 | MCF16 | Deghost filter: up-going velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6 |
| BSSV1 | Beam-steered summation: up-going velocity P-wave, using DH1 - DH6 | MCF17 | Deghost filter: down-going velocity P-wave signal and theoretical noise model, using DH2, DH4, and DH6 |
| BSSV2 | Beam-steered summation: up-going 8.1 km/sec P-wave, using DH1 - DH6 | BSSV5 | Beam-steered summation: down-going 8.1 km/sec P-wave, using DH1 - DH6 |
| BSSV3 | Beam-steered summation: up-going 8.1 km/sec S-wave, using DH1 - DH6 | BSSV6 | Beam-steered summation: down-going 8.1 km/sec S-wave, using DH1 - DH6 |
| BSSV4 | Beam-steered summation: down-going velocity P-wave, using DH1 - DH6 | ΣDVS | Summation of SZ1 - SZ10 and DH1 - DH6, with MAP band- pass filter |

NOTE

Magnification of:

- Short-period measured at 1 cps
- Broad-band measured at 0.8 cps
- Long-period measured at 0.04 cps
- MCF measured at 1 cps
- BSS measured at 1 cps

properly, but all systems except the short-period primary data were shut down after 1 hour and 45 minutes of operation to conserve secondary power. On 6 October, a power failure resulted in the loss of data from all short-period seismographs for 3 hours and 30 minutes.

2.5 SHIPMENT OF DATA TO THE SEISMIC DATA LABORATORY (SDL)

Magnetic-tape seismograms are shipped to SDL about 15 days after the end of the month during which they are recorded. The seismograms from magnetic-tape recorders 1, 2, 3, and 4 recorded at UBSO through 30 September have been shipped to SDL.

All 16-millimeter film seismograms recorded at UBSO through 31 August were sent to SDL. More recent films are currently held in Garland for special studies.

2.6 QUALITY CONTROL

Quality control checks were made on randomly selected runs of all recordings from the observatory. Results of the checks were sent to the observatory for corrective action as necessary.

2.7 SECURITY INSPECTION

On 5 September, UBSO was notified by Mr. William J. Robertson, Industrial Security Specialist, that because UBSO has no classified documents, his quarterly security inspection will be conducted by telephone in the future. This procedure will continue until such time that the observatory holds classified documents.

3. EVALUATE DATA AND PROVIDE MOST EFFECTIVE OBSERVATORY POSSIBLE

3.1 MODIFICATIONS TO INSTRUMENTATION AT UBSO

Modified hose clamps and roller assemblies were installed in the peristaltic pumps of the Develocorders during the report period. The only failure of a modified pump occurred on 22 October when both hoses were split in the pump of Develocorder 3.

On 9 October, the procedure for use of the emergency power system was modified. Because low priority data are being recorded on magnetic-tape recorders 1 and 4, these recorders are turned off during a failure of commercial power. With this load removed from the emergency system, the standby generator can handle the remaining load of all instrumentation, including both battery chargers. The new configuration was successfully tested when during a planned outage of commercial power, the emergency system operated for a total of 1 hour and 40 minutes.

On 30 October, Recorder 6, which was formerly used for MAP 1, was modified for use in the recording of the long-period triaxial system and other long-period test systems.

3.2 ADDITIONS TO INSTRUMENTATION AT UBSO

3.2.1 Long-Period Triaxial Seismometer

The drilling and casing of a 200-foot hole to be used for the evaluation of the long-period triaxial seismometer was completed during August. The drilling and casing were conducted under Project VT/6706 and were coordinated by the UBSO personnel. All of the surface facilities for the long-period triaxial installation were completed during September. In October a cable trench was dug from the central recording building to the site of the long-period triaxial seismometer, poles for the installation of power to the storage building were set, and the power was installed.

3.2.2 Long-Period Array

Suitable sites for the six positions of the long-period array were found by test drilling. The locations of the six sites were surveyed, and Mr. Ray E. Book, U. S. Corps of Engineers, is currently negotiating with representatives of the Ute Indian Tribe and the Bureau of Land Management, State of Utah, for the lease of the sites.

4. TRANSMIT DAILY MESSAGES TO THE COAST AND GEODETIC SURVEY

The arrival time, period, and amplitude measurements for events recorded at UBSO were reported daily to the Director of the Coast and Geodetic Survey in Washington, D. C. The number of events, by type, reported by UBSO during each month in this reporting period is shown in table 5. Table 6 shows the total number of events recorded by the observatory, the number of epicenters determined by the C&GS and reported in the "Earthquake Data Report,"

Table 5. Events reported to the C&GS by UBOSO during August, September, and October 1967

| <u>Month</u> | <u>Local</u> | <u>Near Regional</u> | <u>Regional</u> | <u>Teleseisms</u> | <u>Total</u> |
|--------------|--------------|----------------------|-----------------|-------------------|--------------|
| August | 23 | 363 | 36 | 1256 | 1678 |
| September | 12 | 328 | 66 | 1171 | 1577 |
| October | 10 | 384 | 29 | 1224 | 1647 |

Table 6. Percentage of hypocenters reported in the C&GS "Earthquake Data Report" for which UBOSO data were used

| <u>Month</u> | <u>No. events reported by UBOSO</u> | <u>Percent of C&GS hypocenters for which the C&GS listed a UBOSO P or PKP arrival</u> | <u>Percent of C&GS hypocenters for which UBOSO recorded a P, PKP, or later phase, based on up-dated associated data</u> | <u>Percent of C&GS hypocenters for which UBOSO recorded a P, PKP, or later phase, based on up-dated associated data</u> | |
|--------------|-------------------------------------|---|---|---|------|
| April | 1683 | 426 | 59.5 | 69.2 | 76.3 |
| May | 1659 | 413 | 67.9 | 70.9 | 76.3 |
| June | 1678 | 444 | 65.6 | 68.2 | 71.6 |

the percent of the C&GS hypocenters within 100 degrees of UBSO for which the C&GS report listed a UBSO P or PKP phase, the percent of C&GS hypocenters for which UBSO recorded a P or PKP phase, as determined from associated data, and the percent of C&GS hypocenters for which UBSO recorded a P, PKP, or later phase, based on updated associated data for April, May, and June. Lists of more recent epicenters have not been completed by the C&GS.

Figures 3 and 4 show the world-wide distribution of the C&GS-located epicenters for April, May, and June 1967. The three types of symbols used to show the locations of the epicenters represent the detection by UBSO of a P or PKP, the detection of an event in which the first recorded arrival was not P or PKP, and no detection.

5. PUBLISH MONTHLY EARTHQUAKE BULLETIN

5.1 BULLETIN STATUS

Data from UBSO were combined with data from BMSO, CPSO, TFSO, and WMSO and published in a multistation earthquake bulletin. The bulletins for April, May, and June 1967 were published and distributed during the reporting period. Raw data for July and August were keypunched, transcribed onto magnetic tape, and sent to SDL for association. The raw data for September were sent to SDL for keypunching and association.

5.2 TRANSFER OF KEYPUNCHING RESPONSIBILITY TO SDL

Beginning with the October 1967 raw data, the responsibility of bulletin keypunching was transferred to SDL. Checking and updating of the ABP output and publication of the bulletin will continue to be accomplished by Geotech.

6. MAINTAIN UBSO FACILITIES

The underside of the porch roof of the central recording building was repainted as were the tripod at the long-period vault, the top of the vault, and the multi-conductor cable reel. Also, the back and borders of the UBSO "KEEP OUT" sign were repainted.

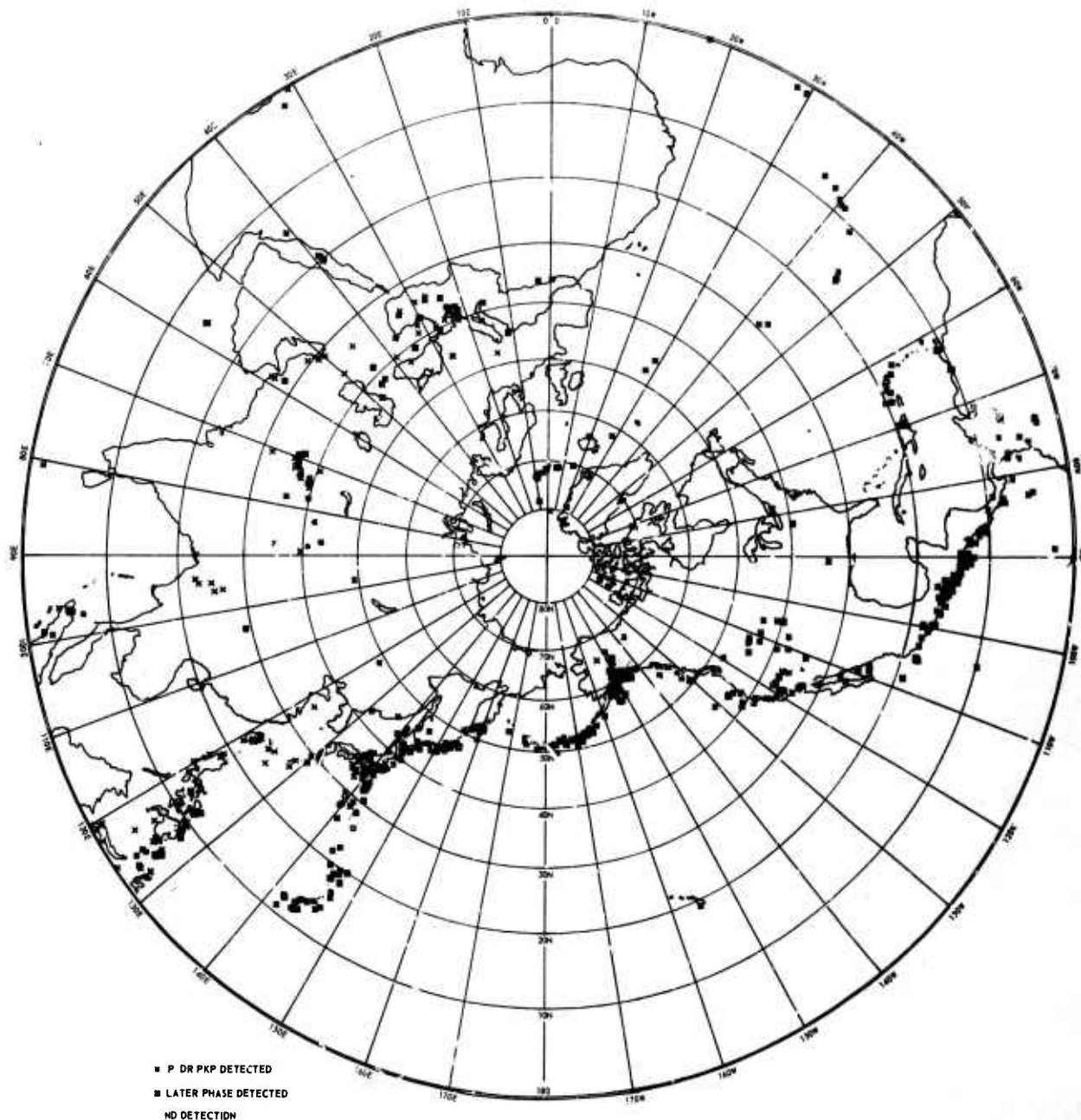


Figure 3. Distribution of Coast and Geodetic Survey located epicenters in the northern hemisphere for April, May, and June 1967

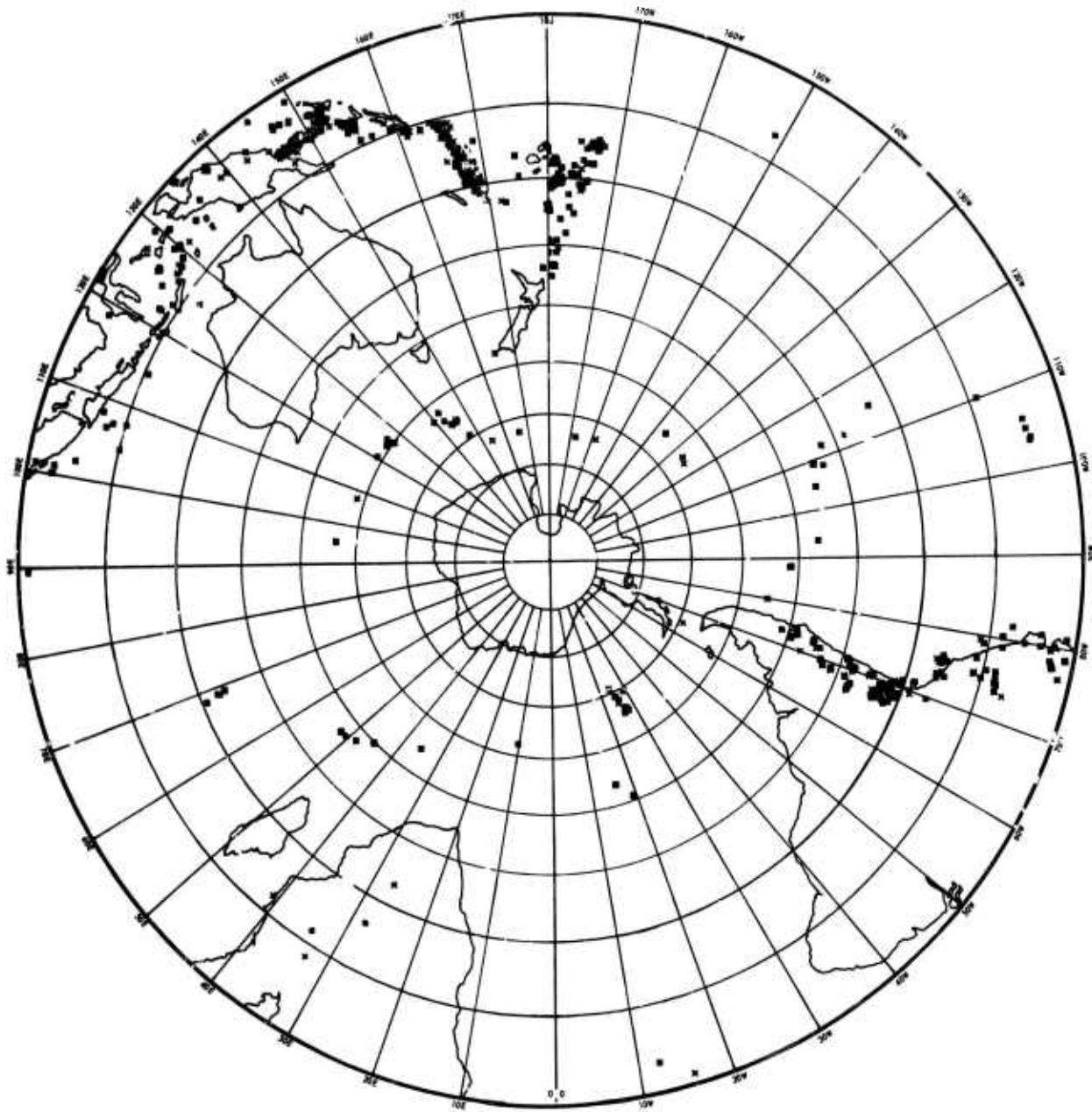


Figure 4. Distribution of Coast and Geodetic Survey located epicenters in the southern hemisphere for April, May, and June 1967

7. MAINTAIN UBSO EQUIPMENT

7.1 MAGNETIC TAPE RECORDERS

A new set of Geotech magnetic tape-recorder heads was installed on recorder 1 on 23 October. The signal-to-tape noise ratio obtained using these heads is currently being evaluated.

A test of the speed of the magnetic-tape transports was made on 31 October. Tape recorders 2 and 3 were found to be out of tolerance, and their speeds were adjusted. The results of the test are shown in table 7.

Table 7. Results of tape transport speed test

| <u>Tape No.</u> | <u>Length of tape read</u> | <u>Reading time</u> | <u>Adjusted reading time</u> |
|-----------------|----------------------------|---------------------|------------------------------|
| 1 | 15 feet | 9 min. 59 sec. | --- |
| 2 | 15 feet | 10 min. 6 sec. | 10 min. 1 sec. |
| 3 | 15 feet | 10 min. 5 sec. | 10 min. 0 sec. |
| 4 | 15 feet | 9 min. 58 sec. | --- |

7.2 DEVELOCORDERS

Samples of water from several points in the UBSO water system and slime samples from the Develocorders were sent to the Western Filter Company, Denver, Colorado, for analysis and recommendations for the prevention of the slime formation. At the close of this reporting period, no results have been received.

7.3 CABLE

Nine, 6-reel lengths of spiral-four cable between the central recording building and the vertical array site were waterproofed with Kearney air seal on 19 August.

8. INSTRUMENT EVALUATION

8.1 EVALUATION OF VERTICAL ARRAY

As reported in section 2.2.4, the vertical array was inoperative during the reporting period; however, a study is currently in progress using previously-recorded vertical array data to relate observed attenuation of noise with depth to theoretically-predicted values.

8.2 TECHNICAL ASSISTANCE AND MONITOR OF SANDIA'S USO

Monitoring of the Sandia USO system continued throughout the reporting period. Sandia personnel were at UBSO on 21 September to replace a malfunctioning time code generator.

When the USO channels were switched to the Helicorder for the daily operational check on 4 October we discovered that the USO seismograph was inoperative. After the system had been recorded overnight and still found to be inoperative, Sandia Corporation was notified of the situation. Sandia personnel were at UBSO on 11 and 12 October to correct the malfunctioning seismograph. The trouble was traced to an amplifier that was saturated by the large earthquake near Richfield, Utah, on 4 October. A modification was installed that will prevent any future outages of this nature. The magnetic tape was changed, and the entire system checked during the Sandia visit.

9. SPECIAL INVESTIGATIONS

9.1 SIGNAL CLASSIFICATION STUDY

A study of a system for the classification of teleseismic earthquake signals was made in response to a need for a concise expression of the physical appearance of seismograms. In addition, a classification system based on the visual appearance of the signal could provide a means of focal mechanism discrimination.

The classification system investigated in this study describes a teleseismic signature by means of a seven-character, alphanumeric code. The seven characters of classification in order of decreasing generality, are as follows:

1. Four possible categories pertaining to the general shape of the signal envelope;

2. Ten possible categories concerned with the time lapse between the signal start and maximum;
3. Ten possible categories pertaining to the time lapse between the signal start and a secondary pulse;
4. Ten possible categories pertaining to the rate of buildup to the maximum;
5. Ten possible categories pertaining to the rate of buildup to a secondary pulse;
6. Eighteen possible categories pertaining to the rate of decay after the first principle pulse of the signal;
7. Six possible categories based on the amplitude of the maximum pulse relative to that of a secondary pulse.

One hundred and fifty-three earthquakes were selected which had epicenters at teleseismic distances from UBSO, TFSO, and WMSO, and whose magnitudes exceeded 5.0. The epicenter and magnitude data were taken from C&GS earthquake data reports of June through August 1966.

The recorded signals at each of the observatories were inspected, and those which had sufficient S/N to exhibit some definite signal character were classified by mutual agreement among a panel of Garland-based analysts. This resulted in a total of 247 signature classifications. These data were designated the "reference" set and were punched onto computer cards. The signatures from the various films were reproduced photographically and reassembled on one composite 16-millimeter film, ordered by date of origin. Copies of this classification study film were sent to UBSO and TFSO along with instructions for use of the system. Four TFSO and three UBSO analysts classified the signatures according to their understanding of the instructions. These classifications were recorded on standard computer data forms and were sent to the Garland facility where they were punched onto computer cards. The classifications of each of the seven categories for each of the seven analysts were compared with the reference classifications for all signals. Since the analysts did not necessarily use the same data trace (system) to classify a signal as did the reference, it was possible to make the comparison for the case of random trace selection by the analyst relative to the reference and for the case where both the analysts and the reference classified the signal from the same trace. To determine if experience in using the system improves the analyst's ability to classify a given signal correctly, the classifications made by two analysts who were experienced in using the system were compared to the reference. The results are summarized in table 8. The maximum percentage agreement with the reference upon a classification is obtained when the analysts are experienced in using

Table 8. Percent of agreement of analysts' classifications with the reference classifications

| Source of reference classification | Source of analysts' classification | CHARACTER | | | | | | | Comments |
|---|--|-----------|------|------|------|------|------|------|--|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Classifications made using various traces (systems) | Classifications made using the trace which, in the analyst's opinion, showed the signal character best | 85.7 | 83.4 | 67.4 | 89.6 | 60.1 | 54.3 | 73.9 | The analysts (7) were inexperienced in the use of classification system. |
| | | 89.9 | 89.7 | 78.3 | 88.1 | 71.5 | 64.0 | 82.2 | |
| Same | Classifications made using the same trace as the reference | 93.8 | 90.7 | 83.3 | 93.8 | 85.2 | 80.4 | 87.8 | The analysts (2) were experienced in applying the system. |

the system, and they use the same trace as that used during the reference classification. These conditions would be the normal ones if the system were used on a routine basis.

Table 8 shows percentage agreements with the reference for each of the seven character positions that constitute the complete signal classification. With the considerations of analysts experience and constancy of the trace used, good agreement is observed for most of the character positions; however, the percentage of agreement on the complete classification (all seven characters) is the product of the seven probabilities (assuming character independence) and is only about 40 percent.

Although the seven-character, alphanumeric system is adequate in the sense that the principle characteristics of the analog signal can be reproduced from the coded signal, it is too subjective in that a given signal cannot be identically classified upon subjection to repeated and independent analysis. The principal factor which introduces subjectivity into the system is that characters 1 through 6 are critically dependent upon the analyst's selection of the start time. A slight shift in the start time can cause a signal to fall into a different category.

We recommend that the seven-character, alphanumeric system be revised so that characters conveying the information now encoded by characters 1-6 would not be dependent upon the signal start. This change could be accomplished by keying on the signal maximum instead of the signal start. This modified classification system should be free of errors associated with picking the signal start time and should, as a result, permit identical classification of a signal under repeated, independent analysis. We also recommend that the modified system be evaluated to determine the degree to which the analog signal can be reproduced from the coded representation of the signal. The reproduction of the analog signal should be accomplished by machine processing to remove bias in the reproduction of the signals and also to evaluate possible routine reproduction of analog signals from codes received at a seismological data reduction center.

If the modified system proves to be sufficiently objective and capable of retaining the principal visual characteristics of a signal, we recommend that a number of signals of known but different source mechanism be classified and that these signals and the corresponding codes be examined to see if a particular type of source mechanism tends to produce signatures which are similarly classified.

9.2 ROUTINE NOISE MEASUREMENTS

Measurements of ambient noise in the 0.4 to 1.4 seconds period range are made daily at UBSO. Data are processed in Garland, and monthly cumulative

probability curves of trace amplitude and ground displacement data are published. Noise data are reported from the SZ10, Σ SS and Σ SSF seismograms. Noise curves for June, July, August, and September were sent to the Project Officer during this reporting period.

10. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

10.1 DATA SENT TO THE UNIVERSITY OF UTAH AND TO C&GS

Analysis information was given to Mr. Waverly J. Persons, C&GS, and Mr. Larry Wilson, University of Utah, concerning a large earthquake that occurred near Richfield, Utah, on 4 October.

10.2 DATA SENT TO ESD

All 16-millimeter film and magnetic-tape seismograms with corresponding logs for 21 October were sent to Mr. Don Clark, ESD, on 25 October at the request of the Project Officer.

10.3 VISITORS

Messrs. E. D. Zaffery, P. A. Fjelseth, and E. R. Stepka, Sandia Corporation, were at UBSO on 16 and 17 August to work on the USO.

Messrs. R. S. Reynolds and E. D. Zaffery, Sandia Corporation, were at UBSO on 21 September to service the USO.

Captain Frederick D. Munzlinger, the VSC Project Officer, and Mr. B. B. Leichter, Geotech Program Manager, visited UBSO on 28 and 29 September.

Messrs. P. A. Fjelseth and E. R. Stepka, Sandia Corporation, were at UBSO on 11 and 12 October for work on the USO.

On October 27, Messrs. John Wise and Noel Doss, Geotech, were at UBSO to work on the long-period triaxial seismograph system.

11. REPORTS

a. Technical Report No. 67-10, Operation of UBSO, Quarterly Report No. 5, Project VT/6705, was mailed to the Project Officer on 28 August.

b. Preparation of the draft of a technical report, Evaluation of Multiple Array Processors at the Uinta Basin Seismological Observatory, is in progress. The draft of this report will be submitted to the Project Officer for review during the week of 20 November.

APPENDIX to TECHNICAL REPORT NO. 67-73

STATEMENT OF WORK TO BE DONE

EXHIBIT "A"
STATEMENT OF WORK TO BE DONE
AFTAC Project Authorization No. VELA T/6705/S/ASD (32)

1. Tasks:

8 February 1966

a. Operation:

- (1) Continue operation of the Uinta Basin Seismological Observatory (UBSO), normally recording data continuously.
- (2) Evaluate the seismic data to determine optimum operational characteristics and make changes in the operating parameters as may be required to provide the most effective observatory possible. Addition and modification of instrumentation are within the scope of work. However, such instrument modifications and additions, data evaluation, and major parameter changes are subject to the prior approval of AFTAC.
- (3) Conduct daily analysis of seismic data at the observatory and transmit daily seismic reports to the US Coast and Geodetic Survey, Wash DC 20230, using the established report format and detailed instructions.
- (4) Record the results of daily analysis on magnetic tape in a format compatible with the automated bulletin program used by the Seismic Data Laboratory (SDL) in their preparation of the seismological bulletin of the VELA-UNIFORM seismological observatories. The format should be established by coordination with SDL through AFTAC. The schedule of routine shipments of these prepared magnetic tapes to SDL will be established by AFTAC.
- (5) Establish quality control procedures and conduct quality control, as necessary, to assure the recording of high quality data on both magnetic tape and film. Past experience indicated that quality control review of one magnetic tape per magnetic tape recorder at the observatory each week is satisfactory unless quality control tolerances have been exceeded and the necessity of additional quality control arises. Quality control of magnetic tape should include, but need not necessarily be limited to, the following items:
 - (a) Completeness and accuracy of operation logs.
 - (b) Accuracy of observatory measurements of system noise and equivalent ground motion.
 - (c) Quality and completeness of voice comments.
 - (d) Examination of all calibrations to assure that clipping does not occur.
 - (e) Determination of relative phase shift on all array seismographs.

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EXHIBIT "A"

(f) Measurement of DC unbalance.

(g) Presence and accuracy of tape calibration and alignment.

(h) Check of uncompensated noise on each channel.

(i) Check of uncompensated signal-to-noise of channel 7.

(j) Check of general strength and quality of timing data derived from National Bureau of Standards Station WWV.

(k) Check of time pulse modulated 60 cps on channel 14 for adequate signal level and for presence of time pulses.

(l) Check of synchronization of digital time encoder with WWV.

(6) Provide observatory facilities, accompanying technical assistance by observatory personnel, and seismological data to requesting organizations and individuals after approval by AFTAC.

(7) Maintain, repair, protect, and preserve the facilities of the seismological observatory in good physical condition in accordance with sound industrial practice.

b. Instrument Evaluation: After approval by AFTAC, evaluate the performance characteristics of experimental or off-the-shelf equipment offering potential improvement in the performance of observatory seismograph systems. Operation and test of such instrumentation under field conditions should normally be preceded by laboratory test and evaluation.

c. Special Investigations: Conduct research investigations as approved or requested by AFTAC to obtain fundamental information which will lead to improvements in the detection capability of UBSO. These programs should take advantage of geological, meteorological, and seismological conditions at UBSO. The following special studies should be accomplished.

(1) Long term evaluation of the multiple array processor units.

(2) Installation and evaluation of a vertical array.

(3) Evaluation of the long-period vault.

(4) Provide technical assistance and monitor an unattended seismological observatory to be installed at UBSO in June 1967.

Research might pursue investigations in, but is not necessarily limited to, the following areas of interest: microseismic noise, signal characteristics, data presentation, detection threshold, and array design (surface and shallow borehole). Prior to commencing any research

EXHIBIT "A"

investigation, AFTAC approval of the proposed investigation and of a comprehensive program outline of the intended research must be obtained.

2. Approval by AFTAC will normally be provided through the project officer.

3. Reports: Provide reports in accordance with the ^{Data} requirements outlined in DD Form 1423 and attachment 1 thereto.

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| 13. ABSTRACT This report describes the operation of the Uinta Basin Seismological Observatory (UBSO) from 1 August through 31 October 1967. Modifications and additions to the observatory instrumentation are described, and tests to improve the operations of the observatory are reported. Also discussed is the status of special investigations designed to evaluate and improve the detection capability of the observatory. | | | |

| 14 KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|--------|----|--------|----|--------|----|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Unattended Seismological Observatory Vertical Array Multichannel Array Processor Seismograph Operating Parameters Long-Period Array | | | | | | |