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ARRAY MONITORING AND FIELD MAINTENANCE REPORT

O. Steinert, et al

Royal Norwegian Council for Scientific and Industrial Research

Prepared for:

Electronic Systems Division

6 August 1973

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) AD 769849

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1 REPORT NUMBER: ESD-TR-73-287

2 GOVT ACCESSION NO.:

3 RECIPIENT'S CATALOG NUMBER:

4 TITLE (and Subtitle): ARRAY MONITORING AND FIELD MAINTENANCE REPORT

5 TYPE OF REPORT & PERIOD COVERED: 1 January - 30 June 1973

6 PERFORMING ORG. REPORT NUMBER: NORSAR Report No. 60

7 AUTHOR(s): O. Steinert, A. Nilsen

8 CONTRACT OR GRANT NUMBER(s): F19628-70-C-0283

9 PERFORMING ORGANIZATION NAME AND ADDRESS: Royal Norwegian Council for Scientific and Industrial Research, Post Box 51, N-2007 Kjeller, NORWAY

10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Code 1F10, ARPA Order No. 800

11 CONTROLLING OFFICE NAME AND ADDRESS: Deputy for Planning and Technology, Hq Electronic Systems Division (AFSC), L G Hanscom Field, Bedford, MA 01730

12 REPORT DATE: 6 August 1973

13 NUMBER OF PAGES:

14 MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Advanced Research Projects Agency

15 SECURITY CLASS. (of this report): UNCLASSIFIED

15a DECLASSIFICATION/DOWNGRADING SCHEDULE:

16 DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18 SUPPLEMENTARY NOTES:

19 KEY WORDS (Continue on reverse side if necessary and identify by block number):

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U S Department of Commerce
Springfield VA 22151

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

The report covers the period from 1 January to 30 June 1973, and describes the tasks of remote monitoring and field maintenance at NORSAR. The corrective maintenance of NORSAR during the first half of 1973 has been of limited extent. A preventive maintenance program for the SP seismograph amplifiers and the WHVs, and a couple of investigations to reduce the maintenance load of certain channel units, were initiated in the period. In general, the different parts of the array field instrumentation have been stable and operated satisfactorily.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ESD-TR-73-287

NTNF/NORSAR
P.O. Box 51
N-2007 Kjeller
NORWAY

NORSAR Report No. 60
Budget Bureau No. 22-R0293

ARRAY MONITORING AND FIELD MAINTENANCE REPORT

1 January - 30 June 1973

by

O. Steinert and A. Nilsen

6 August 1973

The NORSAR research project has been sponsored by the United States of America under the overall direction of the Advanced Research Projects Agency and the technical management of Electronic Systems Division, Air Force Systems Command, through Contract No. F19628-70-C-0283 with the Royal Norwegian Council for Scientific and Industrial Research.

This report has been reviewed and accepted by the European Office of Aerospace Research and Development, London, England.

DDC
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NOV 19 1973
B

ARPA Order No. 800		Program Code No. IF10
Name of Contractor	:	Royal Norwegian Council for Scientific and Industrial Research
Date of Contract	:	15 May 1970
Amount of Contract	:	$2,051,886
Contract No.	:	F19628-70-C-0283
Contract Termination Date	:	30 June 1973
Project Supervisor	:	Robert Major, NTNF
Project Manager	:	Nils Marås
Title of Contract	:	Norwegian Seismic Array (NORSAR)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADC	-	Analog-to-Digital Converter
AM	-	Array Monitoring
ATC	-	Alternate Telemetry Command/EOC
BE Card	-	Lightning Protection Card
CCB	-	NORSAR Change Control Board
CMR	-	Common Mode Rejection
CTV	-	Central Terminal Vault
DI	-	Discrete Input/SLEM
DP	-	Detection Processor
EOC	-	Experimental Operations Console
EP	-	Event Processor
EPU	-	External Power Unit/SLEM
ESD/TPO	-	Electronic Systems Division (Air Force Systems Command)/ Technical Project Officer
FP	-	Free Period
ICW	-	Input Command Word
Ithaco	-	LP Seismograph Amplifier
LP	-	Long Period
LPV	-	LP Sensor Vault
LTA	-	Line Termination Attenuator
MP	-	Mass Position
MUX	-	Multiplexer/SLEM
NAS	-	NORSAR SP Analog Station
NDPC	-	NORSAR Data Processing Center
NMC	-	NORSAR Maintenance Center (Stange)
NTA	-	Norwegian Telegraph Administration
RA-5	-	SP Seismograph Amplifier
RCD	-	Remote Centering Device
RSA/ADC	-	Range Scaling Amplifier/ADC
SLEM	-	Short and Long Period Electronic Module
SP	-	Short Period
SPS	-	Special Processing System (NDPC)
WHV	-	Well Head Vault

SUMMARY

The report covers the period from 1 January to 30 June 1973, and describes the tasks of remote monitoring and field maintenance of NORSAR.

The corrective maintenance of NORSAR during the first half of 1973 has been of limited extent.

A preventive maintenance program for the SP seismograph amplifiers and the WHVs, and a couple of investigations to reduce the maintenance load of certain channel units, were initiated in the period.

In general, the different parts of the array field instrumentation have been stable and operated satisfactorily.

1. INTRODUCTION

The work presented in this report consists of remote monitoring of NORSAR performed at NDPC and array maintenance performed by the NORSAR field technicians. This work is in the following labelled 'AM'. All task objectives indicated in the report were accomplished during the period 1 January - 30 June 1973 and are detailed in the subsequent sections.

The modems of NORSAR have been maintained by the NORSAR field technicians as in the last reporting period, but for convenience the management of this work has been transferred to other NDPC personnel. This also includes responsibility for cooperation with NTA (Norwegian Telegraph Administration) on proper maintenance and monitoring of the communication network between NORSAR and NDPC. This work is therefore documented in (2).

1.1 Objectives

The AM work is defined in contract number F19628-70-C-0283 entered between U.S. Department of the Air Force/ESD and the Royal Norwegian Council for Scientific and Industrial Research (NTNF). The contract objectives for AM are:

Task 1: Maintenance of NORSAR subarrays

a) Develop and perform a preventive and correct field maintenance program that is integrated with the NDPC remote calibration and maintenance analysis capability. This maintenance program will include all 22 subarrays with their physical facilities such as seismometers, intra-subarray communications, electronics, instrumentation, power supplies, vaults and access roads.

   This program will include repair, calibration and replacement of defective subarray components.

b) Provide and maintain workshop facilities for the repair of subarray equipment.

c) Keep detailed records containing work history on subarrays and components, component repair history, failure rates and other pertinent data.

Task 2: Remote array monitoring at NDPC

a) Establish procedures for array monitoring (AM) operation and AM reporting. These procedures will include array monitoring and calibration, routine maintenance and emergency array maintenance actions that are an integral part of the NDPC operation.

b) Evaluate array performance, monitor array status and direct the subarray maintenance (conduct

routine array calibration and array operations verification using the NDPC AM diagnostics).

c) Maintain the NORSAR AM computer programs. This will include analysis, correction and testing of errors and improvements.

d) Establish and maintain procedures and records that indicate all equipment utilization and performance relevant to AM. This includes peripheral support equipment and field equipment where data is gathered by the NDPC operation as part of array calibration, status monitoring and field maintenance assistance.

1.2 AM Personnel

The AM group consisted of eight persons on full time - six field technicians at the NORSAR Maintenance Center (NMC) at Stange, one AM analyst heading the group and his assistant. One person, at NDPC, participated on part time in the regular monitoring of the LP system and other routine tasks.

The field personnel group is organized with one of the technicians as manager of daily activities in the field and at the NMC. He cooperates intimately with the AM analysts and reports to these. The field maintenance work to be accomplished is decided upon in conjunction with him to secure a satisfactory exploitation of available manpower.

2 NDPC AM OPERATING PLAN

The activation rates for the different AM programs are briefly discussed in Section 2.1. Procedures at NDPC for handling AM data, reporting and cooperating with field personnel are described in Section 2.2.

2.1 Scheduled Monitoring

2.1.1 Monitoring rates

The chosen monitoring frequency of a subarray using a certain AM program has been reviewed regularly. The rates have been set based on:

1) Experiences of accuracy and reliability of the program.
2) The error rate of or drift in units monitored by the program.
3) Computer time requirement of the program.

During the reporting period two changes to the monitoring schedule have taken place. The rate of SLEMTEST has been changed from biweekly to monthly - except for one of the programs in the package, the RSA/ADC test. The rate of CHANEV programs has been changed from 4th weekly to 6th weekly.

The array monitoring schedule as of 30 June 1973 is shown in Table 2.1. As will be seen, all AM programs in operation, with the exception of SACPLP, are activated at least once in an eight-week interval. For a brief discussion of monitoring rates and AM programs in use, refer to (1).

2.1.2 Time requirements

Table 2.1 also shows the time requirements of the different AM programs for routine execution. Collection of a data base from a subarray for later off-line analysis is accomplished without interrupting the normal acquisition of seismic data from other subarrays. To the total amount of off-line computer time required per month (34 hours) should

Program	Monitoring Rate	Time Required pr. Subarray (minutes)		Time Required pr. Month (averaged) for Total Array			
		Data Collection	Data Analysis	Data Collection		Data Analysis	
				Hours	Minutes	Hours	Minutes
LPCAL	Biweekly	30	-	22	-		
SLEMTEST	Monthly	85	-	31	10		
RSA/ADC TEST	Biweekly	0.5	-		11		
MISNO	Monthly	35	20	12	50	7	20
CHANEVSP	6th weekly	25	35	7	3	9	43
CHANEVLP	-"-	80	45	22	05	12	23
SACPSP	Bimonthly	10	20	1	50	3	40
SACPLP	6th monthly	50	46	3	3	2	49
Visual Check							
Sensor Time Series	Daily						
Sensor Gain and Phase	Biweekly						
Total off-line computer time per month approx. 34 hours.							

TABLE 2.1

Monitoring Rates and Computer Time Requirements of AM Programs

be added the time required for different types of ad hoc analyses and reruns of off-line programs erroneously executed. Roughly, this adds another 3-4 hours.

2.1.3 Visual inspection

To secure an acceptable quality of the data used in the seismic data processing at NDPC, the array status panel on the EOC is monitored daily. In addition, all sensor outputs are visually reviewed, using the EOC waveform display, to identify channels with deteriorating performance caused by abnormal amplitudes, spikes and non-seismic noise.

All data channels were checked biweekly, previously weekly, for phase and gain failures, using the waveform display and inserting a sine wave of 1 Hz (SP) and 0.04 Hz (LP) at the calibration coil of the sensors.

Other procedures to secure data integrity are:

1) Subarray checkout at NDPC before departure of the maintenance team after a visit. This consists of verbal reporting by visitor, visual channel check using the EOC, and SLEM circuit tests.

2) Emergency actions if the array status alarms are lit on the EOC.

3) Regular logging of time intervals when any subarray has been masked to survey loss of seismic data.

2.2 AM Internal and External Reporting

All actions at NDPC related to AM tasks which interrupt the normal acquisition of seismic data from one or more subarrays are logged. A board located in the NDPC computer hall is kept permanently updated by AM analysts as a reference on array status to be used by

scientists and computer personnel.

The field maintenance personnel mails a daily report to NDPC on activities performed at the array sites. The reports are reviewed by AM analysts to get an on-the-spot evaluation of disclosed malfunctions and a comparison with scheduled maintenance tasks.

In addition, the field technicians issue a monthly report discussing status of NMC and the array in general, and projects not covered by the daily reports.

A report on LP system status is given biweekly to ESD/TPO, and a review of all tasks accomplished by the AM group is sent monthly to the NORSAR change and control board (CCB).

A semi-computerized report on the status of all data channels giving the last available information on their performance is issued daily. This is based on the parameters calculated by the on-line and off-line AM programs and the visual inspection of the seismometer recordings.

3 ARRAY MONITORING AND FIELD MAINTENANCE

This chapter includes a review of actions of remote array monitoring at NDPC and maintenance accomplished at the subarrays by the field technicians. The principles for directing the maintenance of the array are briefly discussed in 3.1. A discussion of disclosed faults and maintenance accomplished within the array is given in 3.2. Work accomplished at the NORSAR workshop is outlined in 3.3. Different projects with the purpose of improving the field equipment are outlined in 3.4. NORSAR Analog Station (NAS) is discussed in 3.5.

3.1 Maintenance Policy

The streng h and flexibility of the AM system implies that the field maintenance should concentrate on corrective maintenance. Preventive maintenance, in the ordinary sense, should in general not be a necessity. The performance of the array is regularly, and in some ways continuously, controlled by NDPC. Therefore the work program for personnel in the field and the assignment of priorities to the different maintenance jobs will depend on the AM analysts' interpretation of the output of the AM programs.

The field technicians are directed by the AM analysts to perform ad hoc operations at sites where malfunctions or deteriorating performance of instrumentation and electronics are disclosed. The number of visits to the different sites has usually been high enough to allow regular on-site inspection and satisfactory maintenance of facilities and installations not monitored by NDPC.

The normal preventive field maintenance at the subarrays is limited to routine control of the DC offset, CMR, gain of the data channels and check of test generators, RSA/ADC and EPU voltages, and is accomplished in connection with scheduled corrective maintenance. Programs for all-over maintenance of vault facilities, regular replacement of critical parts as RA-5 batteries, etc., are initiated when necessary (refer Section 3.2.3).

3.2 Subarray History

3.2.1 Subarray monitoring schedule

The planned schedule for the remote array monitoring has been well met. In the few cases where the monitoring routines have been delayed, the reasons have been

erroneous executions of the AM programs or communication troubles.

3.2.2 Maintenance visits

The objectives of subarray visits - not to mention the corrective maintenance - have been the accomplishment of tasks related to certain preventive maintenance projects (see Section 3.2.3).

Figure 3.1 shows the number of visits to the different subarrays in the period. Excluding visits caused by troubles in the communications system, the subarrays have in average been visited 4.5 times. The larger number of visits to 04B and 05C are due to the accomplishment of different types of experiments (04B) and routine maintenance of the NAS seismic instrumentation (05C).

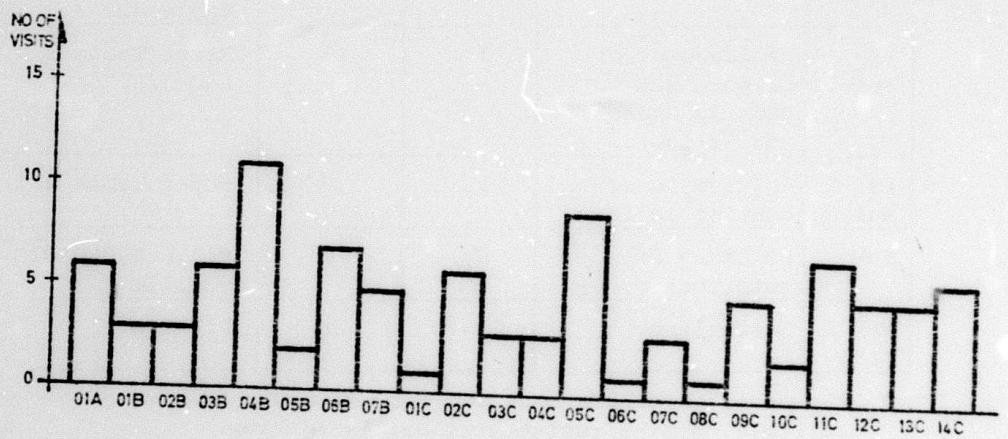

Figure 3.1 Number of maintenance visits to the NORSAR Subarrays (visits caused by faults in the NORSAR/NDPC communications system are not included).

3.2.3 Preventive maintenance projects

Work accomplished as part of this type of preventive maintenance of NORSAR is described in Table 3.1. The work at WHVs consisted of maintenance such as painting of the wood frame, replacement of RA-5 and control of all circuits at the site. The new RA-5 installed has been fully overhauled with new power batteries mounted. The previous problem with SP seismometers having characteristics outside tolerance has caused no work load this period. Only three sensors were replaced during the period.

Unit	Action	No. of Channels/ Subarrays		Comments
		Accomp.	Remaining	
RA-5	Modification of RA-5 input card (see (3), (4))	17	13 *	01A02,05;01B01-04,06;02B06; 03B01,04,05; 05B01,03-06; 11C03. Refer Table 4.2
SP Seism.	Replacement of sensors due to damping and/or nat. freq.	3	1	Refer Table 3.4 and 3.5
LP seism.	Adjustment of damping resis.	9	2	Refer Table 4.1
LPV	Painting of interior	6	0	01A,03B,07B,02C, 03C,11C
WHV & RA-5	Miscellaneous	40	66	01A-07B
* Eleven of these are modified for noise suppression but variable damping resistance, R_d, is lacking.				

TABLE 3.1

Preventive Maintenance accomplished at NORSAR during the period.

3.2.4 Disclosed Malfunctions

3.2.4.1 Instrumentation and Electronics

Table 3.3 shows the number and types of disclosed malfunctions and accomplished adjustments and replacements of field equipment with reference to the faulty channel and the channel characteristics. Table 3.4 gives the number of faults in the total array classified by the involved characteristics and unit in question as in Table 3.3. Table 3.2 explains the codes used in Tables 3.3 and 3.4.

Channel unit parameter	Code	Refer to:				
		Sensor SP/LP	Amplifier RA-5/ Ithaco	LTA	Whole Chan.	SLEM
Damping ratio	λ	x				
Nat. Frequency	F_0	x				
Sensitivity	S	x				
Distortion	D	x	x	x		
Remote Centering Device of LP sensor	RCD	x				
Filter characteristics	F		x	x		
Gain	G		x	x		
Balance	B		x			
DC offset	DCO				x	
CM rejection	CMR			x		
Lightning prot. card	BE card				x	
A/D converter	ADC					x
Test Generators (BB, SP, LP)	Gen's					x
Power Unit/SLEM	EPU					x
Digital Unit/SLEM	DU					x

TABLE 3.2

Explanation of codes for the data channel characteristics used in Tables 3.3 and 3.4.

Period: 1 January - 30 June 1973

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		λ	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		BB	SP	LP			
01A	1																		AA		
	2																				
	3																				
	4																				
	5																				
	6																				
	V																				
	NS																				
	EW																				
01B	1																				
	2																				
	3																				
	4																				
	5											R									
	6						A		A				R								
	V																				
	NS	A																			
	EW																				
02B	1											R									
	2											R									
	3											R									
	4																				
	5																				
	6						A*		A*												
	V																				
	NS																				
	EW																				

Comments: All RA-5's replaced (prev. maint.)

MUX triggered 'high charge' alarm at NDPC erroneous (repaired at site)

Comments: All RA-5's replaced (prev. maint.)

Subarray inoperative 9-12 Feb. due to SPS fault.

Comments: All RA-5's replaced (prev. maint.)

Subarray inoperative 9-12 Feb. due to SPS fault.

*Reported at NDPC as distortion.

Codes:

A - adjustment at site
R - replacement
* - Refer comment field

TABLE 3.3

Adjustments and replacements performed in the array. (Cable, modem and rectifier repairs not included.)

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		A	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		BB	SP	LP			
03B	1							R								AA				AA	
	2																				
	3																				
	4																				
	5																				
	6																				
	V	A																			
	NS	A																			
	EW																				

Comments: All RA-5's replaced (prev. maint.)

04B	1																				
	2												A								
	3																				
	4												A								
	5						p*														
	6																				
	V																				
	NS																				
	EW	A																			

Comments: All RA-5's replaced (prev. maint.)

Abnormal phase shift corrected after installation.

Experimental water monitor connected to door monitor DI from 2 Feb-14 May.

05B	1																				
	2												A								
	3																				
	4												A								
	5												A								
	6																				
	V																				
	NS																				
	EW																				

Comments: All RA-5's replaced (prev. maint.)

Codes:

A - adjustment at site
R - replacement
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Parameter codes are explained in Table 3.2.

Period: 1 January - 30 June 1973

Sub-Array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		λ	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		BB	SP	LP			
06B	1														R	A		A	RAA	R	
	2																				
	3																				
	4														R						
	5														R						
	6																				
	V																				
	NS																				
	EW																				

Comments: All RA-5's replaced (prev. maint.)

MUX/ADC deformed the clock pulses, replaced.

07B	1											AA							A		
	2																				
	3																				
	4																				
	5																				
	6																				
	V																				
	NS																				
	EW																				

Comments: All RA-5's replaced (prev. maint.)

01C	1																		A	A	
	2																				
	3																				
	4																				
	5																				
	6																				
	V	A																			
	NS																				
	EW																				

Comments:

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		λ	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		RB	SP	LP			
02C	1															A			AA	A	
	2																				
	3																				
	4											R*									
	5		RAR																		
	6																				
	V	A																			
	NS																				
	EW																				

Comments: *HF noise generated in Z3 filter.

03C	1															A					
	2																				
	3															Comments:					
	4																				
	5												R								
	6																				
	V																				
	NS																				
	EW																				

04C	1																				
	2										AA							R			
	3															Comments: *HF noise generated in Z3 filter.					
	4																				
	5																				
	6											R*		A							
	V																				
	NS																				
	EW																				

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Parameter codes are explained in Table 3.2.

Period:

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		A	Fo	S	D	Misc	G	D		Misc	G	F	DCO	CMR		BB	SP	LP			
OSC	1																				
	2																				
	3																				
	4										A										
	5																				
	6																				
	V										A										
	NS																				
	EW																				

Comments:

Sub-array	Ch																				
OSC	1															A					
	2																				
	3																				
	4																				
	5																				
	6																				
	V																				
	NS																				
	EW																				

Comments:

Sub-array	Ch																				
OSC	1																				
	2																				
	3																				
	4																				
	5																				
	6																				
	V																				
	NS																				
	EW																				

Comments:

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array
(Cable, modem and rectifier repairs not included.)

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card
		λ	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR	
08C	1														
	2												R		
	3														
	4														
	5														
	6													A	
	V														
	NS														
	EW														

SLEM					
Generators			ADC	EPU	DU
BB	SP	LP			

Comments:

Sub-array	Ch															BE card
09C	1	R									A	R*				R
	2															
	3															
	4															
	5															
	6															
	V															
	NS															
	EW															

R			AAA		

Comments: *Defective K2 relay

One RCD replaced (NS)

One RCD repaired and later replaced.

Sub-array	Ch															BE card
10C	1	A					A				A		A			
	2										A					
	3															
	4															
	5															
	6										A					
	V															
	NS															
	EW	A														

R					

Comments:

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3. 3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Parameter codes are explained in Table 3.2.

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
		A		S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		Generators			ADC	EPU	DU
																SB	SP	LP			
	1											R*	A		R	R	R			R	
	2											R*	A		R						
	3						A		A				A								
L1C	4											R*			R						
	5																				
	6												A								
	V																				
	NS																				
	EW																				
	1												A								
	2												A								
	3																				
L2C	4														R						
	5														R						
	6														R						
	V														R						
	NS	A																			
	EW																				
	1																				
	2												A								
	3																				
L3C	4												AA								
	5													A							
	6																				
	V																				
	NS																				
	EW																				

Comments: *Defective K2 relay.
One RCD repaired.

Comments: One RCD repaired and later replaced.

Comments: One RCD replaced.
Rate selector switch replaced due to erroneous DU output.

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Sub-array	Ch	Seismometer					Amplifier				LTA				BE card	SLEM					
																Generators			ADC	EPU	DU
		λ	Fo	S	D	Misc	G	D	B	Misc	G	F	DCO	CMR		BB	SP	LP			
	1																				
	2												R							A	
	3															Comments:					
LAC	4											R									
	5												R								
	6										A		A								
	V																				
	NS																				
	EW	A																			

Codes:

A - adjusted at site
R - replaced
* - Refer comment field

TABLE 3.3 (continued)

Adjustments and replacements performed in the array (Cable, modem and rectifier repairs not included.)

Parameter codes are explained in Table 3.2 .

Unit	Characteristic	SP		LP	
		Adj.	Repl.	Adj.	Repl.
Seismometer	λ		1	9	
	F_0	1	2		
	S				
	D				
	RCD			3	3
Amplifier	G	4	1		
	D		1		
	B	3			
LTA	G	9			
	F		11		
	DCO	19	5		
	CMR	3			
BE card			11		
SLEM					
BB gen		8	3		
SP gen		1	1		
LP gen		1	2		
ADC		14	1		
EPU		6	2		
DU					

TABLE 3.4

Total number of adjustments and replacements in the NORSAR Data Channels in the period 1 January - 30 June 1973. (Characteristic codes are explained in Table 3.2.)

3.2.4.2 Rectifiers/batteries

No malfunctions of the rectifiers or batteries have been reported.

3.2.4.3 Cables

Cable breakages have occurred twice in the reporting period. Table 3.5 shows the channels affected and the time elapsed before repairs were accomplished.

Sub-array	WHV Cable	Main Data Cable	Breakage (out of operation)		No. of days' work
			From date	To date	
13C	01		5 Jun	8 Jun	4
04C	02,03, 06		28 Jun	29 Jun	2

TABLE 3.5

Cable breakages within NORSAR during the first half of 1973.

3.2.4.4 NORSAR/NDPC communication system

A total of nine subarrays (see Table 3.6) have been visited due to malfunctions of modems or telephone lines. The field technicians performed a total of 12 days' work in the field for these tasks. This work is documented in (2).

Subarray	01A	01B	02B	03B	04B	05B	06B	07B	01C	02C	03C
No. of visits		1				1			2		
No. of days' work		1				1			2		

Subarray	04C	05C	06C	07C	08C	09C	10C	11C	12C	13C	14C
No. of visits				1			1	2	1	1	2
No. of days' work				1			1	2	1	1	2

TABLE 3.6

Subarray Visits
caused by faults in the communications system.

3.3 Workshop Repairs

Faulty units and parts removed from the array sites this period and repaired at NMC are listed in Table 3.7.

Table 3.8 shows faulty units transferred to NMC last reporting period and repaired during this period.

Subarray	Unit/Channel	Week Removed	Index No. S/N	Index No. USP	Diagnostic	Parts Affected/ Repair
04C	LTA 05/06	2	5298		Ch 06 HF oscillation noise	Checked at NMC, faulty Z3 filter
	Test gen. card	26	5159		Loss of .04 Hz signal	At NMC for repair
05C	RA-5 NAS	2	84	0605	Distortion and clipping	Replaced batteries. Adjusted stabilized 12V. Realigned tuned tank.
	Power supply (P2.12.60 K) NAS	14	-	-	No ±12V output	Unrepairable.
07C	AHS-card modem	17	6020-1		B/C loop failure	Replaced Y1
08C	LTA 01/02	11	5242		Ch 02 DCO not adjustable	At NMC for modification
09C	FP RCD NS	11	327		Immovable	Replaced ballbearing. Overhaul
	Seism. 01	17		0368	Damping out of tolerance	At NMC for repair
	LTA 01/02	23	5247		Faulty input relay Ch 01	At NMC for repair
	Test. gen. card	23	5257		-BB failure (not adjustable)	Replaced Z8
10C	Test. gen. card	26	5090		+BB failure (test signal to MUX)	At NMC for repair
11C	LTA 03/04	6	5176		Ripple Ch 04	At NMC for repair
	Modem	15		1647	Periodical Line errors	Observed and tested at NMC, satisfactory operation.
	Line Unit (modem)	15	6776		-"-	
	Test gen. card	25	5027		No 1 Hz output	Replaced defective Z3
	LTA 01/02	26	5180		No BB to cal coil. Caused by defective relay at Ch 01	At NMC for repair

TABLE 3. 7 (Continued)

Diagnostics and repairs of units transferred to NMC.

Subarray	Unit/Channel	Week Removed	Index No. S/N	Index No. USP	Diagnostic	Parts Affected/ Repair
04C	LTA 05/06	2	5298		Ch 06 HF oscillation noise	Checked at NMC, faulty Z3 filter
	Test gen. card	26	5159		Loss of .04 Hz signal	At NMC for repair
05C	RA-5 NAS	2	84	0605	Distortion and clipping	Replaced batteries. Adjusted stabilized 12V. Realigned tuned tank.
	Power supply (P2.12.60 K) NAS	14	-	-	No ±12V output	Unrepairable.
07C	AHS-card modem	17	6020-1		B/C loop failure	Replaced Y1
08C	LTA 01/02	11	5242		Ch 02 DCO not adjustable	At NMC for modification
09C	FP RCD NS	11	327		Immovable	Replaced ballbearing. Overhaul
	Seism. 01	17		0368	Damping out of tolerance	At NMC for repair
	LTA 01/02	23	5247		Faulty input relay Ch 01	At NMC for repair
	Test. gen. card	23	5257		-BB failure (not adjustable)	Replaced Z8
10C	Test. gen. card	26	5090		+BB failure (test signal to MUX)	At NMC for repair
11C	LTA 03/04	6	5176		Ripple Ch 04	At NMC for repair
	Modem	15		1647	Periodical Line errors	Observed and tested at NMC, satisfactory operation.
	Line Unit (modem)	15	6776		-"-	
	Test gen. card	25	5027		No 1 Hz output	Replaced defective Z3
	LTA 01/02	26	5180		No BB to cal coil. Caused by defective relay at Ch 01	At NMC for repair

TABLE 3.7 (Continued)

Diagnostics and repairs of units transferred to NMC.

Subarray	Unit/Channel	Week Removed	Index No. S/N	Index No. USP	Diagnostic	Parts Affected/ Repair
11C (cont.)	EPU	26	8	1753	Improper outputs	At NMC for repair
12C	FP RCD NS	21	265		Immovable	Lubricated and overhauled
	BE-card 04	23	7000		No data output	Replaced 100Ω resistor and Zener diodes
13C	AHS-card modem	7	6232		B/C loop failure	Replaced Y1
	MP RCD NS	24	277		Immovable in plus direction	Lubrication and overhaul
14C	Modem	10		1721	Replaced for testing purpose NDPC-NTA	
	Line unit	10	6836			
	LTA 03/04	10	5214		Ripple Ch 04	At NMC for repair
	LTA 01/02	21	5210		Ch 02 DCO not adjustable	At NMC for repair
	LTA 05/06	21	5215		Ch 05 DCO not adjustable	At NMC for repair

TABLE 3.7 (Continued)

Diagnostics and repairs of units transferred to NMC.

Unit/Channel	Index No.		Diagnostic	Parts Affected/Repair
	S/N	USP		
ST-seis	536		2.5V 50 Hz noise, damping .50	Balance spring adjusted
FP RCD	325		Immovable	Replaced adjusting bolt, cleaned and oiled
SP LPA	5117		Noisy Ch 05	Faulty Z3 filter, not repaired
SP seis	445		Nat. freq. & damping out of tolerance	At NMC for repair
RA-5		0518	Distortion	Replaced batteries
SP seis	289		Cal coil defect	Replaced cal coil, adjusted
Test gen. card	5196		±BB unstable, 1 Hz clipped	Contact failure at Z1, resoldered
RA-5		0498	Chanev SP cancelled	Replaced batteries, overhauled
Digital unit	24	1840	ICW sync/poly failure	Observed at NMC, satisfactory operation
FP RCD	322		Immovable	Overhaul, cleaning and lubrication
SP seis	303		Noisy data	No instrumentation fault
SP seis	121		Noisy data	No instrumentation fault
FP RCD	362		Immovable	Overhaul, cleaning and lubrication
FP RCD	359		Immovable	Overhaul, cleaning and lubrication
SP seis	361*		Freq. & damping out of tolerance	At NMC for repair
SP seis	559		Freq. & damping out of tolerance	At NMC for repair
RA-5	270	0507	Low output	Overhauled, replaced batteries
SP LPA	5178		DC offset 10V on Ch 06	Replaced defective Z3 filter
SP LPA	5177		DC offset not adjustable	Replaced defective Z2.

* Erroneously reported as S/N 561.

TABLE 3.8

Units transferred to NMC last reporting period and repaired during this period. (Refer (1)/Table 3.11)

Unit/Channel	Index No.		Diagnostic	Parts Affected/Repair
	S/N	USP		
SP LTA	5056**		CMR Ch 02 not adjustable	No irregularities found
SP LTA	5312		DC offset not adjustable	Replaced defective Z2
SP LTA	5313		DC offset not adjustable	Adjusted to -2 mV, not repaired

** Erroneously reported as S/N 5062

TABLE 3.8 (Continued)

Units transferred to NMC last reporting period
and repaired during this period. (Refer (1)/Table 3.11)

3.4 Improvements

A number of investigations were initiated during this period to prepare lasting solutions to problems or time-consuming maintenance of certain units experienced during the operation of NORSAR. Some of these projects are listed and commented in Table 3.9.

Topic	Comments
Depression of noise in SLEM discrete inputs	The present logic is not well-suited as line receivers. The best way to enhance the noise immunity is to use a comparator with a suitable input filter and protection, refer also (5).
Too low surge rating of BE protection card	The 1/2 W resistors presently employed may be replaced by wire-wound resistors with higher ratings.
The CTV water monitor triggers at low temperatures.	A modified prototype is constructed and will be tested.
Trends towards negative DC offset in the SP/LTA	The present offset trim should be replaced by one with greater trim range.
Electrolyte boiling in the CTV emergency torches	A proposal for modification of the torches has been presented to the manufacturer.

TABLE 3.9

Proposed improvements of NORSAR field equipment.

3.5 NORSAR Analog Station

The station has been in operation from medio January and has been used by the analysts responsible for the routine analysis of seismic events at NDPC.

By inserting a calibration signal (sine 1 Hz) to the calibration coil of the SP seismometer, the magnification is controlled daily (see Table 3.10). The seismic instrumentation and telemetry equipment are monitored bimonthly. Intermittent maloperation due to degraded quality of the communication line and lack of spare parts to a damaged drum motor implied little use of the station during the last two months of the period.

Magnification (x 1000)	Period	Comments
50	9 Jan - 6 Feb	
35	7 Feb - 12 Mar	
35 - 32	13 Mar - 10 Apr	
35	11 Apr - 14 Apr	
42.5	15 Apr - 16 Apr	
35 - 32	17 Apr - 28 Apr	
35	28 Apr - 1 May	
35	2 May - 30 Jun	Intermittent maloperation due partly to degraded communication and partly to drum motor troubles.

TABLE 3.10

NAS Magnification during first half of 1973.

3.6 New Instruments and Facilities at NMC

A few instruments have been acquired in the period and are listed in Table 3.11 . Refer to (1) for number and types of field maintenance instruments available at NMC at the end of the previous reporting period.

Type of Unit	Manufacturer and Type Description	No. of Units
Digital Multimeter	Fluke 8000A	1
Transistor Tester	Rhode & Schwarz Sunitest V	1
Sweep/Function Generator	Datapulse 410	1

TABLE 3.11

NORSAR field maintenance instruments acquired in the reporting period

A panel for control and testing of the Ithaco LP seismograph amplifier has been constructed and is in use at NMC.

An on-line communication line, 2400 baud, connecting NMC to NDPC was scheduled for implementation this spring. An experimental 1200 baud line was established by NTA in May this year and a line with the requested capacity is expected to be operational late summer or fall.

4. STATUS OF FIELD CHARACTERISTICS

The chapter includes tables giving the values of the damping resistances of the LP and SP sensors after the preventive work discussed in Section 3.2.3 had been accomplished - Tables 4.1 and 4.2 respectively. Figures 4.1 - 4.17 show the spread in SP and LP channel characteristics measured by the AM programs, collected at the end of the reporting period (April-June 1973).

Sub-array	Ch.	ohm	Sub-array	Ch.	ohm
01A	V	2360*	04C	V	2880
	NS	2640*		NS	2350
	EW	2400		EW	2400
01B	V	2660*	05C	V	2910*
	NS	2910*		NS	2780*
	EW	2400		EW	2840*
02B	V	2310*	06C	V	2740*
	NS	2560*		NS	2600*
	EW	2800		EW	2470
03B	V	2680*	07C	V	2550*
	NS	3220*		NS	2450
	EW	2530		EW	2500
04B	V	2300	08C	V	2380
	NS	3990		NS	2670
	EW	3560*		EW	2670
05B	V	2080	09C	V	2330
	NS	2680		NS	2790
	EW	2520		EW	3170
06B	V	2750*	10C	V	2470*
	NS	2800		NS	2550*
	EW	2540		EW	2362*
07B	V	2550	11C	V	2080*
	NS	2440		NS	2480*
	EW	2980		EW	2700*
01C	V	2380*	12C	V	2605
	NS	2650		NS	4230*
	EW	2760		EW	3190*
02C	V	2600*	13C	V	2180
	NS	2530		NS	2600
	EW	2470		EW	2550
03C	V	2680	14C	V	2400
	NS	2820		NS	2820
	EW	2280		EW	2870*

* Adjusted after initial installation 1968.

TABLE 4.1

Damping resistance of the NORSAR LP seismometers
(June 1973)

Sub-Array	Seismometers					
	00/06	01	02	03	04	05
01A	250	250	240	220	180	240
01B	210	210	240	210	270	240
02B	240	220	240	230	200	190
03B	200	220	240	210	240	210
04B	250	260	290	220	310	220
05B	240	240	210	210	215	240
06B	240	230	240	250	190	210
07B	180	220	235	300	220	300
01C	205	250	210	280	215	240
02C	215	X	X	240	300	240
03C	290	XX	XX	200	240	XX
04C	220	215	205	200	215	210
05C	240	200	240	210	275	205
06C	240	200	215	240	200	200
07C	270	220	245	250	200	200
08C	190	190	190	230	240	215
09C	X	240	240	240	215	215
10C	XX	240	240	XX	XX	200
11C	XX	180	280	240	XX	XX
12C	210	180	215	215	240	XX
13C	240	205	240	215	210	265
14C	300	180	190	200	240	240

X - No modifications accomplished (original input card installed).

XX - RA-5 input card modified for noise but variable damping resistance R_d not installed (R_d=240 Kohm).

TABLE 4.2

Modified RA-5 input cards with damping resistance values of the SP seismometer as of 30 June 1973.

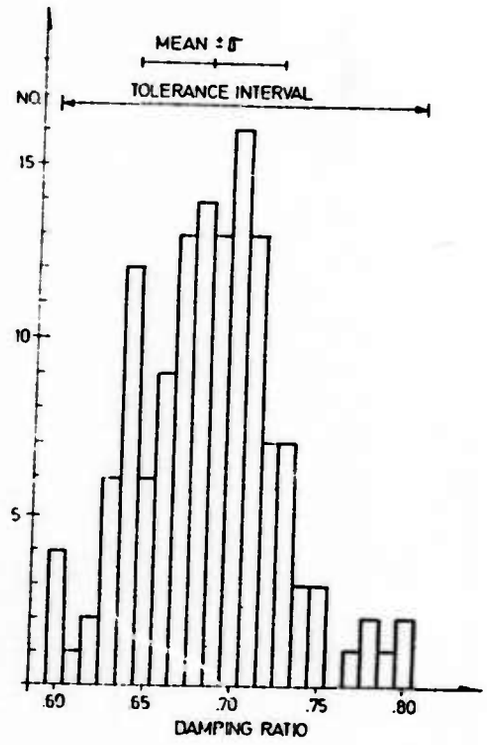

Fig. 4.1 The spread of the damping ratio values of the NORSAR SP seismometers.

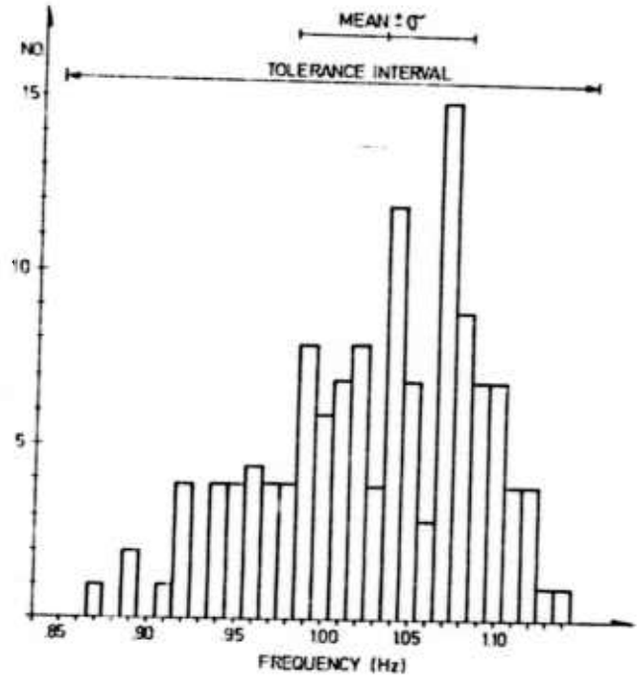

Fig. 4.2 The spread of the natural frequency values of the NORSAR SP seismometers.

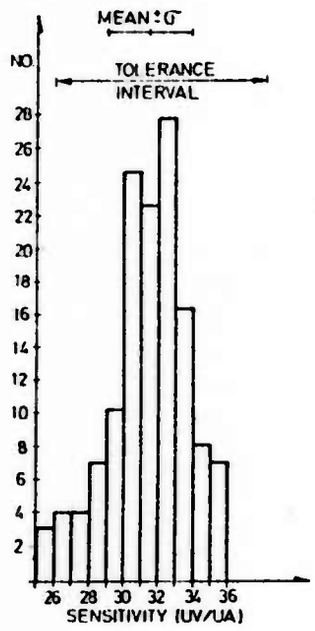

Fig. 4.3 Spread of the coil sensitivity values of the NORSAR SP seismometers.

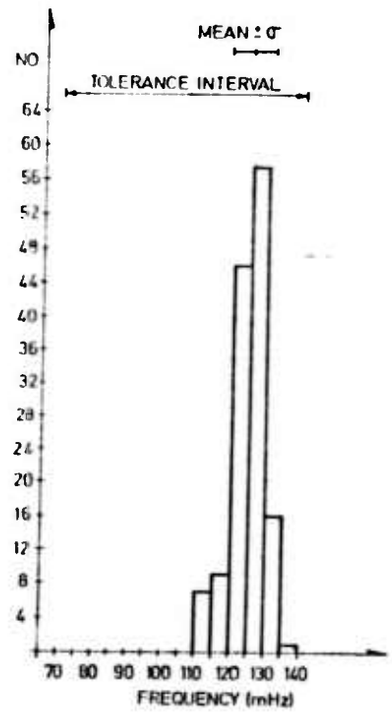

Fig. 4.4 The spread of the lower 3 dB point values of the NORSAR SP seismograph amplifiers (RA-5).

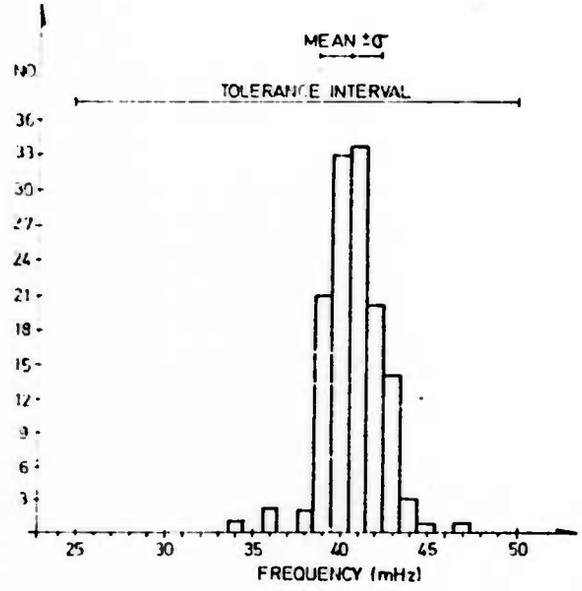

Fig. 4.5 The spread of the lower 3 dB point values of the NORSAR SP/LTA filters.

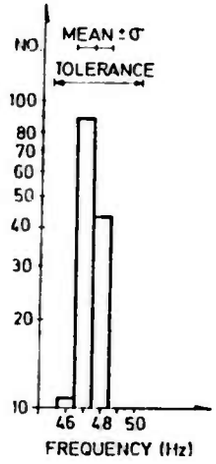

Fig. 4.6 The spread of the upper 3 dB point values of the NORSAR SP/LTA filters.

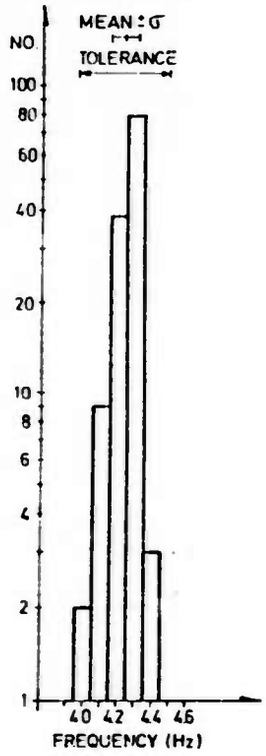

Fig. 4.7 The spread of the cutoff frequency points of the NORSAR SP/LTA filters.

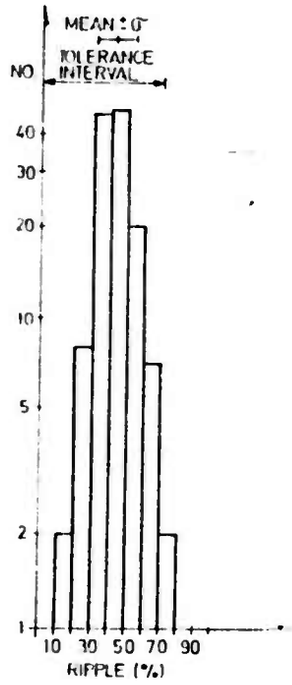

Fig. 4.8 The spread of the ripple values of the NORSAR SP/LTA filters.

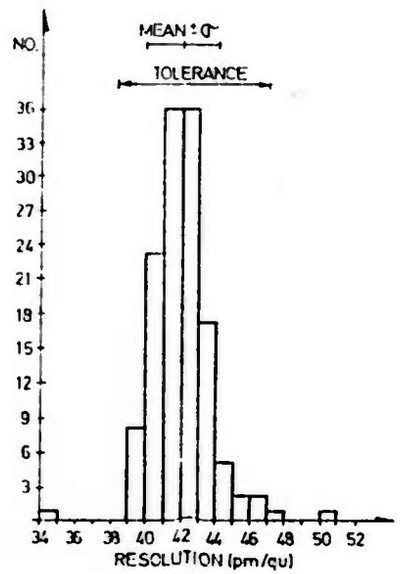

Fig. 4.9 The spread of the channel resolution values of the NORSAR SP channels.

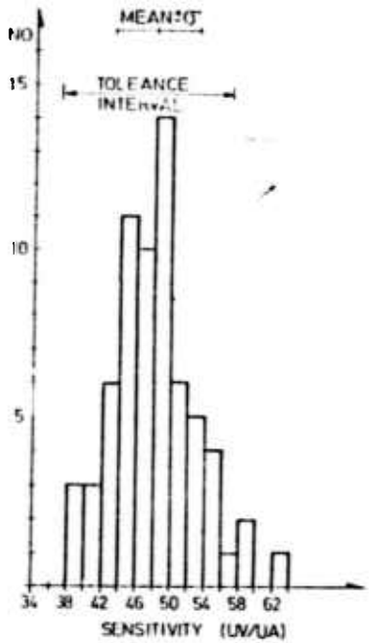

Fig. 4.10 The spread of the coil sensitivity values of the NORSAR LP seismometers.

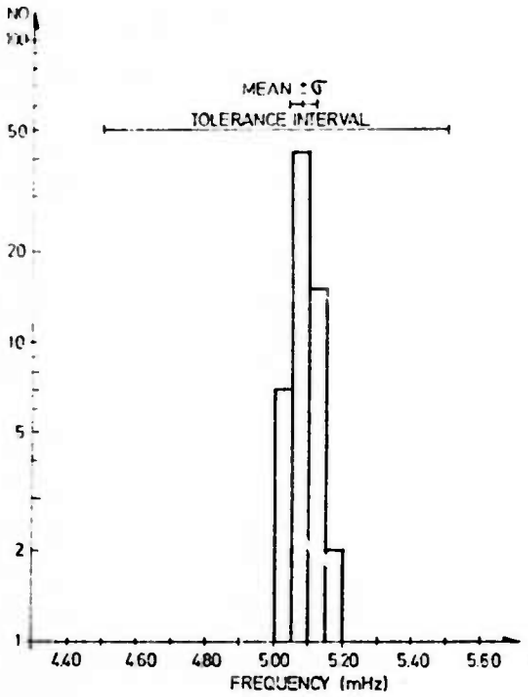

Fig. 4.11 The spread of the lower 3 dB point values of the NORSAR LP seismograph amplifiers (Ithaco).

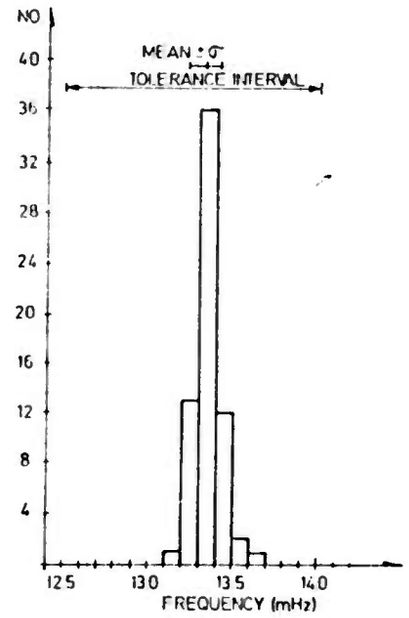

Fig. 4.12 The spread of the zero dB values of the NORSAR LP seismograph amplifiers (Ithaco).

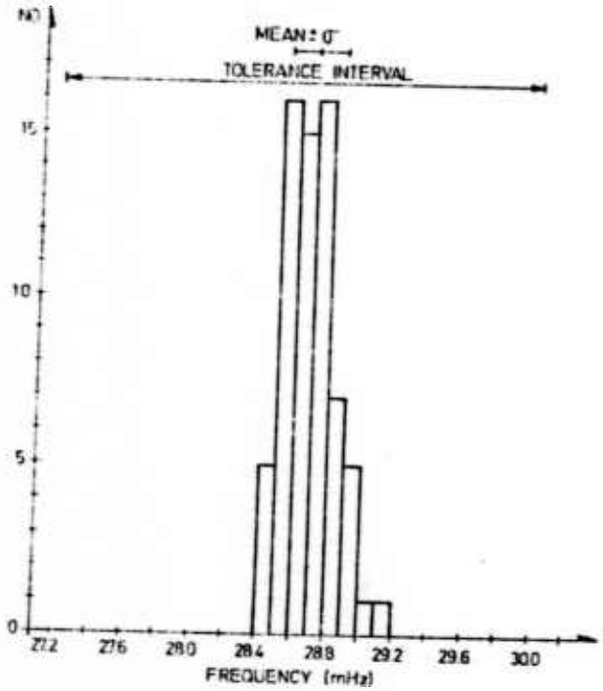

Fig. 4.13 The spread of the upper 3 dB point values of the NORSAR LP seismograph amplifiers (Ithaco).

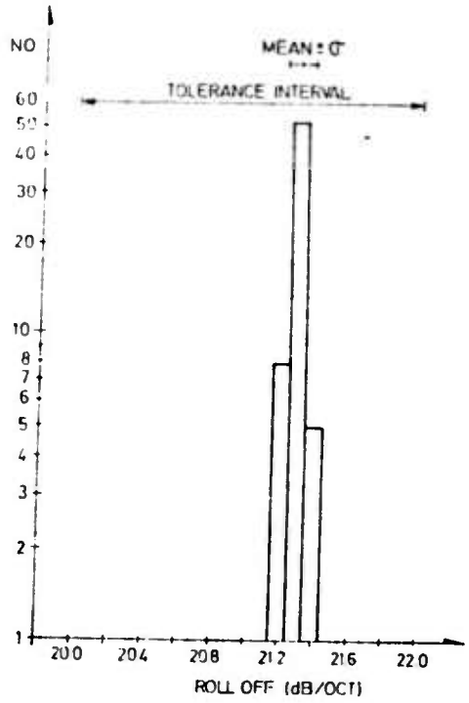

Fig. 4.14 The spread of the roll-off values of the NORSAR LP seismograph amplifiers (Ithaco).

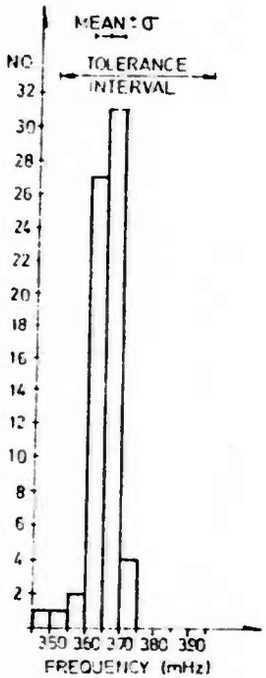

Fig. 4.15 The spread of the lower 3 dB point values of the NORSAR LP/LTA.

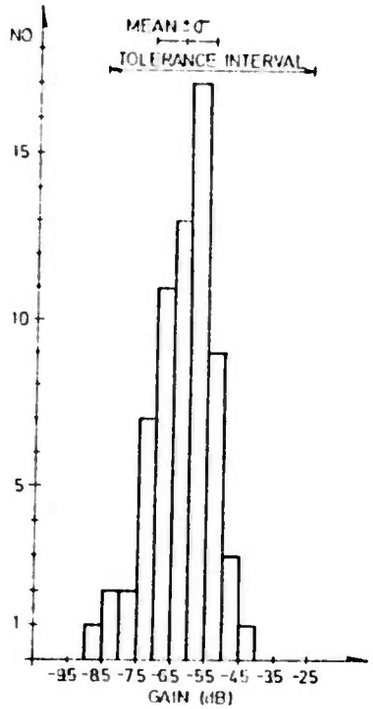

Fig. 4.16 The spread of the gain values of the NORSAR LP/LTA.

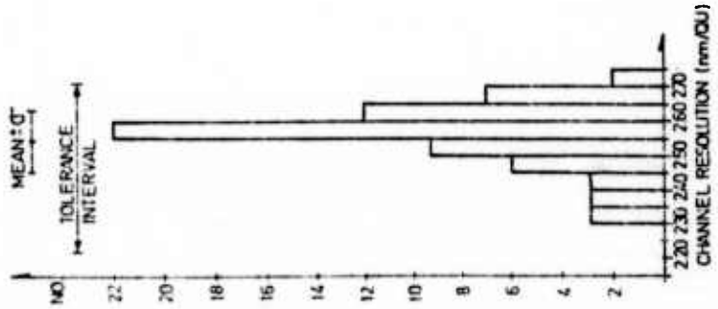

Fig. 4.17 The spread of the channel resolution values of the NORSAR LP channels.

5. AM PROGRAM DEVELOPMENTS

The off-line analysis program package has been improved to facilitate the access to previous monitoring results. Programs for statistical analysis and surveillance of fluctuations of the values of critical array hardware characteristics are in progress and will allow refined monitoring of the array performance and possibly predict deteriorating quality of the data channels.

Modifications to and updating of internal program parameters of CHANEVSP and CHANEVLP have been accomplished. The main new features are options for reprint of previous analysis results, and analysis of both seismic instrumentation of NAS and the simulated subarray configuration at NMC without operator intervention. Features which allow the user to request detailed control of the execution of these programs have been added.

6. EVALUATION

The array has operated satisfactorily throughout the period with no significant deterioration in its performance. Minor variations in error rates among the subarrays are disclosed in Table 3.3. However, taking the types of errors into consideration, it may be right to state that no major part of any subarray shows greater instabilities than identical parts on other subarrays.

The investigations initiated during the period (see Table 3.9) will hopefully further improve the error rates for the array shown in Table 3.4. This refers especially to the DCO of the LTA where a significant trend towards a negative bias is observed, and the channel protection circuits which easily get damaged during thunder storms. A small increase in the error

rate of the EPUs requiring major adjustments or replacements was observed this period. This increase may be of no significance, but we will investigate if the more frequent control and adjustment routine introduced this period as part of the preventive maintenance program accomplished during subarray visits may cause harm to these units.

The imbalance, gain, loss and distortion of SP seismograph amplifiers observed during the last year have in many cases been explained by a decay in the battery power due to aging. Therefore, all batteries will be replaced and the RA-5s fully overhauled as part of the preventive maintenance program for 1973 and 1974 (Section 3.2.3). The oldest part of the array, the A- and B-ring, was completed during this period.

The spread in the values of critical SP and LP channel characteristics measured by the AM programs is shown in Figures 4.1-4.17. The values for most of the parameters have a good clustering with a mean near the center of their tolerance interval, while others disclose a significant bias towards positive or negative values. This will be investigated together with an overall review of the initial fixation of tolerance limits of the instrumentation. These data also disclose the need for other actions. Here should only be mentioned the flux of the LP seismometer magnets, i.e., the coil sensitivities, which will be calibrated as soon as the necessary equipment has been acquired.

REFERENCES

1) Steinert, O., and A.Kr. Nilsen: Array Monitoring and Field Maintenance Report, 1/7-31/12-1972, NORSAR Technical Report No. 51, NTNF/NORSAR, Kjeller, Norway, 1973.

2) System Operations Report 1973[I] (in print).

3) Report on Field Adjustment of the SP Seismometers' Damping Ratio, Noratom-Norcontrol A/S, dated 8 September 1971.

4) Suppression of SP Channel Noise, Teleplan A/S, dated 1 June 1971.

5) Larsen, P.: Noise in SLEM Discrete Input, NORSAR Technical Report No. 52, In print.