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TECHNICAL REPORT NO. 77-4

SEMIANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS

JANUARY THROUGH JUNE 1977

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TELEDYNE GEOTECH

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SEMIANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS

January through June 1977

by

John R. Sherwin
and
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Sponsored by

Advanced Research Projects Agency
ARPA Orders Nos. 2551 and 2897

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31 July 1977

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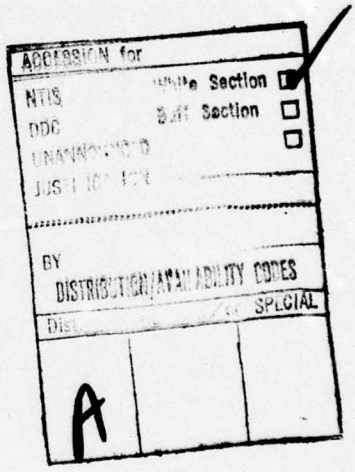

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The work performed under Project T/4703, Special Data Collection Systems, during the period from 1 January through 30 June 1977 is described.

Two SDCS systems which were deployed in early 1975 remained in operation at their original sites. These sites are at Houlton, Maine, and Red Lake, Ontario. The Houlton site uses a Model 36000 borehole seismometer system and the Red Lake Site uses standard SDCS (surface) instrumentation.

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20. ABSTRACT (Continued)

Cont

Three SDCS systems remained in operation at the Nevada Test Site (NTS). These systems record short-period data only on both analog and digital recorders. The site at Oak Spring Butte was operational throughout the period. Two systems located in Pahute Mesa (NT-NV and NT2NV) were relocated to the Yucca Flat area of NTS in order to collect data in the immediate vicinity of known signal anomalies. Single short-period vertical component sites were also added as outriggers in order to complement data from each of the NTS systems.

During May and June, three additional SDCS units were placed in operation at sites near the detonation points of events off the NTS. The sites are in remote areas and record short-period data on analog tape only. These units are to collect data to complement the NTS data being used in present magnitude anomaly studies. The sites are Faultless, Nevada (near the FAULTLESS event); Tatum Dome, Mississippi (near the SALMON event); and Gasbuggy, New Mexico (near the GASBUGGY event).

ABSTRACT

The memory problem in the digital recorder was resolved during this period by installing a newly designed memory in three of the five systems. Additional memory assemblies are being built for installation in the other two digital recorders.

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ILLUSTRATIONS

SEMIANNUAL REPORT, PROJECT T/4703
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1. INTRODUCTION

The Special Data Collection System (SDCS) program, Project T/4703, is a continuation of work begun under the Long-Range Seismic Measurements (LRSM) program in 1960. This work is directed toward advancing the seismic detection, identification and location techniques necessary to detect and identify underground nuclear explosions.

This report describes the work performed under the SDCS program during the period from January through June 1977 and is submitted in accordance with Sequence No. A004 of the Contract Data Requirements List as amended under Modification P00005, 2 January 1975. This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VSC, Alexandria, Virginia 22314, under Contract No. F08606-74-C-0013.

2. FIELD OPERATIONS

2.1 GENERAL

Five Special Data Collection System (SDCS) teams were operational at the start of this report period. These teams were located at Red Lake, Ontario (RK-ON), Houlton, Maine (HN-ME) and three teams on the Nevada Test Site (NTS). The three teams on NTS were located on Pahute Mesa (NT-NV and NT2NV) and near Oak Springs Butte (OB2NV). The systems at RK-ON and HN-ME recorded both short-period and long-period data in digital and analog modes through the period. The teams at the NTS recorded only short-period data but recorded in both digital and analog formats. The two teams on Pahute Mesa (NT-NV and NT2NV) moved to Yucca Flat (YF4NV and YF-NV respectively) which is also on the NTS. At the time of this move, single outrigger short-period vertical instrumentation was added at all three NTS locations. At OB2NV, OB3NV was added and at the Yucca Flat sites YF2NV was added to YF-NV and at YF4NV, YF3NV was installed. Three additional SDCS teams were fielded in May 1977 to record data at sites not on the NTS but near the detonation points of underground devices. Figure 1 is a map showing the locations of the sites occupied during the period January through June 1977.

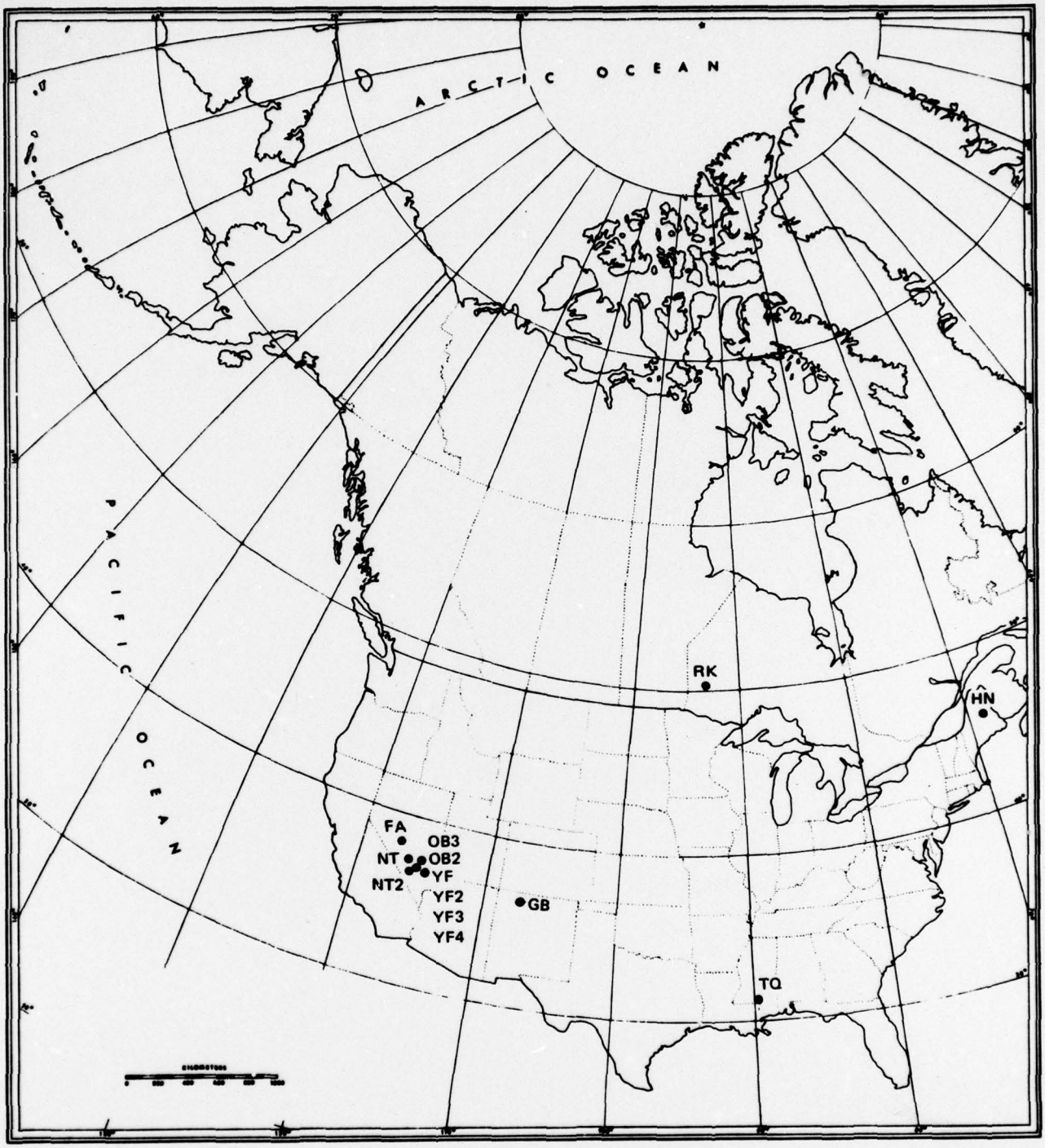

Figure 1. Site locations for SDCS operations during the period from January through June 1977

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2.2 CHANGES IN NEVADA OPERATIONS

In mid-March, the Project Officer requested estimates of cost and time to move the two Pahute Mesa SDCS units in Areas 19 and 20 of the Nevada Test Site (NTS) into the Yucca Flat, Areas 3 and 7. Also, "outrigger" short-period (SP) vertical instruments were to be installed 1 to 2 kilometers from each of three NTS sites. With the approval of the Project Office, sites were selected and extra outrigger equipment was withdrawn from the SDCS inventory. The two SDCS units were moved to Yucca Flat on 01 April and routine operations were resumed on 10 April. The three outrigger sites were placed in operation 20 April. Outrigger data for all sites are recorded on analog magnetic tape and on channel four of the digital recorder. The three outriggers also include separate lines back to the respective recording unit for daily calibration of the seismometers.

The Yucca Flat sites in Areas 3 and 7 are arranged in an east-west line across a fault. From east to west, the sites are YF-NV (3 component), YF2NV (outrigger), YF3NV (outrigger), and YF4NV (3 component); the sites are about 1 kilometer apart. These sites are located on alluvium and are also near major roads and considerable construction activity in Areas 3 and 7 of NTS. Drilling, heavy equipment movements, and occasional windy periods cause almost continuous high seismic background at all four sites at levels of 200 to 400 nm. During the occasional quiet periods, backgrounds drop to as low as 25 nm. These high background levels were expected but the sites were placed here to investigate magnitude anomalies from four detonations - two at each end of the line of sites. It is thought that a north-south fault between the YF-NV and YF2NV sites may be a factor in the observed magnitude differences.

The outrigger associated with the OB2NV site is designated OB3NV and is about 1 kilometer north-northeast of the site. This site, as is OB2NV, is located on the Climax stock. The outrigger site was selected to collect vertical data from a site further removed from potential effects of the PILEDRIVER and HARDHAT cavities than is the OB2NV site. Figure 2 is a map showing the location of the NTS sites.

2.3 ADDITIONAL SDCS SITES

In late March, the Project Office requested a cost estimate to deploy three additional SDCS units. These systems would be located near the detonation points of devices off the NTS as an extension of the present magnitude anomaly studies. During April and early May, the three systems were checked out thoroughly at the Garland plant. Also, two leased pickup trucks and other necessary long lead time items were ordered. When the approval to deploy was received on 6 May, final preparations were made and the teams departed in mid-May. All three were operational with SP instruments only by the end of May or early June.

This additional work was authorized as Amendment 19 to the contract. A detailed proposal (P1-2841) covering the amended statement of work was submitted to the Project Office on 8 June 1977. By the end of the reporting period, the final negotiations had not been completed on the proposal.

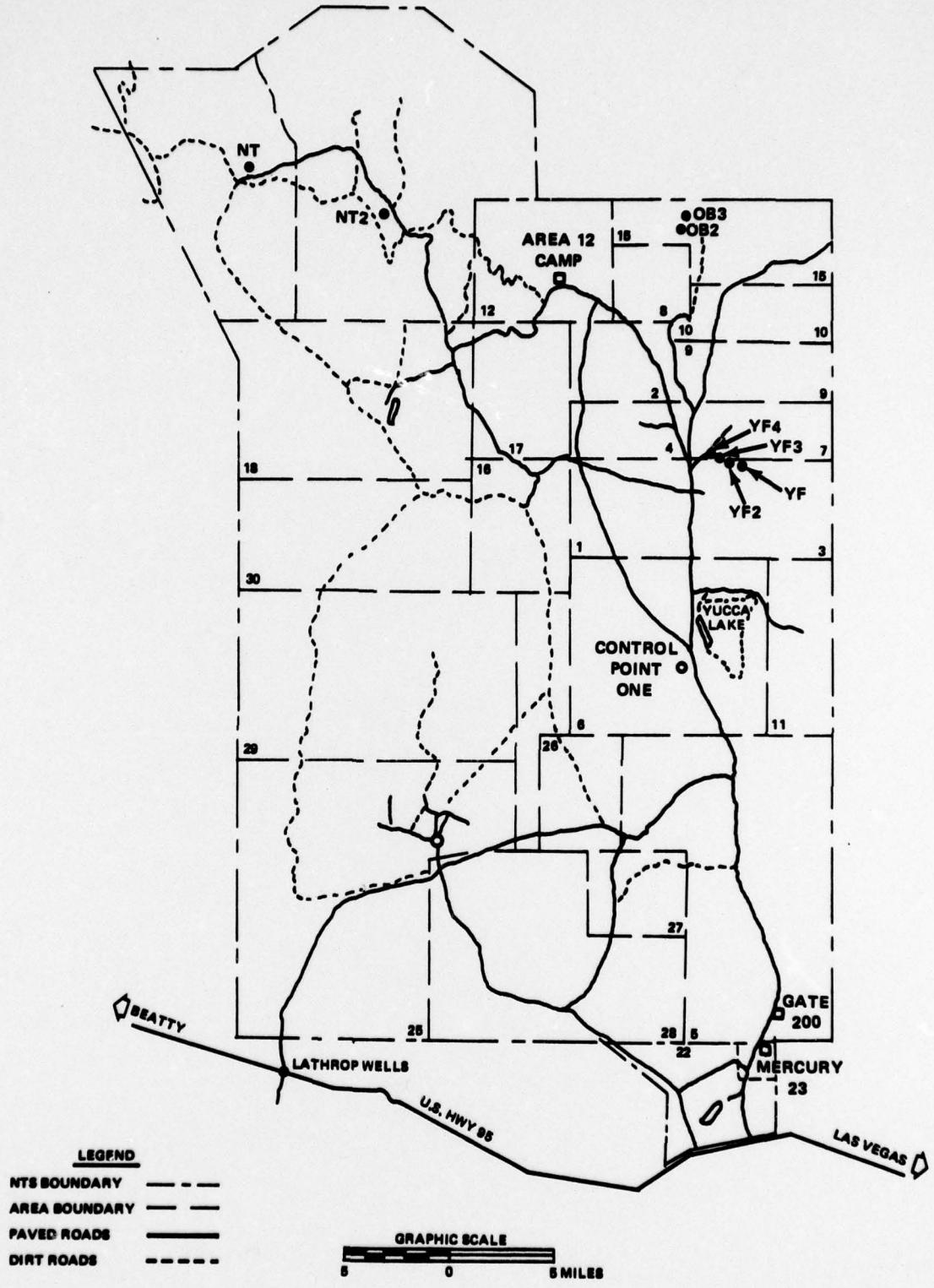

Figure 2. SDCS site locations on the Nevada test site

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2.4 FIELD SITE OPERATIONS

2.4.1 Team 51, Faultless, Nevada (FA-NV)

The team arrived on site on 26 May. A site was selected and a permit to occupy the site was coordinated by the Project Office through the Property Management Office, Nevada Operations Office of the Energy Research and Development Administration (ERDA) in Las Vegas, Nevada. The site is located about 1050 m (3400 ft) NW of the FAULTLESS surface ground zero (SGZ) and the coordinates are:

36°38'26" N

116°13'22" W

Elevation 1920 m (6300 ft)

Site installation and set-up calibrations were completed on 03 June 1977 after which routine operations were begun. No major problems have been encountered during the remainder of this period. Minor problems which are corrected as they occur include low thermoelectric generator (TEG) voltages, tape system capstan motor failures, and timing system instability.

2.4.2 Team 52, Tatum Dome, Mississippi (TQ-MS)

Team 52 arrived in the general site area on 12 May 1977. Site selecting and permitting were completed on 12 May when the equipment was moved on site. The site is located about 520 m (1700 ft) SSW of the SALMON SGZ and the coordinates are:

31°07'58" N

89°34'16" W

Elevation 130 m (425 ft)

Site installation and set-up calibration were completed on 20 May after which routine operations began. Thirteen days of recording were lost due to bearing failure in three capstan motors of the FM magnetic tape recorder. The tape system for this site had a motor and pulley arrangement different from the others and it was discovered that the replacement motors could not be kept operating. The system was changed to the standard configuration (for which a better supply of spare parts is available) and has operated satisfactorily since 16 June. Another minor operational problem in the area is horses which step on the rubber propane lines to the TEGs causing them to go off. A fence was built which solved the problem.

2.4.3 Team 53, Gasbuggy, New Mexico (GB-NM)

Team 53 arrived in the site area on 23 May 1977 and immediately began set-up of the system. The permit to occupy this site was also obtained through the Las Vegas office of ERDA. The site is located about 1900 m (6300 ft) NW of the GASBUGGY SGZ and the site coordinates are:

36°41'26" N

107°13'34" W

Elevation 2160 m (6100 ft)

Site installation and set-up calibrations were completed on 29 May and routine operations began. No major problems have been encountered in operations at this site.

2.4.4 Team 56

2.4.4.1 Nevada Test Site 2 (NT2NV), Area 19

Operations at NT2NV were routine with no major malfunctions in either the digital or analog systems. Minor outages due to drive belt failures in the analog tape recorder were the only reported failures. Early in January, a heavy snowfall prevented site access until the road could be plowed the following day.

2.4.4.2 Yucca Flat (YF-NV) and Yucca Flat 2 (YF2NV), Area 3, Nevada Test Site

The Team 56 equipment was relocated from NT2NV, Area 19, on 01 April 1977. Site set-up and calibrations were completed on 10 April. The YF-NV instrumentation consists of a three-component short-period system only. The YF2NV site is a single SP vertical instrument located 880 m (2900 ft) west of the YF-NV site and is operated from YF-NV as an "outrigger." Instrument installation and cabling were complete on 10 April and data recording began on this date. However, the seismometer data coil was not compatible with the SP solid state amplifier and the YF2NV response did not match that of the prime location until 20 April when the coil was replaced and set-up calibrations were completed.

The old-design memory in the DDS-1103 system failed on 09 May. When the failure was confirmed by QC at Garland, the memory was returned to Garland for repair. It was returned to the field and installed on 29 May and has operated satisfactorily since that time.

Another minor problem has been noise pickup on the long data cable between the outrigger and the prime site. Some of the noise has been traced to operation of the many mobile transmitters in the area, and some seem to be due to distant thunderstorms. Chokes, bypass capacitors, and Zener diodes will be installed in the data lines in July which should reduce the noise pickup and also improve the lightning protection.

The site location information for YF-NV and YF2NV is:

YUCCA FLAT, NEVADA (YF-NV)
37°04'06" N
116°00'07" W
Elevation 1270 m (4170 ft)

YUCCA FLAT 2, NEVADA (YF2NV)
37°04'10" N
116°00'44" W
Elevation 1260 m (4125 ft)

2.4.5 Team 57

2.4.5.1 Nevada Test Site (NT-NV), Area 20

No problems were reported in the analog recording of data. The memory in the digital system failed on 07 February and no data were recorded until 16 February when a replacement memory was installed. This memory malfunctioned on alternate cycles and the data continued to be bad while awaiting a "fix" from the manufacturer.

2.4.5.2 Yucca Flat 3 (YF3NV) and Yucca Flat 4 (YF4NV), Area 7, Nevada Test Site

The Team 57 equipment was relocated from NT-NV, Area 20, on 01 April 1977. Site set-up and initial calibrations were completed on 10 April and routine operation of the prime, three-component station (YF4NV) began. The outrigger, YF3NV, is a single SP vertical and is located about 1100 m (3600 ft) east of YF4NV. As at YF2NV, the seismometer data coil of the outrigger was not compatible with its amplifier and was replaced on 20 April. Routine operation of YF3NV began on that date after set-up calibrations were completed.

Intermittent work on the DDS-1103 system continued during the entire period. On 5 April, the data printed circuit (PC) card in the PERTEC tape transport was replaced due to a problem in the read electronics. This problem only affected on-site verification of the tape. In early June, an apparent tape skew problem was observed by the SDAC QC group. A master skew tape along with detailed instructions was sent to the area. Adjustments were completed and the system was returned to routine operation in early July.

The only major operational problem here was spiking and noise on the outrigger as at YF2NV. Grounding and replacing of one amplifier has helped the problem some, but a final solution depends on the tests with the lightning protection circuits described in the preceding section.

Activity at the NTS during May caused the recording trailer and the seismometers to be displaced. No damage was done. In the future the operator will be advised by test site personnel when anticipated ground motion is high enough to require special preparations.

The site location information for YF3NV and YF4NV is:

YUCCA FLAT 3, NEVADA (YF3NV)
37°04'22" N
116°01'27" W
Elevation 1255 m (4115 ft)

YUCCA FLAT 4, NEVADA (YF4NV)
37°04'29" N
116°02'12" W
Elevation 1244 m (4080 ft)

2.4.6 Team 58, Houlton, Maine (HN-ME)

The failure of the memory in the DDS-1103 on 23 February was the only significant malfunction during the report period. A replacement memory was received from Kinemetrics and installed on 29 April 1977. The unit had been inoperative since late February. The system has operated satisfactorily since repair.

There were no other problems in the operations at this site. The Model 36000 KS seismometer system exhibited occasional low level spikes on the long-period horizontals during the spring thaw, but these were minor.

2.4.7 Team 59, Red Lake, Ontario (RK-ON)

There were no significant instrumentation problems during this report period. A drive belt failure in the analog recorder resulted in the loss of several hours of data and a grounding problem resulted in digital data problems for a few days.

The electrical section of motor-generator No. 1 failed on 23 May and was taken to the Onan dealer in Kenora for checks and replacement of the slip rings. Before parts could be installed, unit No. 2 failed on 7 June which halted digital recording. The operator kept the analog portion of the system on batteries while generator repairs were in progress. Unit No. 2 was picked up from the repair shop in late June but has not been completely checked out. There were no other major operational problems at this site. Rainy weather has caused minor cable leakage in the seismometer vault, but occasional pumping of water from the vault has minimized noise in the systems.

2.4.8 Team 60, Oak Springs Butte 2 (OB2NV) and Oak Springs Butte 3 (OB3NV), Area 15, Nevada Test Site

The analog recording at OB2NV continued uninterrupted throughout the report period. The digital recording continued to be plagued by memory malfunctions until 6 April when the memory was repaired by Kinemetrics personnel. Since that time, the station has operated without major equipment problems.

A single outrigger SP vertical seismometer was installed at OB3NV about 850 m (2800 ft) north-northwest of the OB2NV site. The site, like OB2NV, is situated on the Climax stock and is very quiet. As at the other outrigger locations, data recording started at OB3NV on 10 April 1977, but because of the data coil-amplifier incompatibility, the response of the SPZ outrigger did not correspond to the OB2NV SPZ response until the data coil at OB3NV was replaced on 20 April 1977.

On 05 May 1977, activity was initiated at the PILEDRIVER location by NTS personnel to investigate the possibility of installing an underground waste disposal facility. A large blower and the shaft elevator were being operated and causing an exceptionally high background on all data channels. The equipment has been used infrequently during May and June and no further information concerning the status of the PILEDRIVER location has been received.

The site location information for OB2NV and OB3NV is:

OAK SPRINGS BUTTE 2, NEVADA (OB2NV)

37°13'31" N

116°03'28" W

Elevation 1540 m (5060 ft)

OAK SPRINGS BUTTE 3, NEVADA (OB3NV)

37°13'57" N

116°03'15" W

Elevation 1610 m (5280 ft)

3. ENGINEERING SUPPORT

3.1 GENERAL

The engineering support function in Garland routinely provides for control of government property and replacement or repair of parts for SDCS operations. In addition, changes to system hardware are developed to improve operation or to correct deficiencies. In the following paragraphs, engineering support activities during this period are discussed.

3.2 DIGITAL RECORDING SYSTEMS

The digital recording systems have been in operation throughout this reporting period. The problems with the memory units which had been occurring since the systems were put in operation in 1976 were finally resolved by the manufacturer in April 1977. Other problems were generally minor and routine, but field operator inexperience caused some delays in resolving these problems. By early July, all systems were operating properly and lost recording time is expected to decrease significantly.

3.2.1 Memory Failure in the DDS-1103

As reported previously, the memory units originally installed in the Kinemetrics DDS-1103 systems were found to be defective. As a result Kinemetrics agreed to replace these units as they failed with a new design memory which was less complex and used more reliable components. The memory in the OB2NV system (S/N 115) had been replaced with a new design unit in December 1976. Checks of the data showed that erroneous header information was being recorded occasionally but the data portions of the record were good. The second new memory was installed in February in the system (S/N 120) then located at NT-NV. Initial checks showed occasional bad data records, indicating that this memory was also malfunctioning. These failures were reported to the Kinemetrics representative who began checks of the new circuit at his facility to determine the cause. An independent testing program was also started in the Garland laboratory.

These laboratory tests indicated some potential problem areas and the need for detailed tests on an operating system. From 4 April to 7 April, Garland personnel visited the NTS sites. One of the first problems found was that the clock pulse length was adequate for the old memories but marginal for the new ones. In addition, the active transition of the clock pulse was found to be occurring very near the transition time for the data signals. The result of these problems is that devices which drift slightly outside specifications with age could fail in a manner similar to those observed. Kinemetrics was notified of these problems and a representative visited the NTS on 6 April. Clock pulse circuits were modified to lengthen the pulse and make it more stable. The DDS-1103, S/N 120, then at YF4NV was thoroughly checked but no obvious failures could be found. The system at OB2NV (S/N 115) was found to have two bad memory chips (one in each half of the memory) and a bad multiplexer chip. Replacement of these units solved the problems of occasional bad

headers. Finally, a modification to the clock circuit has been developed to make clock pulses occur slightly earlier to avoid the race condition. Incorporation of the modification will be done as time permits.

At the end of this period, new memories were installed and operating properly in the systems at OB2NV, YF4NV, and HN-ME. The old-type memory at HN-ME (S/N 121) failed in late February but replacement by Kinemetrics was delayed until 29 April pending final resolution of the problems with the new unit and final fabrication of the replacement. The old memory at YF-NV (S/N 122) failed on 9 May. Because a new unit was not readily available from the manufacturer, the memory was returned to Garland for repair. It was returned to the field and installed on 29 May and has operated satisfactorily since that time. The old unit at RK-ON (S/N 116) has operated continuously without problems.

When the problems with the new-design memory were resolved, parts were ordered in May to assemble three new memory units for the DDS-1103 system. The new units will replace the old-type units at YF-NV (S/N 122) and RK-ON (S/N 116) and the third will be kept as a spare. New units will be assembled, tested and shipped to the field in July.

3.2.2 Tape Skew Adjustments at YF4NV

During the field trip in early April, a printed circuit board was replaced in the Pertec tape transport of the DDS-1103 system (S/N 120) at YF4NV. A component in the read section of the original board had failed which prevented on-site data verification but did not affect recording. In early June the digital QC group reported that a tape skew problem had apparently developed which caused numerous parity errors in the data. A master skew tape along with detailed adjustment instructions for the replaced circuit board was sent to the team. The problem was corrected in early July.

3.2.3 System Shutdown Due to Power Fluctuations

The last semiannual report discussed a problem of occasional system shutdowns which were apparently due to power fluctuations. Kinemetrics suggested that one integrated circuit in the control section be replaced with a high-speed unit. This modification was completed in mid-December in all systems. Throughout this reporting period, the number of nuisance shutdowns has been minimal. It therefore appears that an autostart circuit modification will not be necessary.

3.3 FAILURES IN FM TAPE RECORDER CAPSTAN MOTORS

Tests have begun to determine why bearings fail prematurely in the 1800 rpm capstan motors of the Magnetic Tape Recorder, Model 19429. These failures have been a particularly serious problem in the operation of the three new teams. Preliminary checks indicate that there are two problems. First the motors operate at high temperatures characteristic of all hysteresis synchronous motors. Tests indicate that the temperature can be reduced by either reducing the input voltage, or reducing the value of the phasing capacitor, or both. Because a capacitor change is simple, all units will be

modified in July. The second problem discovered involved improper installation and lubrication of the replacement bearings. Installation techniques have been corrected and long term tests in operating systems are underway to evaluate a high temperature lubricant. In addition, motors, pulleys and drive belts are being changed as necessary to standardize components in the recorders. This standardization will result in fewer delays in repairing the recorders.

3.4 GYROSURVEYOR PROBE SYSTEM

The Humphrey, Inc., Gyrosurveyor Probe System is used to determine the orientation of the holelocks used for the Model 36000 Borehole Seismometer System. The unit is assigned to this contract to support operations associated with the SDCS program and is also made available to other organizations with the approval of the Project Office. During this reporting period, the system was used in Alaska under the LPDARTS program to verify slant angle specifications of a new borehole and to orient two holelocks. Upon its return to Garland, it was immediately shipped to the USGS Albuquerque Seismological Center (ASC). Personnel at ASC found that the probe would not operate properly. The unit was returned to Garland for inspection, where it was found that the slant-angle pendulum was broken and the gyro was unstable. The unit was apparently damaged in shipment - either during the return from Alaska or during the trip to ASC - despite the fact that the probe was packed carefully in a separate, padded container. The probe assembly was returned to Humphrey for repair and recalibration during early June. The repaired unit was then returned to ASC. Checkout procedures showed that the gyro was still unstable. At the end of the reporting period, arrangements were being made with Humphrey to perform warranty repair.

4. DATA PROCESSING

The data processing tasks under this contract include routine analog tape quality control and special playouts of data as required. Digital tape quality control and all event processing is performed in Alexandria, Virginia, under the Seismic Data Analysis Center (SDAC) contract.

4.1 DATA PROCESSING ACTIVITY AT GARLAND

4.1.1 Analog Tape QC at Garland

The Quality Control (QC) procedures as performed in Garland are very important to the success of the field operations as they provide the only effective control of on-site operations. The lack of continuous visual recordings of all data channels in the field limits the knowledge that the SDCS operator can have of instrumentation problems that are developing. The playout of data from the analog records provides a ready reference for support personnel to evaluate the performance of the instrumentation.

During the extension of operations which began in January, there was a requirement to reduce expenditures as much as possible. Because the five team operators were thoroughly familiar with their systems, and because of increased emphasis on use of digital records, it was possible to reduce the effort normally required for analog QC. As a result, analog data from the original five sites have received a cursory review and not a thorough critique during this reporting period. Analog data from the three new sites have been more carefully checked to assist new operators as they gain experience in the operation of the system.

4.1.2 Magnetic Tape Playouts from 16 mm Film

Playouts of the FM magnetic tape from field sites on 16 mm film is a potential requirement outlined in the amended statement of work. These films would be used as an aid to analysis of data at SDAC and could result in a considerable saving in time to select suitable data segments for further processing. A sample film was prepared and sent to the Project Office which shows some of the various combinations of tape playback and film speed. The data indicate that a 5X compression (from normal SP film speed of 300 mm/min at X10 view) would be ideal from the point of view of labor and materials expenditures. However, a presentation using 2X compression would be more useful if detailed analysis is to be done from film. These and intermediate compressions are possible using existing SDCS equipment. The equipment is being prepared and techniques are being developed so that production of playouts can be started if requested by the Project Office.

4.1.3 Digital Tape Analysis

Continuing problems with the digital recording system resulted in a requirement to dump tape data at Garland in order to speed the process of failure analysis. Therefore, a dump program was written for Geotech's Raytheon 704 Computer system. The simple program includes options to dump all or part of any selected record and has been very useful in assisting field personnel in system troubleshooting.

4.2 DATA PROCESSING AT THE SDAC

The Seismic Data Analysis Center (SDAC) at Alexandria, Virginia, provides all digital tape QC and data analysis support for this program under the SDAC contract. In addition, digital tapes for use at the SDCS sites are provided by the SDAC. Close coordination with the SDAC personnel has continued to provide adequate information to correct deficiencies in field data. The quality control of digital field tapes has been especially important in diagnosing problems with the digital systems. At the end of June 1977, field digital data through mid-June had been received and inspected by QC.