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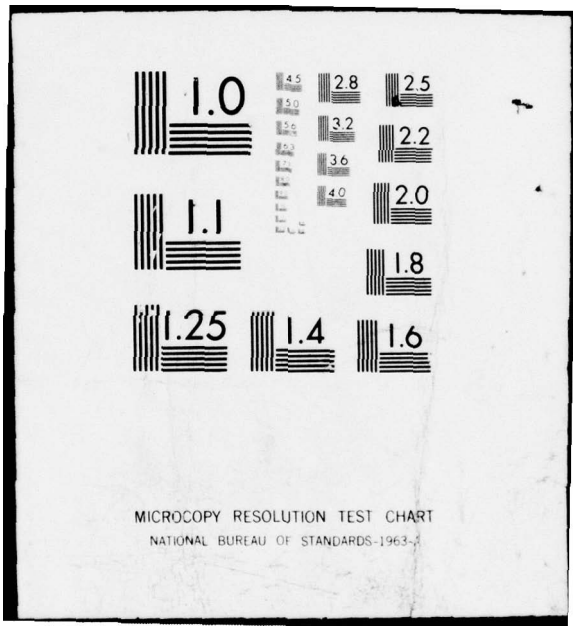
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TECHNICAL REPORT NO. 77-1

SEMI-ANNUAL REPORT, PROJECT T/4703 SPECIAL DATA COLLECTIONS SYSTEMS

July through December 1976

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TELEDYNE GEOTECH

TECHNICAL REPORT NO. 77-1

SEMI-ANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS

July through December 1976

by

John R. Sherwin
and
George C. Kraus

Sponsored by

Advanced Research Projects Agency
ARPA Orders Nos. 2551 and 2897

TELEDYNE GEOTECH
3401 Shiloh Road
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31 January 1977

IDENTIFICATION

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Short Title of Work	Special Data Collection Systems
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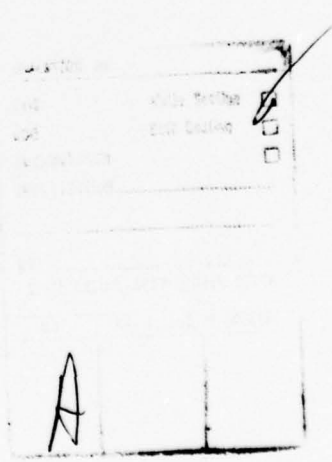

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The work performed under Project T/4703, (Special Data Collection Systems), during the period from 1 July through 31 December 1976 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)

Both sites collect three-component data from long- and short-period systems. The sites at Cumberland Plateau Observatory, Tennessee; Franklin, West Virginia; and Whitehorse, Yukon, remained in operation until 28 July when operations were terminated in order to move the equipment to three locations on the Nevada Test Site. Two of the stations (NT-NV and NT2NV) are located on Pahute Mesa and the third is located on the Climax stock in NTS Area 15 (OB2NV). These stations are being used to collect short-period data only for studies under the Seismic Data Analysis Center program to investigate a potential NTS magnitude bias using teleseismic signals. All data analysis and processing under this program was transferred to the SDAC program on 1 August 1976. All stations used digital recording systems during this period to collect data in digital format for more rapid data processing. The systems have operated properly most of the time but failures in the system memory circuits have been a continuing problem. It is hoped that a new-design circuit will solve these problems soon.

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ILLUSTRATIONS

SEMI-ANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS
July through December 1976

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 July through December 1976 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 Systems (SDCS) have operated in the field during the report period. The systems at Houlton, Maine (HN-ME), and Red Lake, Ontario (RK-ON), have operated continually at their locations with few major malfunctions and little data lost due to equipment failure. The remaining three systems were moved to locations on the Nevada Test Site (NTS). The Whitehorse, Yukon (WH2YK) system moved to Oak Spring Butte, Nevada (OB2NV); the Cumberland Plateau Observatory (CPO) system was moved to Nevada Test Site (NT-NV) and the Franklin, West Virginia, site moved to Nevada Test Site (NT2NV).

2.2 FIELD LOCATIONS

Each field location is similar in the function of the instrumentation utilized and the data recorded. The sites on the NTS, however, record only short-period data instead of both short-period and long-period data recorded at the other locations. The sites differ only in the types of instrumentation used and the environmental conditions under which they are operated. Figure 1 is a map showing the locations of the sites occupied during the period from July through December 1976. The following paragraphs summarize the activities at each site during this period.

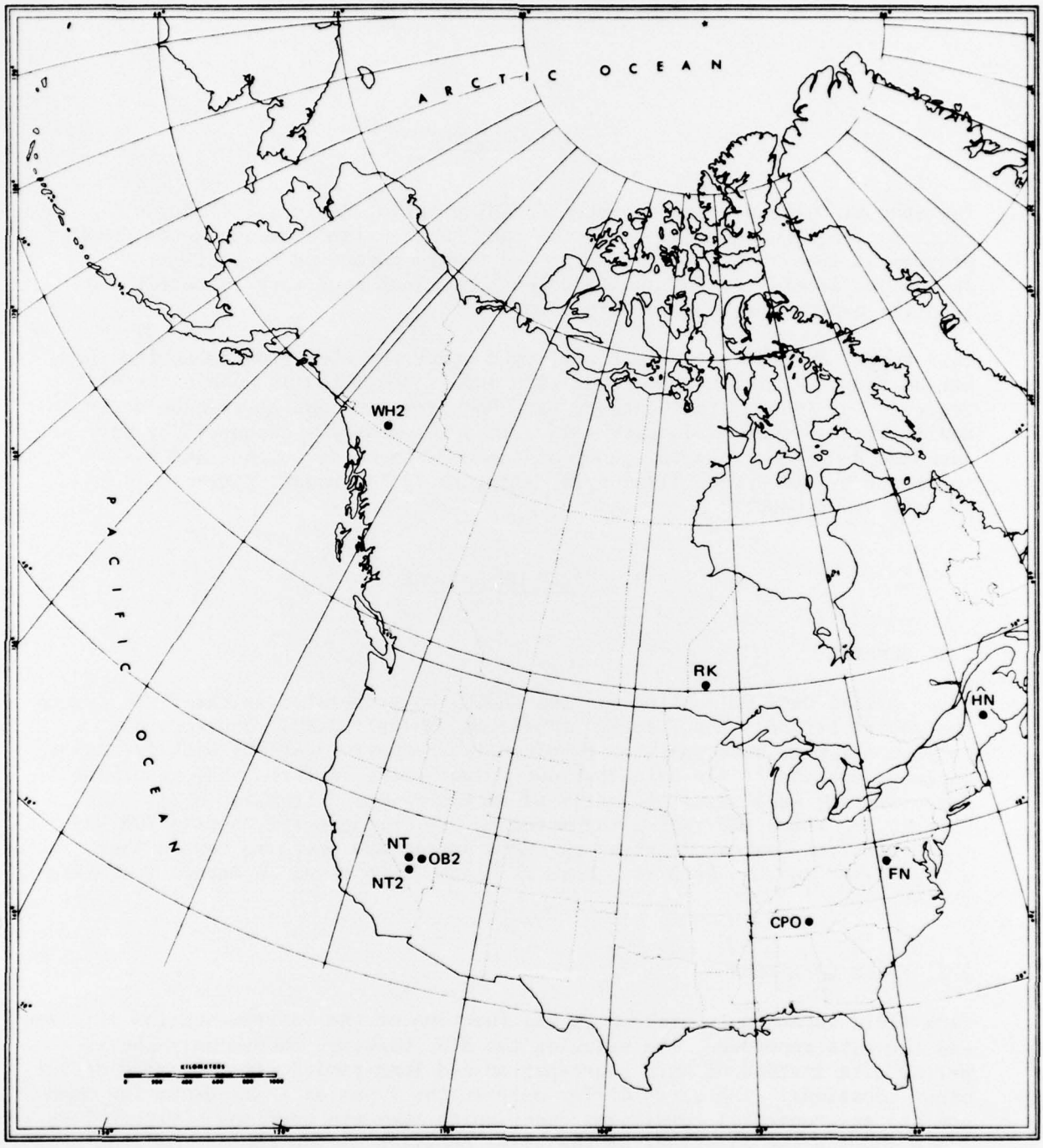

Figure 1. Site locations for SDCS operations during the period from July through December 1976

2.2.1 Team 56

2.2.1.1 Franklin, West Virginia (FN-WV)

On 8 July, both the short-period and long-period transverse data recordings became intermittently noisy and were considered unusable. The Model 36000 KS system was removed from the well on 9 July and during a check of the electronic package, the helium pressure was found to be high. No other discrepancy was found. The helium pressure was reduced to within operating specifications and the seismometer was reinstalled the same day. The effects of this action could not be evaluated until high level signals from a strong earthquake subsided. When evaluation became possible on 11 July, the noise was not observed and did not recur throughout the remaining operating period.

Routine operations at Franklin were terminated at 2100Z on 28 July as directed by the Project Officer. All equipment was removed from the site and returned to Garland, Texas, for restoration to a standard portable system configuration. The instrumentation for the Model 36000 Seismograph System was kept intact for possible redeployment.

The site was closed but the site lease and permission to operate in the deep well will remain effective until 4 February 1977. The operations building was given to the landowner as agreed to in the lease.

2.2.1.2 Nevada Test Site, Area 19, Nevada (NT2NV)

The Team 56 instrumentation was reconfigured at the Garland facility in late August 1976. The system consists of the instrumentation required to record three component short-period data in both the analog and digital modes. The system was transported to Nevada and installed at the Nevada Test Site 2, Nevada (NT2NV) location. Site selection and most of the site preparation had been accomplished prior to the arrival of the instrumentation. The use of a trailer to house the instruments and commercial power were provided by organizations already operational at the NTS. The site installation and calibration were completed on 10 September 1976 at which time routine operations were started.

Figure 2 is a map showing the locations of the three systems operating on the NTS.

Momentary fluctuations in the line power to the site were responsible for the loss of some digital data during the report period. On 14 December a modification to the system control circuit, (an IC replacement) appears to have solved the problem as there were no unexplained outages for the remainder of the month.

Uncontrolled access to NTS Areas 19 and 20 was discontinued on 1 November. The site operator for the NT2NV and NT-NV sites located in these areas must check daily with Control Post 1 personnel at Yucca Pass prior to site entry. Except for the inconvenience of stopping, there has been no difficulty in obtaining site access.

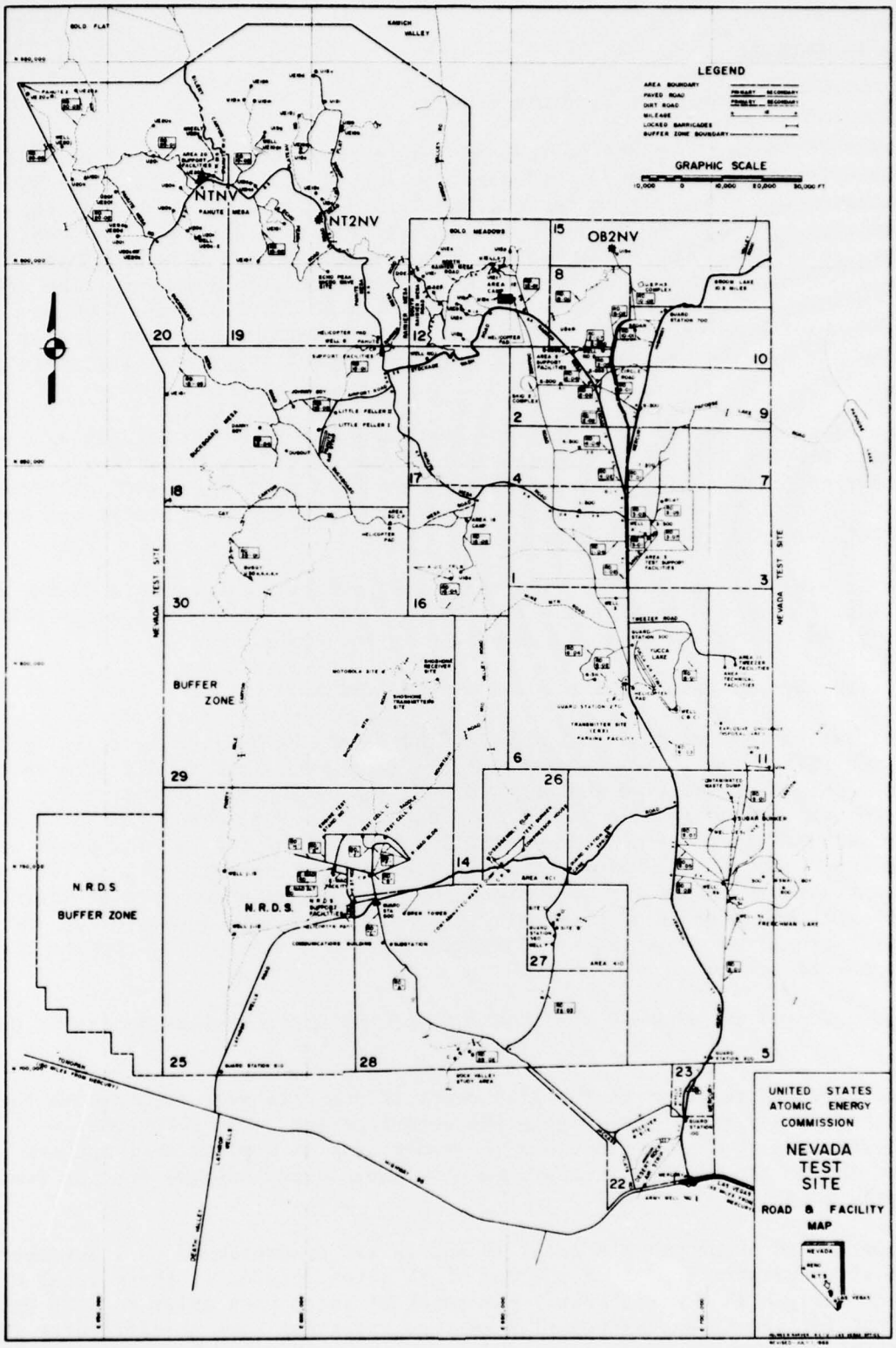

Figure 2. SDCS site locations on the Nevada Test Site

There have been no major instrumentation problems and data recording has continued uninterrupted throughout the period.

2.2.2 Team 57

2.2.2.1 Cumberland Plateau Observatory (CPO)

Site operations at the Cumberland Plateau Observatory near McMinnville, Tennessee were terminated at 2000Z on 28 July 1976 as directed by the Project Office. Departure was coordinated with USGS personnel at Golden, Colorado, and responsibility for the facility was returned to USGS. The system was transported to Garland, Texas, for instrument reconfiguration prior to redeployment in the field.

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

During early August 1976, the Team 57 instrumentation was configured to record three component short-period data in both analog and digital formats. This system was checked and calibrated in Garland, transported to the NTS by truck and system installation and calibration was completed on 25 August 1976. A trailer to house the recording instruments and commercial power were provided by other organizations operating at the NTS.

The loss of digital data due to fluctuations in line power was experienced at this site also. As at NT2NV, this problem appears to have been solved by an IC replacement in the digital recorder control circuit. Quality Control of the digital tape recorded on 29 December indicates an alternate memory problem in the digital system. A replacement memory will be ordered in January.

A satisfactory recording of strong motion signals was completed at NT-NV during December 1976. No problems were experienced in completing the test as recommended in a letter of 3 September 1976 which discussed strong motion studies at the Nevada Test Site.

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

During the first week of July a new memory circuit was installed in the Digital Data Acquisition and Recording System. Good data were confirmed until the 26th of July when it was noted that bit 5 was hanging on an intermittent basis. Kinemetrics, the manufacturer, was notified of the problem and provided a new memory circuit which was installed on 19 August. Subsequent quality control checks confirm the problem has not recurred. There were no other significant problems and routine recordings of analog and digital data were provided from the Model 36000 Borehole Seismometer System (KS) seismograph system during the report period.

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

The Red Lake site is a power generator site. Two 3 kW diesel generators are operated and maintained by the site operator. During this report period only four days of data recording were lost due to generator failure. These power units manufactured by ONAN, Inc., have been in operation since February 1975 and have provided excellent service.

The DDS-1103 digital recording system was inoperative from 8 to 30 July due to a failure of a 400 kHz crystal that was replaced under warranty. The digital recording system was also inoperative from 27 October until 13 November 1976 due to a failure of the -5 volt power supply in the Pertec tape recorder. The data loss was due to the unavailability of replacement parts. Analog data recording continued during the periods of digital recording failure. The site lease was renewed and is effective until 4 October 1977.

2.2.5 Team 60

2.2.5.1 Whitehorse, Yukon (WH2YK)

Routine site operations were maintained until 2000Z, 28 July 1976 when recording was terminated as directed by the Project Office. The digital recording system was shipped by air to Las Vegas, Nevada, to be used at the new site at the NTS. The remainder of the site instrumentation was transported by truck. The Canadian border was crossed on 6 August 1976 and the equipment arrived at the NTS on 9 August 1976.

The instrumentation shelter was sold on site and prior to departure a verbal site release was obtained which was followed up by a writen release from the local Lands Administration office.

2.2.5.2 Oak Spring Butte 2, Nevada (OB2NV)

On 9 August 1976 the site operator and a representative from Garland met with the Energy Research and Development Administration (ERDA) officials to coordinate efforts with them and to arrange for support for the NTS operation. The ERDA office arranged for site access and power as well as coordinating with the U. S. Geological Survey in obtaining the use of some unused recording trailers in which the SDCS recording instrumentation could be housed.

The site was operational on 16 August 1976 with both digital and analog records of the three component short-period system being made. The recording of long-period data at the NTS sites is not required.

The quality of digital data deteriorated during October and November. The trouble was intermittent and difficult to pinpoint until late in November when a dump of the digital data showed a faulty memory to be the cause of the problem. On 9 December, a replacement memory was received from Kinemetrics, but this memory was also found to be faulty and was returned. A replacement memory with different circuitry was received and installed on 22 December and operated satisfactorily for the remainder of the report period, except for an apparently minor problem in header data.

During October the strong motion recording plan was successfully implemented. The modification of the system and revised operating procedures were accomplished with no problems.

2.3 EXTENSION OF OPERATIONS

Operations under the contract were originally scheduled to cease on 31 December 1976. After this date, all SDCS equipment was to again be returned to storage and maintained in a ready condition at a low level of effort through September 1977. In mid-December, notification was received from the Project Office that operation of the five SDCS units was being extended through 30 September 1977. Official authorization to continue operations past 31 December was received in early January. A proposal covering the increased effort will be submitted in January.

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 REPAIR OF MODEL 36000, S/N 002

In the last semi-annual report (TR 76-8), it was reported that the Model 36000, Borehole Seismometer System (KS), S/N 002 had been damaged by lightning while operating at the Franklin, West Virginia site. During this reporting period, repair and final checkout of this unit was completed on a low-priority basis. Initial checks of the individual modules indicate that they had suffered no damage. However, later checks verified that the vertical pod had excessive damping. The pod was replaced with a spare unit assigned to the program and the failed unit was opened for inspection and repair. It was found that a very small amount of silicon grease used to lubricate the mass-lock pins had apparently migrated to the 0.006 in. (0.15 mm) space between the mass and the frame. The unit was carefully cleaned and relubricated with another type silicon grease used on the latest production run. At the end of this period, this pod was awaiting evacuation/checkout and final tests.

Meanwhile, the complete KS unit was assembled and installed in the Garland test borehole for final checks during mid-October. The system checkout was successfully completed and the unit remained in operation until mid-December in order to test a special filter developed for another program. This filter utilizes the "tilt" (horizontal) or "gravity" (vertical) outputs of the KS to provide an output at tidal periods (dc to 628 sec) and another output at normal earth mode periods (3600 to 30 sec). The tidal output from the north horizontal channel was recorded on a chart recorder from 15 November to 12 December which provided nearly one complete 28-day lunar cycle of earth tide data. These data indicate that the KS does indeed have sufficient stability and sensitivity to provide tidal data if it is required for future studies. At the completion of the test, KS, S/N 002 was removed from the borehole and stored for future use.

3.3 DIGITAL RECORDING SYSTEMS

The digital recording systems have been in routine operation throughout most of the reporting period. The three systems at CPO, FN-WV, and WH2YK were transported via air or truck to the three NTS sites and were placed back into operation with no difficulties. However, the systems have had failures in various components which resulted in a loss of about 10 percent of the total available recording time. About two-thirds of the failures were in the DDS-1103 memory circuit, with the balance primarily due to slow parts delivery and slow mail service for two rather routine failures at the Red Lake site.

3.3.1 Memory Failure in the Kinemetrics DDS-1103 System

Table 1 shows the history of memory replacements in the various DDS-1103 systems since they were placed in operation in late 1975. With the initial failures reported in the last semi-annual report, Kinemetrics began a study

Table 1. Memory replacements in DDS-1103 systems

System S/N	Site(s)	Memory replacement dates	Remarks
115	WH2YK,OB2NV	9 Dec 76;22 Dec 76	New design memory
116	RK-ON		No memory problems
120	CPO,NT-NV		Failed 29 Dec 76
121	HN-ME	31 May 76;30 Jun 76;6 Jul 76;19 Aug 76	
122	FN-WV,NT2NV	20 Jan 76;15 Apr 76;6 May 76	

to determine the cause of the failures. The symptoms in almost every case were identical: the data would show intermittent spikes, which increased in frequency of occurrence until it became obvious that they were occurring during alternate cycles of the dual-2048 word buffer. Also, the failures only occurred at the low sampling rates (less than 30 sps) and there was some increase in failures with higher operating temperatures. Kinemetrics reported in August that the problem had been definitely traced to a failure in the Signetics 2527 static shift register used as a memory device. Signetics was unable to explain the chip failures at low data rates and stated that a low-rate test was not normally run on this chip.

With this information, Kinemetrics began supplying memory units with chips selected for proper operation at the slow rates. In addition, replacement memories were checked in an operational system before shipment to the SDCS sites. Even with these procedures, however, two replacement memories were found to operate improperly when first installed in the field systems. When the unit failed at OB2NV after operating properly for nearly a year, it became obvious that these failures could continue indefinitely due to an apparent slow deterioration in the Signetics chips. Kinemetrics was then asked to consider replacement of the DDS-1103 memories with a unit of new design which was then being tested at their plant. This new unit is considerably less complex than the original unit, operates cooler, and uses only one printed circuit board instead of four interconnected boards in the old one. In addition, it uses shift register chips which are available from several manufacturers where the 2527 chip was available only from Signetics.

Kinemetrics then agreed to send a new design memory to the OB2NV site for evaluation. This unit was installed on 22 December and has continued to operate properly except for a possible problem in the header (first ten bytes) of each record. Arrangements were then made to replace any failed memories in the future with the new design unit, provided the header problem can be resolved. At the end of this reporting period, the memory in the DDS-1103 at NT-NV was malfunctioning and a new unit is on order.

3.3.2 Other Problems in the Digital Recording Systems

Two system failures occurred at the RK-ON site which resulted in loss of digital data. The first failure was on 8 July when a 400 kHz crystal unit in the DDS-1103 timing circuit failed. The unit was replaced under warranty on 30 July. On 27 October, a power transistor failed in the -5 volt power supply on the PERTEC tape deck. A replacement part was not on hand at the site and had to be ordered from Garland. In both these cases, the normal slow mail service to Red Lake caused considerable data loss. As operating experience is gained with these units, a reasonable complement of spare components will be supplied to each team and a few high-value spare assemblies will be held for immediate shipment from Garland.

Another problem has been occasional system shutdown. This becomes especially troublesome if it occurs when the site is unmanned because automatic restart functions are not installed. Most shutdowns are the result of line voltage fluctuations which may be of very short duration, but some occur for no apparent reason. Two of the NTS sites experienced repeated shutdowns during November, resulting in the loss of digital recording (analog recordings continued). Power line fluctuations were suspected because both of these stations are on the same feeder circuit and the third NTS station, on another feeder, was unaffected. The problem was discussed with Kinemetrics personnel who suggested that one integrated circuit in the control section of the system be replaced with a high-speed unit. This modification had reportedly reduced the occurrence of nuisance shutdowns in some of their other systems. The parts were ordered and installed in mid-December. This seems to have helped the problem considerably, but continued operation is necessary to determine any real improvement. Meanwhile, an autostart circuit has been

designed which can be easily implemented using unused circuit functions in the DDS-1103 system but it will require a visit by technical personnel from Garland to make the necessary wiring changes. The proposed modification will clear and restart the system after any error condition develops, as long as a power outage is not so long as to cause the tape transport to lose tape tension. Because the tape loading sequence must be done manually, the only solution in this case would be to provide the system with an uninterruptible power source (UPS) which would be expensive.

3.4 STRONG MOTION RECORDING PROCEDURES FOR THE NTS

Special procedures to record strong motion from local NTS activity were developed during September. For special operations, the seismograph magnifications are attenuated up to 60 dB to keep the expected signal within the dynamic range of the system. Also, the digital recorder is operated at four times normal speed (short-period sample rate 80 sps) and the anti-alias filters are slightly modified to record data up to 20 Hz. Because digital recording time is reduced to about seven hours, the system is started automatically using a timer. With Project Officer approval, the procedures were successfully implemented for two separate experiments at two of the NTS sites. Preliminary data analysis by the SDAC showed that both systems operated as expected. If desired, these procedures can be easily implemented at all NTS sites with little disruption of normal operations and no significant cost.

3.5 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 Officer. During this reporting period, approval was obtained to use the system for three programs. First, it was used in conjunction with a test of the KS system under Contract F08606-76-C-0022 during September. After this, the unit was shipped by air to Fairbanks, Alaska, for installation of seven KS systems under the LPDARTS program, Contract F08606-74-C-0045. Routine checks of the borehole slant angle with this instrument revealed that one of the LPDARTS boreholes exceeded specifications. While awaiting completion of another borehole by the drilling subcontractor, the system was loaned to the USGS for use at an installation near Ottawa, Ontario. It was then returned to Alaska to complete the LPDARTS installation. By the end of this reporting period, the system was being shipped back to Garland to be stored for future use.

3.6 SUPPORT VEHICLES

All of the support vehicles not assigned to team operations were sold to the highest bidder in November 1976. The proceeds from the sale were credited to the SDCS contract. The only remaining vehicles assigned to the contract are the four units being used in the field, plus one unit which was not needed for the NTS operation where three sites are being maintained by two men. This vehicle is being held in storage in Garland. Any future SDCS operations for more then the present five will require lease or rental of suitable vehicles.

4. DATA PROCESSING

The data processing for this program has been divided into three parts; analog tape quality control performed at the Garland facility, event processing at the SDAC and the digital data quality control which is also performed at the SDAC.

4.1 ANALOG TAPE QUALITY CONTROL AT GARLAND

The Quality Control 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. Analog record QC for data through late December had been completed by the end of the report period. Analog FM tapes, copies of the QC sheet, and logs are routinely shipped to Alexandria to provide backup recordings while problems with the digital systems are being resolved.

4.2 DATA PROCESSING AT THE SDAC

Data processing at the Seismic Data Analysis Center (SDAC) in Alexandria, Virginia, was divided into two parts: Quality control of digital field tapes and event processing of data into formal event reports as requested by the Project Office. Until 1 August 1976, these functions were performed under Task 4.3.2 of the SDCS contract; after this time, responsibility was transferred to the SDAC project. Upon transfer to the SDAC contract, direct control of SDCS data processing from the Garland office was terminated, but full cooperation and support by the SDAC personnel has continued without interruption. By the effective date of the transfer, all assigned event reports through May 1976 had been completed, and work was underway on June and July events.

The Quality Control (QC) function has continued to be of primary importance to SDCS operations. The QC of digital field tapes has been especially important in diagnosing problems with the digital systems. By the end of December, digital tapes through mid-December had been received and inspected from all teams. These QC checks indicated the previously mentioned memory problems at the OB2NV and NT-NV sites.